Pacific branch («TINRO») of Russian Federal
«Research Institute of Fisheries and Oceanography»
(«VNIRO»)

Problems of the Pacific cod stock assessment in the western Bering Sea in relation to temporal warming

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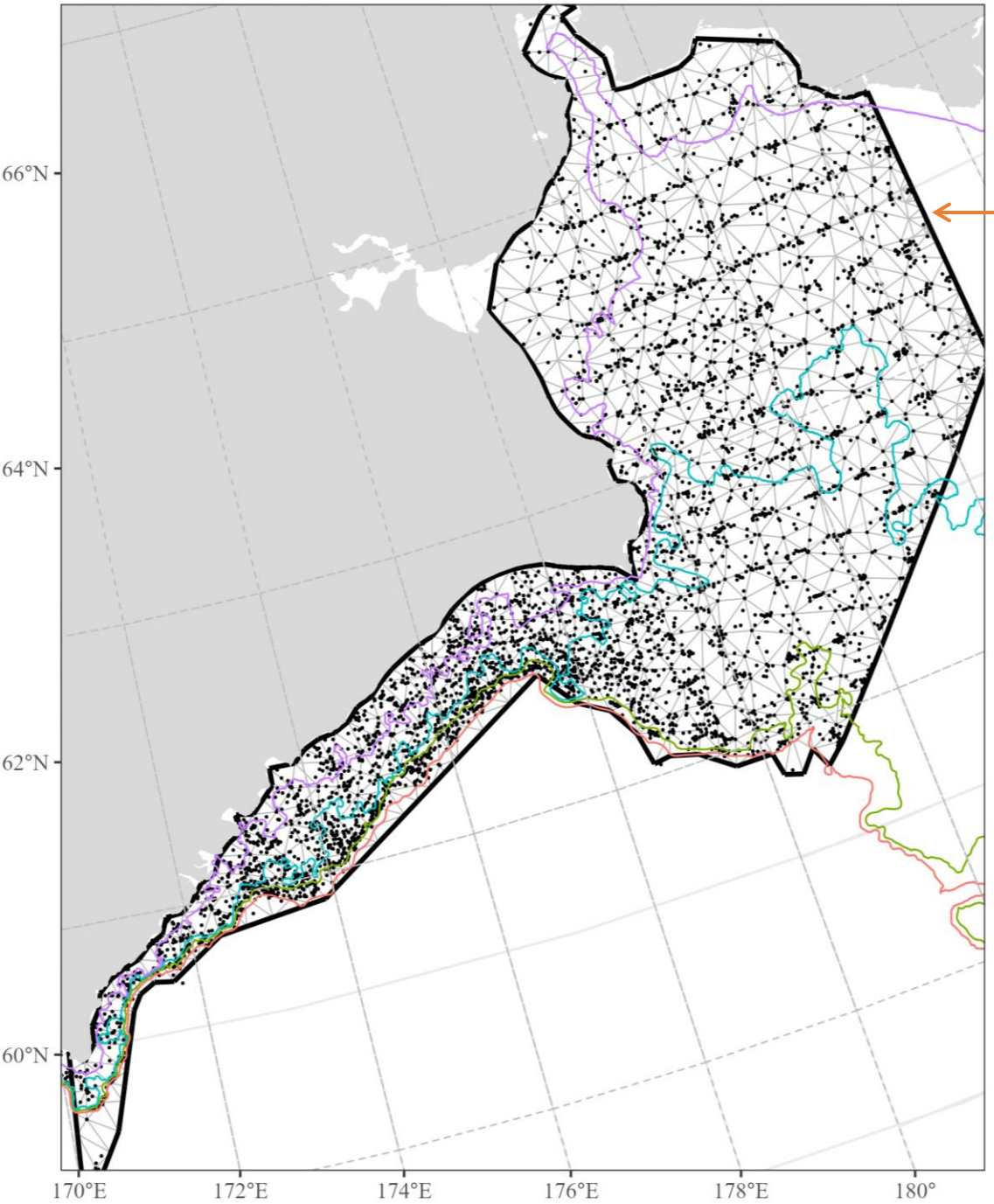


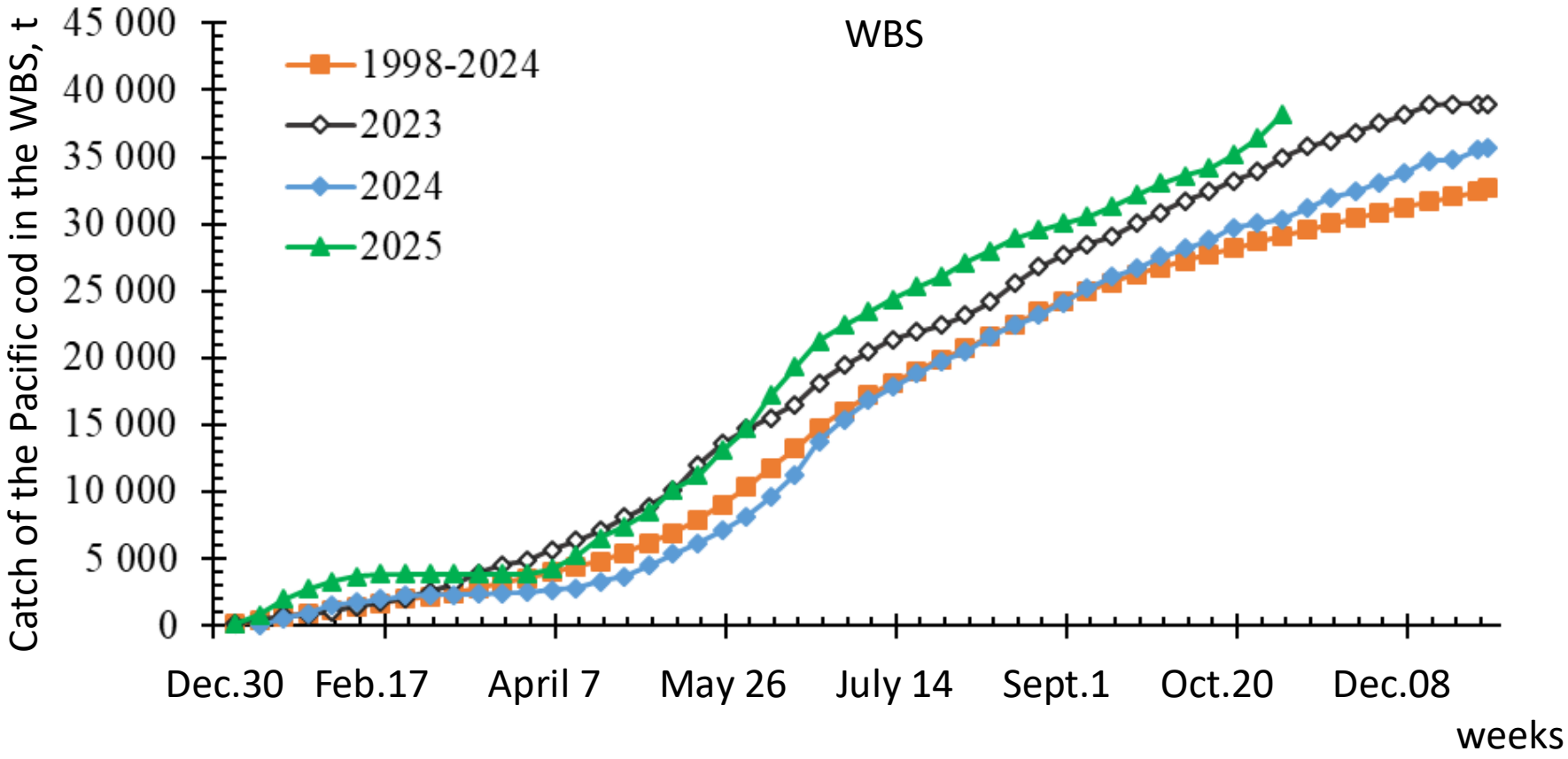
The Pacific cod (*Gadus macrocephalus*) is a very important demersal fish species in Russian bottom fisheries. Primarily it is harvested in the **western Bering Sea (WBS) fishing zone** (between 170°E and 175°W longitude in Russian EEZ).

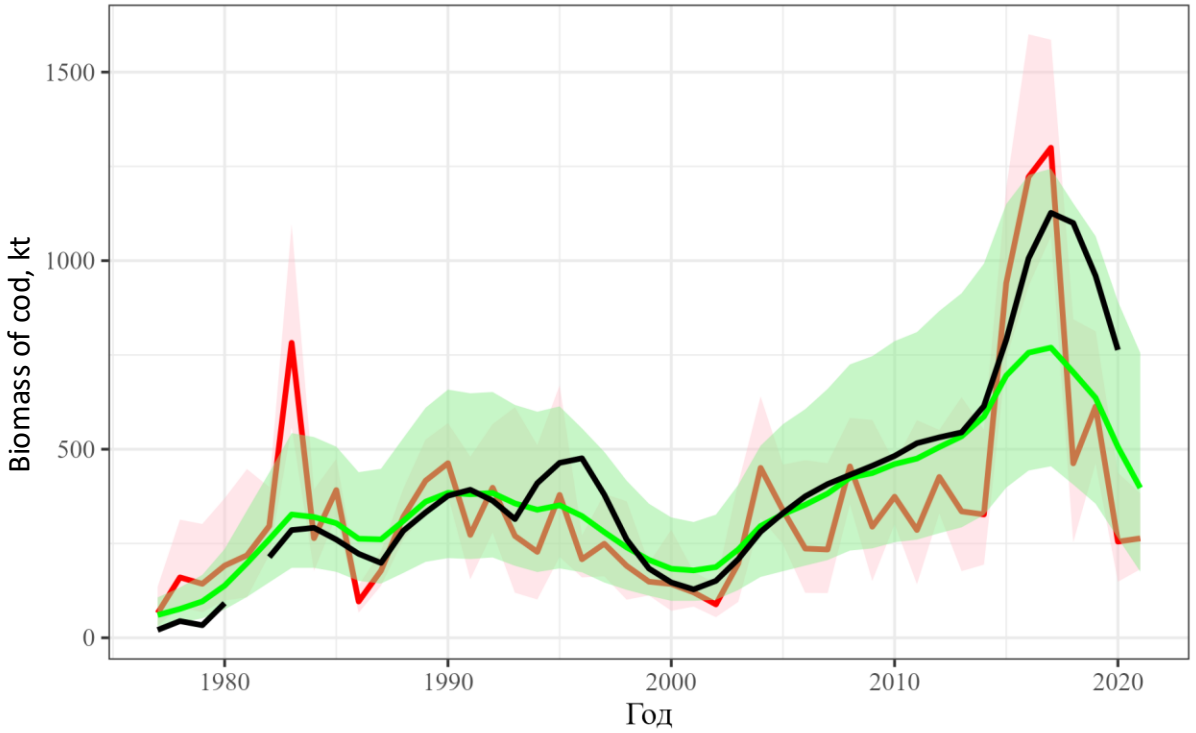
Year	2015	2016	2017	2018	2019	2020
Catch, kt	23.4	25.0	35.5	64.9	88.2	101.9
TAC, kt	25.3	27.4	36.2	66.3	86.0	105.0
% TAC	92.5%	91.2%	98.1%	97.9%	102.6%	97.0%

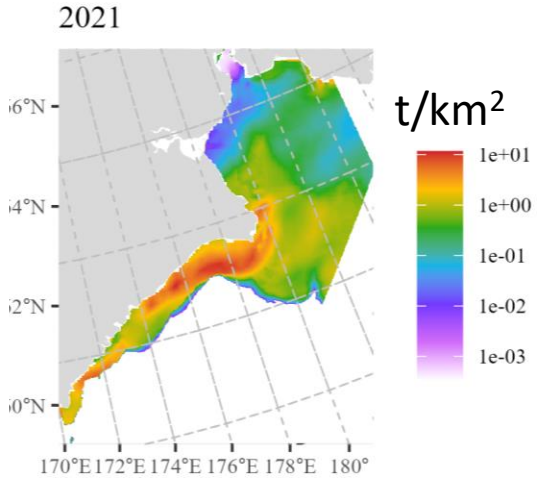
Year	2021	2022	2023	2024	2025*	2026
Catch, kt	89.9	60.5	39.0	35.9	38.3	
TAC, kt	105.0	90.0	84.5	57.0	48.0	50.0
% TAC	85.6%	67.2%	46.2%	63.0%	79.8%	

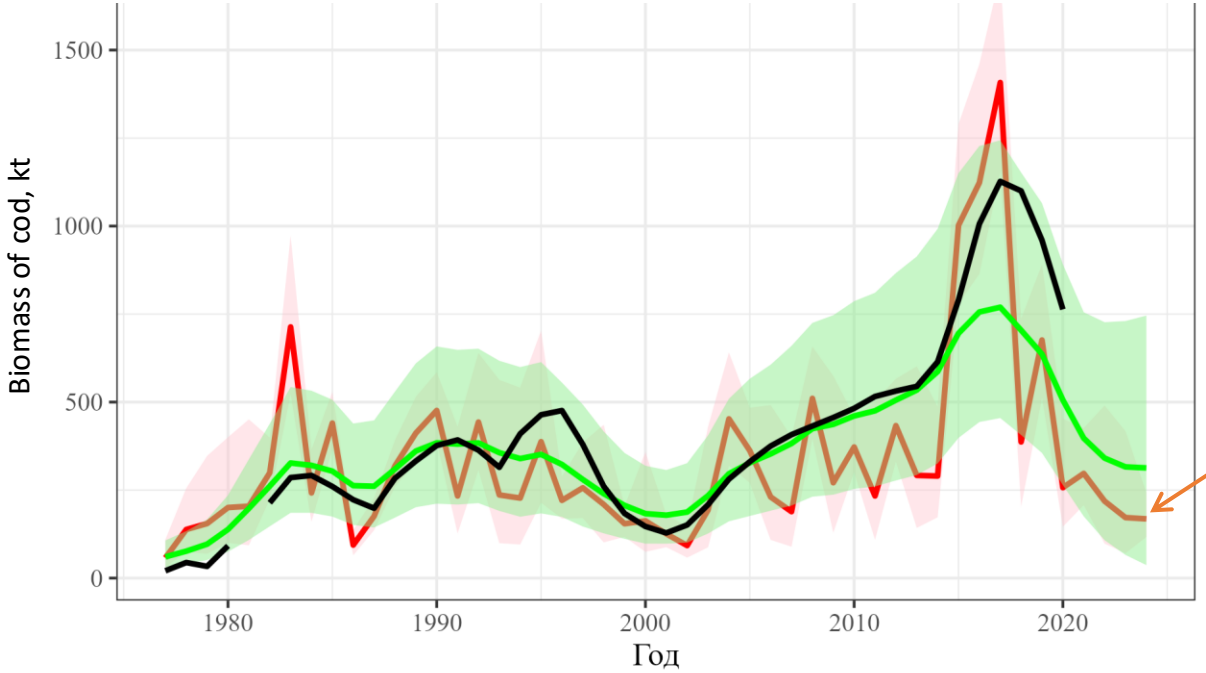
*2025-11-05

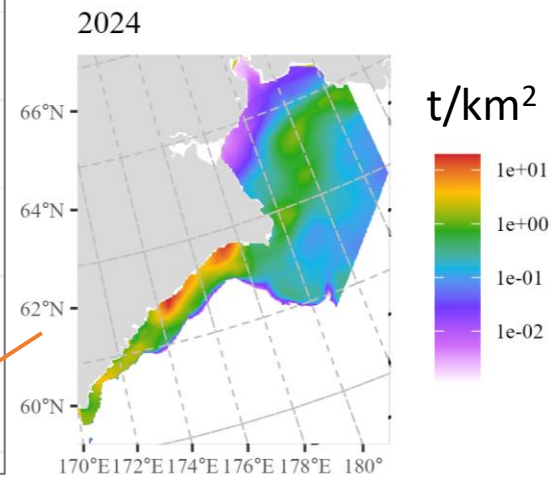
http://tinro.vniro.ru/ru/operativnaya-informatsiya/operativnaya-informatsiya-v-rajone









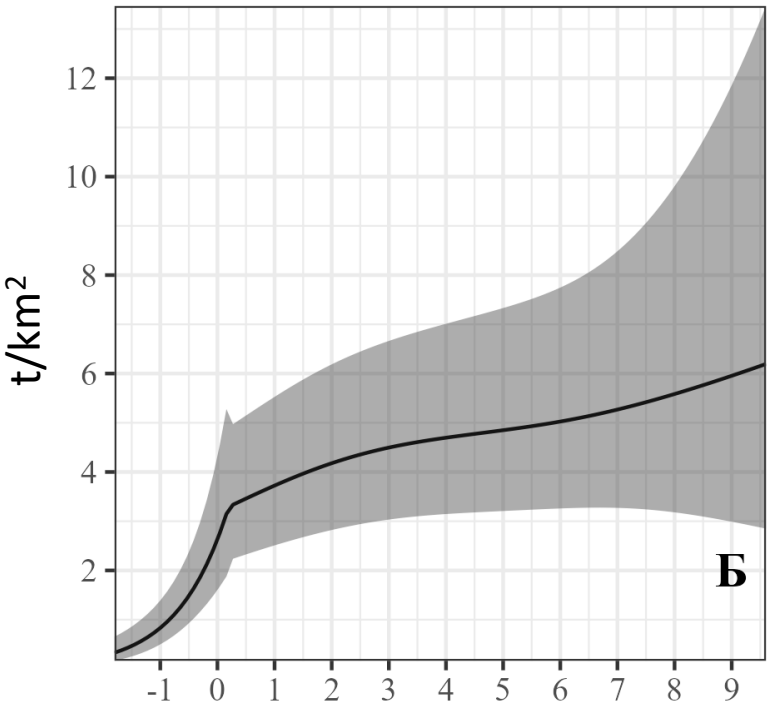


Distribution of C.I. around the median cod biomass (kt = 10^3 t) in the ensemble sdmTMB (*red line*) with q = 0.666 and dynamics of cod biomass assessed by JABBA considering SSB (*green line*) and **SSB** [Savin, 2023] with new q = 1.18 (***black line***) on top of predefined q = 0.4, so final q is 0.472

Kulik V.V., Savin A.B. (2024). Vector Autoregressive Spatio-Temporal (VAST) models for biomass distribution of pacific cod *Gadus macrocephalus* (Gadidae) considering water temperature at the sea bottom in the West Bering Sea zone, *Izv. TINRO*, 204(3), pp. 722–744. (In Russ).
DOI: 10.26428/1606-9919-2024-204-722-744

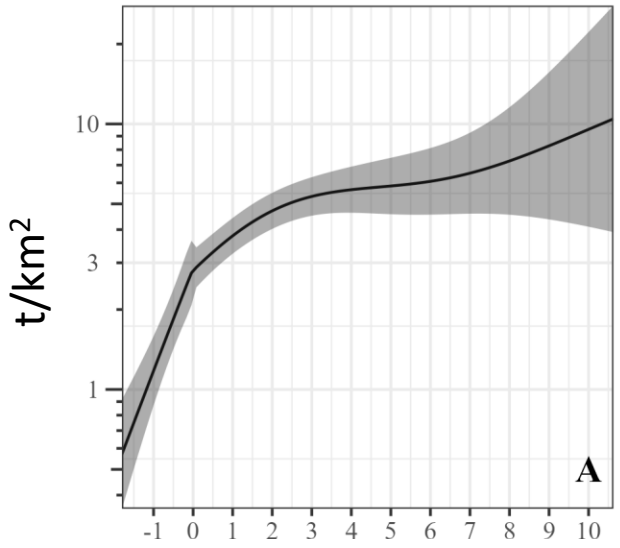
Kulik V.V. et al. (2024). Cod biomass index in the west Bering Sea zone, considering bottom temperature from 1977 to 2024, *Proceedings of the II International Scientific and Practical Conference, Moscow, VNIRO, November 18-22,* pp. 95–98. (In Russ).

Distribution of C.I. around the median cod density (t/km^2) by water temperature at the bottom (℃) for the median Depth = 93 m in the ensemble sdmTMB in 2021 (Kulik, Savin, 2024)

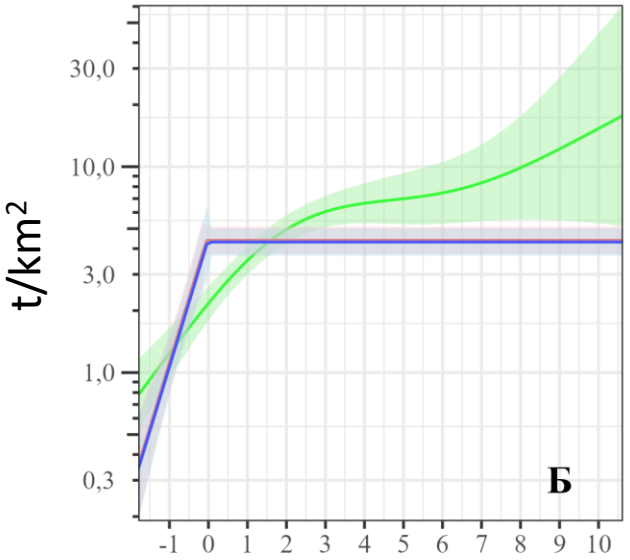


water temperature at the bottom, ℃

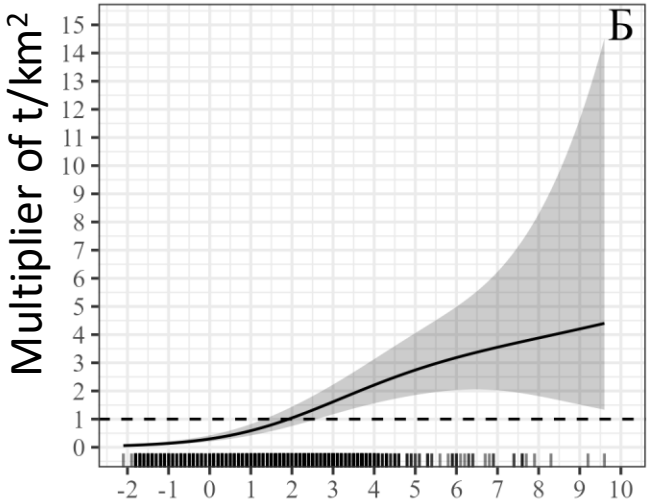
+2024 year (Kulik et al., 2024)



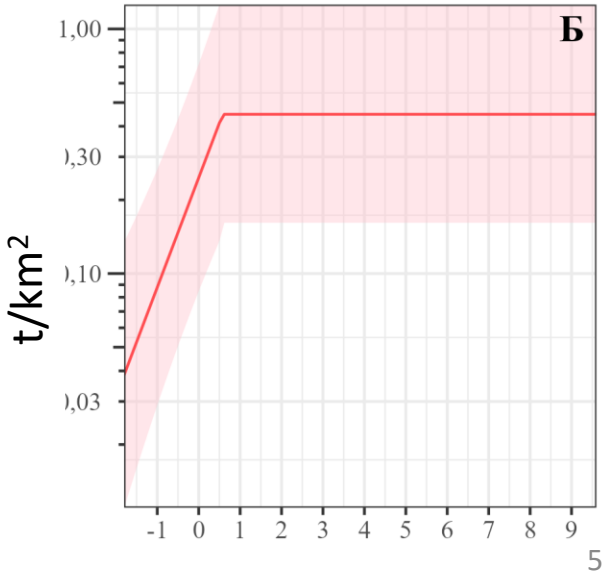
water temperature at the bottom, ℃



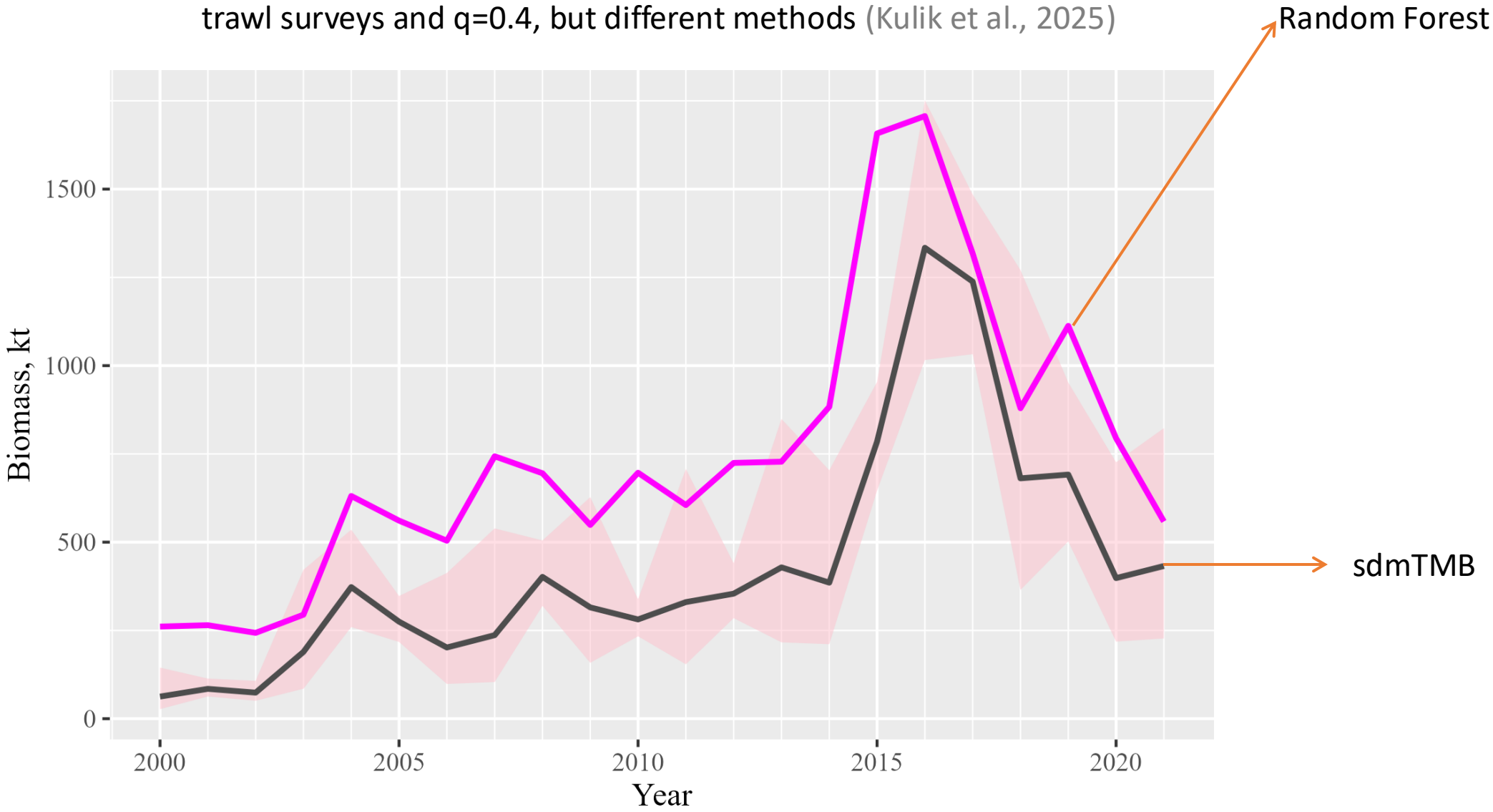
Kulik et al., 2025. Lagrangian Analysis of Satellite Data for the Pacific Cod Biomass Estimation in the West Bering Sea Zone, *Issledovanie Zemli iz Kosmosa, 4, pp. 87–107.* (In Russ)



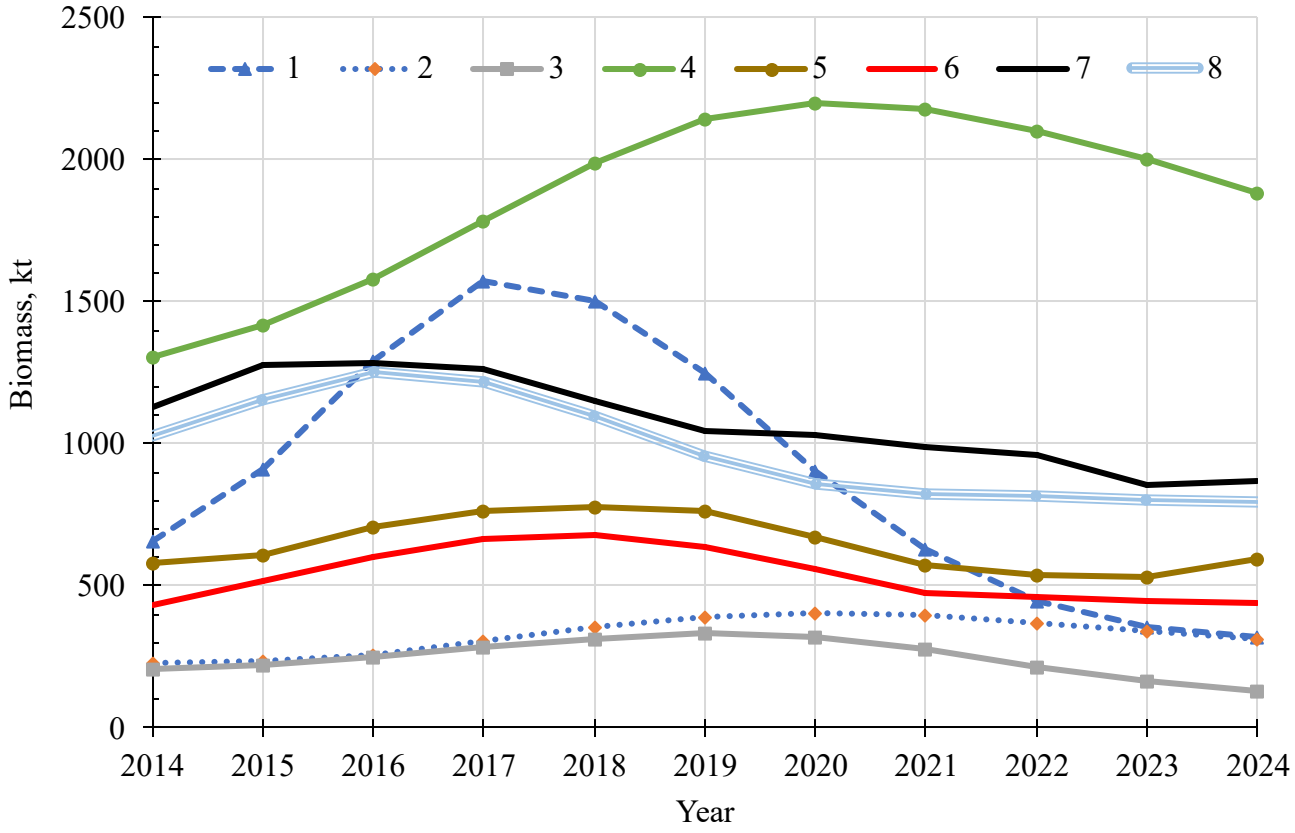
water temperature at the bottom, ℃



Scaling issue of biomass estimated from the same data from bottom trawl surveys and q=0.4, but different methods (Kulik et al., 2025)



Warming of bottom temperatures after 2014 is suspected in unusual distribution of biomass of cod in such a way that its sum in WBS could not be reproduced in the models of biomass dynamics and statistical catch at age (SCAA) models assuming independence and stationarity of biological parameters of the WBS stock.



Cod ***SSB*** estimates:

<u>in the WBS zone</u>

1 – in the Synthesis model with forced biomass scaling equal to scientific surveys area-swept estimates,

2 – in the Synthesis model with maximum likelihood,

3 – in the model with unscented Kalman Smoother (UKS) and logistic selectivity,

4 – in the model with UKS and exponential-logistic selectivity,

_____

5 – in the model with UKS and exponential-logistic selectivity for the **entire northern Bering Sea (WBS+EBS)**,

6 – in the SS3 model for the **northeastern part of the sea (EBS+NBS)**;

TSB estimates for cod:

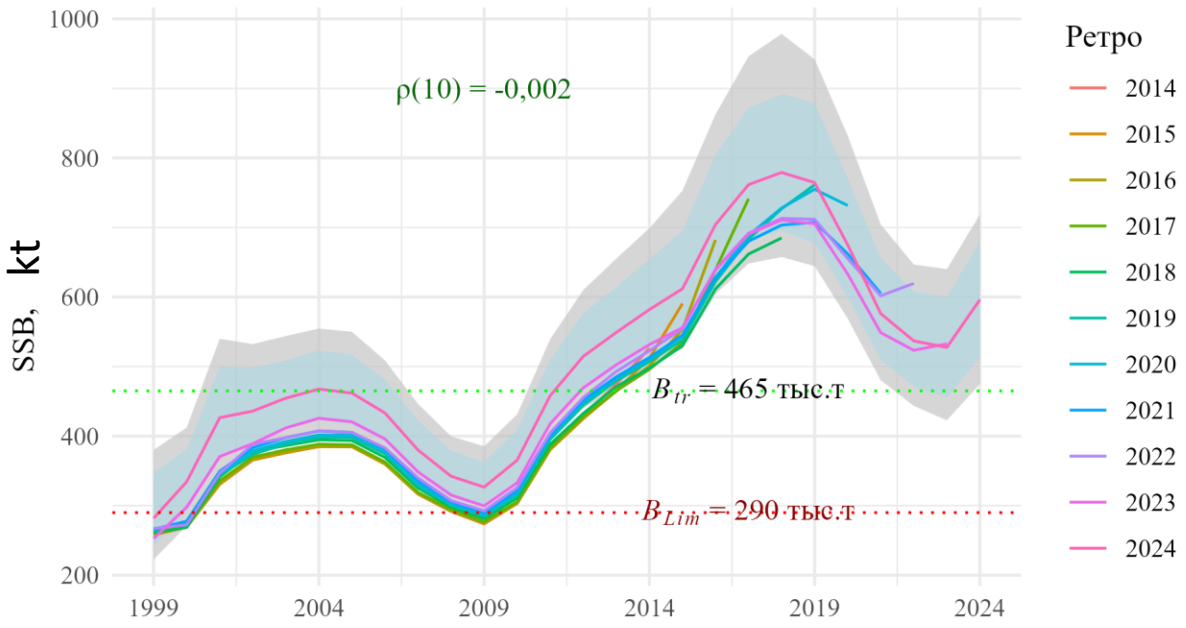
7 – in the model with UKS and exponential-logistic selectivity for the **entire northern Bering Sea (WBS+EBS)**

8 – in the SS3 model for the **EBS**

Kulik V.V., Baitaliuk A.A., Savin A.B. (2025). Reliability of forecasting Pacific cod biomass in the northern Bering Sea in different models, *Proceedings of the III International Scientific and Practical Conference and the V School of Young Scientists and Specialists: a collection of scientific articles "Fisheries Science in the 21st Century: Key Development Directions", Moscow, VNIRO, April 7-10*. pp. 214-219.

in the model with UKS and exponential-logistic selectivity for the **entire northern Bering Sea (WBS+EBS)**

Year, t	SSB, kt				Mohn		Absolute errors		
	P_t	Naïve, P_t	Y_t	T_t	ρ_t	$\rho_{(t)}$	e_t	Naïve e_t	$\|q_t\|$
2014			526.31	581.95	-0.096				
2015	595.88	526.31	590.61	611.84	-0.035	-0.026	5.27	64.30	0.08
2016	760.23	590.61	682.18	704.22	-0.031	0.080	78.05	91.57	0.85
2017	787.19	682.18	741.32	761.59	-0.027	0.034	45.88	59.13	0.78
2018	811.24	741.32	684.99	779.14	-0.121	0.041	126.26	56.33	2.24
2019	646.49	684.99	761.40	764.52	-0.004	-0.154	-114.91	76.41	1.50
2020	688.00	761.40	731.70	675.16	0.084	0.019	-43.70	29.70	1.47
2021	638.80	731.70	605.23	576.18	0.050	0.109	33.57	126.47	0.27
2022	556.52	605.23	619.64	536.93	0.154	0.036	-63.12	14.41	4.38
2023	676.90	619.64	532.73	527.55	0.010	0.283	144.17	86.91	1.66
2024	638.77	532.73		596.22		0.071	638.77	532.73	1.20
				Mohn's ρ (10)	-0.002	0.049	MASE(10)		1.44
				Mohn's ρ (5)	0.06	0.10	MASE(5)		1.79



P_t – SSB forecast in year t from the previous year's estimates.

Y_t – SSB estimate in the terminal year t, T_t – SSB terminal estimates (full set of data)

$e_t = Y_t - P_t$

Naïve $P_t = Y_{t-1}$

Naïve e_t = Naïve $P_t - Y_t$

$q_t = e_t / |$ Naïve $e_t |$

MASE is equal to the average of the absolute values $|q_t|$ over the selected period of years (5 or 10).

Kulik V.V., Baitaliuk A.A., Savin A.B. (2025). Reliability of forecasting Pacific cod biomass in the northern Bering Sea in different models, *Proceedings of the III International Scientific and Practical Conference and the V School of Young Scientists and Specialists: a collection of scientific articles "Fisheries Science in the 21st Century: Key Development Directions", Moscow, VNIRO, April 7-10*. pp. 214-219.

EBS

2. Assessment of the Pacific Cod Stock in the Eastern Bering Sea

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7600 Sand Point Way NE., Seattle, WA 98115-6349

November 16, 2024

With contributions from:

Kerim Aydin, Asia Beder, Mathew Callahan, Bridget Ferriss, Kirstin Holsman, Beth Matta, Susanne McDermott, Jens Nielsen, Jordan Watson, and Stephani Zador

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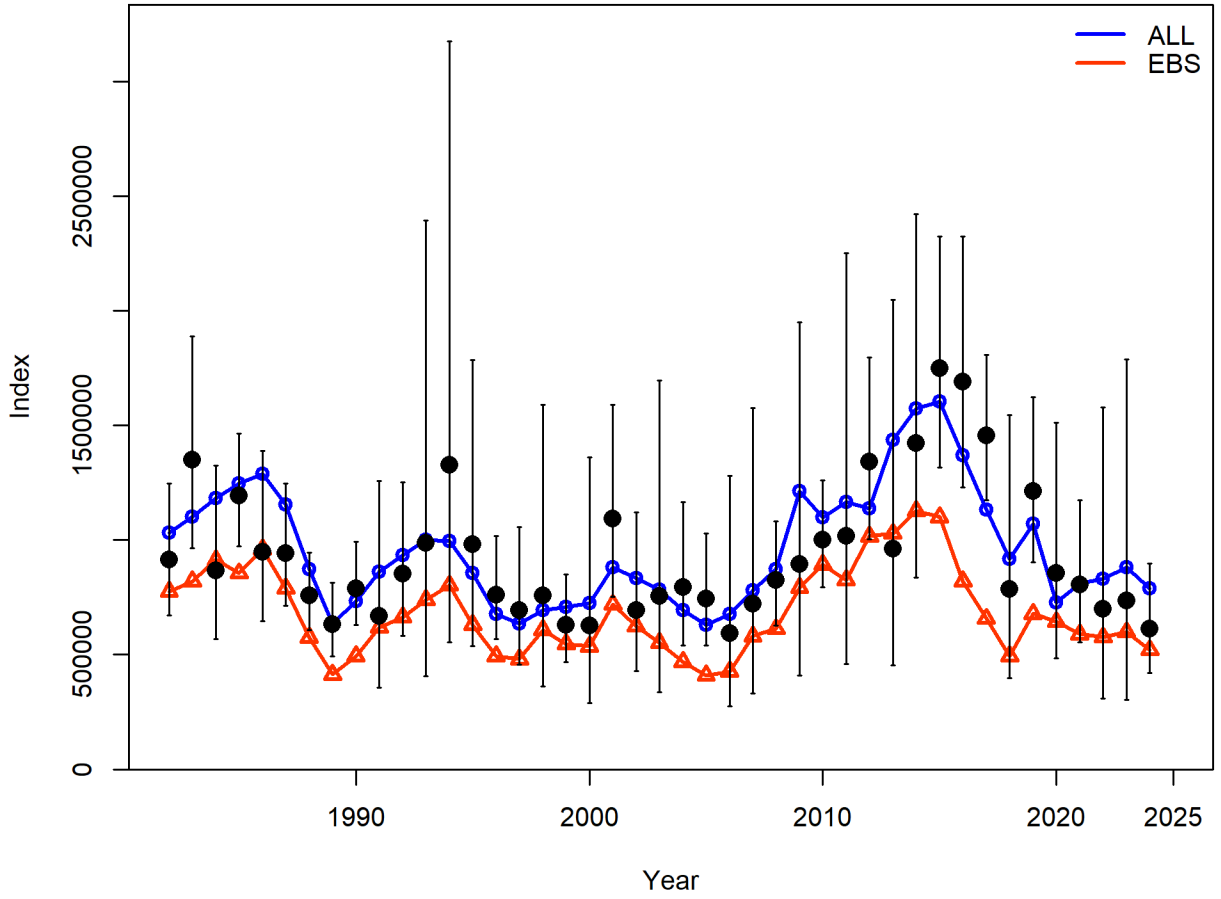
Barbeaux, S. J., Barnett, L., Hulson, P., Nielsen, J., Shotwell, S. K., Siddon, E., and Spies, I. 2024. Assessment of the Pacific cod stock in the Eastern Bering Sea. *In* Plan Team for the Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 1-150. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

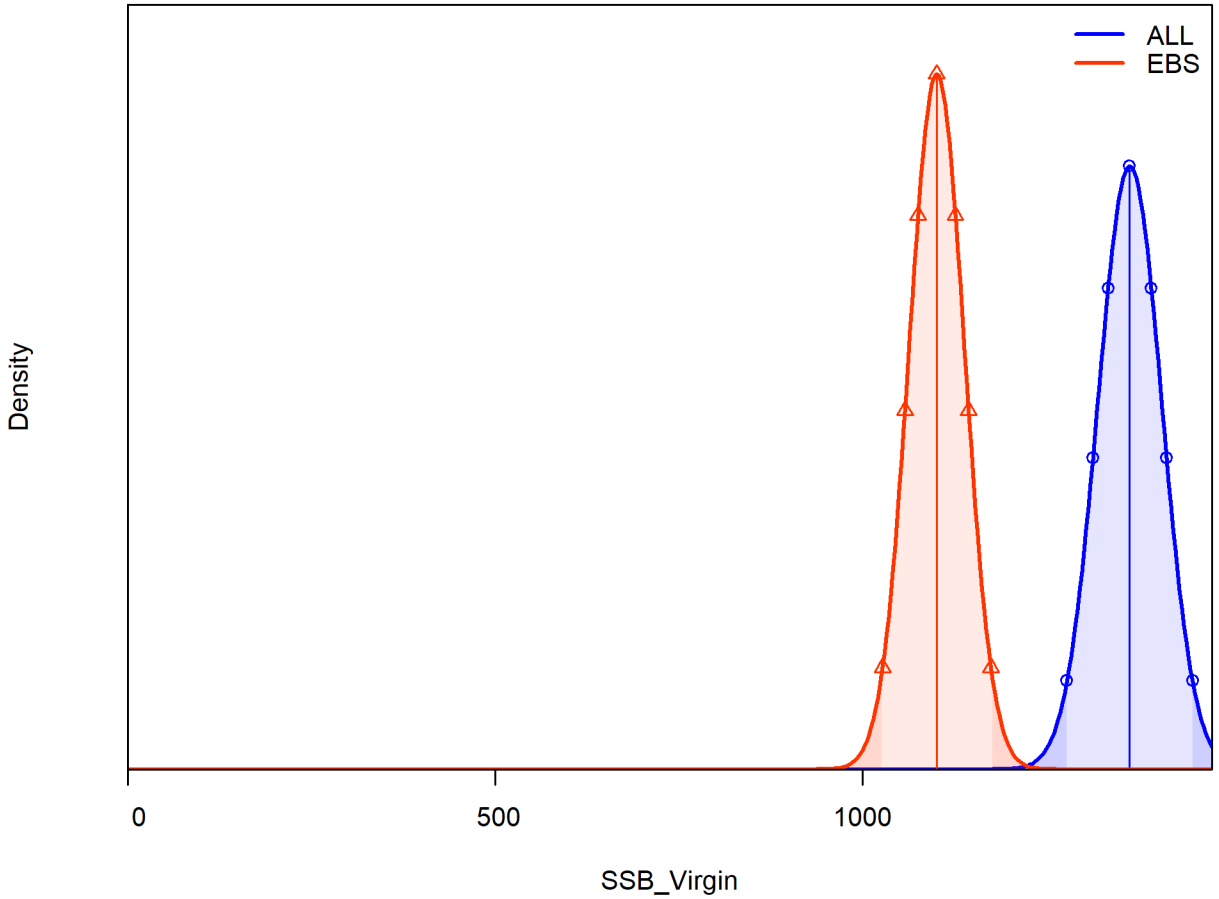
+WBS=ALL in SS3?

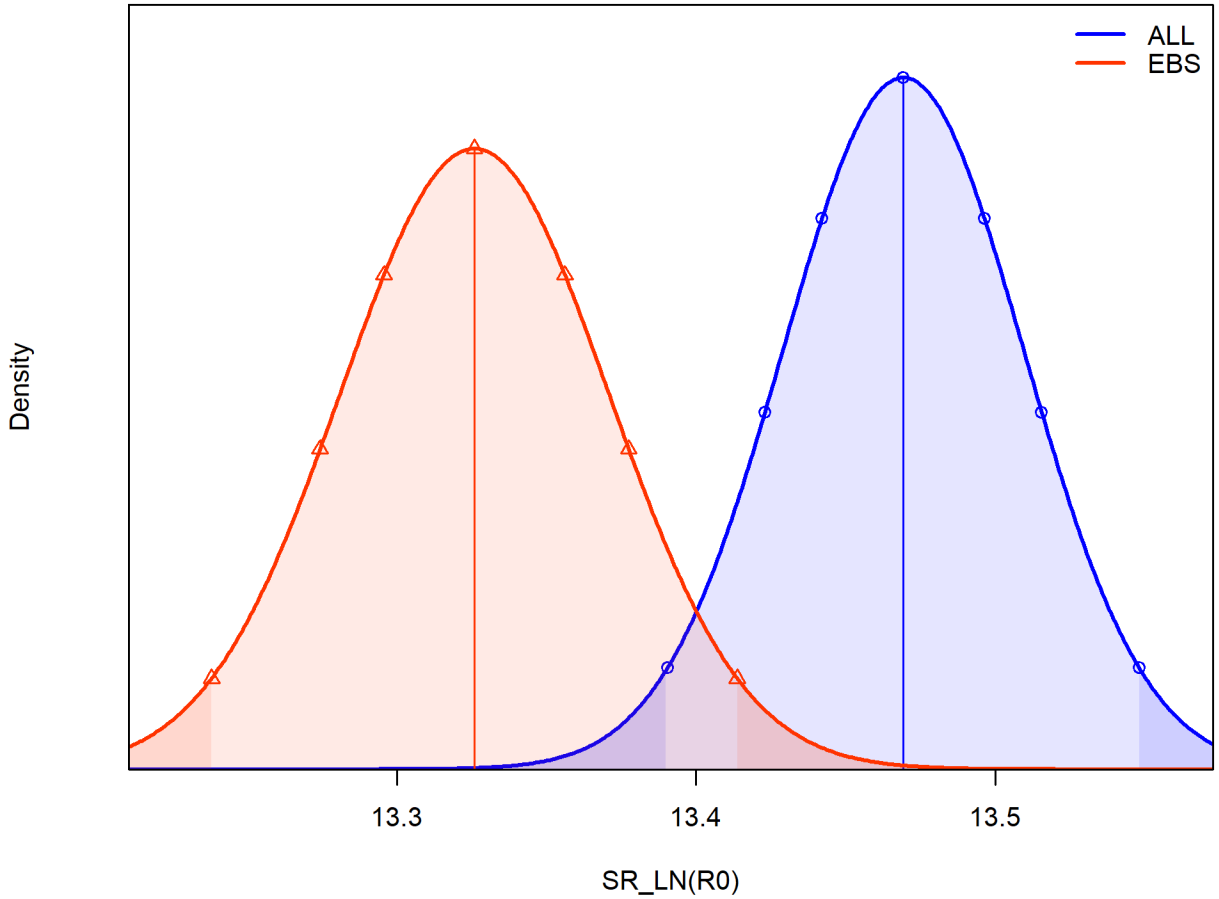
+ Russian data.

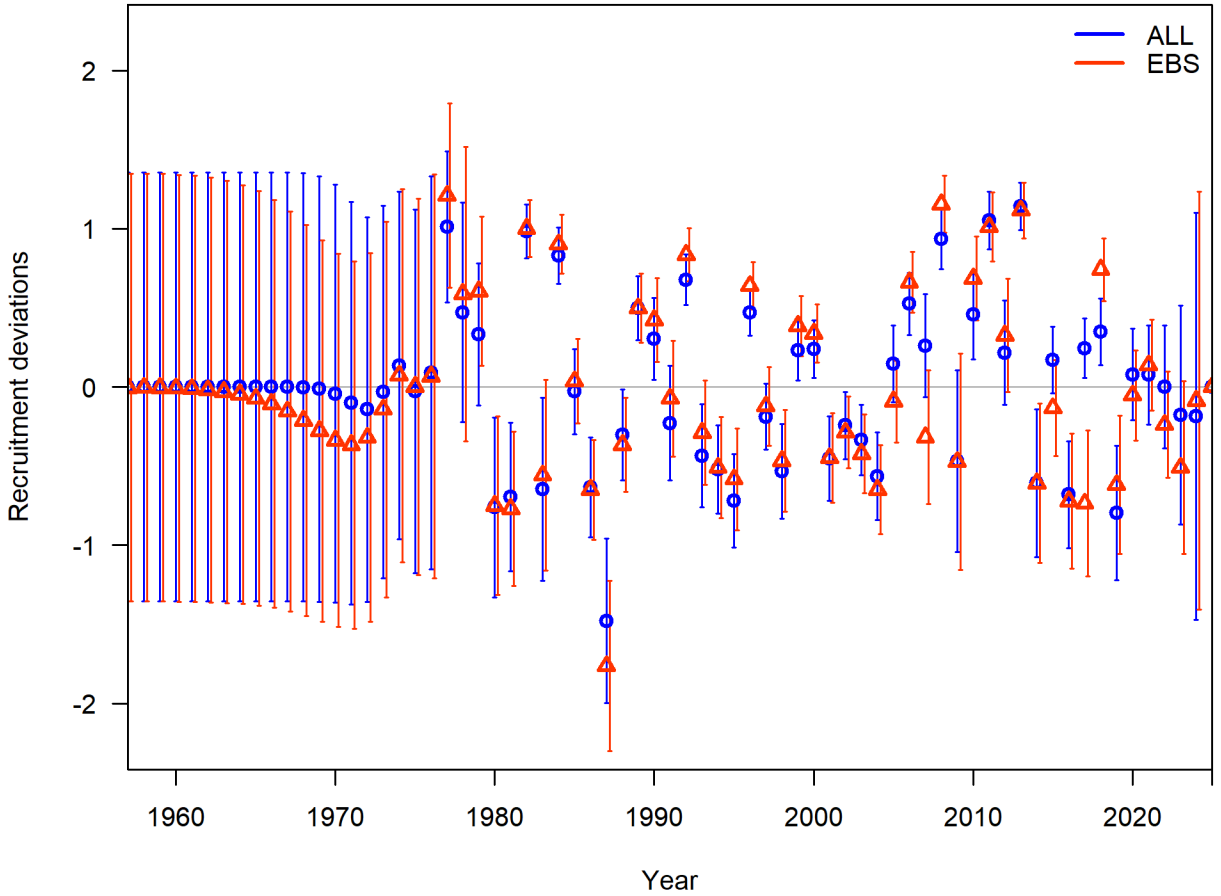
SS3 model 24.1 after inclusion of catch, age, and length data from Russia.

correlation between survey index input and output increased from 0.769 (EBS) to 0.782 (ALL)

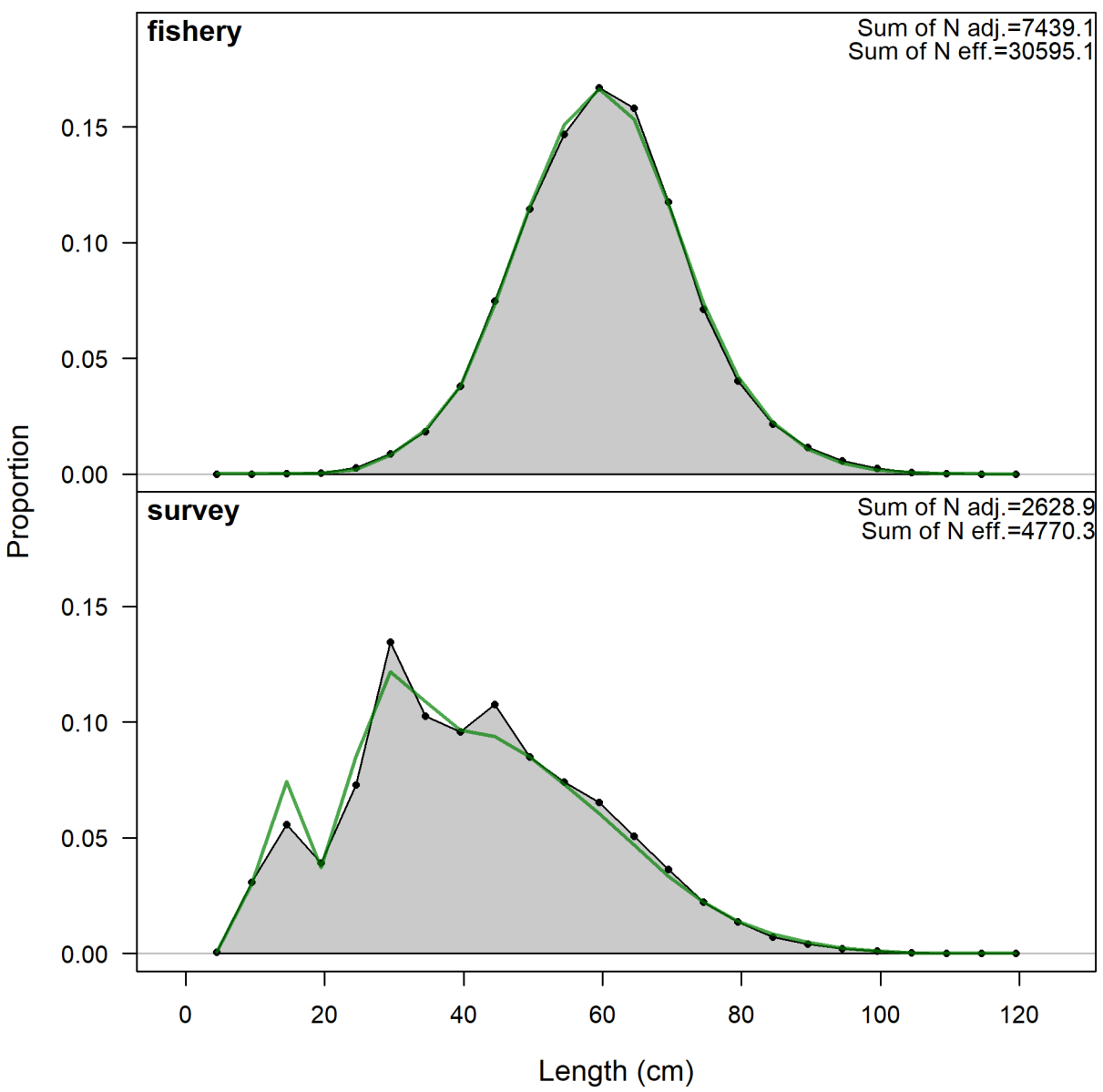




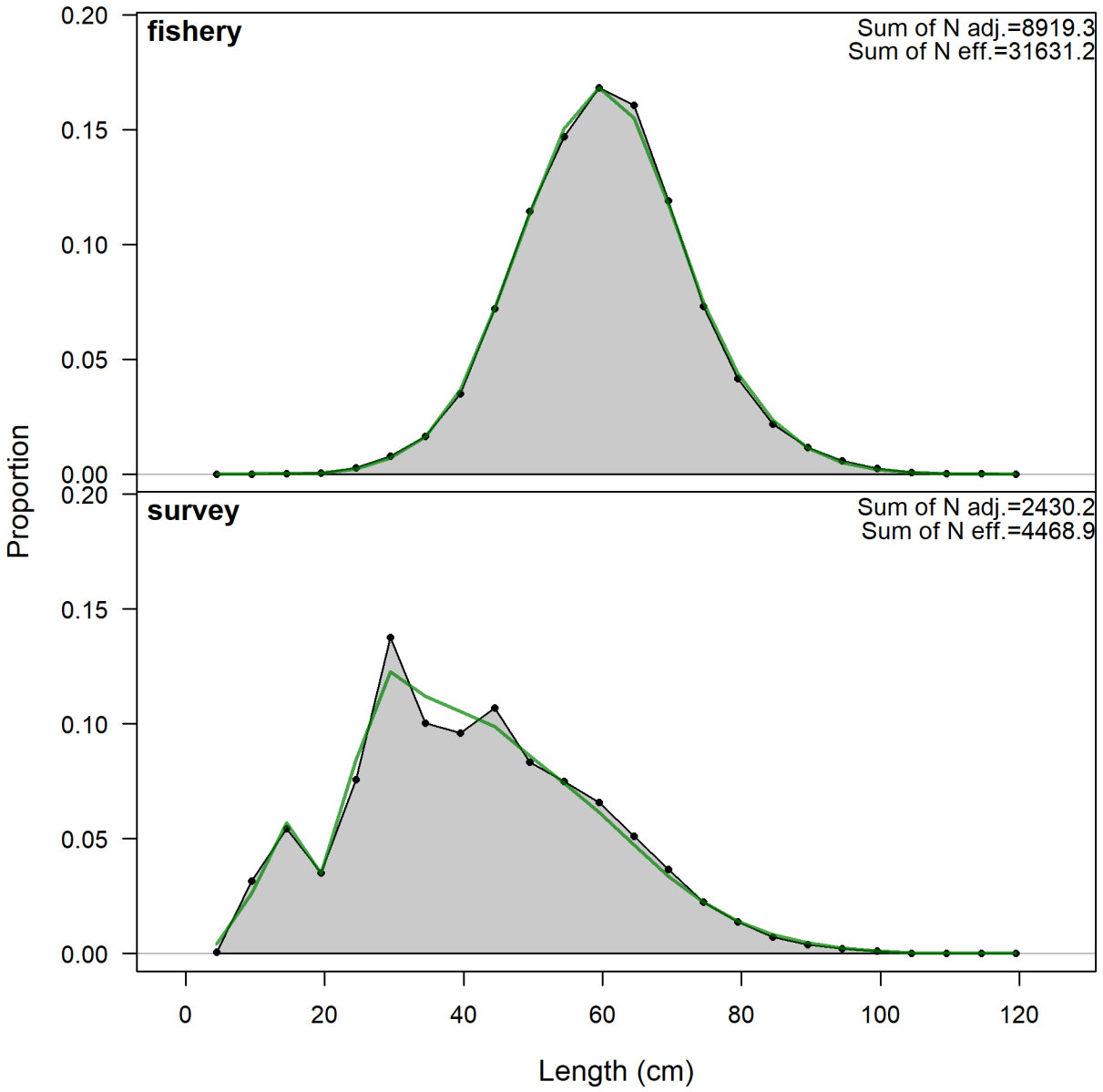

ALL
EBS
Density
13.3
13.4
13.5
SR_LN(R0)


ALL
EBS
Recruitment deviations
2
1
0
-1
-2
1960
1970
1980
1990
2000
2010
2020
Year

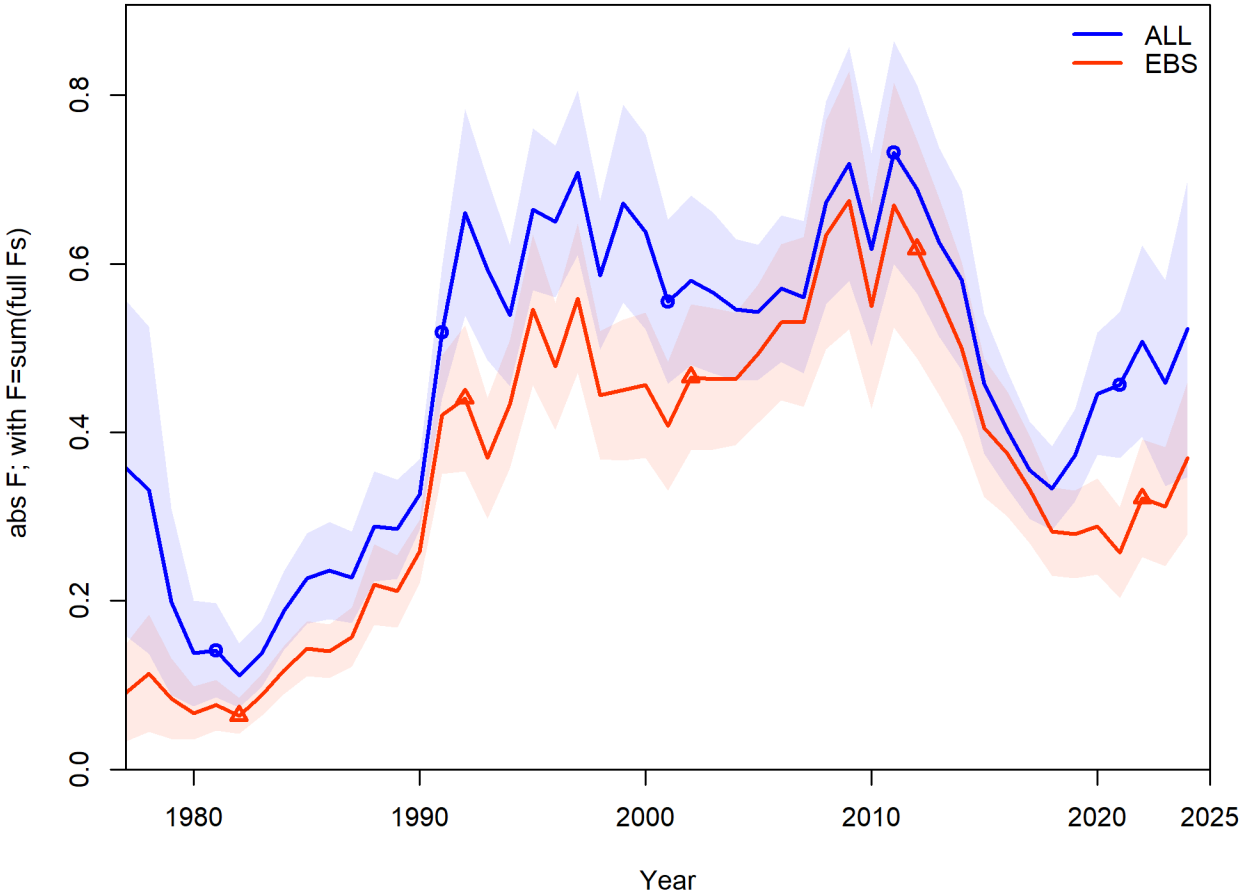
EBS

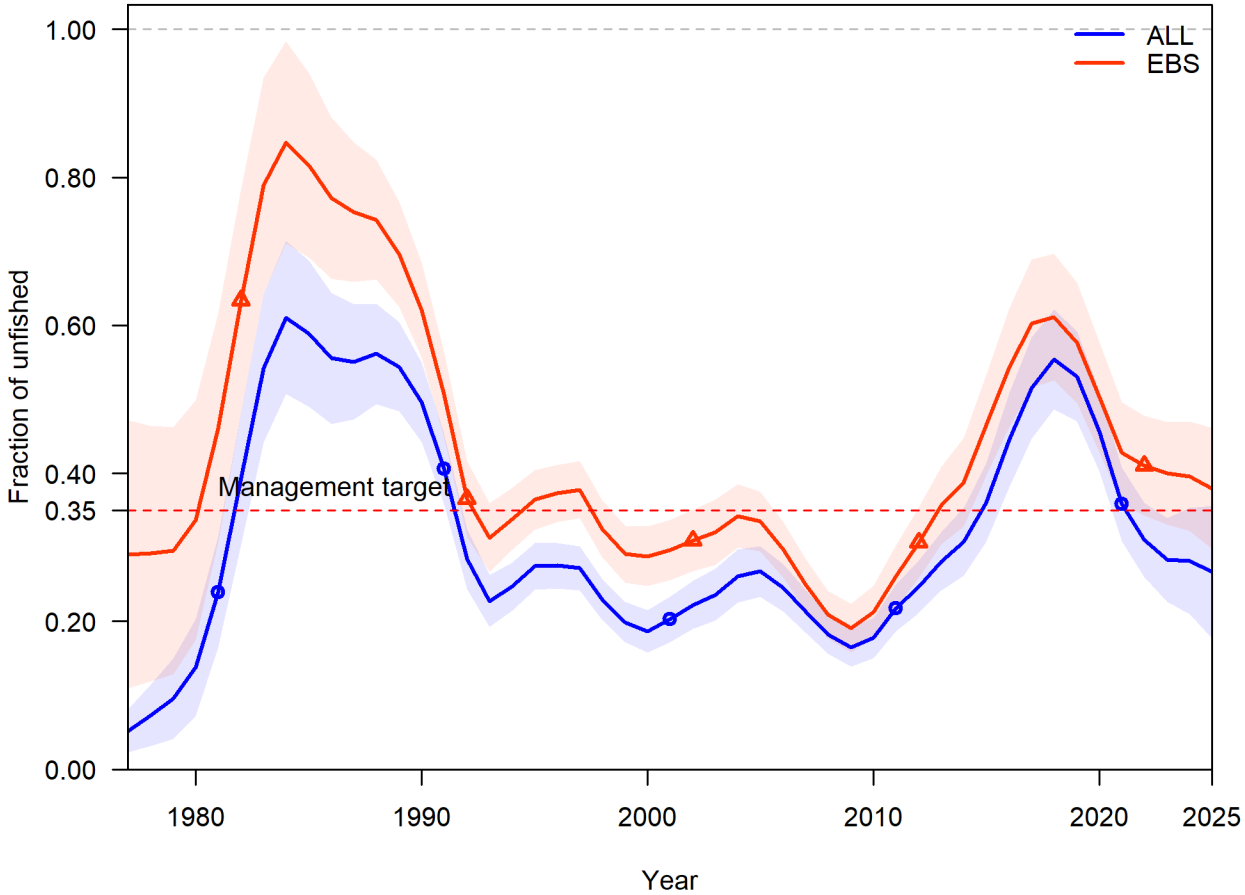


ALL

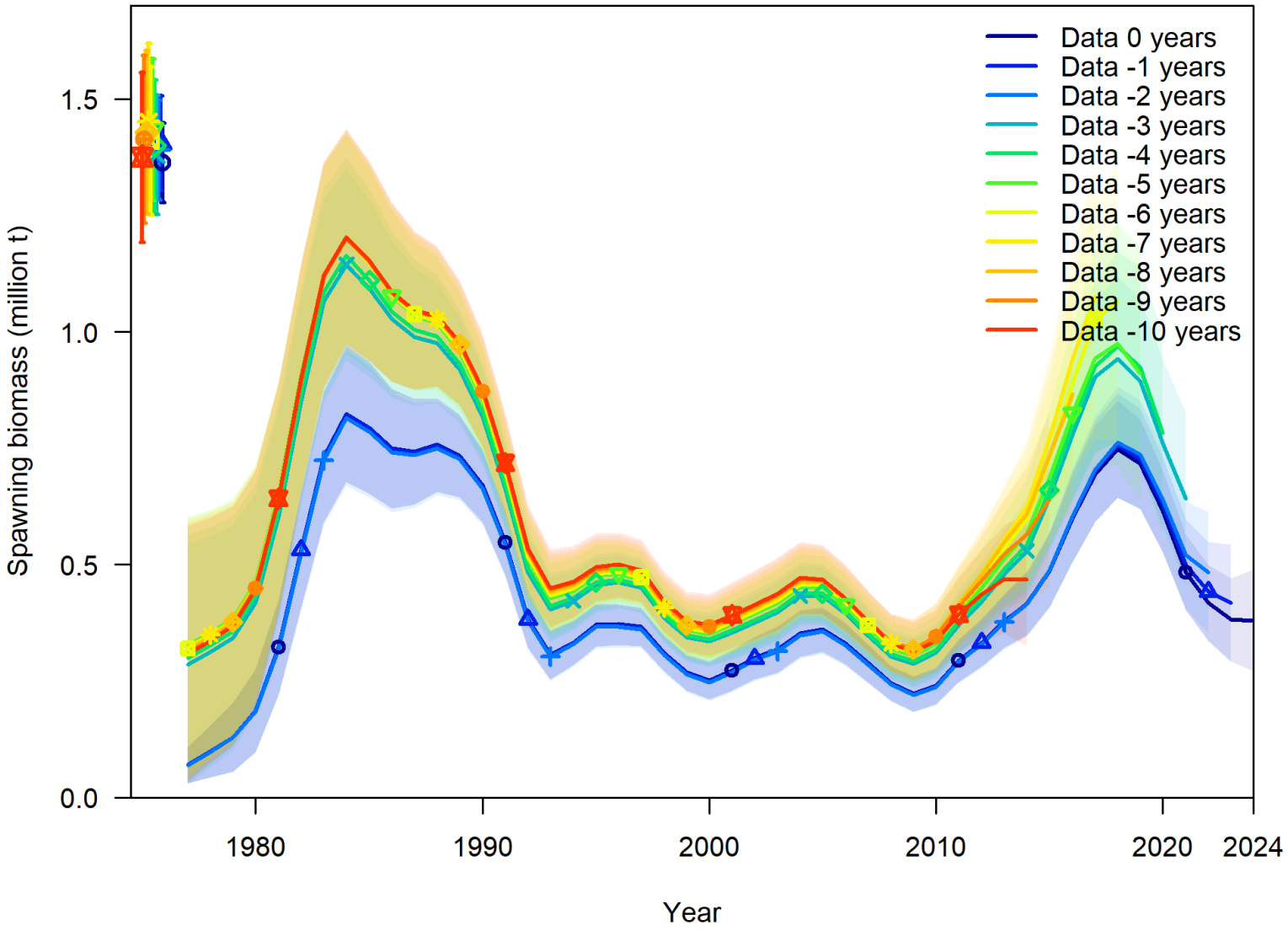


comp_lenfit__aggregated_across_time


ALL
EBS
abs F; with F=sum(full Fs)
0.0
0.2
0.4
0.6
0.8
1980
1990
2000
2010
2020
2025
Year


ALL
EBS
Fraction of unfished
1.00
0.80
0.60
0.40
0.35
0.20
0.00
Management target
1980
1990
2000
2010
2020
2025
Year

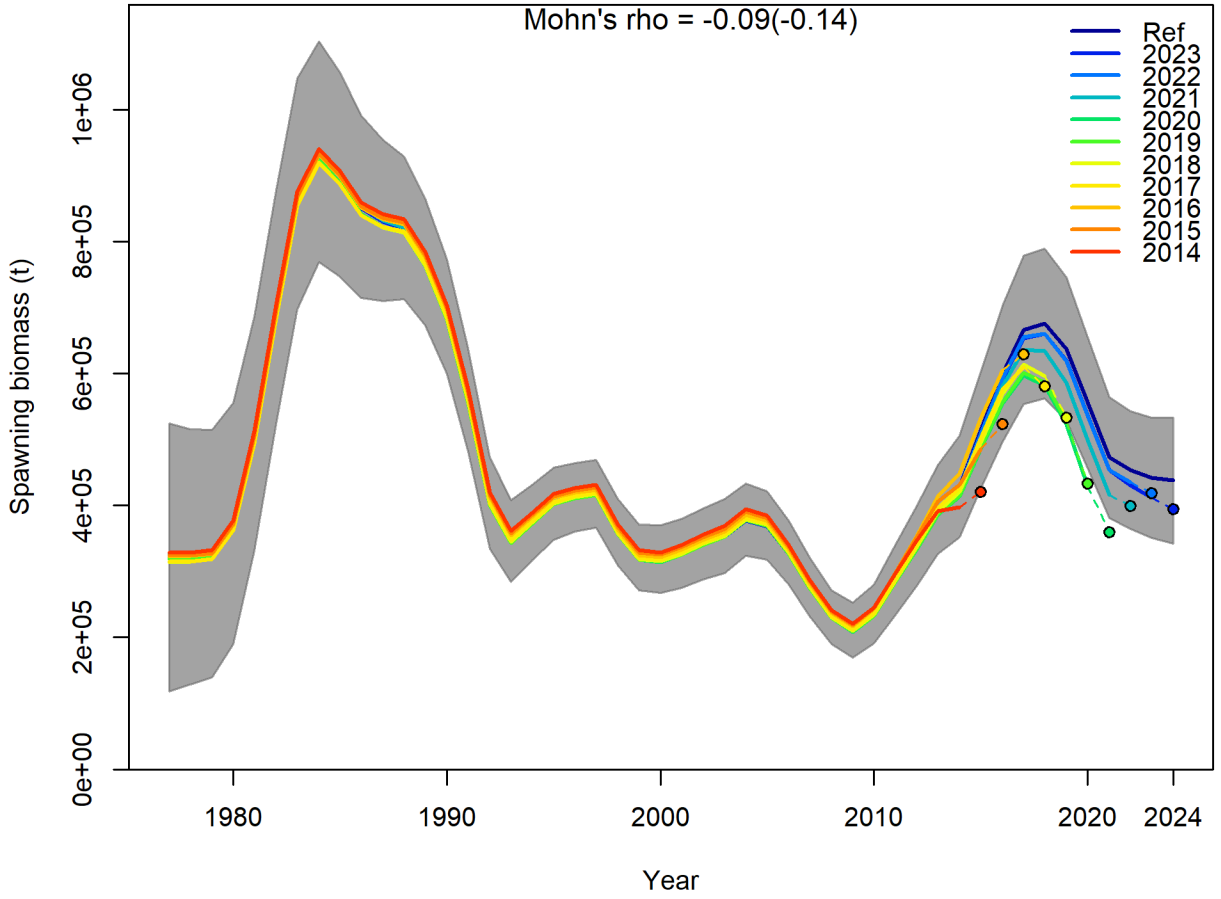
ALL. Scaling problem



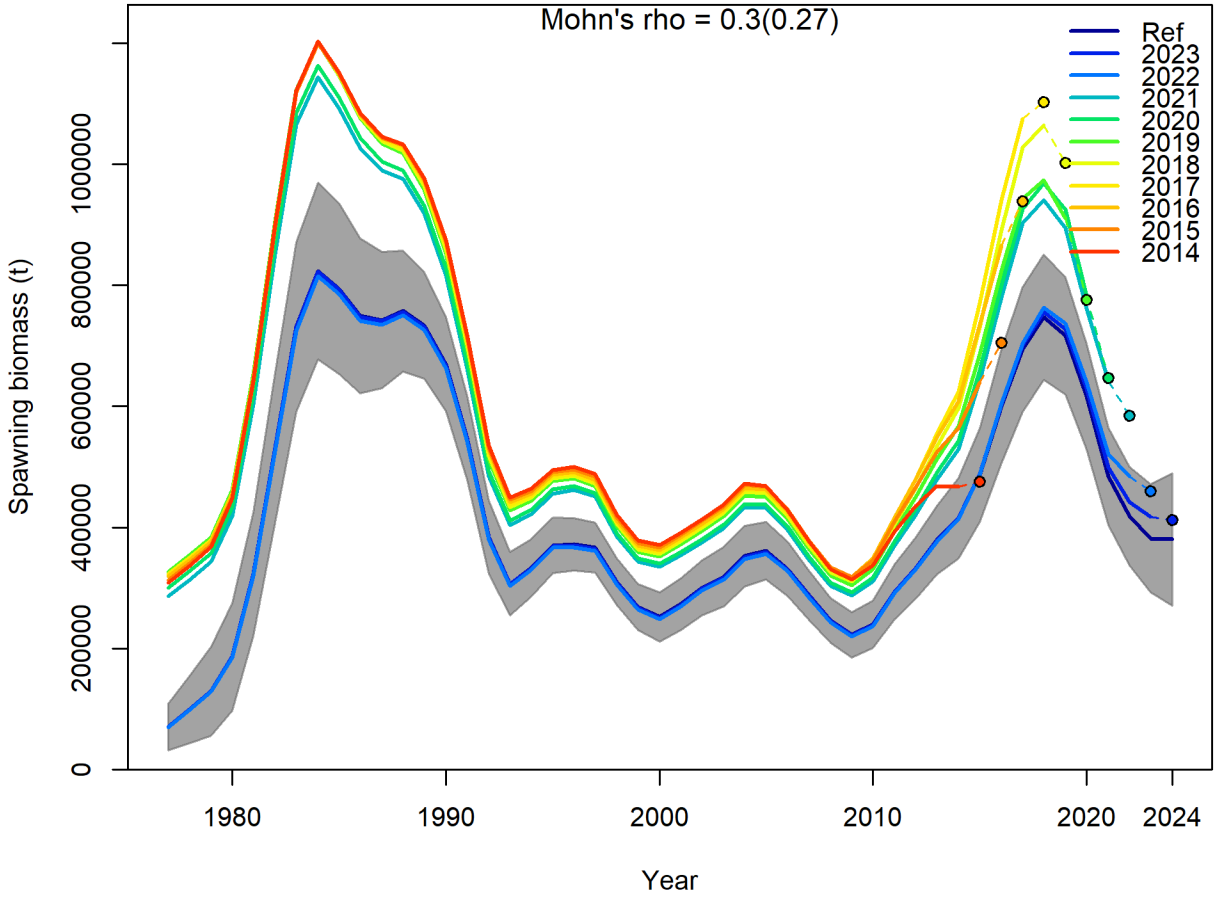
SSmohnsrho(retroSummary)

```
# $SSB
# [1] 2.972534
# $Rec
# [1] 2.789893
# $Bratio
# [1] 2.467982
# $F
# [1] -2.134977
# $WoodHole_SSB.all
# [1] 3.922503
# $WoodHole_Rec.all
# [1] 1.169955
# $WoodHole_Bratio.all
# [1] 3.38335
# $WoodHole_F.all
# [1] -2.431093
# $AFSC_Hurtado_SSB
# [1] 0.2972534
# $AFSC_Hurtado_Rec
# [1] 0.2789893
# $AFSC_Hurtado_F
# [1] -0.2134977
# $AFSC_Hurtado_Bratio
# [1] 0.2467982
```

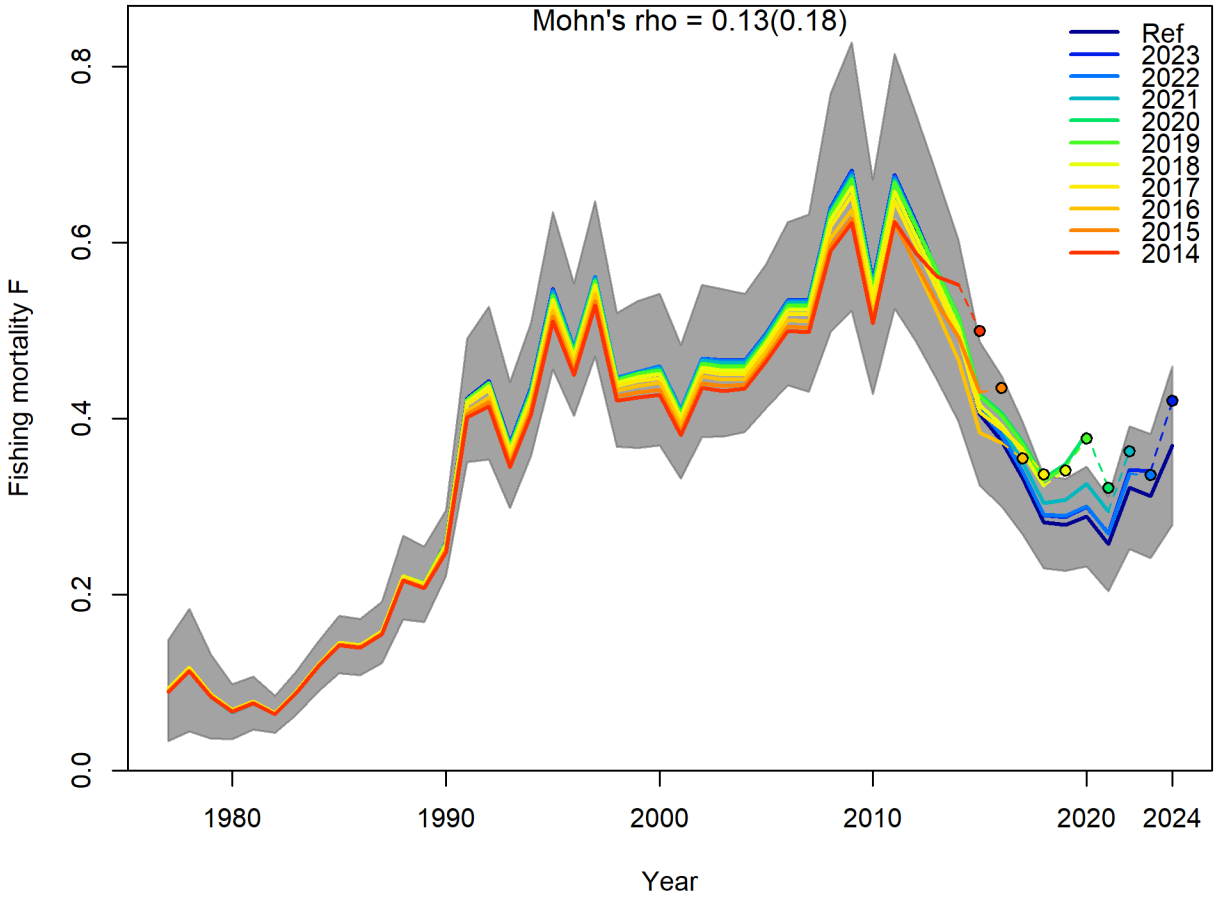
EBS


Mohn's rho = -0.09(-0.14)
Ref
2023
2022
2021
2020
2019
2018
2017
2016
2015
2014
Spawning biomass (t)
0e+00
2e+05
4e+05
6e+05
8e+05
1e+06
1980
1990
2000
2010
2020
2024
Year

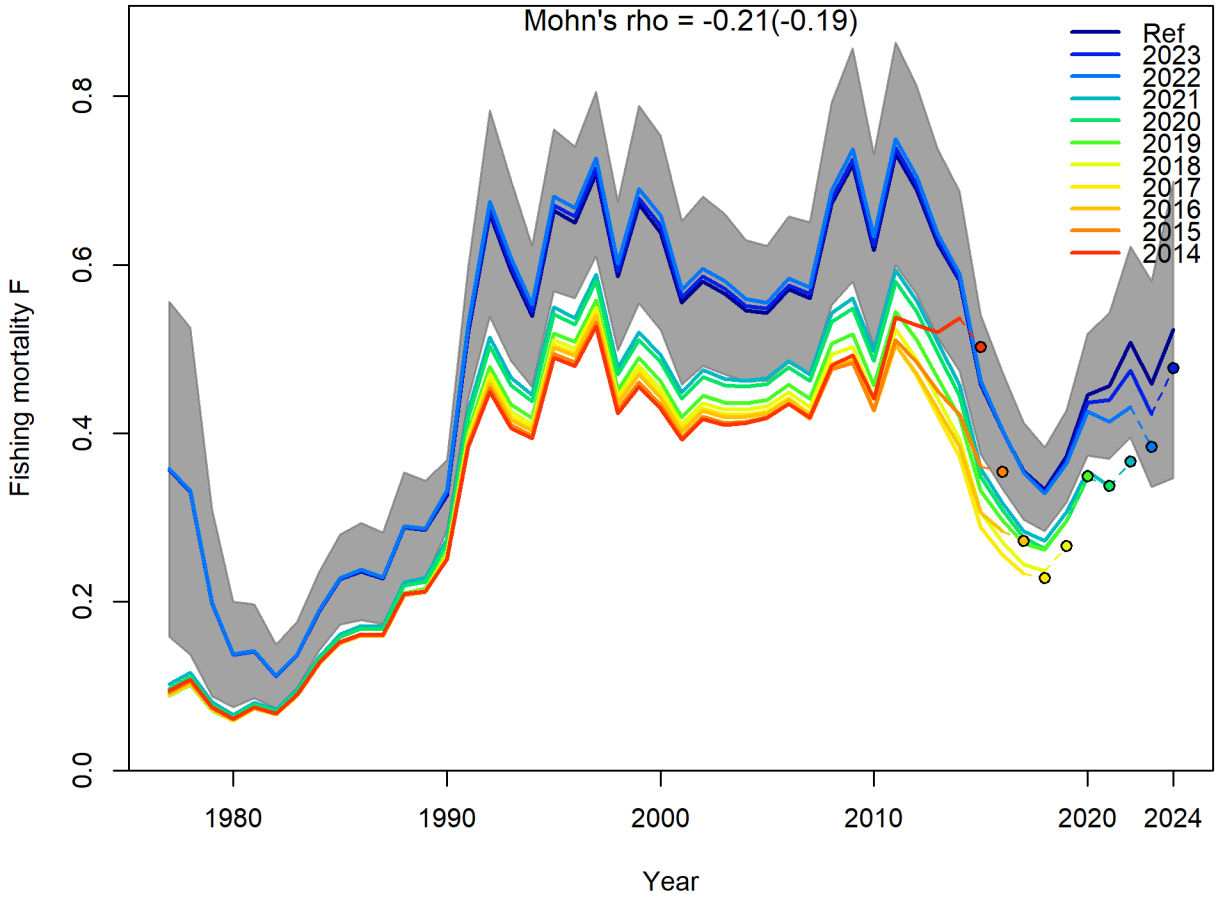
ALL


Mohn's rho = 0.3(0.27)
Ref
2023
2022
2021
2020
2019
2018
2017
2016
2015
2014
Spawning biomass (t)
0
200000
400000
600000
800000
1000000
1980
1990
2000
2010
2020
2024
Year

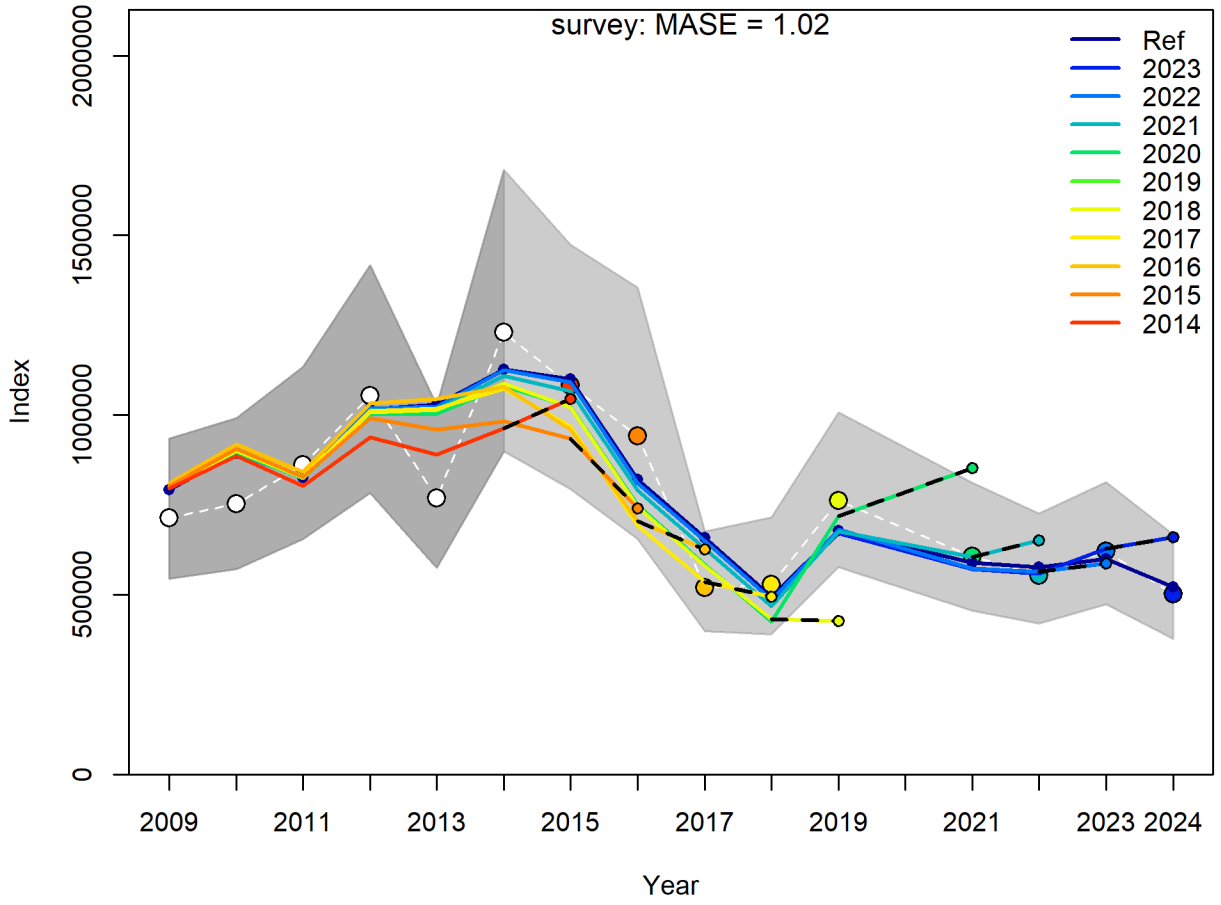
EBS


Mohn's rho = 0.13(0.18)
Ref
2023
2022
2021
2020
2019
2018
2017
2016
2015
2014
Fishing mortality F
0.0
0.2
0.4
0.6
0.8
1980
1990
2000
2010
2020
2024
Year

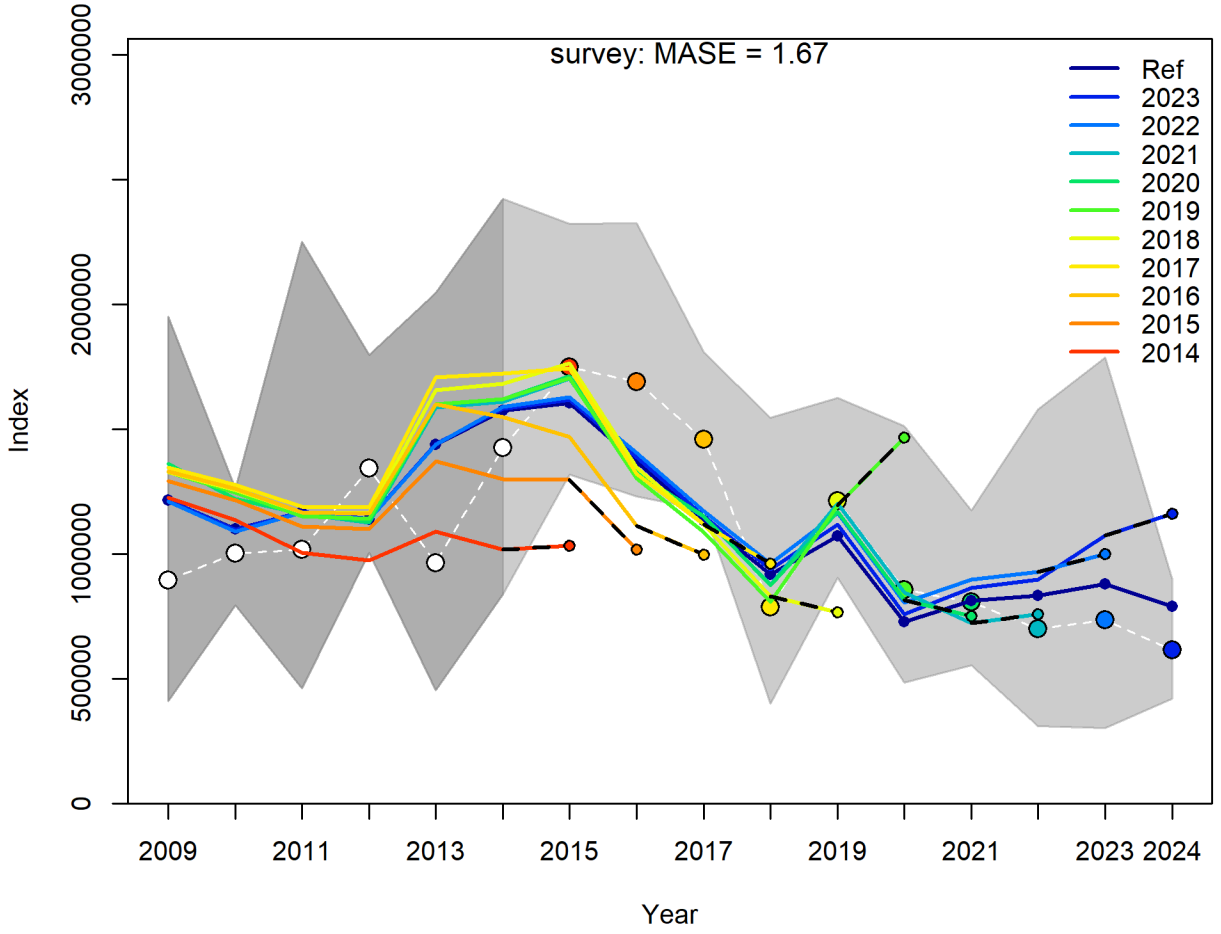
ALL


Mohn's rho = -0.21(-0.19)
Ref
2023
2022
2021
2020
2019
2018
2017
2016
2015
2014
Fishing mortality F
0.0
0.2
0.4
0.6
0.8
1980
1990
2000
2010
2020
2024
Year

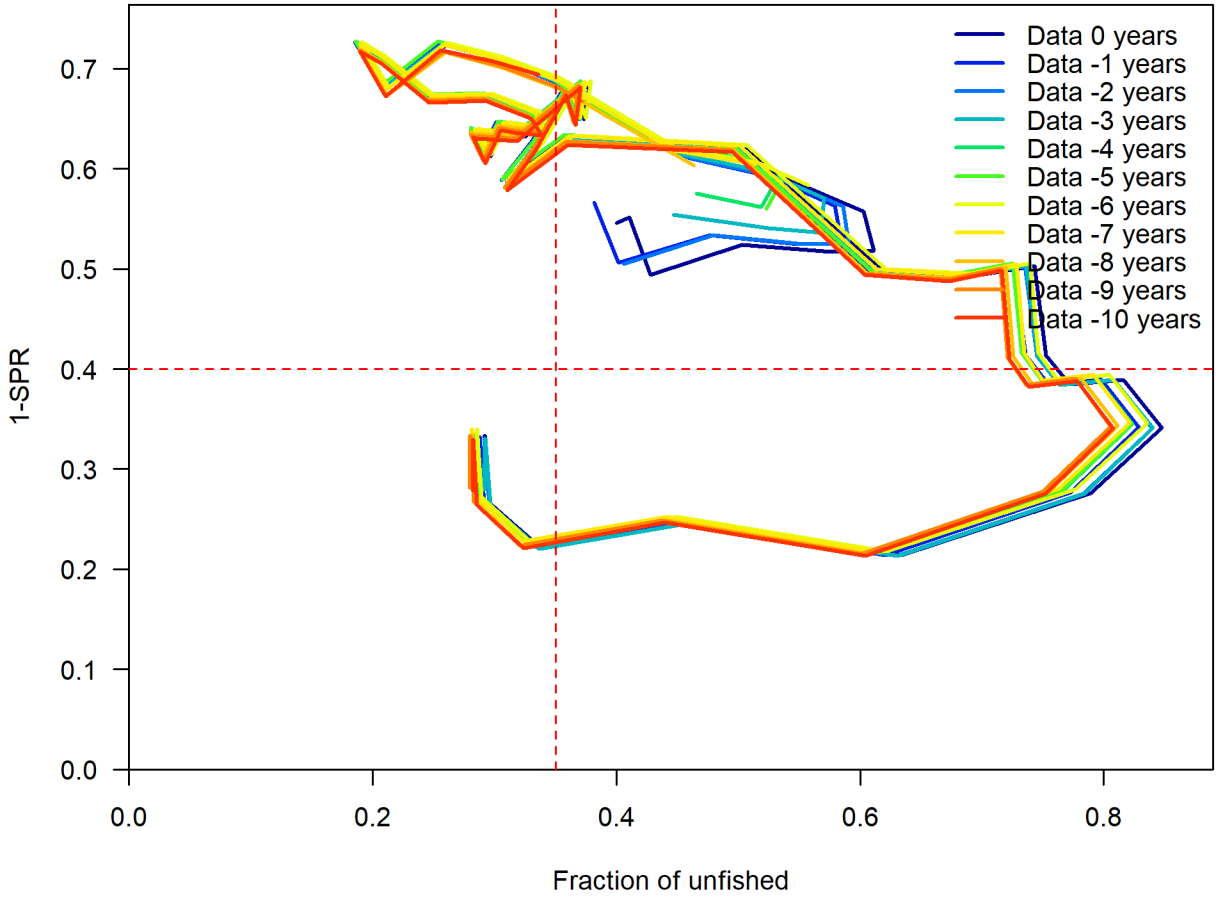
EBS


survey: MASE = 1.02
Ref
2023
2022
2021
2020
2019
2018
2017
2016
2015
2014
Index
0
500000
1000000
1500000
2000000
2009
2011
2013
2015
2017
2019
2021
2023
2024
Year

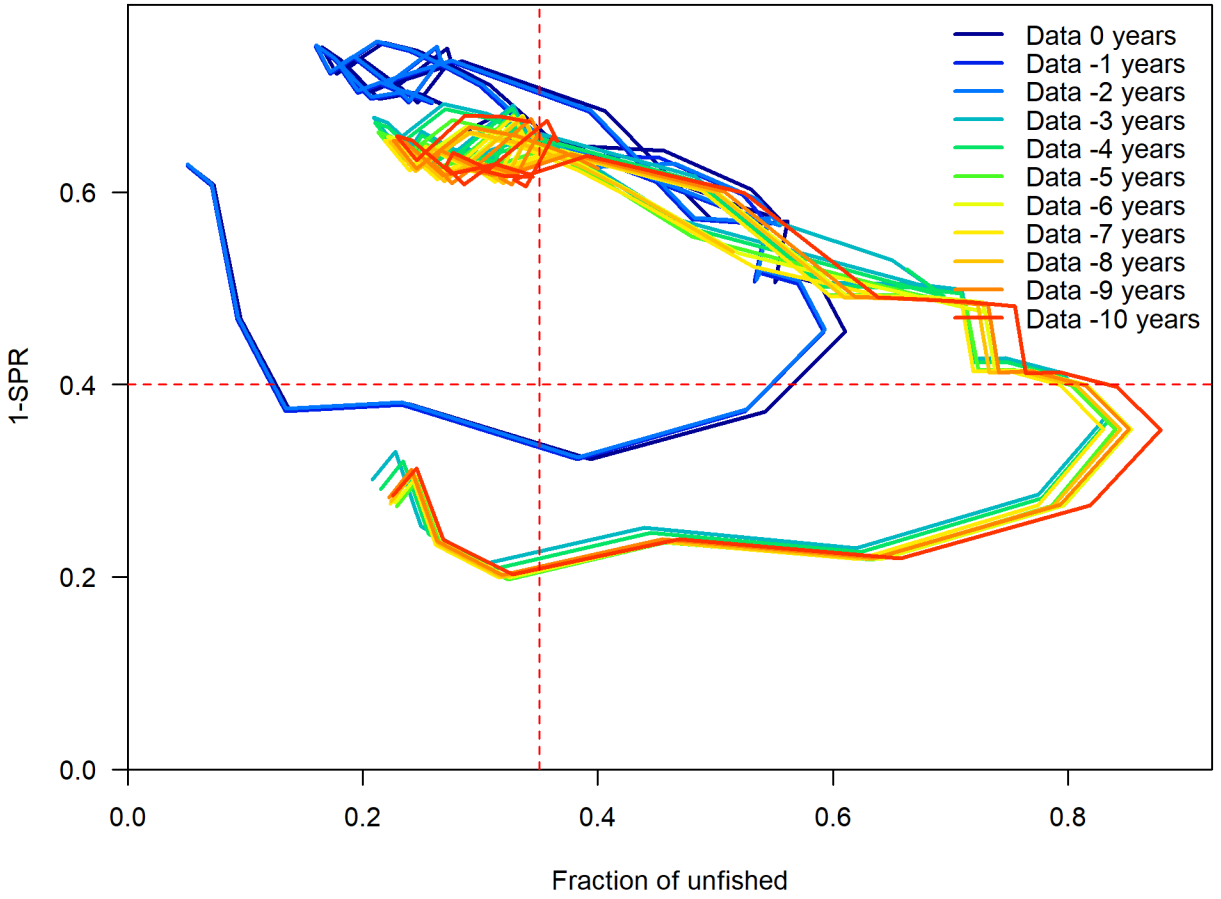
ALL


survey: MASE = 1.67
Ref
2023
2022
2021
2020
2019
2018
2017
2016
2015
2014
Index
0
500000
1000000
2000000
3000000
2009
2011
2013
2015
2017
2019
2021
2023
2024
Year

EBS



ALL



These results are preliminary and should not be considered for management purposes

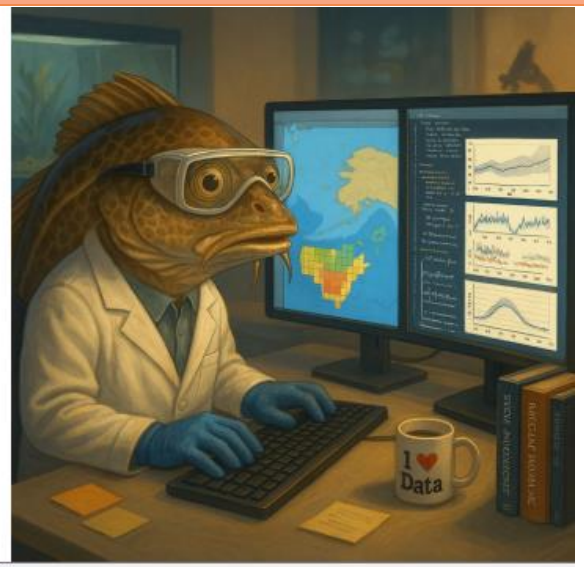
Probably summing the data from WBS and EBS was not a good idea to imitate one superpopulation of cod since MASE and Mohn's rho became very bad in SS3 24.1, though correlation between survey index input and output increased from 0.769 to 0.782 in SS3 model 24.1 after inclusion of data from Russia.

Further improvement of the models is ongoing via imitating migrations.

Pacific cod explorations

Steve Barbeaux, Pete Hulson,
Julie Nielsen and Ingrid Spies

Joint NPFMC Groundfish Plan Team
September 16, 2025

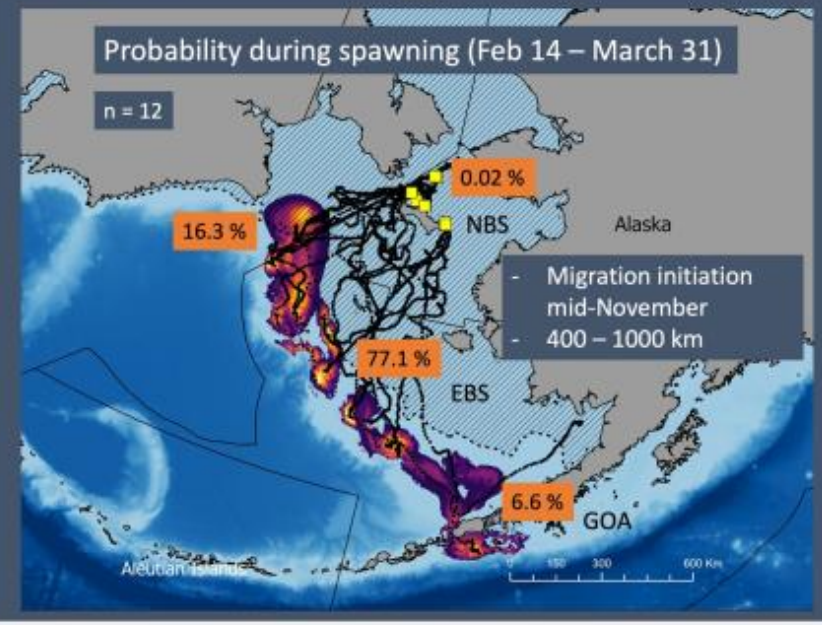


Pacific cod satellite tagging research in Alaska: An overview

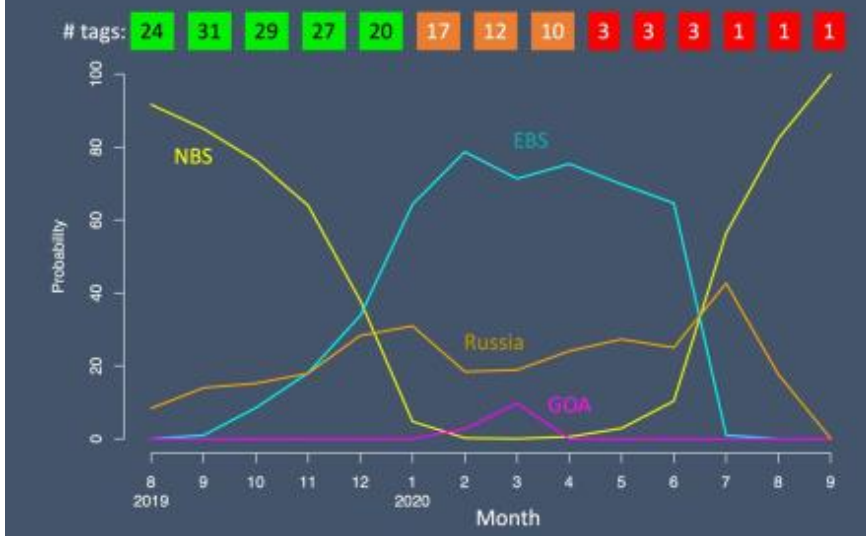
Susanne McDermott[1], Julie Nielsen[2], Charlotte Levy[3], Kimberly Rand[4], Bianca Prohaska[1], Sean Rohan[1], Alexandra Dowlin[1]
[1]Alaska Fisheries Science Center , [2]Kingfisher Marine Research, [3]Aleutians East Borough, [4]Lynker Technologies

NOAA
ALEUTIANS EAST BOROUGH
Kingfisher Marine Research

Movement to spawning areas from NBS (2019)



Results: 2019 NBS (summer to winter and annual movement)



Pacific branch («TINRO») of Russian Federal
«Research Institute of Fisheries and Oceanography»
(«VNIRO»)

So, we hope that PICES scientists will help us in collaboration.

Thank you for your attention!