BSAI Northern rock sole

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Dan Nichol, and Rebecca Haehn

Nov 17, 2020

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
	2020	2021	2021*	2022*
M (natural mortality rate)	0.15	0.15	0.15 (f) 0.17 (m)	0.15 (f) 0.17 (m)
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	1,154,000	1,729,000	923,197	1,359,440
Projected Female spawning biomass (t)	415,000	389,000	294,627	286,381
B_0	546,800	546,800	476,820	476,820
B_{MSY}	197,400	197,400	158,972	158,972
F_{OFL}	0.147	0.147	0.157	0.157
$maxF_{ABC}$	0.146	0.146	0.152	0.152
F_{ABC}	0.142	0.142	0.152	0.152
OFL (t)	168,000	251,800	145,180	213,783
maxABC (t)	163,700	245,400	140,306	206,605
ABC (t)	163,700	245,400	140,306	206,605
Status	As determined *last* year for:		As determined *this* year for:	
	2018	2019	2019	2020
Overfishing	no	n/a	no	n/a
Overfished	n/a	no	n/a	no
Approaching overfished	n/a	no	n/a	no

* Projections are based on estimated catches of 25,800 t used in place of maximum permissible ABC for 2020 and 47,500 t used in place of maximum permissible ABC for 2021 and 2022. The final catch for 2020 was set equal to the 2019 final catch. The 2021 and 2022 catch was estimated as the average over the past decade of final catches.

Responses to SSC and Plan Team Comments on Assessments in General

The SSC recommends thinking beyond the current (2020) situation to develop methods for making stock assessment analyses more robust to possible future survey reductions/loss. These may include:

- *Renewed investigation of data conflicts in the assessment models, perhaps addressed through data weighting and/or identification of un-modelled processes, or occasional anomalous data points.*
- *Model-based survey time series (e.g., vector-autoregressive spatio-temporal (VAST) models) that can accommodate incomplete data, changes in survey design, or alternative survey platforms and still produce indices of abundance with statistical variance estimates. These may be particularly helpful for stocks (e.g., Tier 4 crab and Tier 5 groundfish) where harvest levels are informed directly by trends in survey data rather than solely by the results of the stock assessment.*
- *Exploration of harvest control rules that are explicitly linked to survey and assessment uncertainty and the lag between surveys and assessments.*

A data conflict between recent survey biomass and age composition data was explored in the 2020 assessment by evaluating an exploratory model downweighting age composition data. The RACE Division is now providing VAST survey biomass estimates for northern rock sole. Due to COVID-19, these estimates were not explored within models for this assessment cycle, but is planned for the next assessment cycle.

Responses to SSC and Plan Team Comments on Assessments specific to this assessment

Four new models (18.1-4) were introduced this year in addition to the base model that has been in use since 2006 (15.1). The new models all estimated separate natural mortality rates for males. Model 18.2 estimates survey catchability in addition to male M and model 18.3 adds an offset for male selectivity in the fishery (allowing the asymptote to differ from females) based on earlier recommendations to address sex-specific targeting in the fishery. Model 18.4 was an equally weighted ensemble of the other four models. This model was included in response to an SSC request in October to pursue ensemble modeling in this assessment. While the models resulted in considerable differences in spawning stock biomass, the resulting reference points differed little among models. Model 15.1 provided a better fit to the survey sex ratios and survey age composition. Therefore, and because the other models were not presented in September, the PT recommended model 15.1 but noted that model 18.3 was a good candidate for future assessments.

Model 18.3 is the author's preferred model for 2020.

BSAI Plan Team comment 11/2018: The Team thanks the authors for volunteering to examine a model averaging approach. The Team recommends that the authors consider alternative weightings if they decide to pursue model averaging further; noting that, if the ensemble consists of nested models, the choice of weighting approach may be simplified somewhat. The Team also encourages the authors to consider whether the present ensemble might usefully be expanded by including models that span a greater range of structural uncertainty. Finally, the Team recommends that the authors further investigate Model 18.3, which may be the most biologically plausible model in the present ensemble.

Model 18.3 is presented as the author's preferred model in 2020.

BSAI Plan Team comment 11/2019: The Team recommended that the Bering Sea survey group conduct a spatial analysis looking specifically at the spatial overlap of this species (and other commercially important flatfish species) with Pacific cod.

Author Response: CRM is conducting two studies that could be expanded to address this question: (1) a study of length-specific species overlap of small-bodied flatfish species in the EBS and (2) a study of spatial distribution and seasonal movement of two flatfish species in the EBS using a spatio-temporal modeling approach.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 2: Substantially increased concerns	Level 1: no increased concerns	Level 1: no increased concerns	Level 1: no increased concerns

- Risk table

2, 1, 1, 1,

Fishery patterns

Table 8.2. Proportion of catches by NMFS reporting area through Oct 25, 2020. Green-white shading indicates areas with high proportions of catches (green) to low proportions of catches (white).

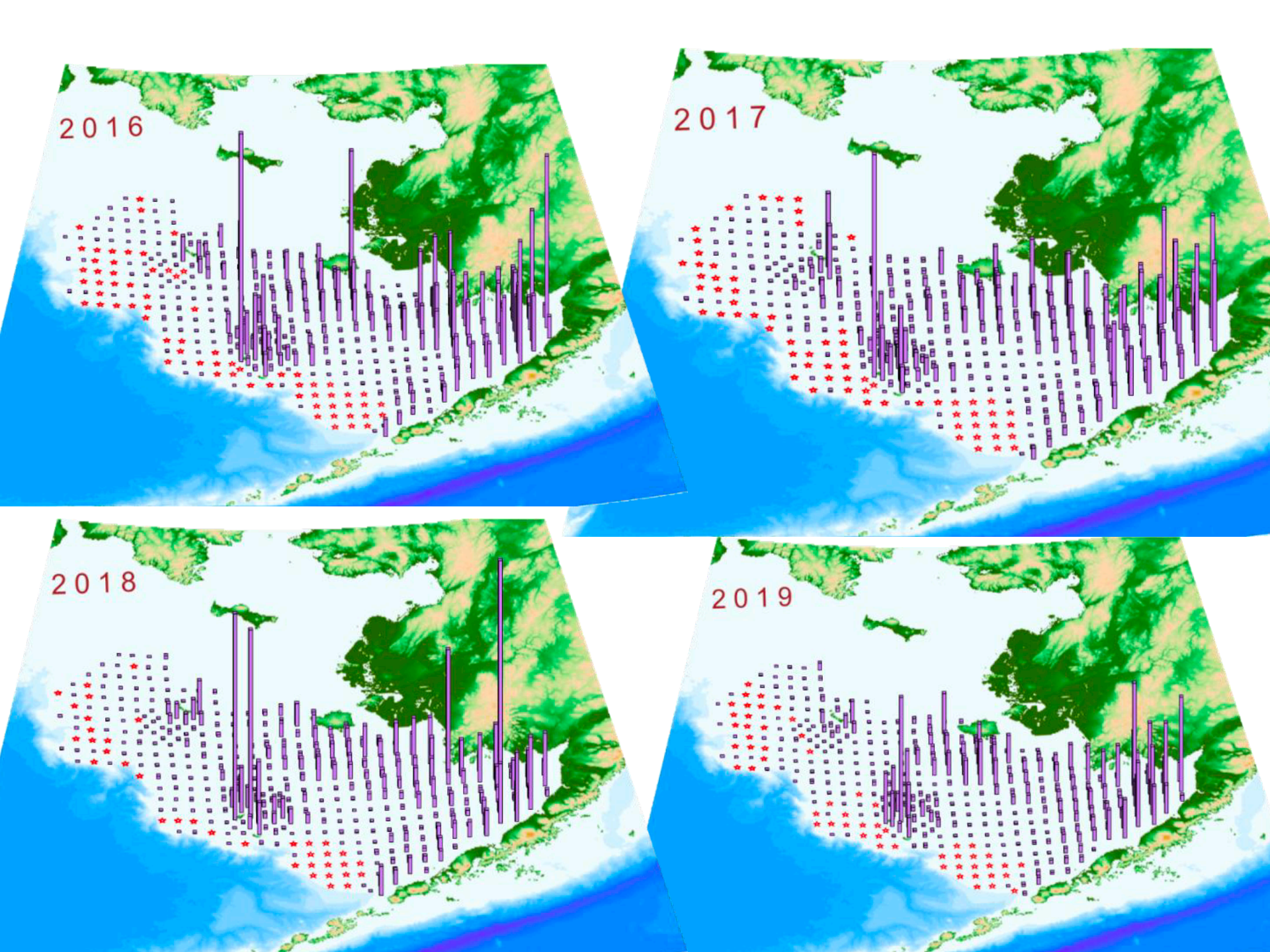
Year	509	511	512	513	514	516	517	518	519	521	522	523	524	540	541	542	543
1991	0.00	0.16	0.00	0.13	0.16	0.03	0.15	0.01	0.03	0.24	0.04	0.00	0.00	0.04	0.00	0.00	0.00
1992	0.00	0.16	0.00	0.18	0.15	0.04	0.13	0.02	0.03	0.19	0.04	0.00	0.00	0.07	0.00	0.00	0.00
1993	0.20	0.00	0.00	0.20	0.12	0.04	0.15	0.01	0.01	0.13	0.00	0.01	0.04	0.07	0.01	0.01	0.00
1994	0.27	0.00	0.00	0.23	0.05	0.06	0.15	0.01	0.03	0.12	0.00	0.01	0.01	0.00	0.04	0.03	0.00
1995	0.26	0.00	0.00	0.20	0.06	0.03	0.22	0.02	0.05	0.08	0.00	0.01	0.02	0.00	0.03	0.02	0.01
1996	0.32	0.00	0.00	0.18	0.06	0.03	0.19	0.01	0.05	0.06	0.00	0.01	0.01	0.00	0.03	0.02	0.02
1997	0.23	0.00	0.00	0.23	0.09	0.01	0.19	0.00	0.06	0.10	0.00	0.01	0.02	0.00	0.04	0.02	0.01
1998	0.29	0.00	0.00	0.18	0.02	0.02	0.21	0.01	0.05	0.12	0.00	0.01	0.01	0.00	0.05	0.03	0.01
1999	0.25	0.00	0.00	0.17	0.04	0.04	0.23	0.01	0.03	0.12	0.00	0.01	0.00	0.00	0.05	0.02	0.01
2000	0.29	0.00	0.00	0.19	0.03	0.01	0.21	0.01	0.02	0.12	0.00	0.01	0.01	0.00	0.05	0.03	0.01
2001	0.26	0.00	0.00	0.19	0.02	0.05	0.16	0.01	0.05	0.16	0.00	0.01	0.01	0.00	0.03	0.03	0.02
2002	0.23	0.00	0.00	0.18	0.04	0.04	0.20	0.00	0.04	0.15	0.00	0.00	0.02	0.00	0.04	0.03	0.02
2003	0.30	0.00	0.00	0.18	0.11	0.05	0.10	0.00	0.04	0.13	0.00	0.00	0.02	0.00	0.04	0.02	0.01
2004	0.31	0.00	0.00	0.13	0.11	0.07	0.09	0.00	0.05	0.16	0.00	0.00	0.03	0.00	0.03	0.02	0.01
2005	0.29	0.00	0.00	0.14	0.12	0.06	0.07	0.00	0.03	0.15	0.00	0.00	0.06	0.00	0.04	0.01	0.01
2006	0.31	0.00	0.00	0.17	0.08	0.02	0.11	0.00	0.02	0.21	0.00	0.00	0.02	0.00	0.04	0.02	0.01
2007	0.25	0.00	0.00	0.16	0.12	0.02	0.10	0.00	0.02	0.20	0.00	0.00	0.03	0.00	0.06	0.02	0.01
2008	0.44	0.00	0.00	0.13	0.04	0.02	0.11	0.00	0.02	0.15	0.00	0.00	0.03	0.00	0.02	0.01	0.01
2009	0.47	0.00	0.00	0.10	0.02	0.03	0.12	0.00	0.01	0.15	0.00	0.00	0.03	0.00	0.03	0.03	0.01
2010	0.34	0.00	0.00	0.12	0.06	0.13	0.09	0.00	0.02	0.16	0.00	0.00	0.00	0.00	0.04	0.02	0.02
2011	0.36	0.00	0.00	0.18	0.08	0.04	0.15	0.00	0.03	0.11	0.00	0.00	0.01	0.00	0.03	0.01	0.00
2012	0.39	0.00	0.00	0.12	0.12	0.02	0.14	0.00	0.03	0.10	0.00	0.00	0.00	0.00	0.06	0.01	0.00
2013	0.36	0.00	0.00	0.17	0.04	0.06	0.15	0.00	0.01	0.16	0.00	0.00	0.00	0.00	0.02	0.01	0.00
2014	0.37	0.00	0.00	0.24	0.07	0.04	0.11	0.00	0.02	0.12	0.00	0.00	0.00	0.00	0.02	0.01	0.00
2015	0.27	0.00	0.00	0.20	0.23	0.04	0.07	0.00	0.03	0.14	0.00	0.00	0.00	0.00	0.02	0.01	0.00
2016	0.21	0.00	0.00	0.28	0.22	0.07	0.05	0.01	0.03	0.08	0.00	0.00	0.02	0.00	0.02	0.01	0.00
2017	0.35	0.00	0.00	0.25	0.13	0.06	0.05	0.00	0.01	0.07	0.00	0.00	0.01	0.00	0.03	0.02	0.01
2018	0.24	0.00	0.00	0.24	0.23	0.04	0.06	0.00	0.02	0.05	0.00	0.00	0.07	0.00	0.03	0.01	0.01
2019	0.20	0.00	0.00	0.31	0.24	0.05	0.03	0.00	0.02	0.05	0.00	0.00	0.04	0.00	0.03	0.02	0.01
2020	0.28	0.00	0.00	0.23	0.13	0.05	0.08	0.01	0.03	0.13	0.00	0.00	0.03	0.00	0.03	0.02	0.01

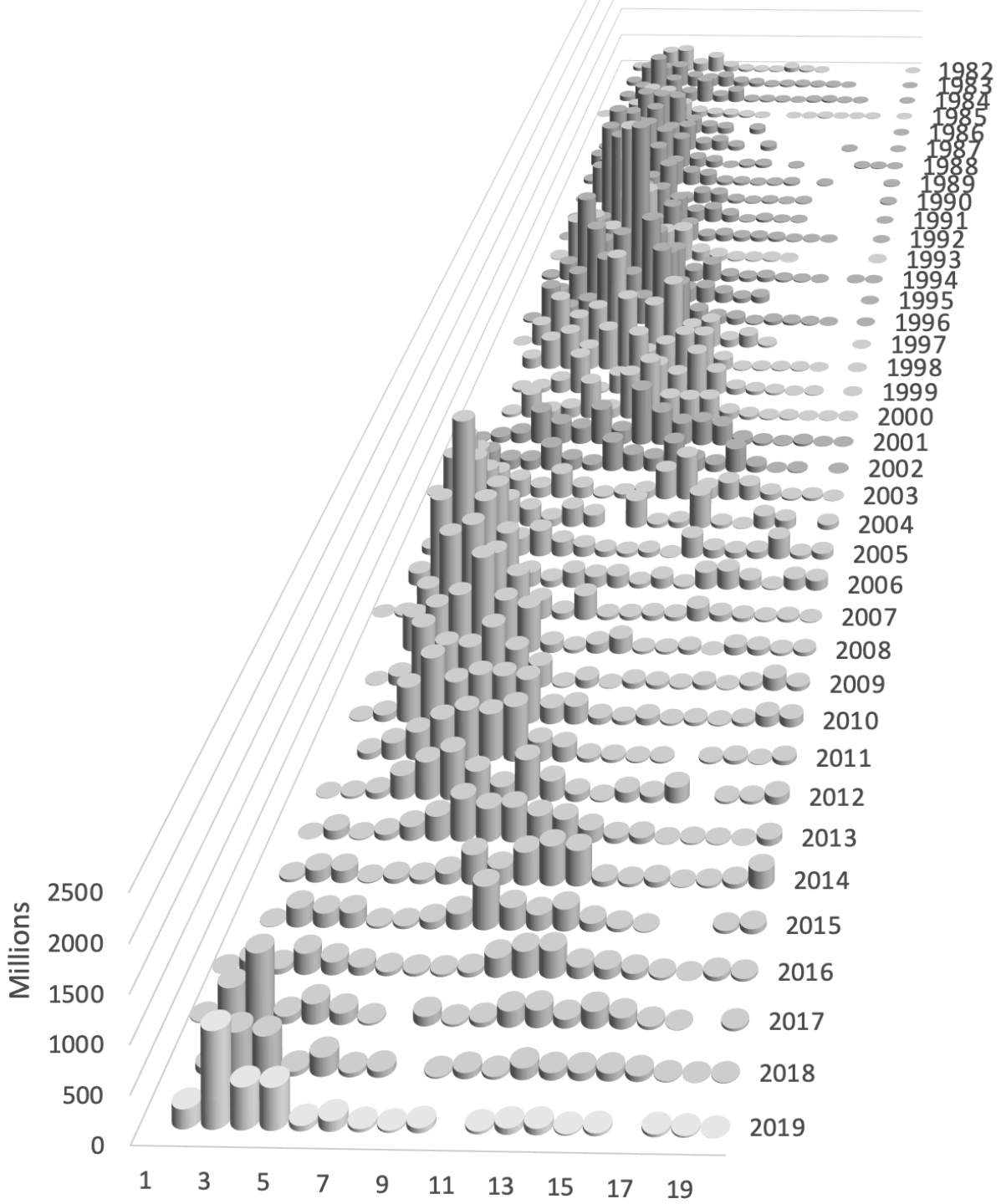
Fishery patterns

By season…

Things have changed!

Year	Jan-March	April-June	July-Sep	Oct-Dec
1991	0.61	0.22	0.16	0.02
1992	0.56	0.15	0.24	0.05
1993	0.68	0.17	0.12	0.03
1994	0.78	0.14	0.05	0.03
1995	0.68	0.12	0.20	0.01
1996	0.57	0.28	0.14	0.02
1997	0.60	0.22	0.16	0.02
1998	0.71	0.15	0.11	0.03
1999	0.63	0.23	0.11	0.03
2000	0.75	0.16	0.08	0.01
2001	0.57	0.16	0.24	0.03
2002	0.64	0.19	0.16	0.01
2003	0.60	0.22	0.18	0.00
2004	0.68	0.27	0.05	0.00
2005	0.57	0.34	0.09	0.00
2006	0.49	0.24	0.26	0.01
2007	0.53	0.19	0.27	0.00
2008	0.64	0.21	0.10	0.04
2009	0.69	0.15	0.12	0.04
2010	0.57	0.13	0.24	0.06
2011	0.68	0.20	0.10	0.03
2012	0.80	0.14	0.04	0.02
2013	0.68	0.17	0.12	0.03
2014	0.69	0.22	0.06	0.03
2015	0.64	0.23	0.11	0.02
2016	0.48	0.44	0.06	0.02
2017	0.42	0.46	0.10	0.02
2018	0.38	0.55	0.05	0.01
2019	0.34	0.57	0.07	0.03
2020*	0.44	0.30	0.23	0.03


2016
2017
2018
2019


Millions
2500
2000
1500
1000
500
0
1
3
5
7
9
11
13
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19
1982
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1984
1985
1986
1987
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2014
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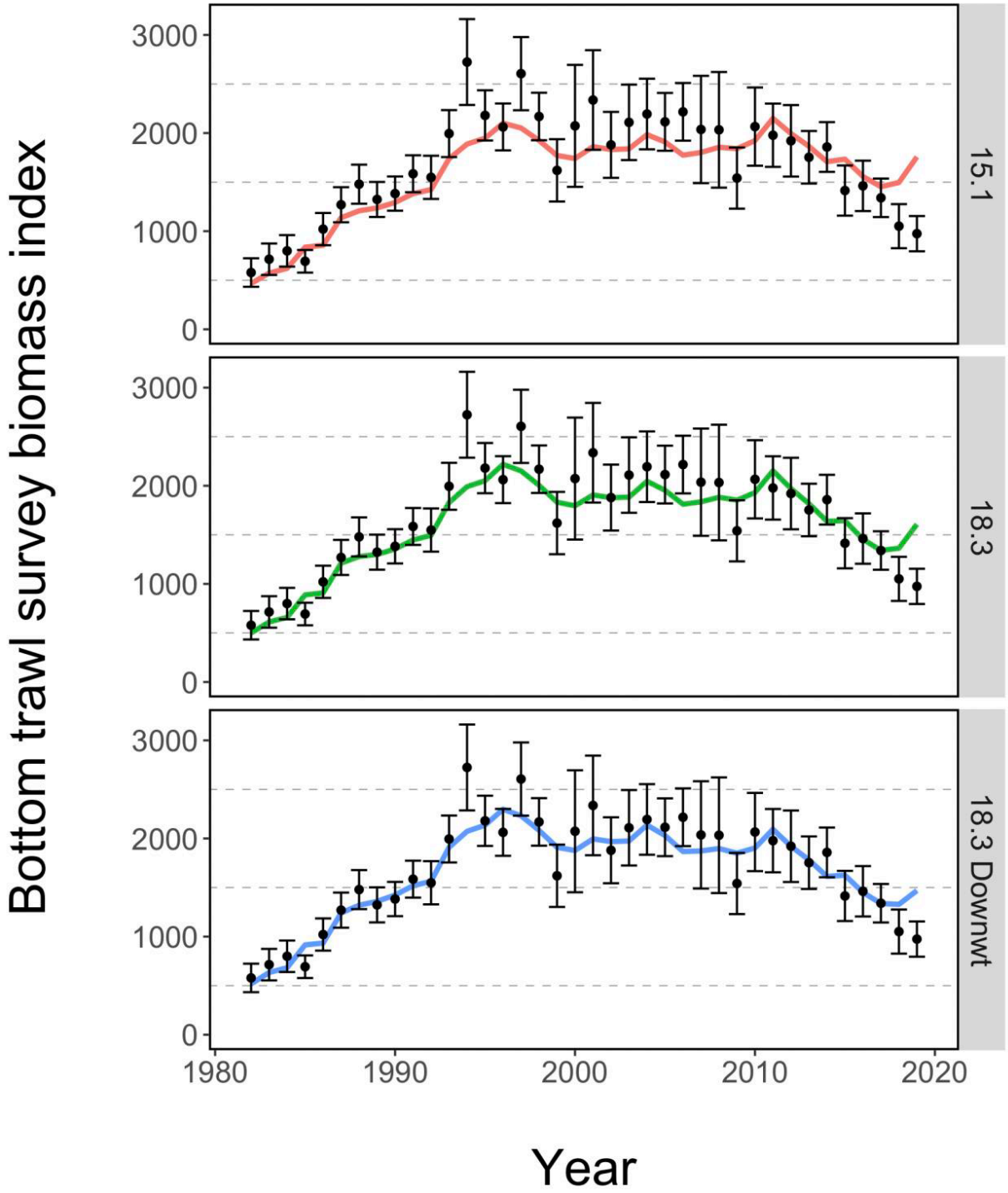
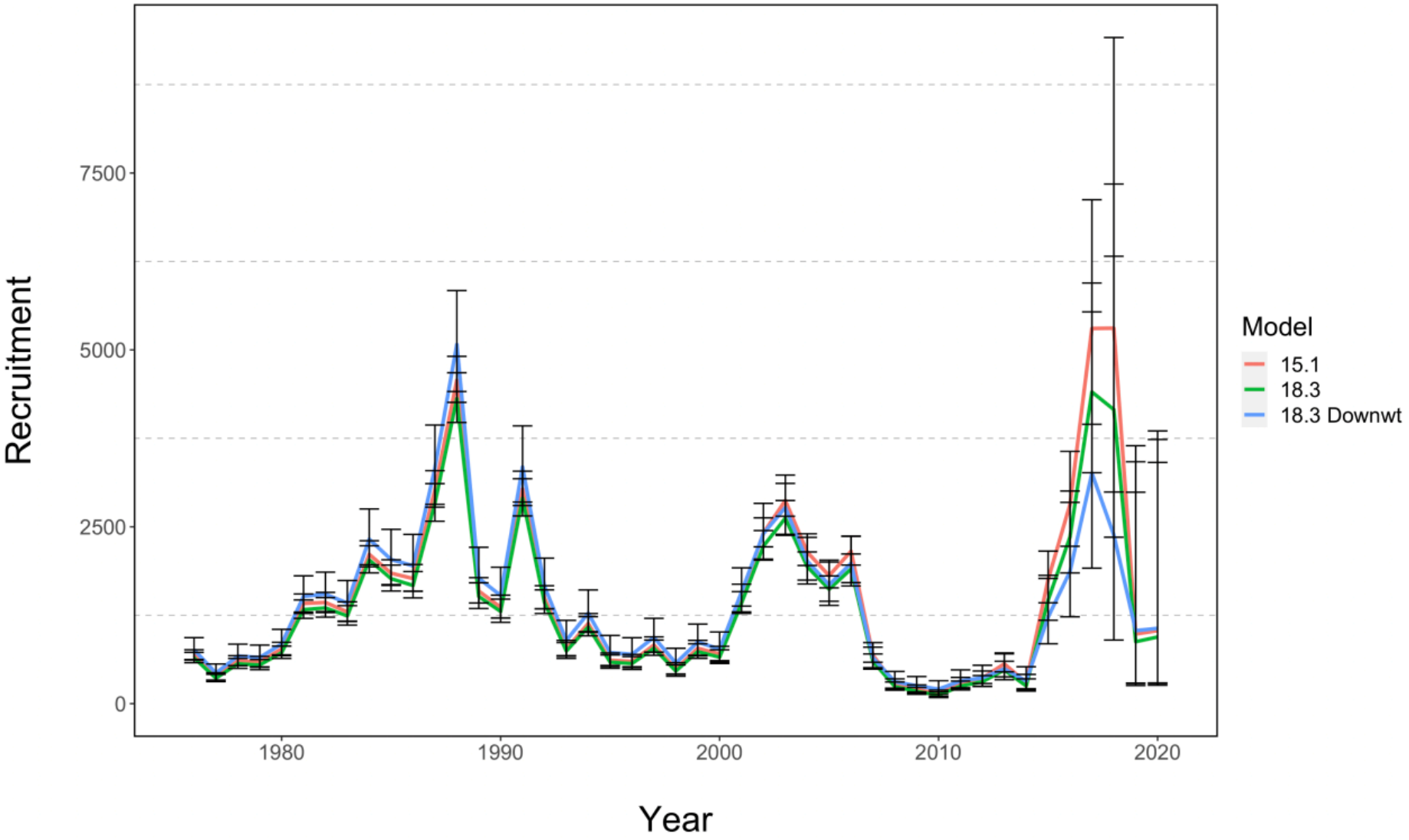
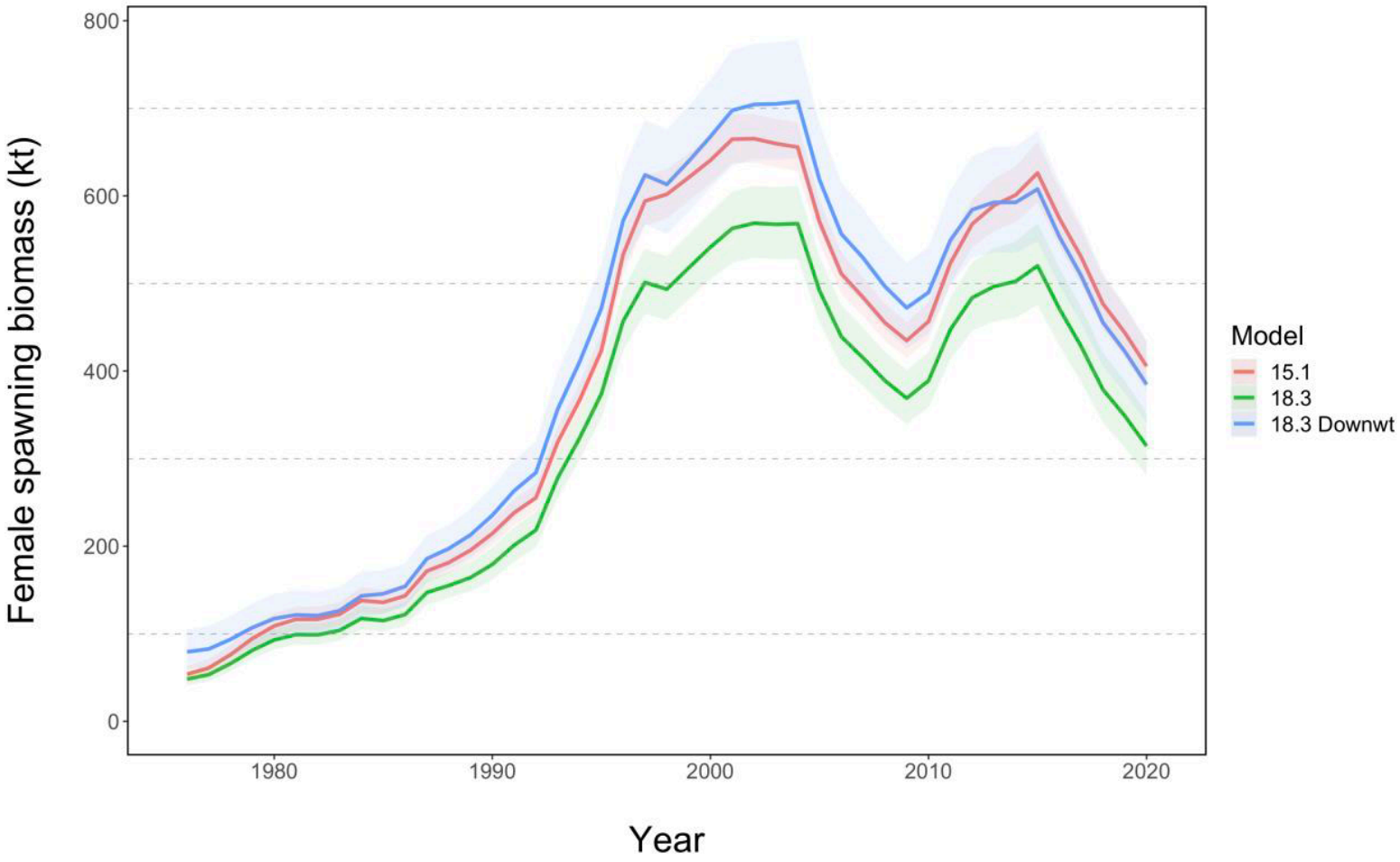
2016
2017
2018
2019

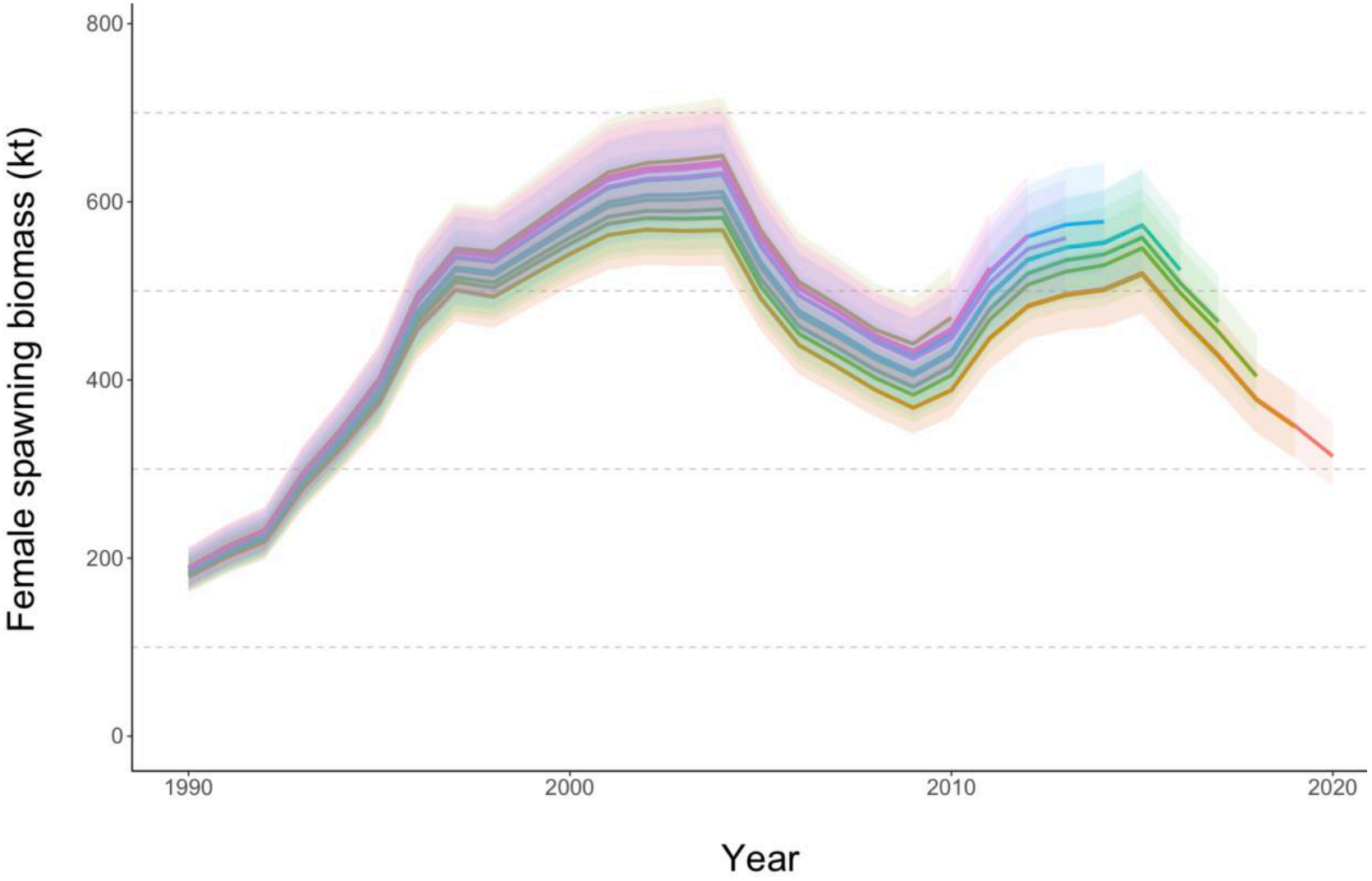
Survey fits

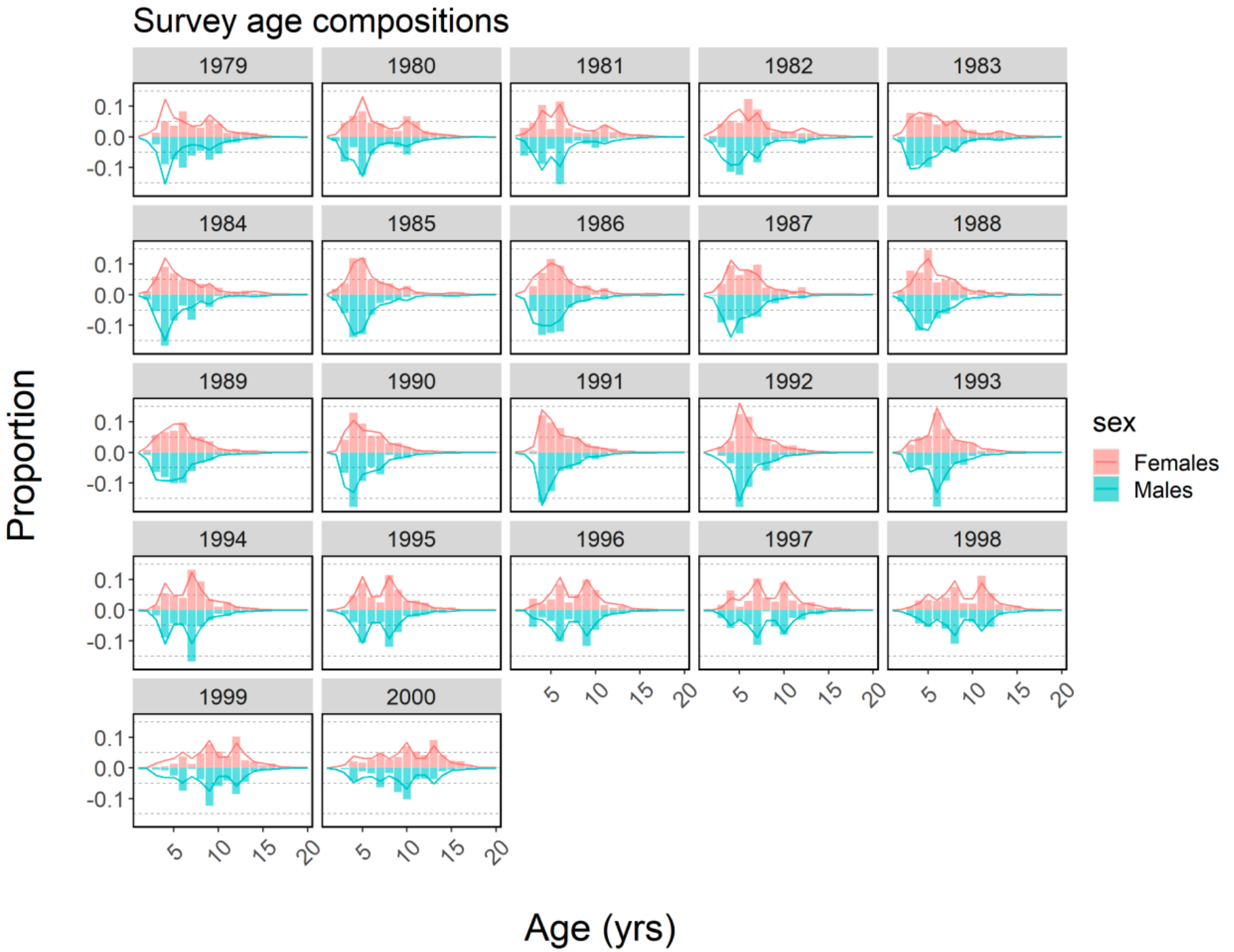
By model

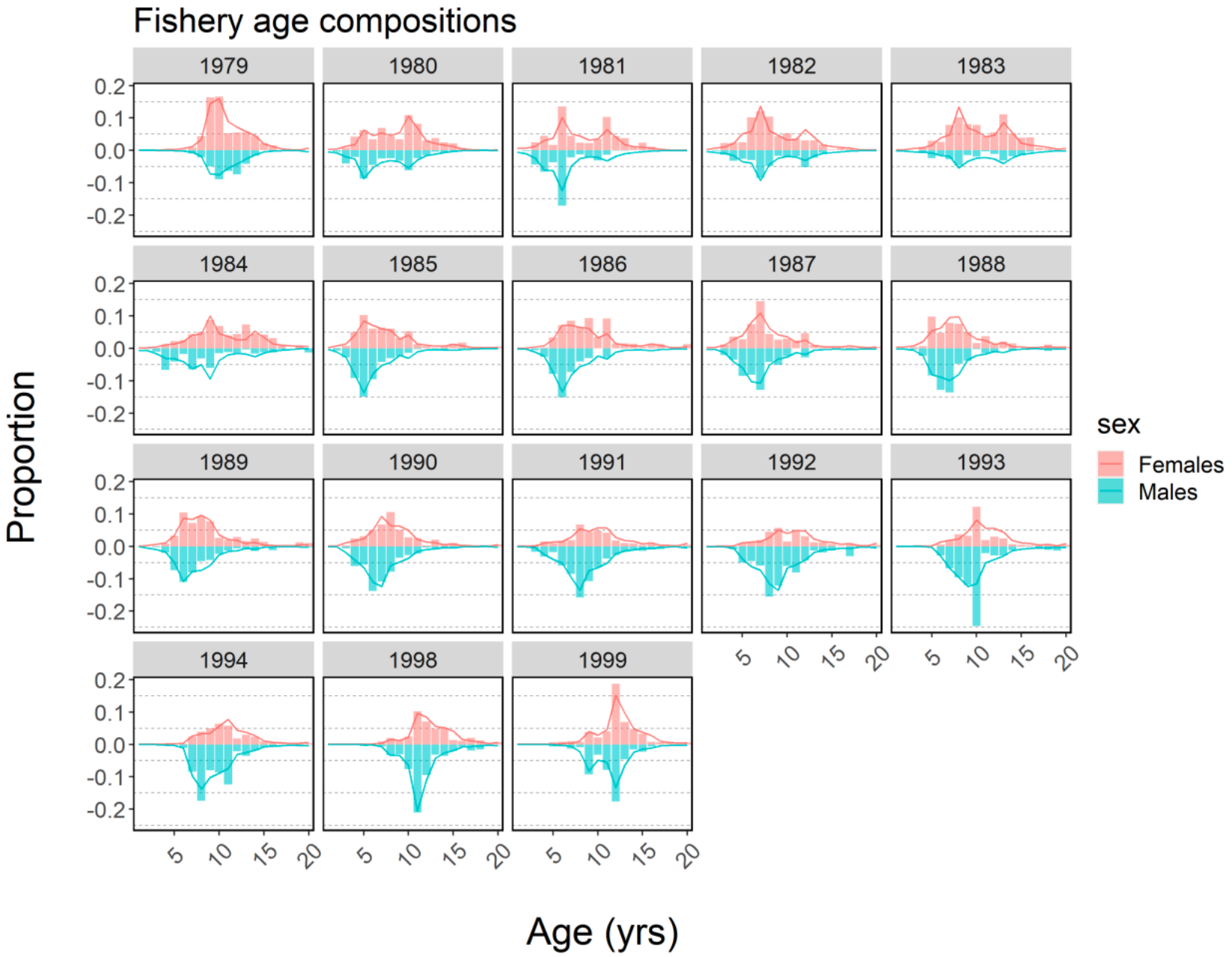



Recruitment
7500
5000
2500
0
1980
1990
2000
2010
2020
Year
Model
15.1
18.3
18.3 Downwt


Female spawning biomass (kt)
800
600
400
200
0
1980
1990
2000
2010
2020
Year
Model
15.1
18.3
18.3 Downwt


Female spawning biomass (kt)
800
600
400
200
0
1990
2000
2010
2020
Year


Survey age compositions
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
0.1
0.0
-0.1
5
10
15
20
Proportion
Age (yrs)
sex
Females
Males


Fishery age compositions
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1998
1999
0.2
0.1
0.0
-0.1
-0.2
5
10
15
20
Proportion
Age (yrs)
sex
Females
Males

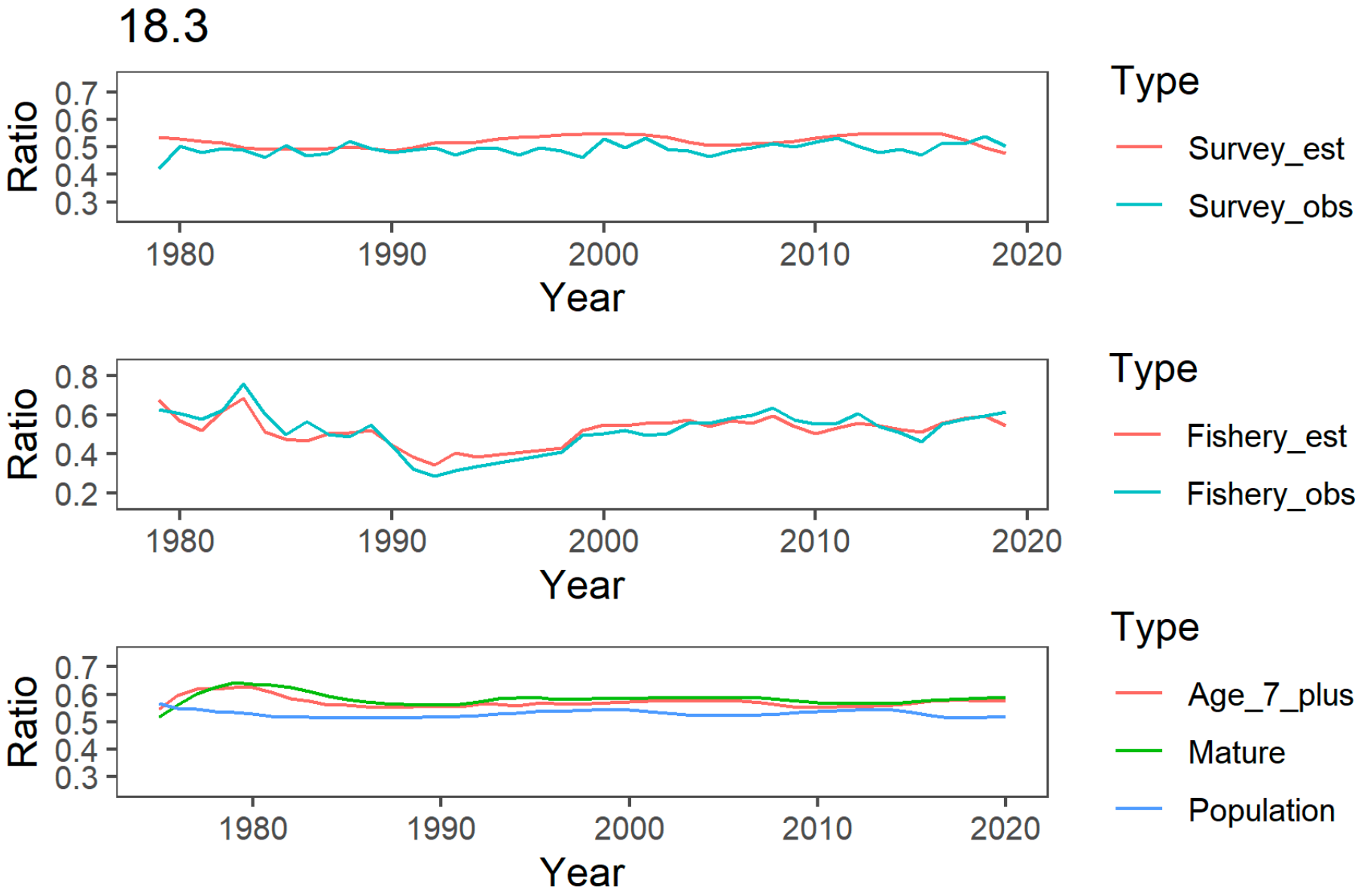

18.3
Ratio
0.7
0.6
0.5
0.4
0.3
1980
1990
2000
2010
2020
Year
Type
Survey_est
Survey_obs
Ratio
0.8
0.6
0.4
0.2
1980
1990
2000
2010
2020
Year
Type
Fishery_est
Fishery_obs
Ratio
0.7
0.6
0.5
0.4
0.3
1980
1990
2000
2010
2020
Year
Type
Age_7_plus
Mature
Population

Table 8.7. Components of the objective function for Models 15.1, 18.3, and the exploratory model based on 18.3, but with 75% down-weighting of survey and age composition data. The age composition components (and therefore the total likelihood) from the exploratory model cannot be compared directly to the other two models because of the differences in data weighting.

Likelihood Component	15.1	18.3	18.3 Downwt*
Total	1599	1476	519
Survey Biomass	87	59	44
Survey Age	680	673	188
Fishery Age	646	541	168

*Cannot directly compare values in grey boxes to the other models due to smaller input sample sizes

Tier 3 projected catch

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2020	25,800	25,800	25,800	25,800	25,800	25,800	25,800
2021	63,503	47,500	31,298	31,895	0	77,023	63,503
2022	59,354	63,459	33,771	34,382	0	68,208	59,354
2023	74,338	77,440	40,212	40,917	0	83,899	90,557
2024	99,683	100,581	50,139	51,000	0	117,340	119,382
2025	116,795	117,455	60,518	61,533	0	135,810	137,327
2026	126,943	127,423	68,336	69,444	0	145,304	146,407
2027	126,086	126,433	71,130	72,231	0	141,610	142,396
2028	117,446	117,696	69,680	70,702	0	129,346	129,899
2029	107,132	107,313	66,470	67,393	0	116,133	116,522
2030	99,154	99,285	63,644	64,487	0	105,658	105,992
2031	93,587	93,700	61,995	62,786	0	96,002	96,254
2032	87,388	87,476	60,434	61,183	0	89,441	89,597
2033	83,734	83,793	59,121	59,836	0	86,438	86,534

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
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* Projections are based on estimated catches of 25,800 t used in place of maximum permissible ABC for 2020 and 47,500 t used in place of maximum permissible ABC for 2021 and 2022. The final catch for 2020 was set equal to the 2019 final catch. The 2021 and 2022 catch was estimated as the average over the past decade of final catches.