Assessment of the Pacific cod stock in the Aleutian Islands

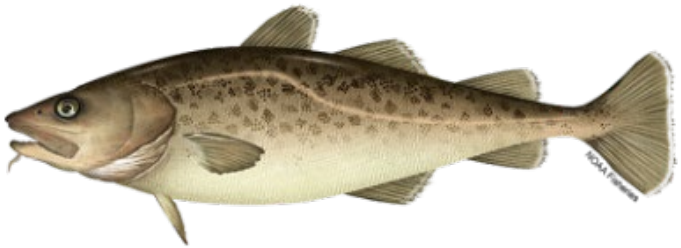
Ingrid Spies, Steve Barbeaux, Pete Hulson, Maia Kapur, Ivonne Ortiz

November, 2023 Presentation to the SSC

NOAA FISHERIES

Summary

- Models presented for 2023
- Justification
- Diagnostics
- Forecasts under Tier 3 Models



Model Description and Justification

Three age-structured models were presented (in addition to Tier 5 model).

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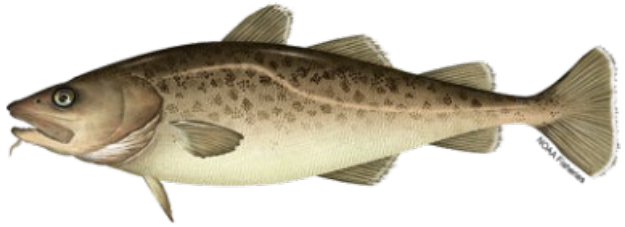

AGE STRUCTURED MODELS:
M23.0
- Time blocked growth (1991-2003, 2004-2017, 2018-2023)

M23.1
- Time blocked growth (1991-2003, 2004-2017, 2018-2023)
- Time-blocked fishery selectivity (1991-2002, 2003-2012, 2013-2016, 2017-2019, 2020-2022)

M23.2
- Time-blocked growth (1991-2003, 2004-2023)
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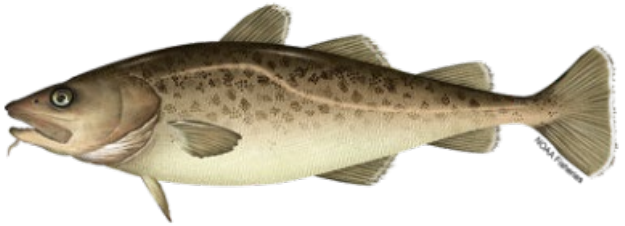

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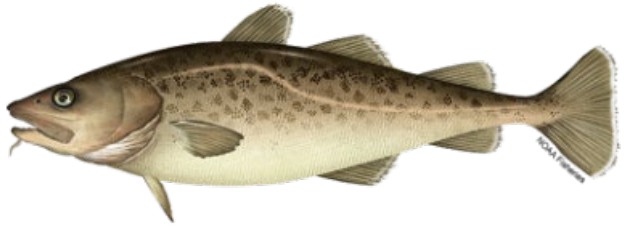

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Kapur et al. (2020) growth analysis
Nested von Bertalanffy indicated change in L_0 and K.
Only the K parameter was time blocked.

Kapur, M., Haltuch, M., Connors, B., Rogers, L., Berger, A., Koontz, E., Cope, J., Echave, K., Fenske, K., Hanselman, D. and Punt, A.E., 2020. Oceanographic features delineate growth zonation in Northeast Pacific sablefish. *Fisheries Research*, *222*, p.105414.

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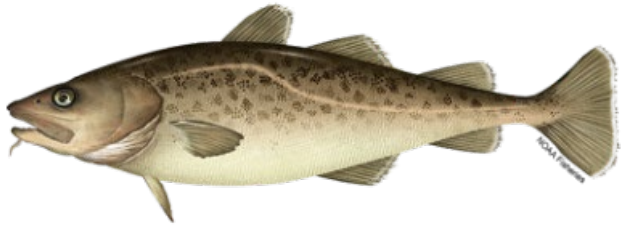

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Addressed a shift in the 2010s.

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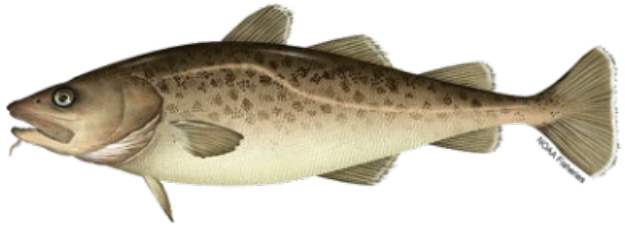

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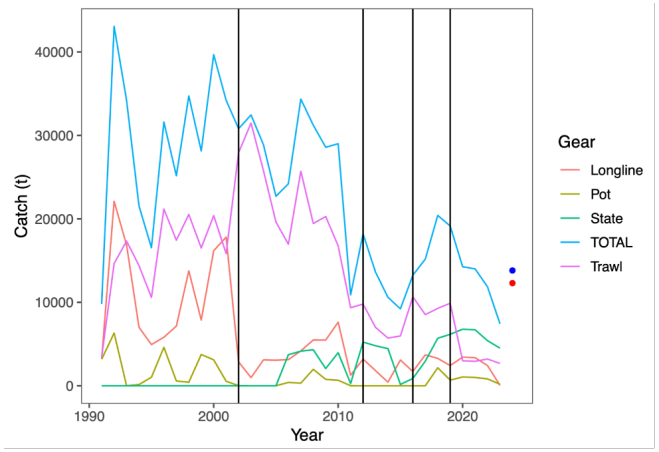

Adding selectivity time blocks did not improve the model significantly.

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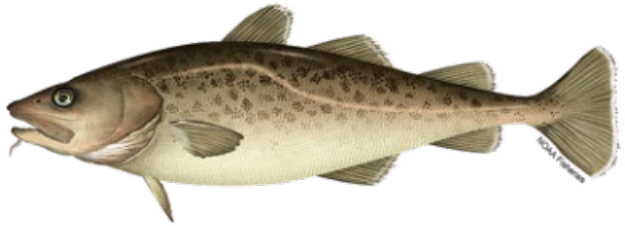

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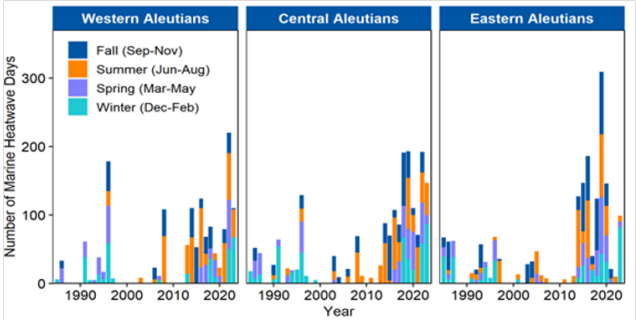
Kapur et al. (2020) growth analysis.
Only the K parameter was time blocked.

M23.2
- Time-blocked growth (1991-2003, 2004-2023)
- Time-blocked natural mortality (1991-2015, 2016-2023)

Time block on natural mortality

Time block on natural mortality was incorporated to explain the shift in the 2010s.

Pacific cod are sensitive temperature, which can result in increased mortality.



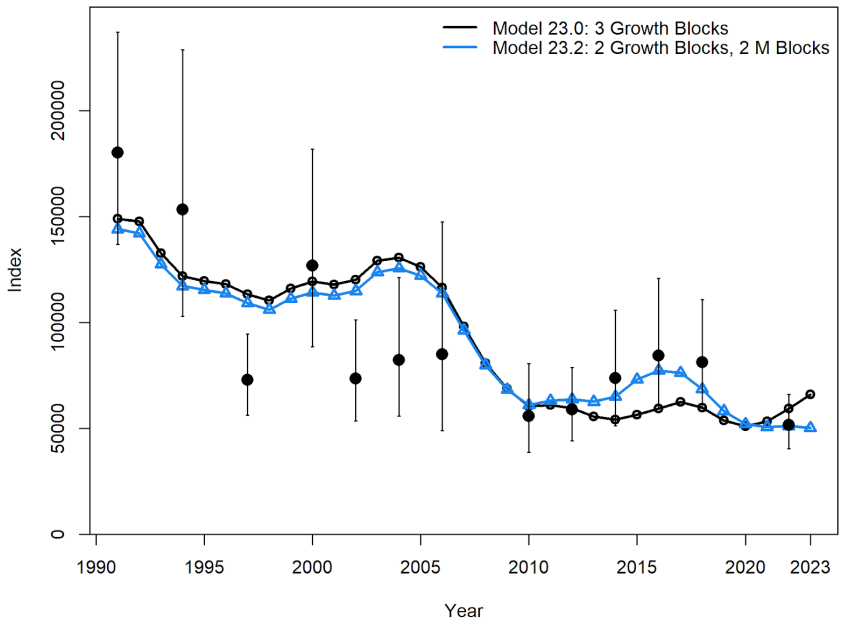
The break between 2015 and 2016 was justified by a 2-year lag from the start of the increased temperatures (2013/2014).

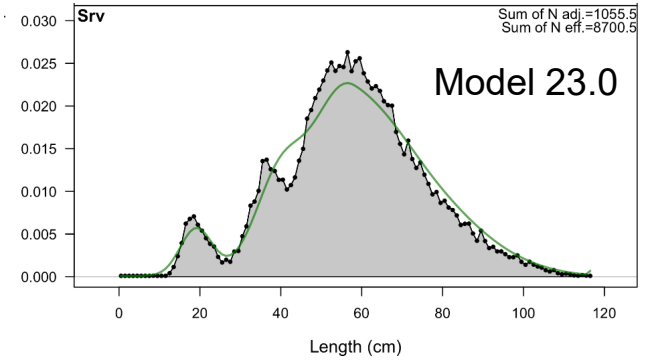
Time varying M has been implemented for GOA Pacific cod as a result of heatwave conditions

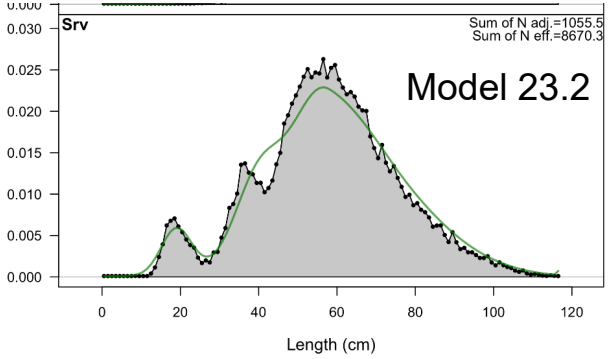
Lemagie E. and M. Calahan. 2023, Regional Sea Surface Temperature and Marine Heatwaves. In: Ortiz, I. and Zador, S. 2023. Ecosystem Status Report 2023: Aleutian Islands, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Xiao, D. and Ren, H.L., 2023. A regime shift in North Pacific annual mean sea surface temperature in 2013/14. *Frontiers in Earth Science*, *10*, p.987349.

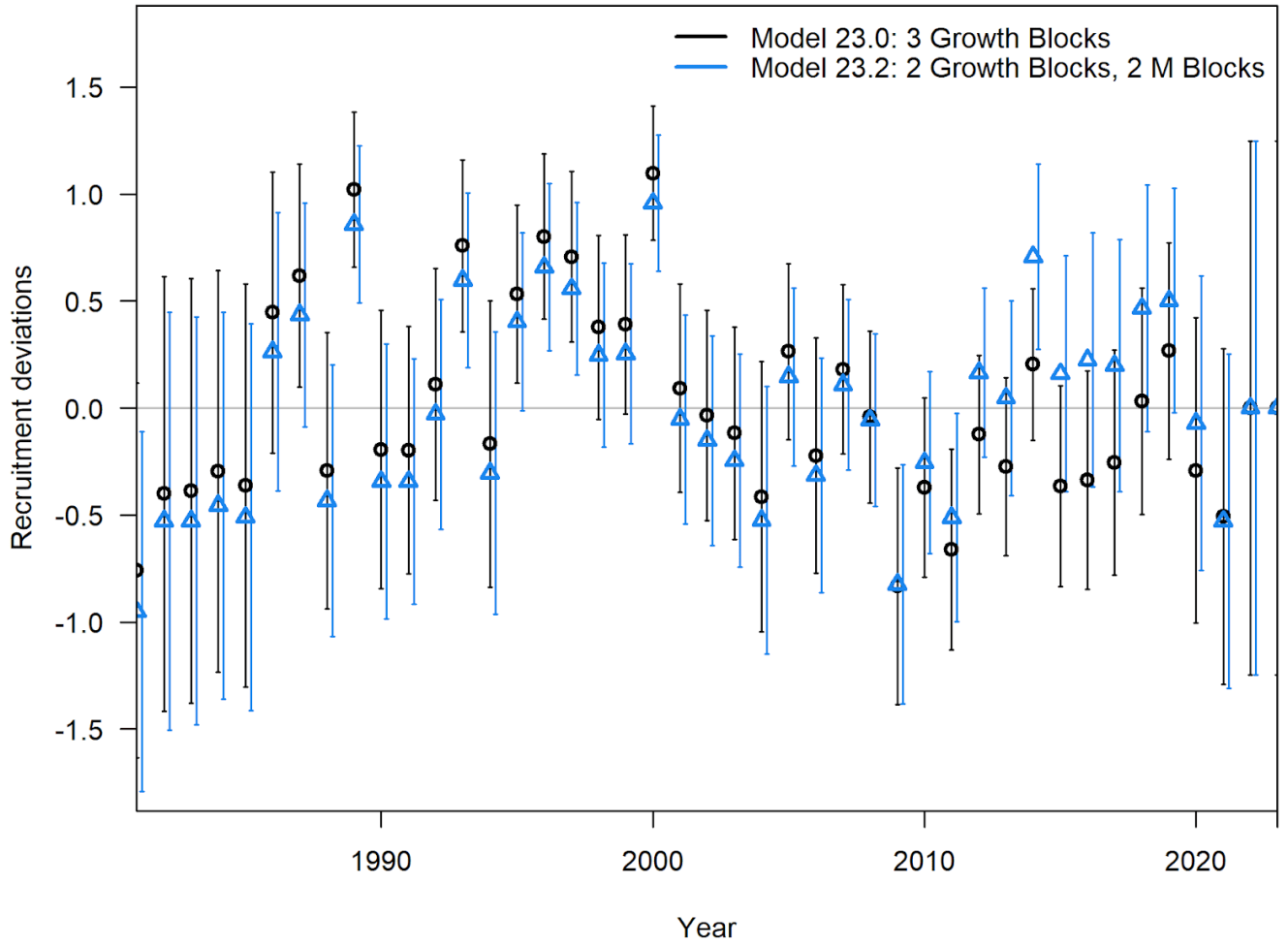
Model comparison: fits to survey data







Model comparison: recruitment deviations



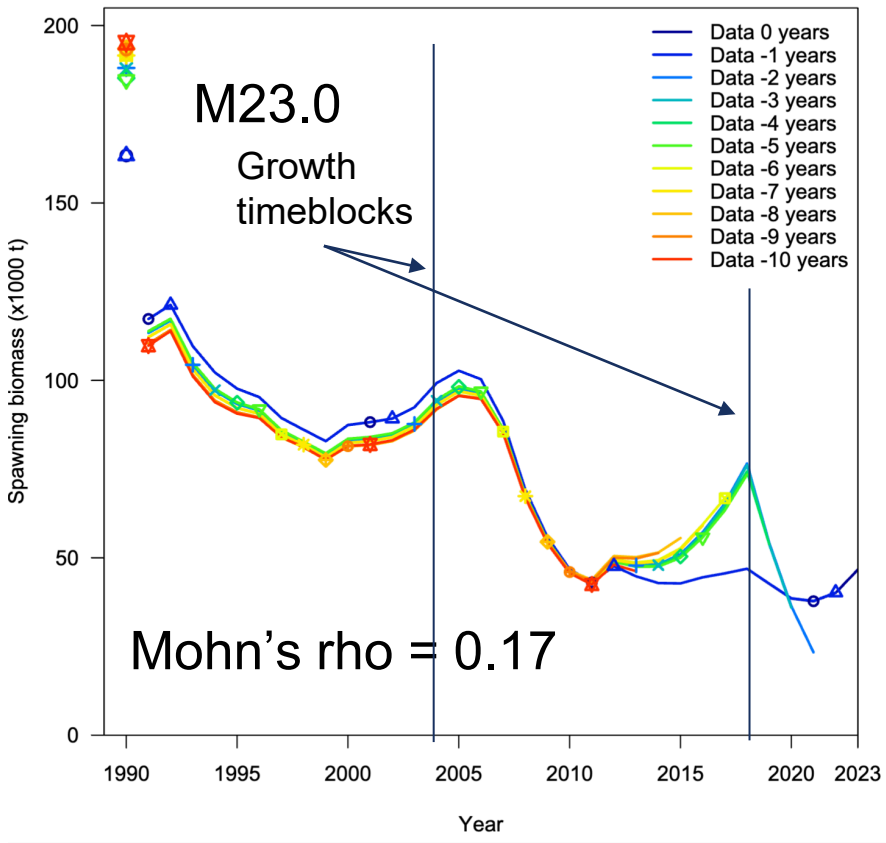
Diagnostics

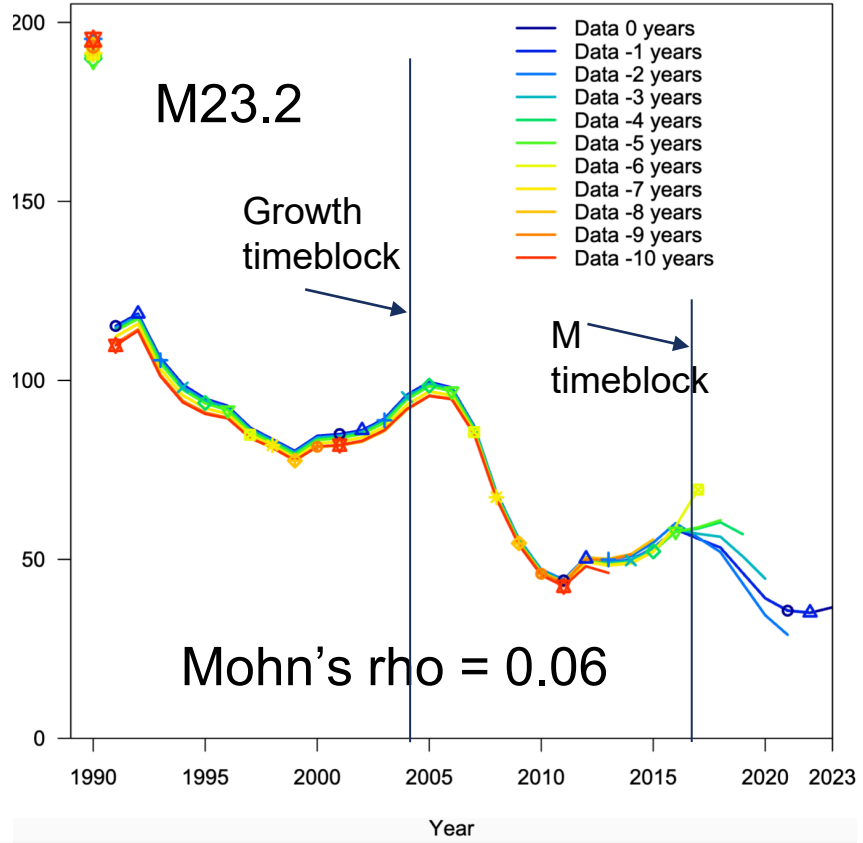
Model 23.2 provides an improved fit to the data, as well as significant improvement in AIC

Label	M23.0	M23.2
TOTAL_like	777.811	769.871
Survey_like	-1.9788	-8.21467
Length_comp_like	141.079	141.552
Age_comp_like	641.532	639.635
Recruitment_like	-3.76371	-4.10777
Forecast_Recruitment_like	0.316745	0.346509
Parm_priors_like	0.622181	0.655364
Recr_Virgin_millions	23.633	24.3493
SR_BH_steep	1	1
NatM_uniform_Fem_GP_1	0.338611	0.40351
NatM_uniform_Fem_GP_1_BLK2add_1991	NA	-0.083867
NatM_uniform_Fem_GP_1_BLK2add_2016	NA	0.0838674
SmryBio_unfished	79980	79434
SSB_2023_thousand_mt	23295	18261
Bratio_2023	0.29	0.23
SPRratio_2022	0.558857	0.47736
Ret_Catch_MSY	22444.9	22589.9
Dead_Catch_MSY	22444.9	22589.9
npar	71	72
AIC	1697.622	1683.742
Mohn's rho	0.17	0.058

M23.0 is long term average, M23.2 is “base M”.

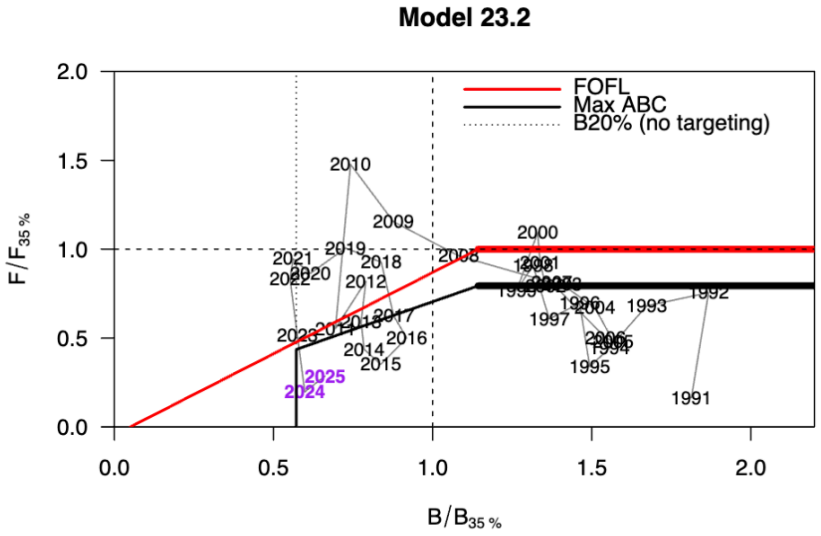
Model 23.2 significantly improved the retrospective pattern.





Discussion - Tier 5 vs. Tier 3 - pros and cons

- Tier 5 has been used since 2013
- Tier 3 provides a control rule
- Tier 5 model provides no information on $B/B_{20\%}$.



Forecasts and reference points

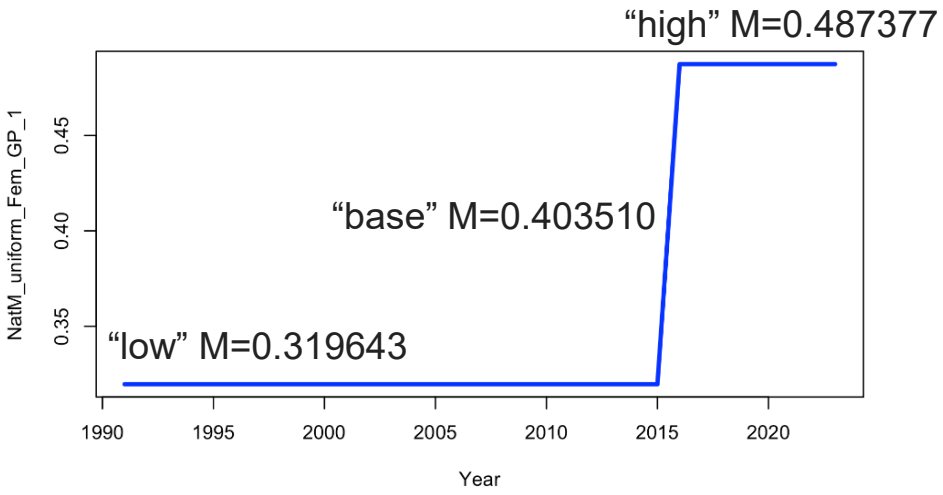
Tier 5 Summary Table

Summary table for Model 13.4.

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2023	2024	2024	2025
M (natural mortality rate)	0.34	0.34	0.34	0.34
Tier	5	5	5	5
Biomass (t)	54,165	54,165	54,166	54,166
F_{OFL}	0.34	0.34	0.34	0.34
$maxF_{ABC}$	0.255	0.255	0.255	0.255
F_{ABC}	0.255	0.255	0.255	0.255
OFL	18,416	18,416	18,416	18,416
$maxABC$	13,812	13,812	13,812	13,812
ABC	13,812	13,812	13,812	13,812
Status	2021	2022	2022	2023
Overfishing	No	n/a	No	n/a

Specifying parameters for forecasting, Model 23.2

Model 23.2 Natural mortality time block



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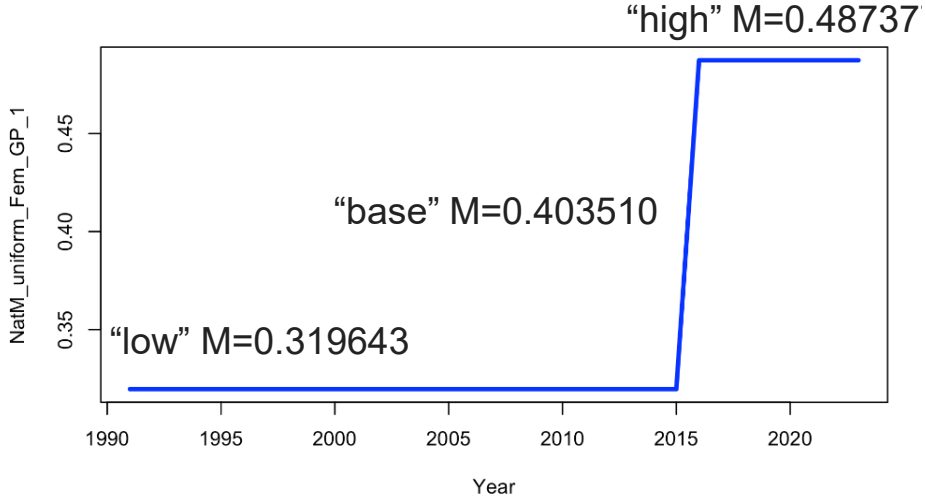
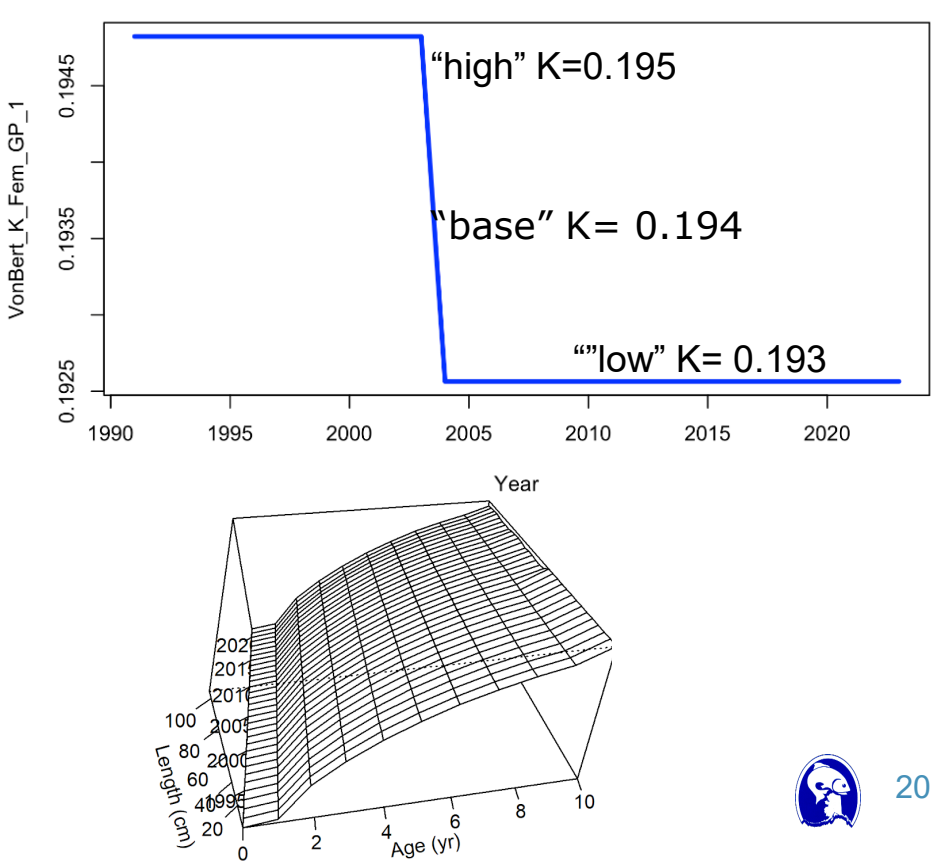


Model 23.2 Growth time block on K



Reference point calculations and forecasts shown in further slides are not in the document

•There are many method for doing forecasts when you have time varying growth and M that can have large impacts on harvest advice.

•Different forecasts have been shown and an erratum can be provided that represent a reasonable range of forecasts.

•There are no clear guidelines on accepted forecast methods for what assumptions to make for NPFMC stock assessments given time varying biology.

•Next, I show alternative methods for calculating reference points and completing forecasts that differ between 1) the range of years used to calculate reference points, and 2) the range of years used to select values for the growth parameter k, and M.

•These forecasts provide a range of forecast options and clarify the impact of alternative forecasts methods for AI Pacific cod given time varying biology. As there is no accepted forecast method at this time the selection of an individual forecast method for AI Pacific Cod would benefit from SSC discussion.

Specifying parameters for forecasting, Model 23.2

Reference years 1991-2023 Low M, high K

	SSB	SSB_PER	SB100	SB40	SB35	F40	F35	C_ABC	C_OFL
2024	19257.5	0.242434	79434	31773.7	27801.95	0.143491	0.172013	3821.5	4547.11
2025	23055.9	0.2902523	79434	31773.7	27801.95	0.260803	0.316906	8499.06	10166.3

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Reference years 1991-2023 base M, base K

	SSB	SSB_PER	SB100	SB40	SB35	F40	F35	C_ABC	C_OFL
2024	19003.45	0.2392357	79434	31773.7	27801.95	0.135631	0.162242	3474.47	4127.79
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Reference years 1991-2023 High M, low K

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2024	18752.5	0.2360765	79434	31773.7	27801.95	0.127879	0.152606	3152.58	3738.62
2025	19178.4	0.2414382	79434	31773.7	27801.95	0.138923	0.165468	3656.09	4322.64

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Reference years 1991-2004 with base M and base K projection

	SSB	SSB_PER	SB100	SB40	SB35	F40	F35	C_ABC	C_OFL
2024	19177.25	0.1970981	97298	38919.15	34054.25	0.0310877	0.0336917	818.338	886.279
2025	22193.05	0.2280936	97298	38919.15	34054.25	0.0954191	0.112883	3020.69	3555.66

The document conducted projections using different reference years.

Reference years 1991-2023 Low M, high K

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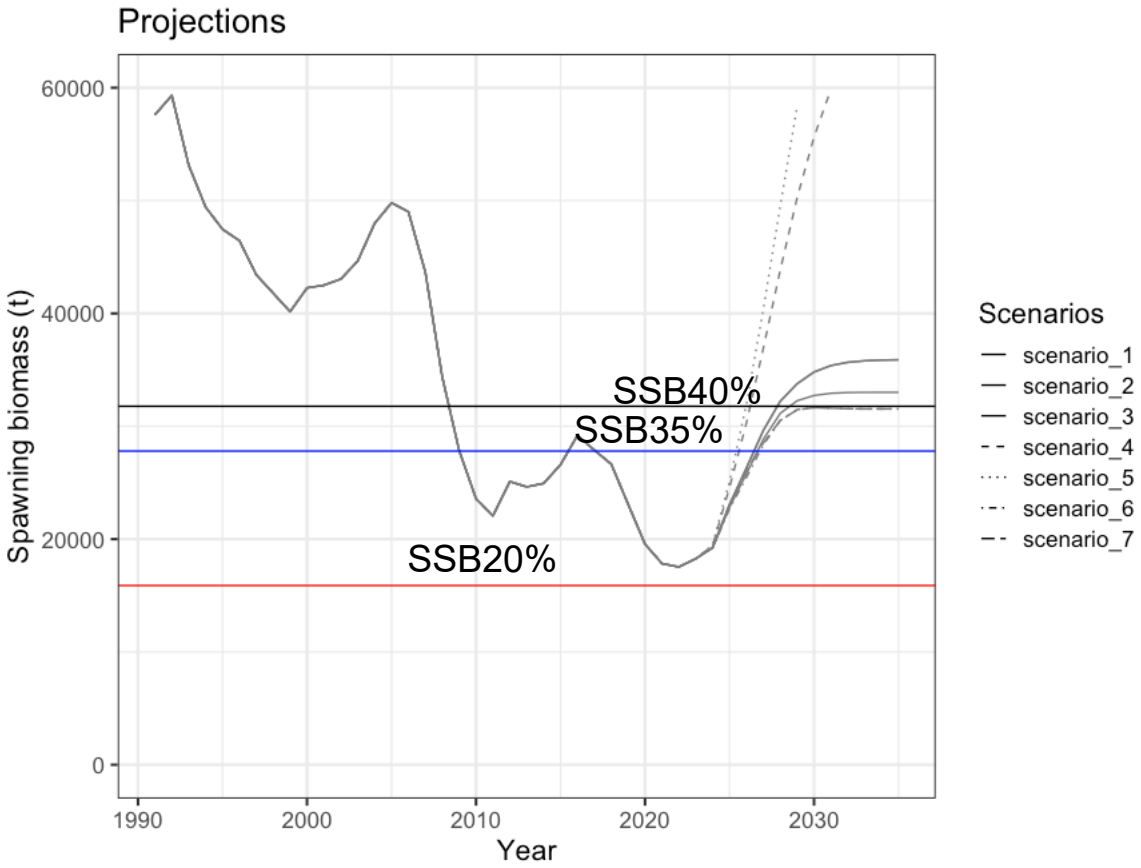

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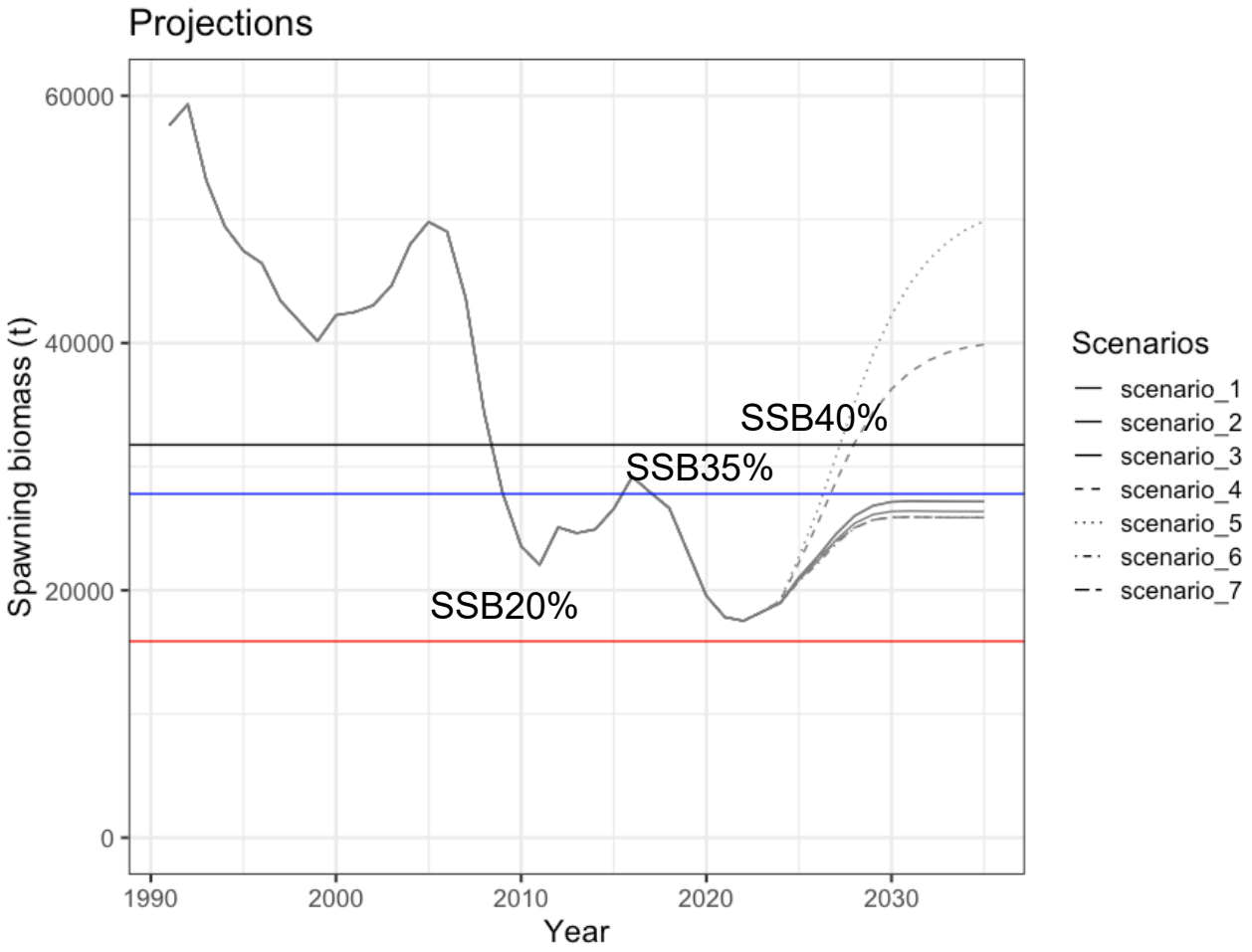

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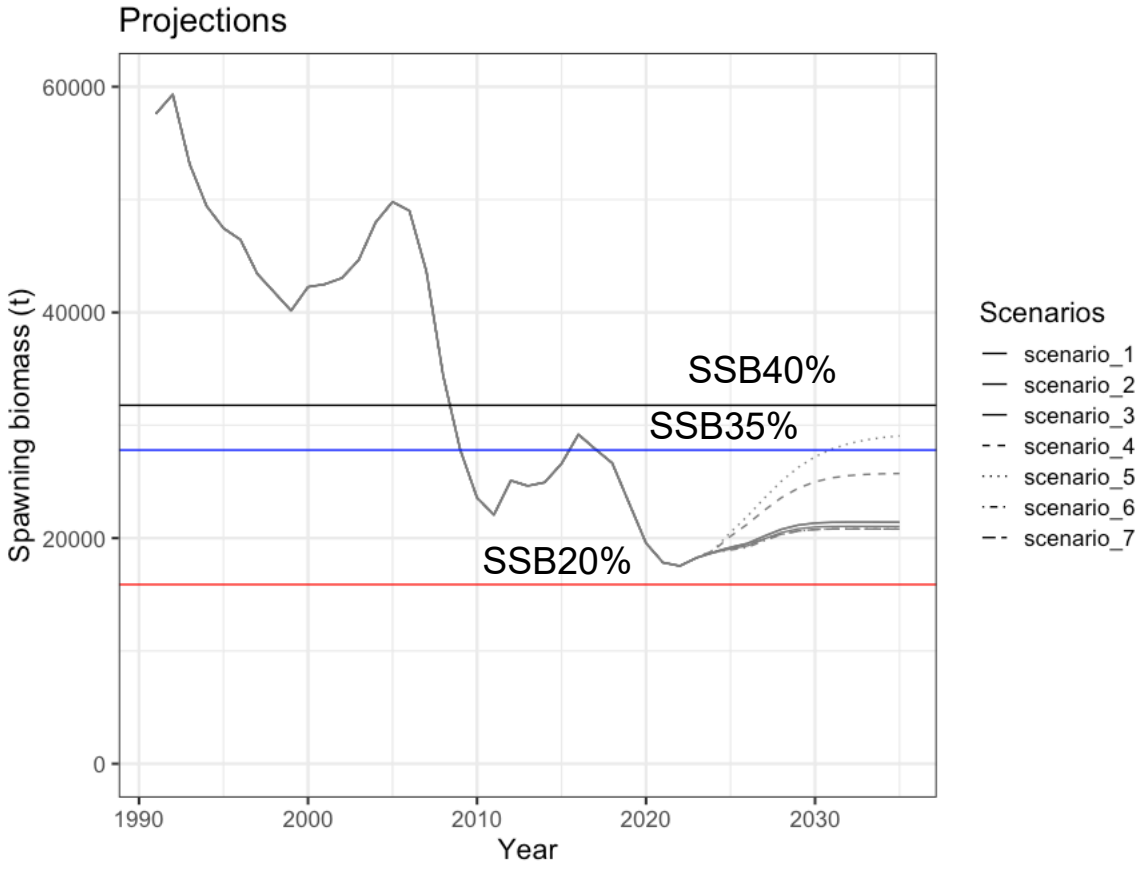

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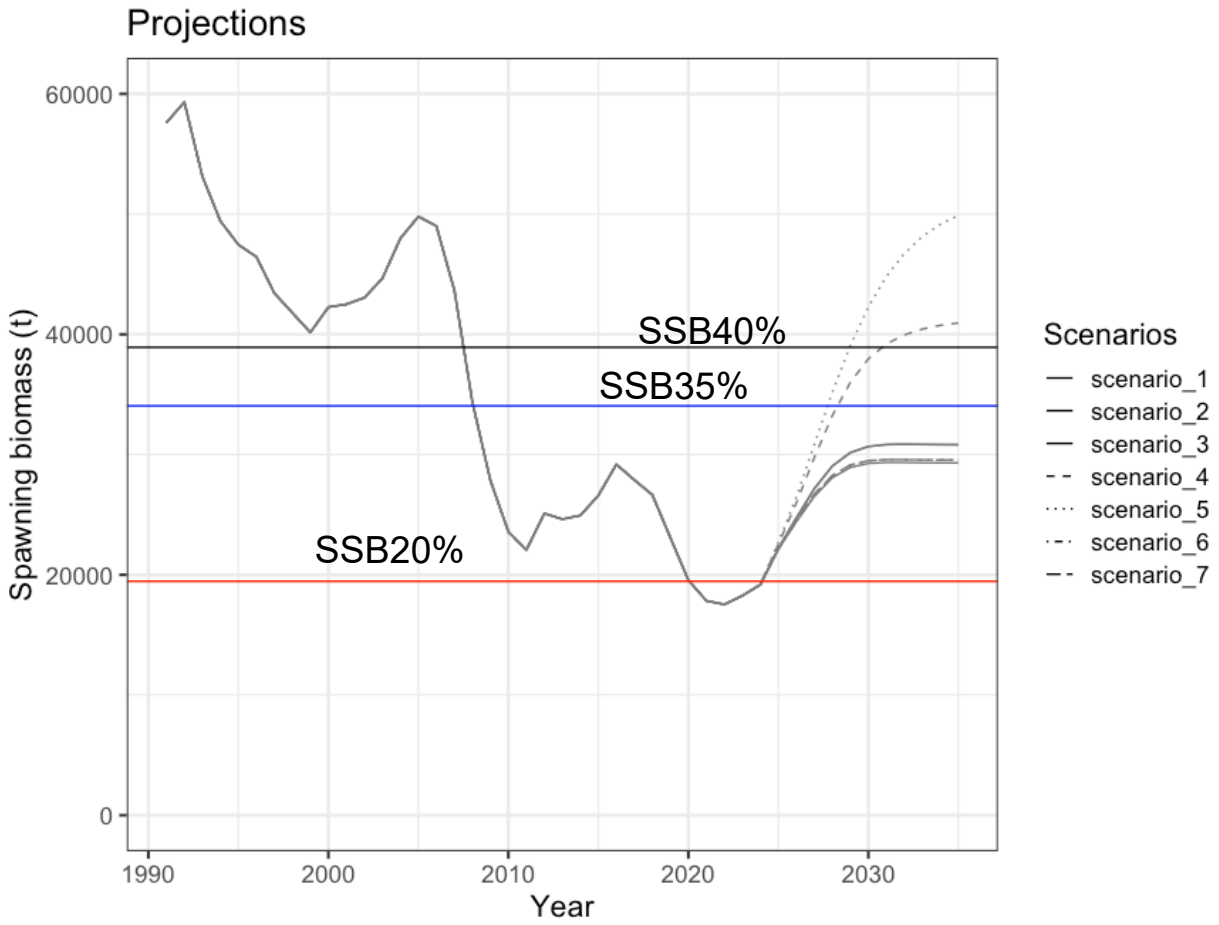
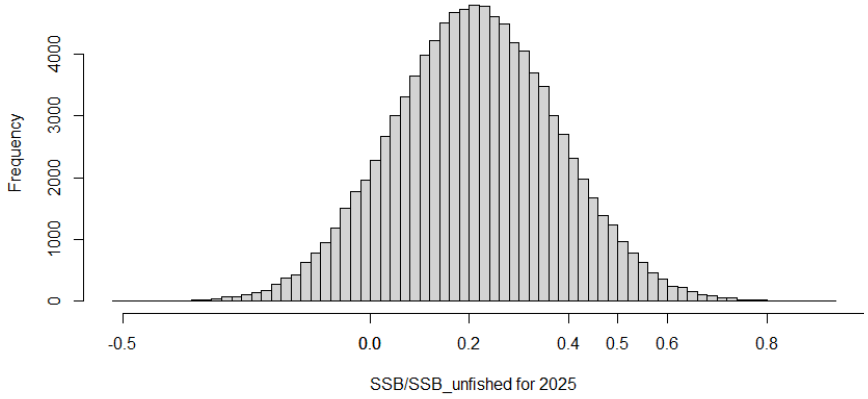


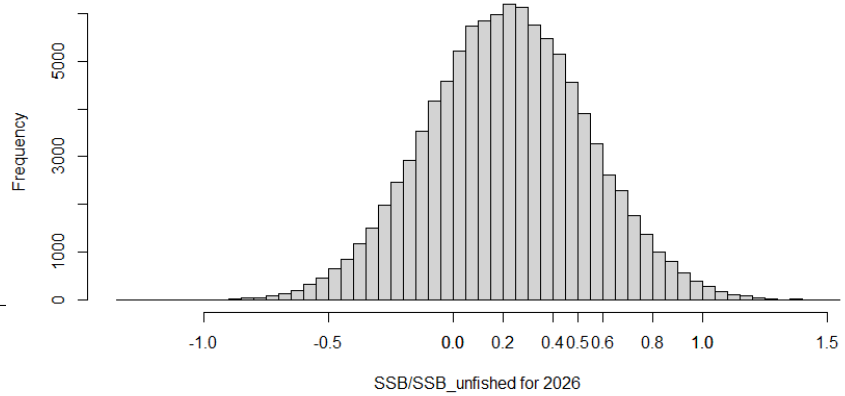
Tier 3 Model 23.2 represents the best scientific information.

If model 23.2 were a true representation of the dynamics of the stock, and fishing takes place at the Tier 5 OFL in 2024 and 2025 of 13,812 t,

In 2025, there is a:
47.5% probability of being at or below $B_{20\%}$
41.6% of being at or below MSST.



In 2026, there is a:
47.9% probability of being at or below $B_{20\%}$
44.9% probability of being at or below MSST.



This is assuming a normal distribution on the MLE estimates. This assumes all base parameters with 1991-2023 reference points.

Questions?

Extra slides

Summary table presented in the document, using 2004-2023 for reference points, base M, base K.

Table 2A.3: Summary table for Model 23.2. Last year's assessment was a Tier 5 model. Projections were based on annual catches of 7,898 t for 2023 and the ABC for 2024. Natural mortality is provided for both time blocks, in order.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2023	2024	2024	2025
M (natural mortality rate)	0.34	0.34	0.32, 0.49	0.32, 0.49
Tier	5	5	3b	3b
Projected total (age 1+) biomass (t)	54,165	54,165	54,611	61,611
Projected female spawning biomass (t)	-	-	18,687	18,302
$B_{100\%}$	-	-	56,572	56,572
$B_{40\%}$	-	-	22,628	22,628
$B_{35\%}$	-	-	19,800	19,800
F_{OFL}	0.34	0.34	0.544	0.666
$maxF_{ABC}$	0.255	0.255	0.445	0.422
F_{ABC}	0.255	0.255	0.445	0.422
OFL	18,416	18,416	12,732	17,304
$maxABC$	13,812	13,812	10,660	10,214
ABC	13,812	13,812	10,660	10,214
Status	2021	2022	2022	2023
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Model 23.2 summary table with forecast file benchmark years 1991-2023 and projection with low M, high K.

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2023	2024	2024	2025
M (natural mortality rate)	0.34	0.34	0.32, 0.49	0.32, 0.49
Tier	5	5	3b	3b
Projected total (age 1+) biomass (t)	54,165	54,165	54,611	61,611
Projected female spawning biomass (t)	-	-	18,687	18,302
$B_{100\%}$	-	-	56,572	56,572
$B_{40\%}$	-	-	22,628	22,628
$B_{35\%}$	-	-	19,800	19,800
F_{OFL}	0.34	0.34	0.544	0.666
$maxF_{ABC}$	0.255	0.255	0.445	0.422
F_{ABC}	0.255	0.255	0.445	0.422
OFL	18,416	18,416	12,732	17,304
$maxABC$	13,812	13,812	10,660	10,214
ABC	13,812	13,812	10,660	10,214
Status	2021	2022	2022	2023
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Model 23.2 summary table with forecast file benchmark years 1991-2023 and projection with base M, base K.

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2023	2024	2024	2025
M (natural mortality rate)	0.34	0.34	0.32, 0.49	0.32, 0.49
Tier	5	5	3b	3b
Projected total (age 1+) biomass (t)	54,165	54,165	54,160	61,363
Projected female spawning biomass (t)	-	-	19,003	21,034
$B_{100\%}$	-	-	79,434	79,434
$B_{40\%}$	-	-	31,773	31,773
$B_{35\%}$	-	-	27,801	27,801
F_{OFL}	0.34	0.34	0.162	0.237
$maxF_{ABC}$	0.255	0.255	0.136	0.197
F_{ABC}	0.255	0.255	0.136	0.197
OFL	18,416	18,416	4,127	6,881
$maxABC$	13,812	13,812	3,474	5,770
ABC	13,812	13,812	3,474	5,770
Status	2021	2022	2022	2023
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Model 23.2 summary table with forecast file benchmark years 1991-2023 and projection with high M, low K.

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2023	2024	2024	2025
M (natural mortality rate)	0.34	0.34	0.32, 0.49	0.32, 0.49
Tier	5	5	3b	3b
Projected total (age 1+) biomass (t)	54,165	54,165	54,160	61,363
Projected female spawning biomass (t)	-	-	18,752	19,178
$B_{100\%}$	-	-	79,434	79,434
$B_{40\%}$	-	-	31,773	31,773
$B_{35\%}$	-	-	27,801	27,801
F_{OFL}	0.34	0.34	0.153	0.165
$maxF_{ABC}$	0.255	0.255	0.128	0.139
F_{ABC}	0.255	0.255	0.128	0.139
OFL	18,416	18,416	3,738	4,322
$maxABC$	13,812	13,812	3,152	3,656
ABC	13,812	13,812	3,152	3,656
Status	2021	2022	2022	2023
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Model 23.2 summary table with forecast file benchmark years 1991-2004 and projection with base M, base K.

	As estimated or *specified* *last* year for:		As estimated or *recommended* *this* year for:	
Quantity	2023	2024	2024	2025
M (natural mortality rate)	0.34	0.34	0.32, 0.49	0.32, 0.49
Tier	5	5	3b	3b
Projected total (age 1+) biomass (t)	54,165	54,165	54,160	61,363
Projected female spawning biomass (t)	-	-	19,177	22,193
$B_{100\%}$	-	-	97,298	97,298
$B_{40\%}$	-	-	38,919	38,919
$B_{35\%}$	-	-	34,054	34,054
F_{OFL}	0.34	0.34	0.034	0.113
$maxF_{ABC}$	0.255	0.255	0.031	0.095
F_{ABC}	0.255	0.255	0.031	0.095
OFL	18,416	18,416	886	3,555
$maxABC$	13,812	13,812	818	3,020
ABC	13,812	13,812	818	3,020
Status	2021	2022	2022	2023
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No