Photo from PFMC website

2021 North and South Lingcod Stock Assessments and Stock Assessment Review (STAR) Panel Report

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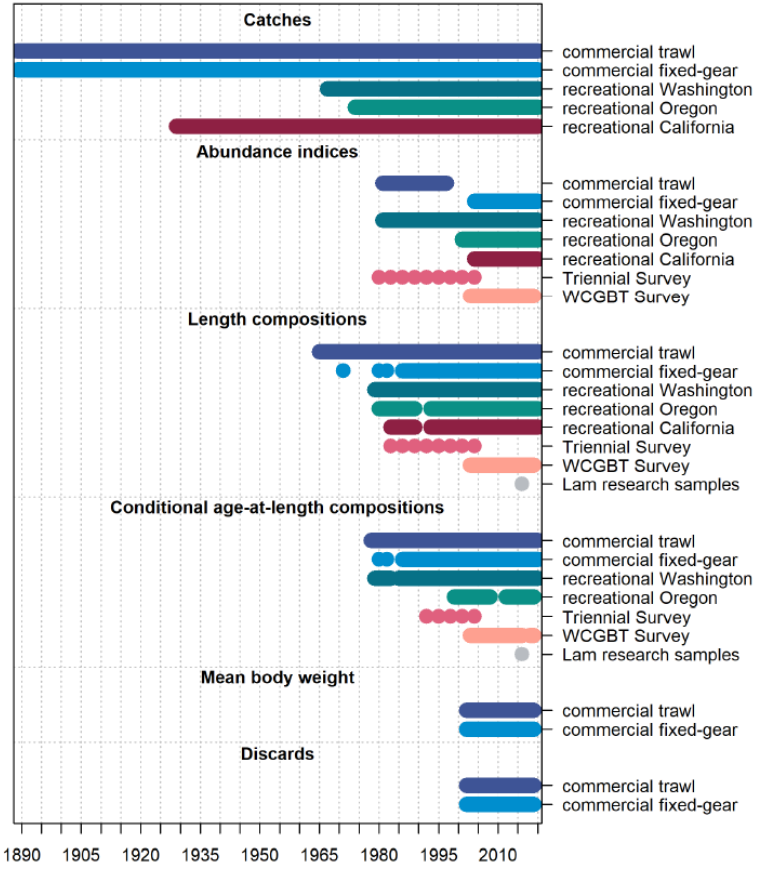
Data Sources

- Start late 1800s, historical catch estimates improved
- Change in North/South boundary from CA/OR border to Cape Mendocino (supported by genetic analyses, other considerations)
- Commercial catches broken into trawl and fixed gear, recreational catches state-specific (but not mode-specific)
- North has considerable age data from fisheries, South age data generally limited to WCGBTS data
- Both models have robust historical and contemporary (ongoing) indices
- Length data include male, female, unsexed; CAAL are male and female only, unlike the previous assessment where unsexed individuals were assigned 50:50 to gender
- Discard rates modelled for commercial fisheries based on WCGOP data (starting 2002), fits not always good...
- Final base models changed only modestly from the draft models and documents provided to the review panel

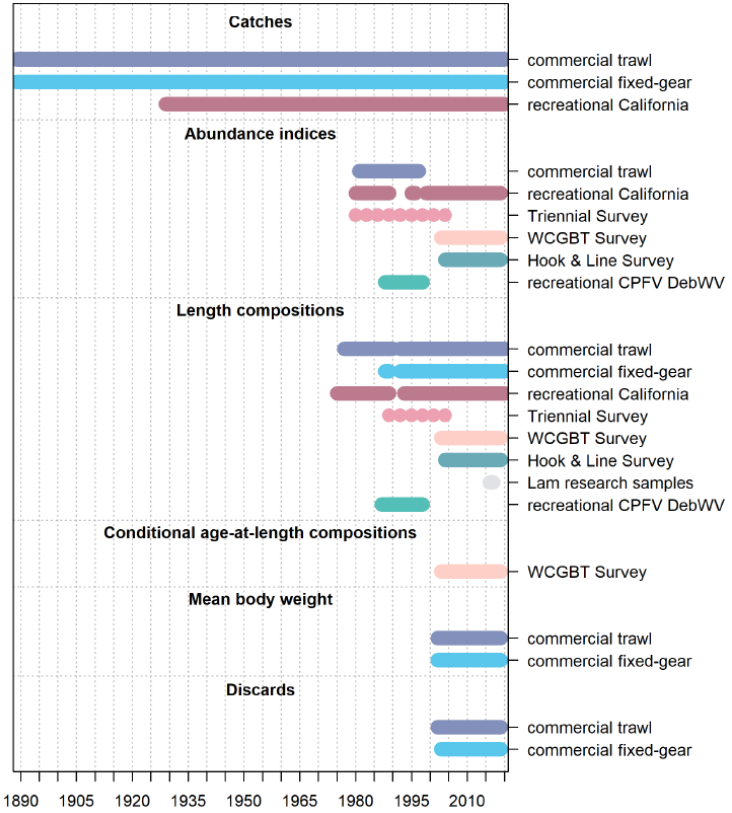
North Model



North/South differences

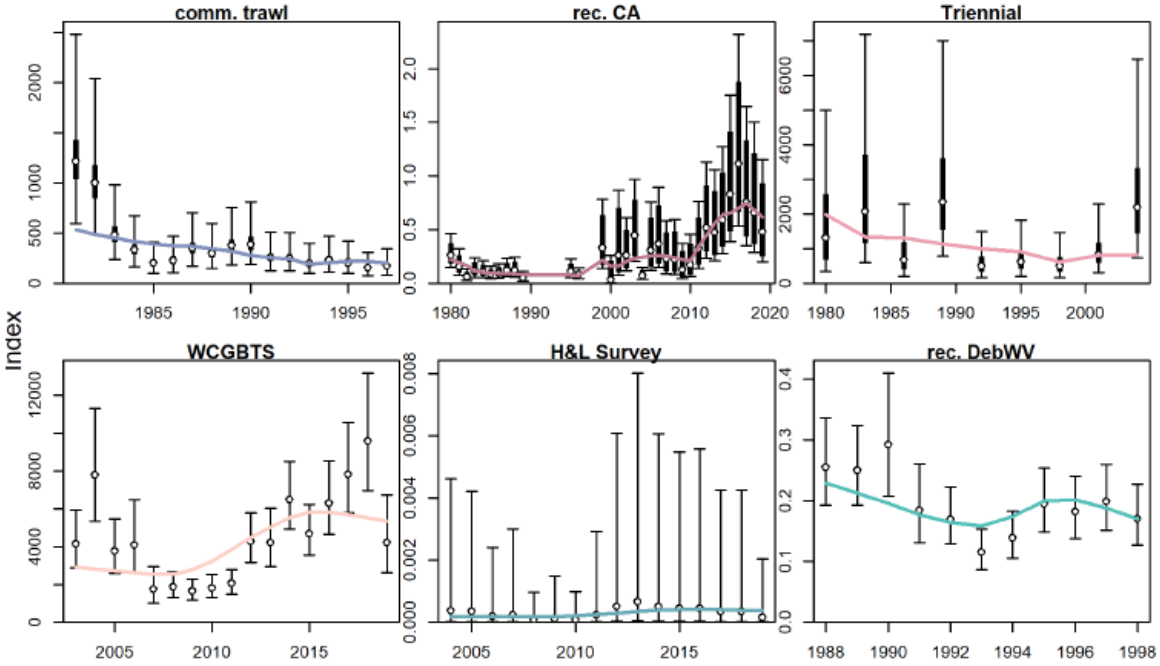
- The 2021 models used the 99th percentile age as basis for Natural mortality (M) prior, rather than max age. 2021 prior means were 0.3 for females and 0.42 for males (rel. to 0.257 for both sexes in 2017 models, at which values were fixed).
- The 2021 base model estimated natural mortality rates were 0.42 and 0.41 for females and males in the northern model; for the southern model the estimates were 0.17 and 0.22.
- Similarly, steepness estimates were also considerably different between models, with the northern model steepness estimated at 0.80 and the southern model estimated at 0.51.
- The unusual differences in the estimates of natural mortality by region (and to a lesser extent, steepness) were discussed extensively during the STAR Panel.
- An overarching conclusion by both the STAT and the STAR Panel is that neither model is capturing key aspects of the population dynamics, there are many clues as to why this is, but no clear short-term fixes from a modeling perspective.

South Model



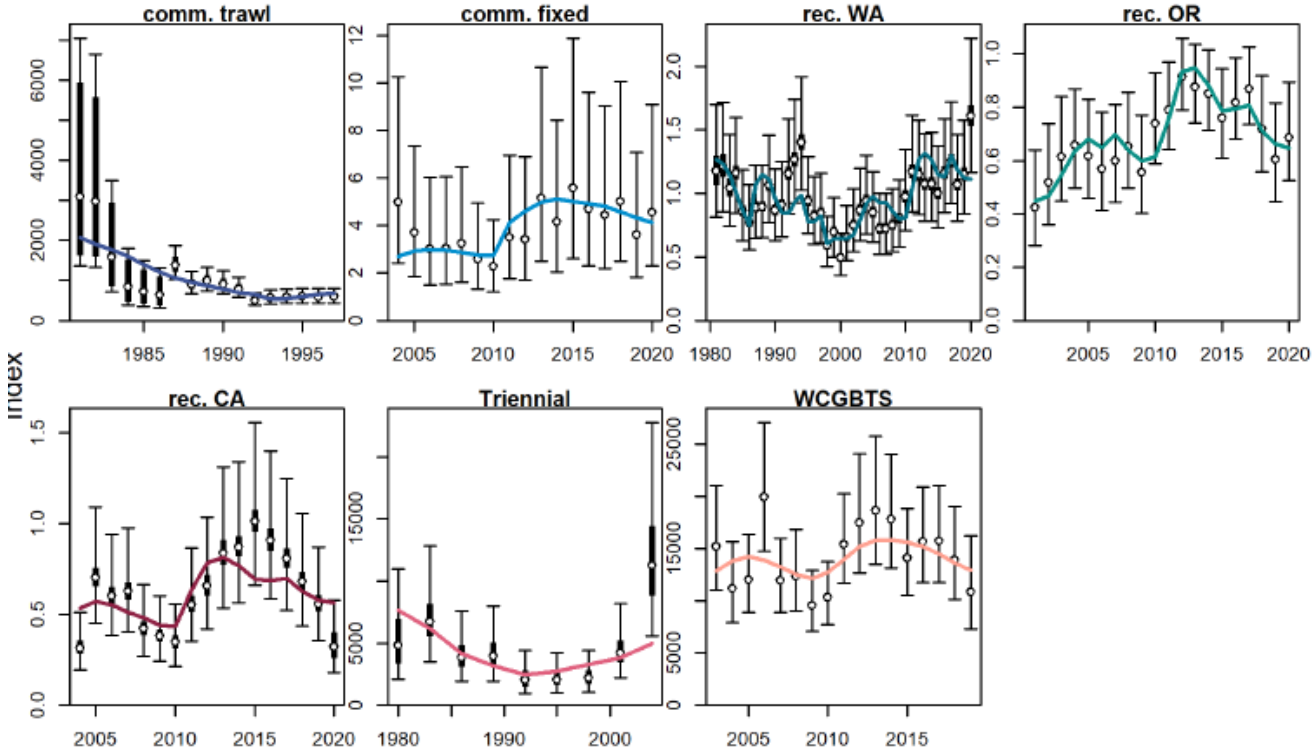
Southern Model

- Both models include informative indices (both fisheries independent and fisheries dependent)
- General agreement between STAT and Panel that recent indices provide robust information on trends, stock status
- Some indices not used in 2021 (e.g., CCFRP in south), should be considered in future



Northern Model

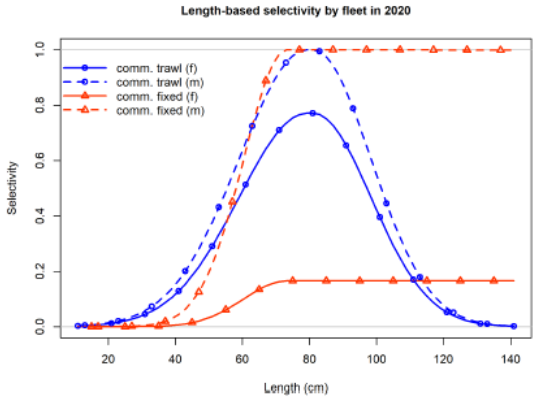
- Both models include informative indices (both fisheries independent and fisheries dependent)
- General agreement between STAT and Panel that recent indices provide robust information on trends, stock status.

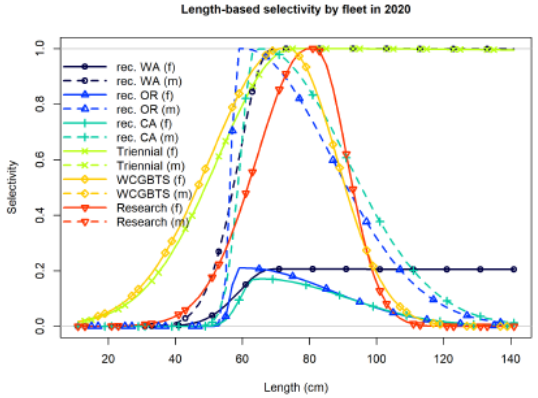


Both models continue to suggest tension among many key data sources, particularly age and length data (as in 2017).

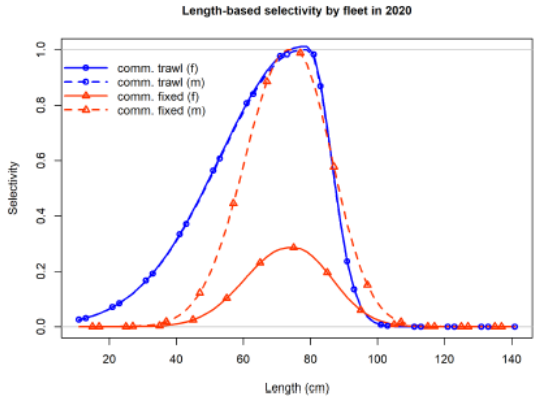
STAT and Panel discussed and explored evidence for time-varying growth, for sex-specific selectivity patterns, and more. All held some level of promise for understanding sources of tension in the model, but "*Without further research and likely a different approach to handling fleet structure and age data… there is not an acceptable way to capture these dynamics with the current model structure.*"

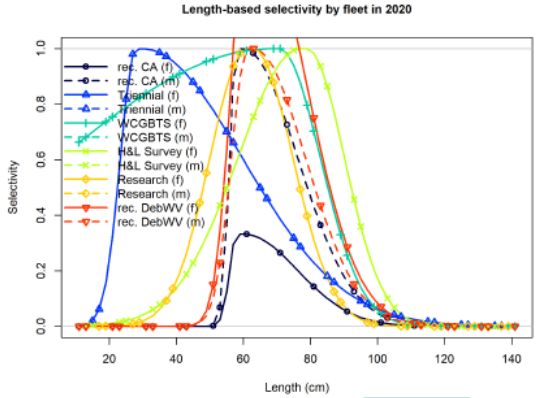
North





South





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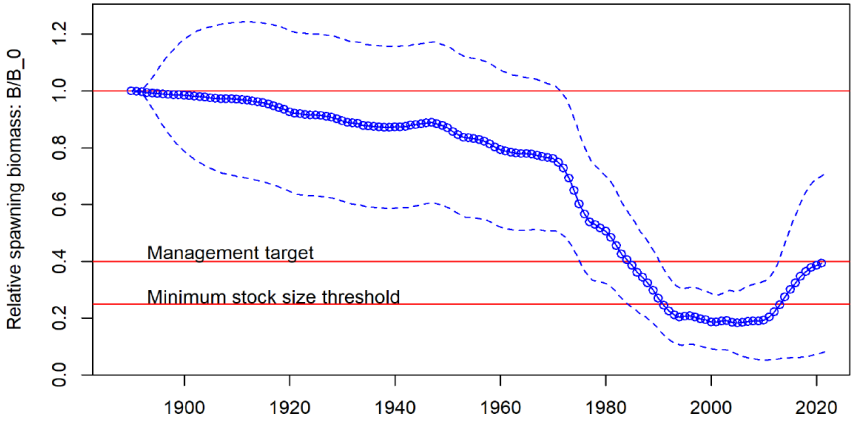
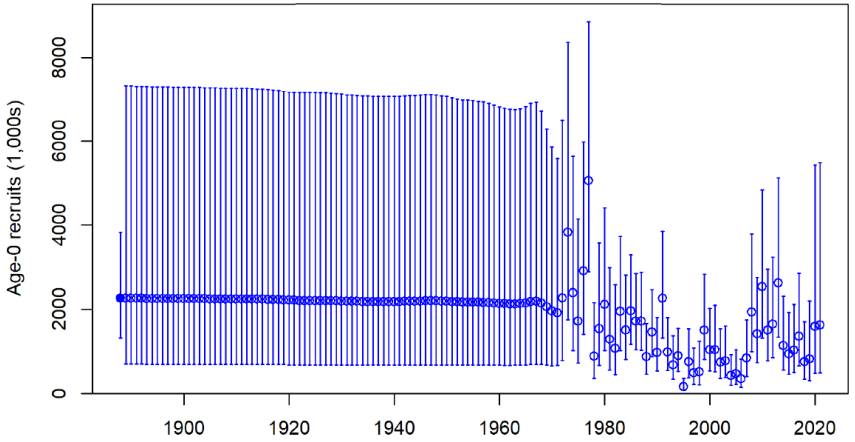
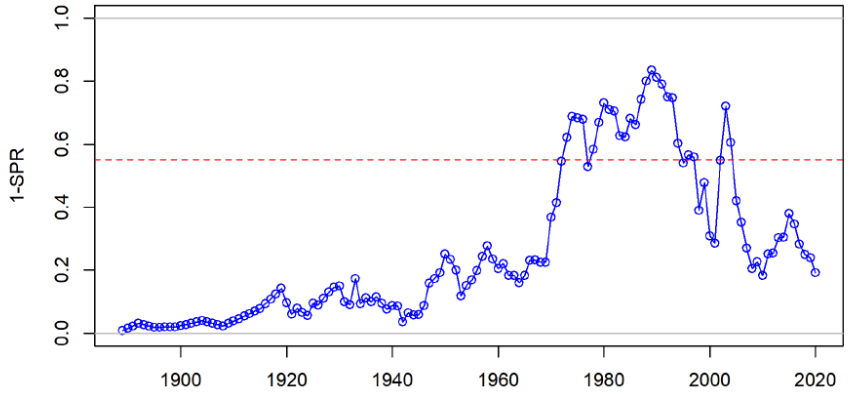
Southern Model Results







Model estimates stock declines below target levels from late 80s through early 2000s when fishing intensity was greatest, with recent increases in abundance associated with strong recruitment from 2008 through 2013. Fraction unfished is 39% in 2021, with recent estimates of poor recruitment from 2014 onwards leading to slight population declines in model forecasts.

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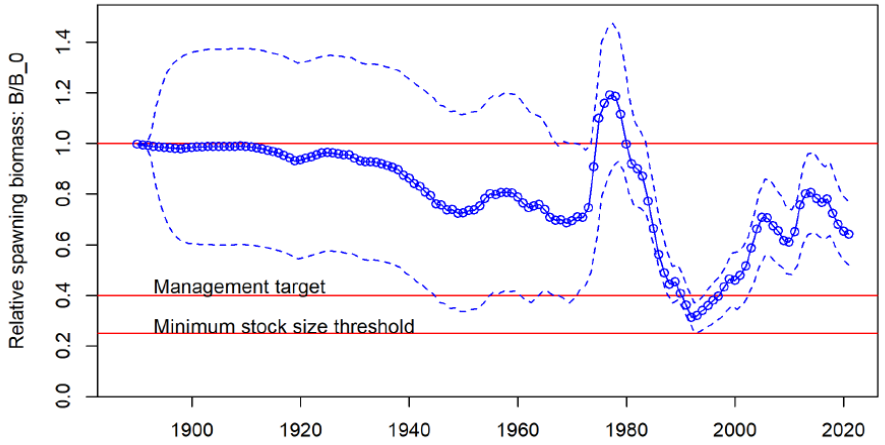
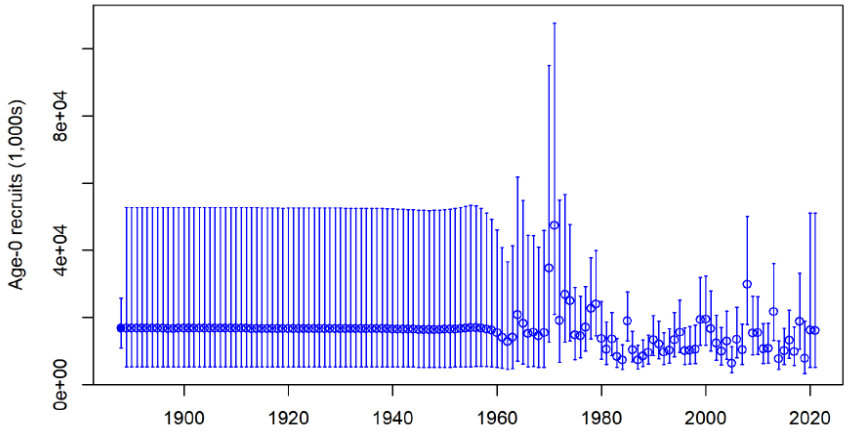
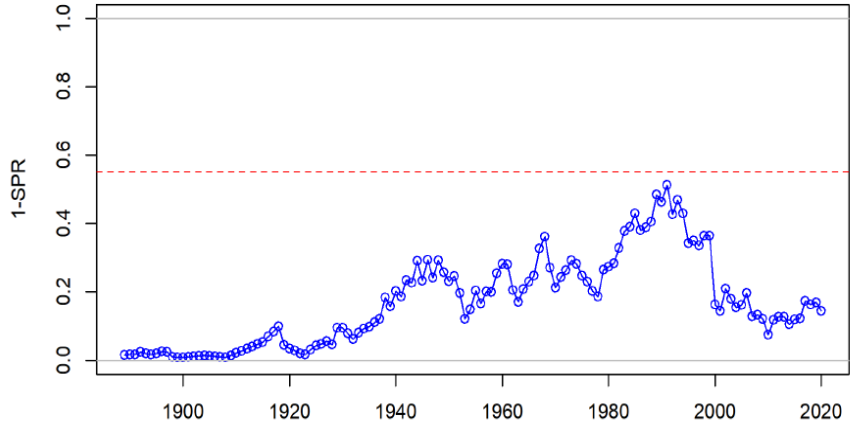
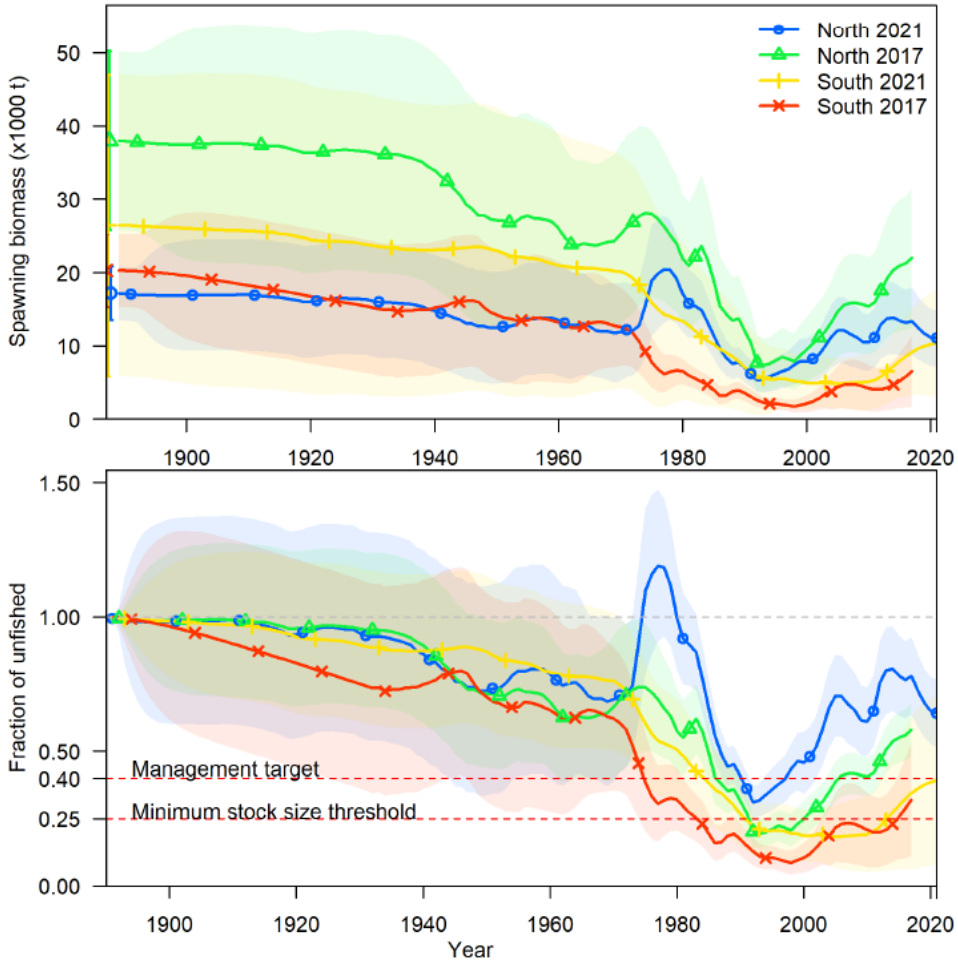
Northern Model Results







Model estimates stock declined below target levels only briefly in late 80s/early 90s, and that harvest rates were never above target levels. Current relative abundance is 64%, well above target levels, with recent strong recruitments in 2013 and 2018 consistent with a relatively stable population trend in forecast (depending on removals).



Comparison to 2017 models

Recognizing change in boundary, results general consistent with 2017 trends and productivity estimates (cumulative equilibrium MSY values are very comparable among the 2017 and 2021 suites of models)

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Decision Table: South Model

For the southern model, uncertainty over the model estimate of natural mortality was determined to be an appropriate axis of uncertainty, with the high and low states of nature based on the high (0.22) and low (0.11) quantiles of female natural mortality, as inferred by the likelihood profile (in which the base estimate was 0.17).

Catch stream advice was provided by the GMT, and was based on recent average catch, the estimated ACL with a category 2 designation and a P* of 0.45, and the estimated ACL with a category 2 designation and a P* of 0.40.

As the base model indicates relatively weaker recruitment from 2014 through recent years, most model trajectories in the decision table indicate stable or declining trends for all three catch scenarios. All trajectories in the decision table leading to depletion estimates within the precautionary zone (e.g., between 25% and 40% of the unfished level).

			Low M (0.11)		Base (M ~ 0.17)		High M (0.22)	
Asm.	Year	Catch	SSB (mt)	Frac. unfished	SSB (mt)	Frac. unfished	SSB (mt)	Frac. unfished
Recent avg. catch	2021	700.0000	15065.6	0.296	10415.0	0.394	6475.3	0.419
	2022	700.0000	15199.8	0.299	10224.3	0.387	6137.8	0.397
	2023	700.0000	15220.8	0.299	9994.6	0.378	5848.7	0.378
	2024	700.0000	15234.3	0.299	9858.0	0.373	5722.5	0.370
	2025	700.0000	15251.6	0.300	9809.9	0.371	5715.4	0.369
	2026	700.0000	15263.4	0.300	9812.7	0.371	5762.3	0.372
	2027	700.0000	15264.6	0.300	9845.7	0.372	5830.8	0.377
	2028	700.0000	15261.8	0.300	9901.0	0.374	5908.5	0.382
	2029	700.0000	15256.4	0.300	9972.3	0.377	5990.6	0.387
	2030	700.0000	15256.8	0.300	10057.2	0.380	6075.4	0.393
	2031	700.0000	15263.9	0.300	10151.7	0.384	6161.7	0.398
	2032	700.0000	15283.5	0.300	10254.2	0.388	6248.5	0.404
ACL P^*=0.40	2021	700.0000	15065.6	0.296	10415.0	0.394	6475.3	0.419
	2022	700.0000	15199.8	0.299	10224.3	0.387	6137.8	0.397
	2023	642.3000	15220.8	0.299	9994.6	0.378	5848.7	0.378
	2024	642.9000	15269.8	0.300	9890.0	0.374	5751.5	0.372
	2025	668.2000	15330.5	0.301	9878.1	0.374	5775.3	0.373
	2026	691.4284	15372.5	0.302	9902.4	0.374	5837.4	0.377
	2027	706.2000	15386.7	0.302	9939.5	0.376	5904.8	0.382
	2028	712.3000	15382.4	0.302	9985.8	0.378	5970.6	0.386
	2029	713.0000	15366.1	0.302	10041.2	0.380	6036.7	0.390
	2030	710.5000	15350.4	0.302	10107.7	0.382	6105.6	0.395
	2031	706.3187	15339.5	0.302	10184.6	0.385	6178.3	0.399
	2032	702.3000	15341.4	0.302	10271.9	0.388	6255.0	0.404
ACL P^*=0.45	2021	700.0000	15065.6	0.296	10415.0	0.394	6475.3	0.419
	2022	700.0000	15199.8	0.299	10224.3	0.387	6137.8	0.397
	2023	731.4257	15220.8	0.299	9994.6	0.378	5848.7	0.378
	2024	727.8698	15200.6	0.299	9827.9	0.372	5695.2	0.368
	2025	754.0078	15184.2	0.298	9751.9	0.369	5665.3	0.366
	2026	779.3000	15138.5	0.298	9707.8	0.367	5673.8	0.367
	2027	795.0000	15054.5	0.296	9672.7	0.366	5687.2	0.368
	2028	801.8603	14943.0	0.294	9644.1	0.365	5699.3	0.368
	2029	804.1052	14811.7	0.291	9622.8	0.364	5712.0	0.369
	2030	802.3000	14673.2	0.288	9610.9	0.363	5727.2	0.370
	2031	798.8116	14533.3	0.286	9608.8	0.363	5746.4	0.371
	2032	795.5971	14400.7	0.283	9616.7	0.364	5769.9	0.373

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Decision Table: North Model

For the northern model, we used an “expert judgement” alternative approach to address the key uncertainties in the model.

Here, the “high” state of nature is reflected by excluding the fishery-dependent age data, which are a source of considerable tension in the model, and without which the model estimates of productivity are greater. Alternatively, the “low” state of nature reflects the model with sex specific selectivity (reflecting model structure uncertainty). While the resulting SSB is higher than the base model, natural mortality and productivity are very low.

Although the ending relative spawning output is generally comparable across these three states of nature, the equilibrium MSY levels have a broader range, such that they are approximately 34% of the base model equilibrium MSY for the “low” state of nature, and 125% of the base model equilibrium MSY for the “high” state of nature.

			Low (sex-selectivity)		Base		High (no fishery ages)	
Asm.	Year	Catch	SSB (mt)	Frac. unfished	SSB (mt)	Frac. unfished	SSB (mt)	Frac. unfished
Recent avg. catch	2021	1200.100	22435.2	0.614	11010.2	0.642	17623.3	0.719
	2022	1200.100	22194.3	0.608	11090.4	0.646	18276.0	0.746
	2023	1200.100	21709.7	0.595	10721.6	0.625	17921.4	0.731
	2024	1200.100	21377.6	0.585	10967.4	0.639	18031.2	0.736
	2025	1200.100	21145.4	0.579	11415.0	0.665	18325.2	0.748
	2026	1200.100	20980.3	0.575	11879.4	0.692	18656.2	0.761
	2027	1200.100	20871.0	0.572	12298.8	0.717	18975.3	0.774
	2028	1200.100	20809.3	0.570	12657.4	0.738	19263.9	0.786
	2029	1200.100	20786.0	0.569	12955.4	0.755	19515.2	0.797
	2030	1200.100	20788.7	0.569	13199.0	0.769	19729.0	0.805
	2031	1200.100	20817.0	0.570	13396.0	0.781	19908.4	0.813
	2032	1200.100	20858.4	0.571	13554.2	0.790	20057.3	0.819
ACL P^*=0.40	2021	1200.100	22435.2	0.614	11010.2	0.642	17623.3	0.719
	2022	1200.100	22194.3	0.608	11090.4	0.646	18276.0	0.746
	2023	4218.900	21709.7	0.595	10721.6	0.625	17921.4	0.731
	2024	3742.100	19086.2	0.523	9568.7	0.558	16389.5	0.669
	2025	3462.900	16655.6	0.456	9083.0	0.529	15516.5	0.633
	2026	3294.800	14416.5	0.395	8892.8	0.518	15024.1	0.613
	2027	3190.100	12350.6	0.338	8830.0	0.515	14759.0	0.602
	2028	3144.049	*10433.8*	*0.286*	*8810.0*	*0.513*	*14616.2*	*0.597*
	2029	3100.379	*8651.0*	*0.237*	*8811.3*	*0.513*	*14545.7*	*0.594*
	2030	3057.372	*6986.9*	*0.191*	*8830.4*	*0.515*	*14522.4*	*0.593*
	2031	3016.131	*5437.5*	*0.149*	*8865.9*	*0.517*	*14532.8*	*0.593*
	2032	2981.179	*3997.6*	*0.109*	*8915.1*	*0.520*	*14567.8*	*0.595*
ACL P^*=0.45	2021	1200.100	22435.2	0.614	11010.2	0.642	17623.3	0.719
	2022	1200.100	22194.3	0.608	11090.4	0.646	18276.0	0.746
	2023	4771.800	21709.7	0.595	10721.6	0.625	17921.4	0.731
	2024	4167.600	18653.6	0.511	9309.6	0.543	16091.7	0.657
	2025	3825.402	15829.1	0.434	8672.2	0.505	15031.2	0.614
	2026	3631.700	13234.6	0.362	8384.5	0.489	14417.0	0.588
	2027	3520.437	10838.8	0.297	8249.0	0.481	14065.2	0.574
	2028	3477.993	*8610.5*	*0.236*	*8166.7*	*0.476*	*13853.1*	*0.565*
	2029	3441.948	*6534.6*	*0.179*	*8111.1*	*0.473*	*13721.4*	*0.560*
	2030	3404.869	*4603.2*	*0.126*	*8075.8*	*0.471*	*13639.7*	*0.557*
	2031	3372.458	*3016.4*	*0.083*	*8060.7*	*0.470*	*13595.0*	*0.555*
	2032	3348.244	*1857.3*	*0.051*	*8062.0*	*0.470*	*13577.0*	*0.554*

Technical Merits of the Assessment

Both the northern and southern assessment are relatively data rich, each are informed by both fishery independent and fishery dependent index data, each have robust time series of length composition data for the major fisheries, and the northern model has a considerable amount of age data (the southern model has limited age data). Although there is clear tension among data sources in the model, for most plausible parameterizations of the model the management quantities and estimates of relative abundance are within the confidence bounds of the base model.

Notable improvements since the 2017 include

- Incorporation of fishery ages into the Northern model as CAAL rather than marginal
- Boundary change with basis on genetic analysis (and other factors)
- Improvement to historical catch estimates (both commercial and recreational)
- Estimation of key parameters, particularly steepness and natural mortality rates

The assessments were very thorough with respect to documentation, diagnostics, sensitivities and complementary information on all of the above. Significantly, surveys appear sufficiently informative to estimate the relative abundance of the stocks over recent time periods, there will be an ability to qualitatively evaluate relative abundance trends (based on those indices) to help ensure that stocks are not at significant risk of depletion.

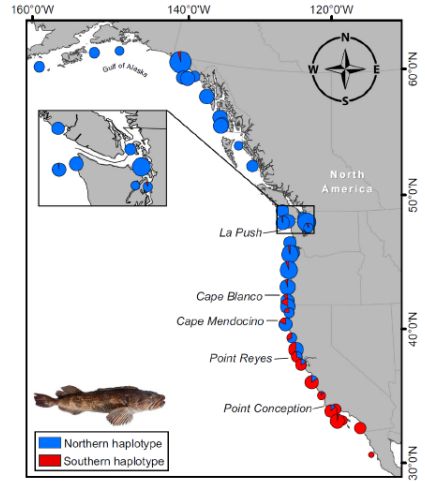
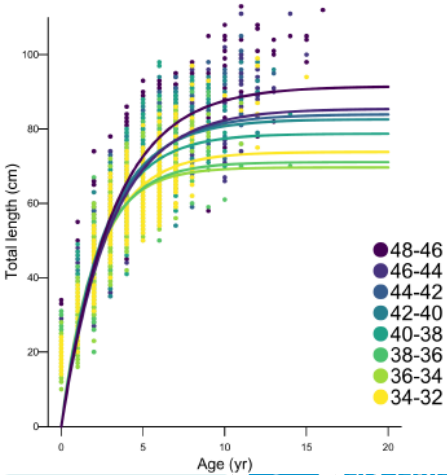


Figure 2 from Longo et al. 2020. https://doi.org/10.1111/eva.13037



Technical Deficiencies of the Assessment

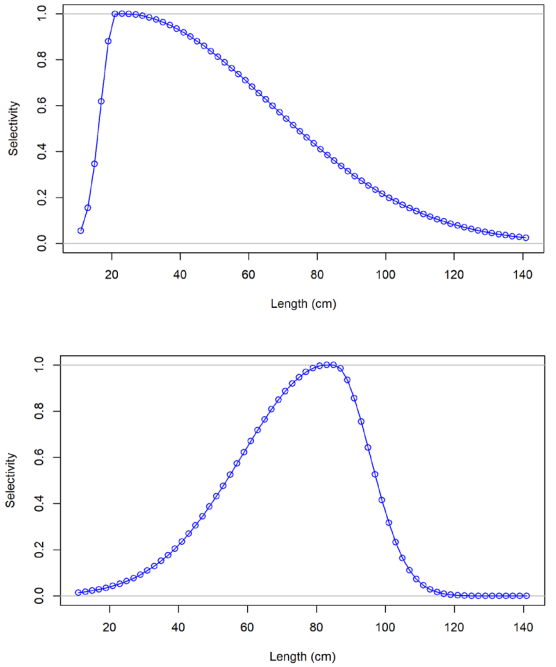
Tension between age and length/index data in the northern model remains a key challenge for the northern assessment, while the lack of fishery-dependent age data is a key uncertainty in the southern model.

The substantial differences between model estimates of natural mortality among the two areas are disconcerting, although not unheard of or unprecedented, and may be related to the described differences in stock structure and genetics, or potentially habitat-driven differences in dominant life history types.

Other differences between north and south also appear non-intuitive. These include survey and fishery selectivities between northern and southern models being strikingly different (see WCGBTS, right). The lack of consistency between estimated biological and fishery parameters between the two models is an indication of the overall model uncertainty.

In general, the retrospectives of both assessments suggest that the recent years' data are providing information about scaling, with high uncertainty in scaling when these data are removed. Depletion is generally more stable than spawning output and biomass.

WCGBTS selectivity south (top) and north (bottom)



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Unresolved Problems and Major Uncertainties

Northern model can be described as data-rich, but information-poor. Challenges faced here were present in the 2017 model, but avoided by excluding most age data and fixing the natural mortality rate at the mean of the prior. As the current northern model includes additional data and other improvements relative to the 2017 assessments, and provides relatively consistent management advice to the earlier models, the Panel agrees that the 2021 assessment models are an improvement, and should be used to inform management.

Panel recognizes that the results of both models, particularly the northern model, indicate so much tension in the models that they almost indicate two divergent life histories, one high and one low productivity, which leads to a high level of discomfort with the model results. This is true both between the northern and southern models, as well as within the northern model… Both models also had retrospective patterns that diverged and rescaled model estimates relative to the base runs, contributing to additional concerns about model stability.

Panel recommends category 2 status for the purposes of providing management advice. Similarly, the Panel does not recommend a routine update for this model, but rather recommends that future assessments be full assessments.

Photo: Jarrod Santora

Research Recommendations (subset of high priority only)

- Consider alternative means of modeling sex-varying selectivity curves, as the explorations suggest that there are likely to be differences in selectivity by sex that are driving a considerable fraction of the tension in the model.
- Better information and exploration of the differences in fishing strategies throughout the fixed gear fisheries, particularly the live fish fishery in the northern model, and how that fishery is modeled.
- Further exploration of natural mortality for both Northern and Southern stocks which may include; tag based investigations, simulation modeling, incorporation of Lorenzen/Charnov/Then et al. information, and more
- The STAT indicated that discard length composition data are better sampled than retained length composition data, yet when the data are treated within the same fleet the tuning and weighting approaches.
- Consider including the CCFRP dataset in future assessments as a fishery-independent data source. Several other data sources exist for both models.
- Additional and expanded age structure collection for the southern model continues to be a high data need for this stock.

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