Gulf of Alaska Pacific cod

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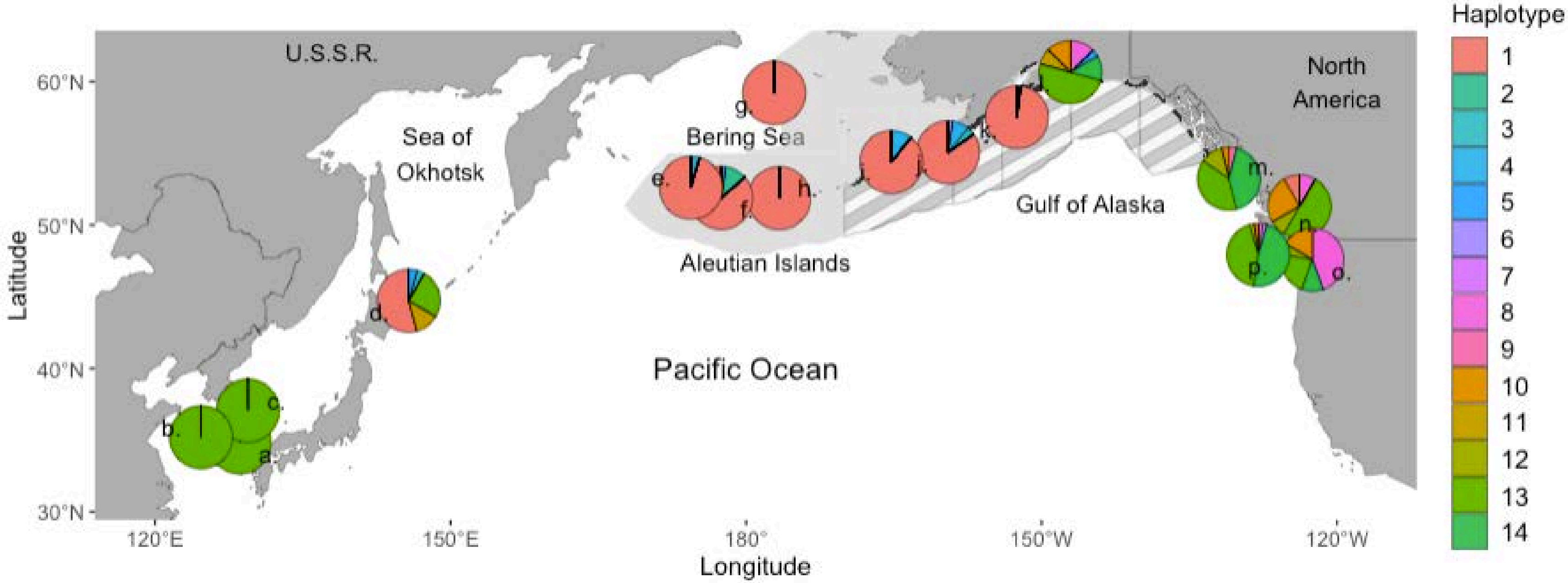
November 2021



- Strong evidence for selective differentiation, including one that aligned to the zona pellucida glycoprotein 3 (ZP3)
- ZP3 a reproductive protein known to undergo rapid selection shown to neofunctionalize as an antifreeze protein in Antarctic icefishes (Spies et al. 2021).

Latest Pacific cod genetics

- 3,599 SNP loci and spawning samples throughout the range of Pacific cod off Alaska, as well as a summer sample from the Northern Bering Sea in August 2017 show significant differentiation among all spawning groups.
- The three spawning groups examined in the GOA, Hecate Strait, Kodiak Island, and Prince William Sound, were all genetically distinct and could be assigned to their population of origin with 80-90% accuracy.

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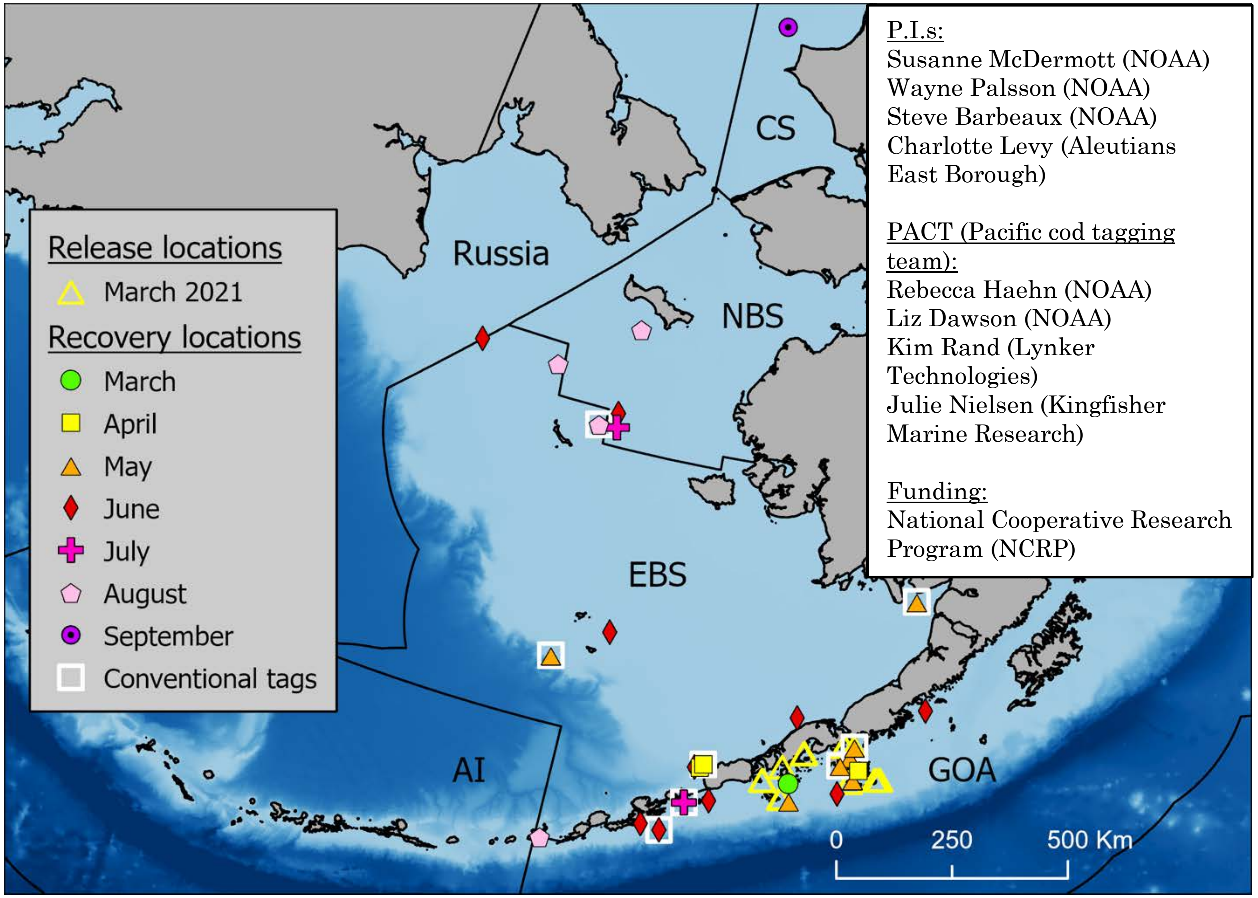

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Julie Nielsen (Kingfisher Marine Research)

Funding:
National Cooperative Research Program (NCRP)

- More than half (10/17) of the tags recovered in the June-September in Bering Sea
- One tag recovered in the Chukchi Sea
- Indicates substantial connectivity between he WGOA and other regions

Western GOA PSAT tagging

- 25 satellite-tagged and 957 conventionally-tagged Pacific cod released in Western GOA.
- Satellite tags were programmed to pop-up and transmit data after 90, 180, or 365 days.
- Locations of tags recovered in March, April, and May in the vicinity of release area.
- Fish recovered June through September had moved west toward the Aleutian Islands and north into the EBS, Northern Bering Sea, Russia, and the Chukchi Sea.

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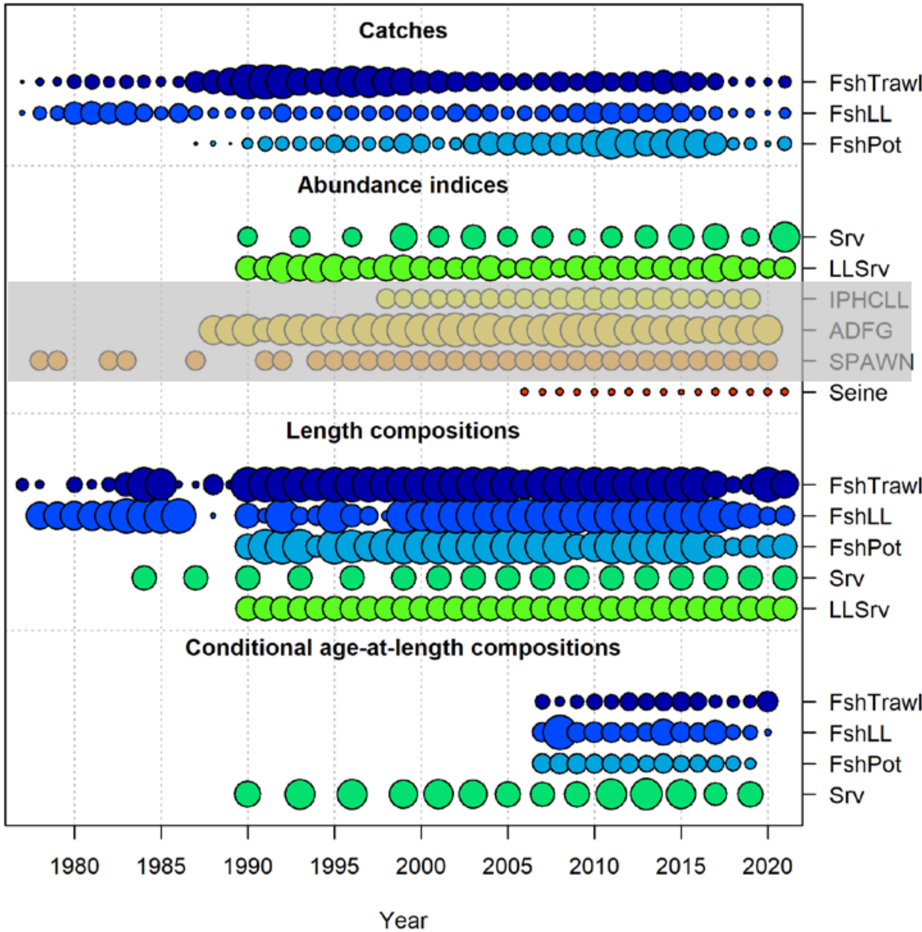
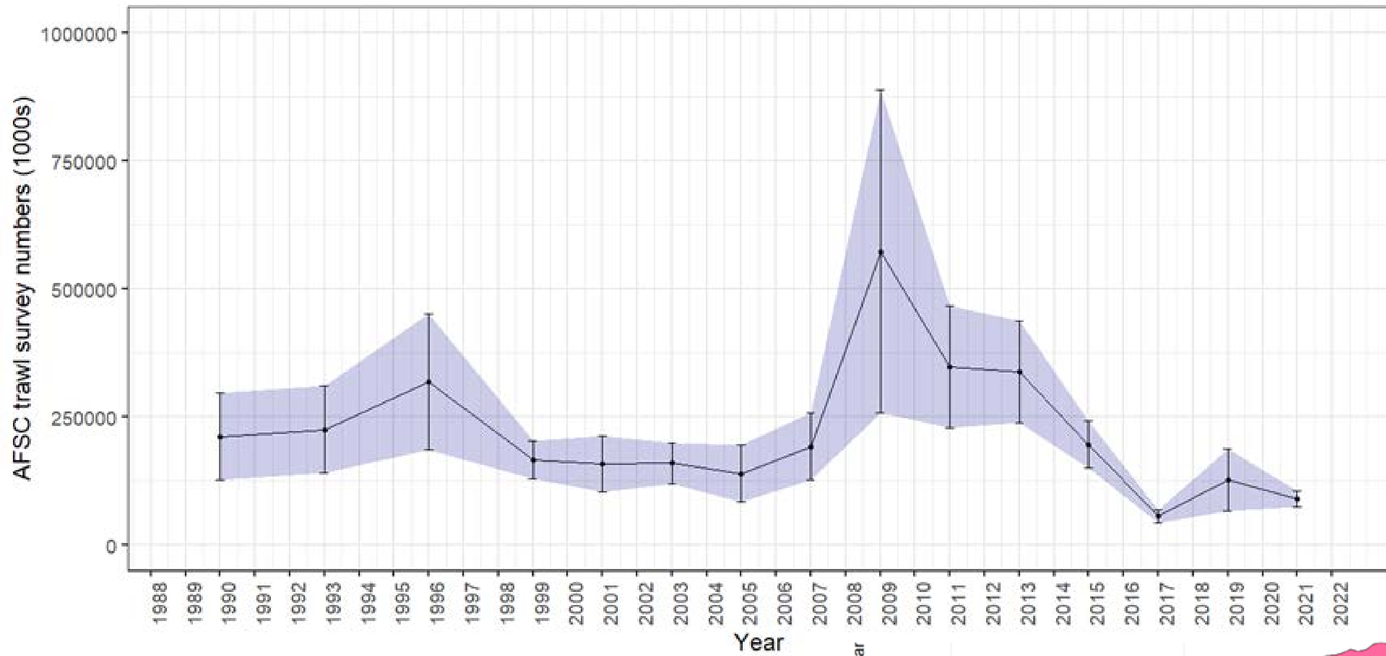
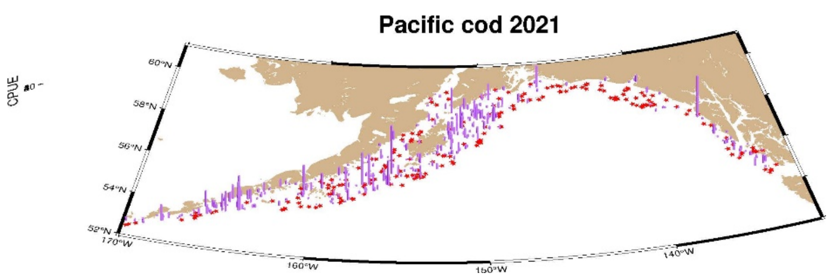


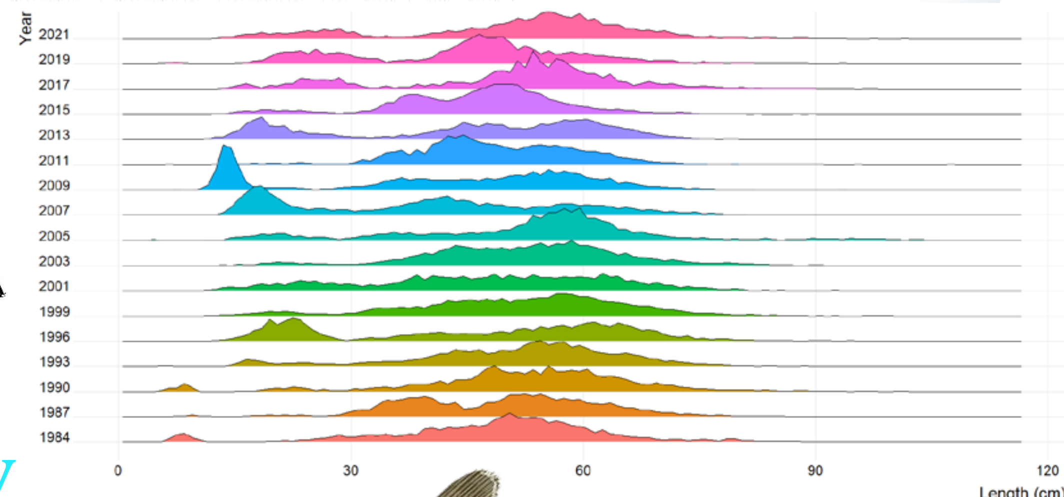
- Federal and state catch data updated;
- Fishery size composition data updated;
- Bottom trawl survey abundance and length composition data for 2021 included;
- Longline survey abundance index and length composition data for 2021 were included;
- Age-0 beach seine survey index was included in one alternative model.

2021 data changes

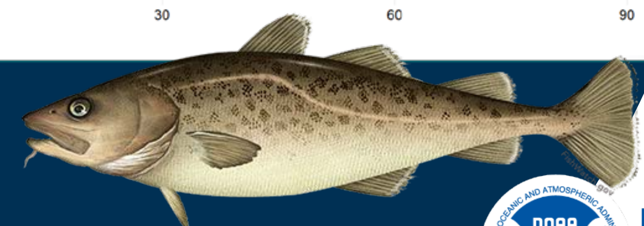
- IPHC Longline, ADF&G trawl, and the spawning habitat indices were included in the data files, however they are not included in any model likelihood.







AFSC Bottom trawl Survey



- 2021 28% decrease in abundance from 2019
- 2021 4% decrease in biomass from 2019
- Low uncertainty – well spread-out distribution
- Still remains low (second lowest in the time series after 2017)

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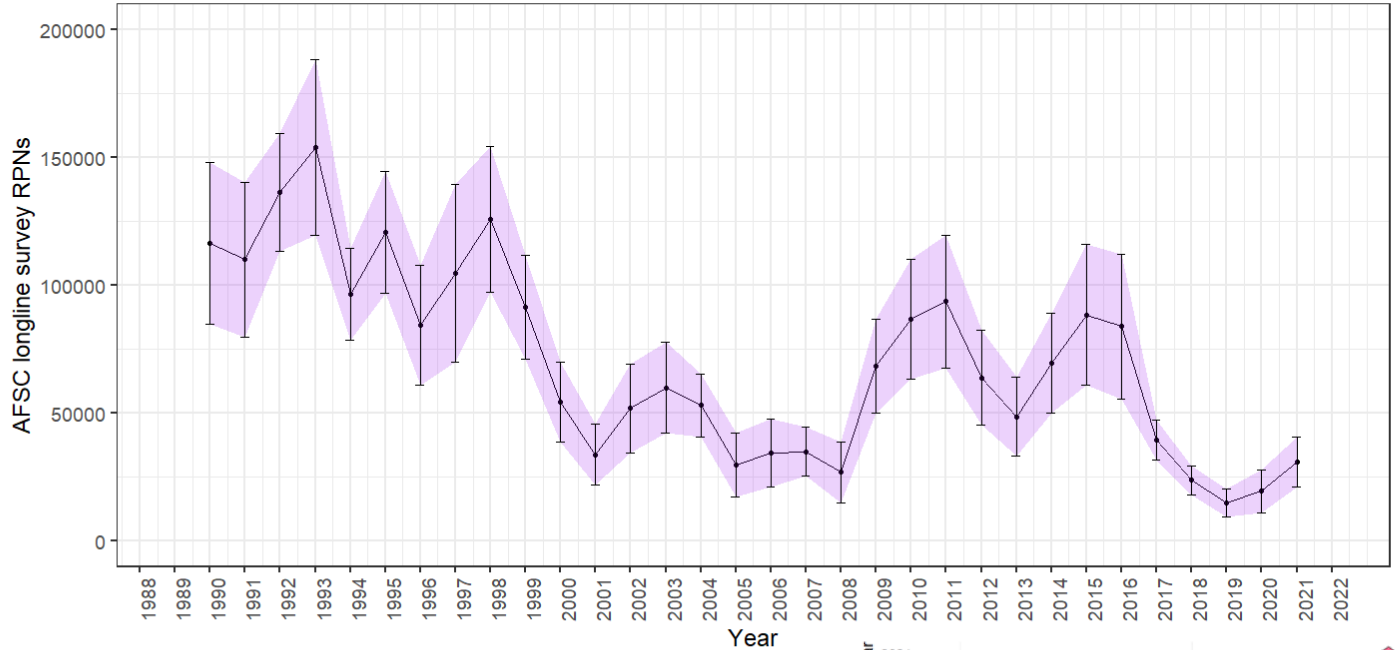
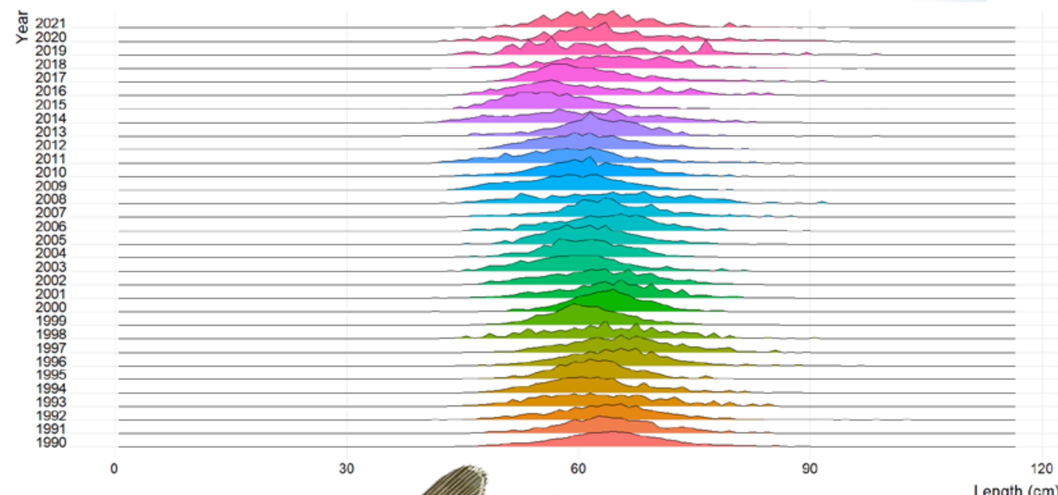
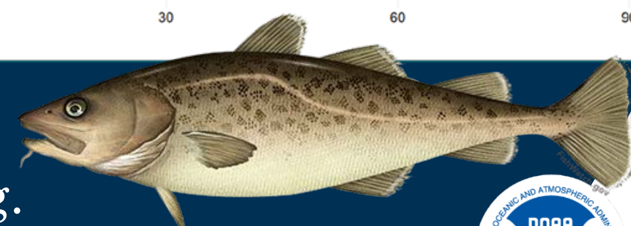
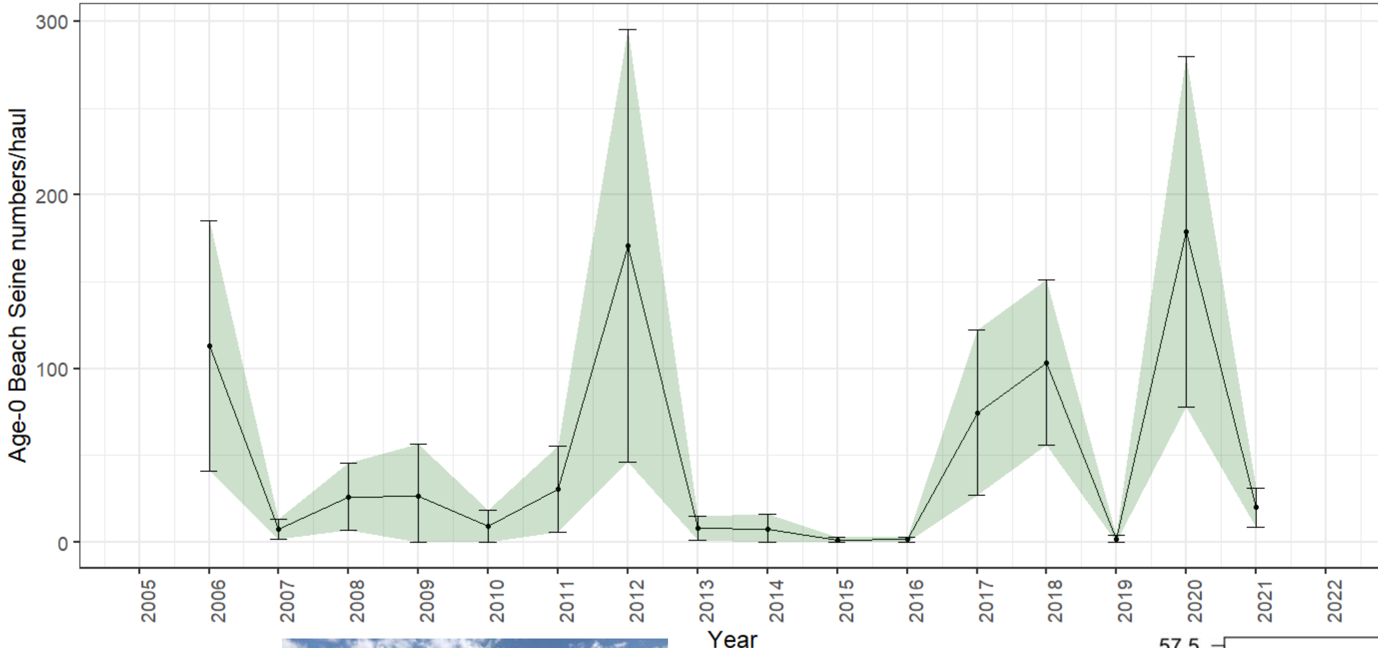


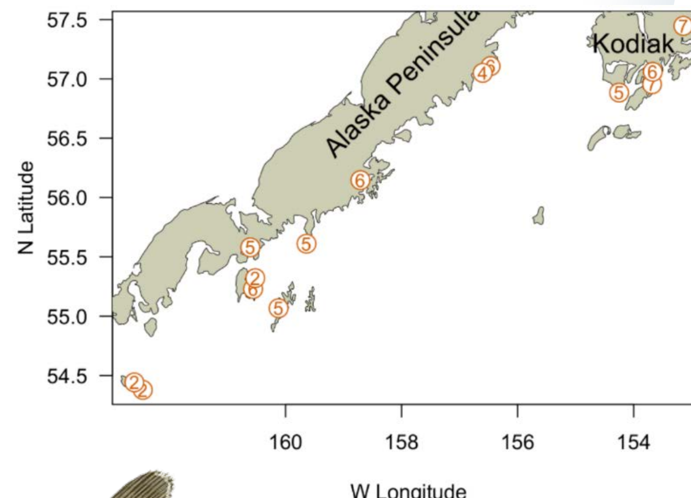


AFSC Longline Survey



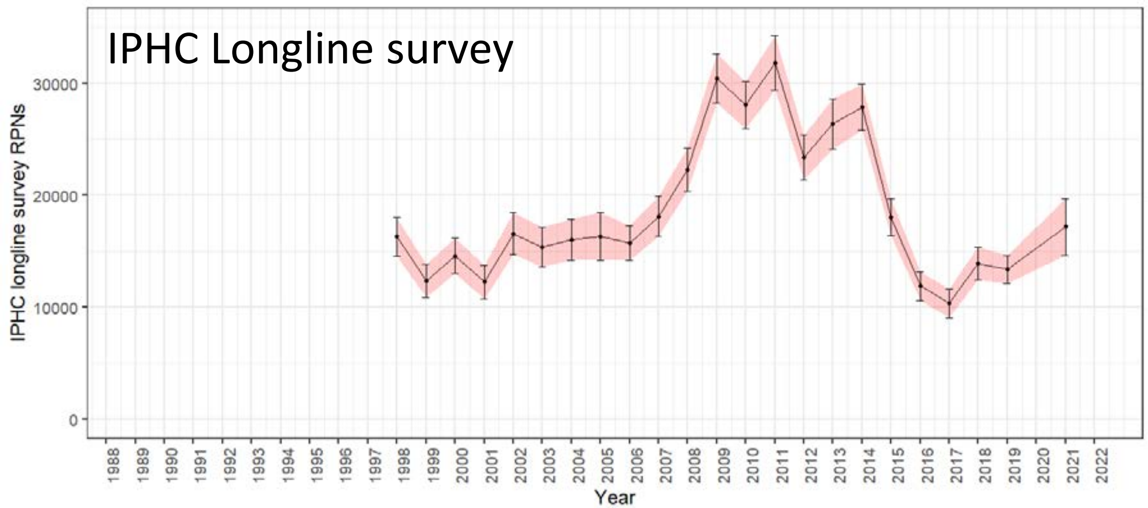
- 58% increase from 2020
- Remains below average, but improving.

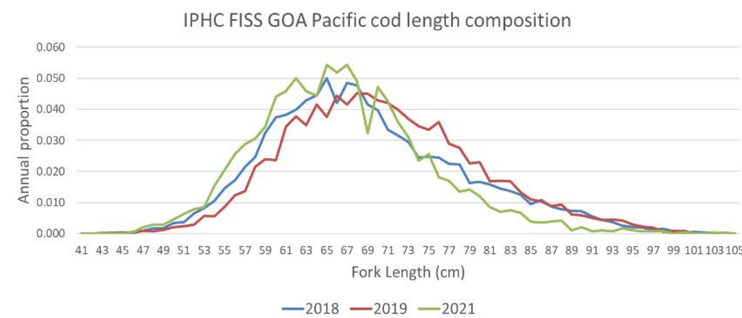


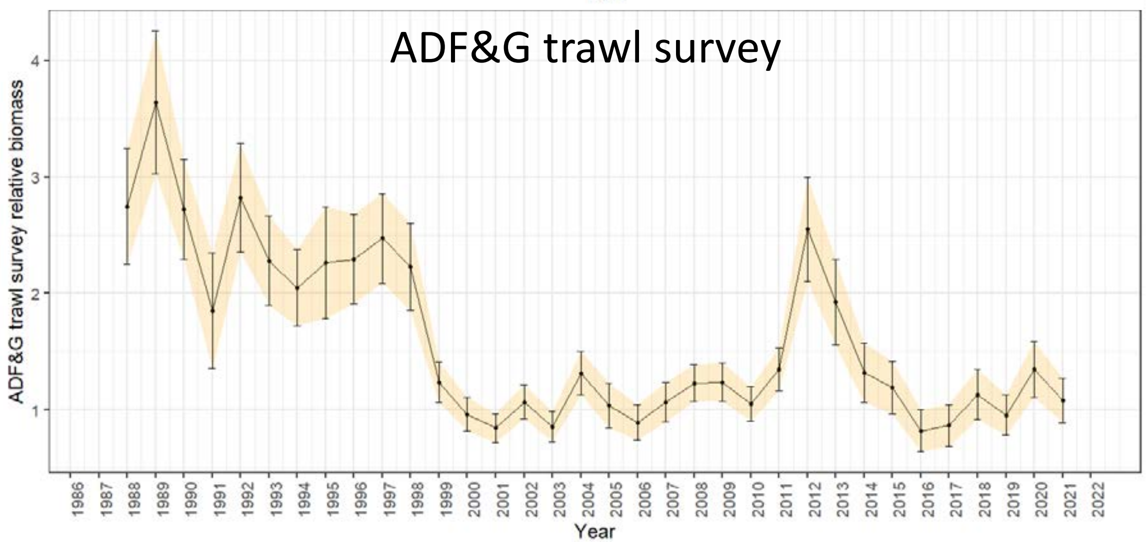


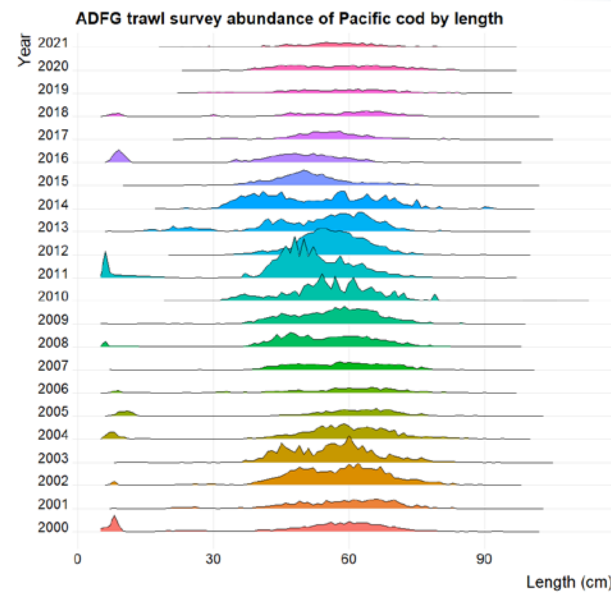
Age-0 beach seine index

- Low 2013-2016 and 2019
- High 2012, 2017,2018 and 2020
- Near average 2021









Other Surveys (not included in models)

- IPHC Longline
  - 28% increase from 2019
- ADF&G trawl indices.
  - 19.8% decrease from 2020

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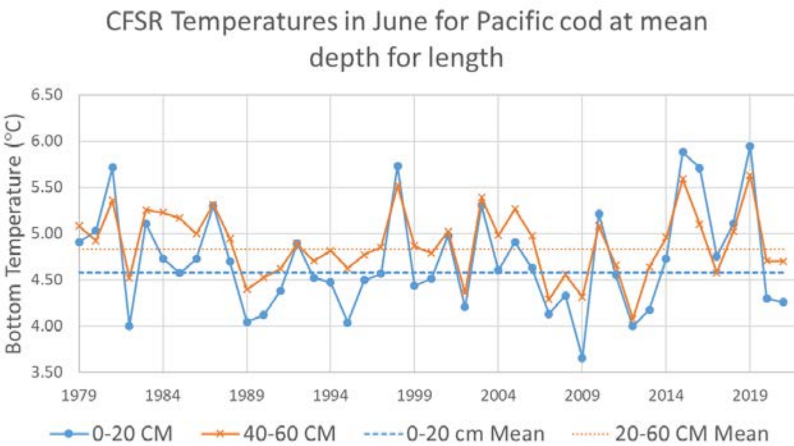

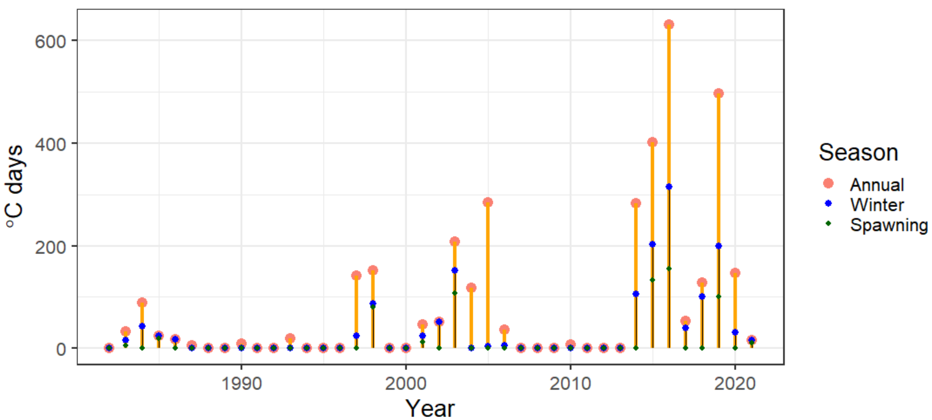

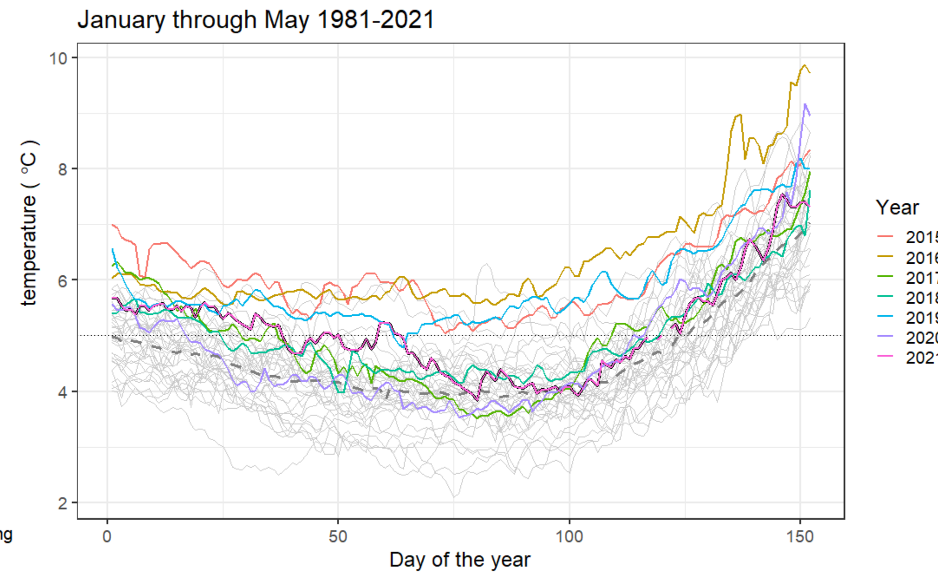

Environmental Indices used in models

- CFSR Temperatures for 0-20cm Pacific cod
  - Cooler in 2020 and 2021
- Heatwave indices
  - Short and low intensity heatwave in Jan-Feb 2021
  - Cooler for remainder of year

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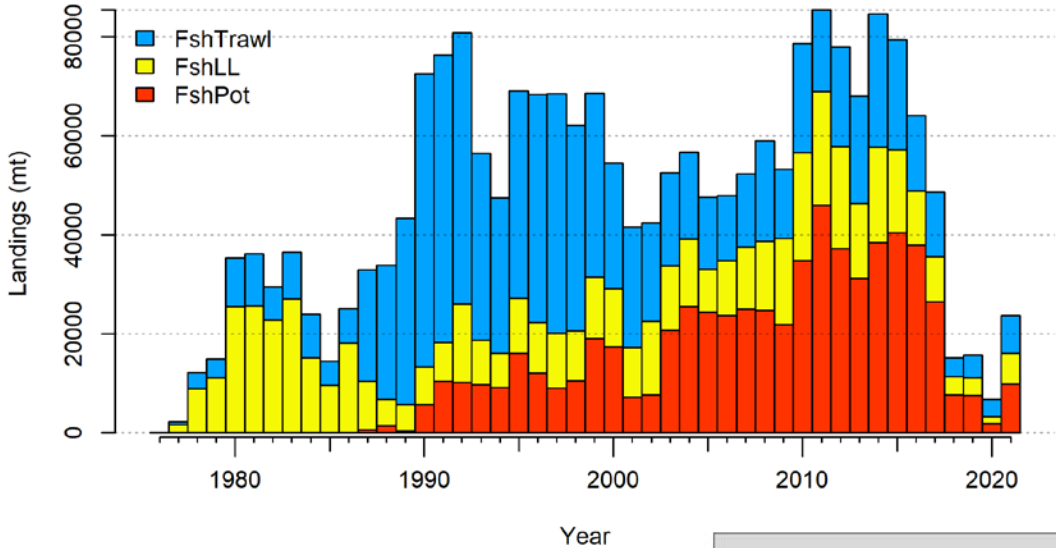
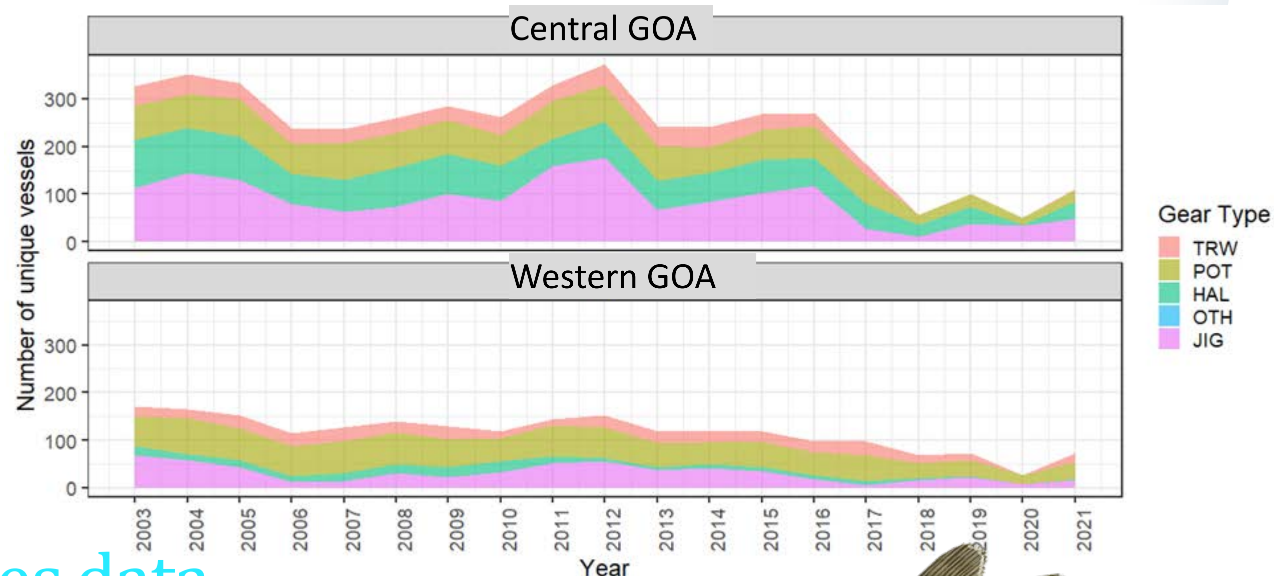


2020 Total catch = 6,233 t
2021 Total Catch = 18,040 t*
*As of Nov 15

- Overall descending trend in participation
- More vessels targeting cod in 2021 than 2020



Commercial fisheries data

- Catch remains low, but increasing in 2021
- Number of participating vessels increased in both regions in 2021

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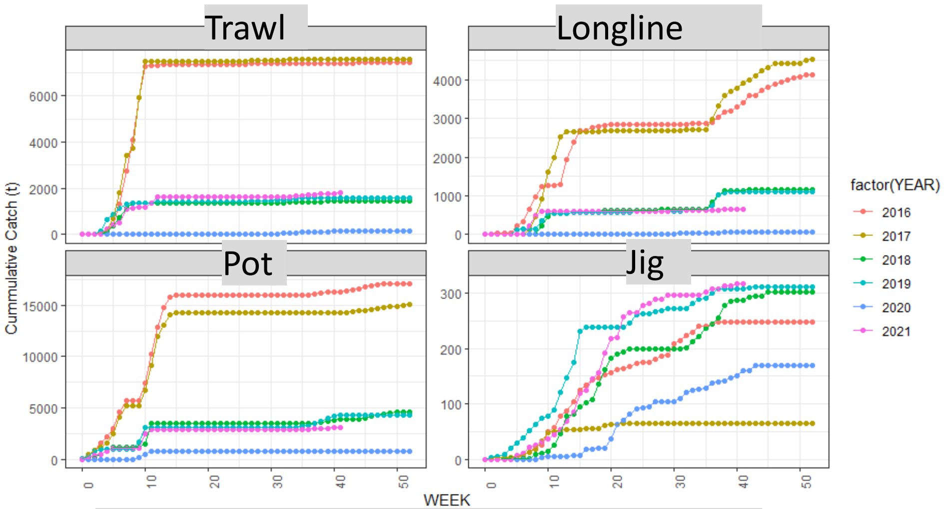
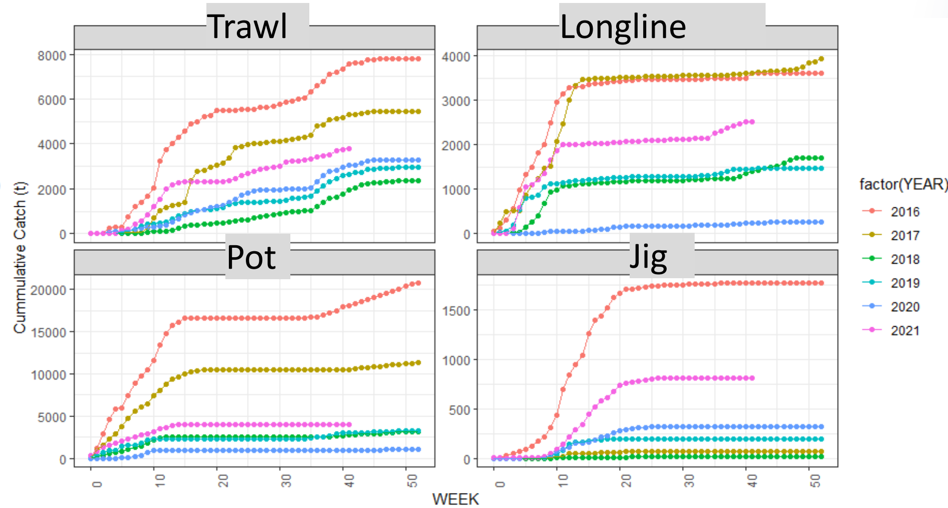
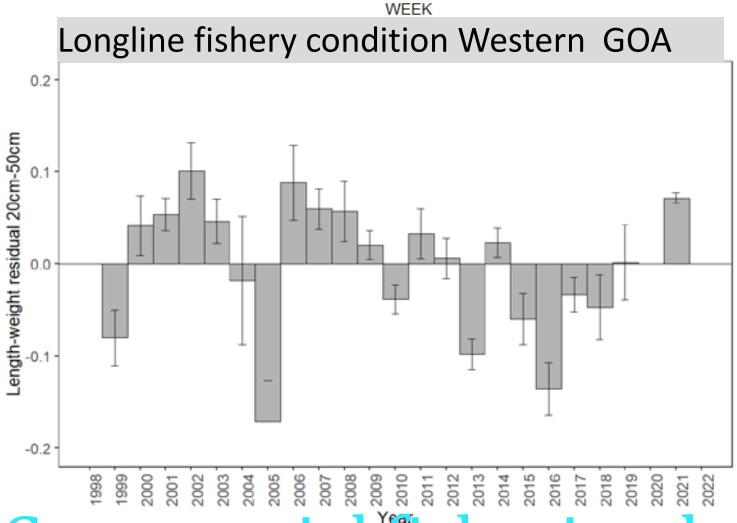
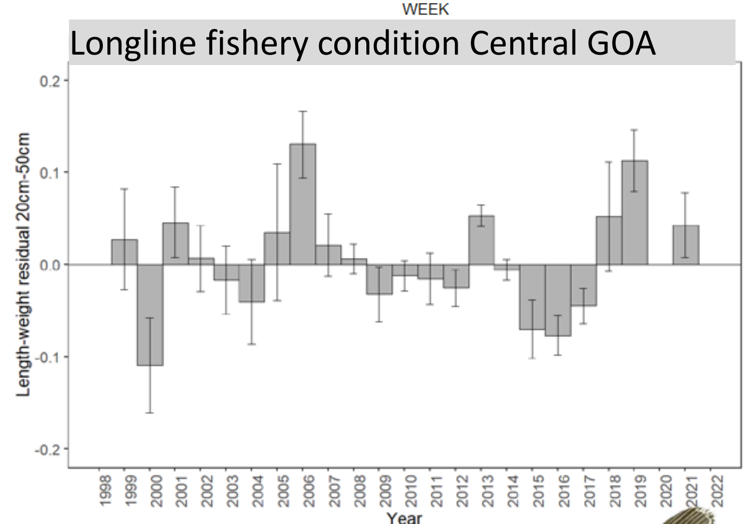
Western GOA



Central GOA







Commercial fisheries data

- Western and Central GOA fisheries appear to be recovering
    - For most gears fishing rate comparable or exceeding 2018-2019
- Condition (length-weight) were better than average

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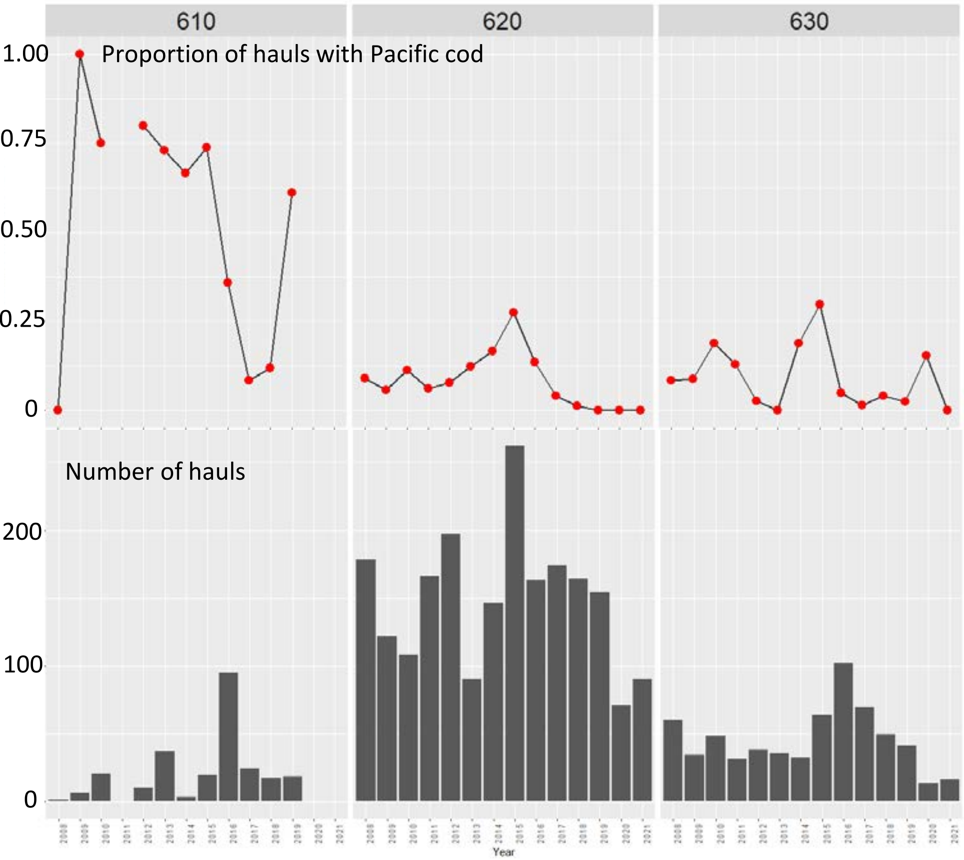
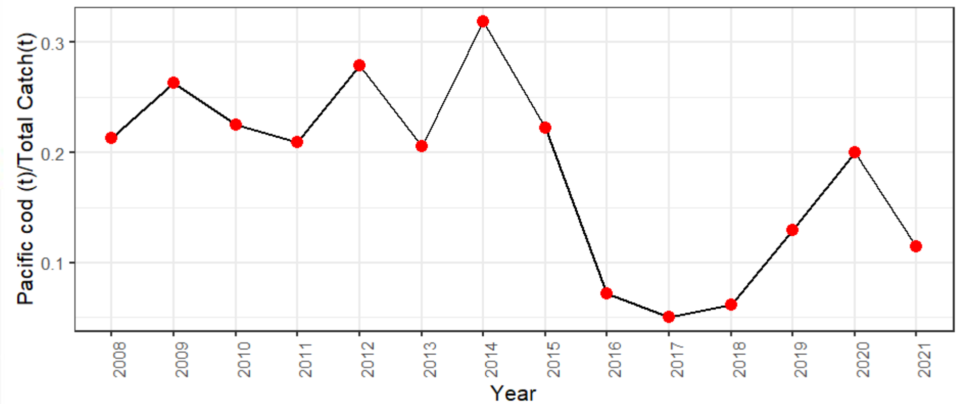
Pelagic trawl fisheries



Shallow water flatfish fishery



Commercial fisheries data

- After increase in 2020, drop in Pacific cod bycatch in 2021

- 1-10+ age bins
- 1-117+cm length bins
- Key estimated parameters:
  - M lognormal prior, mean -0.81, CV 0.41
  - Survey catchability uninformative prior
  - M anomaly for the 2014-2016 period
- Stock recruitment relationship: Beverton-Holt
  - $\sigma R = 0.44$, steepness = 1.0
- Growth
  - Three-parameter von Bertalanffy growth (informative priors based on 2007-2018 survey size at age data
- Selectivity: length-based double normal
  - Different periods for bottom trawl survey
  - Longline and trawl
  - pre-1990 annually varying
  - blocks for post-1990
- Longline survey catchability
  - scaled to CFSR temperatures for 0-10 cm Pacific cod mean depth

Last year's model (Model 19.1)

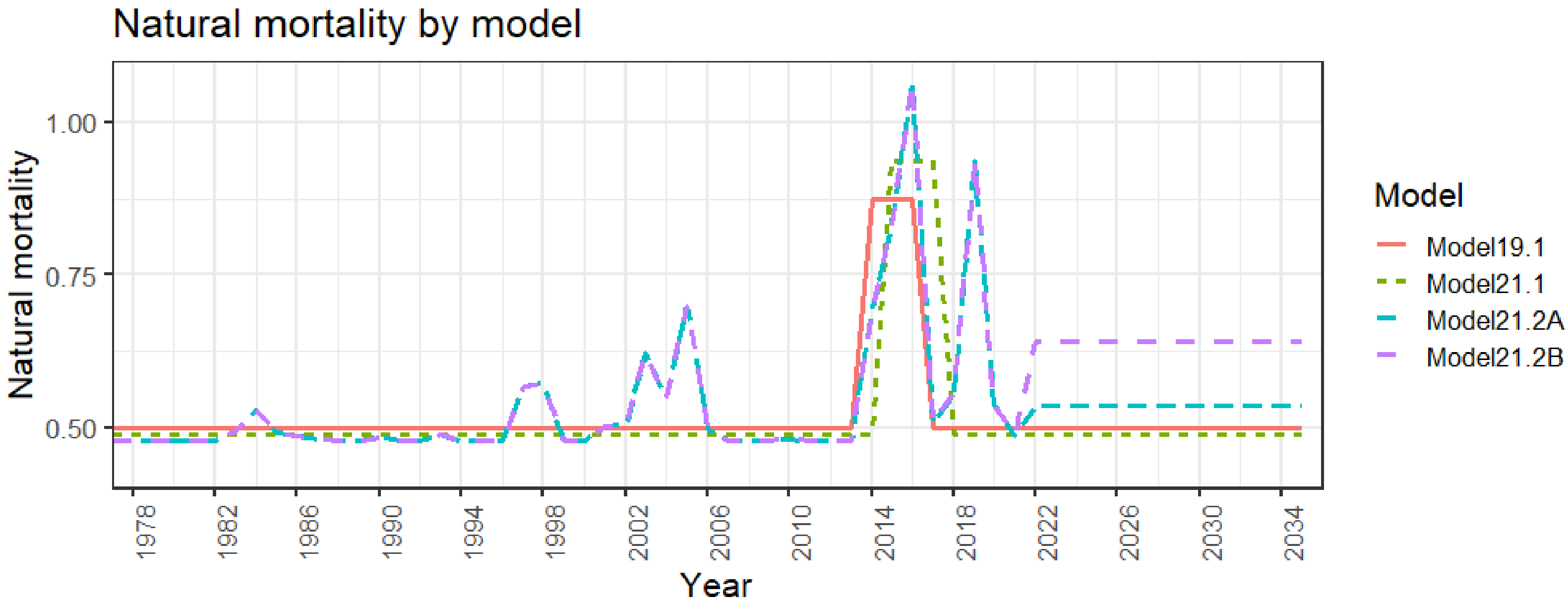
- Rerun of 2019 model with up-to-date data included

2021 model configurations

- **Model 19.1**
  - Same as last year's base model
- **Model 21.1**
  - Same as 19.1 except:
    - Natural mortality block for 2015-2017
- **Model 21.2**
  - Same as Model 19.1 except:
    - Age-0 beach seine index,
    - Annual heatwave linked Natural mortality,
    - Spawning heatwave linked recruitment,
    - June CFSR temp linked growth.

	M-block 2015-2017	Temperature			Beach seine index
		Growth	M	Recruits	
Base					
21.1					
21.2					

- Based on September, 2021 model explorations (Appendix 2.7)
- Note: Reweighting of models was not conducted as explorations using the Dirichlet multinomial indicated current were weights appropriate

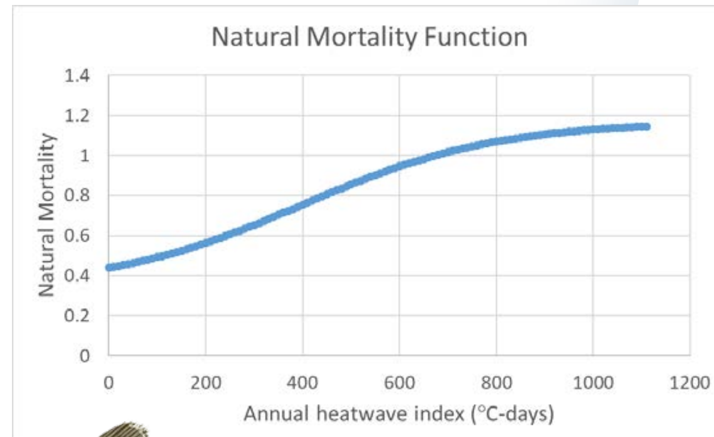


- Model 21.2: annual heatwave linked natural mortality with asymptote

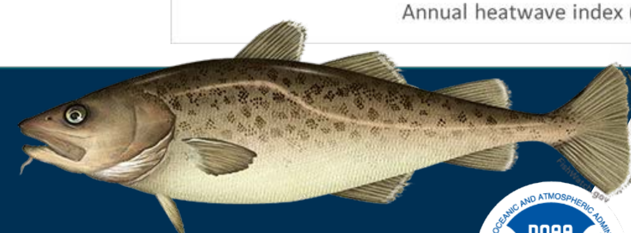
$$M_y = \widehat{M} + \boldsymbol{\eta} l_y$$

$$l_y = {}^{\lambda}\!\Big/\!\left(1 + e^{-\varsigma(I_{Ay} - \psi)}\right)$$

- Logistic function fit iteratively
  - $\lambda = 0.65$
  - $\varsigma = 0.05$
  - $\psi = 400$



Natural Mortality



- 19.1 – 2014-2016 block
- 21.1 – 2015-2017 block
- 21.2 – Annual heatwave index link

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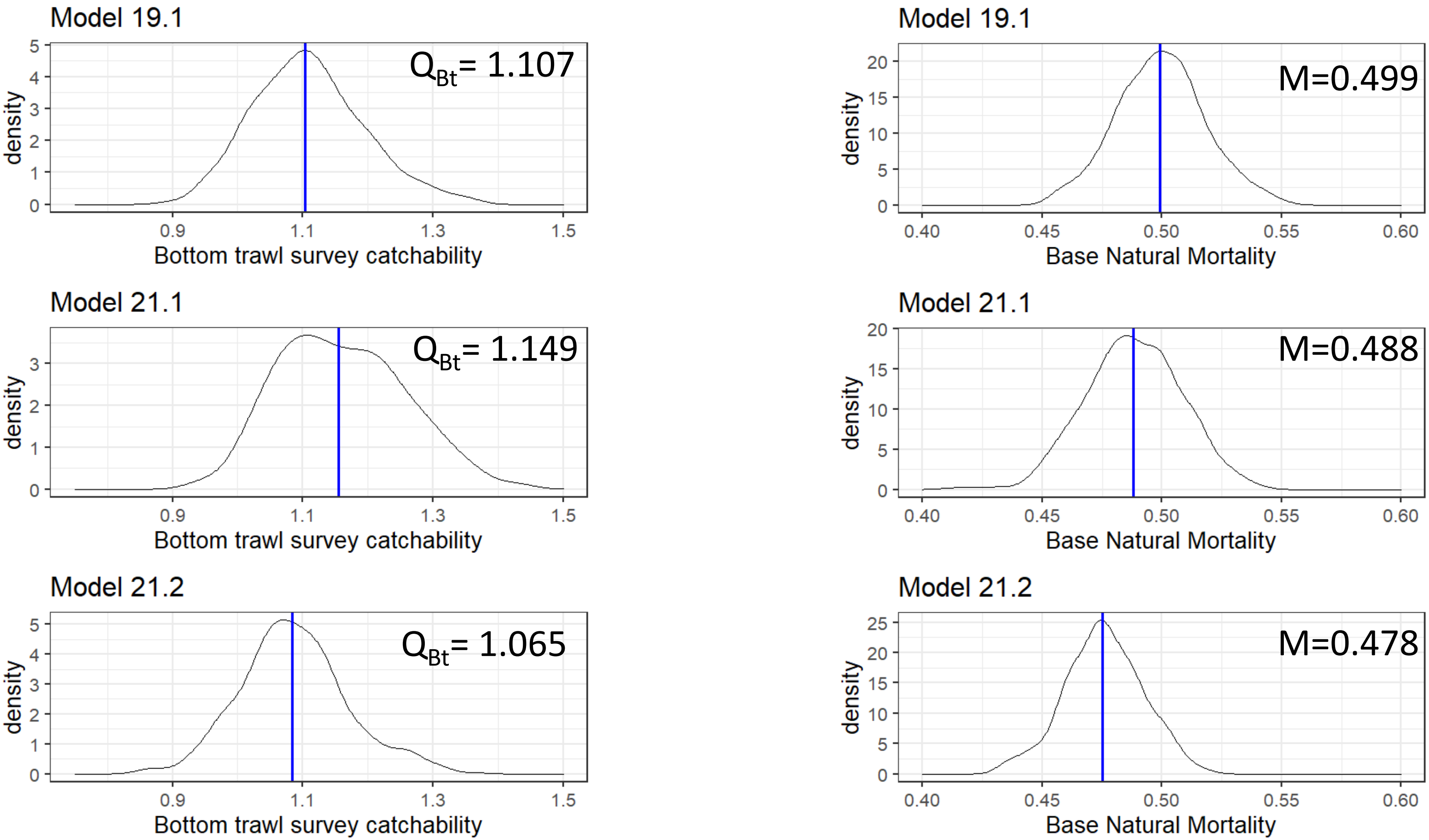

Posterior catchability and natural mortality

- Similar bottom trawl survey abundance index catchability (Q_{Bt})
    - Posterior distributions are wide
    - Lowest estimate from Model 21.2
- Lowest base natural mortality in Model 21.2

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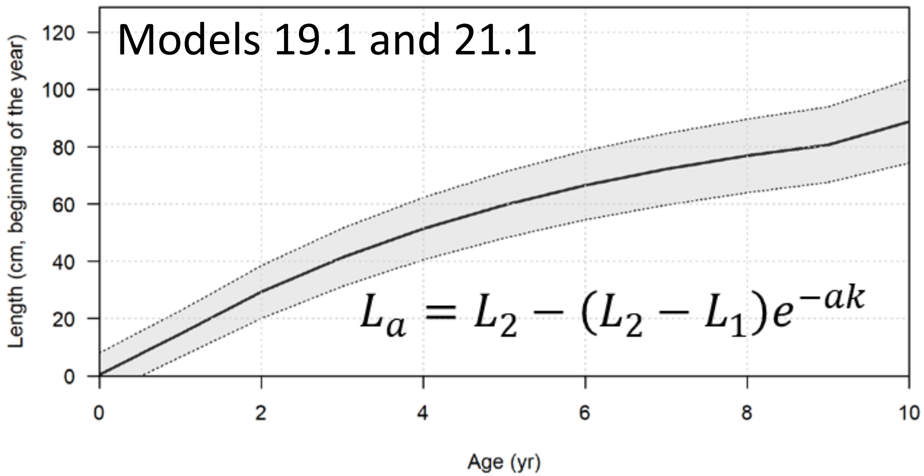
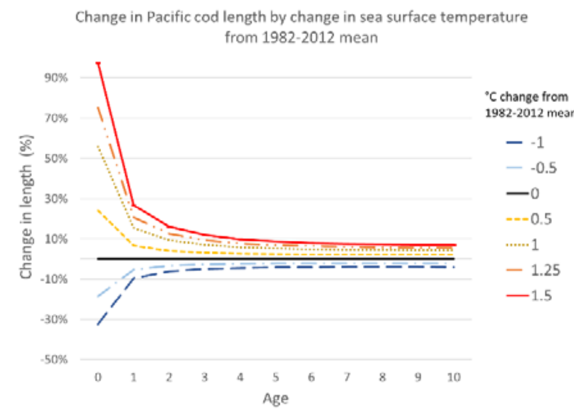


Models 21.2

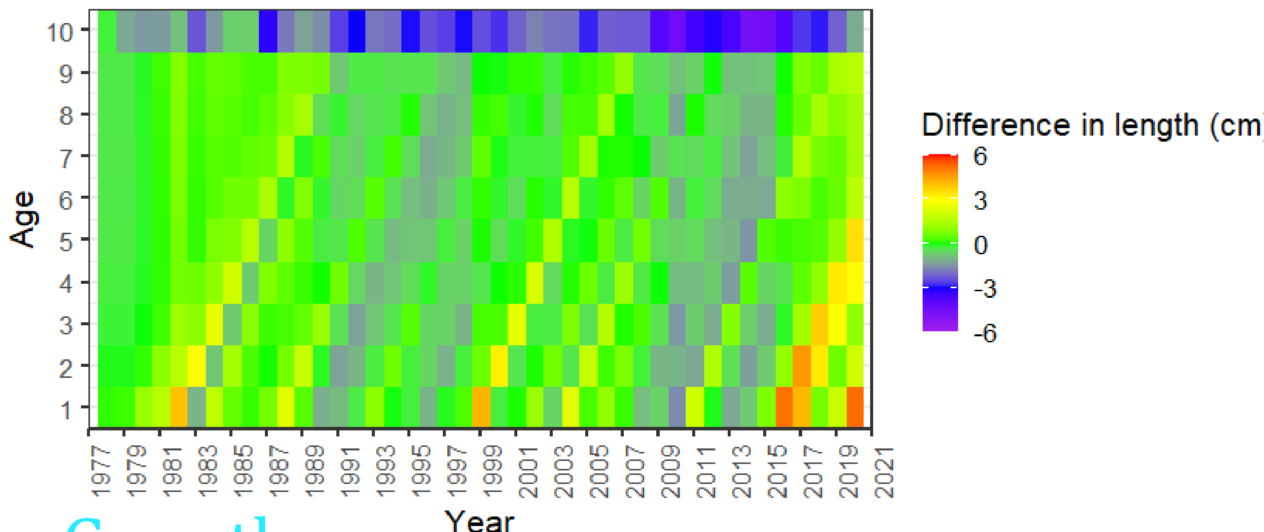
$$L_{ay} = L_{2y} - (L_{2a} - L_{1a})e^{-ak\left(e^{-\varphi f_{jy}}\right)}$$

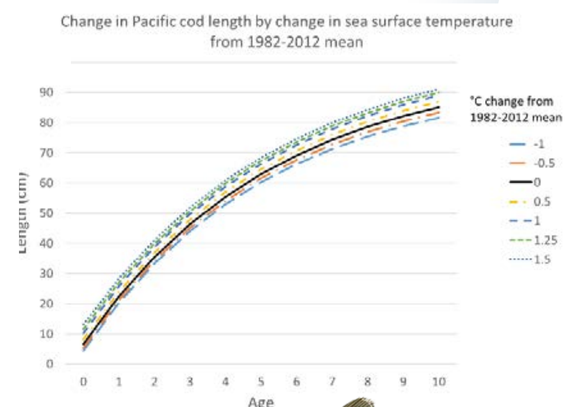
$$L_{1a} = \bar{L}_1\left(\gamma\frac{e^{\left(0.2494+0.3216(\bar{t}+f_{jy})-0.0069(\bar{t}+f_{jy})^2-0.0004(\bar{t}+f_{jy})^3\right)}}{e^{(0.2494+0.3216(\bar{t})-0.0069(\bar{t})^2-0.0004(\bar{t})^3)}}\right)$$

$$L_{2y} = \overline{L_2}e^{\nu f_{jy}}$$



Model 21.2 vs Model 19.1





Growth

- Model 19.1 and Model 21.1 standard von Bertalanffy growth
- Model 21.2 temperature dependent von Bertalanffy growth
    - L_{1a} based on Laurel et al. (2015) larval growth rate by temperature

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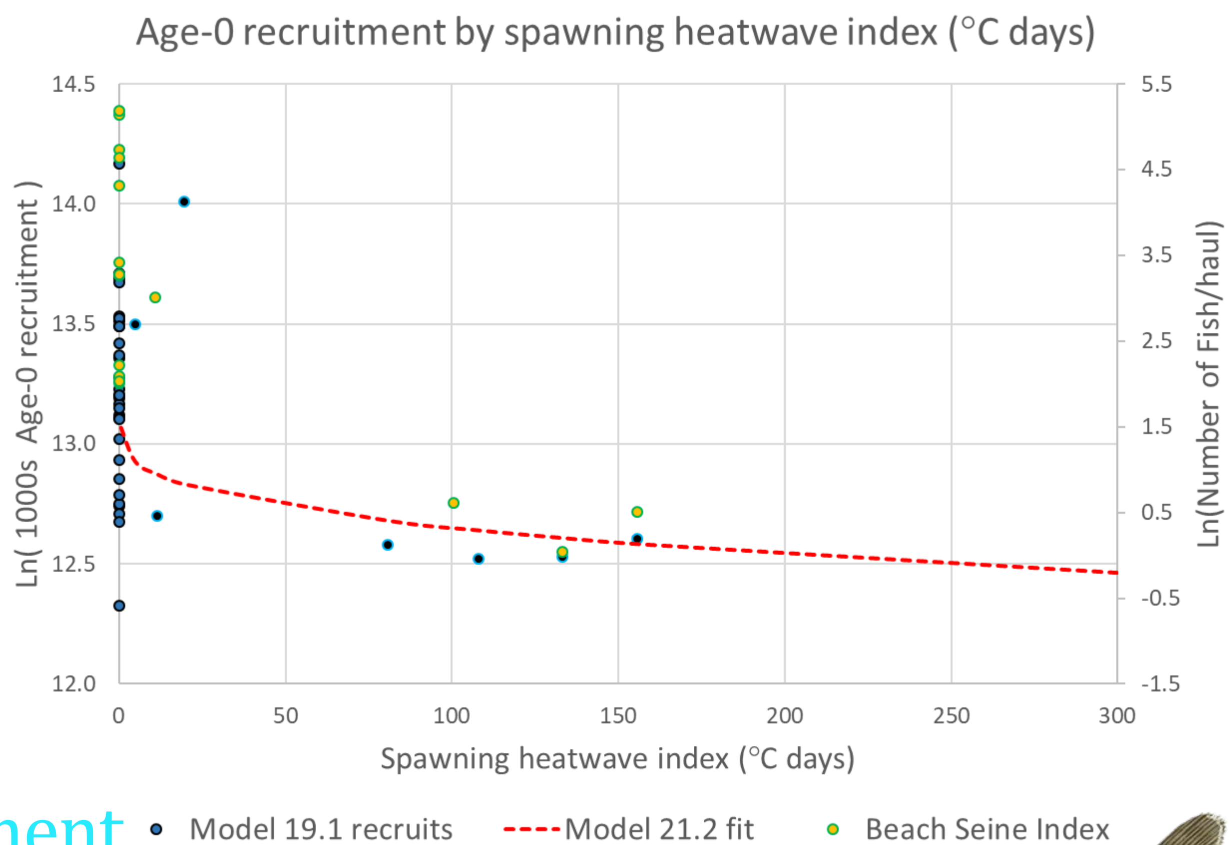
Models 19.1 and 21.1

$$R_y = \left(R_0 e^{\vartheta}\right) e^{-0.5 b_y \sigma_R^2 + \tilde{R}_y}$$

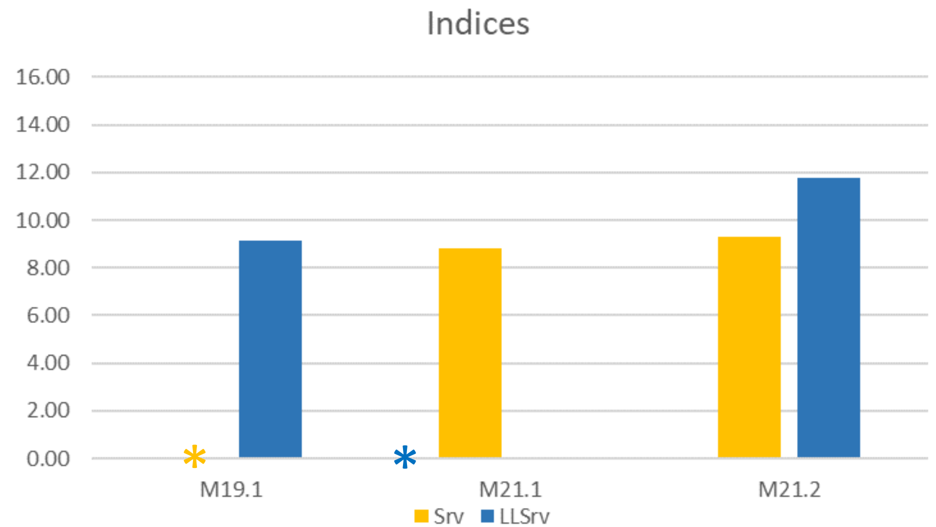
Model 21.2

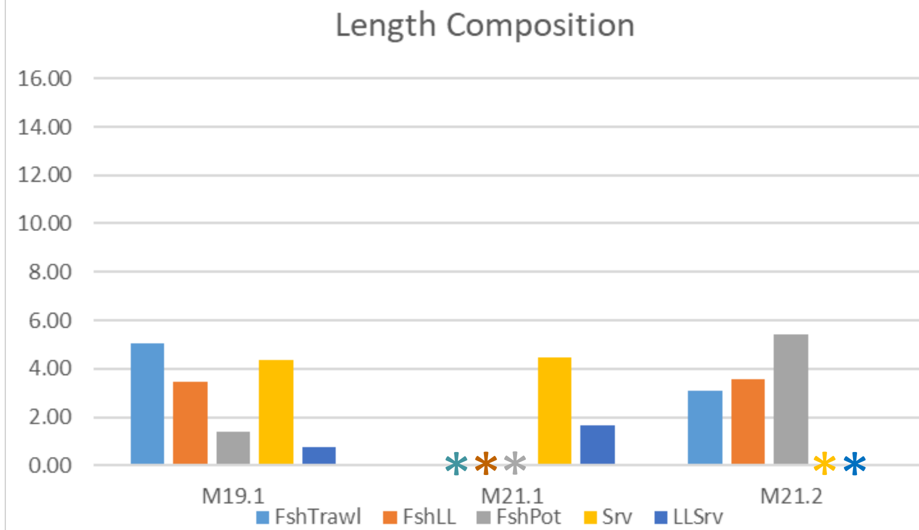
$$R_y = e^{\vartheta + \ln\left(R_0 e^{\omega I_{Sy}^{\frac{1}{3}}}\right)} e^{-0.5 b_y \sigma_R^2 + \tilde{R}_y}$$

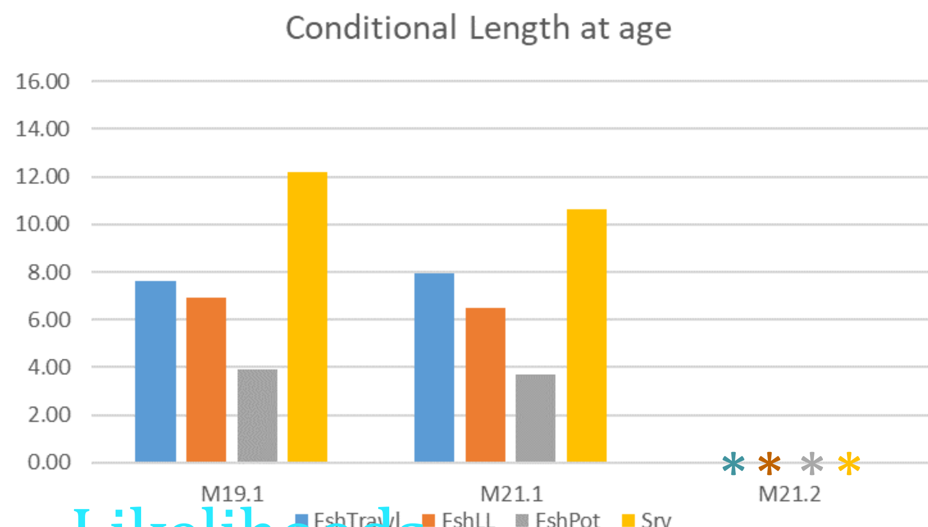


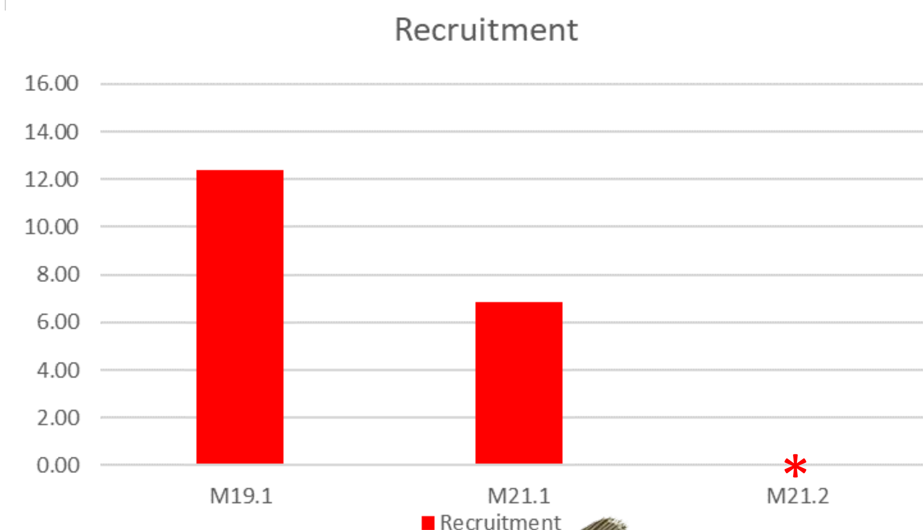
Recruitment

- Model 19.1 and Model 21.1 standard Beverton-Holt with steepness h = 1 and $\sigma_R = 0.44$
- Model 21.2 – Spawning heatwave index linked Beverton-Holt with steepness h = 1 and $\sigma_R = 0.44$









Likelihoods

- Model 21.2 has best overall fit
  - Worst fit to trawl and longline survey indices
  - Best fit to Survey length composition
  - Best fit to length at age data
  - Best fit to Recruitment

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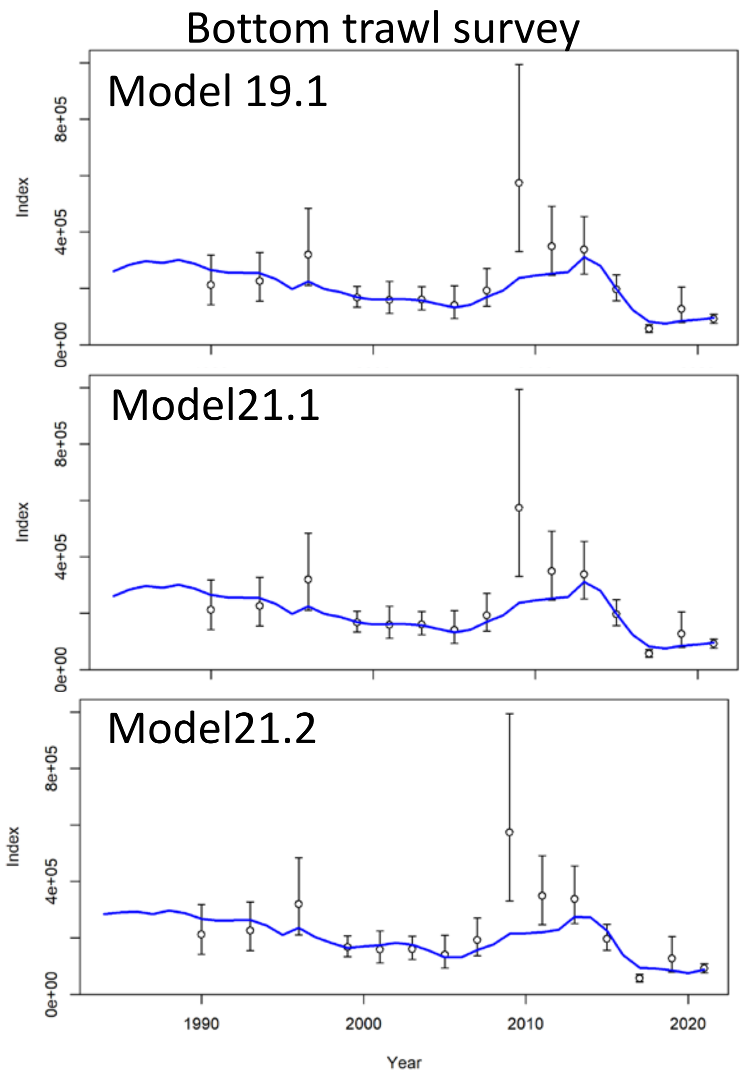
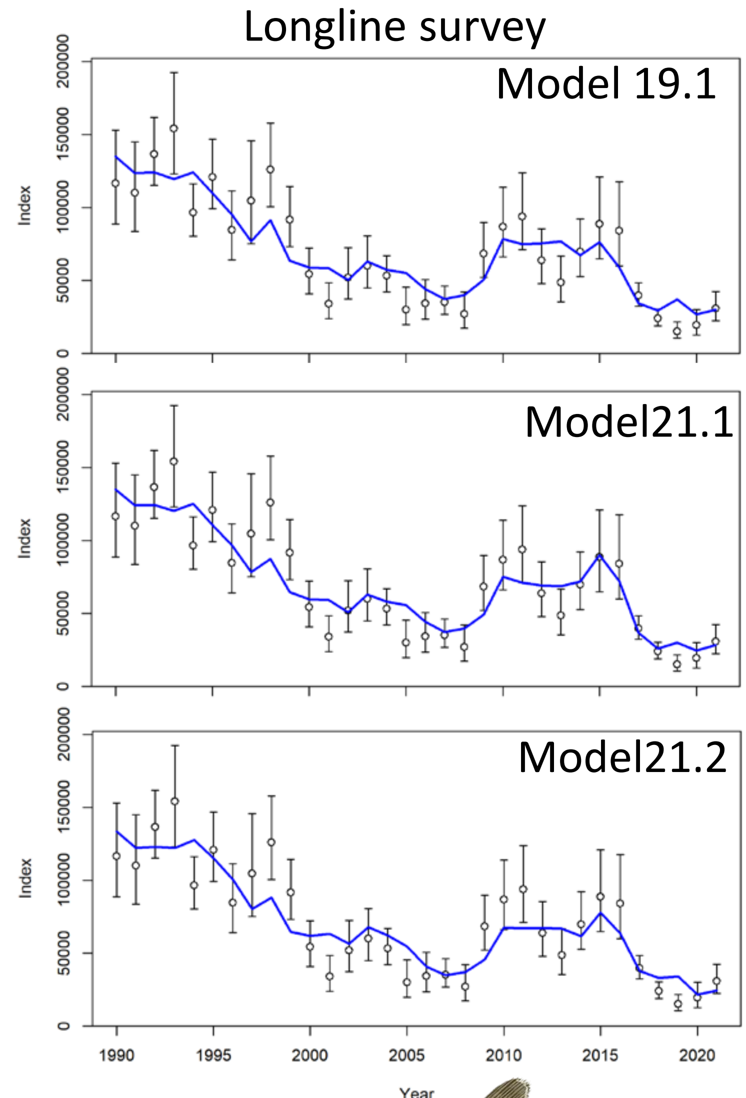
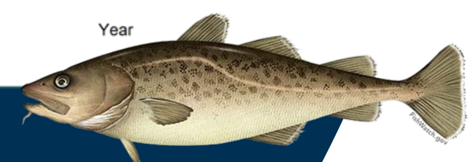




Survey index fits



- Model 19.1 better fit to bottom trawl survey
- Model 21.1 better fit to longline survey
- Model 21.2 included beach seine and fits both worse

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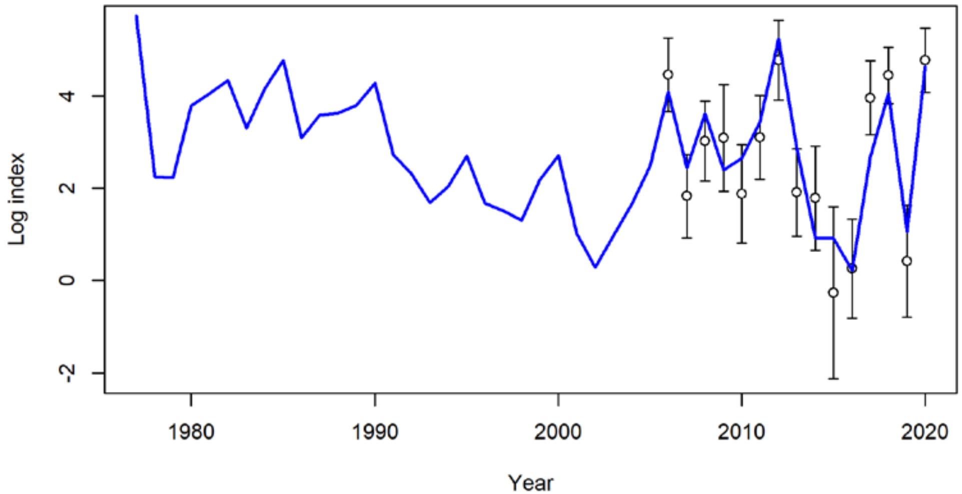
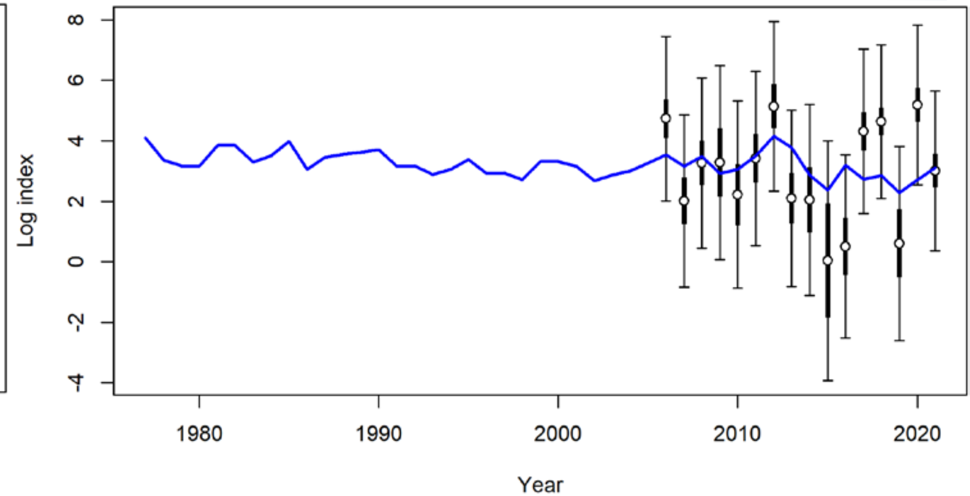
September beach seine index fit



Model 21.2 beach seine index fit



Beach seine index

- Added constant fit to survey standard deviation as per SSC request
    - 138% increase in index standard deviation
    - Little influence in the model

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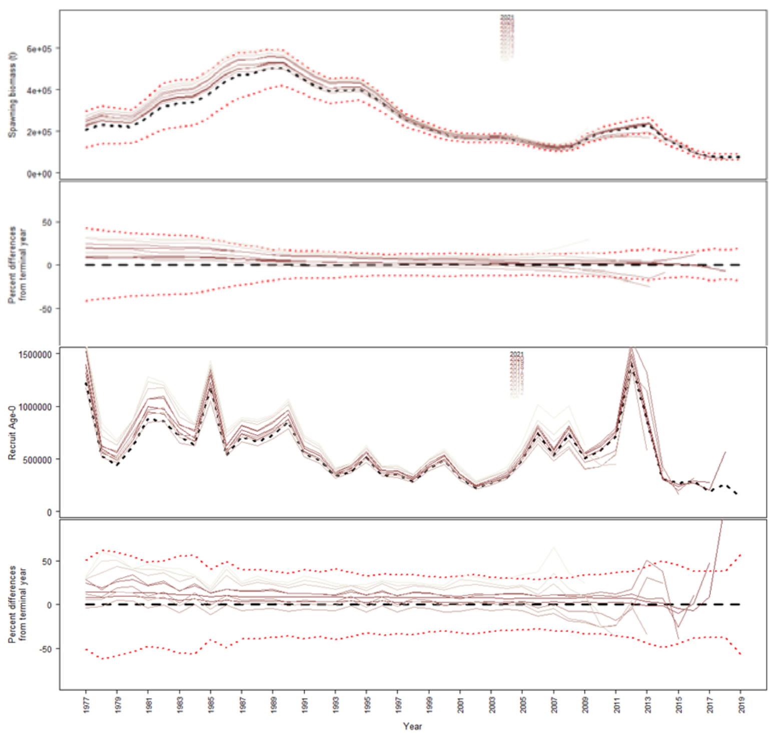
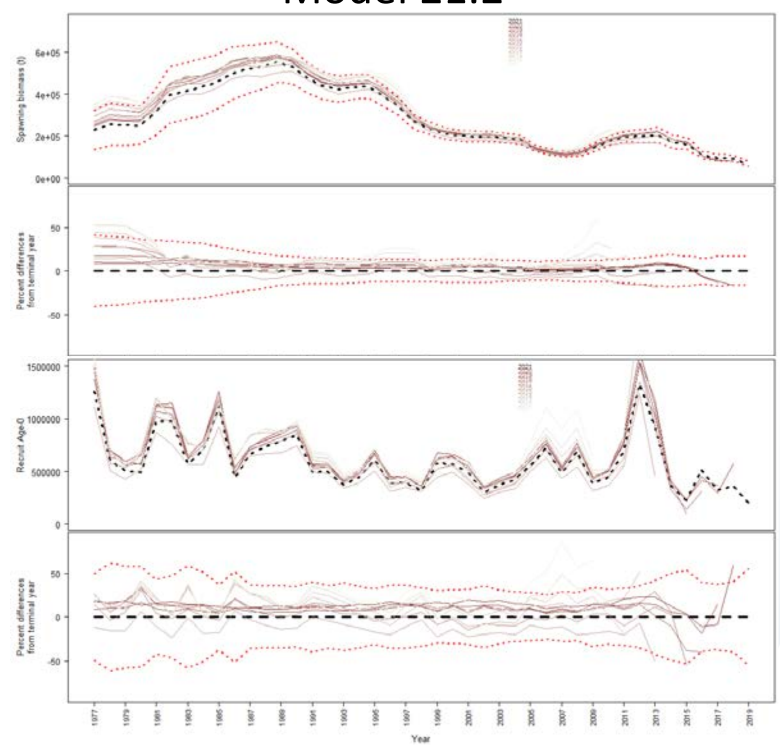
	Spawning stock biomass			Age-0 Recruitment		
Model	Mohn's ρ	Woodshole ρ	RMSE	Mohn's ρ	Woodshole ρ	RMSE
19.1	-0.0002	0.0837	0.1159	0.1084	0.1195	0.1737
21.1	0.0440	0.1280	0.1476	0.0564	0.1339	0.1503
21.2	0.0557	0.0841	0.1230	0.0448	0.1034	0.1716

Model 19.1



Model 21.2



Retrospectives and jitter

- Model 19.1 has best Mohn's ρ for SSB
- Model 21.2 has best Mohn's ρ for Age-0 recruitment
- All models within acceptable bounds with low bias
- Jitter 50 runs at 0.05

Model	#	Not Conv.	At MLE	Below MLE	% converged at MLE
19.1	50	1	32	0	65%
21.1	50	3	37	0	79%
21.2	50	12	23	0	61%

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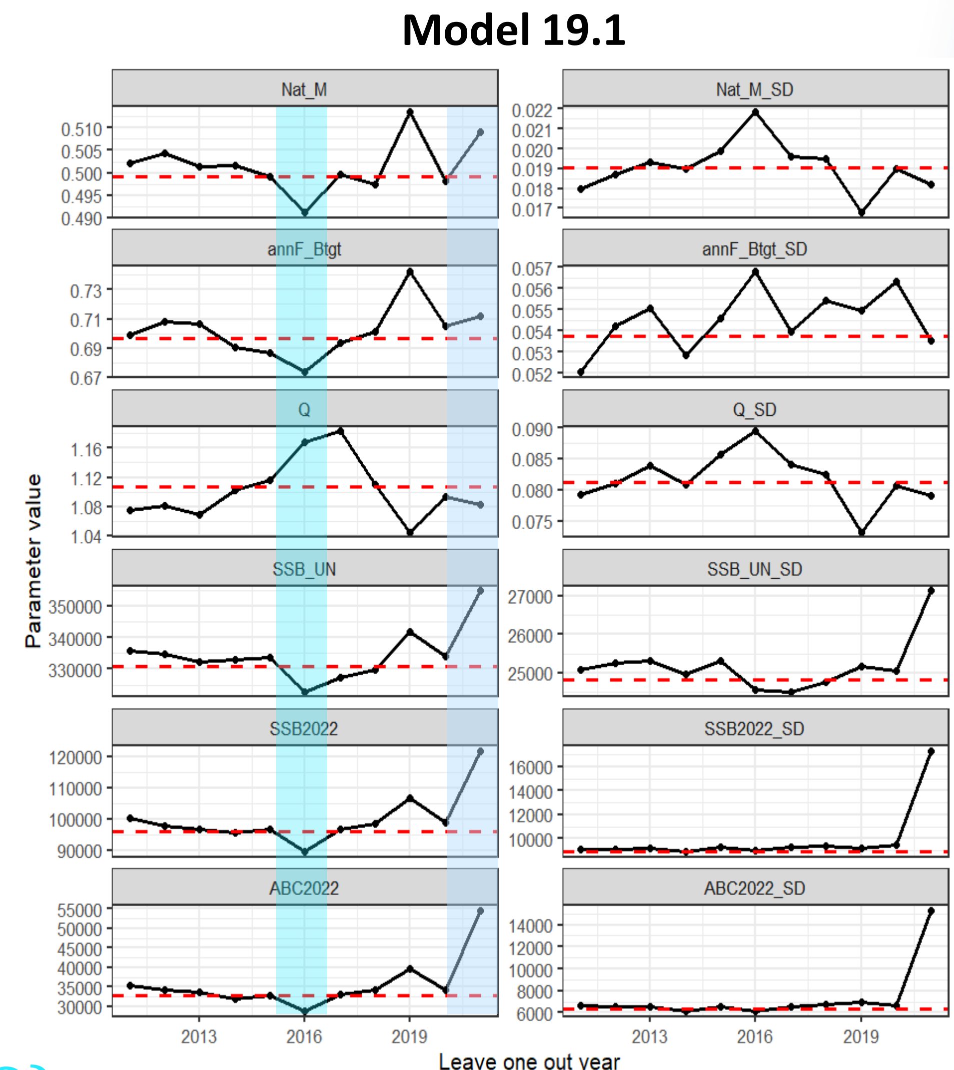
	MLE			Leave-one-out		
Label	Value	σ	CV	Mean bias	Mean bias/MLE Value	Model
ABC_{2022}	32811	6335	0.193	2860.32	0.0872	19.1
ABC_{2022}	26759	5513	0.206	1873.84	0.0700	21.1
ABC_{2022}	23099	4345	**0.188**	**1378.89**	**0.0597**	21.2
$F_{40\%}$	0.696	0.054	**0.077**	0.0054	**0.0078**	19.1
$F_{40\%}$	0.687	0.056	0.086	0.0067	0.0098	21.1
$F_{40\%}$	0.734	0.051	0.082	0.0066	0.0090	21.2
M_{base}	0.499	0.019	**0.038**	**0.0024**	**0.0049**	19.1
M_{base}	0.499	0.022	0.044	0.0032	0.0066	21.1
M_{base}	0.369	0.020	0.054	0.0033	0.0090	21.2
Q_{Bt}	0.101	0.081	NA	**-0.0045**	**-0.0041**	19.1
Q_{Bt}	0.091	0.088	NA	-0.0060	-0.0052	21.1
Q_{Bt}	0.063	0.080	NA	-0.0055	-0.0052	21.2
SSB_{Unfish}	165508	12407	**0.075**	1755.86	0.0106	19.1
SSB_{Unfish}	159948	12114	0.076	1645.18	0.0103	21.1
SSB_{Unfish}	162426	12205	**0.075**	**1178.41**	**0.0073**	21.2
SSB_{2022}	48061	4476	0.093	1934.96	0.0403	19.1
SSB_{2022}	42763	4175	0.098	1354.25	0.0317	21.1
SSB_{2022}	39873	3651	**0.092**	**1109.95**	**0.0278**	21.2



- Low bias across all three models
- 2016 data are highly influential
- 2021 data are highly influential on Biomass estimates

Leave-one-out analyses (LOO)

- Remove single year's data from models iteratively
- Investigate impacts on key model parameters and results

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	MLE			Leave-one-out		
Label	Value	σ	CV	Mean bias	Mean bias/MLE Value	Model
ABC_{2022}	32811	6335	0.193	2860.32	0.0872	19.1
ABC_{2022}	26759	5513	0.206	1873.84	0.0700	21.1
ABC_{2022}	23099	4345	0.188	1378.89	0.0597	21.2
$F_{40\%}$	0.696	0.054	0.077	0.0054	0.0078	19.1
$F_{40\%}$	0.687	0.056	0.086	0.0067	0.0098	21.1
$F_{40\%}$	0.734	0.051	0.082	0.0066	0.0090	21.2
M_{base}	0.499	0.019	0.038	0.0024	0.0049	19.1
M_{base}	0.499	0.022	0.044	0.0032	0.0066	21.1
M_{base}	0.369	0.020	0.054	0.0033	0.0090	21.2
Q_{Bt}	0.101	0.081	NA	-0.0045	-0.0041	19.1
Q_{Bt}	0.091	0.088	NA	-0.0060	-0.0052	21.1
Q_{Bt}	0.063	0.080	NA	-0.0055	-0.0052	21.2
SSB_{Unfish}	165508	12407	0.075	1755.86	0.0106	19.1
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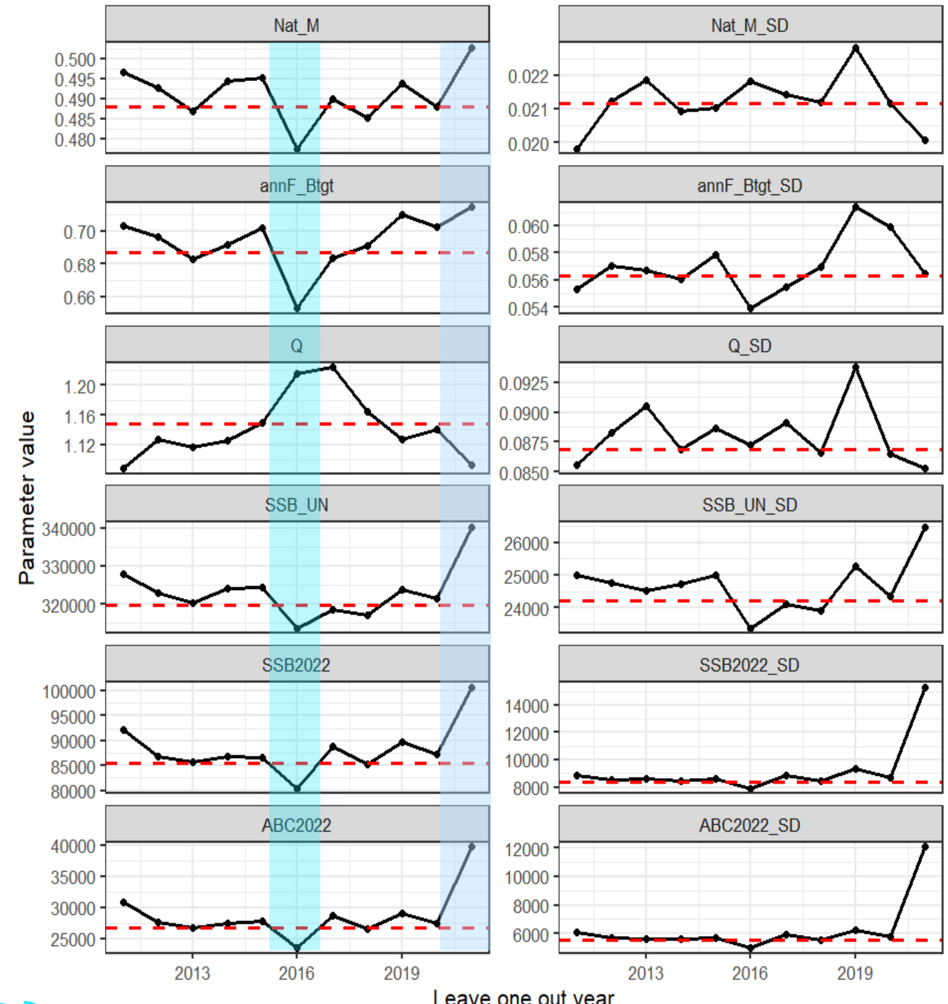
Model 21.1



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NOAA FISHERIES

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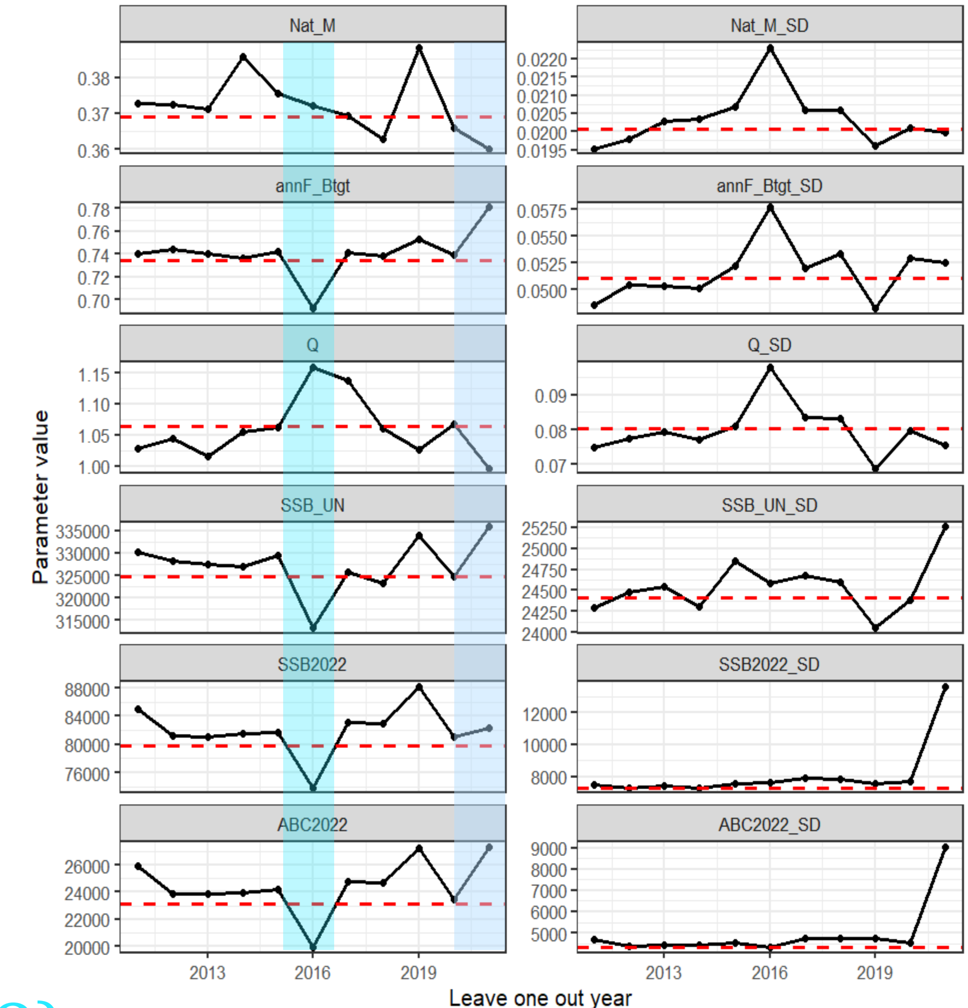
Model 21.2



- Low bias across all three models
- 2016 data are highly influential
- 2021 data are **LESS** influential on biomass &ABC estimates

Leave-one-out analyses (LOO)

- Remove single year's data from models iteratively
- Investigate impacts on key model parameters and results

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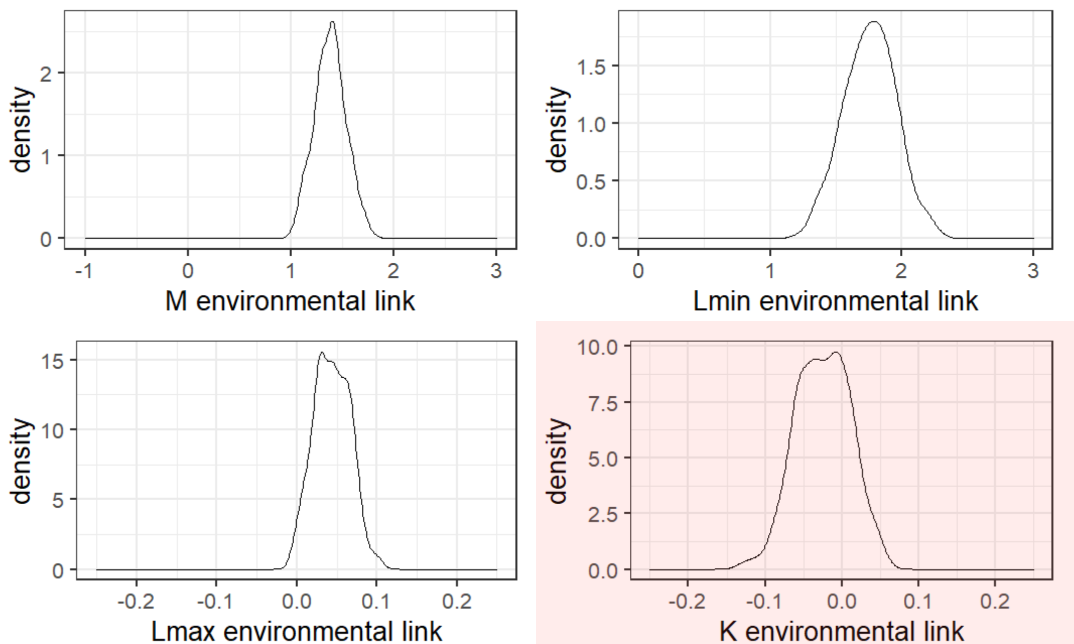
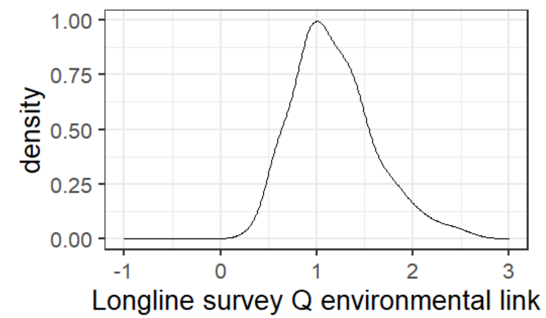
		MCMC link posterior percentile				Link MLE		
Parameter	Link	2.50%	50%	97.50%	p	Value	σ	Gradient
M	η	1.0974	1.3865	1.7005	< 0.002	1.4098	0.14725	-3.91E-06
L_1	γ	1.3676	1.7659	2.1559	< 0.002	1.8003	0.20917	5.98E-07
L_2	ν	0.0023	0.0434	0.0854	0.02	0.0476	0.02208	2.68E-06
K	**ϕ**	**-0.0893**	**-0.0235**	**0.0423**	**0.25**	**-0.0299**	**0.03510**	**1.32E-06**
R_0	ω	-0.0141	-0.0076	-0.0015	0.002	-0.0072	0.00351	-2.66E-06
Q_{BT}	τ	0.5235	1.1259	2.2078	< 0.002	1.3188	0.56170	9.55E-0.8





Model 21.2 Environmental links

- Link parameters fit with uninformative priors
- Inverse Hessian and MCMC results agree
- ϕ link to K not significantly different from 0

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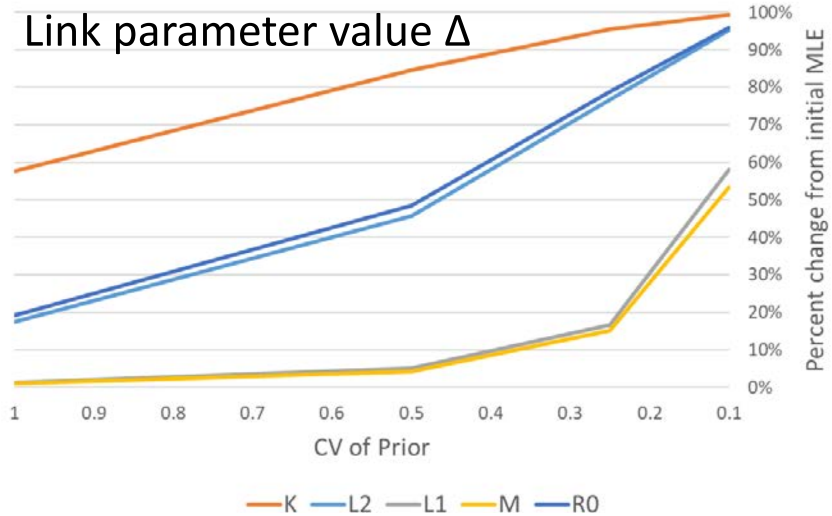
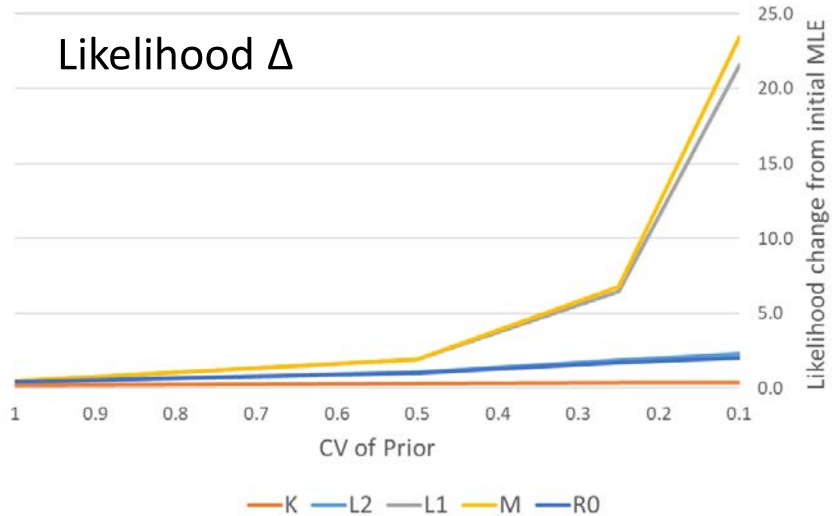
Prior CV	Prior σ	Param	Link	Value	% Δ	LL Δ
0.1	**0.002990**	**K**	**ϕ**	**-0.00022**	**99.3%**	**0.364**
0.25	**0.007474**	**K**	**ϕ**	**-0.00131**	**95.6%**	**0.350**
0.5	**0.014949**	**K**	**ϕ**	**-0.00464**	**84.5%**	**0.309**
1	**0.029898**	**K**	**ϕ**	**-0.01264**	**57.7%**	**0.211**
0.1	0.004763	L_2	ν	0.002230	95.3%	2.301
0.25	0.011909	L_2	ν	0.011098	76.7%	1.843
0.5	0.023817	L_2	ν	0.025918	45.6%	1.084
1	0.047635	L_2	ν	0.039279	17.5%	0.412
0.1	0.180026	L_1	γ	0.755919	58.0%	21.564
0.25	0.450065	L_1	γ	1.499503	16.7%	6.434
0.5	0.900130	L_1	γ	1.709467	5.0%	1.899
1	1.800260	L_1	γ	1.776392	1.3%	0.493
0.1	0.140976	M	η	0.656814	53.4%	23.445
0.25	0.352440	M	η	1.197071	15.1%	6.799
0.5	0.704880	M	η	1.350543	4.2%	1.916
1	1.409760	M	η	1.394530	1.1%	0.495
0.1	0.000716	R_0	ω	-0.00030	95.9%	2.046
0.25	0.001791	R_0	ω	-0.00151	78.8%	1.679
0.5	0.003581	R_0	ω	-0.00369	48.5%	1.026
1	0.007163	R_0	Ω	-0.00578	19.3%	0.404





Model 21.2 Environmental links

- Normal prior with mean of 0.0 fit iteratively with decreasing CV on prior for each link parameter
- Suggested by SSC

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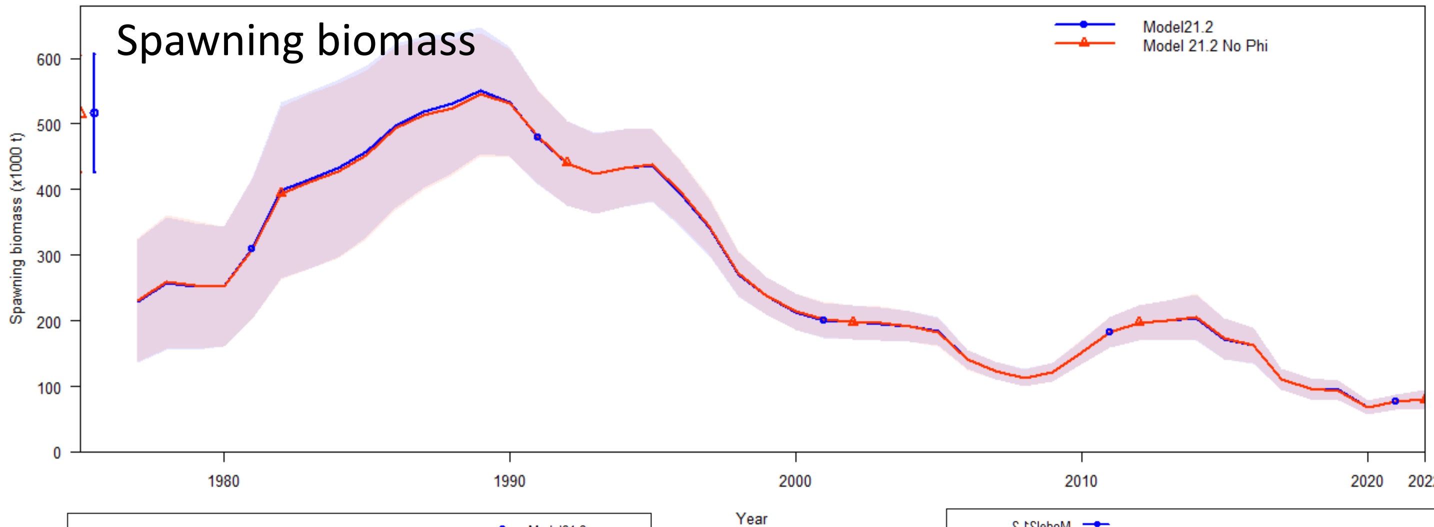
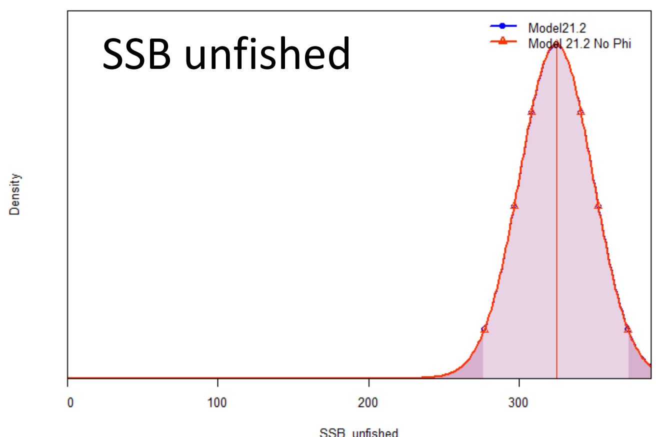
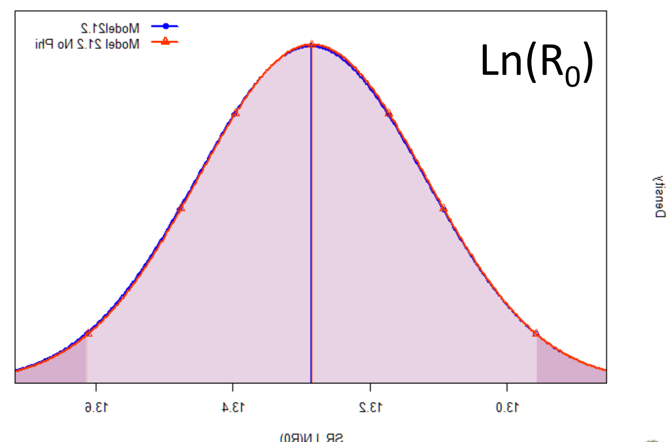
Removal of ϕ link on K makes little to no difference in model results

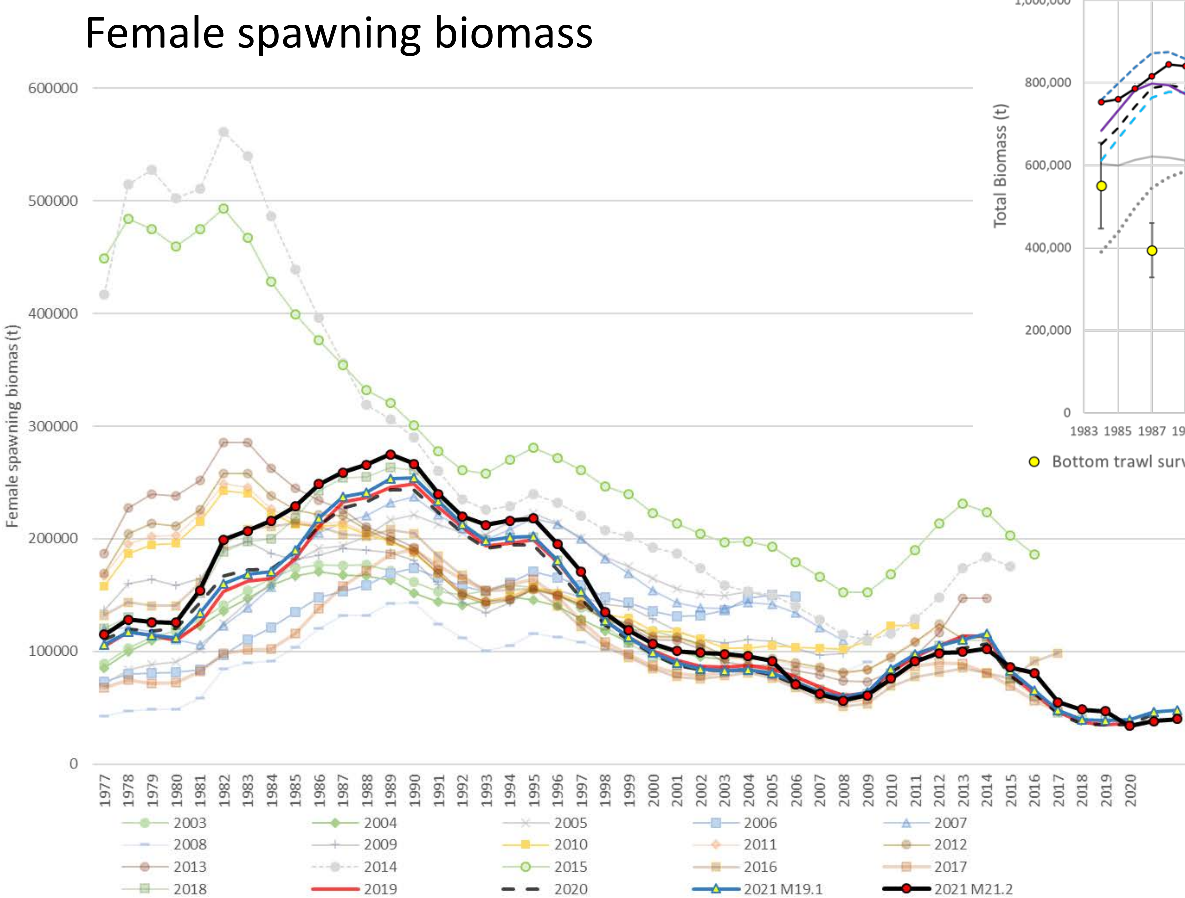


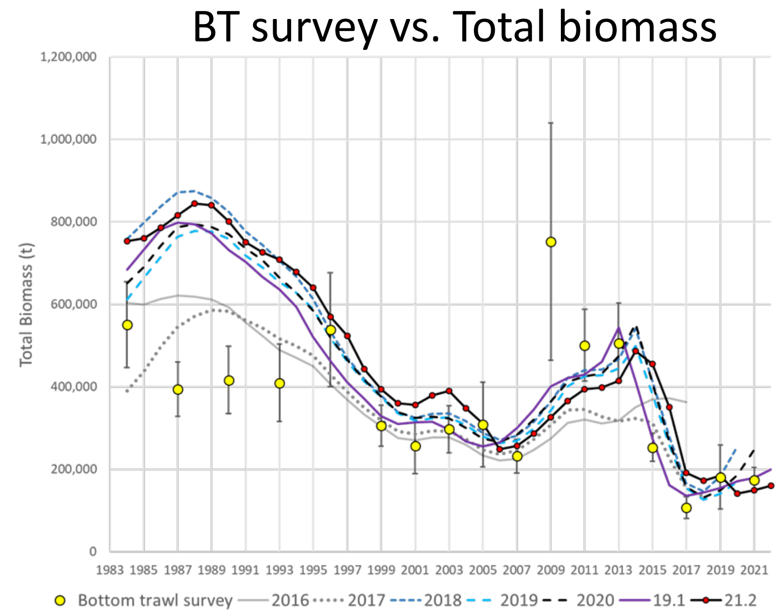




Model 21.2 without K link parameter

- Model 21.2 retains ϕ link on K parameter





Summary model selection

- All three models within the realm of models considered previously
- Relative catchability (survey biomass/total biomass) is 1.0 for all three models considered.

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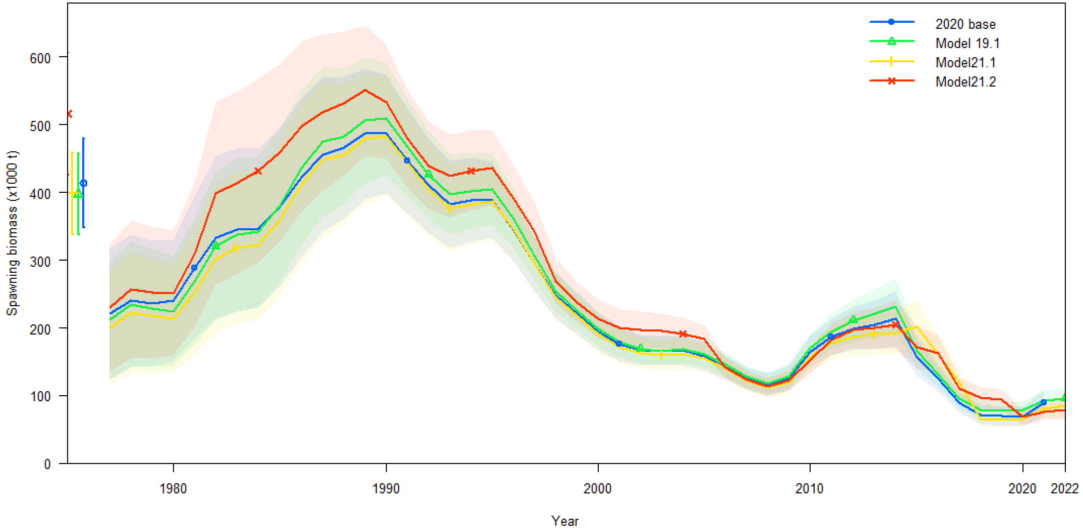

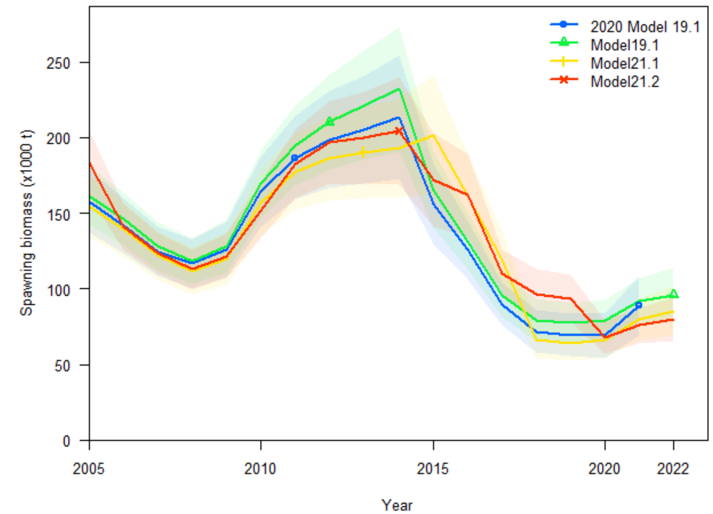

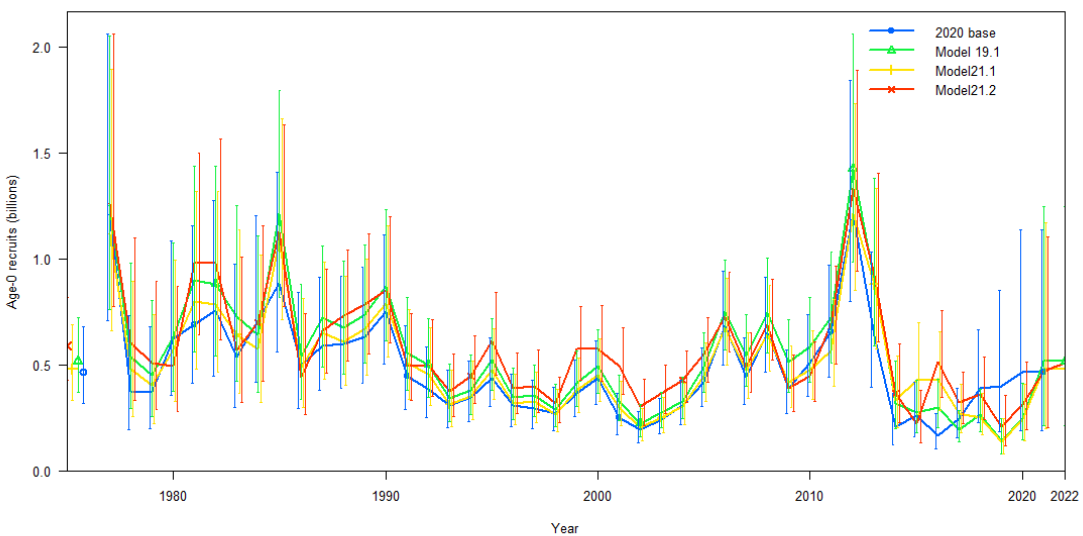

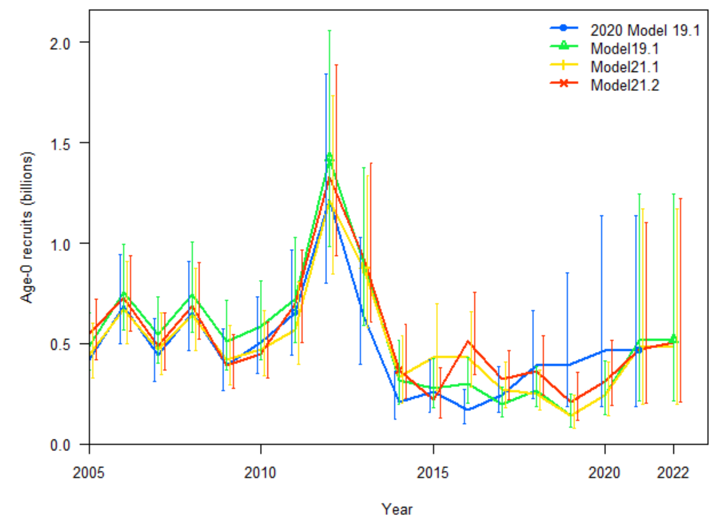

Summary model selection

- All models relatively similar
    - Later drop in biomass for Models 21.1 and 21.2
    - Slower drop for Model 21.2
    - Recruitment low for all three models since 2014

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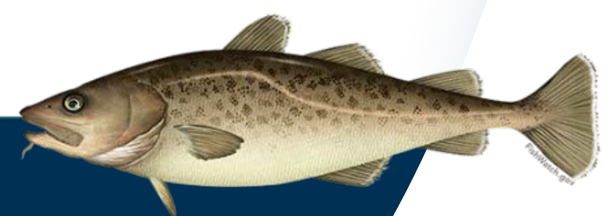
- Model 21.2 had the best overall fit to all of the data where direct comparisons are possible
- All models performed well in retrospective
- All models had little overall bias in LOO analysis
  - Model 21.2 ending year data was less influential

- Environmental links in Model 21.2 are well fit and should improve projections

Summary model selection

- Likelihood
- Retrospective
- Leave-one out
- Model behavior



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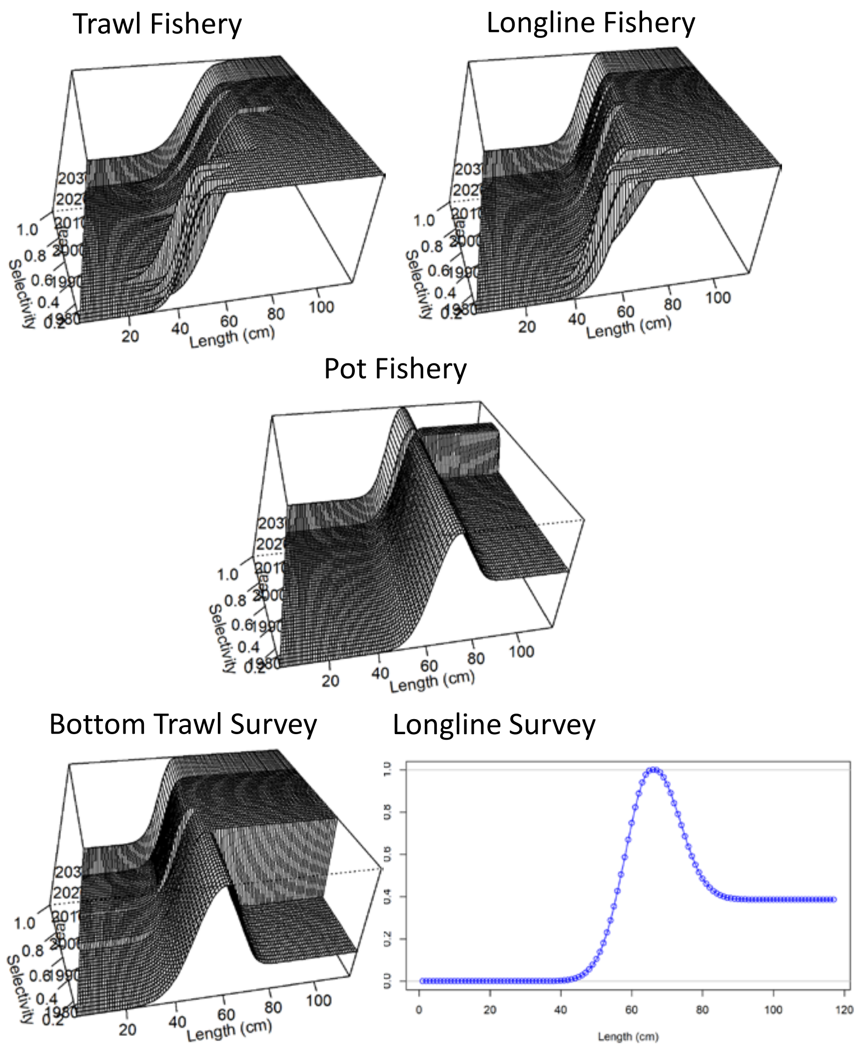
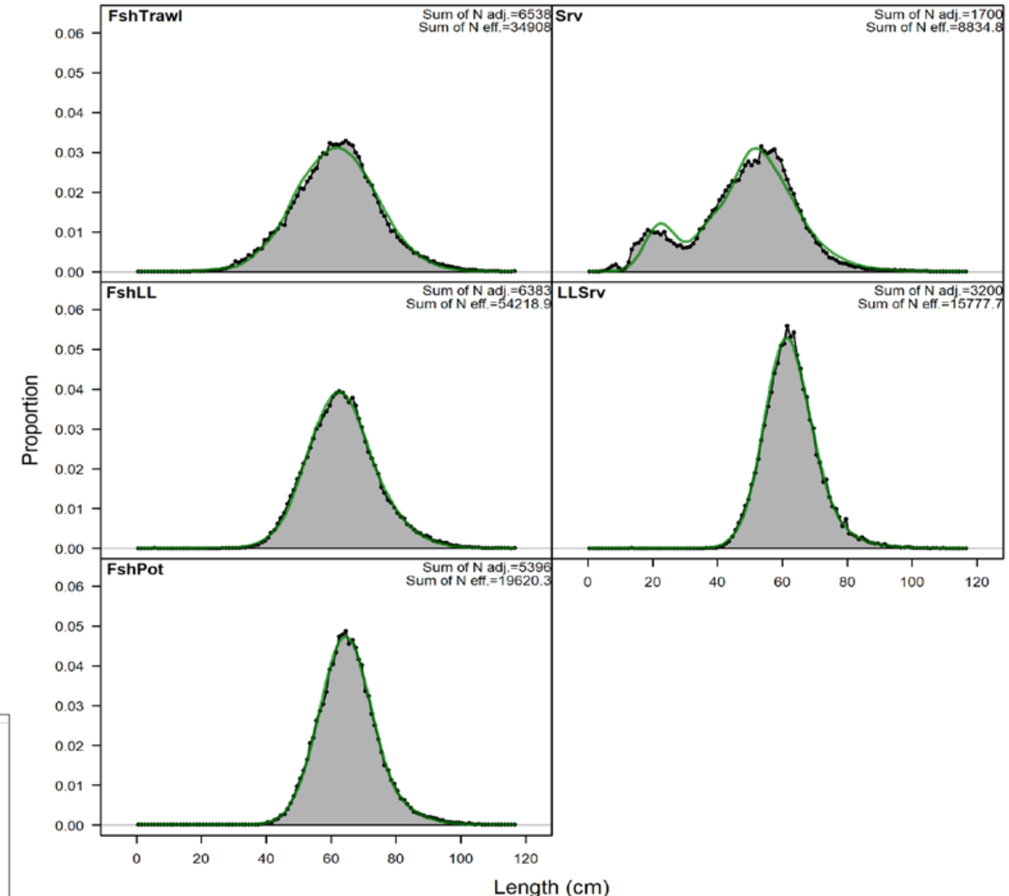
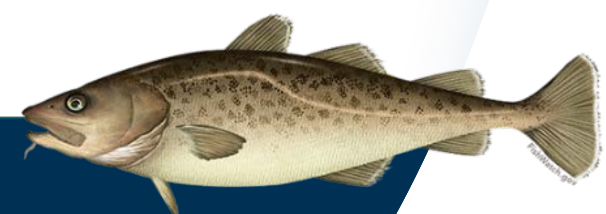




Model 21.2 Length composition fits



- Good overall fit to the length composition data
- Bottom trawl survey may underfit some small size classes

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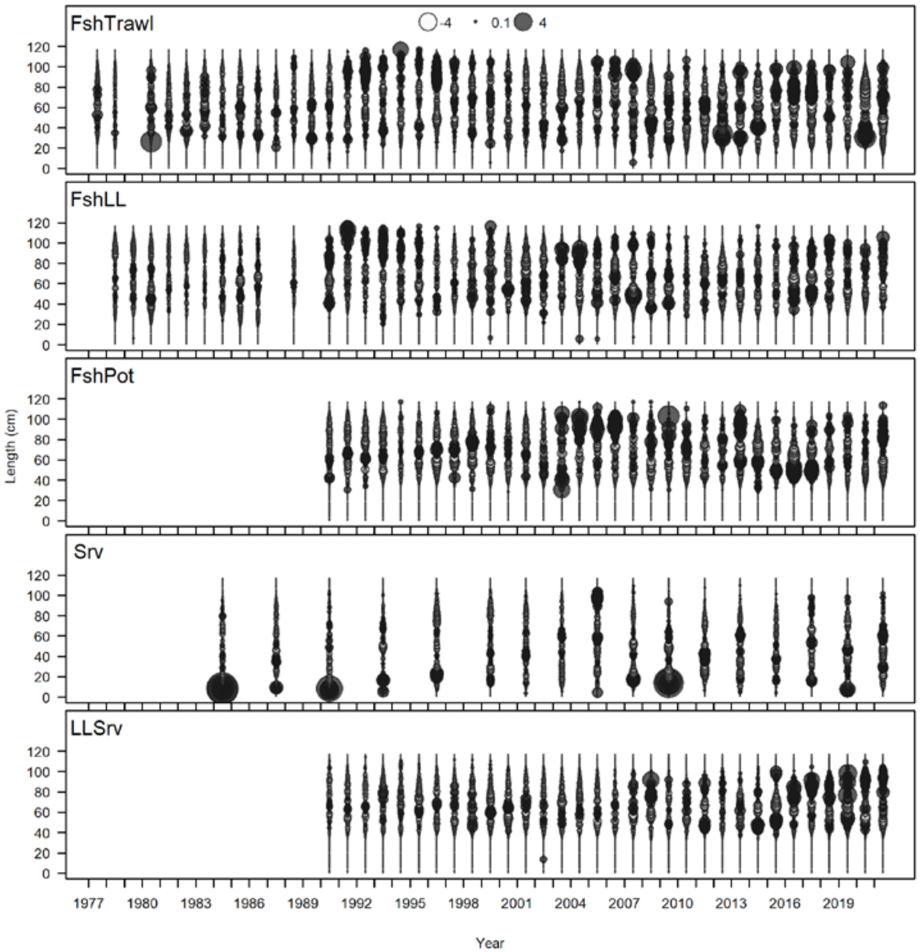

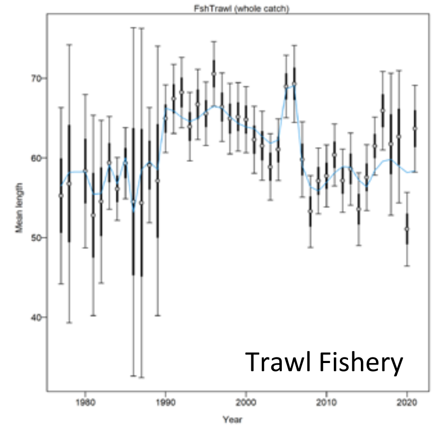

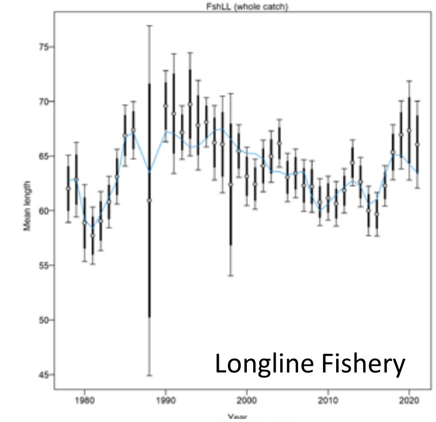

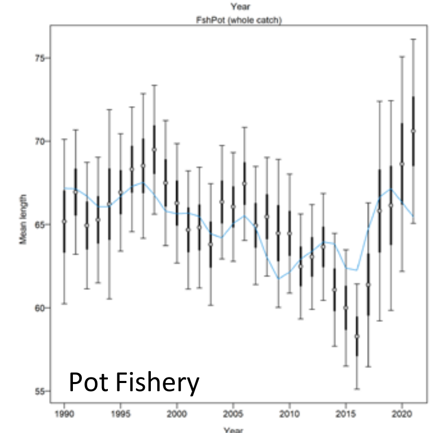

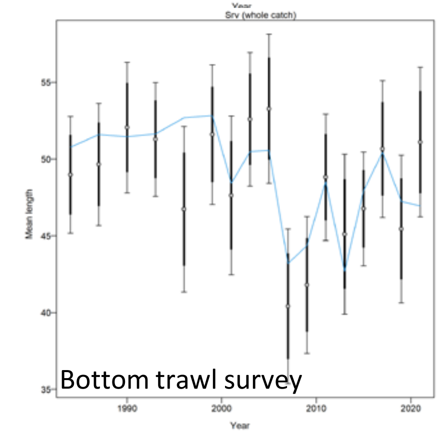

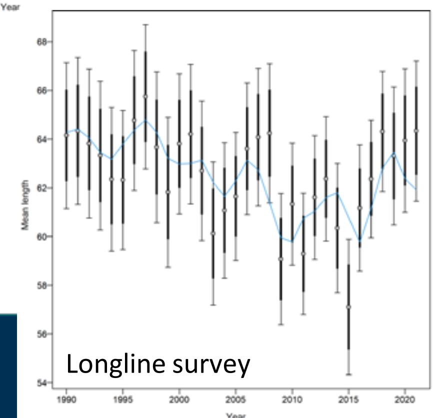

Model 21.2 Length composition fits

- Good overall fit to length composition data
- Bottom trawl survey may underfit some small size classes
- 2021 projected mean sizes are smaller than observed in all fisheries and surveys

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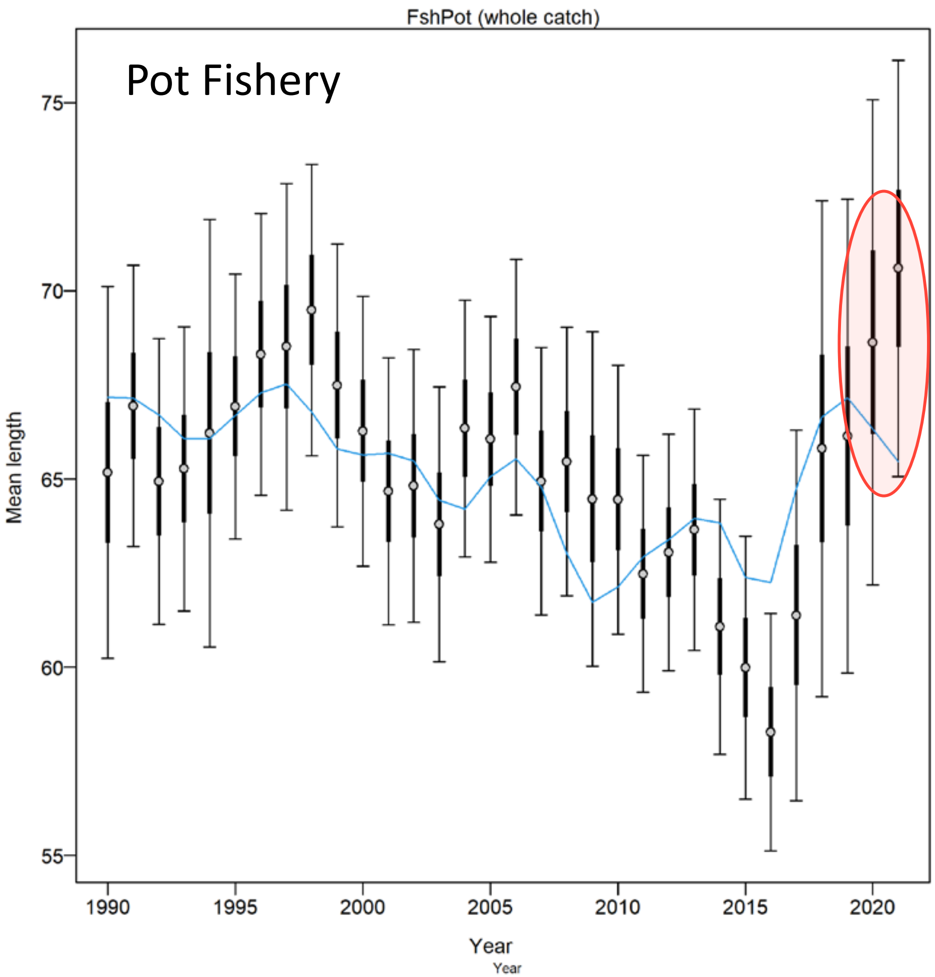

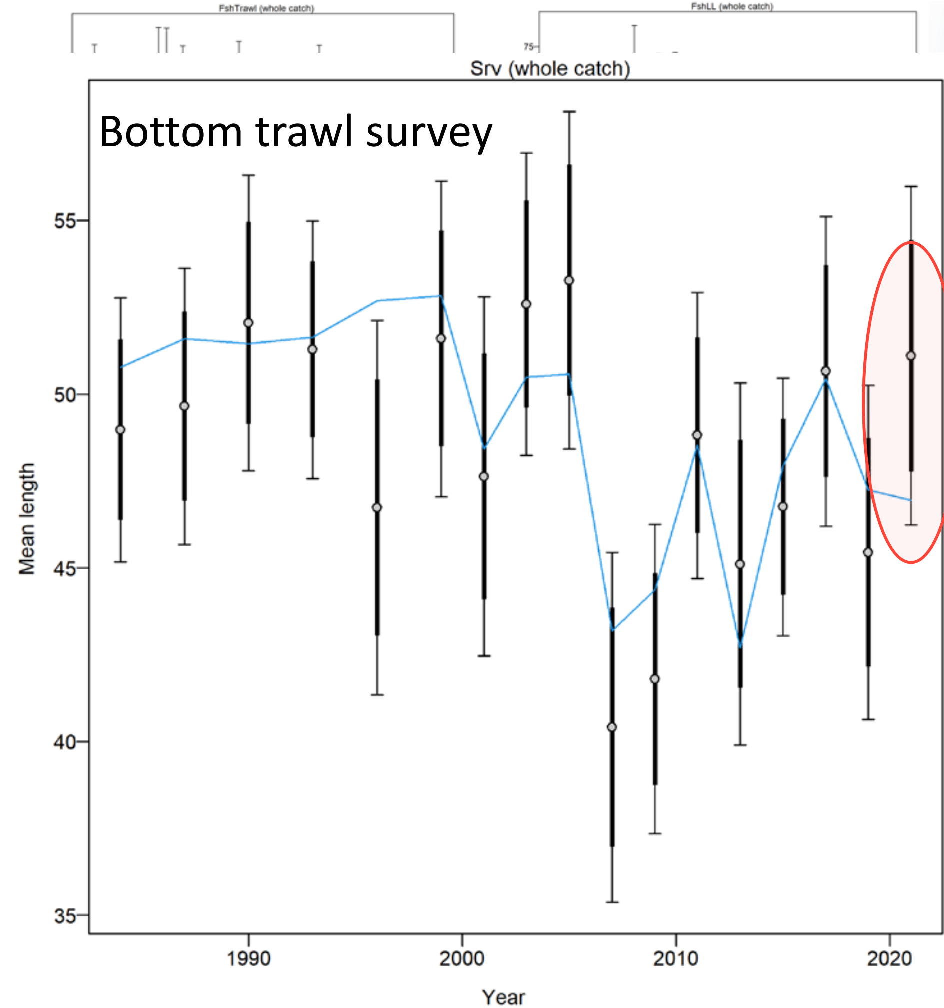

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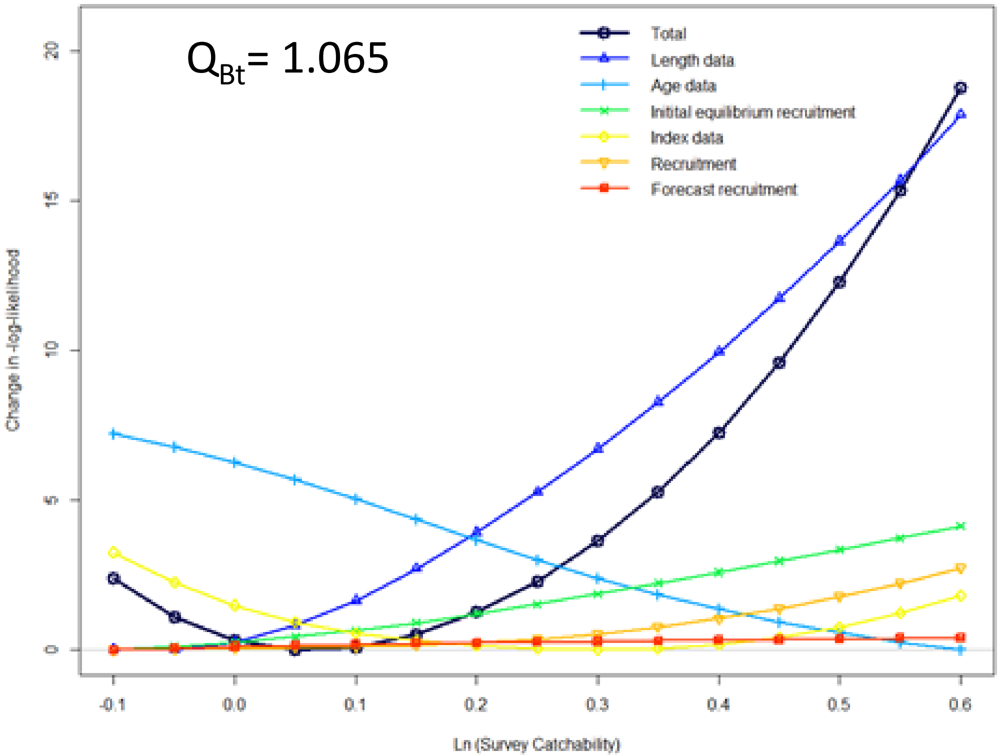

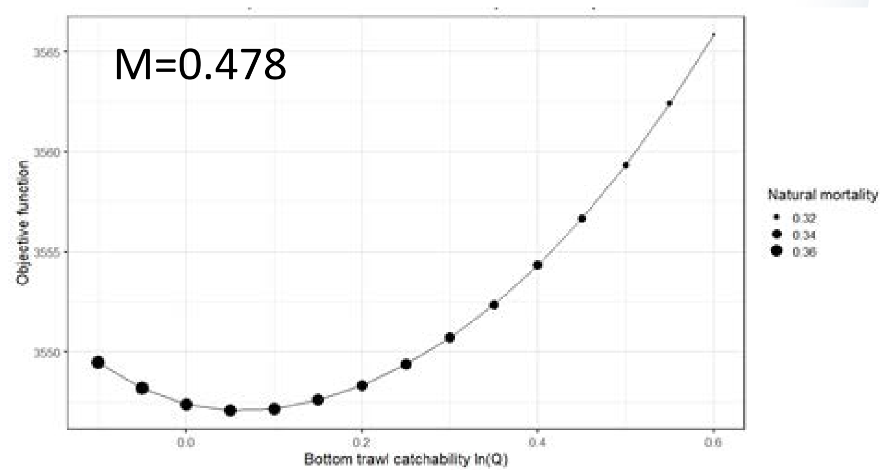

Model 21.2 Catchability and natural mortality

- Q is well fit in Model 21.2
- Q and M are inversely correlated.

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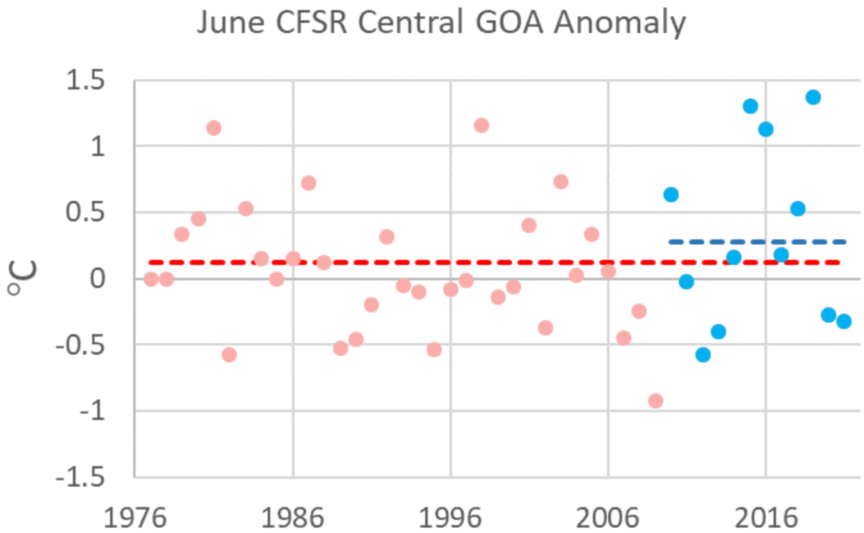
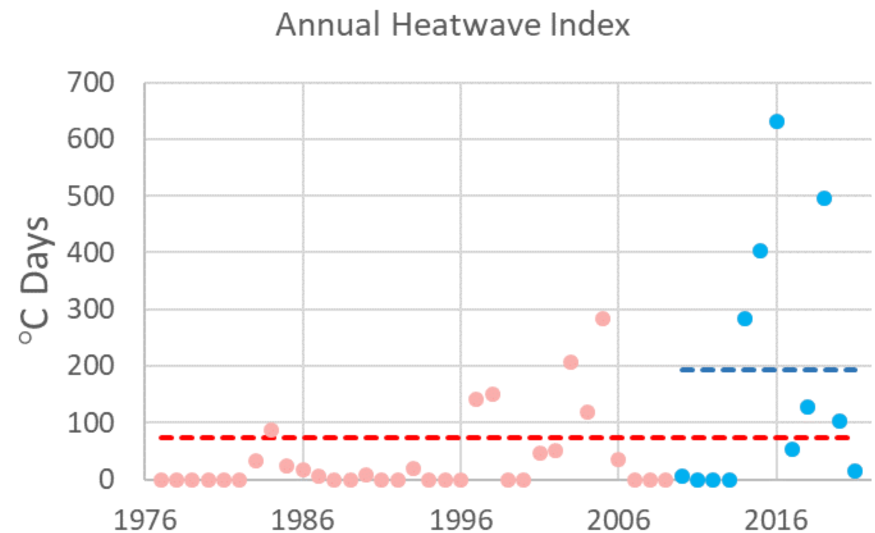
For projections the environmentally linked Model 21.2 requires assumptions about future conditions



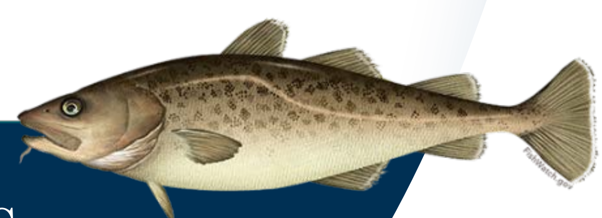


Projection A: 1977-2021 mean conditions

Projection B: 2010-2021 mean conditions

Model 21.2 Projection decision

- 1977-2021 matches timeframe for setting reference points
- 2010-2021 may better reflect future conditions under IPCC scenarios with increasing temperature trends for Central GOA



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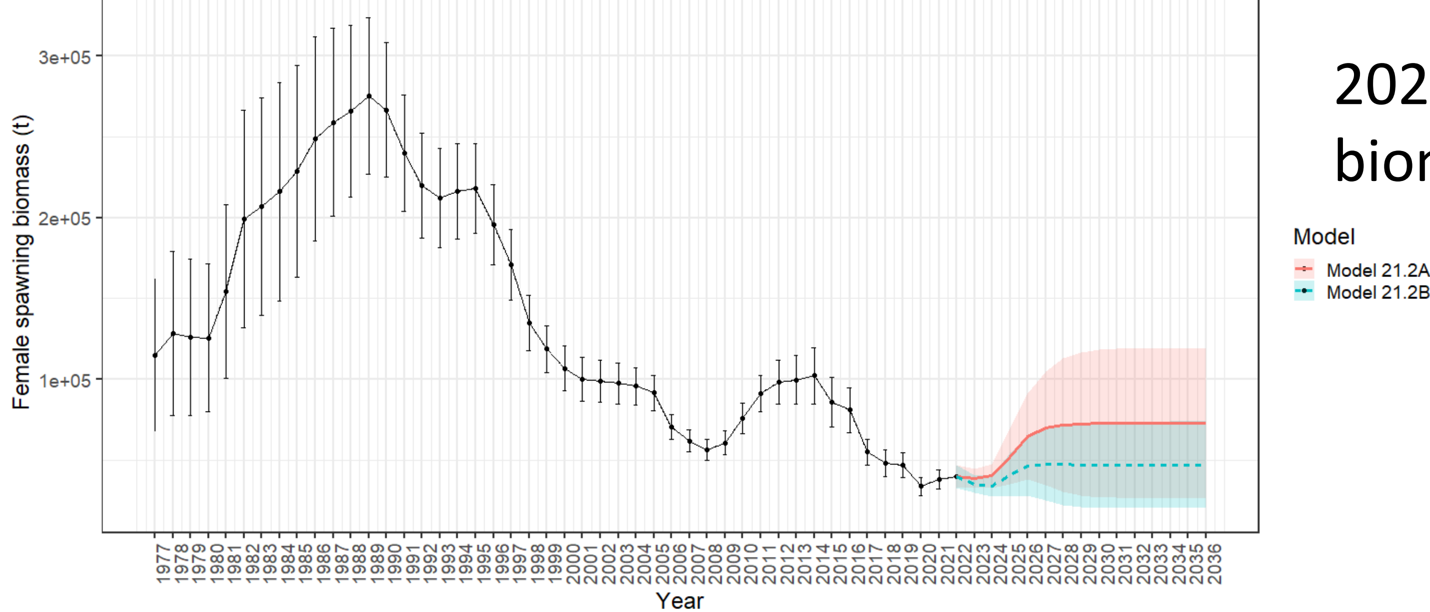
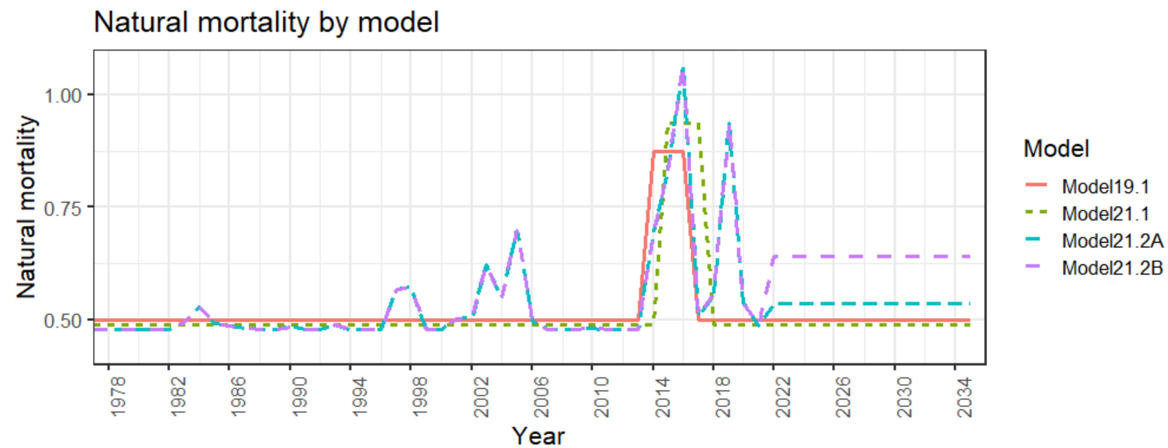
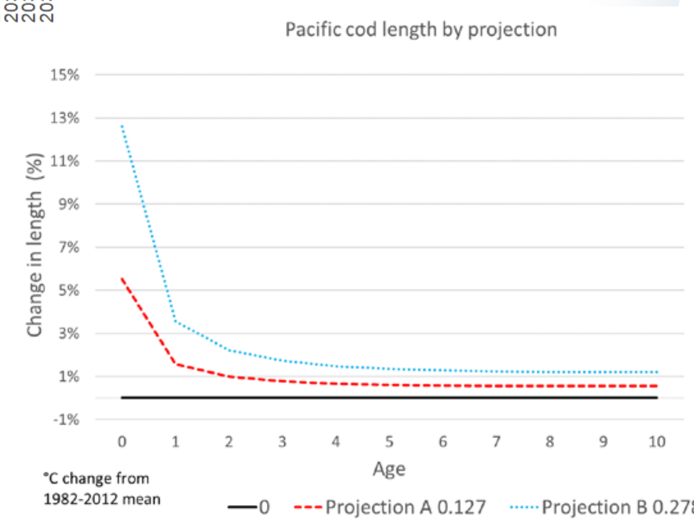
2022 spawning biomass at $B_{24.5\%}$

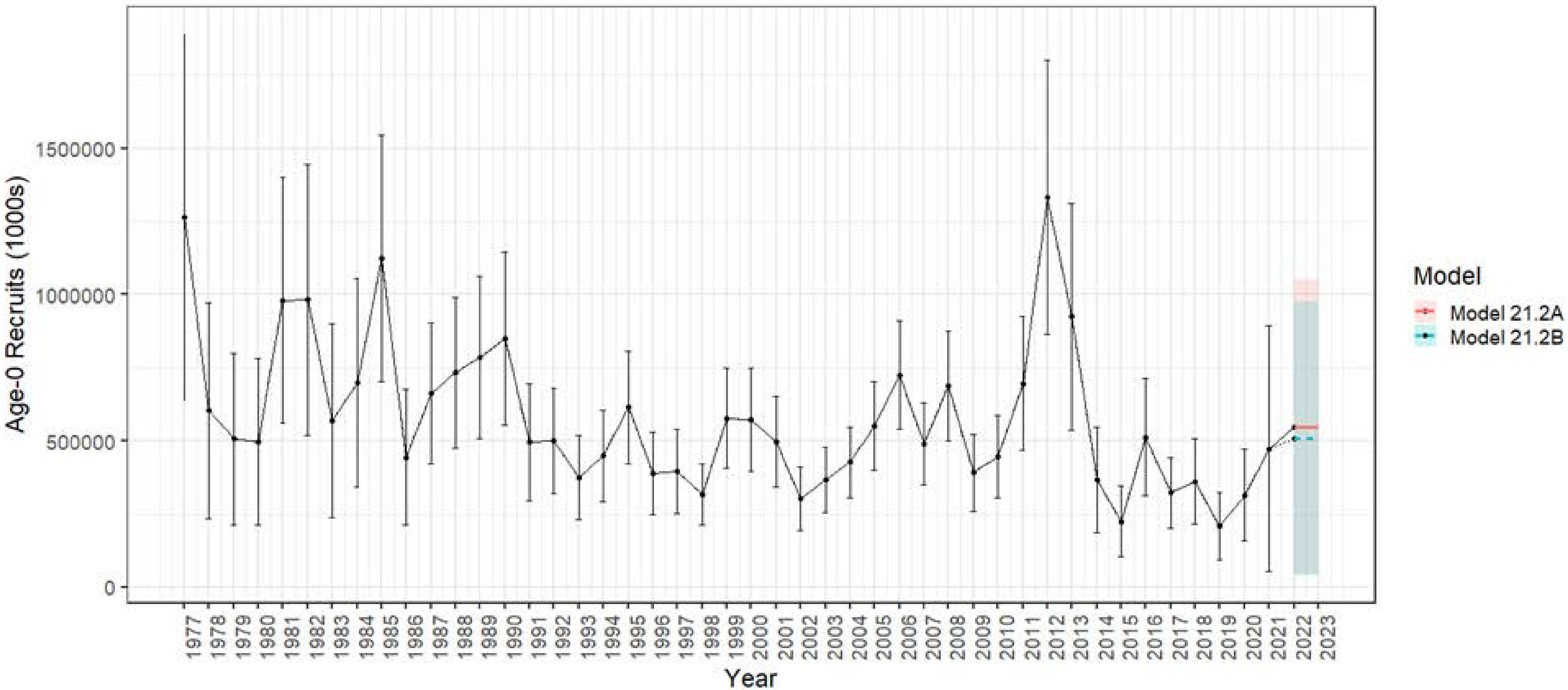






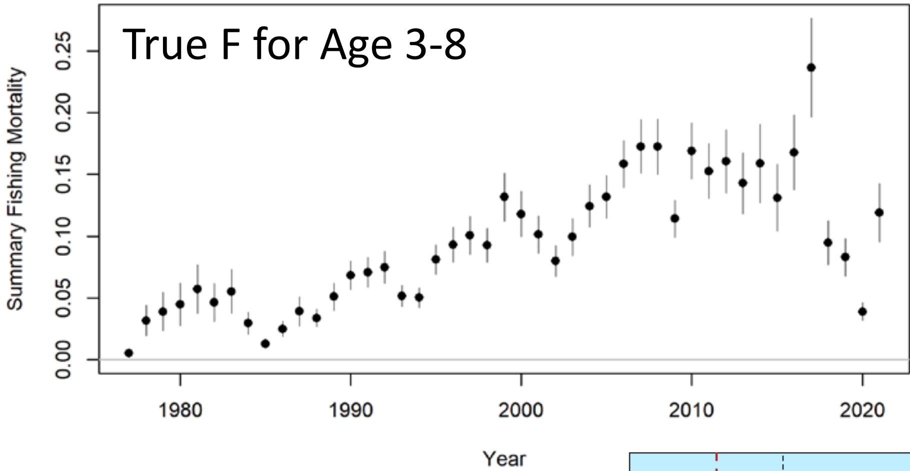
Model 21.2 Results spawning biomass

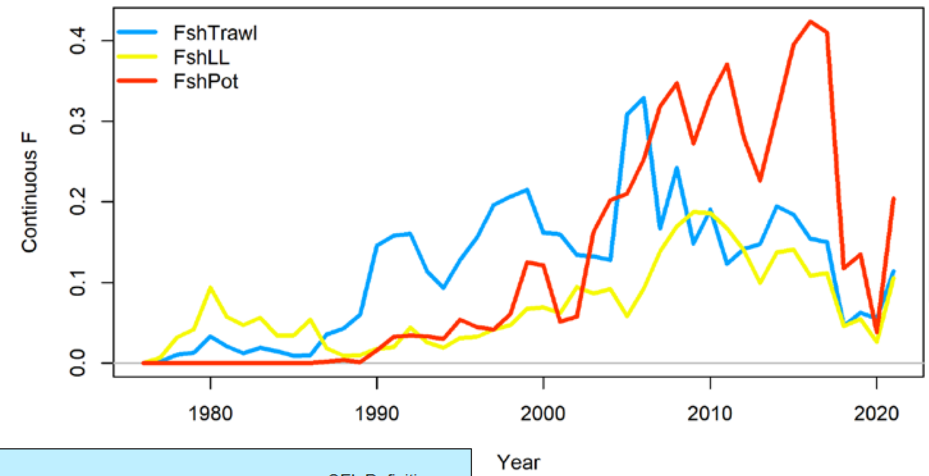
- Both projection have increased M and growth
- Increase in growth is small between projections

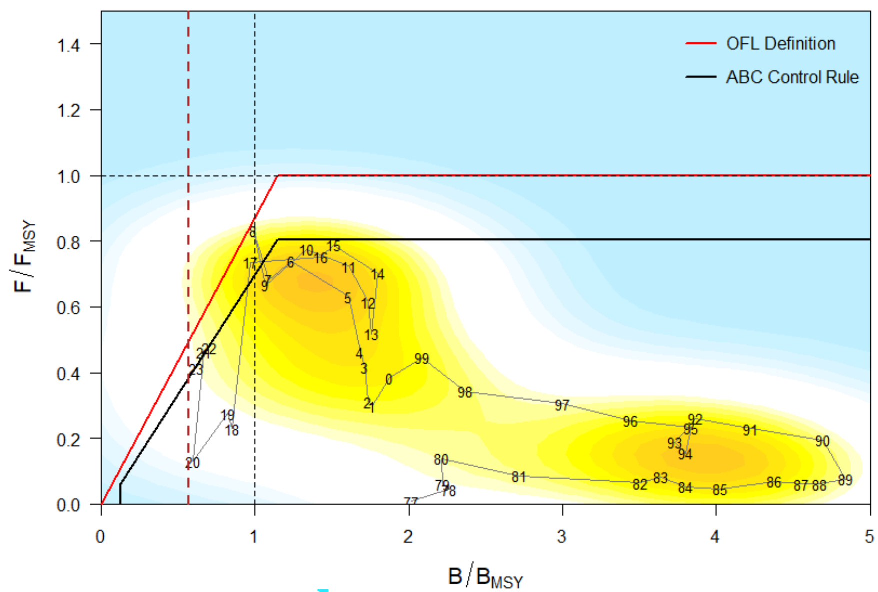


Model 21.2 Results recruitment

- Both projection have decreased recruitment
- Difference is small



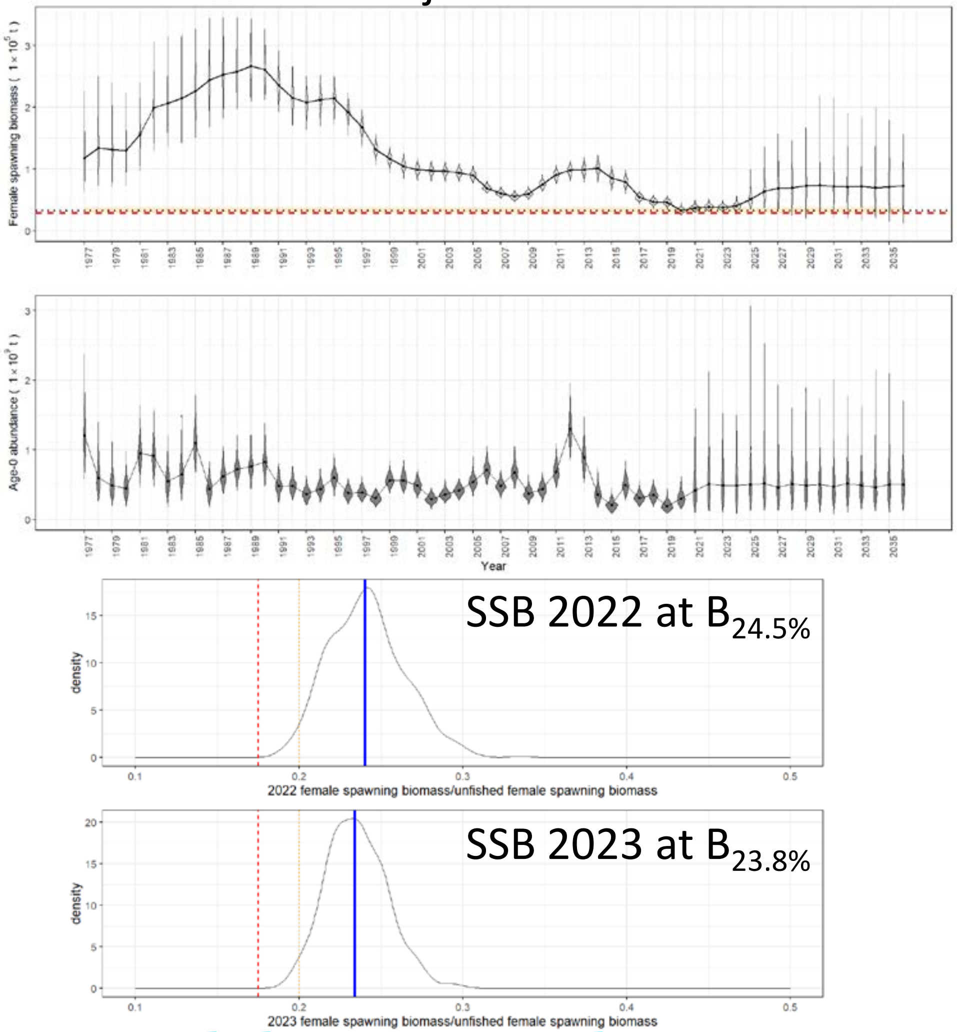




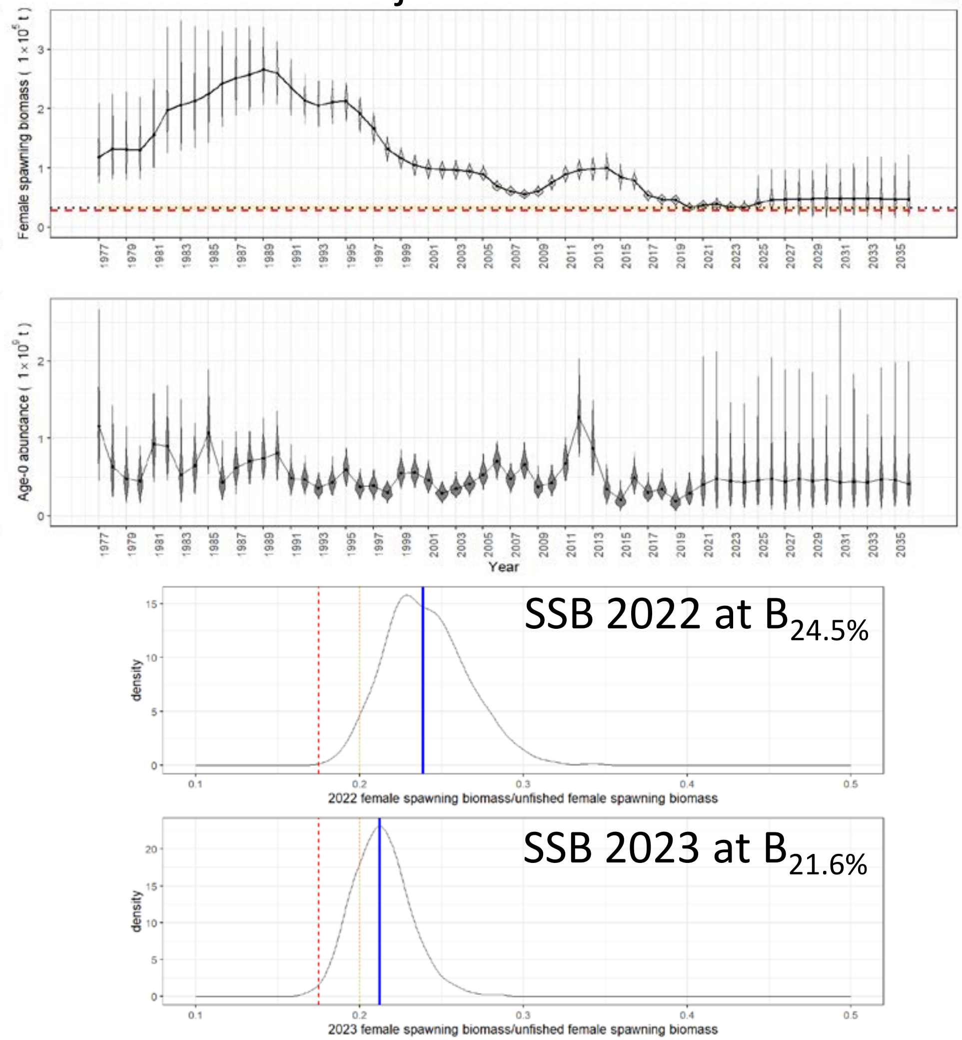
Model 21.2 Fishing mortality

- Increasing F over time however overall relatively low fishing mortality
- Highest F in 2017 as stock collapsed
- 2018-2021 continued low fishing mortality

Projection A



Projection B



Model 21.2 Results

- MCMC 1 million draws, burn in of 10,000, thinned at 2,000
- Projection A: 2% probability of $<B_{20\%}$ in 2023
- Projection B: 22% probability of $<B_{20\%}$ in 2023

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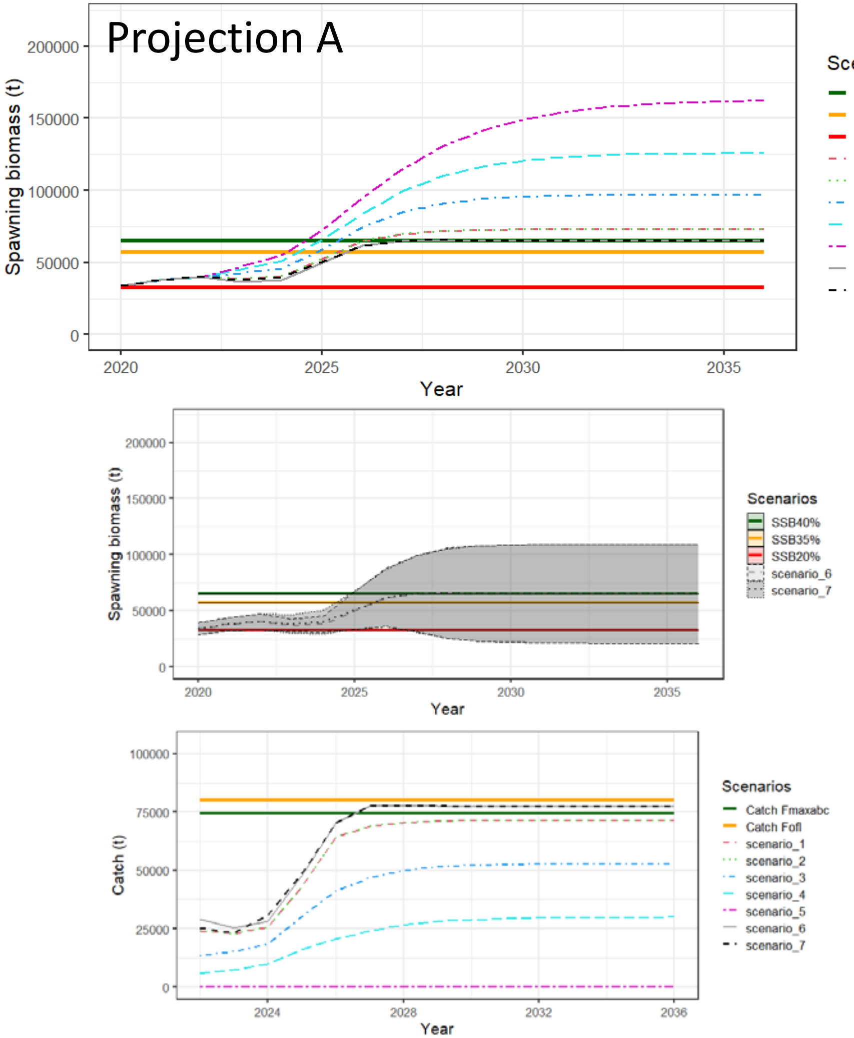

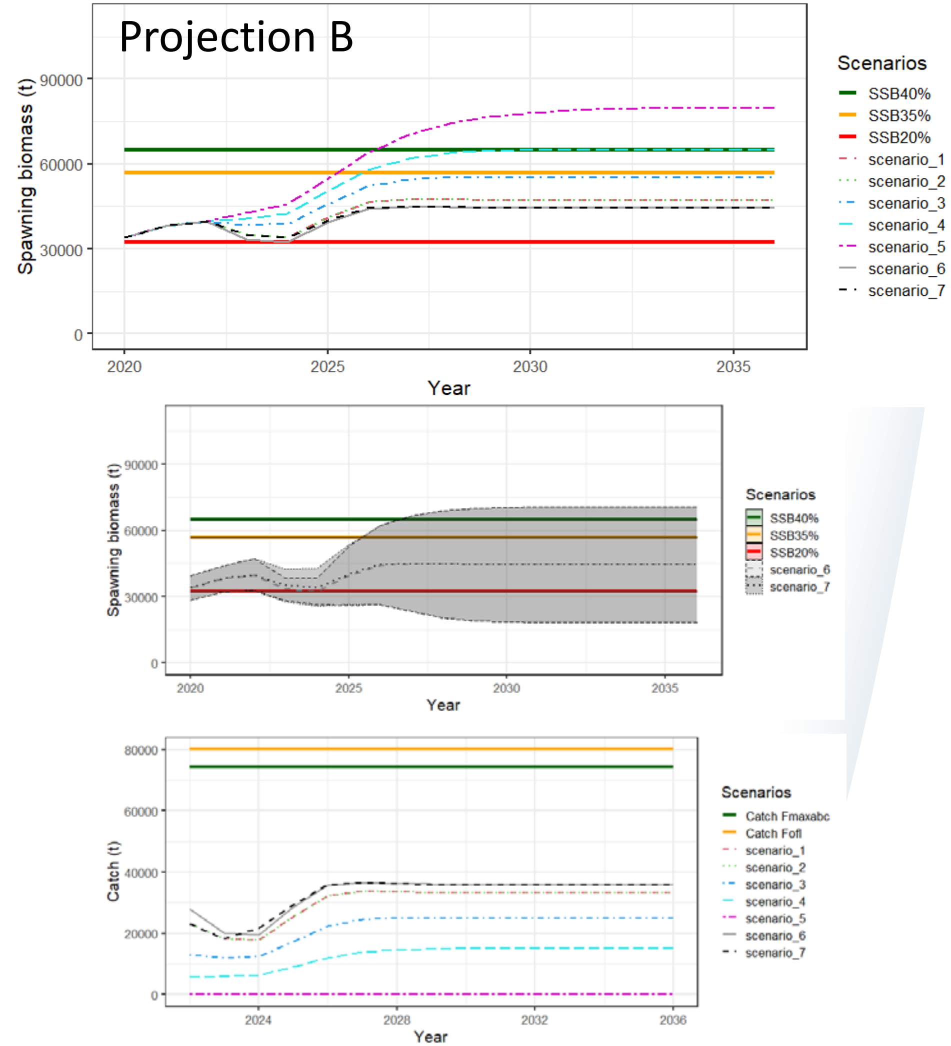

Model 21.2 status projections

- Both projections are highly uncertain after 2025

- Projection A: Not overfished or approaching an overfished condition
- Projection B: Overfished and approaching an overfished condition

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Assessment-related considerations	Population dynamics considerations	Environmental/ ecosystem considerations	Fishery Performance	Overall score (highest of the individual scores)
Level 1: Normal	Level 1: Normal	Level 1: Normal	Level 1: Normal	Level 1: Normal

- **Assessment related** – Still some uncertainty on pre-1985 population, but improved over last year's model
- **Population dynamics** – Still low spawning biomass, but appears to be improving, signs of good recruitment in 2020 and average in 2021.
- **Environmental/ecosystem** – Cooling in 2021 to average or below and overall better conditions.
- **Fishery performance** – Mixed results as normal, EM adds some uncertainty in how to measure performance.

Risk table

- Level 1: Normal for all components

Model21.2 Quantity	Projection A (Mean 1977-2021 conditions projected)		Projection B (Mean 2010-2021 conditions projected)	
	2022	2023	2022	2023
Tier	3b	3b	3b	3b
Projected total (age 0+) biomass (t)	159,837	185,745	160,755	169,832
Female spawning biomass (t)				
Projected	39,873	38,594	39,873	35,050
$B_{100\%}$	162,426	162,426	162,426	162,426
$B_{40\%}$	64,970	64,970	64,970	64,970
$B_{35\%}$	56,849	56,849	56,849	56,849
F_{OFL}	0.54	0.52	0.54	0.47
$maxF_{ABC}$	0.44	0.42	0.44	0.38
F_{ABC}	0.44	0.42	0.44	0.38
OFL (t)	**29,131**	**27,715**	**28,000**	**22,072**
maxABC (t)	24,043	22,882	23,099	18,170
ABC (t)	**24,043**	**22,882**	**23,099**	**18,170**
Status	2020	2021	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	Yes
Approaching overfished	n/a	No	n/a	Yes

Model 21.2 Recommendations

- Assumed 2021 catch at the ABC, 23,627t. For 2023 projections the 2022 catch was assumed to be at the projected ABC.

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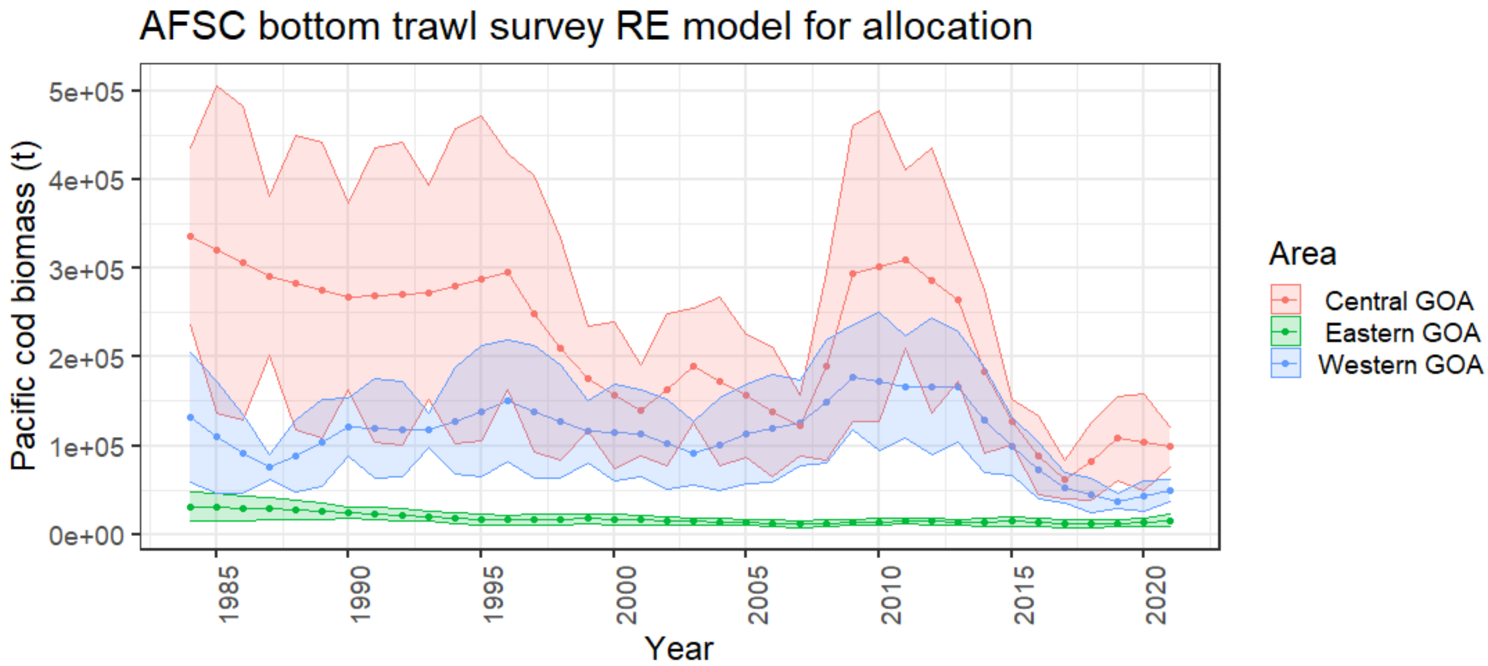

		Western	Central	Eastern	Total
Random effects area apportionment		30.3%	60.2%	9.5%	100%
Projection A	2022 ABC	7,285	14,474	2,284	24,043
	2023 ABC	6,933	13,775	2,174	22,882
Projection B	2022 ABC	6,999	13,905	2,194	23,099
	2023 ABC	5,505	10,938	1,726	18,170

Model 21.2 area allocation

- Random effects model used for allocation
- Increase in Western GOA over previous survey

Quantity	Model 19.1		Model 21.1	
	2022	2023	2022	2023
Tier	3b	3b	3b	3b
Projected total (age 0+) biomass (t)	178,961	199,841	166,852	194,580
Female spawning biomass (t)				
Projected	48,061	44,530	42,763	42,872
$B_{100\%}$	165,508	165,508	159,948	159,948
$B_{40\%}$	66,203	66,203	63,979	63,979
$B_{35\%}$	57,928	57,928	55,982	55,98
F_{OFL}	0.62	0.57	0.56	0.56
$maxF_{ABC}$	0.50	0.46	0.45	0.45
F_{ABC}	0.50	0.46	0.45	0.45
OFL (t)	**39,554**	**34,673**	**32,366**	**32,869**
maxABC (t)	32,811	28,708	26,759	27,195
ABC (t)	**32,811**	**28,708**	**26,759**	**27,195**
Status				
	2020	2021	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Model 19.1 and 21.1 Recommendations

- Assumed 2021 catch at the ABC, 23,627t. For 2023 projections the 2022 catch was assumed to be at the respective projected ABCs.

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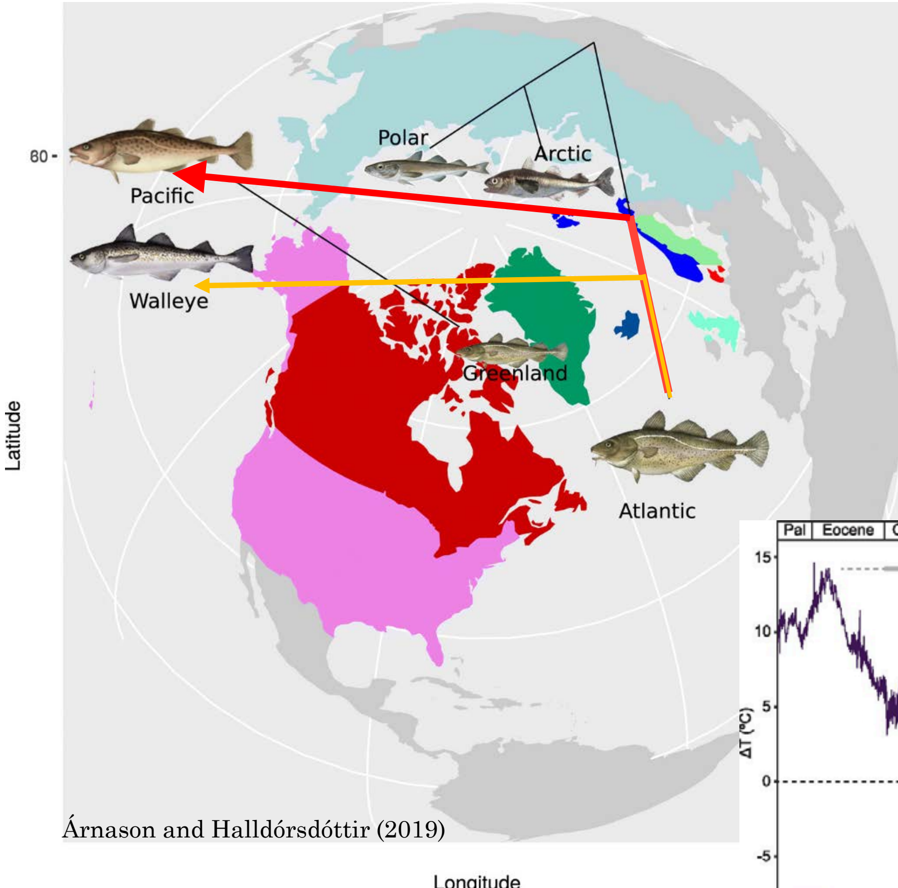
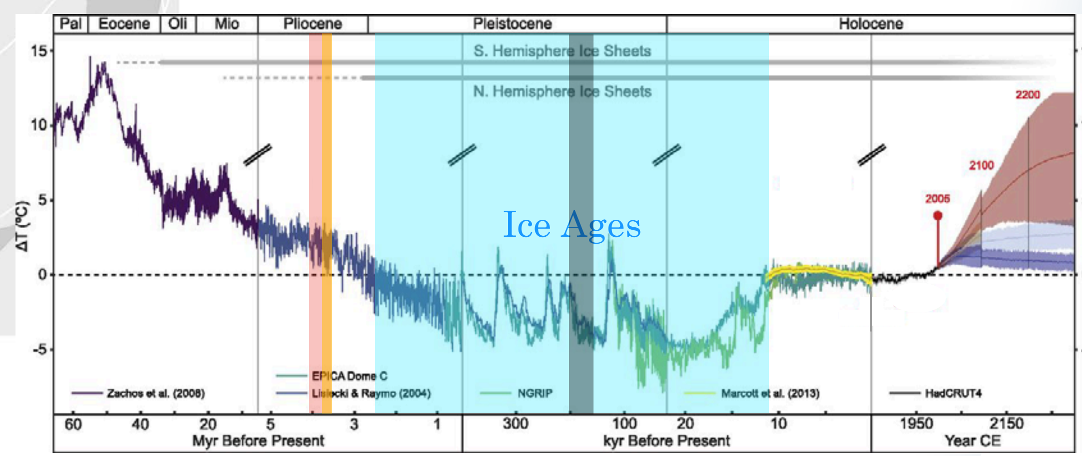


Árnason and Halldórsdóttir (2019)

- Pacific cod and walleye pollock are both derived from Atlantic cod common ancestor
- Pliocene divergence
  - Pacific cod ~4 million years
  - Pollock ~3.8 million years



Burke et al. (2018.)

Pre-history of gadids (cods)

- Pre-history from genetic studies

Coulson, M.W., Marshall, H.D., Pepin, P. and Carr, S.M., 2006. Mitochondrial genomics of gadine fishes: implications for taxonomy and biogeographic origins from whole-genome data sets. Genome, 49(9), pp.1115-1130

Árnason, E. and Halldórsdóttir, K., 2019. Codweb: Whole-genome sequencing uncovers extensive reticulations fueling adaptation among Atlantic, Arctic, and Pacific gadids. Science advances, 5(3), p.eaat8788.

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