



ALASKA SABLEFISH

DAN GOETHEL, DANA HANSELMAN, CARA RODGVELLER, KALEI SHOTWELL, KATY ECHAVE, BEN WILLIAMS, JANE SULLIVAN, PETE HULSON, PAT MALECHA, KEVIN SIWICKE, CHRIS LUNSFORD

MARINE ECOLOGY AND STOCK ASSESSMENT

ALASKA FISHERIES SCIENCE CENTER

JUNEAU, AK



2 OUTLINE

- Model Development and Comparisons
- Stock Assessment Overview
 - Review Key Data Inputs
 - Results and Model Fit
 - Diagnostics
- ABC Projections
 - Risk Table
- Summary of Assessment and ABC
- Apportionment



3 BOTTOM LINE

- New model, same upward trends
- More consistent recruitment estimation allows use of max ABC projections
- 2022 Author's ABC = Max ABC = 34,521 t
- **Apportionment based on 5-year average survey biomass proportions and year 2 (50%) of SSC 4-year stair step**

Year	2021				2022*		2023*	
Region	OFL _w	ABC _w	TAC	Catch**	OFL _w	ABC _w ***	OFL _w	ABC _w ***
BS	--	3,396	3,396	3,667	--	5,264	--	6,529
AI	--	4,717	4,717	1,359	--	6,463	--	7,786
GOA	--	21,475	17,992	12,919	--	22,794	--	22,003
WGOA	--	3,224	2,428	1,609	--	3,727	--	3,951
CGOA	--	9,527	8,056	5,868	--	9,965	--	9,495
***WYAK	--	3,451	2,929	2,156	--	3,437	--	3,159
***EY/SEO	--	5,273	4,579	3,286	--	5,665	--	5,398
Total	60,426	29,588	26,105	17,945	40,432	34,521	42,520	36,318

4 MODEL BUILDING RECAP

- Sept. PT meeting presented model *21.10_Proposed*
 - Updated weight and length with data through 2019
 - Updated maturity with recent histological data and incorporated skipped spawning information
 - Removed catchability priors
 - Added recent (starting in 2016) time block for:
 - Fishery catchability and selectivity
 - Survey selectivity
 - Applied Francis reweighting



5 MODEL UPDATES RATIONALE

- New biological data better represents current dynamics and are more accurate (e.g., histological maturity estimates)
- Freely estimating catchability gives model more flexibility to perform internal scaling
- Data reweighting is best practice, while CIE recommended fixed weights were causing poor fits to indices



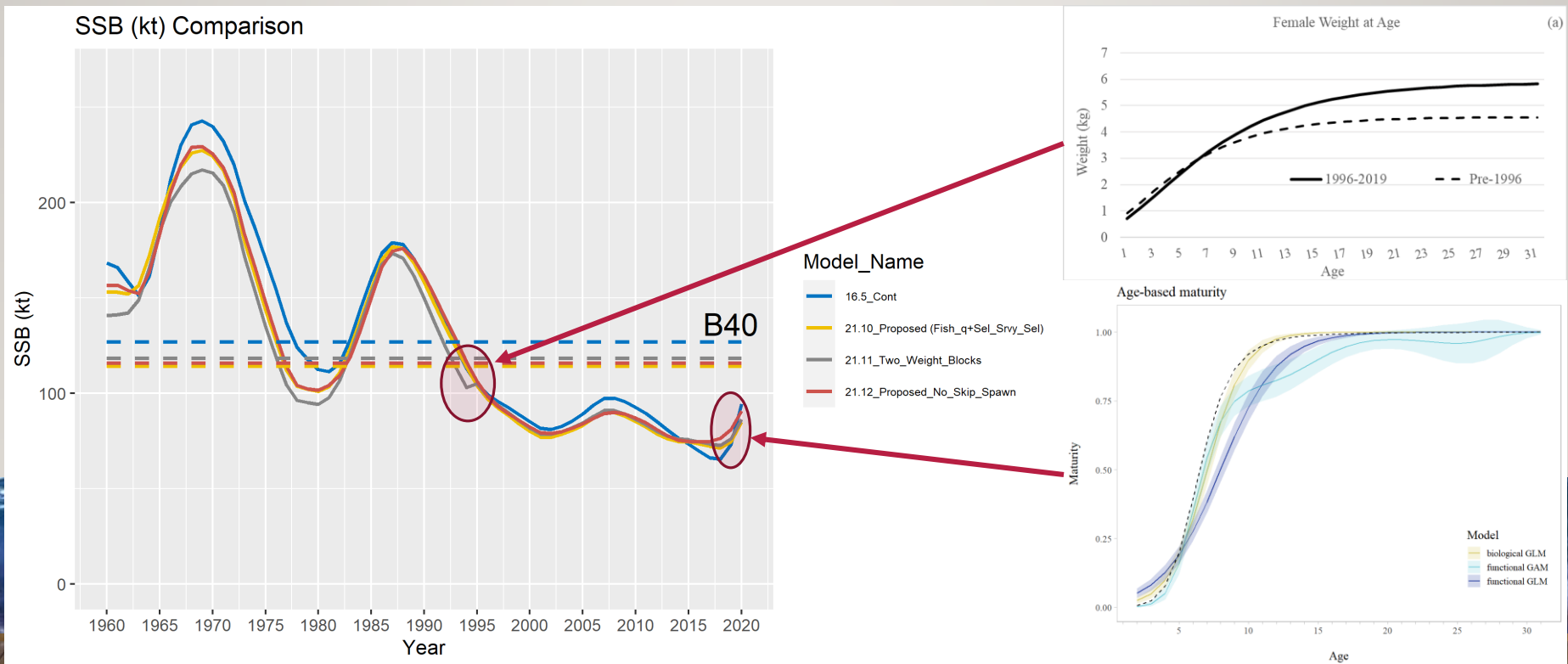
6 MODEL UPDATES JUSTIFICATION

- Gear composition (>50% catch from pots) and targeting (avoidance of small sablefish) clearly changing
 - Impacts availability (catchability) and selectivity
- Indications that survey availability may be changing, but primarily for younger ages (smaller sizes)
 - Impacts availability of certain ages, which is best accounted for through selectivity (not catchability)



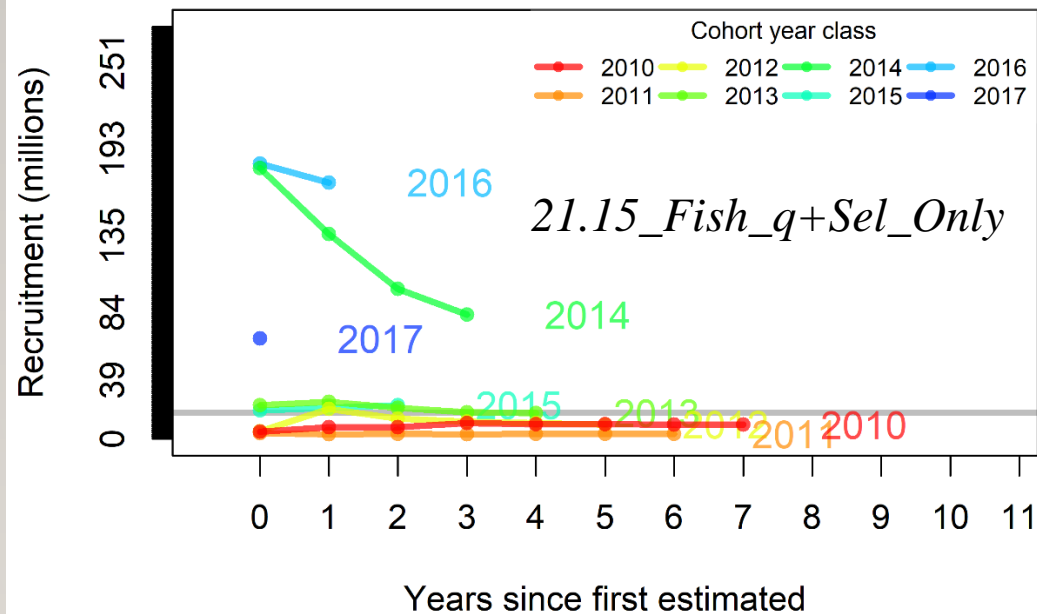
8 PT & SSC CONCERNS — WEIGHT BLOCKS & SKIPPED SPAWNING

- Historic weight-at-age not realistic
- Skipped spawning has limited impact until recent years (due to young fish), but high uncertainty



9 FULL MODEL BUILDING RESULTS

Sablefish recruitment retrospective



- Summary:
 - Survey time blocks have biggest impact
 - Catchability changes scaling, selectivity impacts recent recruitment
 - Fishery catchability allows better fit to CPUE data, while causing minor population rescaling
 - Fishery selectivity reduces recruitment, but does not resolve retrospective patterns

10 2021 SAFE PROPOSED MODEL

- *21.12_Proposed_No_Skip_Spawn*
 - Same as *21.10_Proposed*, but using an **age-based GLM to estimate maturity *without* incorporating information on skipped spawning**
 - 2 time blocks for growth, updated with recent data
 - 1 time block for weight, updated with recent data
 - No catchability priors
 - Recent time block (starting in 2016) for fishery catchability+selectivity and survey selectivity
 - Francis reweighting

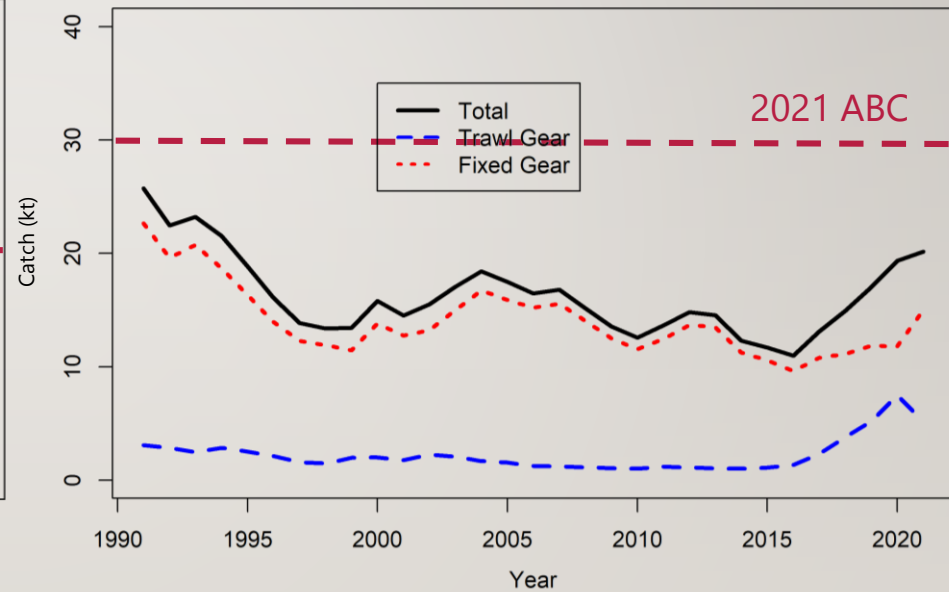
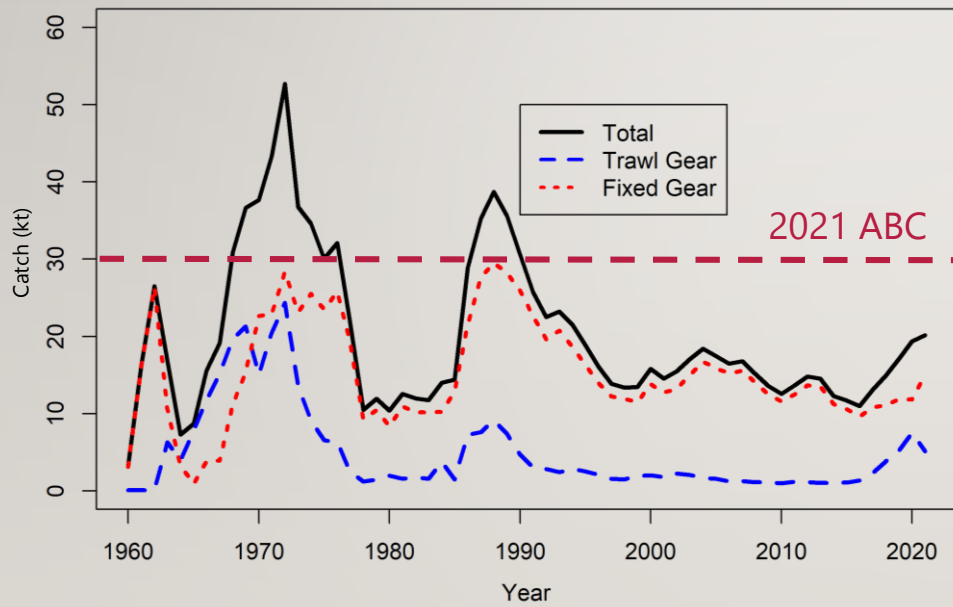


11 NEW DATA

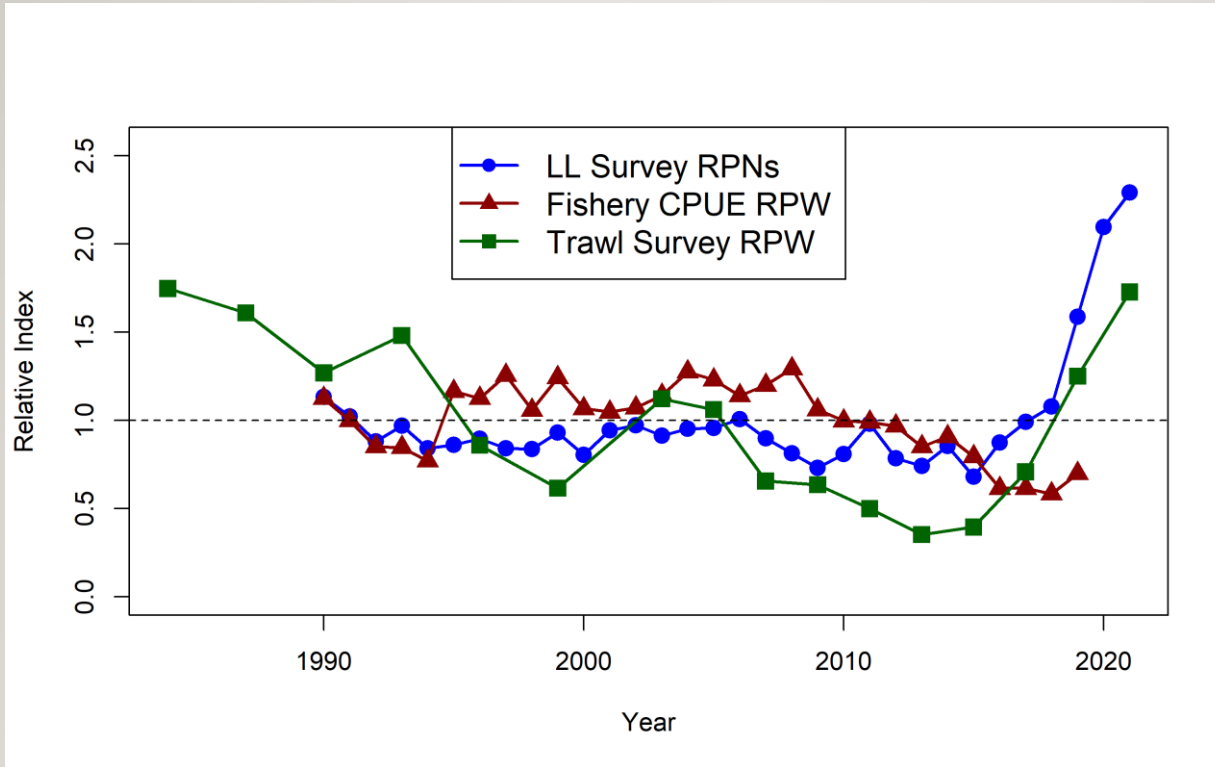
- Catch
 - Updated catch for 2020
 - New estimated/specified catch for 2021 – 2023
 - Updated whale depredation estimates for 2021 – 2023
- Relative abundance
 - 2021 longline survey (GOA+BS)
 - 2021 GOA trawl survey (<500m)
 - 2019 longline fishery CPUE—no 2020 updates
- Ages
 - 2020 longline survey
 - 2020 fixed gear fishery
- Lengths
 - 2021 longline survey
 - 2021 trawl survey
 - 2020 fixed gear fishery
 - 2020 trawl fishery



12 RECENT CATCH



13 INDICES IN THE MODEL



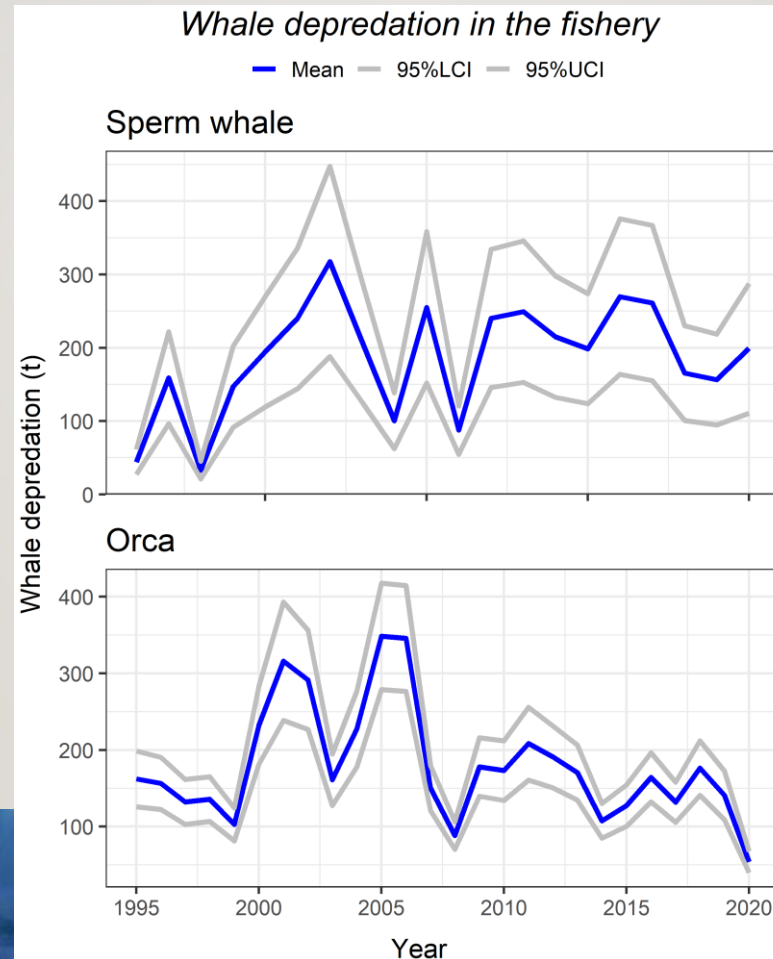
10% Increase

40% Increase

10% Increase
(in 2019; no 2020 data)

14 WHALES IN THE FISHERY

We are now getting whale observations in logbooks! But not yet incorporated due to short time series.



Depredation directly accounted for in assessment and projections.

MODEL SPECIFICATION

15 (21.12_PROPOSED_NO_SKIP_SPAWN)

- 1 Area across entire GOA+BSAI
 - All data and assumed dynamics aggregated across entire area
- Sex-specific dynamics (i.e., growth and selectivity)
- Input biological parameters (i.e., growth, maturity, weight)
- No stock-recruit relationship
 - Yearly recruit deviations from average recruitment (+deviations for initial abundance)
 - Terminal year recruitment fixed at average
- Fit longline survey (i.e., coop and domestic) and trawl survey indices and associated composition data (length and/or age)
 - Trawl survey selectivity assumes power function (i.e., exponential decay) with age
 - Longline survey assumes logistic selectivity with recent (since 2016) time block



MODEL SPECIFICATION

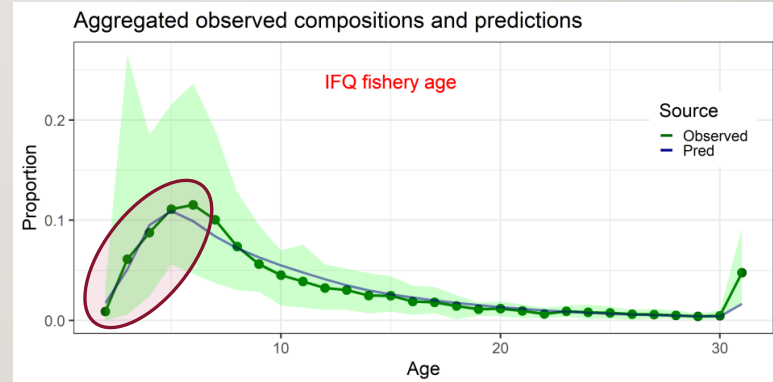
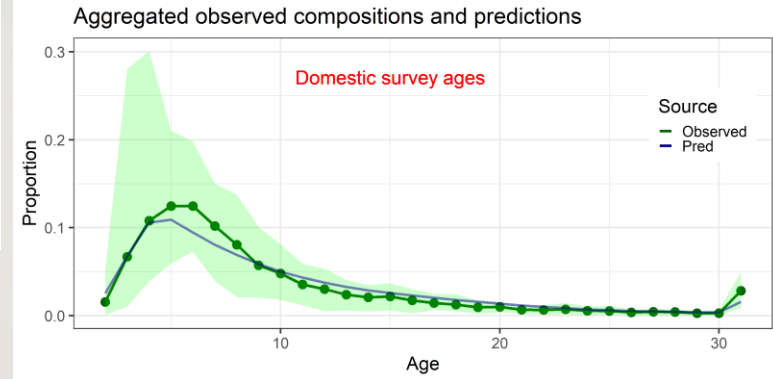
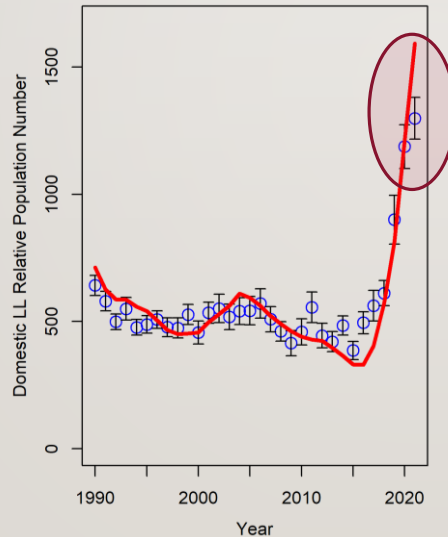
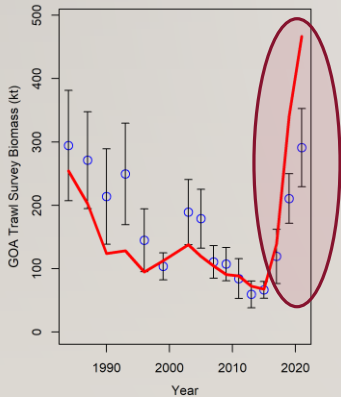
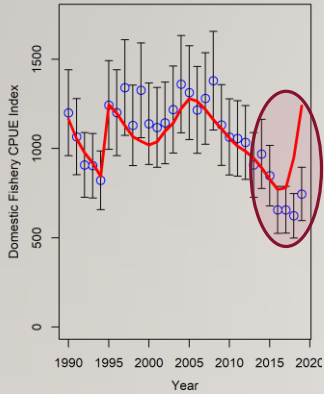
16 (21.12_PROPOSED_NO_SKIP_SPAWN)

- Natural mortality (M) is time-/age-invariant and estimated with prior
- 2 fleets: fixed gear and trawl
 - Trawl fleet assumes domed selectivity
 - Fixed gear fleet assumes logistic selectivity
 - Fixed gear fishery dynamics modeled separately before and after IFQ, and with an additional recent (since 2016) catchability+selectivity time block
- Yearly fishing mortality deviations for each fleet
- Catch = landings + discards (100% mortality)
- Maximum likelihood estimation
 - Francis reweighting applied

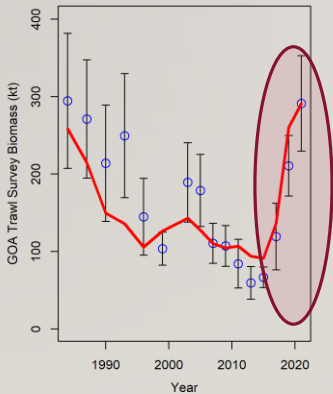
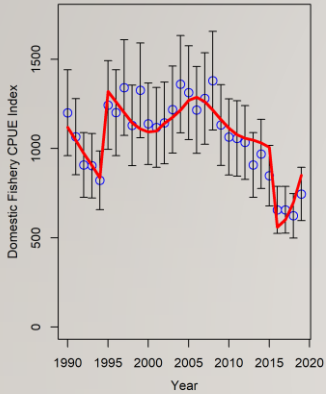


17 MODEL 16.5: POOR FIT TO INDICES

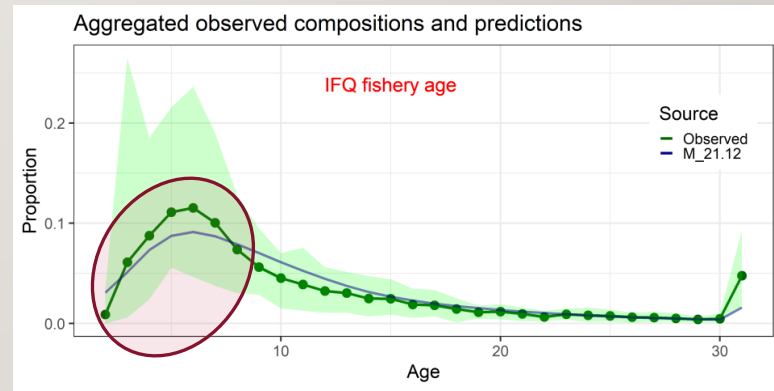
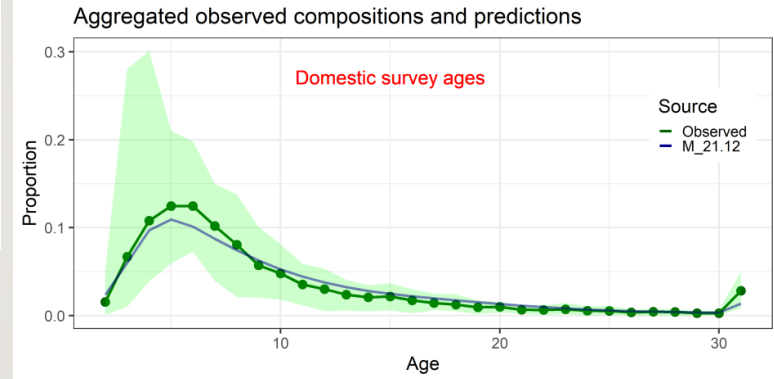
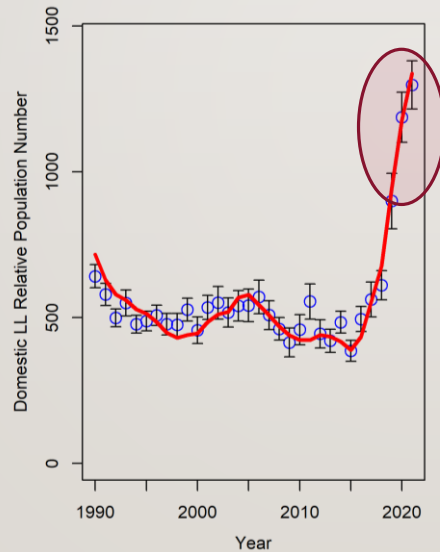
Extreme year class strength informed by compositional data, which leads to overpredicting population growth from indices.



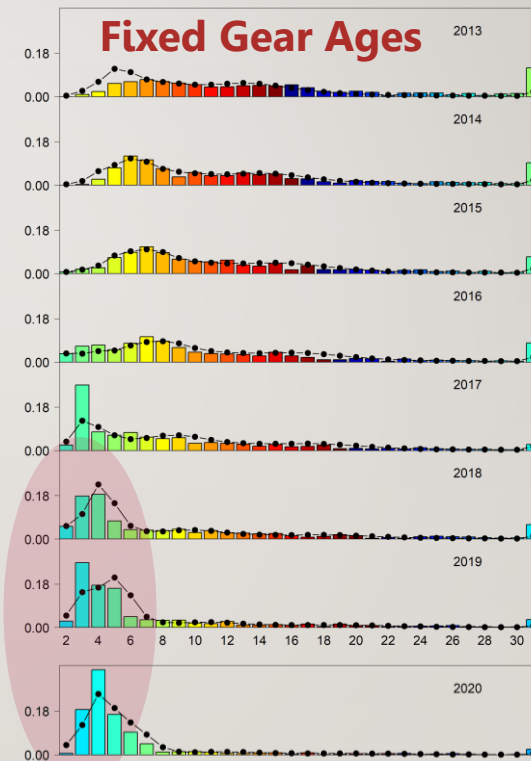
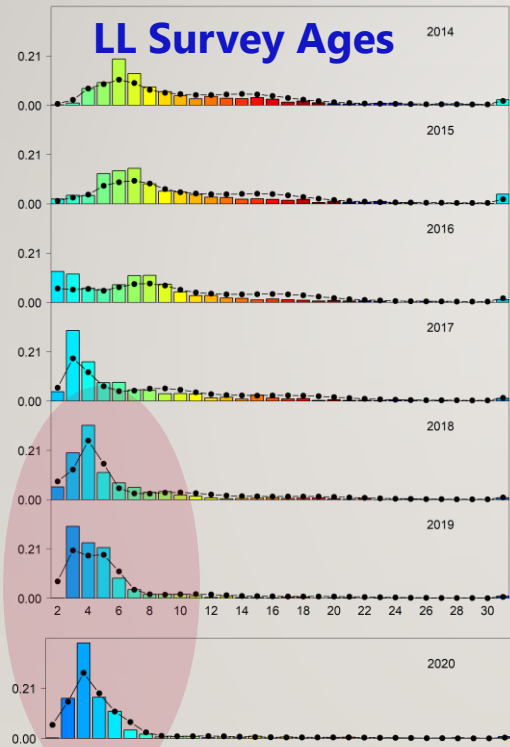
18 MODEL 21.12: WHO DO YOU TRUST?



New parametrization with Francis reweighting better fits indices, but at cost of fitting age compositions.

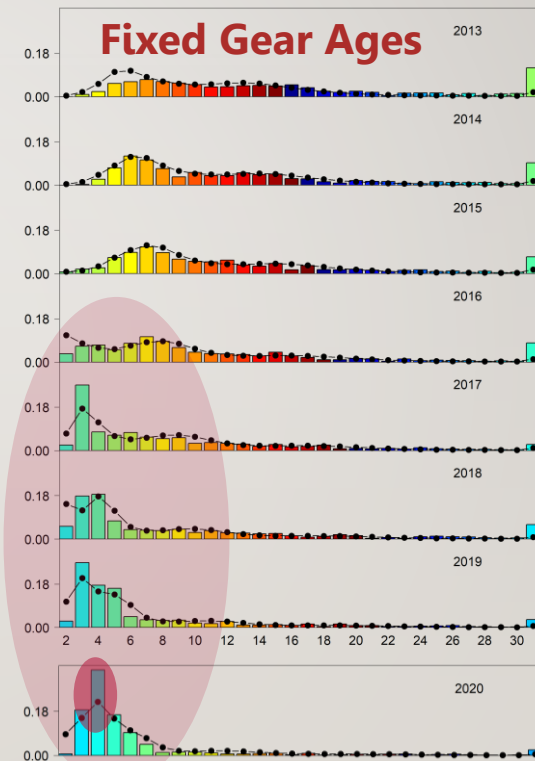
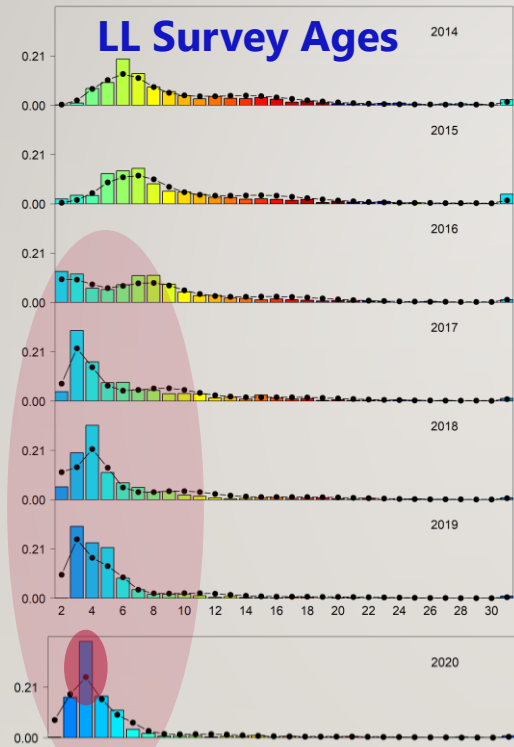


19 MODEL 16.5 CONTFIT TO AGES



Decent fit to high LL survey age comps for recent cohorts, but underestimates age-3 and age-4 abundance. Overestimating cohort sizes as they age in fishery.

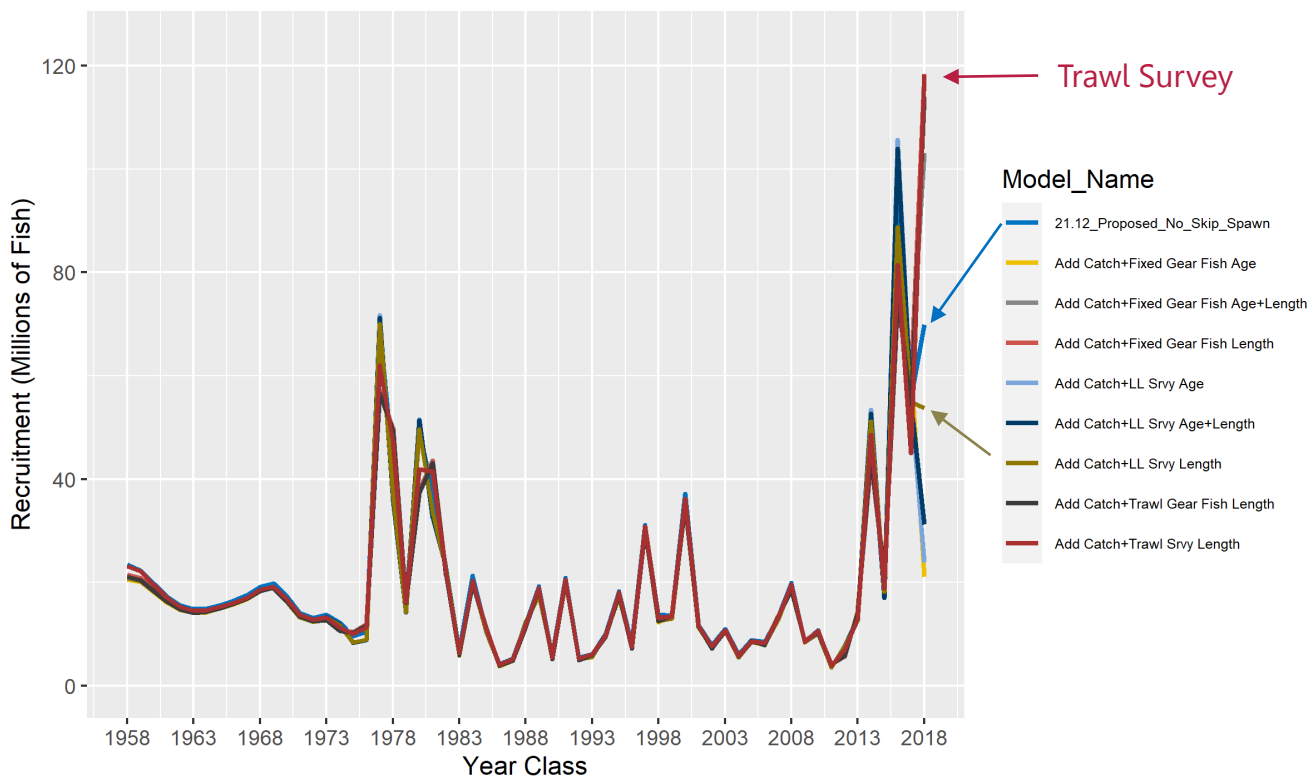
20 MODEL 21.12 FIT TO AGES



Overestimation of age-2 abundance.
Underestimation of age-3+age-4 abundance.
Good fit to cohort decay in fishery.

21 DATA UPDATE IMPACTS

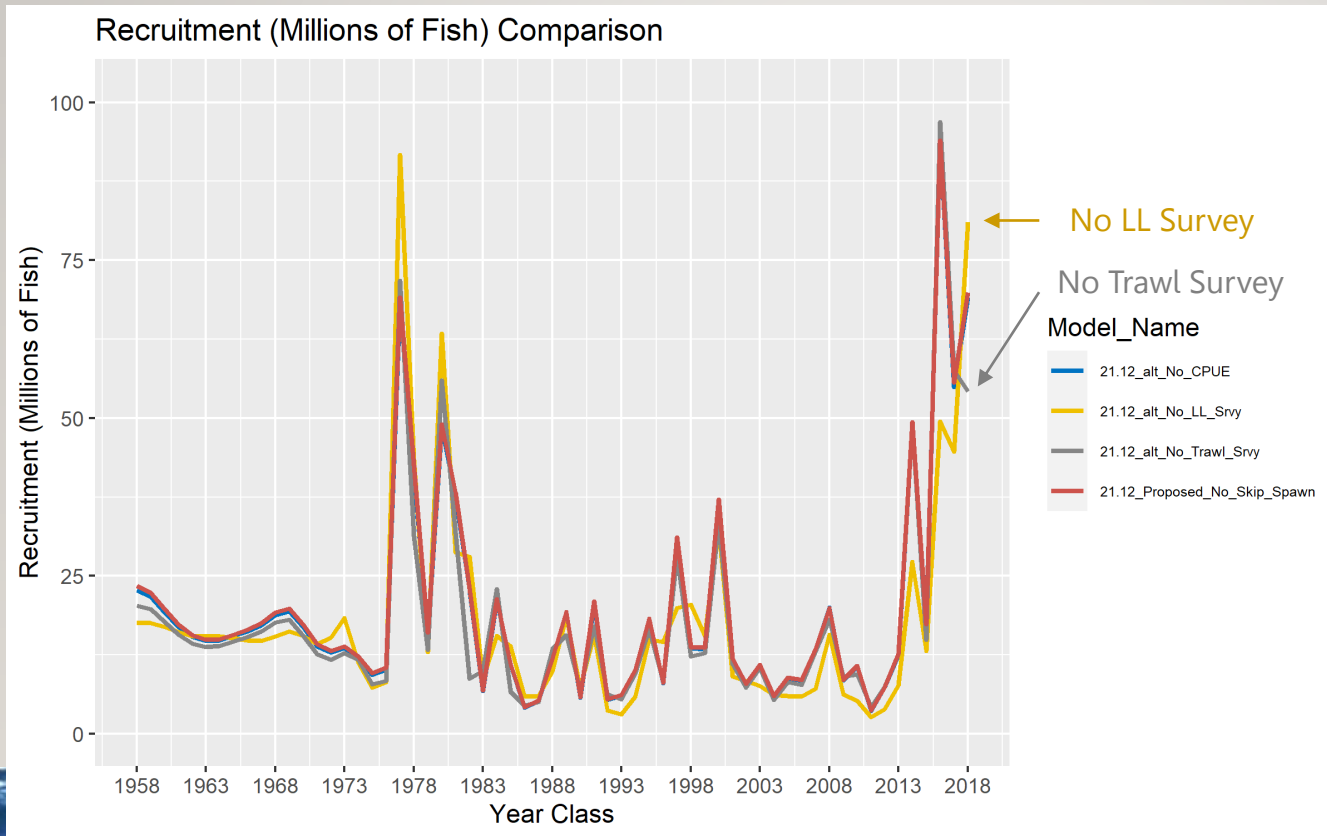
Recruitment (Millions of Fish) Comparison



2018 recruitment based primarily on 2021 trawl survey.

LL survey lengths suggest more moderate year class size.

22 INDEX JACKKNIFE ANALYSIS



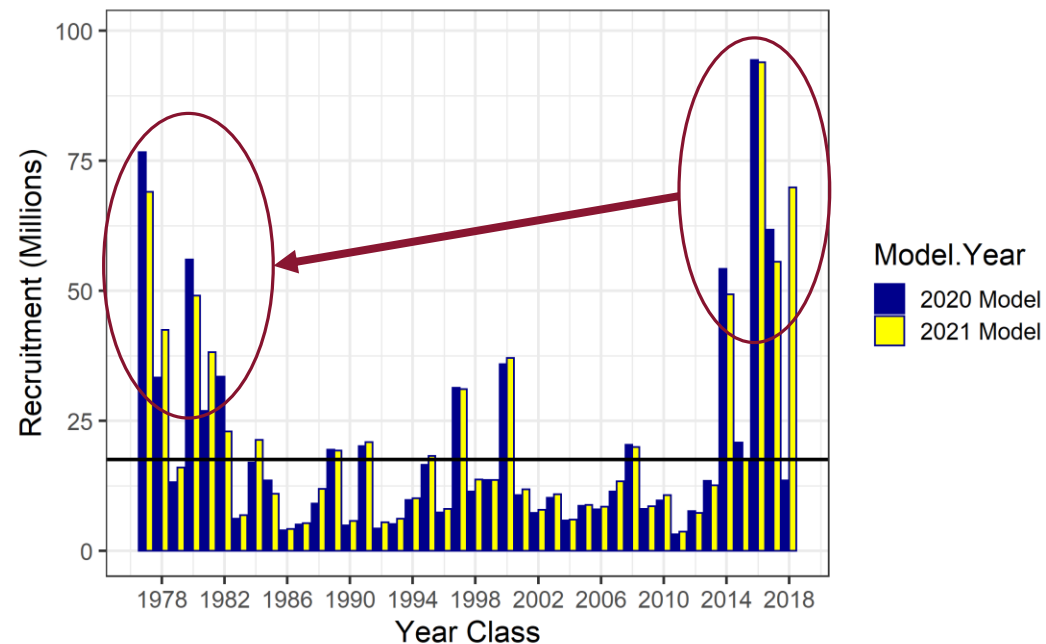
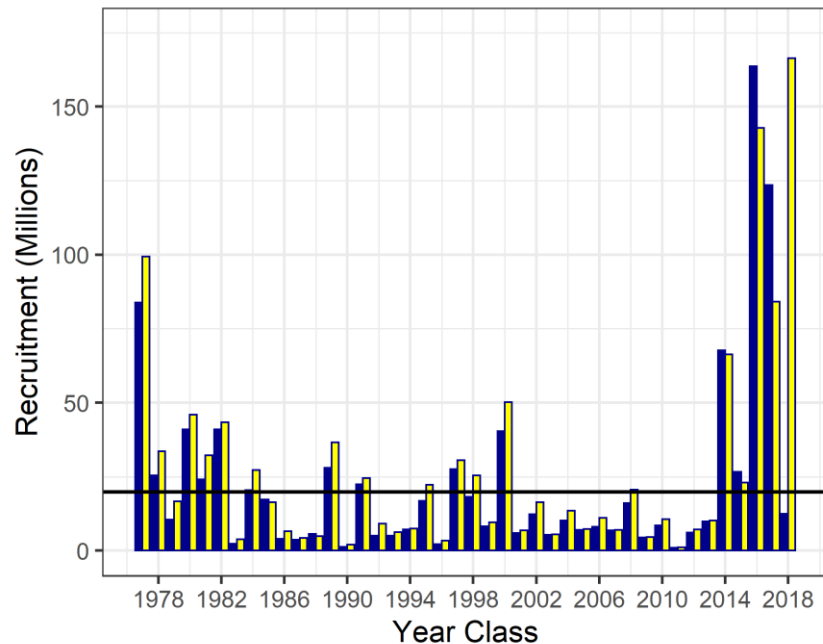
2018 recruitment based primarily on 2021 trawl survey.

LL Survey driving recent recruitment patterns.

23 RECRUITMENT

16.5_Cont

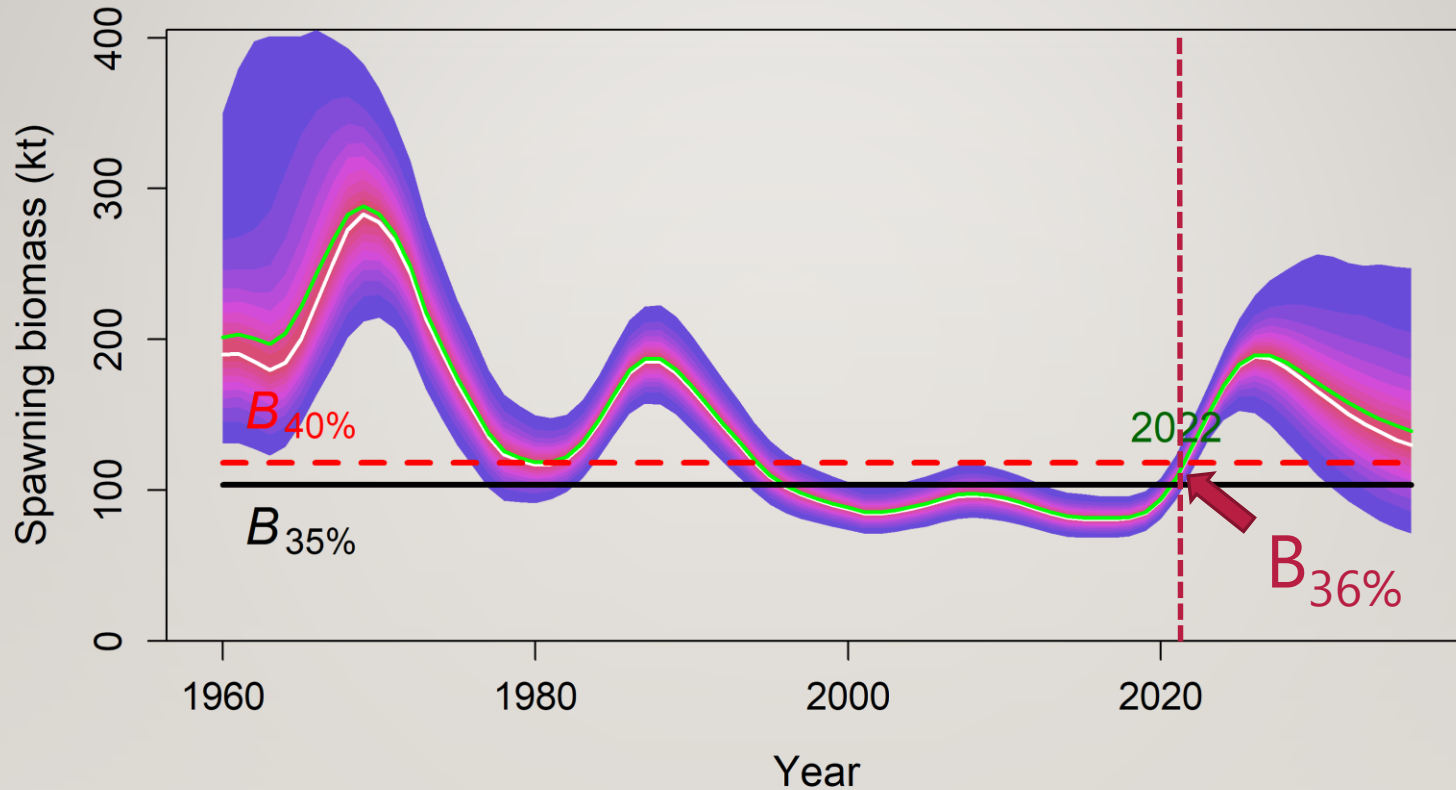
21.12_Proposed_No_Skip_Spawn



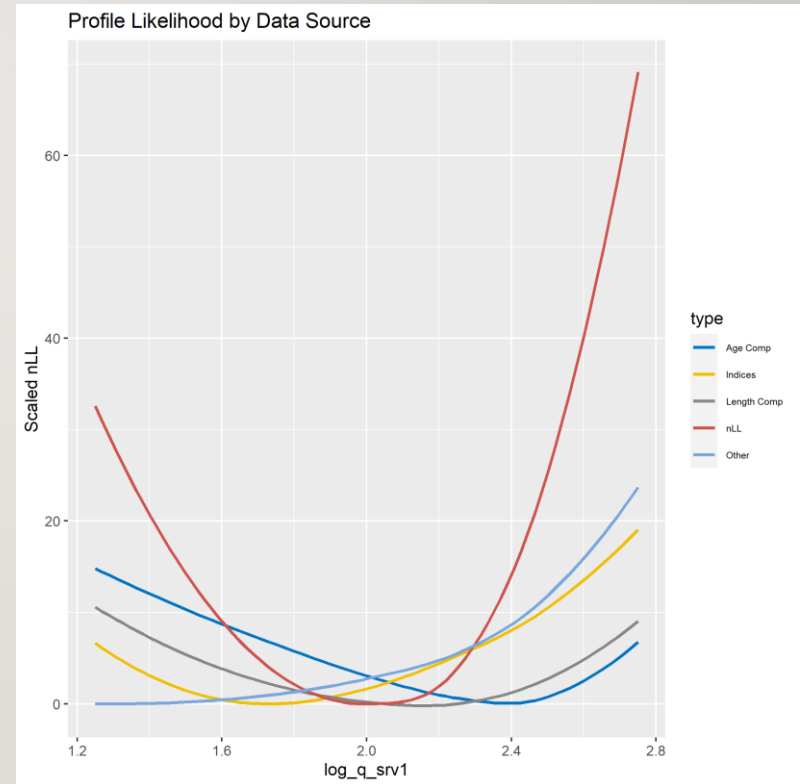
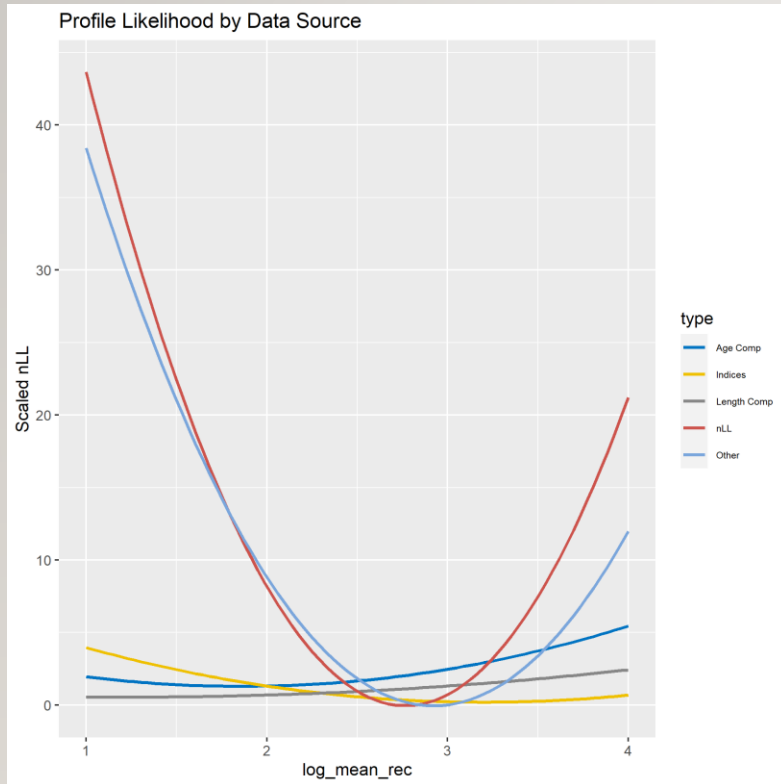
Notice rescaling of magnitude of recruitment across models.

Current series of recruitment appears to match pattern of late 1970s recruitment.

24 SPAWNING BIOMASS INCREASING



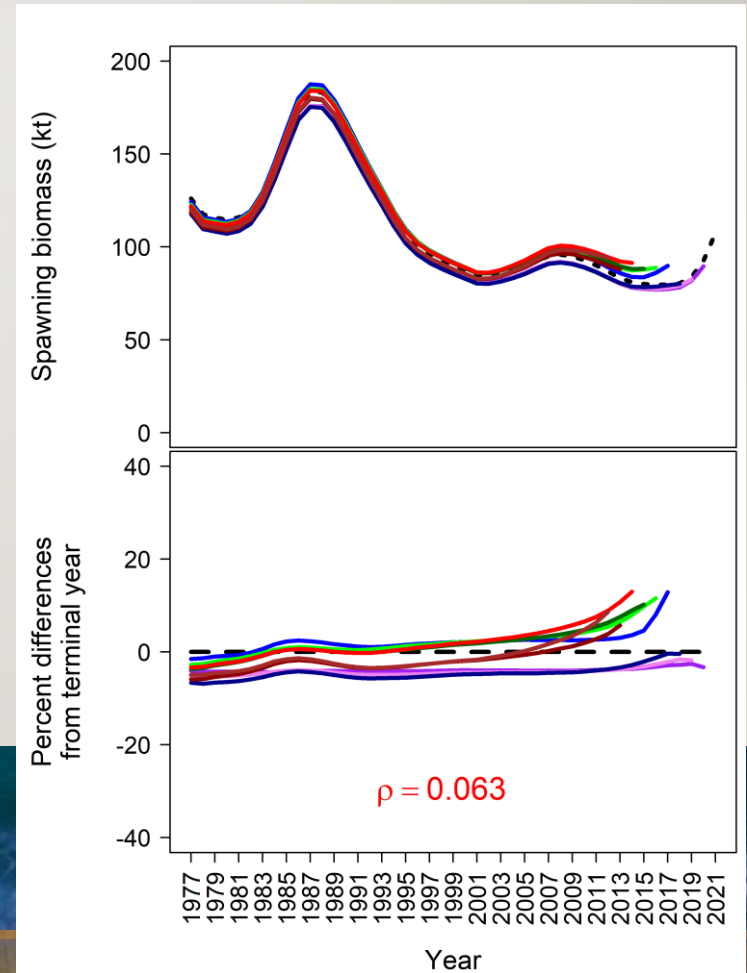
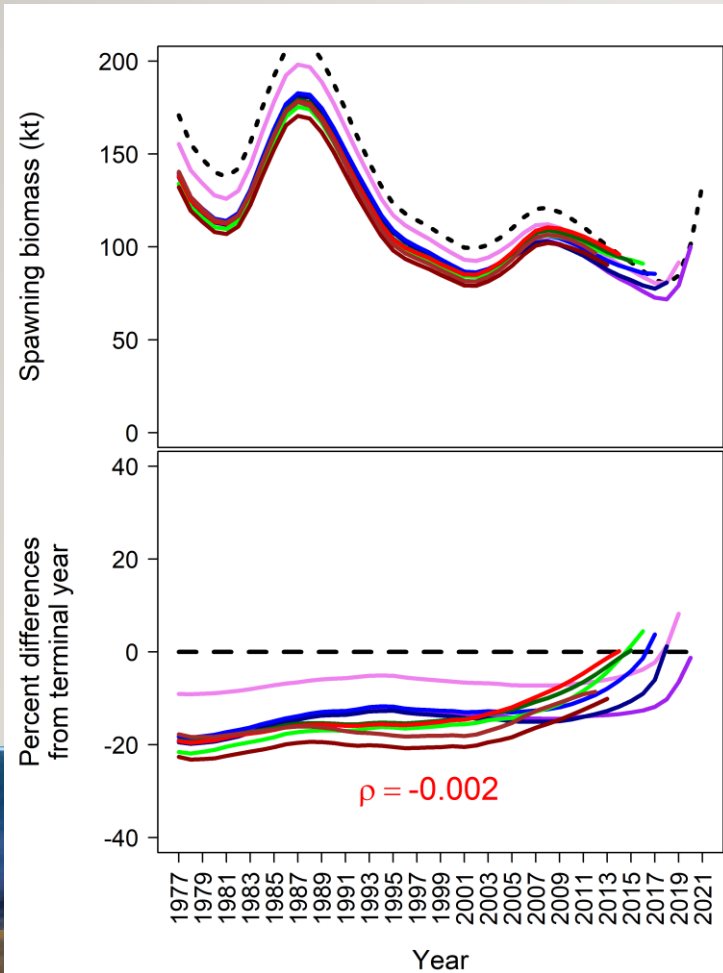
25 LIKELIHOOD PROFILES



26 RETROSPECTIVE BIAS, RESOLVED?

16.5_Cont

21.12_Proposed_No_Skip_Spawn

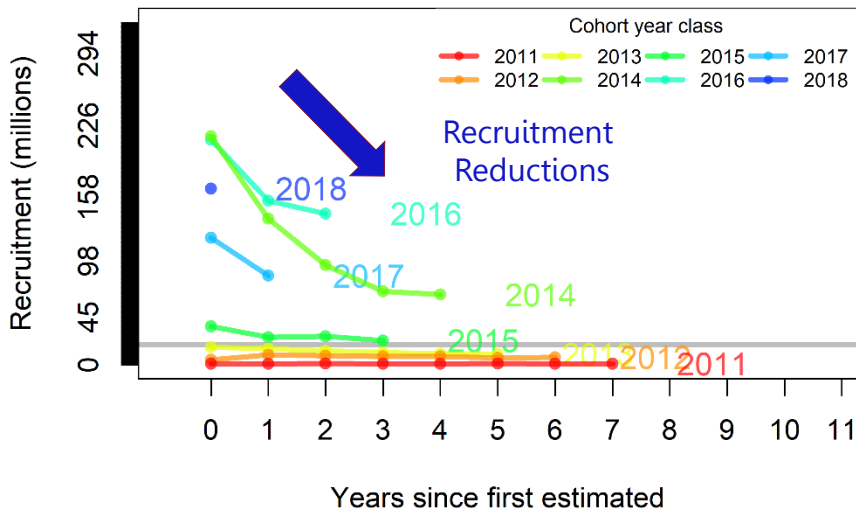


27 INCREASED CONSISTENCY

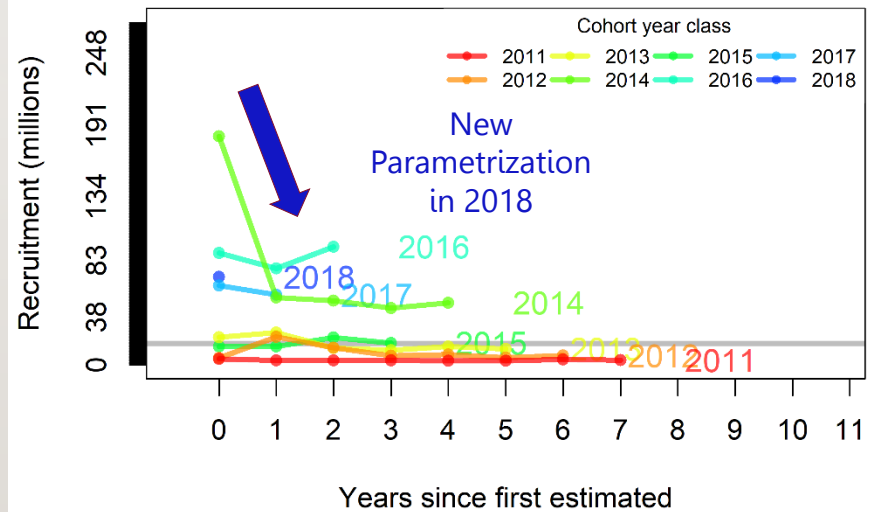
16.5_Cont

21.12_Proposed_No_Skip_Spawn

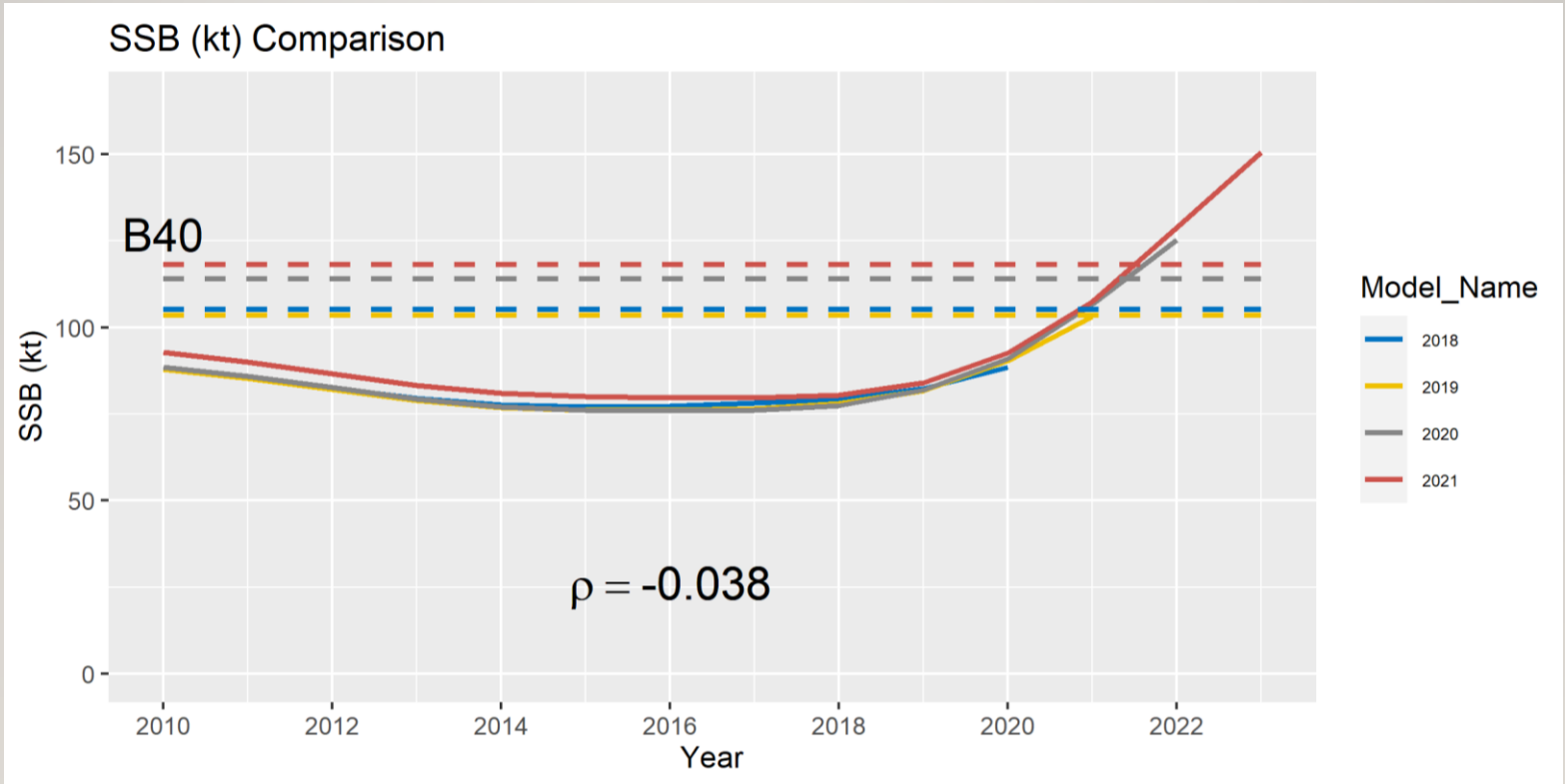
Sablefish recruitment retrospective



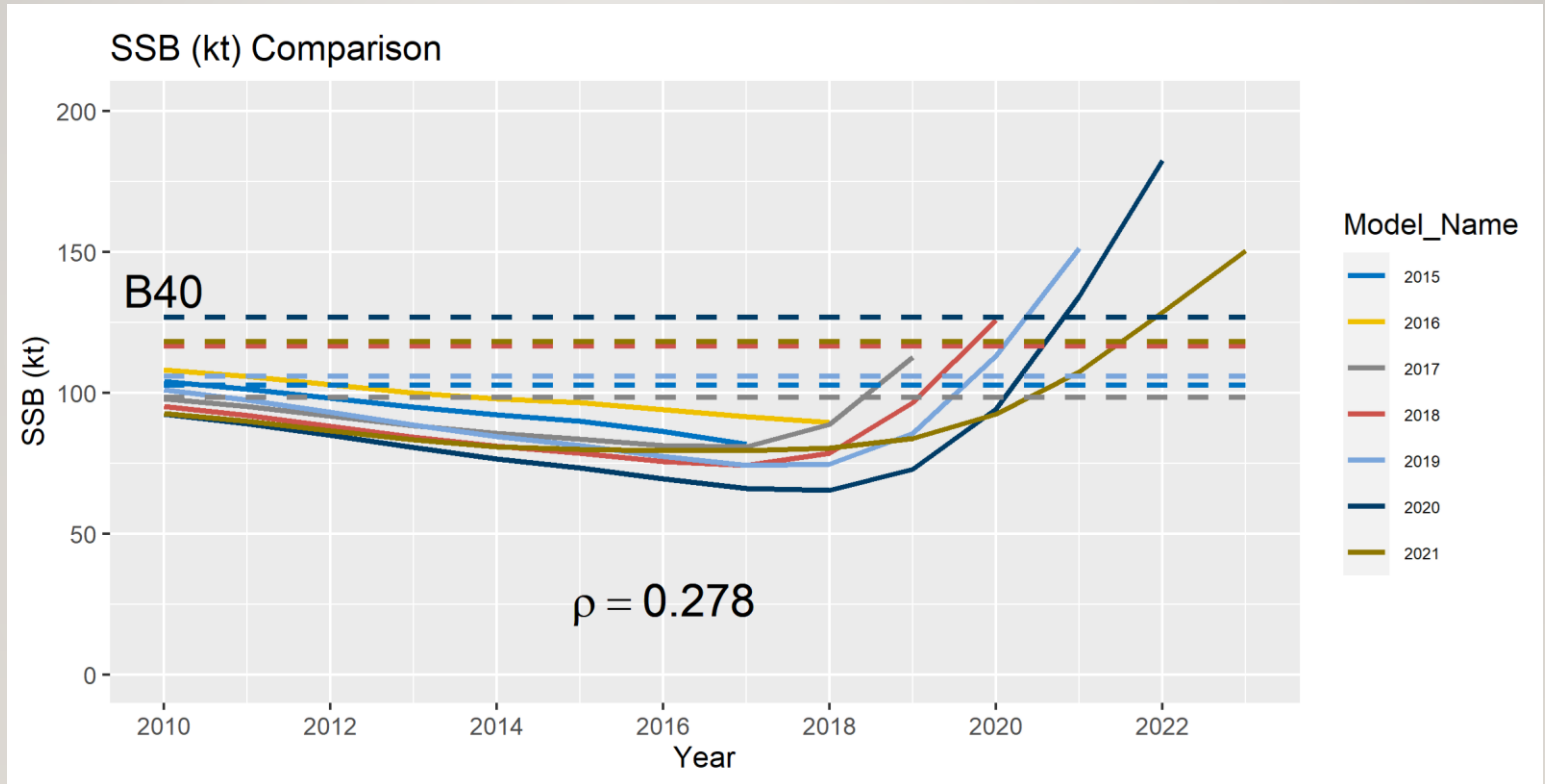
Sablefish recruitment retrospective



28 PROJECTION CONSISTENCY

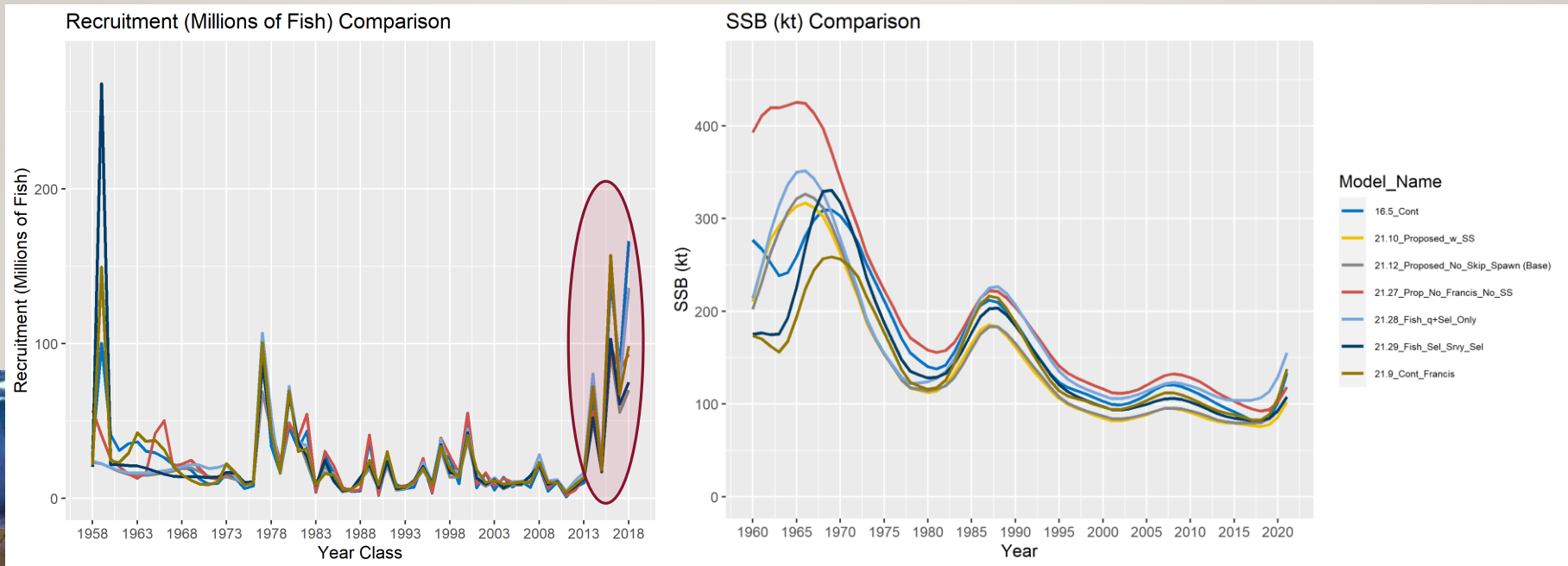


29 SAFE TO SAFE CHANGES



30 SENSITIVITY RUNS

- *21.12_Proposed_No_Skip_Spawn* is one of the most pessimistic models
- *21.28_Fish_q+Sel_Only* is one of the most optimistic models (still has retro issues)
- Francis reweighting leads to better fits to the indices and reduced terminal year recruitment (+more consistent scaling)
- *16.5_Cont* estimates much higher recruitment and more rapid rebuilding (still has retrospective issues)



31 ASSESSMENT SUMMARY

- Model tension between fitting indices and compositional data
- Model indications:
 - Model 16.5 is:
 - Overfitting variability in compositional data
 - Reweighting helps, but does not solve retrospectives
 - Likely, suffering from process error, potentially due to:
 - Increased juvenile mortality from age-2 to age-7 (overestimating abundance)
 - Change in availability/selectivity (overestimating recruitment)
 - Model 21.12 is:
 - Emphasizing indices over compositions (due to reweighting)
 - Assuming a change in availability/selectivity, which leads to smaller estimates of initial year class sizes and better fit to cohort decay in age data



32 ASSESSMENT SUMMARY

- Recent year classes are large, but may not be unprecedented
 - Align (yet still exceed) period of strong recruitment in late 70s and early 80s
 - 2018 looks to be another very strong year class, but may decrease slightly as more age observations are obtained and the first precise age data observations (i.e., at age-3 in 2021) are included in 2022 SAFE
- SSB increasing rapidly and should be above *B40%* in 2022
- F is decreasing and well below M
- Reduced retrospective patterns
- *21.12_Proposed_No_Skip_Spawn* is one of the more pessimistic models explored, but seems justified given data and performance
 - Longline survey recent selectivity time block needed to remove retrospective bias
- 2-year projections are remarkably consistent with realized SSB in subsequent year models



33 FUTURE DATA ISSUES

- Logbook data availability uncertain, which is key component of CPUE index
- How can electronic monitoring data be incorporated into CPUE index?
- What is the future of biological sampling as EM coverage quickly replaces observer coverage?
- How do we account for pot gear transition?
 - Incorporate into CPUE index and/or directly within assessment model?
 - Need to get a better handle on dynamics and usage of rigid vs. slinky pots
- Age sampling from trawl gear could be helpful for the assessment
- Improved data collection from BSAI, given apparent shift in distribution

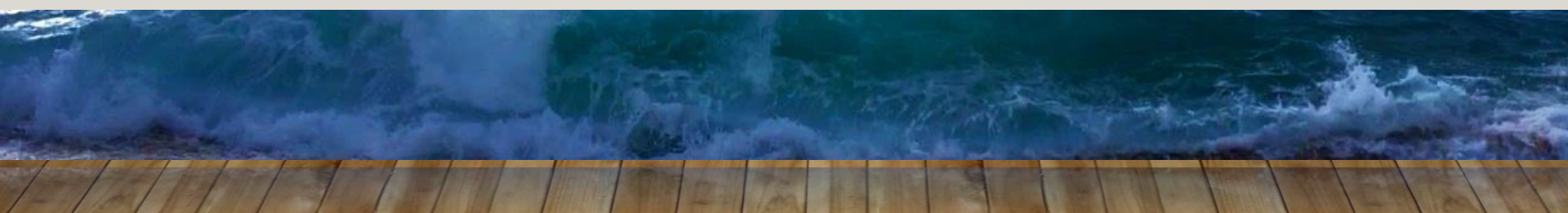
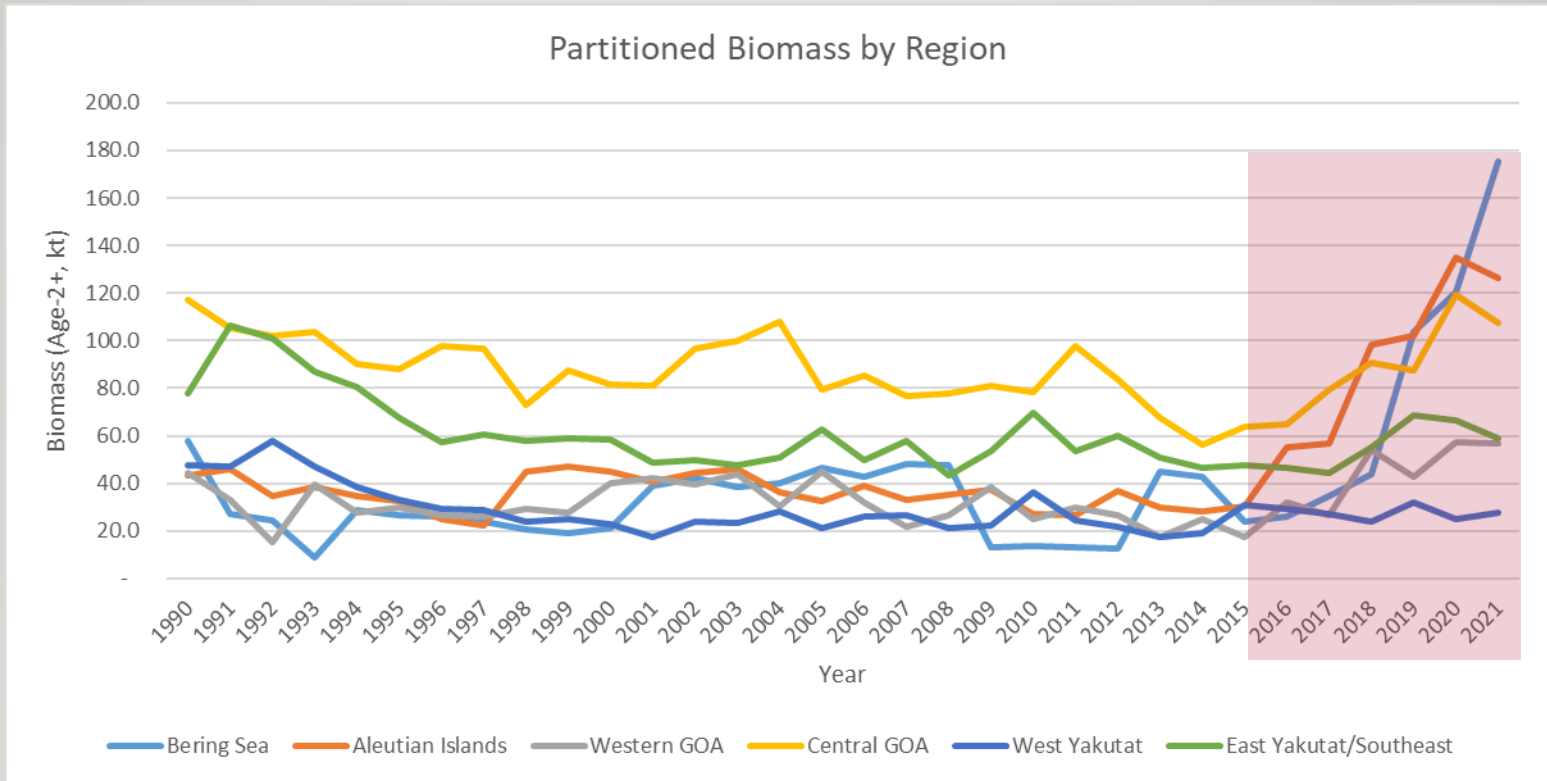


34 FUTURE DIRECTIONS

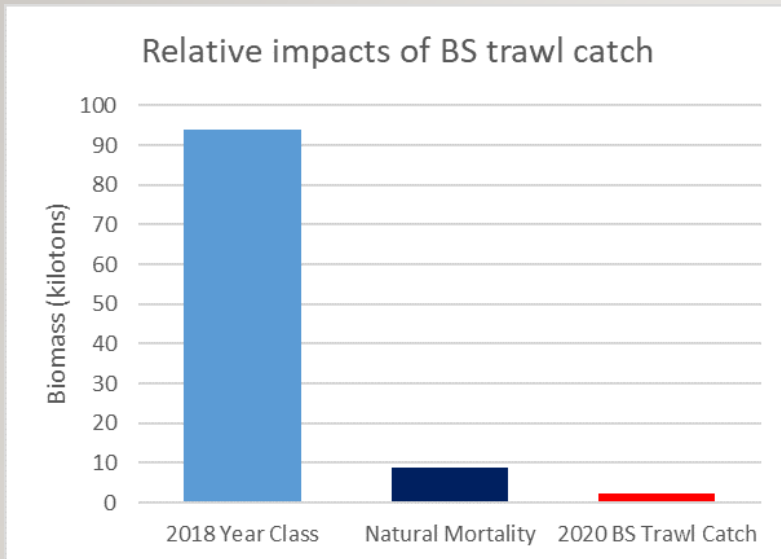
- ~~Improve data weighting and move on from CIE recommendations~~
- ~~Address changes in availability and targeting by estimating time-varying selectivity (in conjunction with data weighting)~~
 - Explore full time-varying, non-parametric selectivity
- ~~Reassess biological parameters and assumptions (growth, mortality)~~
- Explore time- or age-varying natural mortality and develop parsimonious parametrizations
- Update whale depredation coefficients (M. Williams working on this and will have new values for 2022)
- Refine CPUE index and account for pot gear transition
 - Masters student at UAF currently working on these issues
- Incorporate tagging data
- Further refine spatial modeling efforts
 - Post-doc in process of being hired to develop tag-integrated spatial model
- Develop MSE to test robustness of NPFMC HCR to spasmodic recruitment dynamics of sablefish
 - Post-doc being sought to develop MSE tool



35 APPROXIMATE DISTRIBUTION



36 EBS TRAWL REMOVALS



Trawl removals in BS represent a small proportion of total biomass.

Year	Non-pelagic	Pelagic	Total
2010	29	1	30
2011	44	0	44
2012	93	0	93
2013	133	0	133
2014	34	0	34
2015	17	0	17
2016	239	18	257
2017	588	91	679
2018	623	395	1,018
2019	1,283	1,223	2,506
2020	1,071	3,397	4,468
2021	1,248	1,076	2,324

BS trawl catch decreased in 2021 (as did % catch coming from the trawl fleet).



37 RISK TABLE FRAMEWORK

- Assessment model: 1 -- Normal
 - No data issues, retrospective patterns eliminated
- Population dynamics: 2 -- Increased Concern
 - Contracted age structure, rapid change in abundance
- Ecosystem: 1 -- Normal
 - Neutral to positive indicators, reduced competition
- Fishery Performance: 2 -- Increased Concern
 - Rapid transition to pot gear, potential changes in targeting
- **No recommended reduction in Max ABC**



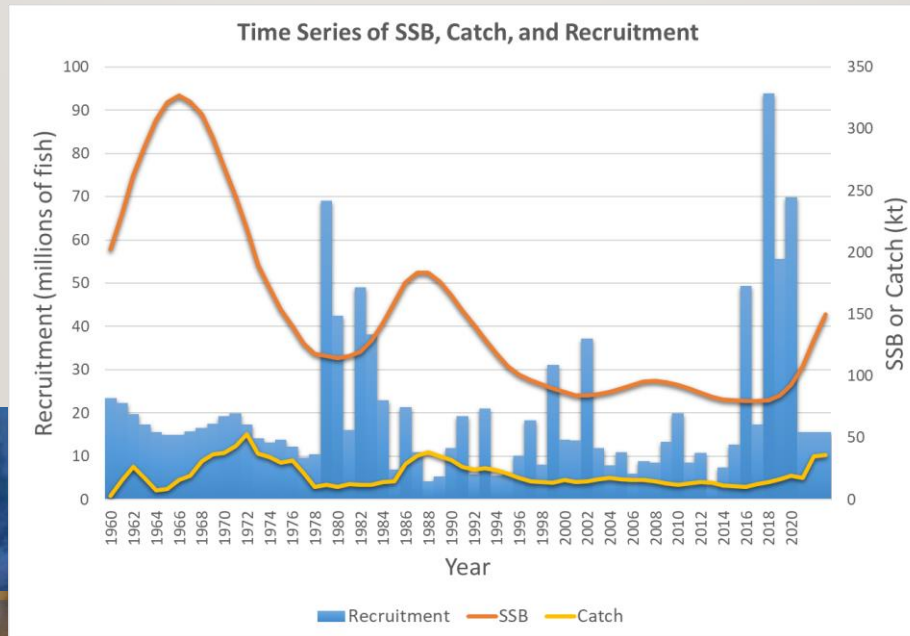
38 BOTTOM LINE

- New model, same upward trends
- More consistent recruitment estimation allows use of max ABC projections
- 2022 Author's ABC = Max ABC = 34,521 t
 - **+18% from 2021 ABC**
 - Would represent an ~tripling of quota since 2016 (11,795 t)
- **Apportionment based on 5-year average survey biomass proportions and year 2 (50%) of SSC 4-year stair step**

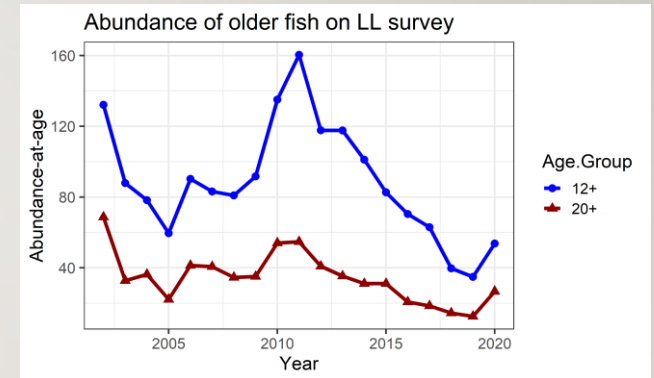
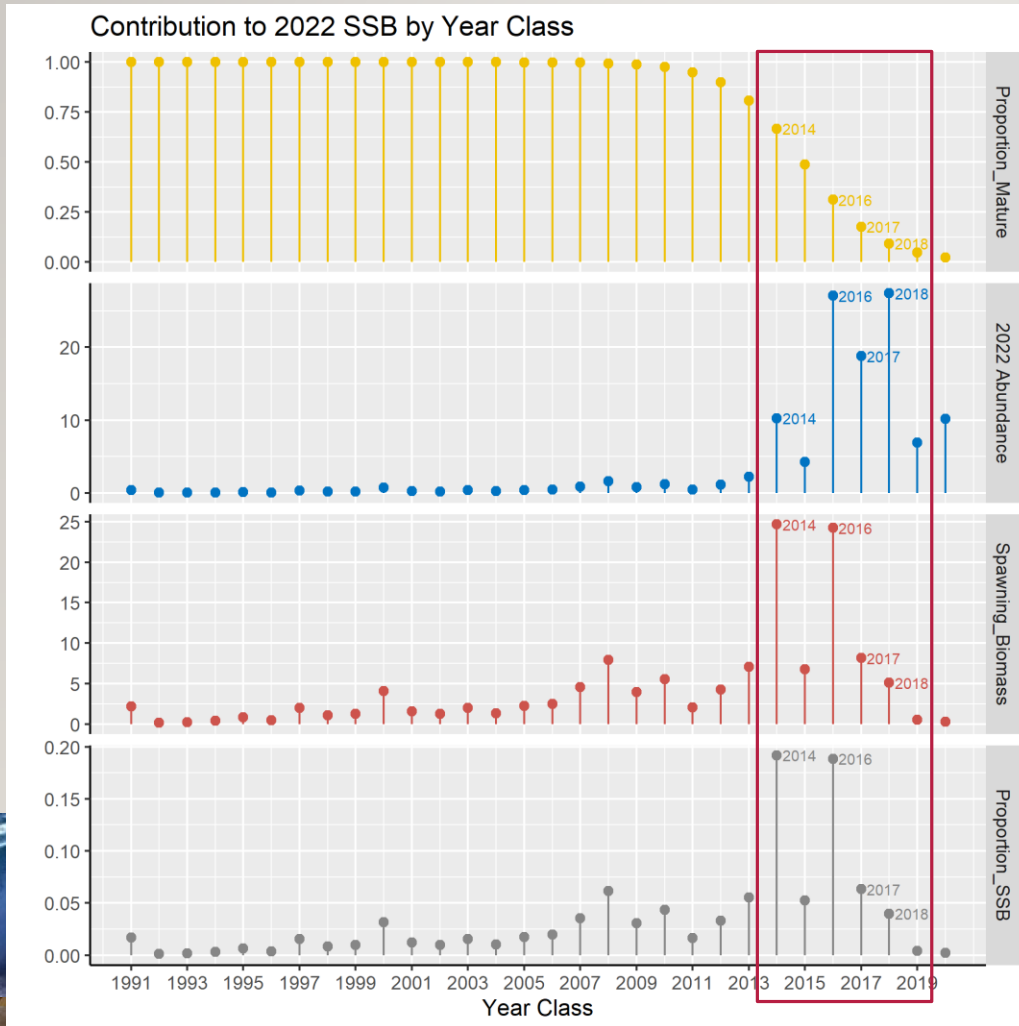


39 FOOD FOR THOUGHT

- ABC would be highest catch since late 1980s and early 1970s
 - Both periods were associated with subsequent, protracted population declines
- Beware high catches if recruitment reverts to a low productivity regime
- Capped management procedures could maximize long-term harvest
- Alternate SSB metrics could protect the age structure and improve resilience
 - SSB would be reduced by >50% if only fully mature ages included (important implications for HCR)



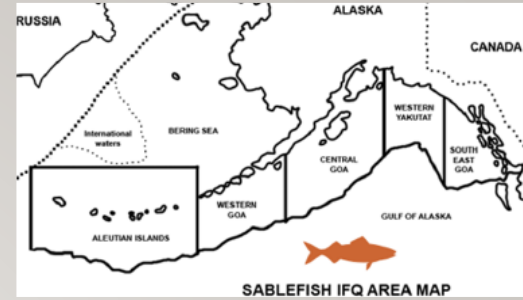
40 IMMATURE SABLEFISH



SSB relies heavily on these recent year classes (> 50% of SSB), which are not fully mature.



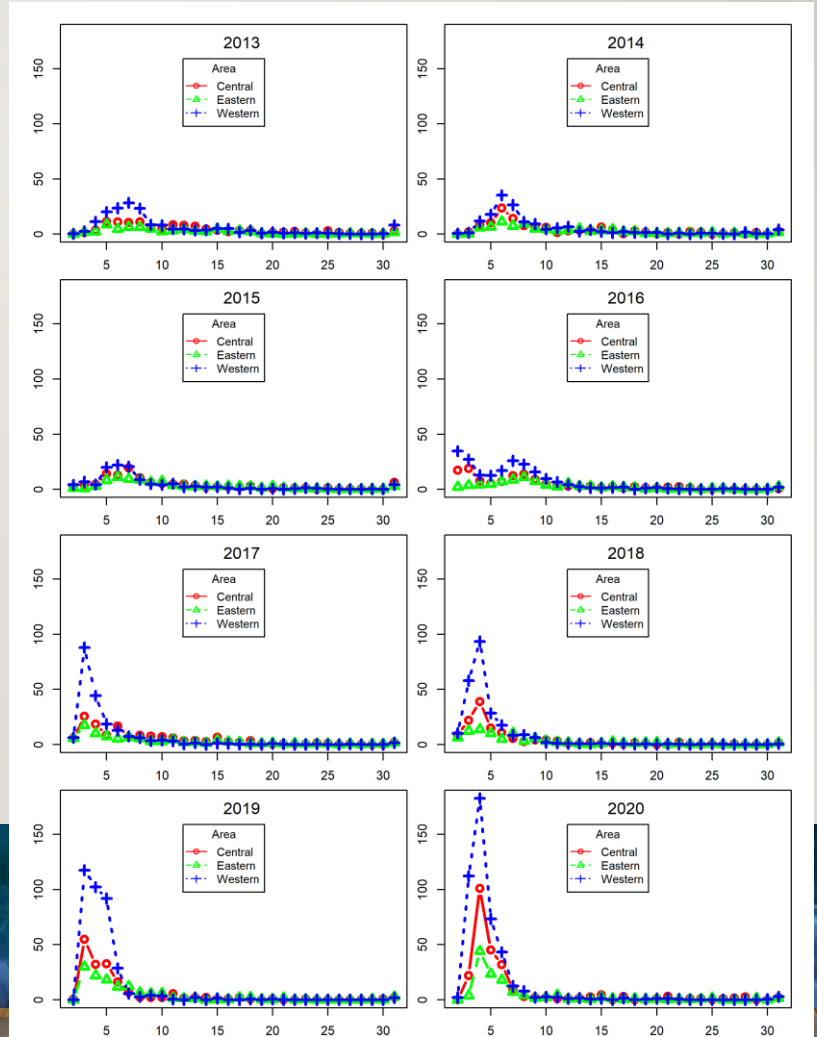
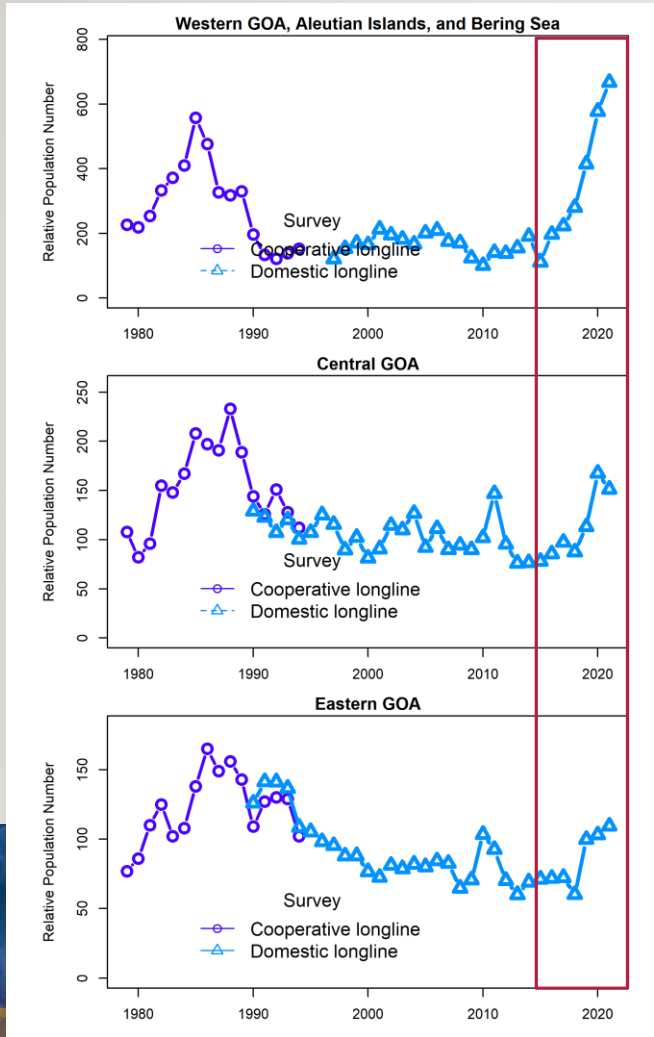
41 APPORTIONMENT



- 5-year average of regional survey biomass proportions
 - Addresses biological concerns (avoids localized depletion)
 - This is **NOT** a static apportionment, the proportions will change yearly based on changing distributions and updated survey biomass
 - High BS longline survey catch in 2021 (~32% of LL survey biomass) resulted in increased apportionment to BS region
- Continuation of the SSC 4-year stair step approach
 - 50% step in 2022 (but SSC decision)



LL SURVEY BY AREA



43 WHALE ADJUSTED AUTHOR ABC

- Assumes 5-year average of regional survey biomass proportions
- 50% step from 2020 Fixed apportionment to 2021 5-year survey average apportionment

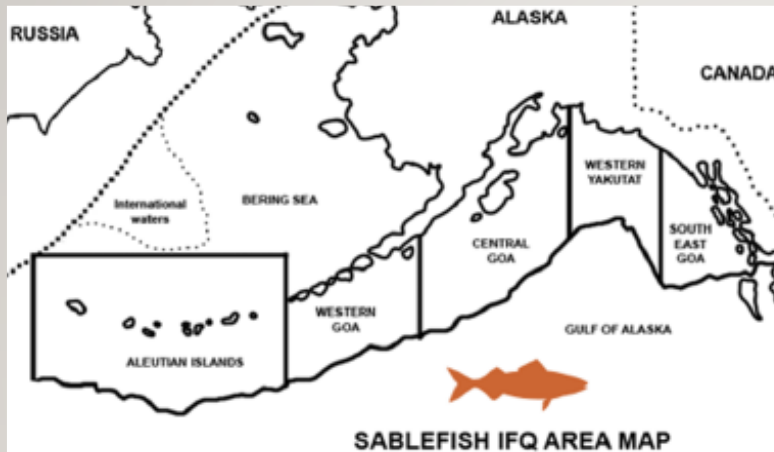
Year	2021				2022*		2023*	
Region	OFL _w	ABC _w	TAC	Catch**	OFL _w	ABC _w ***	OFL _w	ABC _w ***
BS	--	3,396	3,396	3,667	--	5,264	--	6,529
AI	--	4,717	4,717	1,359	--	6,463	--	7,786
GOA	--	21,475	17,992	12,919	--	22,794	--	22,003
WGOA	--	3,224	2,428	1,609	--	3,727	--	3,951
CGOA	--	9,527	8,056	5,868	--	9,965	--	9,495
***WYAK	--	3,451	2,929	2,156	--	3,437	--	3,159
***EY/SEO	--	5,273	4,579	3,286	--	5,665	--	5,398
Total	60,426	29,588	26,105	17,945	40,432	34,521	42,520	36,318

*Based on model *21.12_Proposed_No_Skip_Spawn* and assuming a 50% stair step from fixed apportionment towards author recommended 5-year average survey apportionment.

**As of October 28, 2021 Alaska Fisheries Information Network, (www.akfin.org).

***After 95:5 trawl split and after whale depredation adjustments.

44 QUESTIONS?



45 SUMMARY TABLE

Quantity/Status	As estimated or specified <i>last</i> year for:		As estimated or recommended <i>this</i> year for:	
	2021*	2022*	2022*	2023*
M (natural mortality rate)	0.098	0.098	0.100	0.100
Tier	3a	3a	3a	3a
Projected total (age 2+) biomass (t)	753,110	789,584	574,599	582,536
Projected female spawning biomass (t)	134,401	191,503	128,789	153,820
$B_{100\%}$	317,096	317,096	295,351	295,351
$B_{40\%}$	126,389	126,839	118,140	118,140
$B_{35\%}$	110,984	110,984	103,373	103,373
F_{OFL}	0.117	0.117	0.094	0.094
$maxF_{ABC}$	0.100	0.100	0.080	0.080
F_{ABC}	0.042	0.048	0.080	0.080
OFL (t)	61,319	71,756	40,839	42,948
OFL_w (t)**	60,426	70,710	40,432	42,520
max ABC (t)	52,427	61,393	34,863	36,670
ABC (t)	22,551	29,723	34,863	36,670
ABC_w (t)**	22,237	29,309	34,536	36,325
Status	As determined this year for:			
	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No



46 PLAN TEAM TABLES

Area	Year	Biomass (4+)*	OFL	ABC	TAC	Catch
GOA	2020	387,000	--	16,883	14,393	12,494
	2021	390,000	--	21,475	17,992	12,919
	2022	240,600	--	19,043	--	--
	2023	236,500	--	20,030	--	--
BS	2020	116,000	--	2,174	1,861	5,301
	2021	142,000	--	3,396	3,396	3,667
	2022	168,000	--	7,151	--	--
	2023	165,200	--	7,522	--	--
AI	2020	154,000	--	2,952	2,039	1,210
	2021	175,000	--	4,717	4,717	1,359
	2022	121,200	--	8,341	--	--
	2023	119,100	--	8,774	--	--

2022 ABC assumes 5-year survey average apportionment & 50% step from 2020 Fixed apportionment to 2021 5-year survey average apportionment.

*Biomass represents the value projected by the model used to determine the ABC in that year.



47 PLAN TEAM TABLES: 2022 ABC

Area	AI	BS	WG	CG	WY*	EY*	Total
2021 ABC	4,727	3,420	3,253	9,644	3,471	5,326	29,841
2022 ABC	6,486	5,305	3,821	10,008	3,179	6,064	34,863
2018 - 2020 Avg. Depredation	16	26	81	41	44	89	297
Ratio 2022:2021 ABC	1.37	1.55	1.17	1.04	0.92	1.14	1.17
Deduct 3-Year Adjusted Avg.	-23	-41	-95	-43	-40	-101	-342
**2022 ABC_w	6,463	5,264	3,727	9,965	3,139	5,963	34,521
Change from 2021 ABC _w	37%	55%	16%	5%	-9%	13%	17%

Assumes 5-year survey average apportionment & 50% step from 2020 Fixed apportionment to 2021 5-year survey average apportionment.

* Before 95:5 hook and line: trawl split.

** ABC_w is the author recommended ABC that accounts for whale depredation.



48 PLAN TEAM TABLES: 2023 ABC

Area	AI	BS	WG	CG	WY*	EY*	Total
2021 ABC	4,727	3,420	3,253	9,644	3,471	5,326	29,841
2023 ABC	7,813	6,580	4,051	9,536	2,911	5,778	36,670
2018 - 2020 Avg. Depredation	16	26	81	41	44	89	297
Ratio 2023:2021 ABC	1.65	1.92	1.25	0.99	0.84	1.08	1.23
Deduct 3-Year Adjusted Avg.	-27	-51	-100	-41	-37	-96	-352
**2023 ABC_w	7,786	6,529	3,951	9,495	2,875	5,682	36,318
Change from 2021 ABC _w	65%	92%	23%	0%	-17%	8%	23%

Assumes 5-year survey average apportionment & 50% step from 2020 Fixed apportionment to 2021 5-year survey average apportionment.

* Before 95:5 hook and line: trawl split.

** ABC_w is the author recommended ABC that accounts for whale depredation.



PLAN TEAM TABLES: WY-EY/SE 49 ADJUSTMENT

Year	West Yakutat	E. Yakutat/ Southeast
2022	3,437	5,665
2023	3,159	5,398

Assumes 5-year survey average apportionment & 50% step from 2020 Fixed apportionment to 2021 5-year survey average apportionment.

*ABCs represent total regional ABC across gears, but with the 5% trawl allocation in EY/SE reallocated to WY.



50 PLAN TEAM TABLES: OFL

Year	2022	2023
2021 ABC	29,841	29,841
OFL	40,839	42,948
3-year Avg. Depredation	297	297
Ratio	1.37	1.44
Deduct 3-year Avg.	-407	-428
*OFL_w	40,432	42,520
2021 and 2022 OFL _w	60,426	70,710
Change from 2020 SAFE	-33%	-40%

* OFL_w is the author recommended OFL that accounts for whale depredation.



51 2020 APPORTIONMENT RECS

- Goal is to balance tracking **regional biomass** (conservation metric) vs. **stability in area proportions** (economic metric valued by stakeholders)
- Fixed apportionment is not responsive to changing biomass distributions
- BS ABC exceeded by >2,000 t in 2020, but also sharp recent increases in biomass in BS
- Tracking regional biomass or a best proxy thereof is likely the best defense against localized depletion
- Important to protect spawning biomass in all areas and keep fishing mortality on immature fish to reasonable levels
- Recommendation: use the five-year average survey proportions by region



52 APPORTIONMENT OPTIONS

Method	Area						
	AI	BS	WG	CG	WY*	EY*	ABC
2021 ABC ⁺	4,727	3,420	3,253	9,644	3,471	5,326	29,841
Status Quo (Fixed at Current)**	5,558	4,001	3,799	11,226	4,066	6,213	34,863
2020 5-year Survey Avg. Fixed***	8,231	5,742	4,296	8,945	2,990	4,660	34,863
25% Stair Step	5,543	4,353	3,791	10,950	3,590	6,635	34,863
50% Stair Step****	6,486	5,305	3,821	10,008	3,179	6,064	34,863
75% Stair Step	7,428	6,256	3,852	9,066	2,768	5,493	34,863
5-year Survey Avg. [^]	8,371	7,207	3,882	8,124	2,357	4,922	34,863
50% Stair Step from 2021 [#]	6,964	5,604	3,840	9,675	3,212	5,568	34,863

⁺This is the final 2021 ABC and associated regionally apportioned ABCs based on the 2020 SAFE. Other approaches utilize the 2022 ABC.

*Before 95:5 hook and line : trawl split shown below.

**Apportionment fixed (i.e., status quo) at the 2020 SSC recommended apportionment that used a 25% stair step from fixed apportionment to the 2020 5-year survey average apportionment.

*** Fixed at the 2013 assessment apportionment proportions (Hanselman et al. 2012b).

**** A 50% stair step from fixed apportionment to the 2021 5-year survey average apportionment. This represents the next incremental step in the 2020 SSC recommended 4-year stair step approach.

[^]The 5-year survey average is the biologically recommended long-term apportionment strategy. This approach does not utilize a stair step (i.e., it represents a 100% step).

[#]The 50% stair step from the 2020 SAFE apportionment values to the 2021 5-year survey average apportionment is an alternative to a 50% stair step from the fixed apportionment.

53 APPORTIONMENT % CHANGE FROM 2021

Method	Area						
	AI	BS	WG	CG	WY*	EY*	ABC
2021 ABC ⁺	4,727	3,420	3,253	9,644	3,471	5,326	29,841
Status Quo (Fixed at Current)	18%	17%	17%	16%	17%	17%	17%
2020 5-year Survey Avg.	74%	68%	32%	-7%	-14%	-13%	17%
Fixed	-3%	-1%	16%	23%	15%	35%	17%
25% Stair Step	17%	27%	17%	14%	3%	25%	17%
50% Stair Step	37%	55%	17%	4%	-8%	14%	17%
75% Stair Step	57%	83%	18%	-6%	-20%	3%	17%
5-year Survey Avg.	77%	111%	19%	-16%	-32%	-8%	17%
50% Stair Step from 2021	47%	64%	18%	0%	-7%	5%	17%

⁺This is the final 2021 ABC and associated regionally apportioned ABCs based on the 2020 SAFE. Other approaches utilize the 2022 ABC.

*Before 95:5 hook and line : trawl split shown below.

**Apportionment fixed (i.e., status quo) at the 2020 SSC recommended apportionment that used a 25% stair step from fixed apportionment to the 2020 5-year survey average apportionment.

*** Fixed at the 2013 assessment apportionment proportions (Hanselman et al. 2012b).

**** A 50% stair step from fixed apportionment to the 2021 5-year survey average apportionment. This represents the next incremental step in the 2020 SSC recommended 4-year stair step approach.

^The 5-year survey average is the biologically recommended long-term apportionment strategy. This approach does not utilize a stair step (i.e., it represents a 100% step).

#The 50% stair step from the 2020 SAFE apportionment values to the 2021 5-year survey average apportionment is an alternative to a 50% stair step from the fixed apportionment.

54 APPORTIONMENT HARVEST RATE

Method	Area						
	AI	BS	WG	CG	WY*	EY*	ABC
Status Quo (Fixed at Current)**	0.03	0.03	0.06	0.10	0.14	0.10	0.06
2020 5-year Survey Avg. Fixed***	0.05	0.04	0.07	0.08	0.10	0.08	0.06
25% Stair Step	0.03	0.03	0.06	0.10	0.12	0.11	0.06
50% Stair Step****	0.04	0.04	0.06	0.09	0.11	0.10	0.06
75% Stair Step	0.04	0.05	0.07	0.08	0.10	0.09	0.06
<i>5-year Survey Avg.</i> ^	<i>0.05</i>	<i>0.05</i>	<i>0.07</i>	<i>0.07</i>	<i>0.08</i>	<i>0.08</i>	<i>0.06</i>
50% Stair Step from 2021#	0.04	0.04	0.06	0.09	0.11	0.09	0.06

†This is the final 2021 ABC and associated regionally apportioned ABCs based on the 2020 SAFE. Other approaches utilize the 2022 ABC.

*Before 95:5 hook and line : trawl split shown below.

**Apportionment fixed (i.e., status quo) at the 2020 SSC recommended apportionment that used a 25% stair step from fixed apportionment to the 2020 5-year survey average apportionment.

*** Fixed at the 2013 assessment apportionment proportions (Hanselman et al. 2012b).

**** A 50% stair step from fixed apportionment to the 2021 5-year survey average apportionment. This represents the next incremental step in the 2020 SSC recommended 4-year stair step approach.

^The 5-year survey average is the biologically recommended long-term apportionment strategy. This approach does not utilize a stair step (i.e., it represents a 100% step).

#The 50% stair step from the 2020 SAFE apportionment values to the 2021 5-year survey average apportionment is an alternative to a 50% stair step from the fixed apportionment.

55 APPORTIONMENT CAVEATS

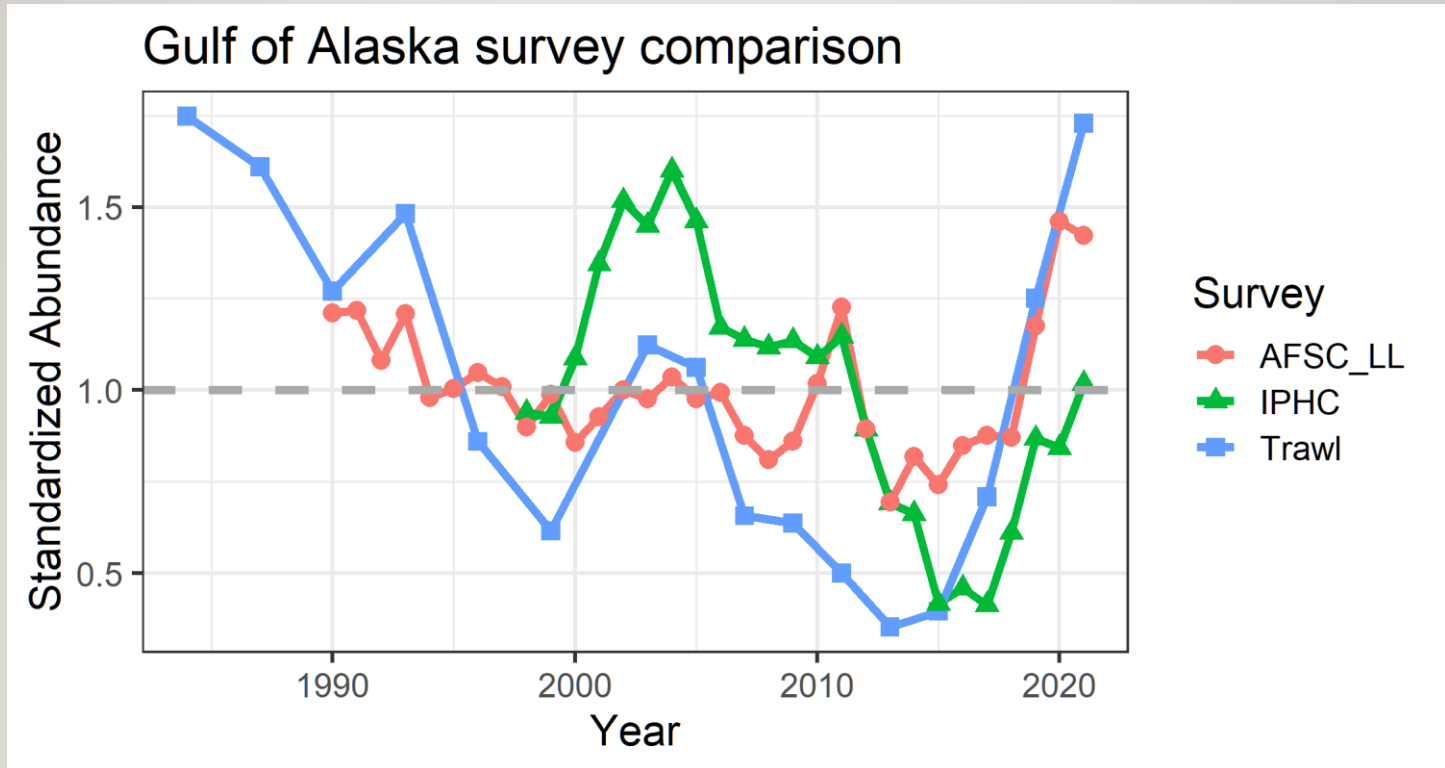
- This is *one potential* **biological recommendation**, but **socioeconomics cannot be adequately addressed** with our tools
- This is **NOT** a static apportionment, the proportions will change yearly based on changing distributions and updated survey biomass
- Stair step approach recommended, but more of a socioeconomic decision on how to implement



LL SURVEY BIOMASS PROPORTIONS BY REGION

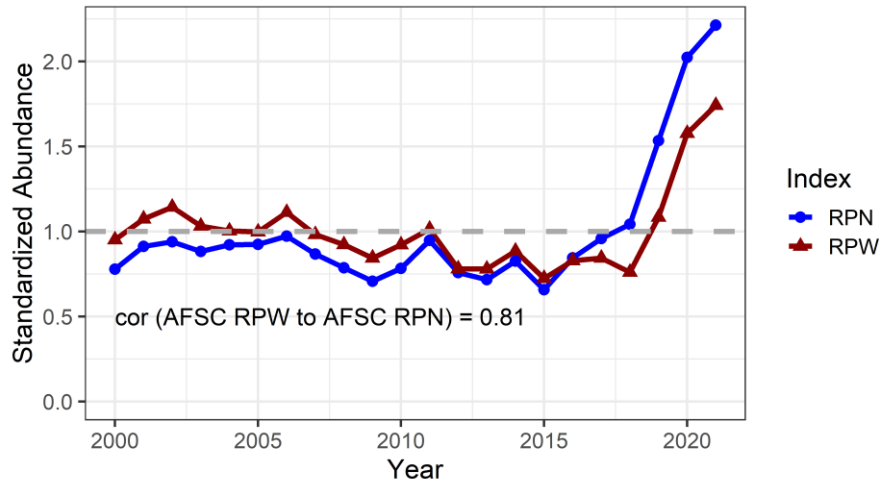
Year	BS	AI	WG	CG	WY	EY
1990	0.15	0.11	0.11	0.30	0.12	0.20
1991	0.07	0.13	0.09	0.29	0.13	0.29
1992	0.07	0.10	0.05	0.31	0.17	0.30
1993	0.03	0.12	0.12	0.32	0.14	0.27
1994	0.10	0.12	0.09	0.30	0.13	0.27
1995	0.10	0.12	0.11	0.32	0.12	0.24
1996	0.10	0.09	0.10	0.37	0.11	0.22
1997	0.09	0.09	0.10	0.37	0.11	0.23
1998	0.08	0.18	0.12	0.29	0.10	0.23
1999	0.07	0.18	0.10	0.33	0.09	0.22
2000	0.08	0.17	0.15	0.30	0.08	0.22
2001	0.14	0.15	0.16	0.30	0.06	0.18
2002	0.14	0.15	0.13	0.33	0.08	0.17
2003	0.13	0.15	0.15	0.33	0.08	0.16
2004	0.14	0.12	0.10	0.37	0.10	0.17
2005	0.16	0.11	0.16	0.28	0.07	0.22
2006	0.16	0.14	0.12	0.31	0.09	0.18
2007	0.18	0.12	0.08	0.29	0.10	0.22
2008	0.19	0.14	0.11	0.31	0.08	0.17
2009	0.05	0.15	0.16	0.33	0.09	0.22
2010	0.05	0.11	0.10	0.31	0.15	0.28
2011	0.05	0.11	0.12	0.40	0.10	0.22
2012	0.05	0.15	0.11	0.35	0.09	0.25
2013	0.20	0.13	0.08	0.30	0.08	0.22
2014	0.20	0.13	0.11	0.26	0.09	0.21
2015	0.11	0.14	0.08	0.30	0.14	0.22
2016	0.10	0.22	0.13	0.26	0.12	0.18
2017	0.13	0.21	0.10	0.29	0.10	0.17
2018	0.12	0.27	0.15	0.25	0.06	0.15
2019	0.24	0.23	0.10	0.20	0.07	0.16
2020	0.23	0.26	0.11	0.23	0.05	0.13
2021	0.32	0.23	0.10	0.19	0.05	0.11

57 OTHER SURVEYS

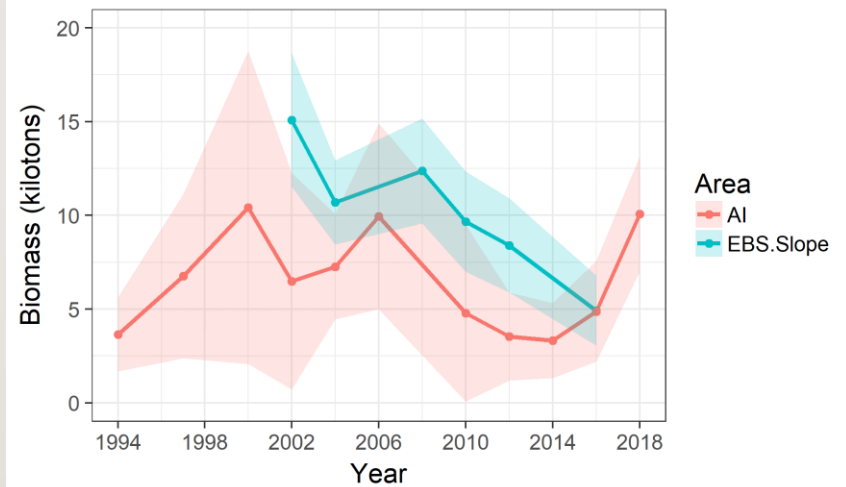


58 OTHER SURVEYS

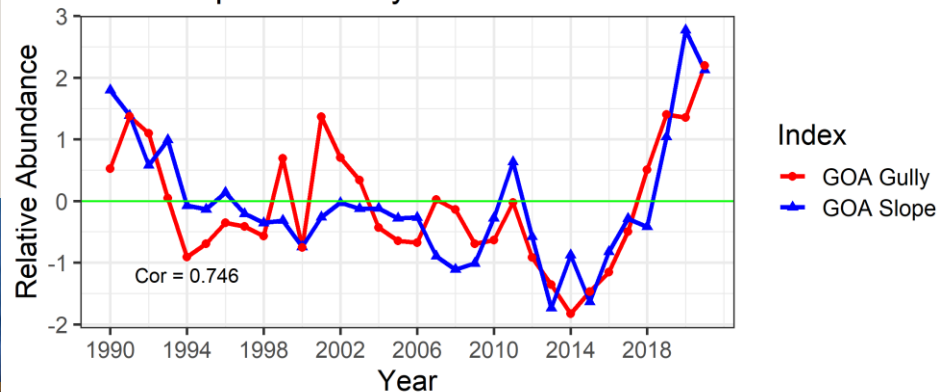
RPN and RPW comparison



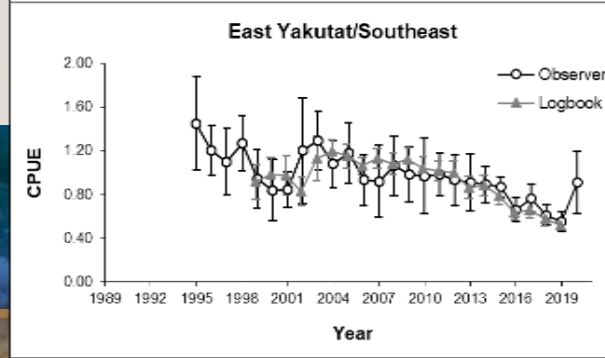
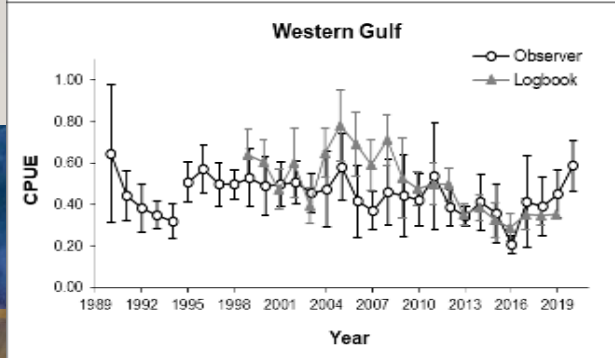
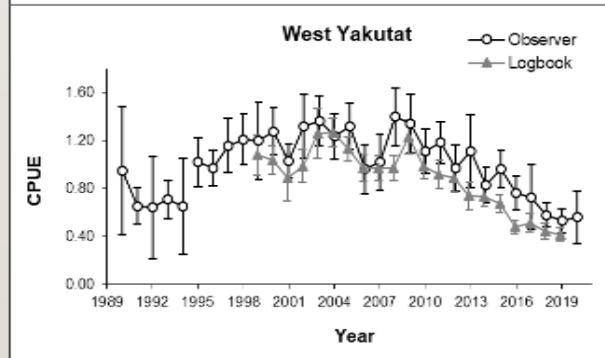
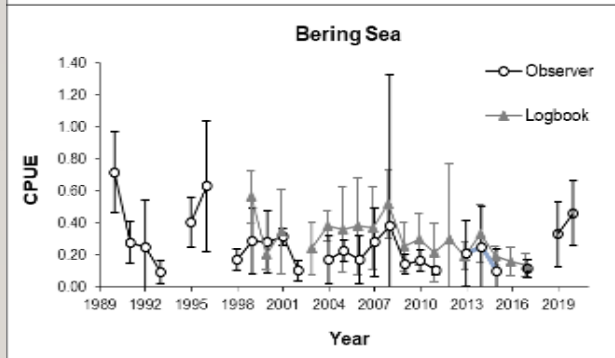
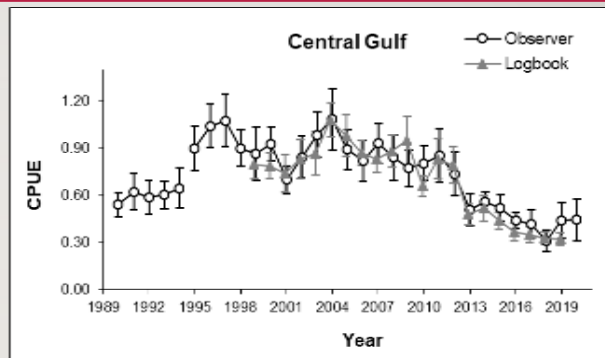
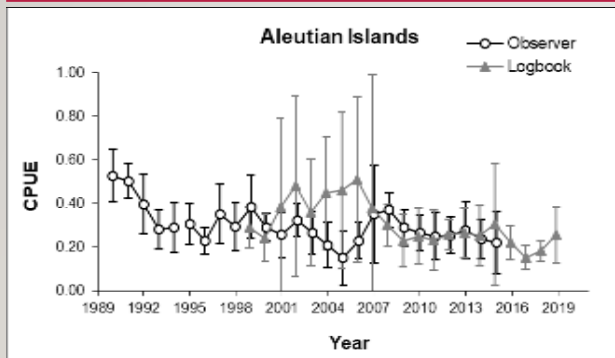
Other NMFS trawl surveys



GOA Slope and Gully RPNs

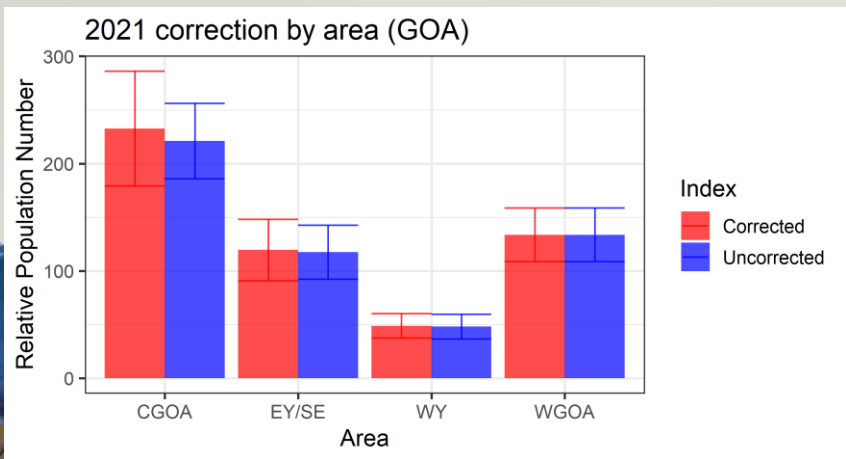
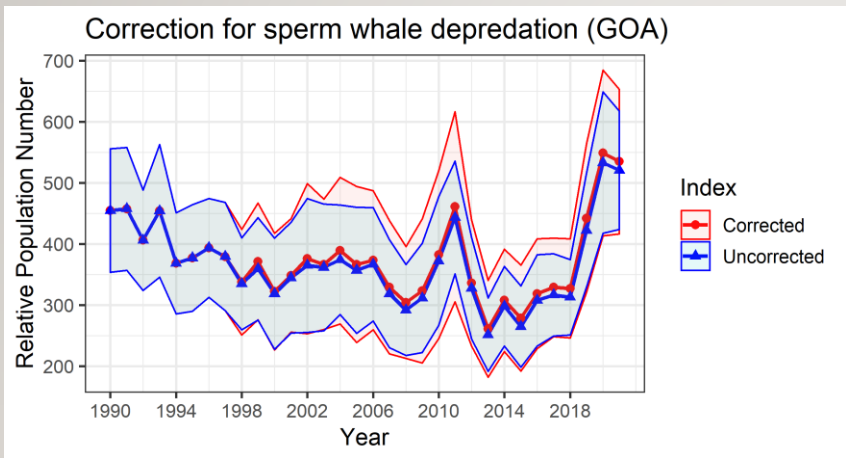


FISHERY CPUE BY AREA

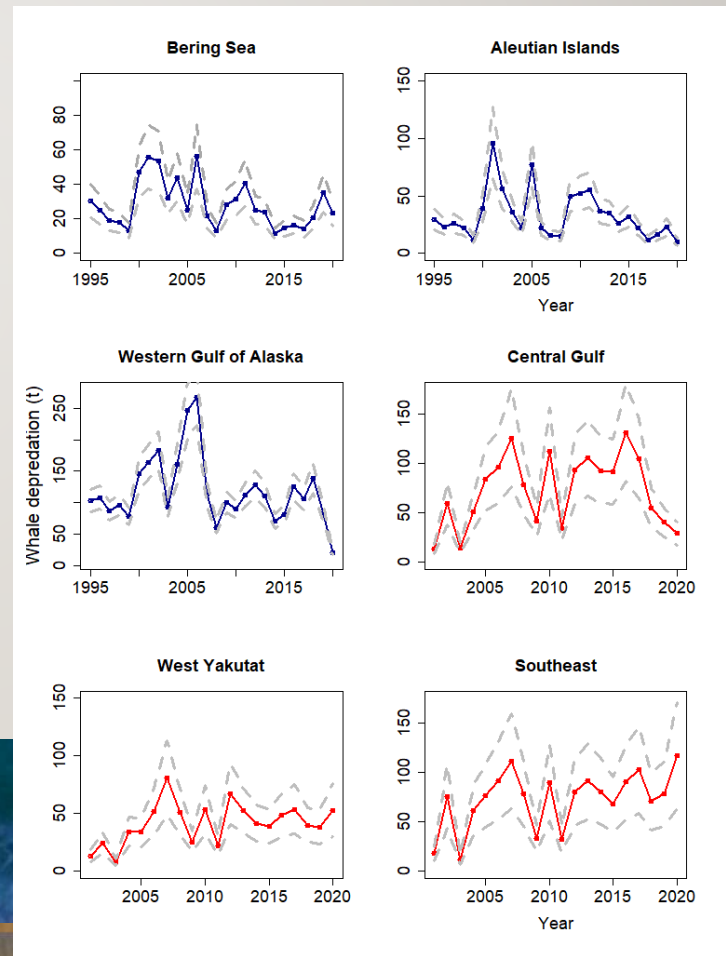


60 WHALE DEPREDEATION

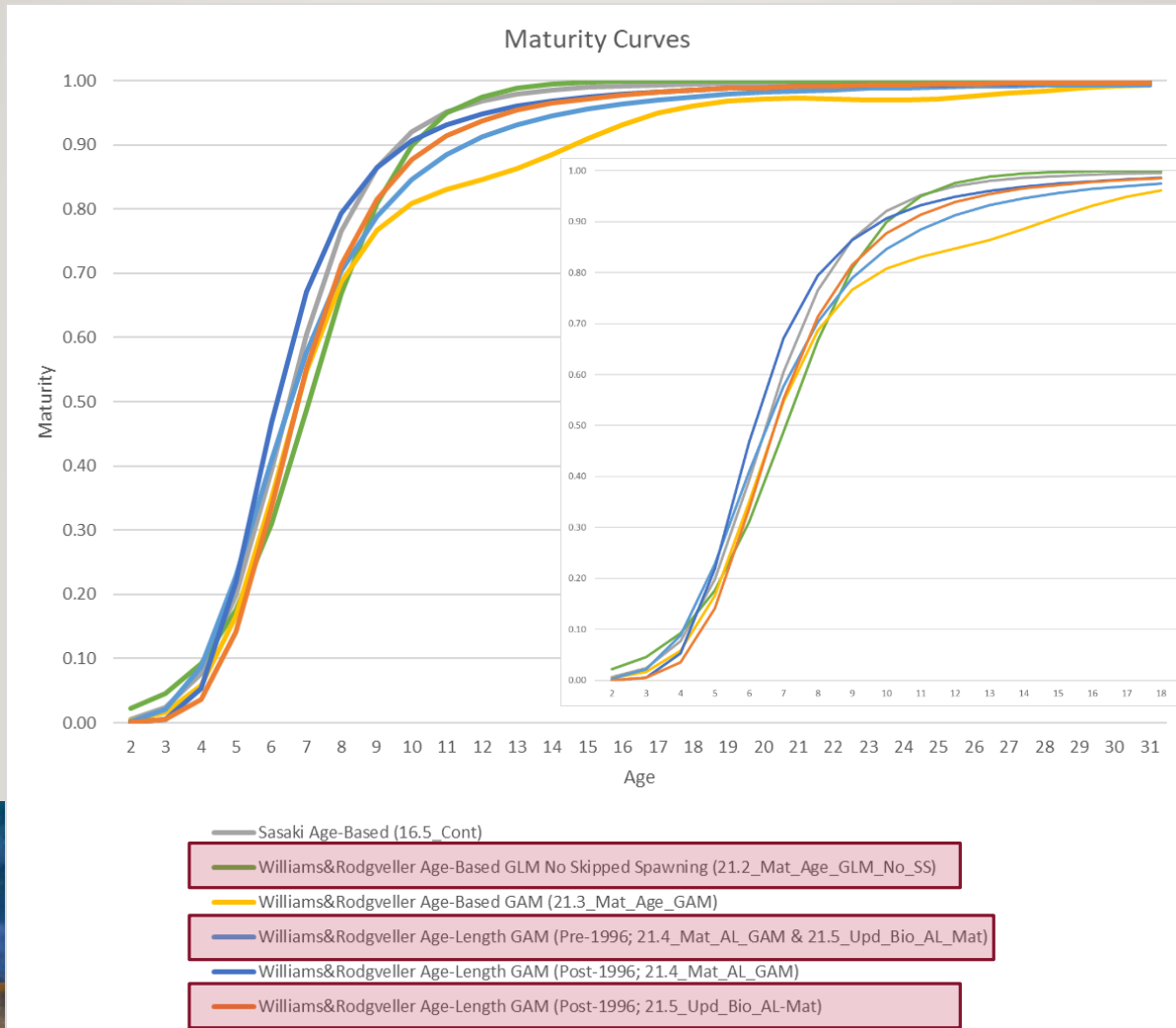
Survey Corrections



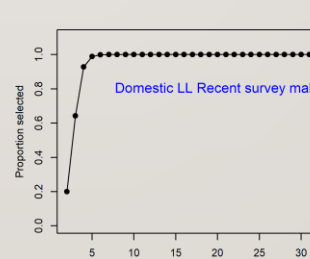
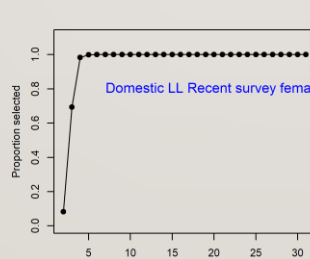
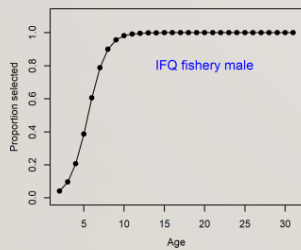
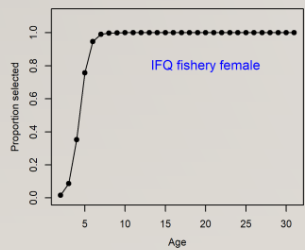
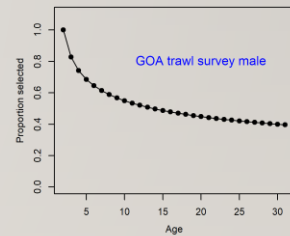
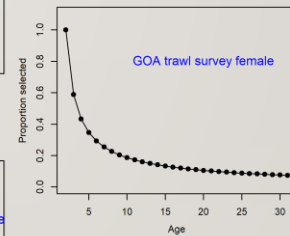
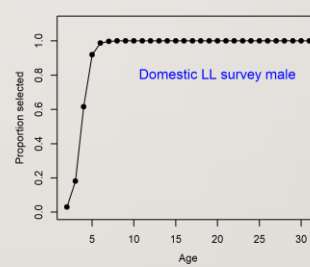
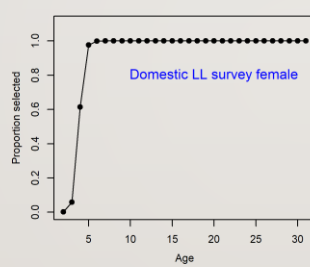
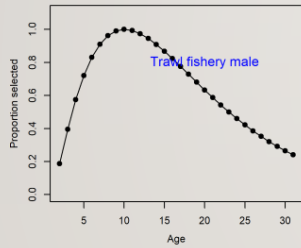
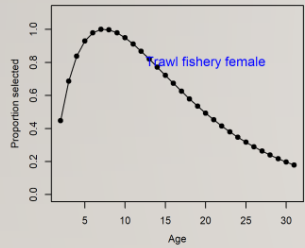
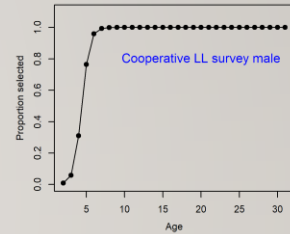
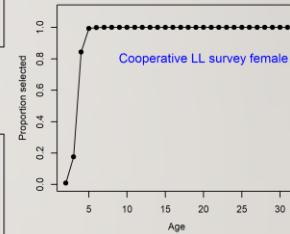
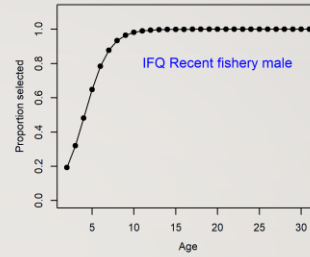
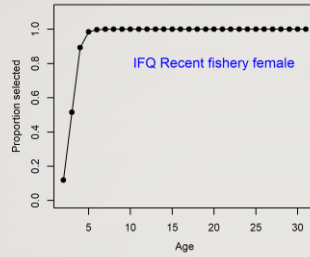
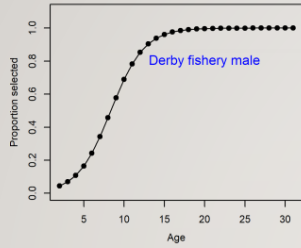
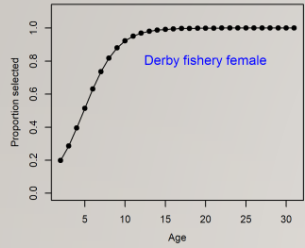
Area Depredation Fishery



MATURITY CURVE COMPARISONS

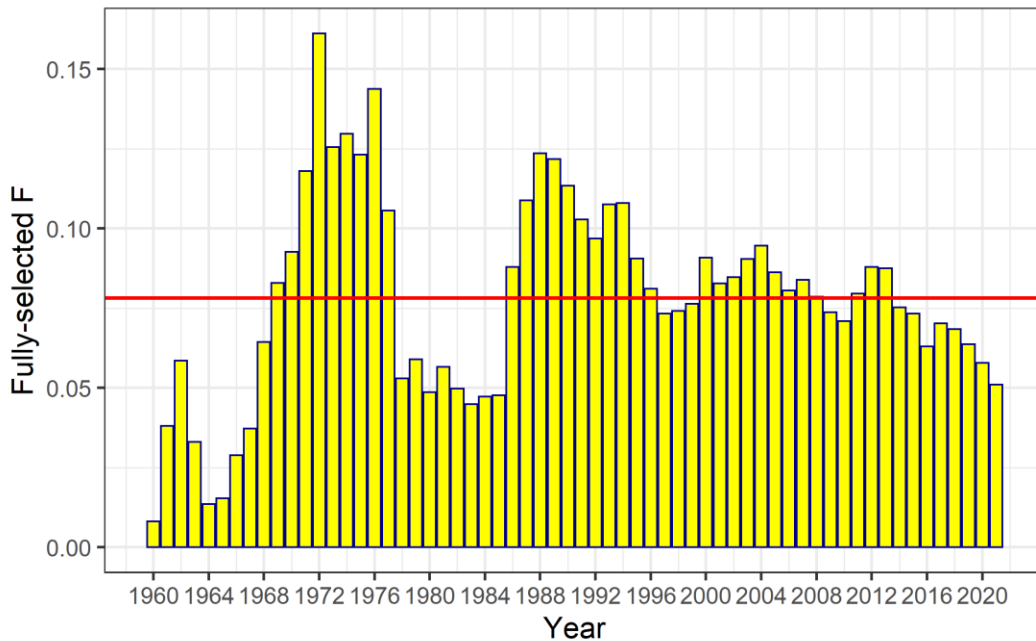
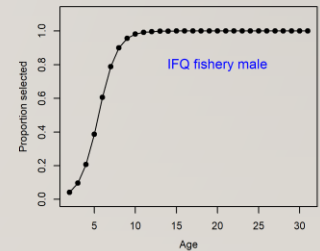
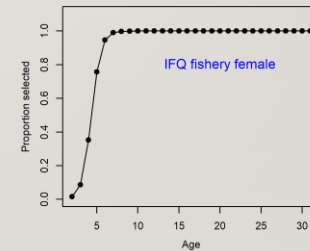
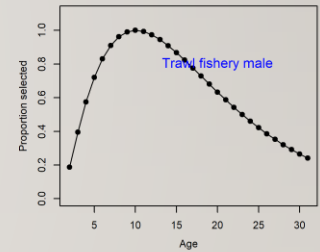
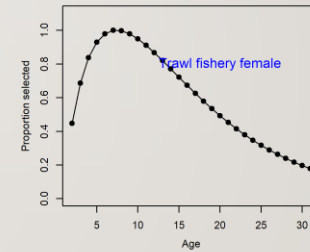
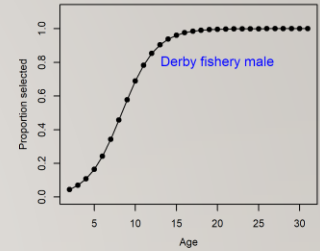
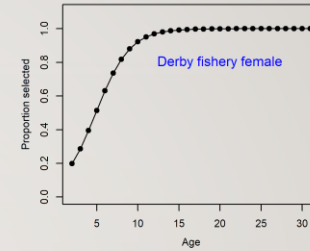
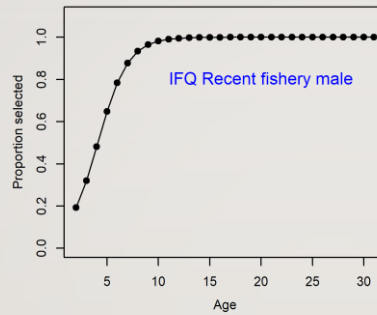
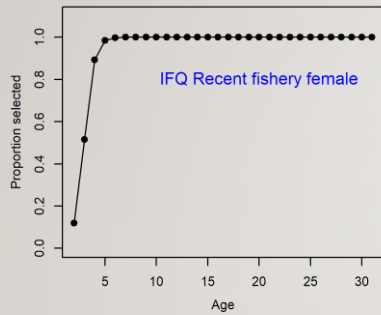


62 ESTIMATED SELECTIVITY



63

DECREASING FISHING MORTALITY

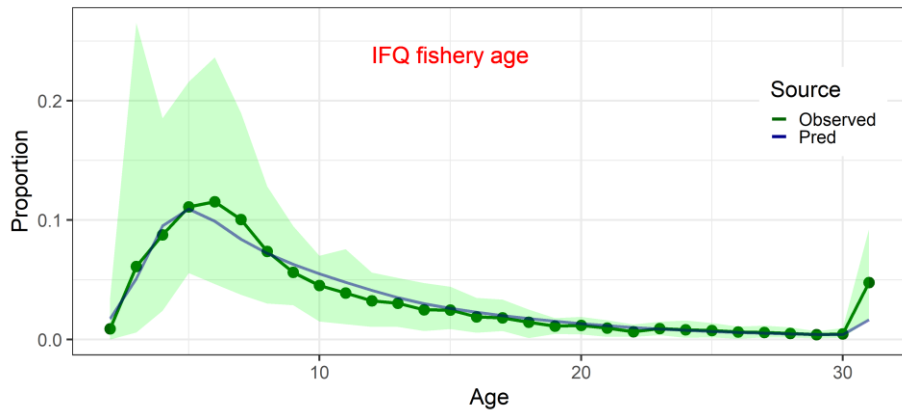


64 DEGRADED FIT TO FISHERY AGES

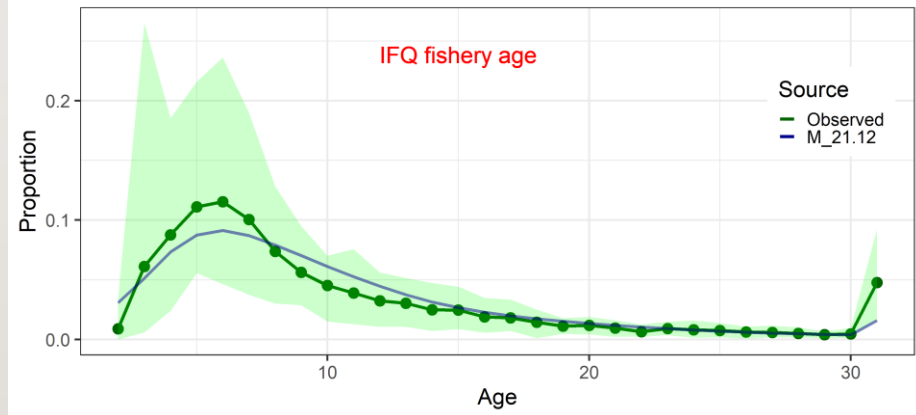
16.5_Cont

21.12_Proposed_No_Skip_Spawn

Aggregated observed compositions and predictions



Aggregated observed compositions and predictions

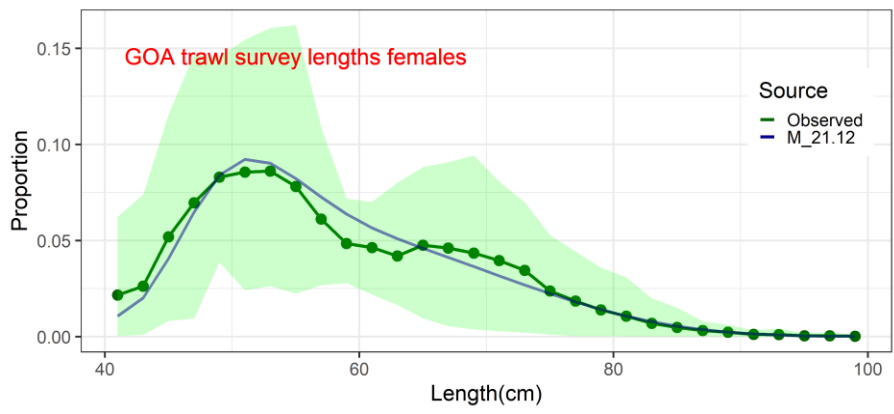


FIT TO TRAWL SURVEY LENGTH COMPS

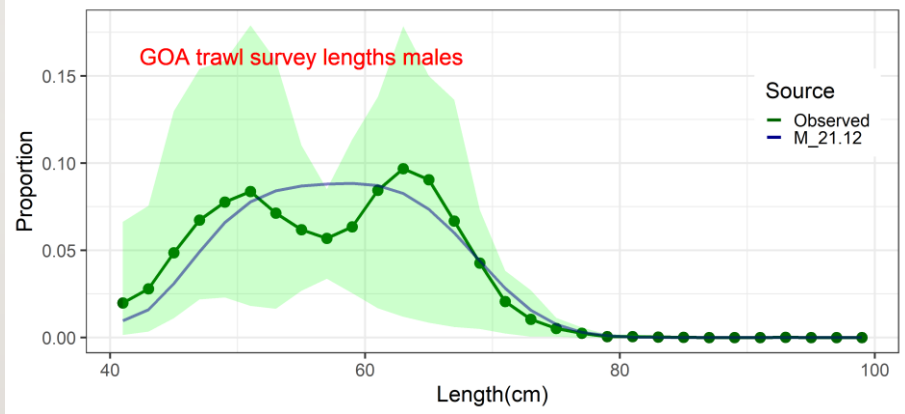
65

COMPS

Aggregated observed compositions and predictions

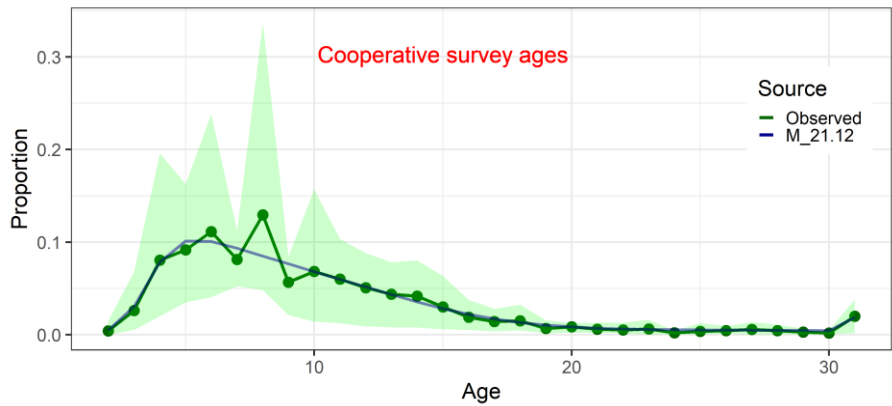


Aggregated observed compositions and predictions

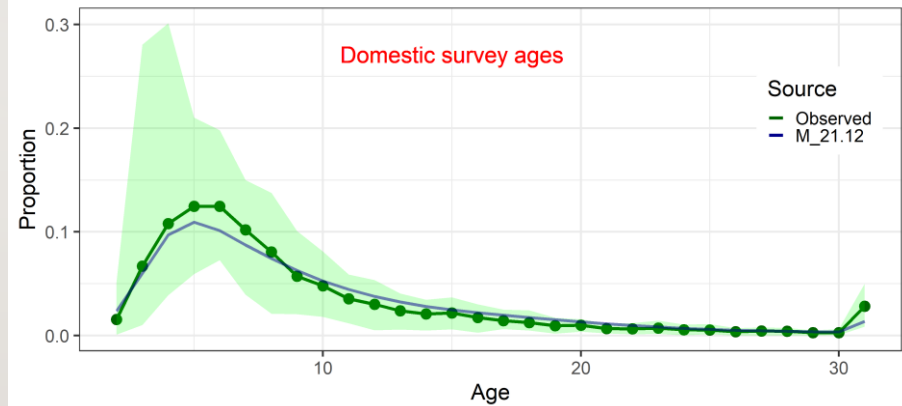


66 FIT TO LL SURVEY AGE COMPS

Aggregated observed compositions and predictions



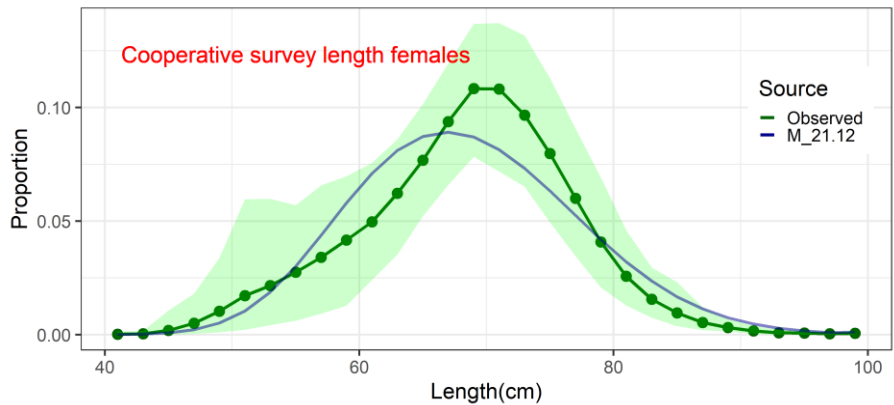
Aggregated observed compositions and predictions



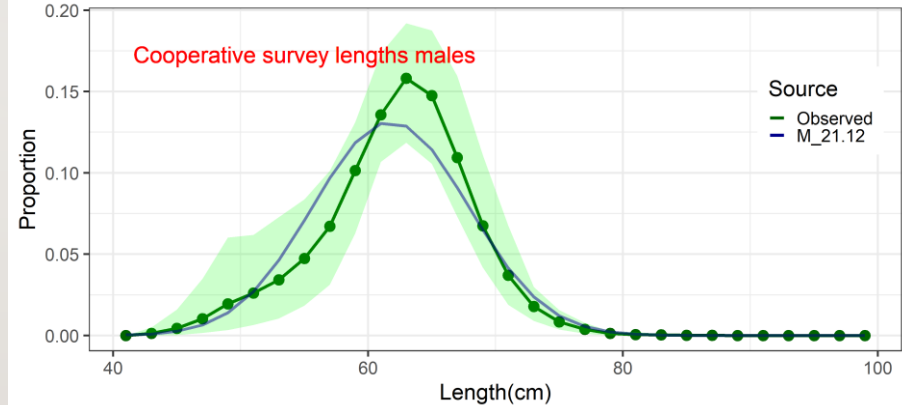
FIT TO COOP LL SURVEY LENGTH COMPS

67

Aggregated observed compositions and predictions

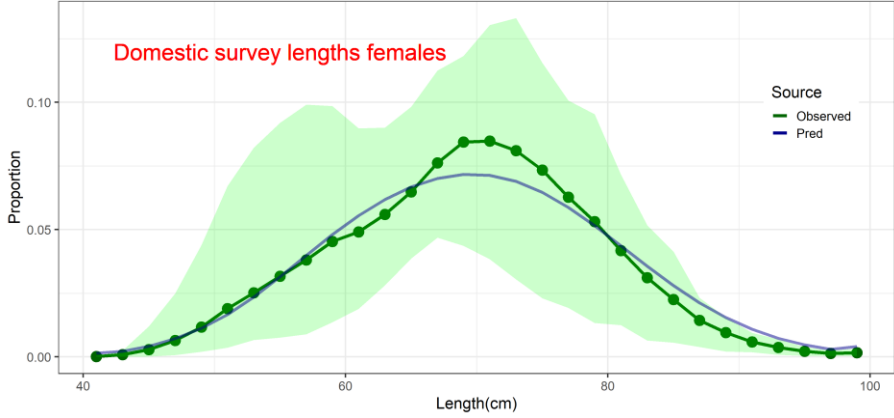


Aggregated observed compositions and predictions

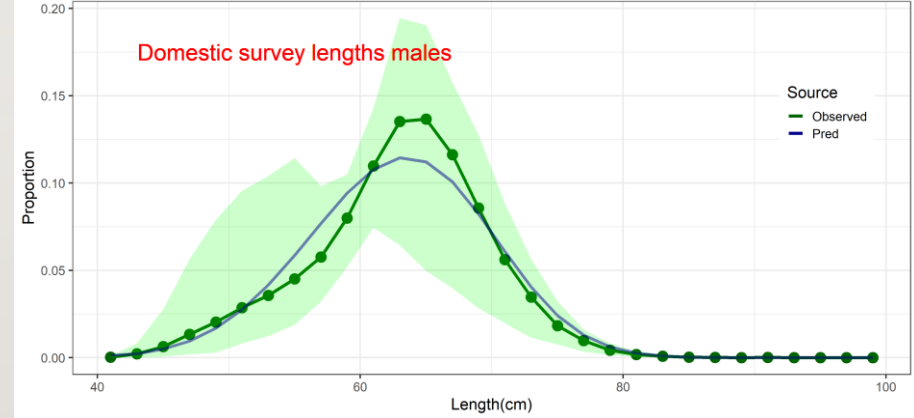


FIT TO DOMESTIC LL SURVEY 68 LENGTH COMPS

Aggregated observed compositions and predictions



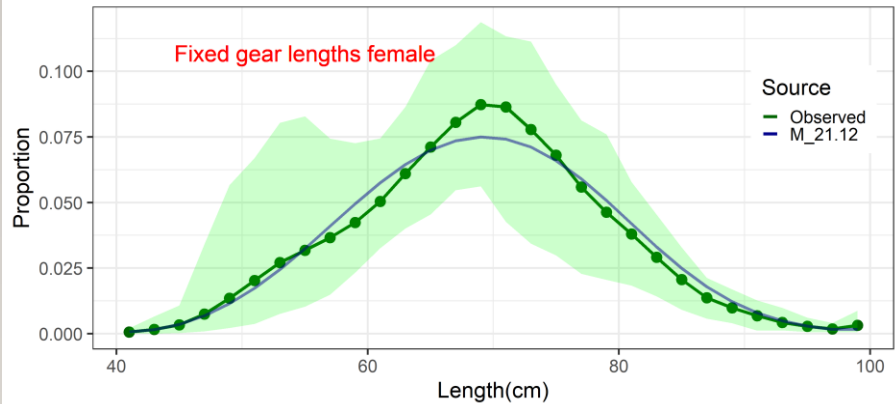
Aggregated observed compositions and predictions



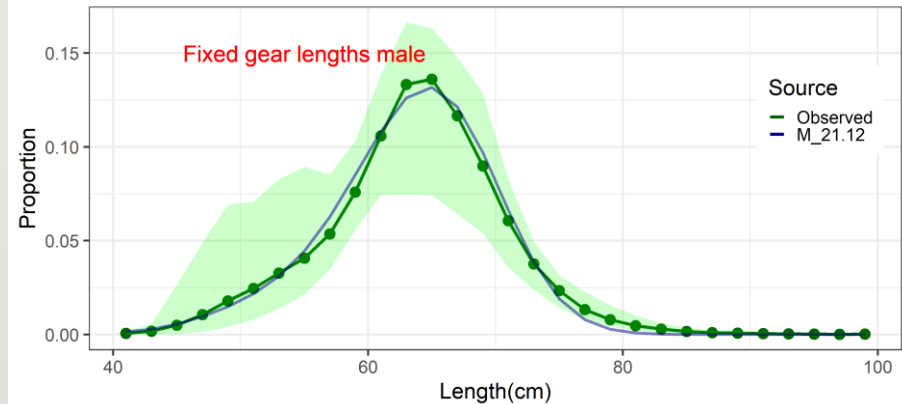
FIT TO FIXED GEAR FISHERY LENGTH COMPS

69

Aggregated observed compositions and predictions



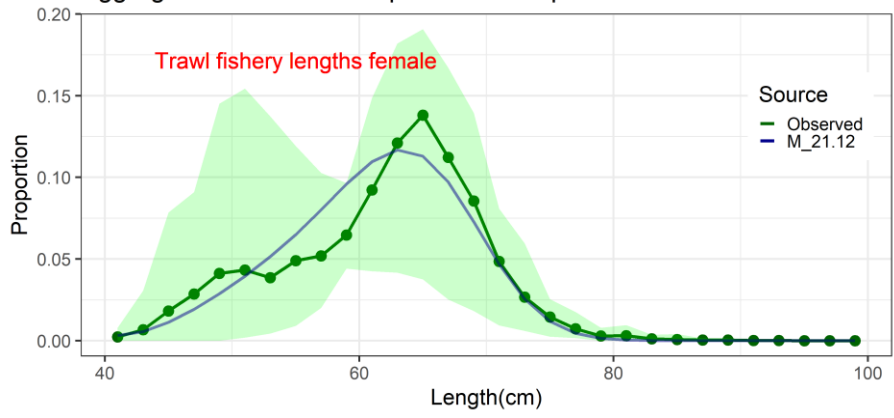
Aggregated observed compositions and predictions



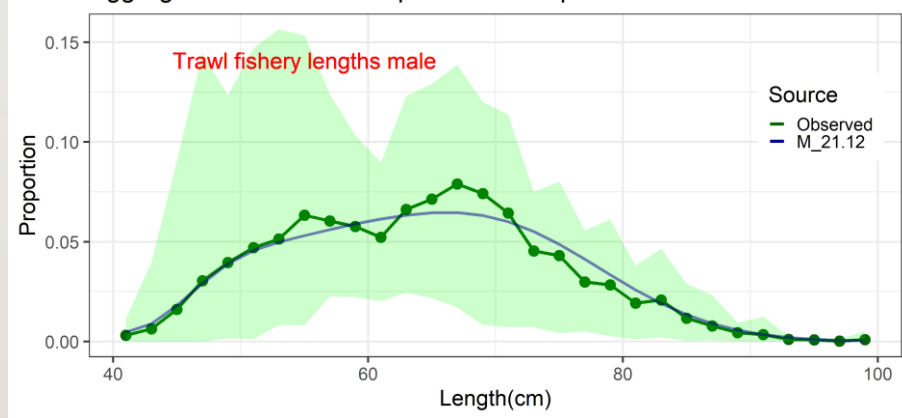
FIT TO TRAWL FISHERY LENGTH COMPS

70

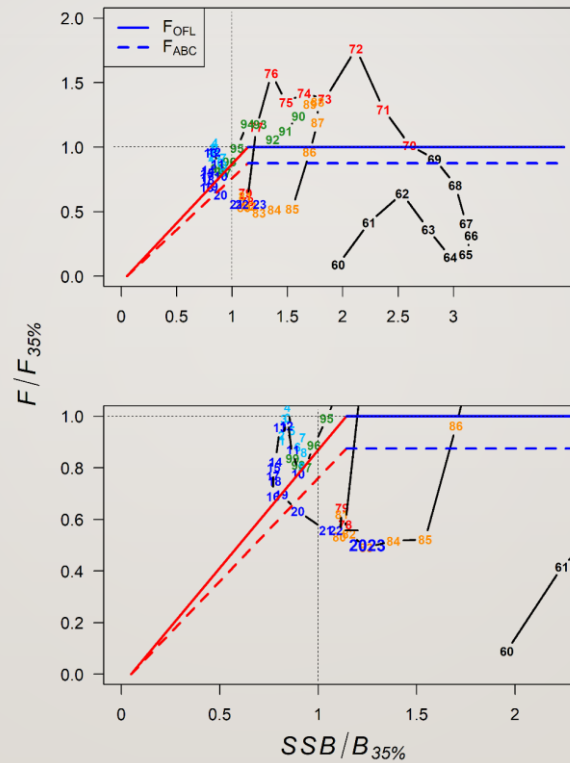
Aggregated observed compositions and predictions



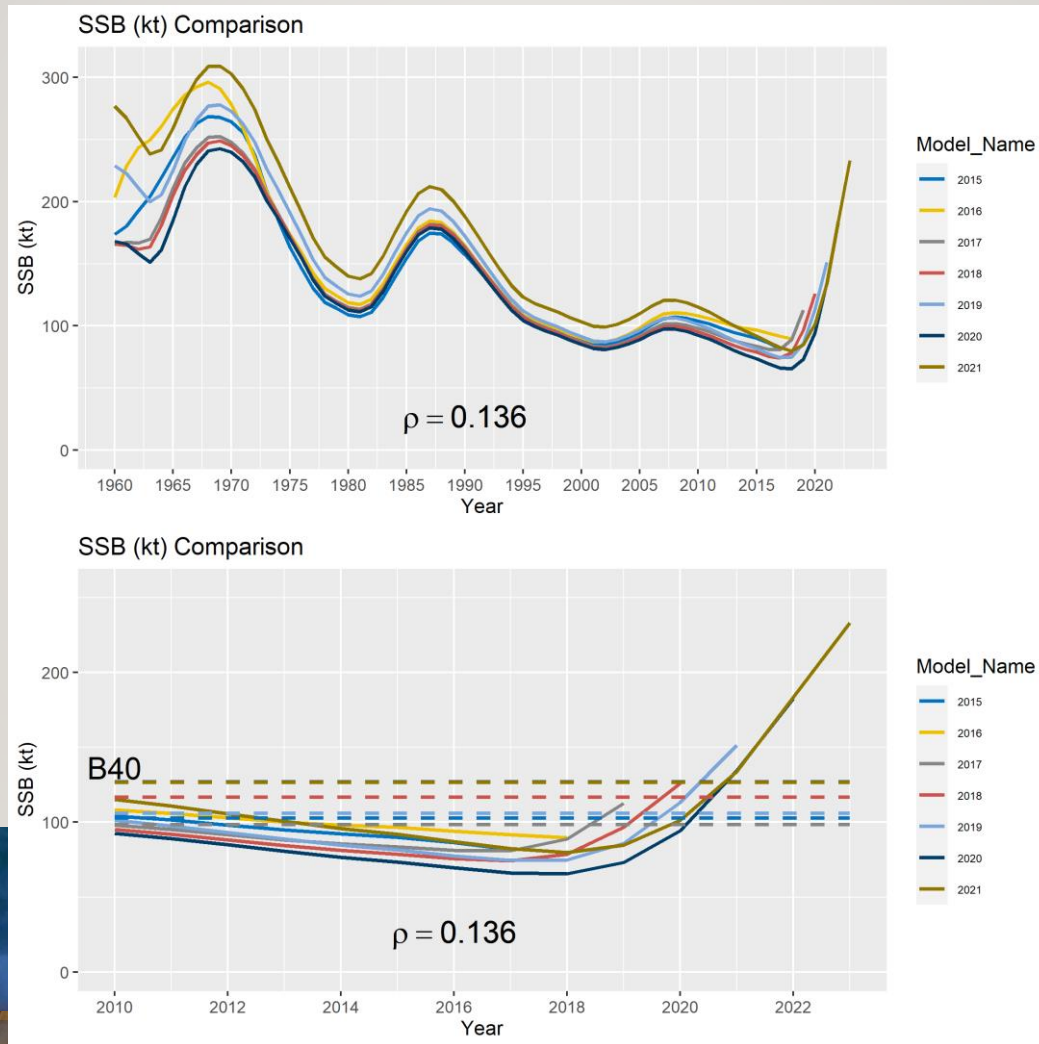
Aggregated observed compositions and predictions



71 PHASE PLANE DIAGRAM



72 HISTORICAL ASSESSMENT RETRO



73 SENSITIVITY RUN RECRUITMENT

