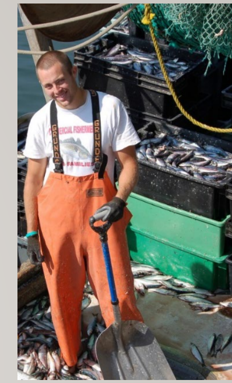


ALASKA SABLEFISH

DAN GOETHEL, DANA HANSELMAN, CARA RODGVELLER, KARI FENSKE, KALEI SHOTWELL, KATY ECHAVE, PAT MALECHA, KEVIN SIWICKE, CHRIS LUNSFORD

MARINE ECOLOGY AND STOCK ASSESSMENT

ALASKA FISHERIES SCIENCE CENTER

JUNEAU, AK

2 OUTLINE

- Stock Assessment Overview
  - Review Key Data Inputs
  - Results and Model Fit
  - Sensitivity Runs
  - EBS Bycatch Overview

- ABC Projections
  - Caveats and Considerations
- Summary of Assessment and ABC
- Apportionment
  - Simulation and Retrospective Analyses Results
  - Recommendations

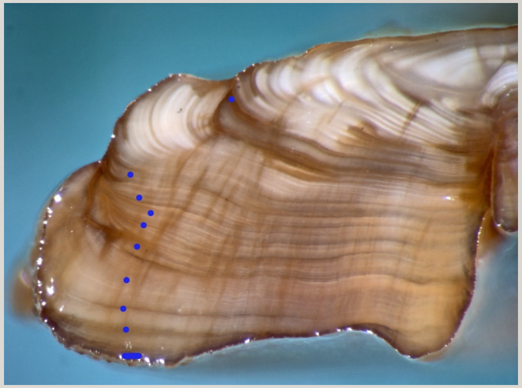
3 BOTTOM LINE

- Biomass increasing, but not as strongly as projected
- Maximum permissible ABC increasing rapidly, but projections are overly optimistic
- 2021 Author's ABC = 2020 SSC recommended ABC
  - F_ABC_2021 (0.0423) = F_ABC_2020 (0.043) ≈ F_2020 (0.046)
  - **+17% from author's ABC in 2020, because population is rebuilding**
- Risk table approach utilized as rationale

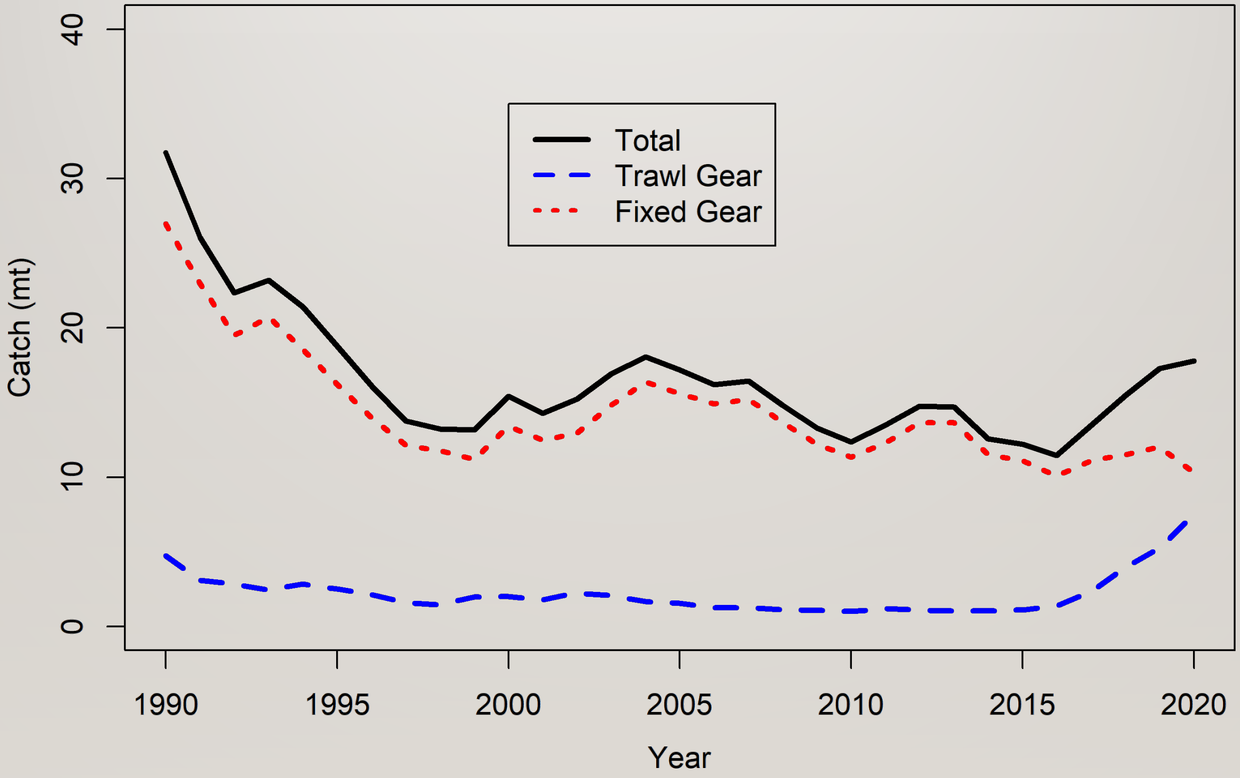
Year	2020	2021	2022
ABC	22,551	22,551	29,723
ABC_w	**22,009**	**22,237**	**29,309**
OFL	51,726	61,319	71,756
$*OFL_w$	**50,481**	**60,426**	**70,710**

NEW DATA

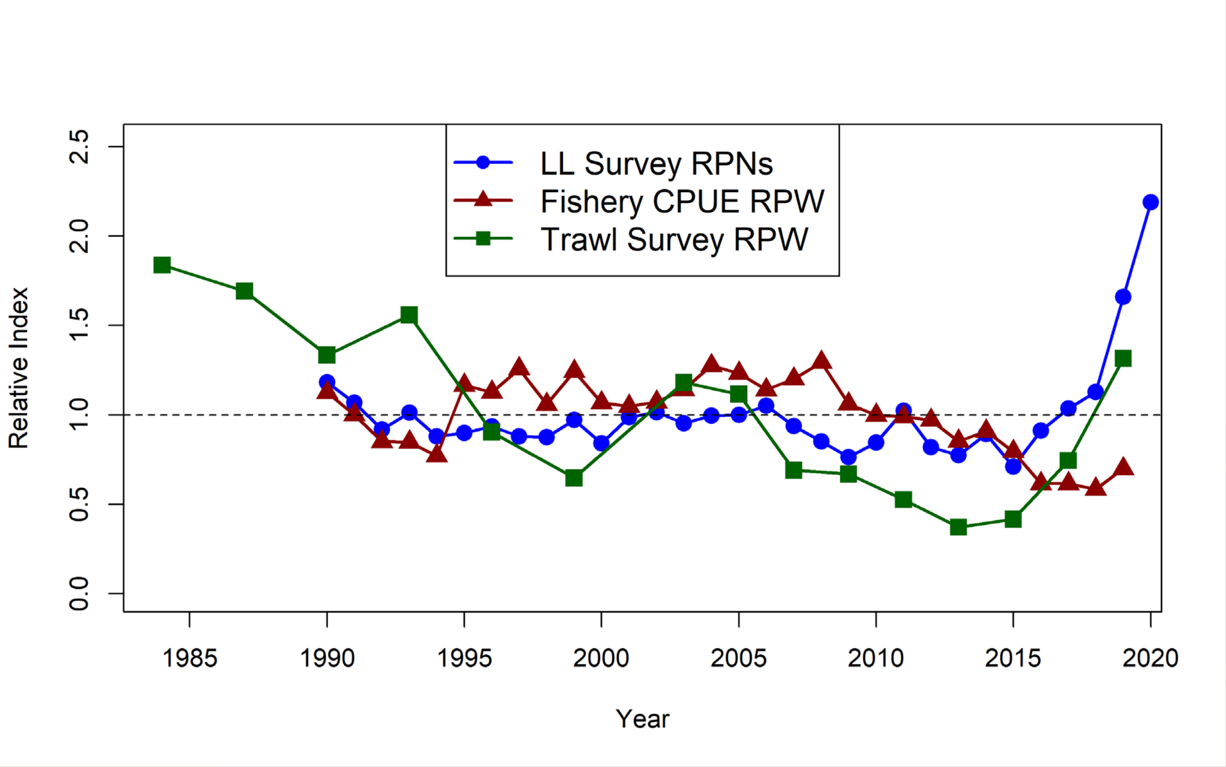
- Catch
  - Updated catch for 2019
  - New estimated/specified catch for 2020 - 2022
- Relative abundance
  - **2020 Longline survey**
  - 2019 longline fishery CPUE
- Ages
  - 2019 longline survey
  - 2019 fixed gear fishery
- Lengths
  - **2020 longline survey**
  - 2019 fixed gear fishery
  - 2019 trawl fishery



5 RECENT CATCHES



6 INDICES IN THE MODEL

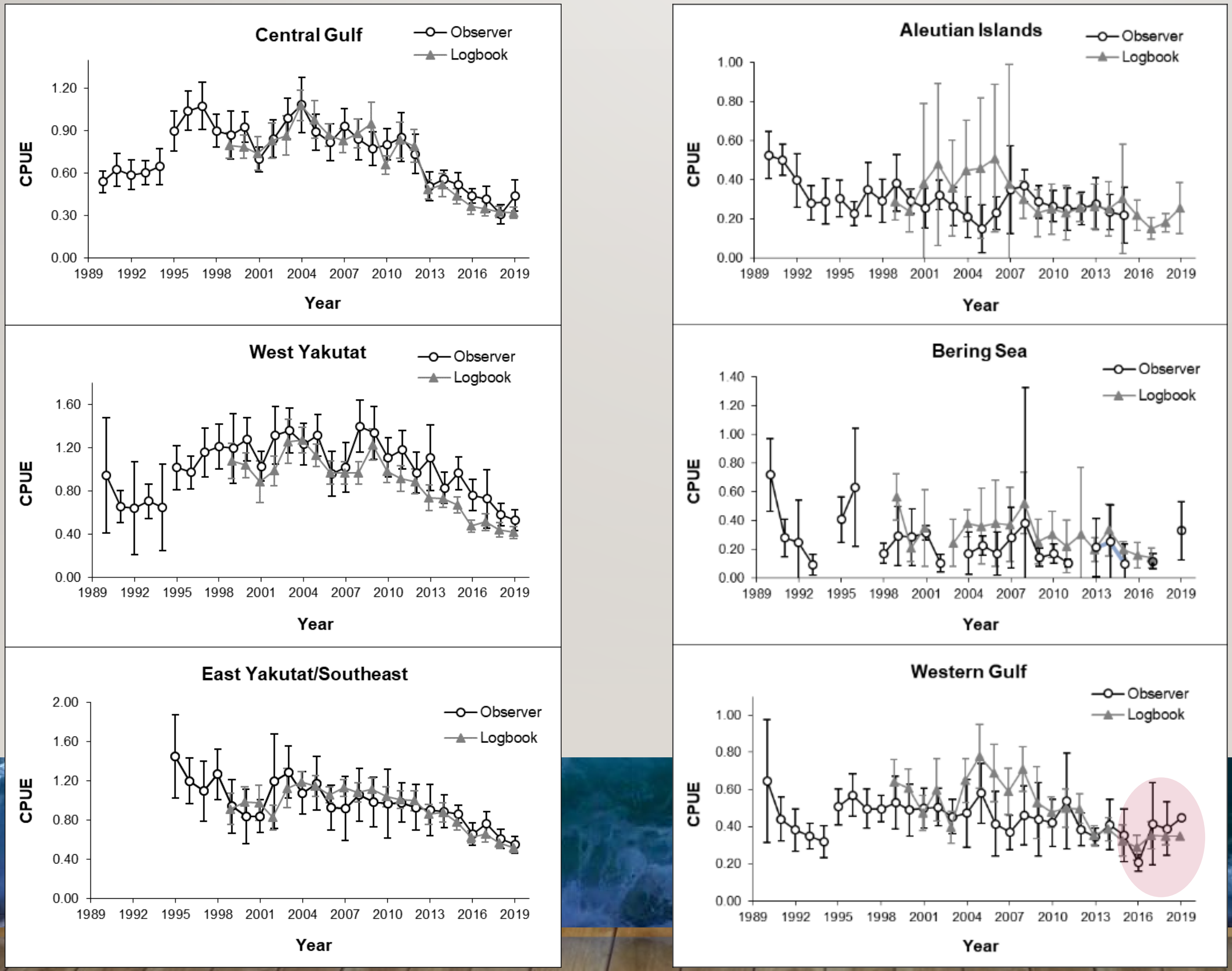


32% Increase

77% Increase

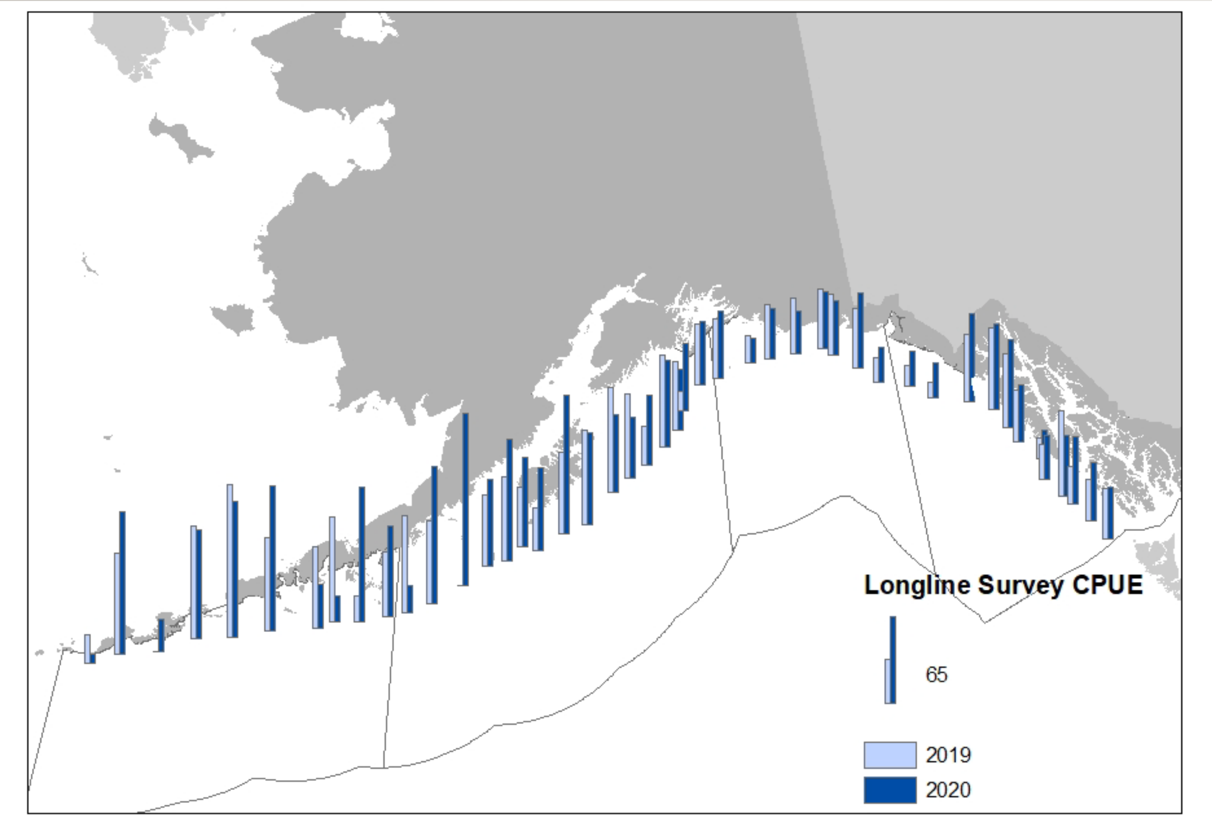
20% Increase

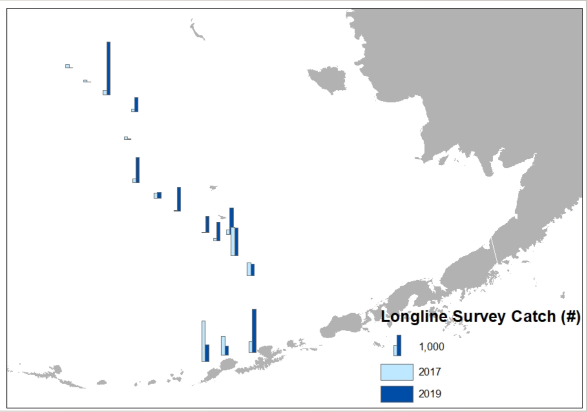
FISHERY CPUE BY AREA

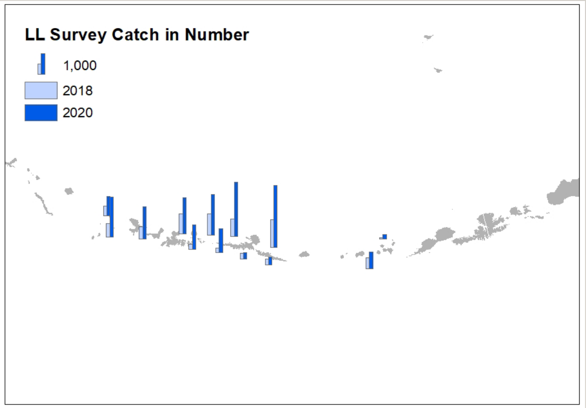


20% increase primarily due to catch rates in western areas

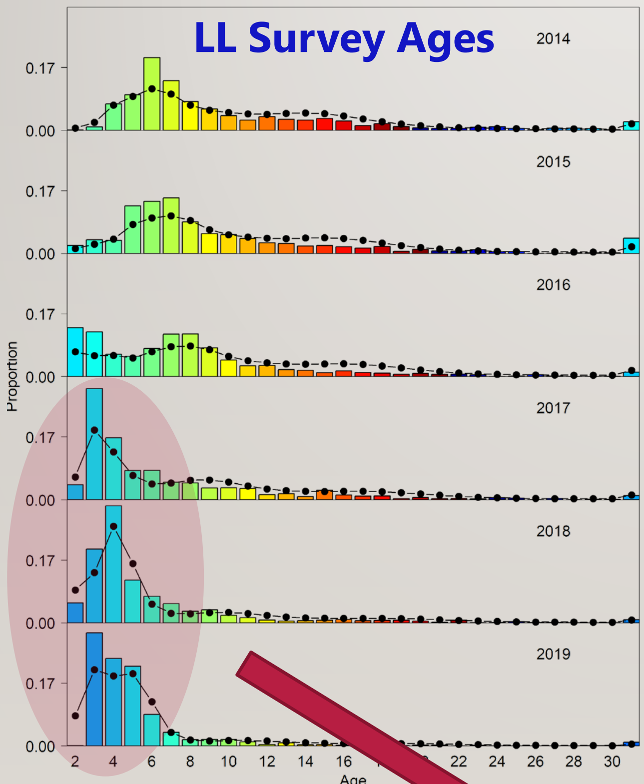
8 LONGLINE SURVEY

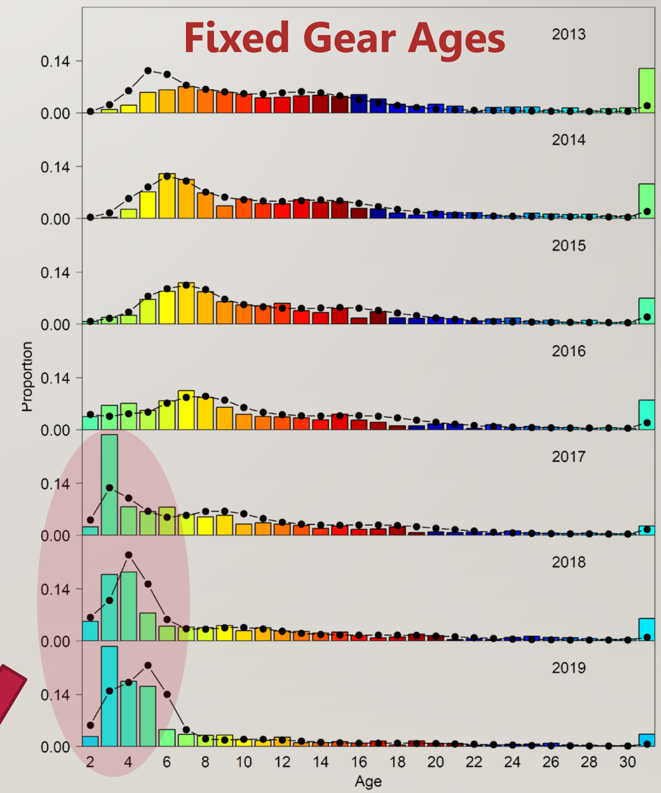






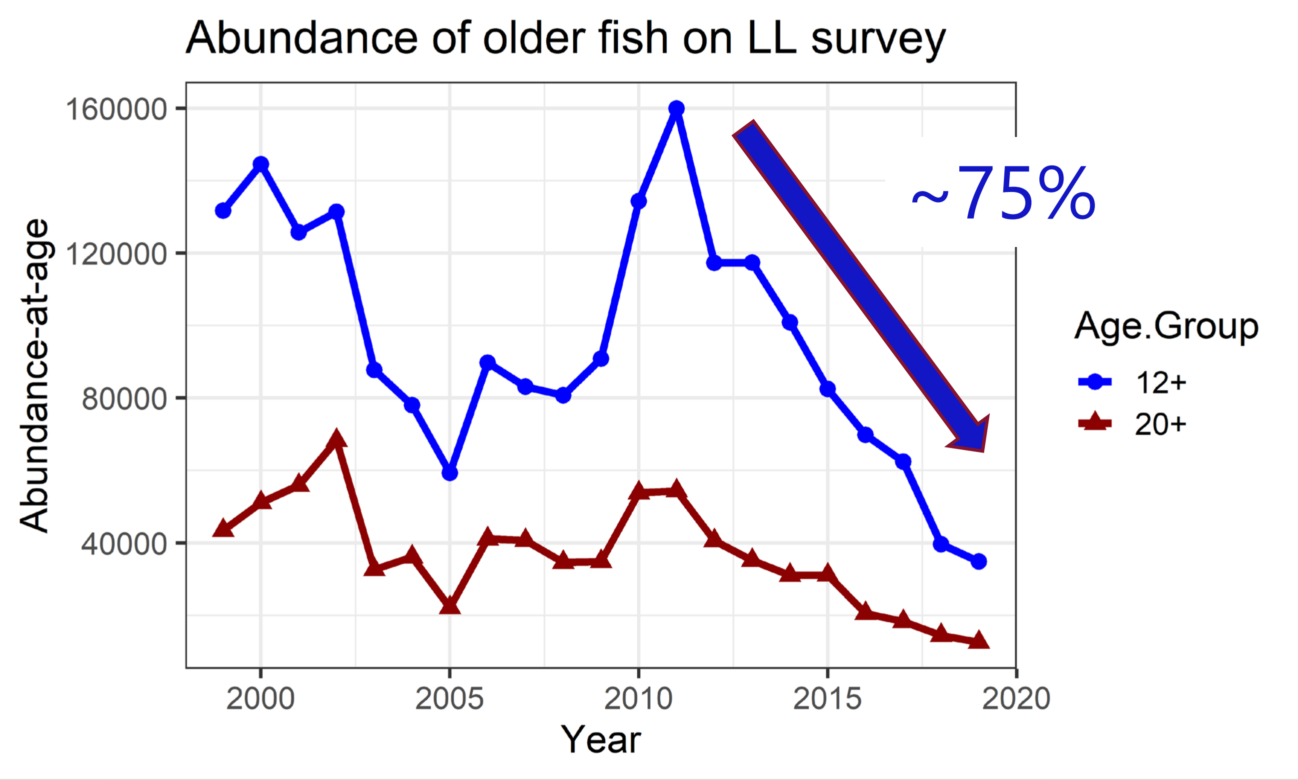
9 GROW UP!





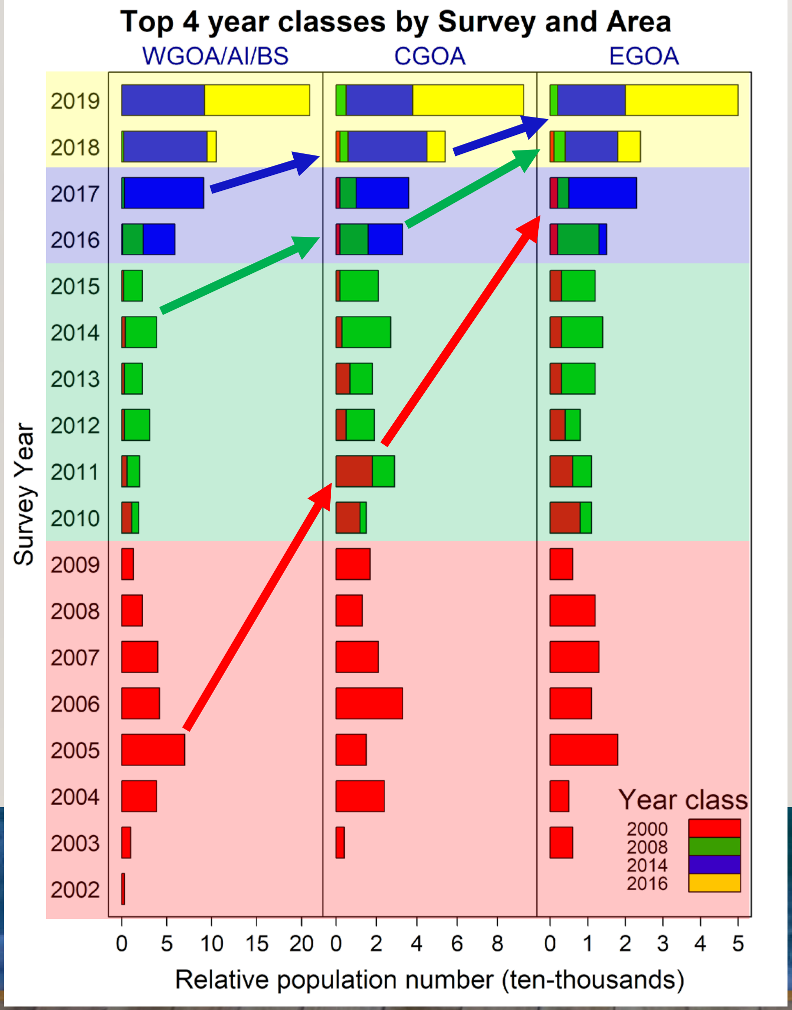
> 50% Age-6 or under

10 GROW UP!



Abundance of older fish on LL survey
Abundance-at-age
160000
120000
80000
40000
2000
2005
2010
2015
2020
Year
~75%
Age.Group
12+
20+

11 GROW UP!



2016 Year Class

2014 Year Class

2008 Year Class

2000 Year Class

12

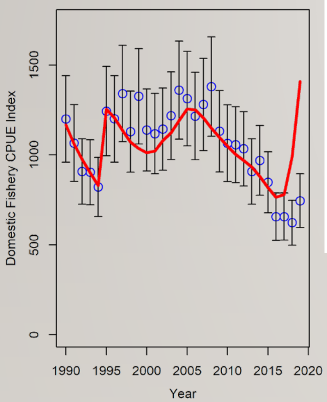
MODEL SPECIFICATION

- 1 Area across entire GOA+BSAI
- Sex-specific dynamics (i.e., growth and selectivity)
- 2 fleets: fixed gear and trawl
  - Dynamics (i.e., selectivity and F) and catch aggregated across entire area
  - Fixed gear fishery dynamics modeled separately before and after IFQ
- Catch = landings/bycatch + discards (100% mortality)
- All data aggregated across entire area
- Fixed and input biological parameters (growth, maturity, weight)

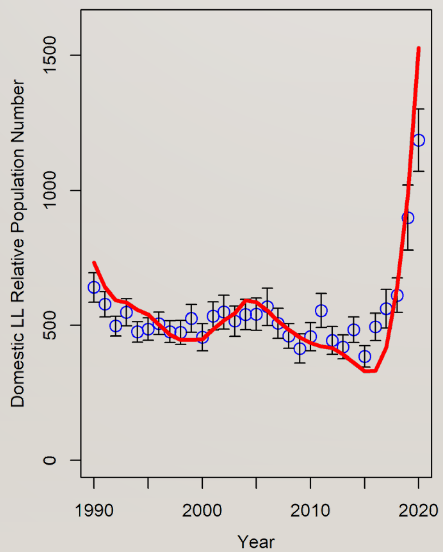
MODEL SPECIFICATION

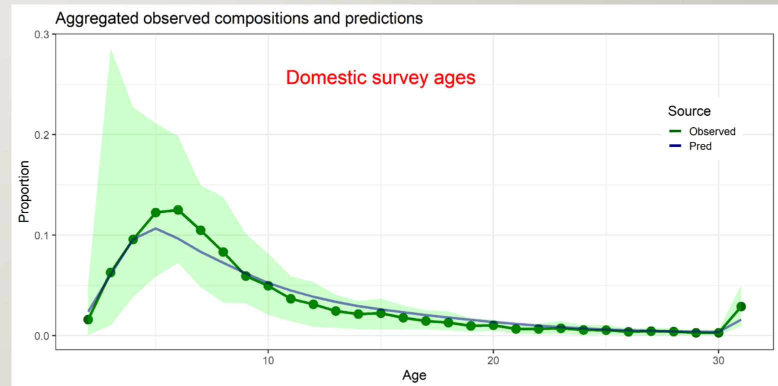
- No stock-recruit relationship
  - Yearly recruit deviations from average recruitment
  - Terminal year recruitment fixed at average
- Yearly F deviations for each fleet
  - Limited time-varying selectivity (only fixed gear IFQ)
- Natural mortality (M) is time-/age-invariant and estimated with prior
- Maximum likelihood estimation
  - 2016 CIE review specified data weights that emphasized compositional data over indices (rationale: overfitting LL survey)

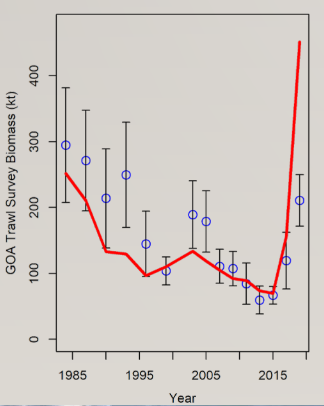
14 MODEL FIT: WHO DO YOU TRUST?

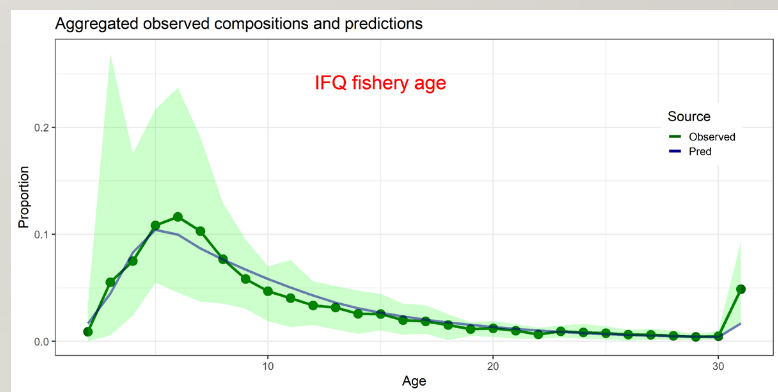


Large year class strength informed by compositional data leads to overpredicting population growth from indices.

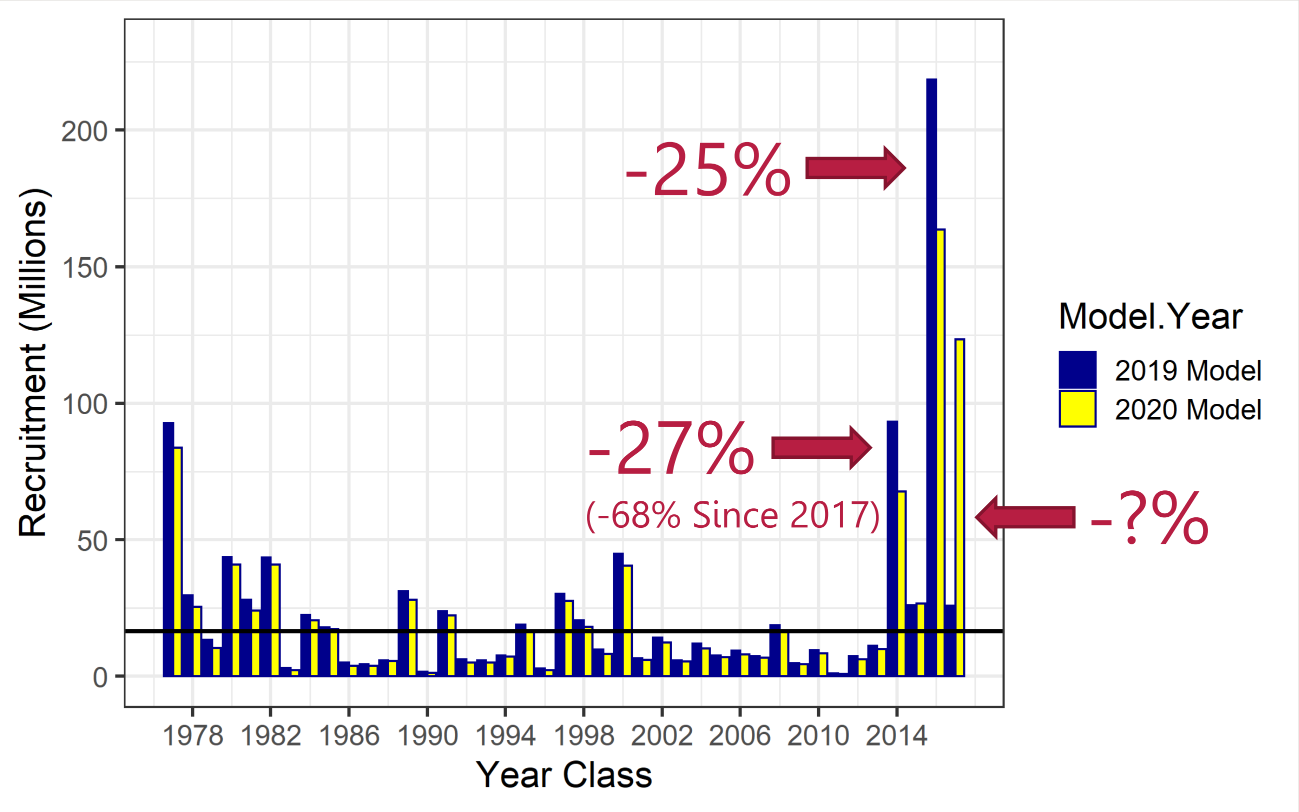






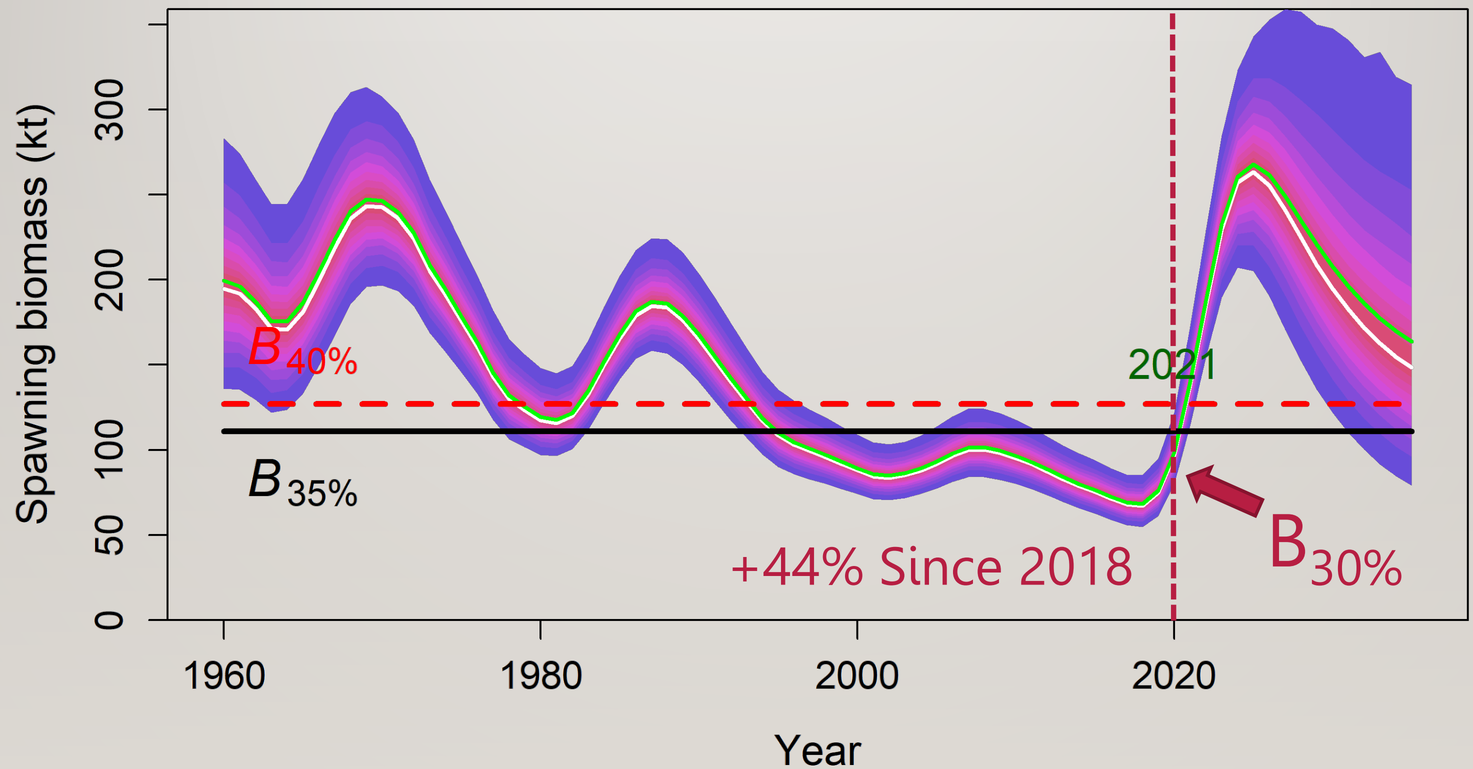


THE 2014 YEAR CLASS DECREASED (AGAIN), 2016 ON SAME TRAJECTORY

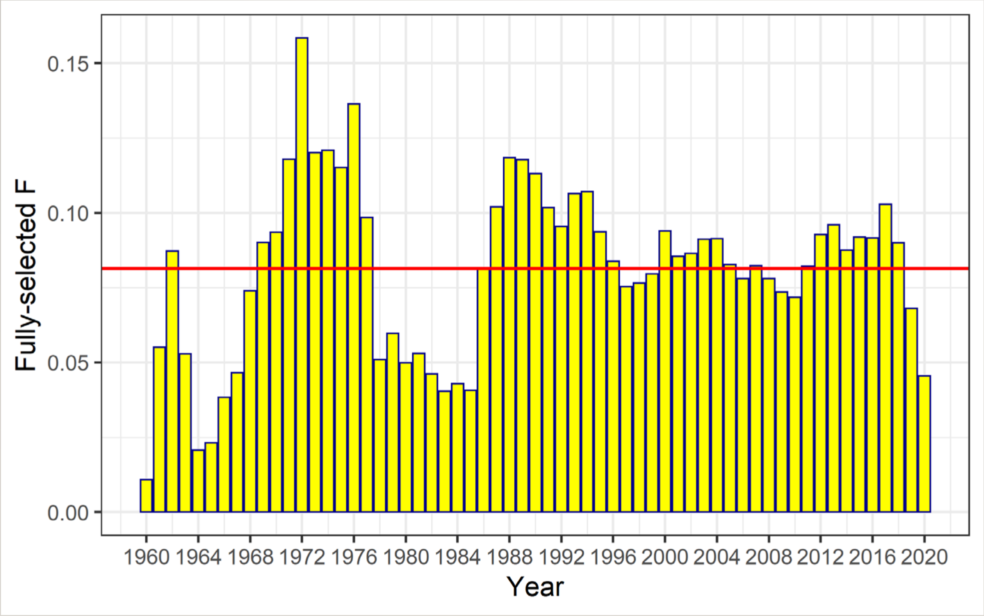


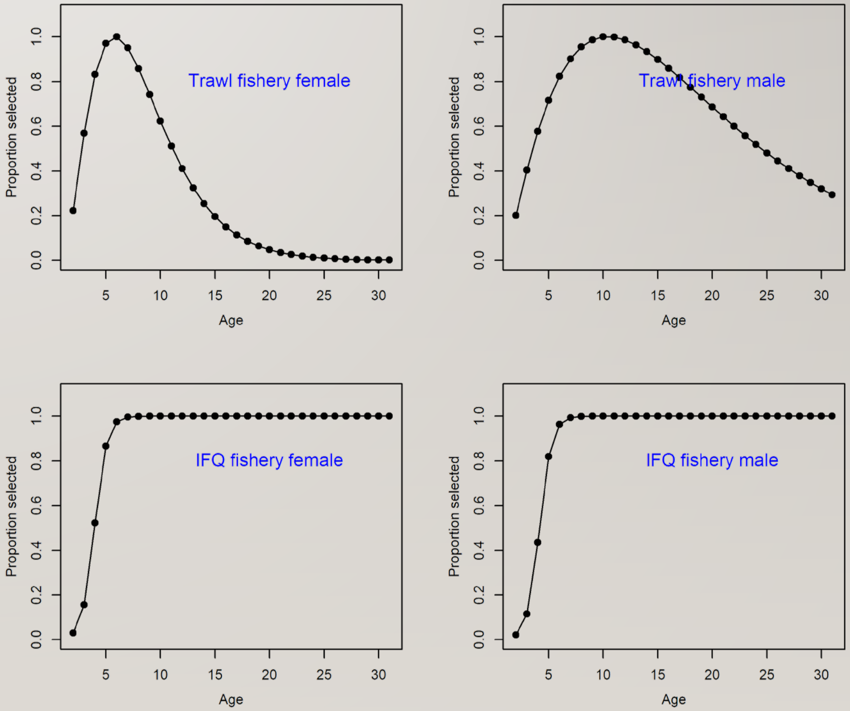
16

SPAWNING BIOMASS INCREASING, BUT STILL LOW

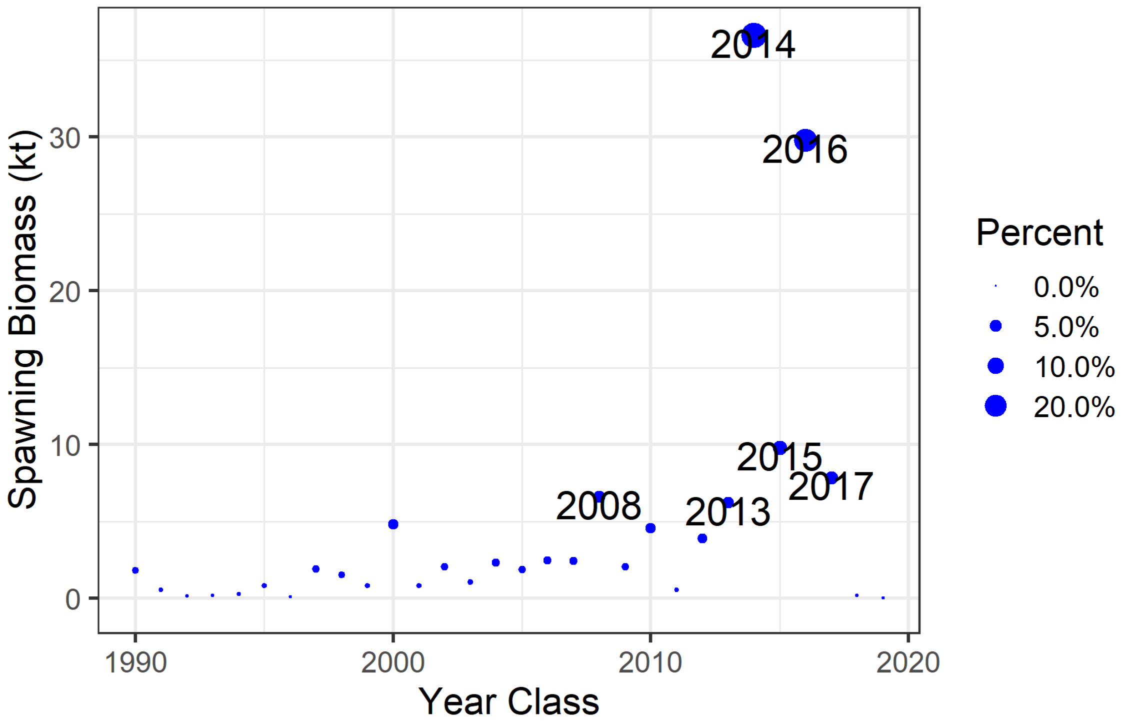


17 DECREASING FISHING MORTALITY





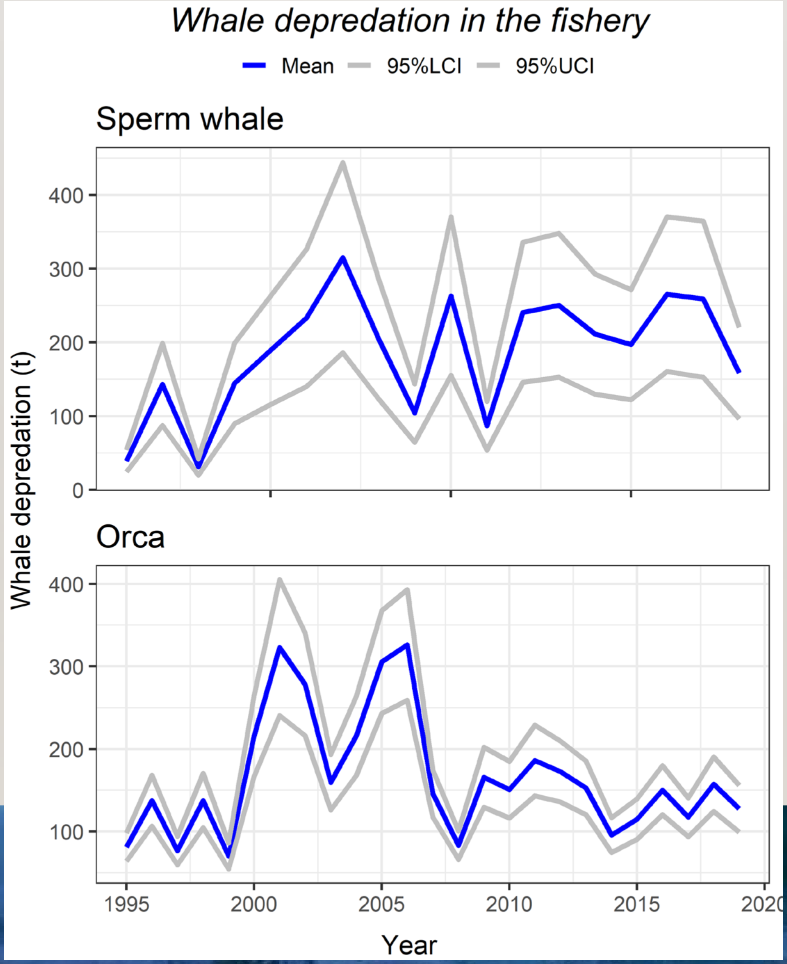
18 # NEW KIDS ON THE BLOCK



2014 and 2016 Year Classes ~50% of SSB, 60% and 20% Mature, Respectively

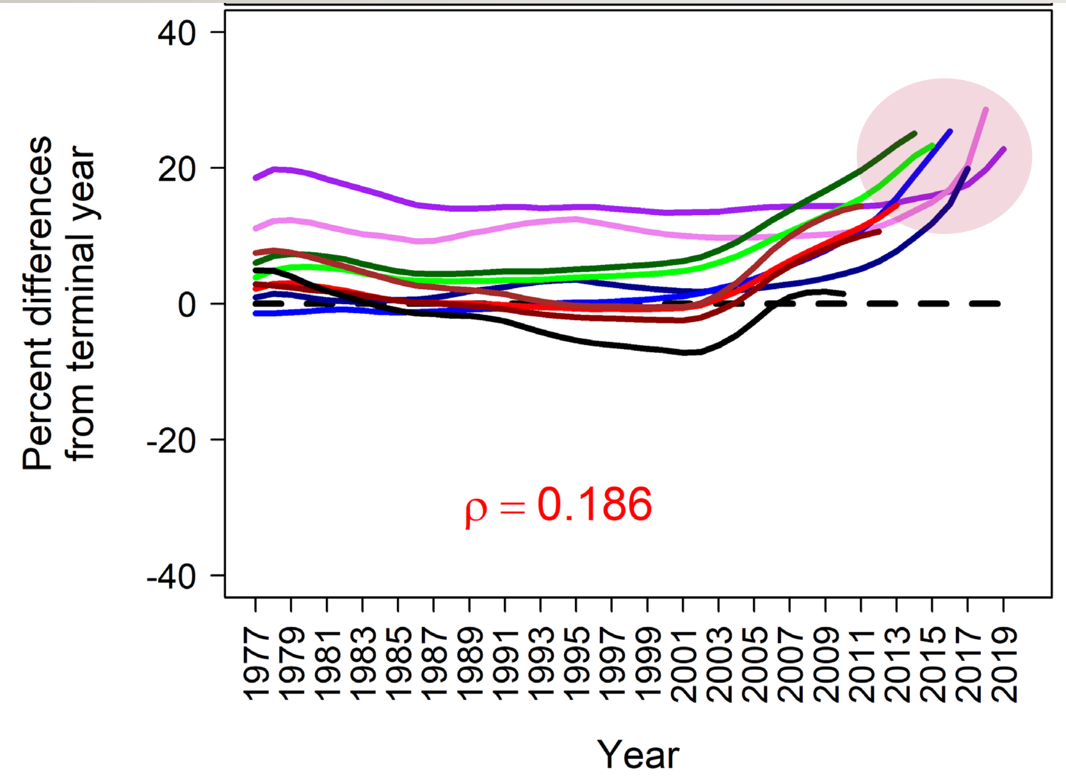
19 WHALES IN THE FISHERY

We are now getting whale observations in logbooks!



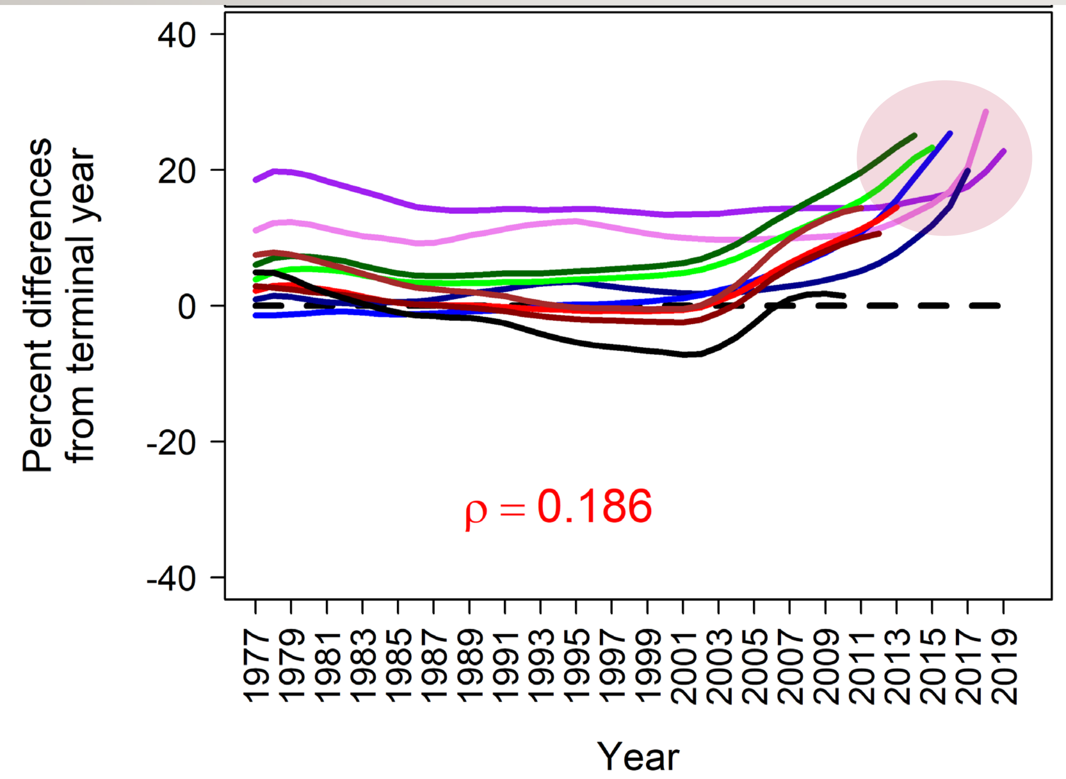
Directly accounted for in assessment and projections.

20 RETROSPECTIVE BIAS INCREASED

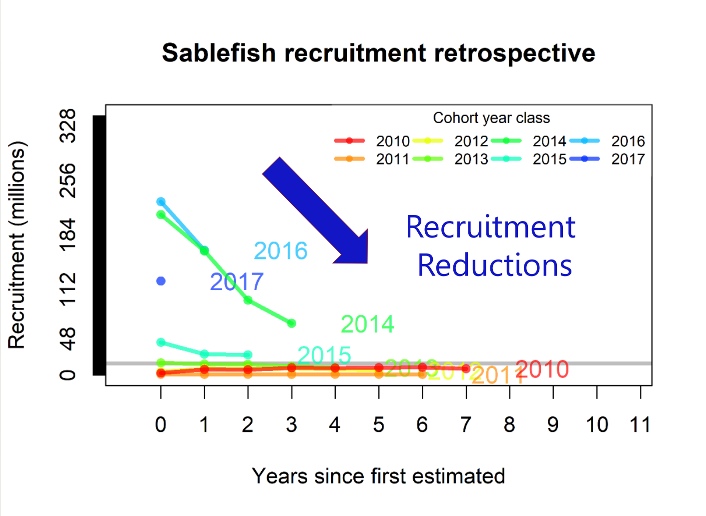


20% reduction in terminal SSB when subsequent year of data is added to model.

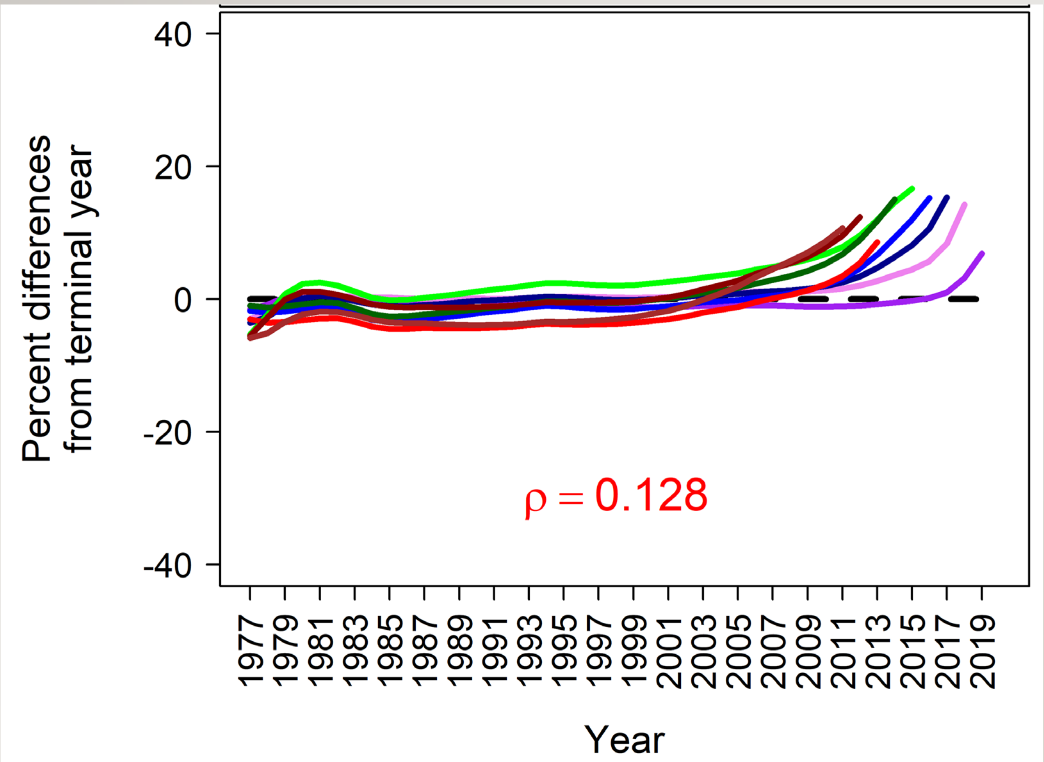
21 RETROSPECTIVE BIAS INCREASED



20% reduction in terminal SSB when subsequent year of data is added to model.

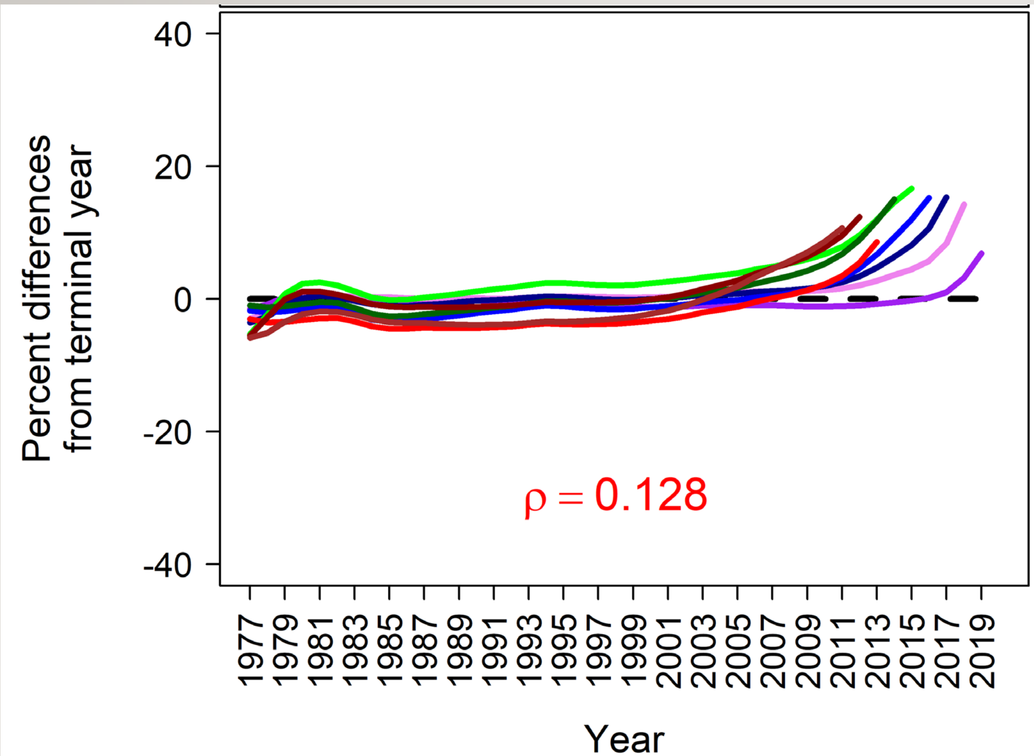


22 PESKY DATA WEIGHTING



Francis reweighting greatly improved model consistency, but there are still issues in the terminal year likely due to data lags and fixed recruitment.

23 PESKY DATA WEIGHTING



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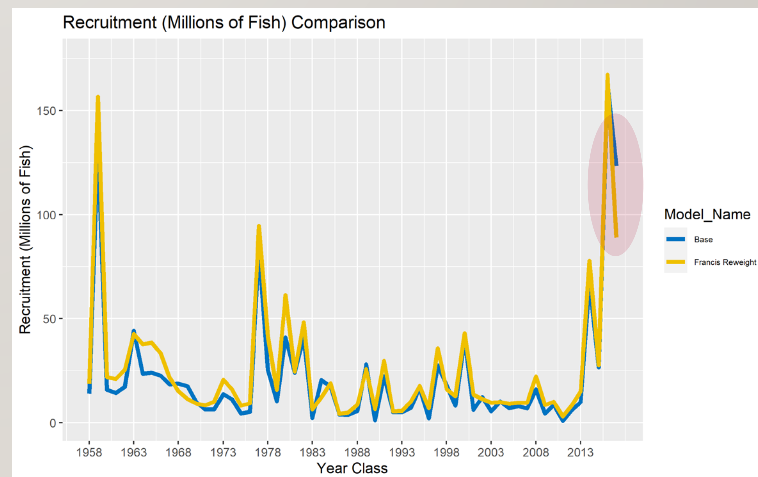
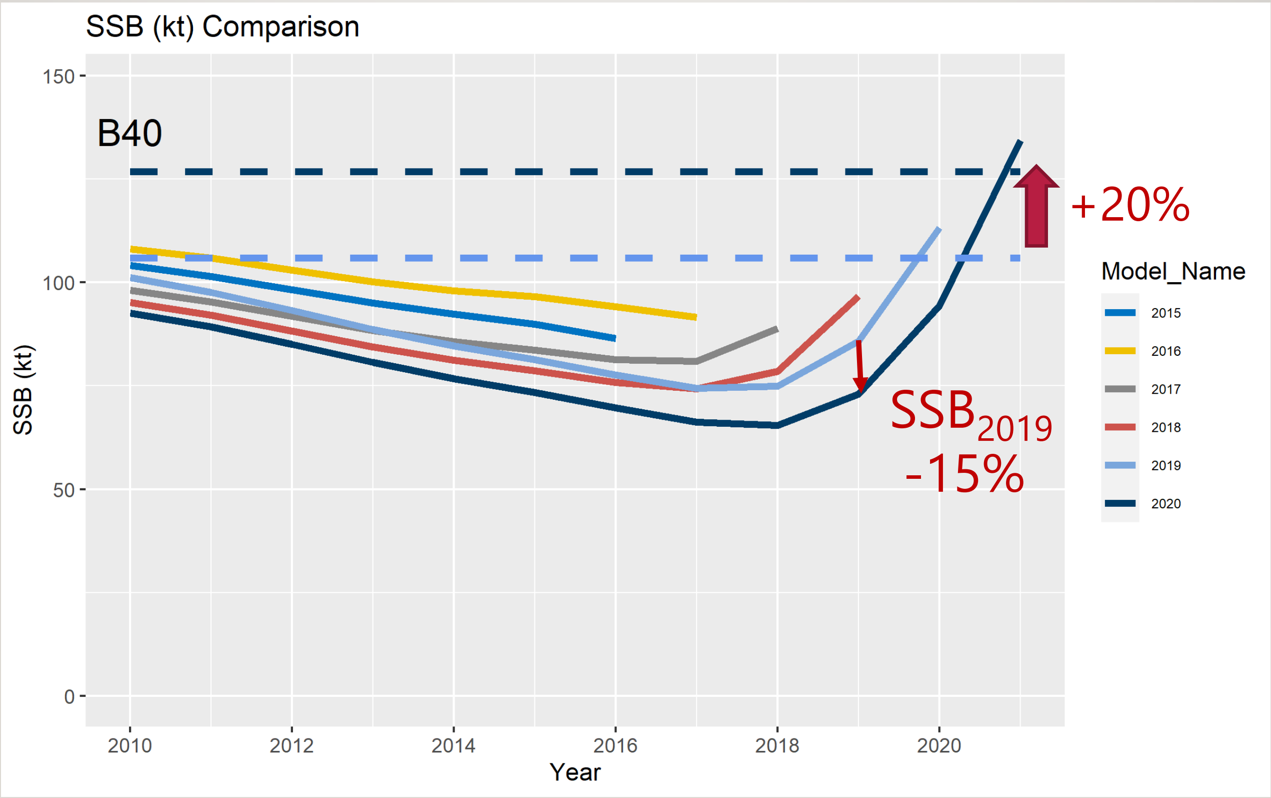
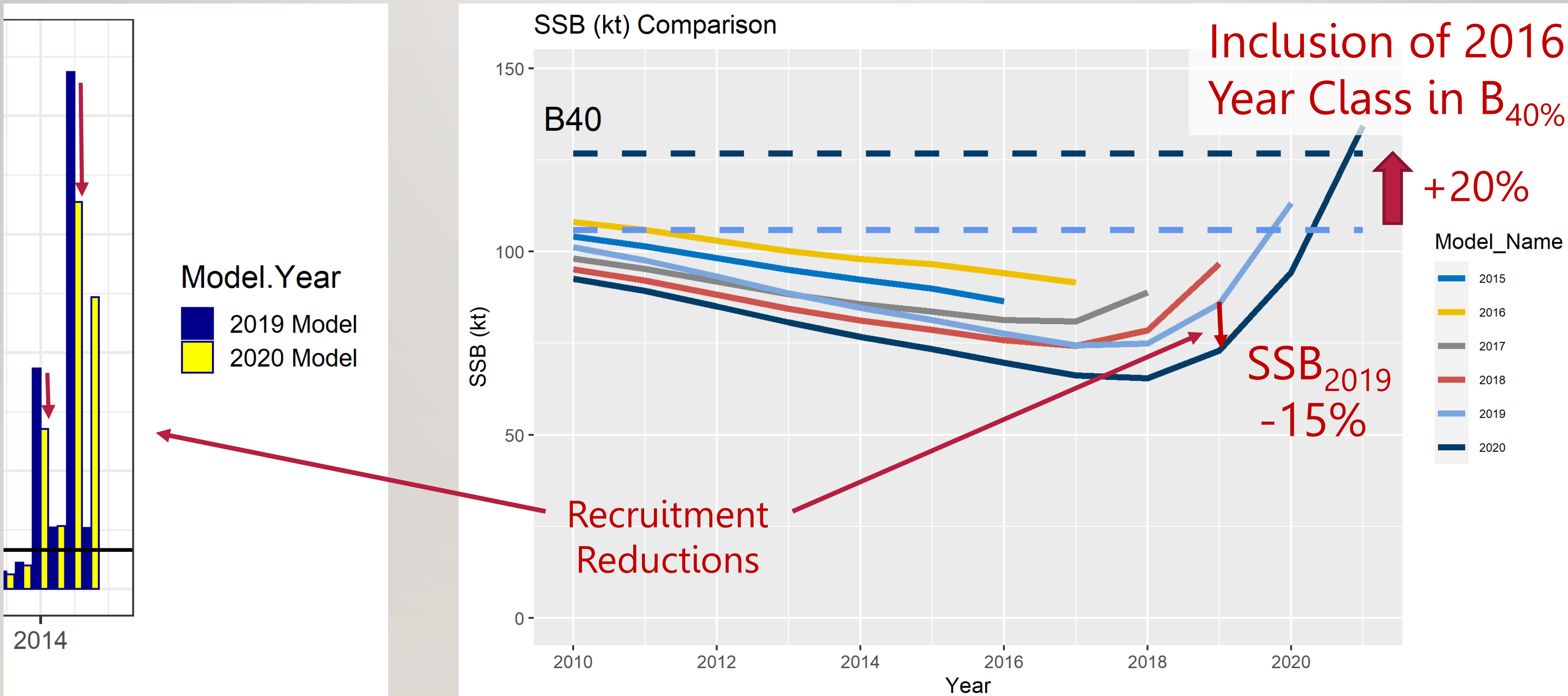


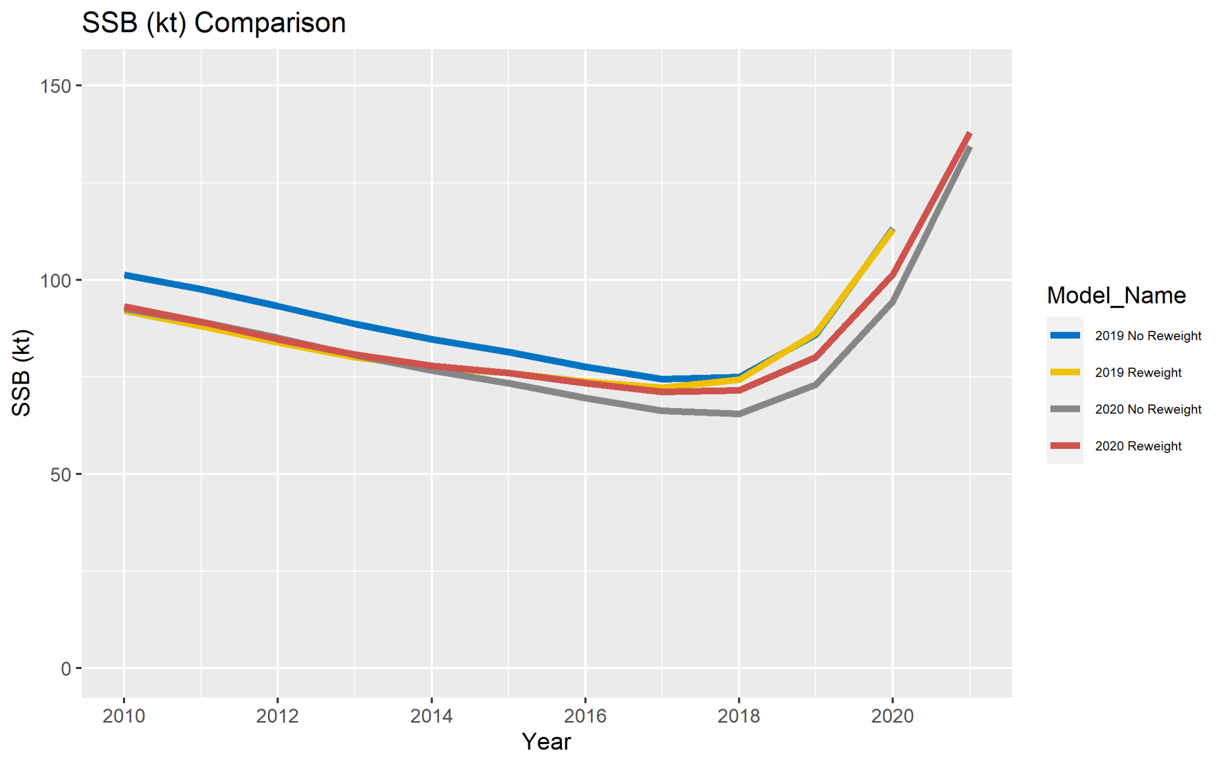
24 SAFE TO SAFE CHANGES



REFERENCE POINTS INCREASED



IMPACT OF DATA REWEIGHTING

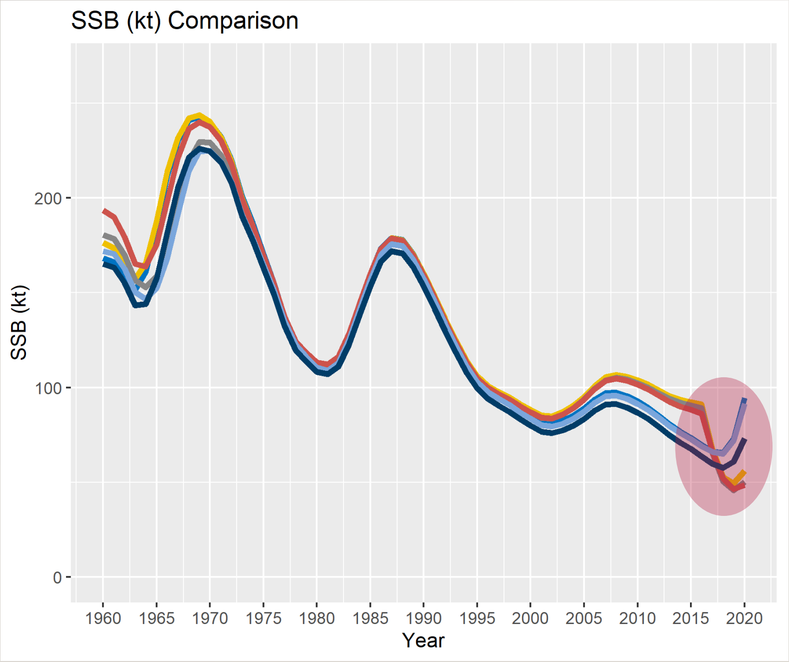


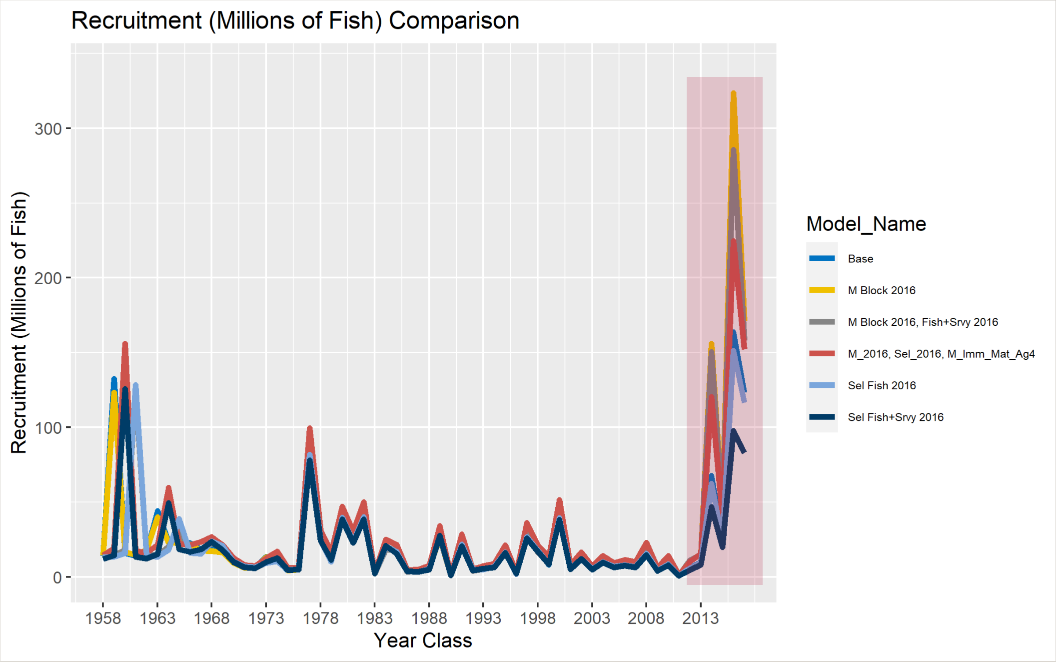
If we can improve data weighting, then model updates should be more consistent in the future.

SENSITIVITY RUNS

- Explored nine areas of model sensitivity and/or parametrization
- Focused on allowing new selectivity time blocks and/or time-/age-variation in natural mortality
- Also explored impact of maturity assumptions and data weighting
- Alternate parametrizations and assumptions had strong impact on terminal SSB (ranging from ~49 kt to 136 kt) and ABC

28 SENSITIVITY RUNS





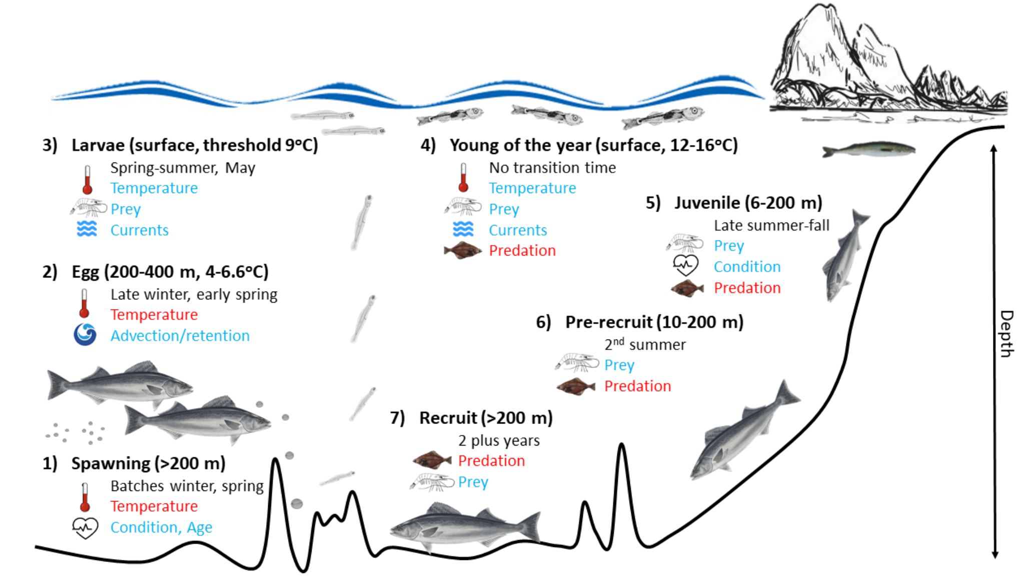
FUTURE DIRECTIONS

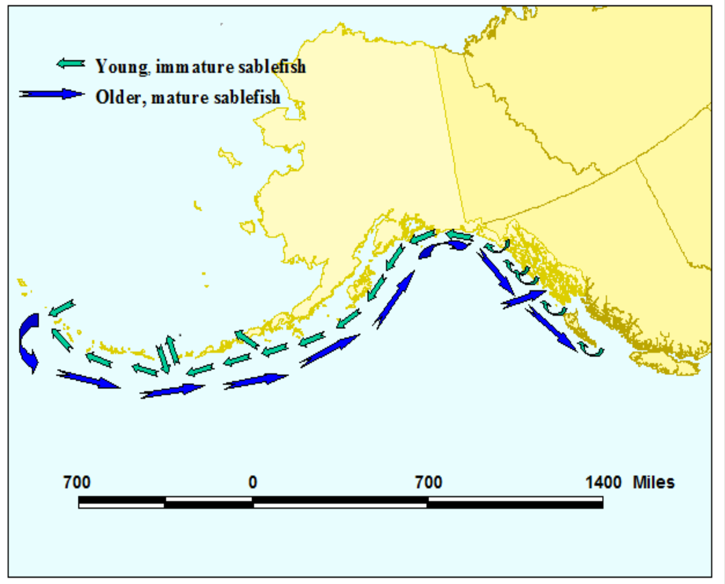
- Improve data weighting and move on from CIE recommendations
- Address changes in availability and targeting by estimating time-varying selectivity (in conjunction with data weighting)
- Reassess biological parameters and assumptions (growth, mortality)
- Explore time-varying or age-varying natural mortality, develop parsimonious parametrizations, and determine appropriate priors
- Assess impact of terminal year data and estimation assumptions
- Incorporate tagging data
- Further refine spatial modeling efforts

ASSESSMENT SUMMARY

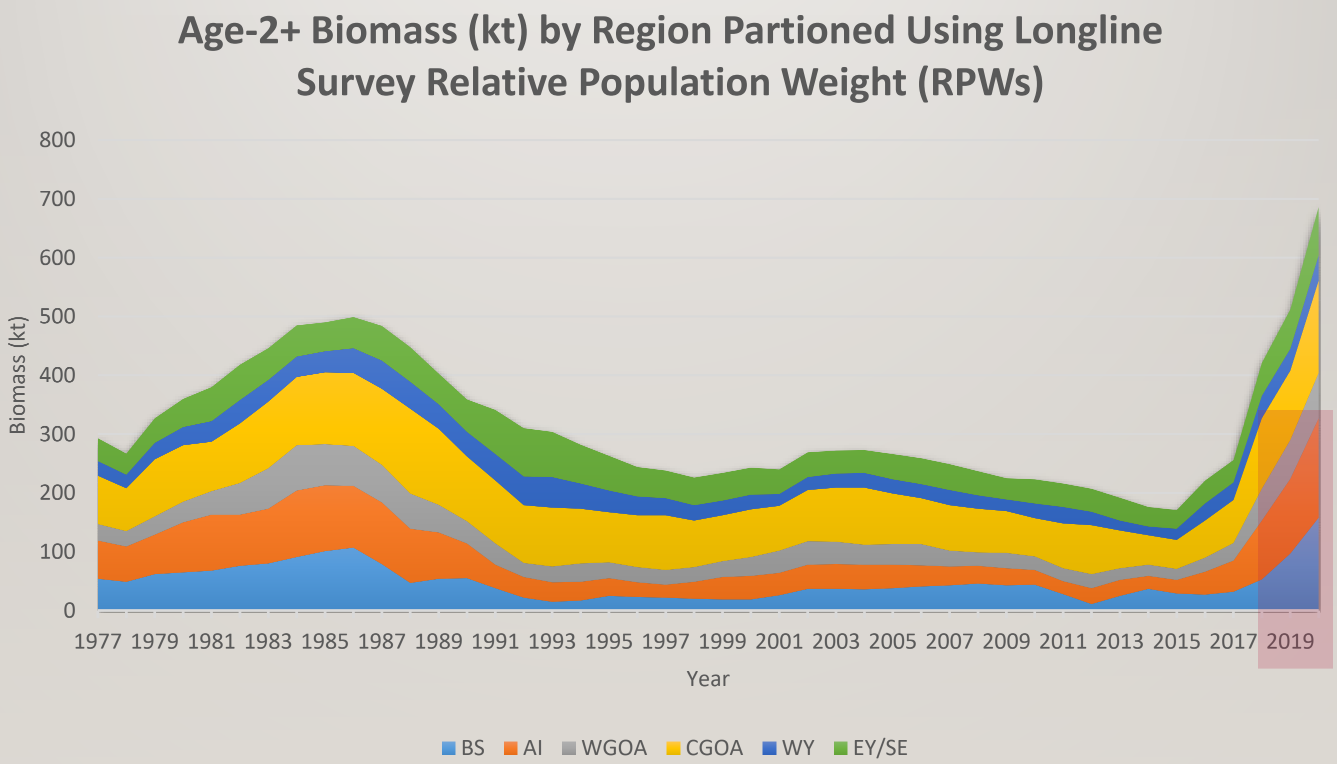
- Model tension between fitting indices and compositional data
- Recent year classes are large, but continue to be downgraded
- SSB increasing rapidly, but still below target rebuilding
- Reference points have increased due to inclusion of 2016 year class
- F is decreasing and well below M
- Retrospective patterns increased and indicate consistent overestimation
- Sensitivity runs indicate that the model may be overestimating SSB and/or underestimating M
- Realized population growth in terminal year SSB from 2019 SAFE to 2020 SAFE was ~10%

31 # MOVEMENT AND DISTRIBUTION

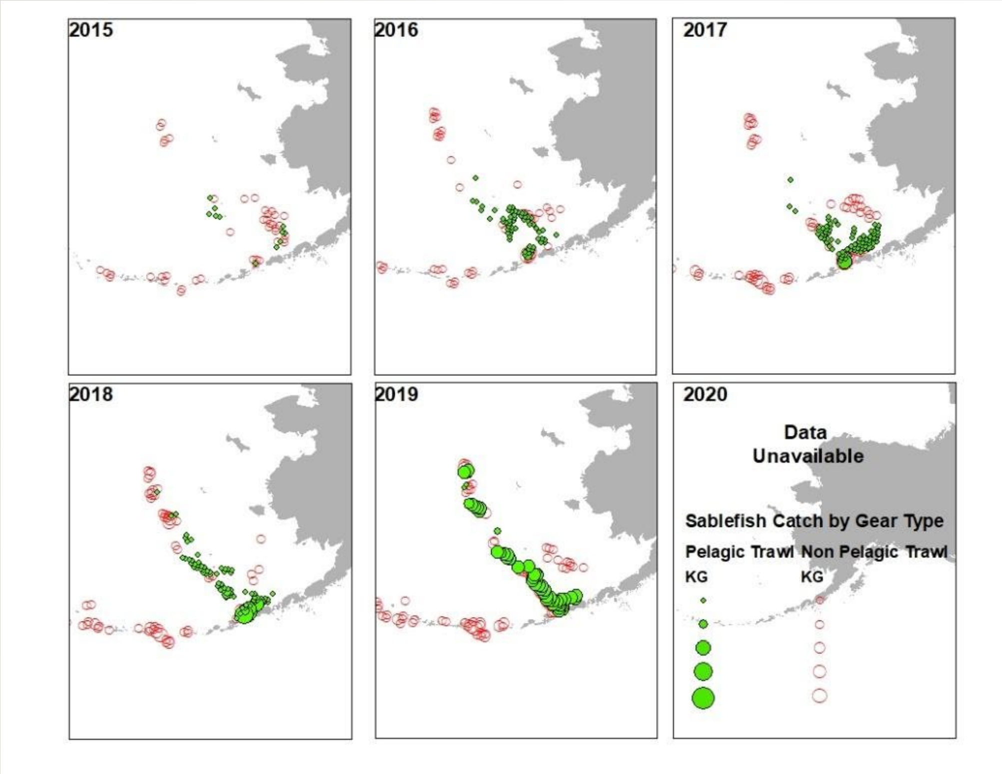


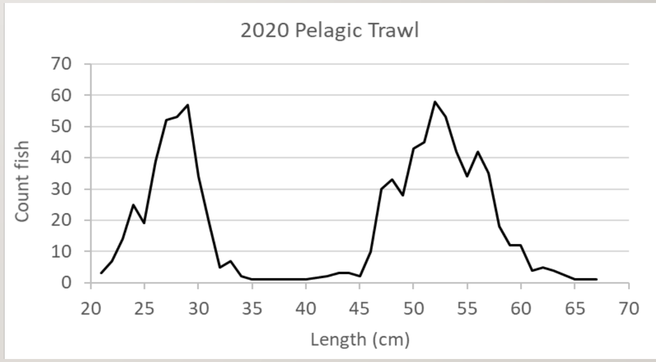


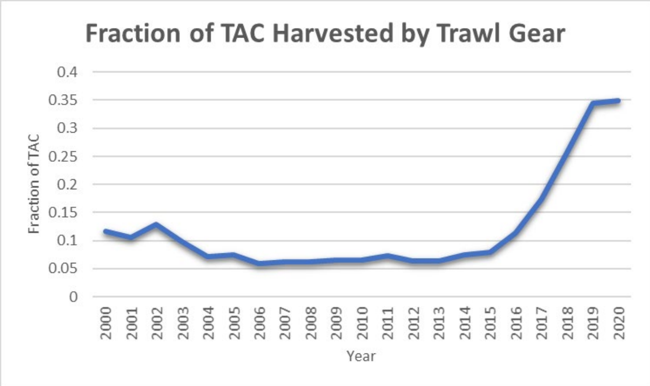
32 APPROXIMATE DISTRIBUTION



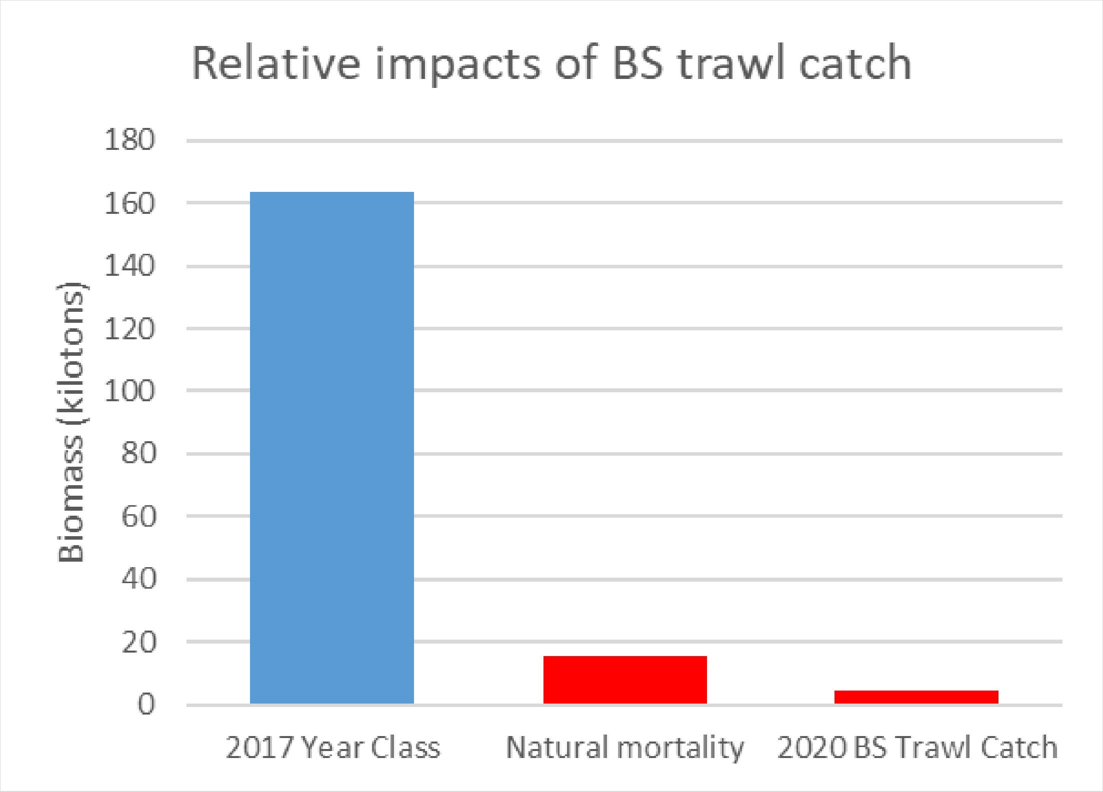
33 EBS TRAWL BYCATCH



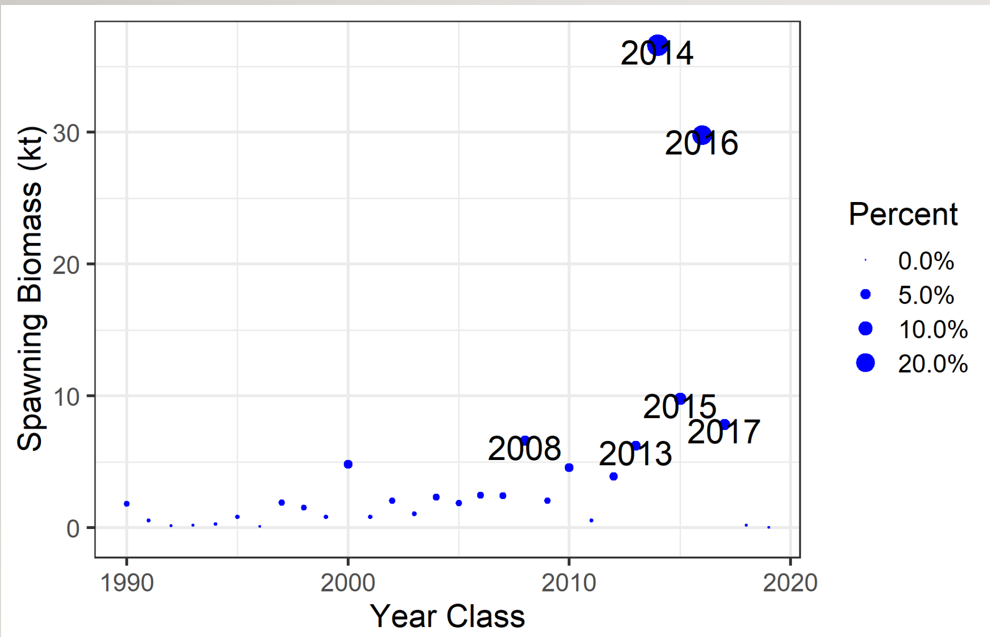


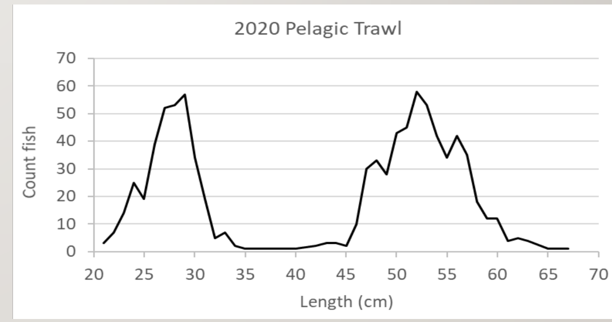


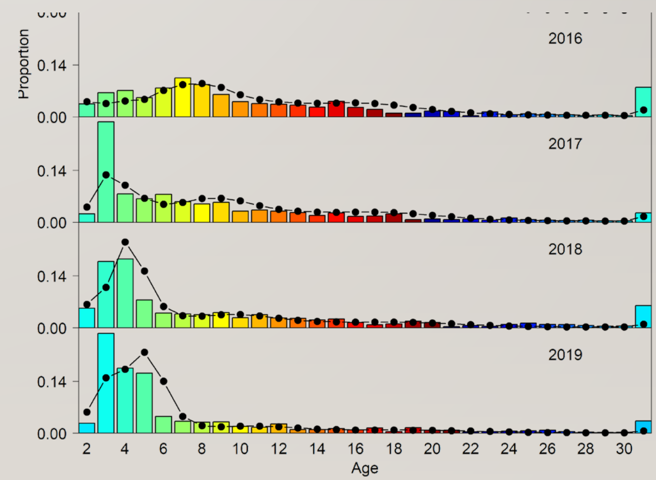
TRAWL BYCATCH



AGE MATTERS

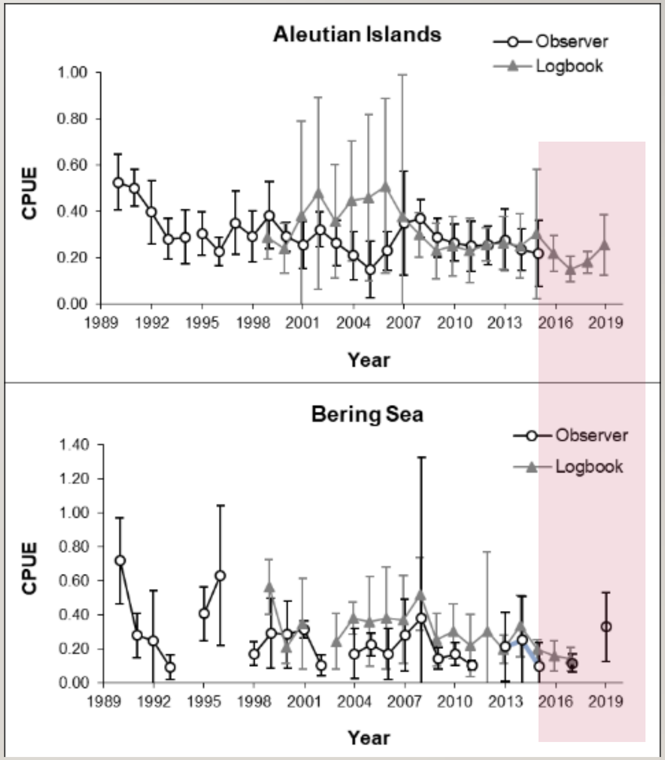

Spawning Biomass (kt)
Year Class
Percent
0.0%
5.0%
10.0%
20.0%
2014
2016
2015
2017
2008
2013
0
10
20
30
1990
2000
2010
2020


2020 Pelagic Trawl
Count fish
Length (cm)
0
10
20
30
40
50
60
70
20
25
30
35
40
45
50
55
60
65
70

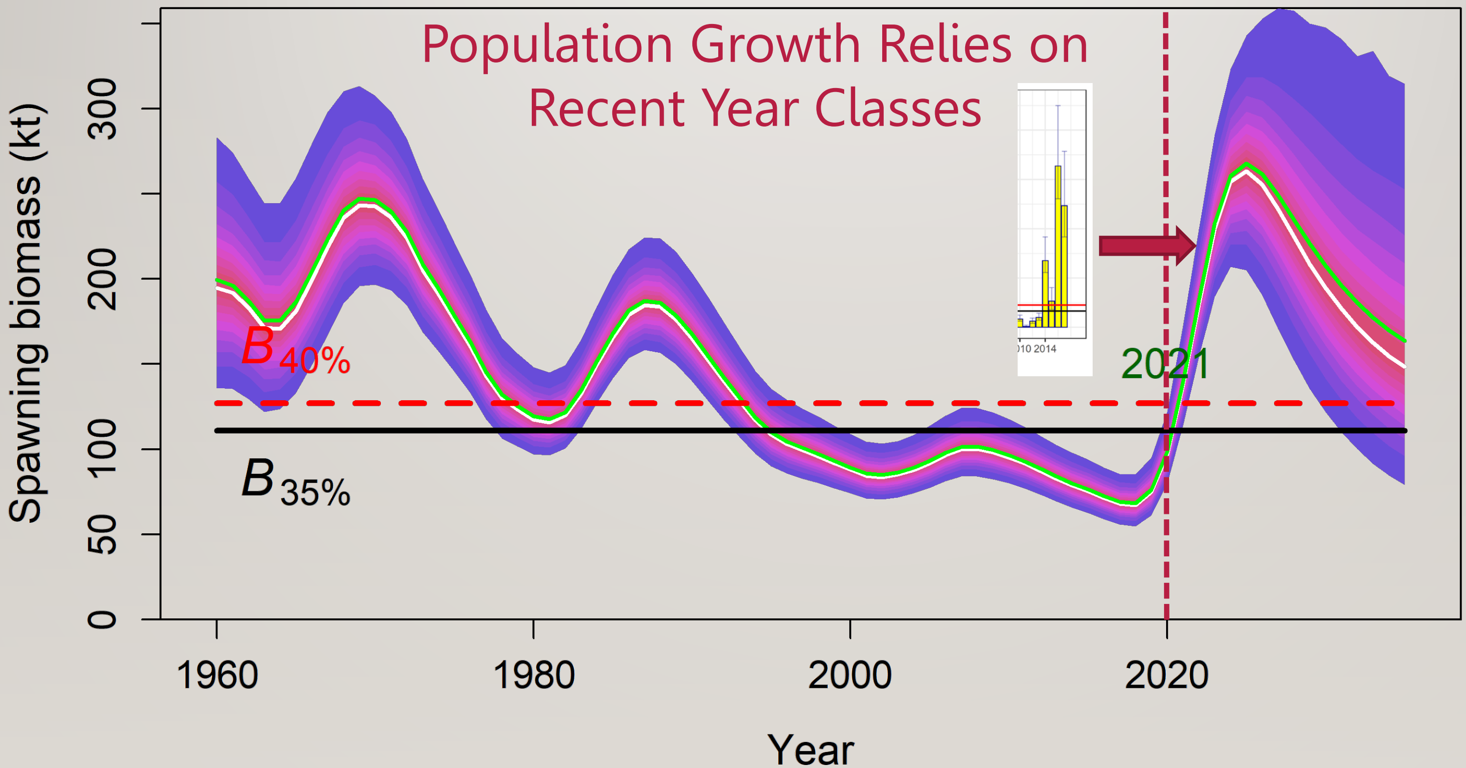

Proportion
2016
2017
2018
2019
0.14
0.00
Age
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

DATA NEEDS

- Fishery-dependent data
  - Low observer coverage on directed trips in BSAI
  - Sablefish are low priority on non-directed trips in EBS
- LL survey occurs every other year in BSAI
- Other surveys poorly sample both juvenile and adult sablefish
- Limited information on juvenile habitat and movement patterns
- Unknown impact of large year classes on condition and survival (e.g., density-dependence)



MAX ABC PROJECTIONS



Projected
+94% in SSB
2020 → 2022

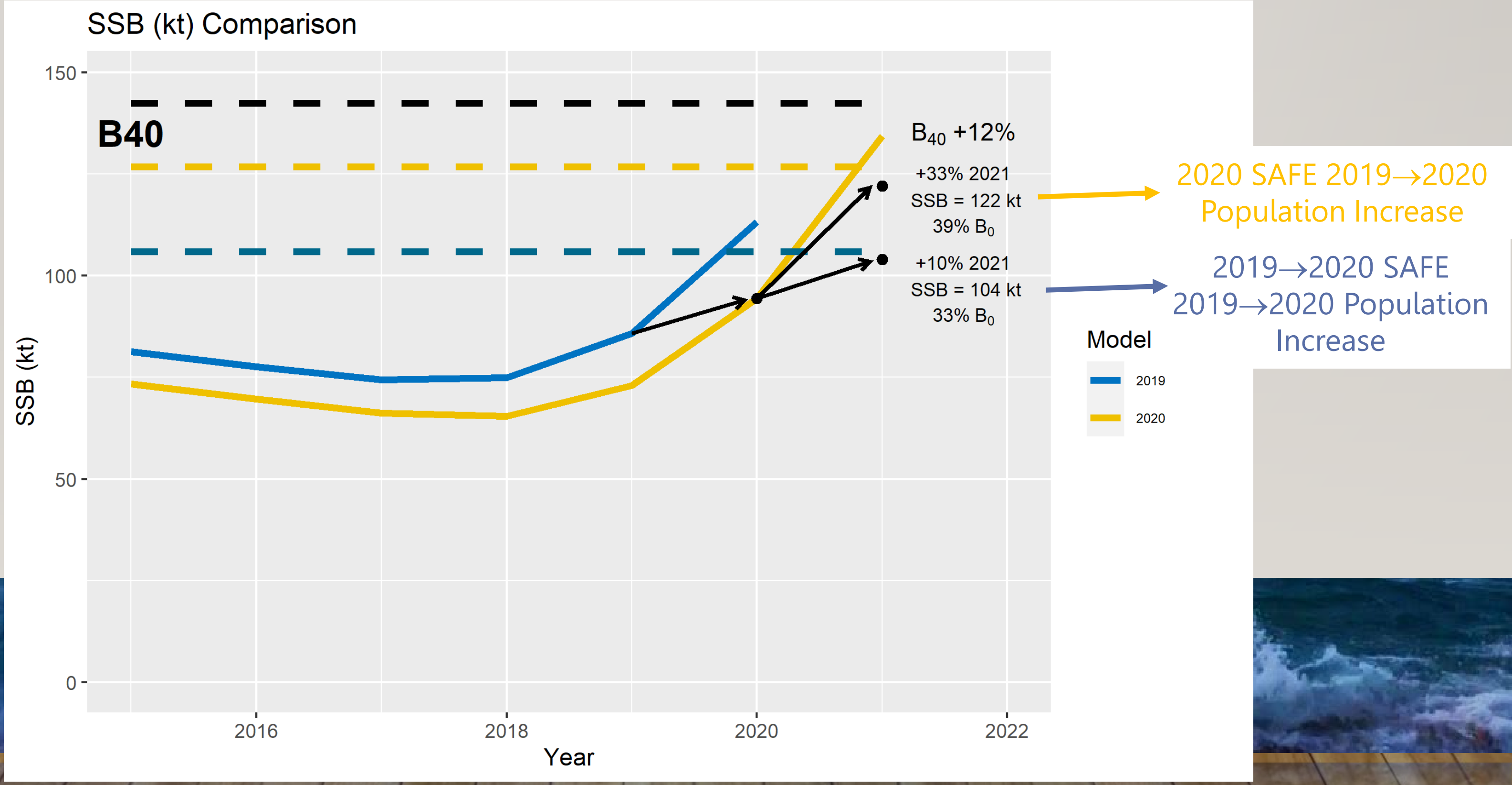
REDUCED RECRUITMENT PROJECTION

- Fix uncertain 2016 and 2017 year classes at average levels

	Max ABC Projection		Avg. Recruitment Projection	
Quantity	**2021**	**2022**	**2021**	**2022**
SSB (t)	134,000	192,000	98,000	109,000
ABC (t)	52,400	61,400	22,100	23,400
OFL (t)	61,300	71,800	25,800	27,400

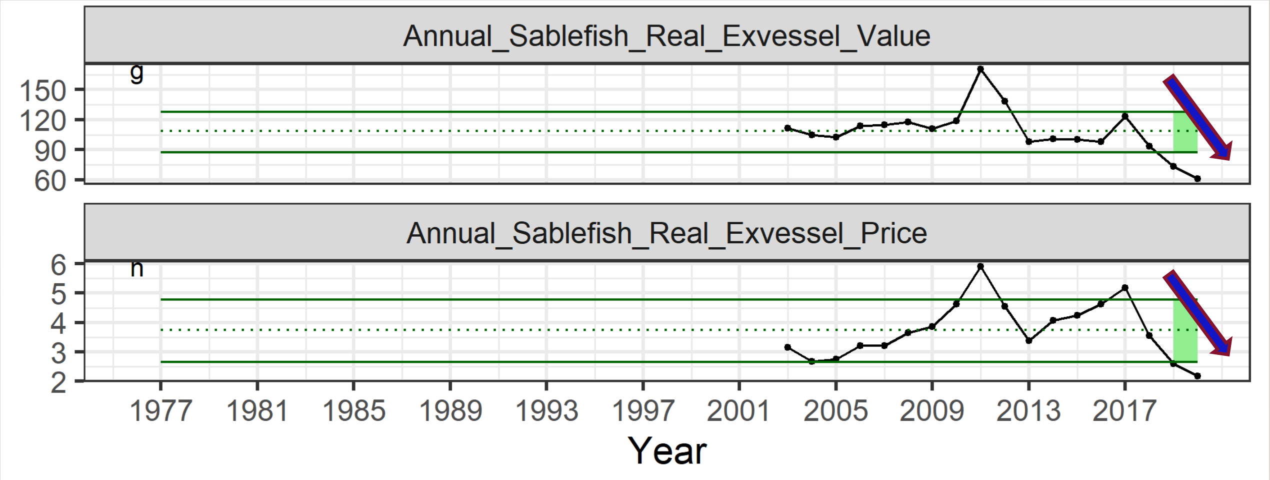
EXTRAPOLATED GROWTH

- Assume consistent retrospective patterns and population growth and include 2017 year class in B_{40}

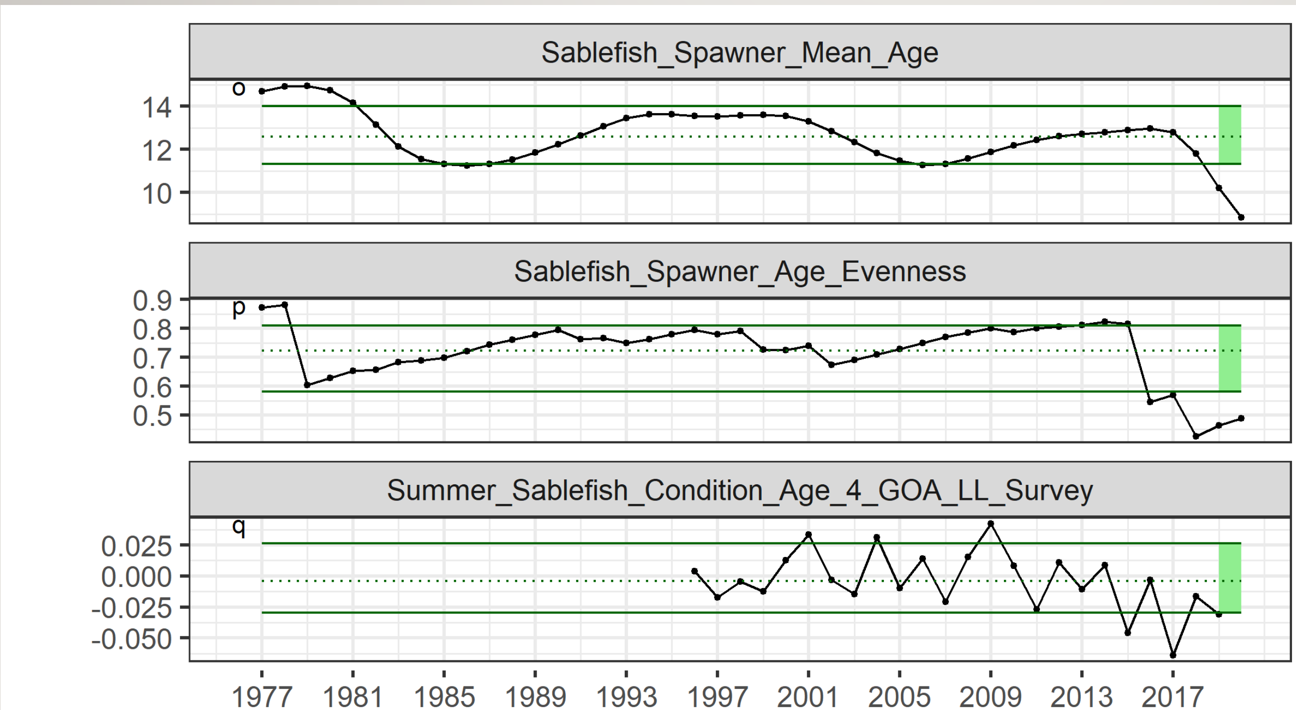


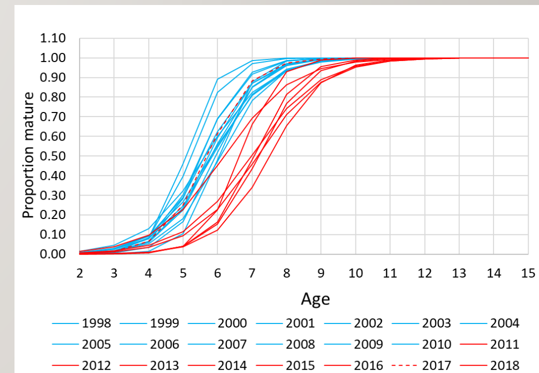
FISHERY PERFORMANCE

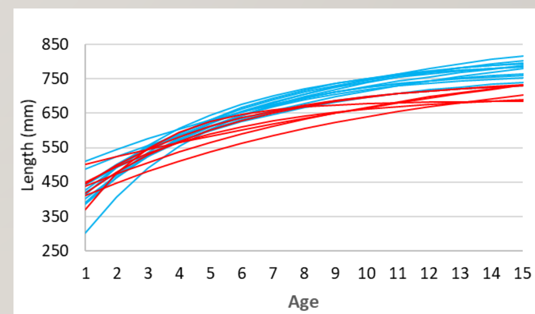
- Fishery performance (CPUE, Value) declining
- Rapid shifts in fishery composition



POOR CONDITION, CHANGES IN VITAL RATES (ESP)







ECOSYSTEM AND SOCIO-ECONOMIC PROFILE (ESP)

- Eco-Positives: Continued presence of 2016 and now 2019 YC in ADF&G large-mesh, ↑ adult condition
- Eco-Negatives: Spawners and age evenness remain low, ↑ overlap with arrowtooth fishery
- Socio-Positives: TACs no longer ↓, ↓ incidental catch in GOA
- Socio-Negatives: ↑ incidental catch in BSAI, ex-vessel value and average price continue to decline

43

RISK TABLE FRAMEWORK

- Assessment model: **3** (major concern)
- Population dynamics: **3** (major concern)
- Ecosystem: **2** (increased concern)
- Fishery performance: **3** (major concern)
- Reduced ABC would aid in more rapidly rebuilding spawning biomass and improving age structure

BOTTOM LINE

- Biomass increasing, but not as strongly as projected
- Maximum permissible ABC increasing rapidly, but projections are overly optimistic
- 2021 Author's ABC = 2020 SSC recommended ABC
  - F_ABC_2021 (0.0423) = F_ABC_2020 (0.043) ≈ F_2020 (0.046)
  - **+17% from author's ABC in 2020, because population is rebuilding**
- Risk table approach utilized as rationale

Year	2020	2021	2022
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OFL	51,726	61,319	71,756
***OFL_w**	**50,481**	**60,426**	**70,710**

45 ABC SUMMARY

- **Rationale**: maintain F from previous years, because the stock has not rebuilt despite setting conservative ABCs in recent years
- **May need to temper the control rule F**: Do not support strong increases in fishing mortality when we do not fully understand the size of recent year classes and associated potential changes in natural mortality or other biological processes (e.g., growth, maturity, general condition) that may be occurring
- **Strong increases in retrospective patterns** escalate concern that the model may not be adequately capturing changing processes and that projections are overly optimistic

WHY CHANGE APPORTIONMENT?

- Biological considerations
  - Changing distributions
  - Age distribution of mortality
- SSC has requested ‘resolution’ of apportionment
  - Dec 2019: “The SSC notes that the distribution of sablefish has changed considerably since 2013 and there remains a need to resolve how ABC allocations will be derived in the future. The SSC requests that the author finalizes the allocation process no later than September 2020.“
  - Dec 2018: “The SSC continues to request that a new apportionment approach be presented next year, noting that the percentages have now been static for many years. The potential for changes in distribution in the fishery and/or the population may become more pronounced with the increasing contribution of the 2014 year class.”

PRIMARY APPORTIONMENT STRATEGIES

- Fixed (status quo)
  - Ignores rapidly changing distribution of biomass
- NPFMC (exponentially weighted survey and fishery data)
  - Limited fishery-dependent data (i.e., BSAI observer data)
- Survey (5-year average survey proportions)
  - Best represents biomass distribution

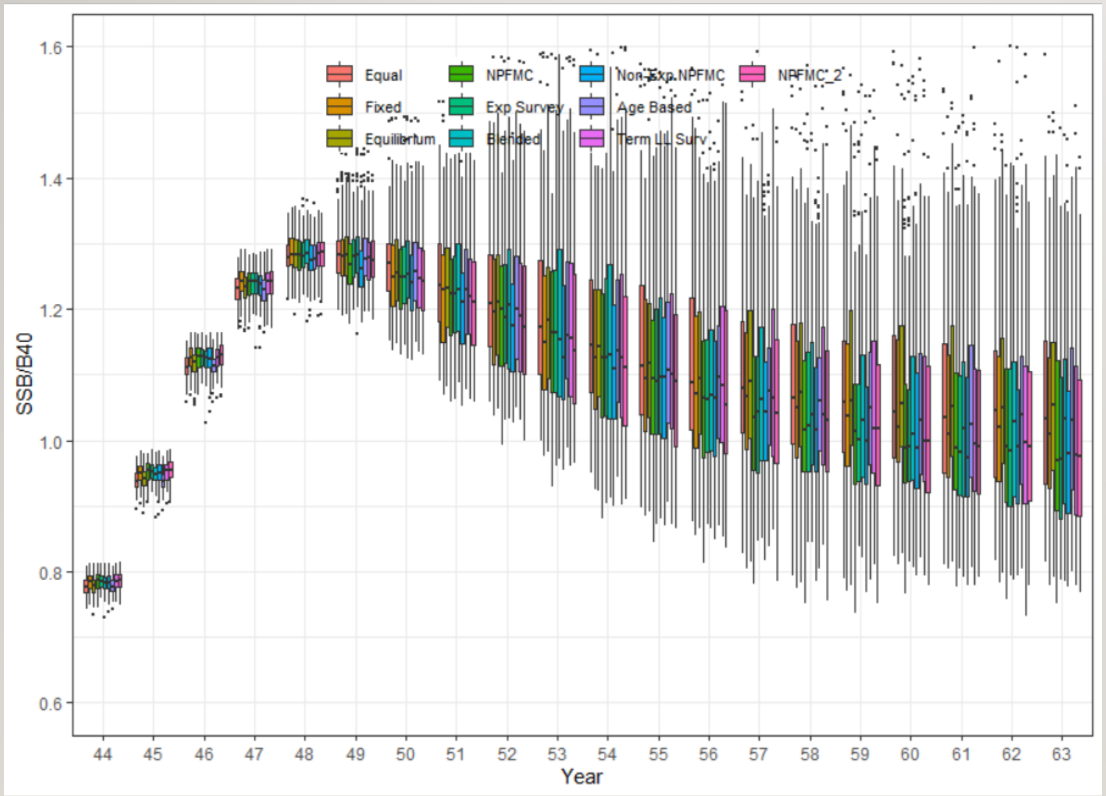
ALTERNATE APPORTIONMENTS

- Stakeholders suggested apportioning based on survey distribution of 65+ cm fish
- Used an age-based proxy in simulations
  - Results essentially mimicked Fixed apportionment
- Similar biological concerns as the Fixed strategy
  - Focus removals on diminishing mature cohorts
  - Need to adjust ABC to account for increased removals of older, mature fish (instead of removals from full age/size structure)

49 SIMULATION WORK

- Conditioned the operating model on the data/assessment model through 2018 (excluding 2016 year class)
- Applied estimation model similar to SAFE model
- Applied current harvest control rule
- Many SSC recommendations led to recurring convergence issues
  - Desired results not possible due to limitations in simulation framework

SIMULATION WORK

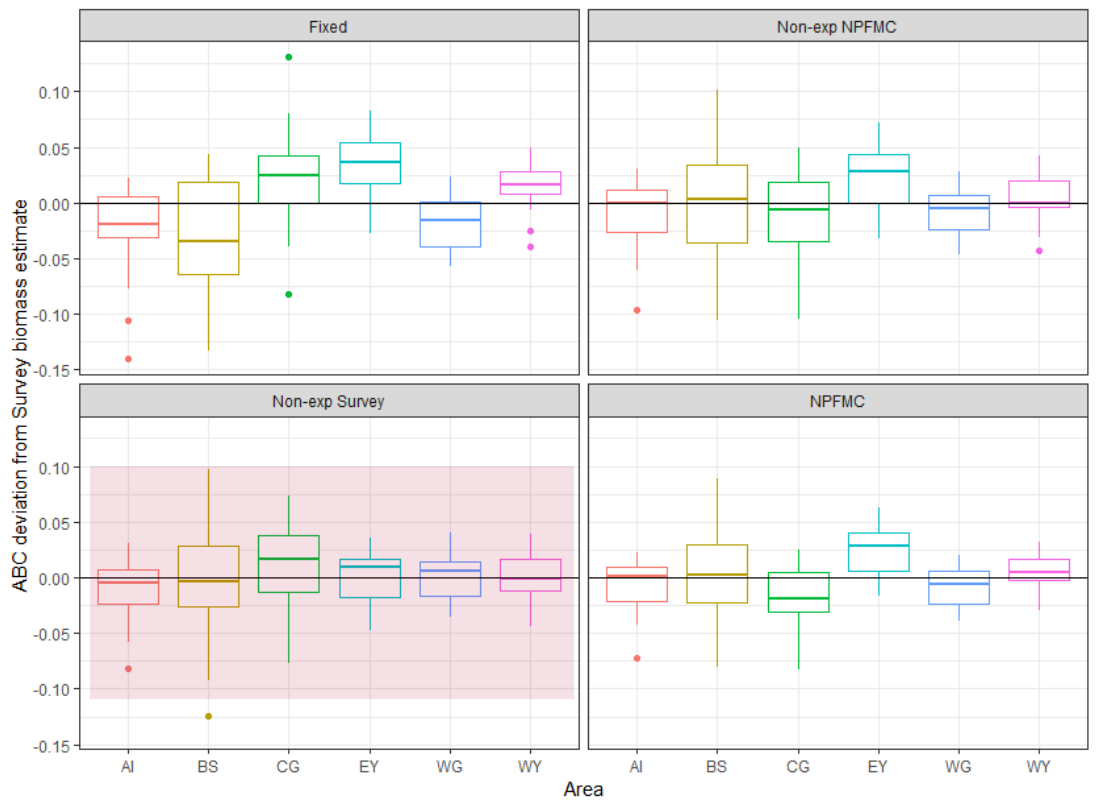


ON AVERAGE most apportionment strategies perform similarly given the assumed dynamics.

51 LIMITATIONS

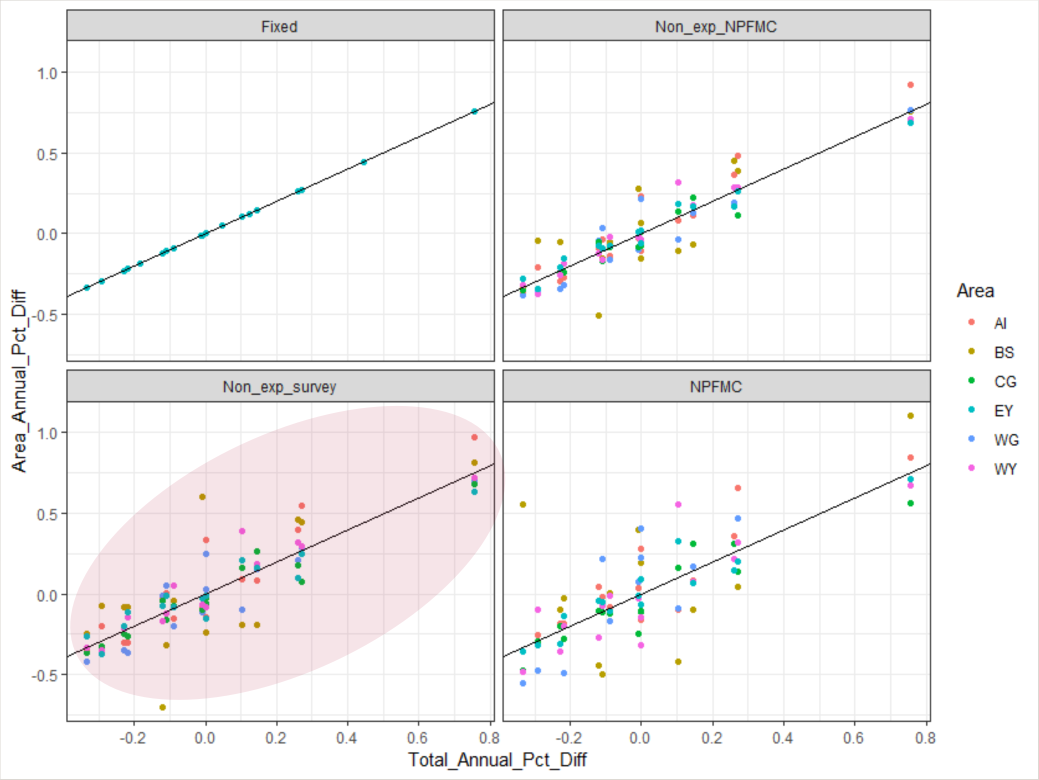
- Expectations/conclusions from MSE work need to be tempered
  - Conditioned on extant dynamics as of ~2018
  - Does not specifically account for current dynamics (i.e., strong year classes and resulting distributional shifts), because we don't have data to adequately address
  - Have not tested alternate population dynamics or exceptional circumstances for which apportionment strategies might perform poorly

52 RETROSPECTIVE ANALYSIS



How does area ABC differ from biomass proportions by area from LL survey?

53 RETROSPECTIVE ANALYSIS



How does year-to-year variation in area ABCs compare to total ABC ?

APPORTIONMENT CONCLUSIONS

- 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

APPORTIONMENT SUGGESTION

- **Suggestion**: 5-year average of regional survey biomass proportions
- Stair step approach is likely warranted to avoid drastic changes in 2021 by area

Area	2020 ABC*	NPFMC 'Standard' Apportionment for 2021 ABC	Fixed Apportionment for 2021 ABC*	*Recommended Non-Exp. Survey Apportionment for 2021 ABC*	% Difference from 2020 ABC	Stair Step Non-Exp. Survey Apportionment for 2021 ABC	% Difference from 2020 ABC
Total	22,551	22,551	22,551	**22,551**	0%	22,551	0%
Bering Sea	2,201	4,538	2,201	**3,714**	69%	2,958	34%
Aleutians	2,976	5,021	2,976	**5,324**	79%	4,150	39%
Gulf of Alaska	17,374	12,991	17,375	**13,513**	-22%	15,444	-11%
Western	2,433	2,589	2,433	**2,779**	14%	2,606	7%
Central	7,692	5,097	7,693	**5,786**	-25%	6,739	-12%
W. Yakutat**	2,587	1,742	2,588	**1,934**	-25%	2,261	-13%
E. Yak. / Southeast**	4,662	3,563	4,662	**3,014**	-35%	3,838	-18%

56 APPORTIONMENT SUGGESTION

- 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

57 THE FUTURE OF APPORTIONMENT?...

- Limitations to the existing simulation framework
  - Difficult to simulate or predict biological consequences of apportionment related to extreme recruitment events
  - We do not currently have the tools to account for socioeconomic considerations
- Better undertaken outside assessment recommendations in the SSC/Council Process
  - Needs to address uncertainty, risk, and socioeconomic considerations
- Spatial models may be able to directly estimate area ABCs...
  - ...BUT they are limited by lack of area-specific data (e.g., compositional data)

WHALE ADJUSTED AUTHOR ABC

Year	**2020**				**2021**		**2022**	
Region	OFL_w	ABC_w	TAC	Catch*	OFL_w	ABC_w**	OFL_w	ABC_w**
BS	--	2,174	1,861	4,581	--	5,294	--	6,978
AI	--	2,952	2,039	1,104	--	3,674	--	4,843
GOA	--	16,883	14,393	9,208	--	13,269	--	17,489
WGOA	--	2,278	1,942	1,113	--	2,671	--	3,521
CGOA	--	7,560	6,445	4,151	--	5,738	--	7,563
**WYAK	--	2,521	2,343	1,547	--	2,050	--	2,702
**EY/SEO	--	4,524	3,663	2,398	--	2,809	--	3,703
Total	50,481	22,009	18,293	14,894	60,426	22,237	64,765	29,309

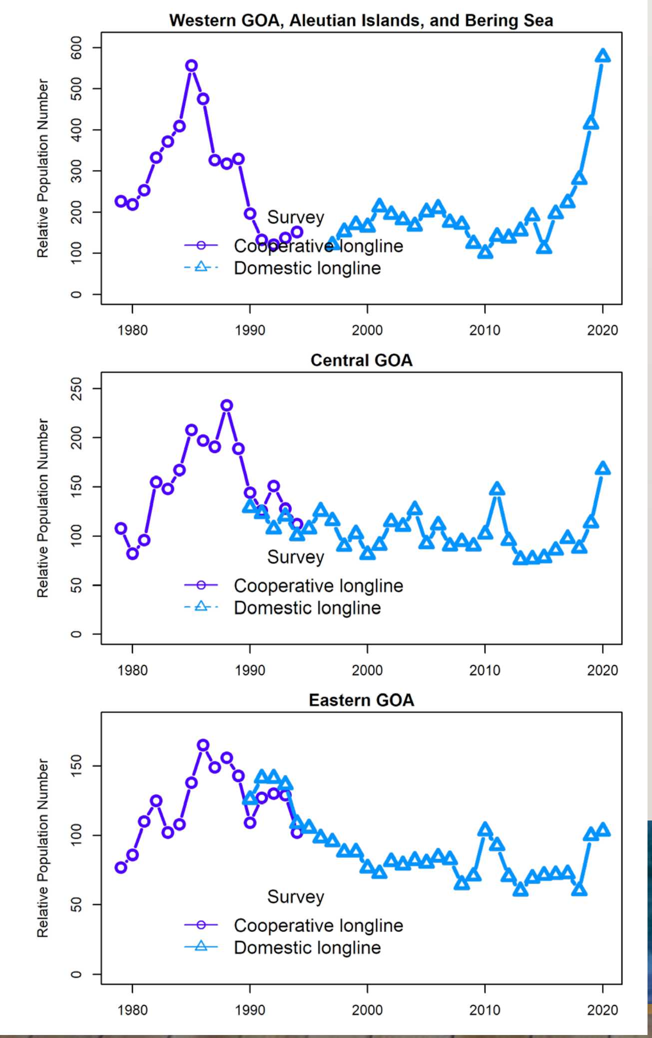
WHALE ADJUSTED AUTHOR ABC

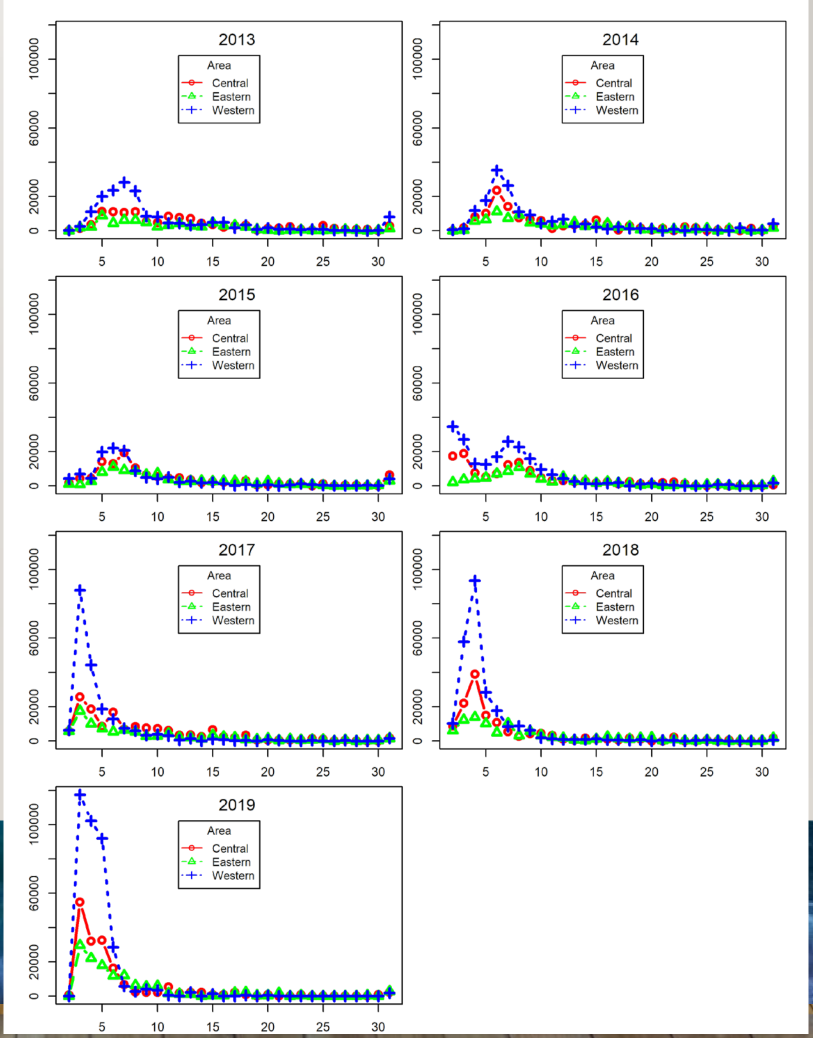
Area	Year	Biomass (4+)	OFL	ABC	TAC	Catch
GOA	2019	264,000	22,703	11,571	11,571	12,772
	2020	387,000	--	16,883	14,393	9,208
	2021	390,000	--	13,269	--	--
	2022	383,000	--	17,489	--	--
BS	2019	52,000	2,887	1,489	1,489	3,191
	2020	116,000	--	2,174	1,861	4,581
	2021	142,000	--	3,674	--	--
	2022	139,000	--	4,843	--	--
AI	2019	98,000	3,917	2,008	2,008	661
	2020	154,000	--	2,952	2,039	1,104
	2021	175,000	--	5,294	--	--
	2022	172,000	--	6,978	--	--

SUMMARY TABLE

Quantity/Status	As estimated or specified *last* year for: 2020	2021	As estimated or recommended *this* year for: 2021*	2022*
M (natural mortality rate)	0.105	0.105	0.098	0.098
Tier	3a	3a	3a	3a
Projected total (age 2+) biomass (t)	704,683	741,029	753,110	789,584
Projected female spawning biomass (t)	113,368	156,854	134,401	191,503
$B_{100\%}$	264,940	264,940	317,096	317,096
$B_{40\%}$	105,976	105,976	126,389	126,839
$B_{35\%}$	92,729	92,729	110,984	110,984
F_{OFL}	0.121	0.121	0.117	0.117
$maxF_{ABC}$	0.102	0.102	0.100	0.100
F_{ABC}	0.043	0.041	0.042	0.048
OFL (t)	51,726	66,361	61,319	71,756
OFL_w (t)**	**50,481**	**64,765**	**60,426**	**70,963**
max ABC (t)	44,065	56,589	52,427	61,393
ABC (t)	22,551	29,723	22,551	29,723
ABC_w (t)**	22,009	29,008	**22,237**	**29,309**
Status	As determined *last* year for: 2018	2019	As determined *this* year for: 2019	2020
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

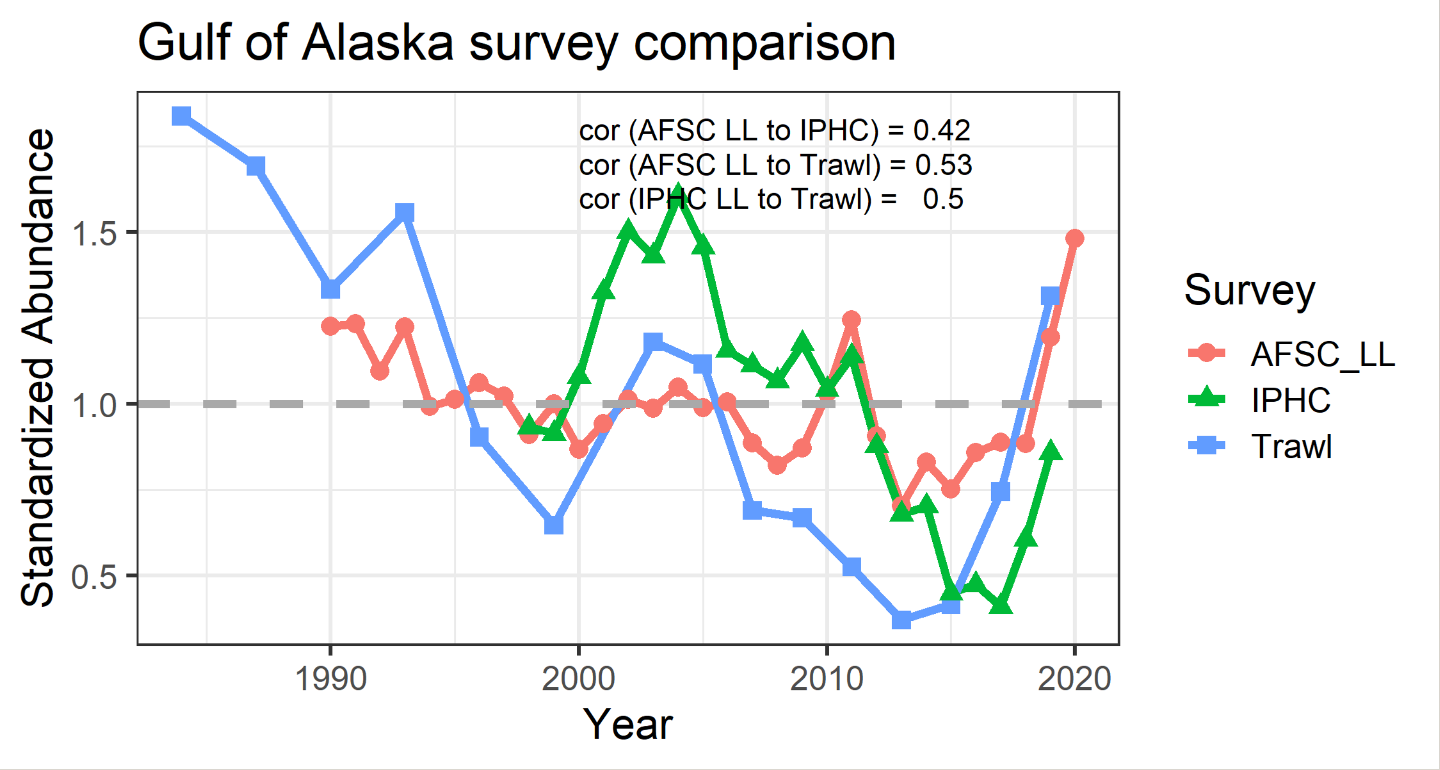
LL SURVEY BY AREA



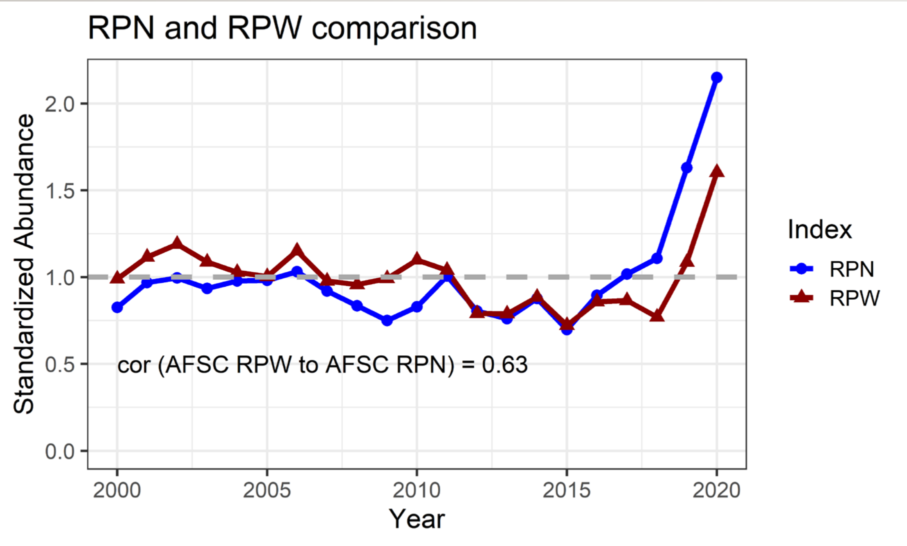


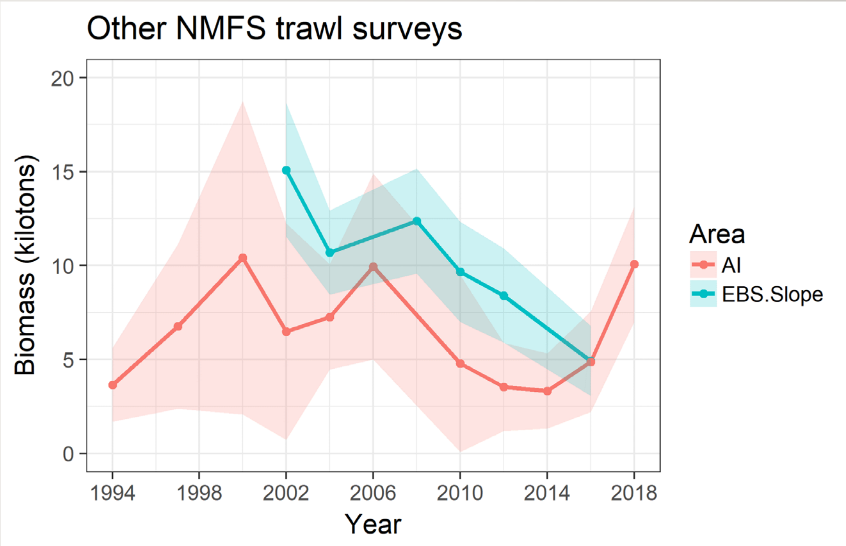
63

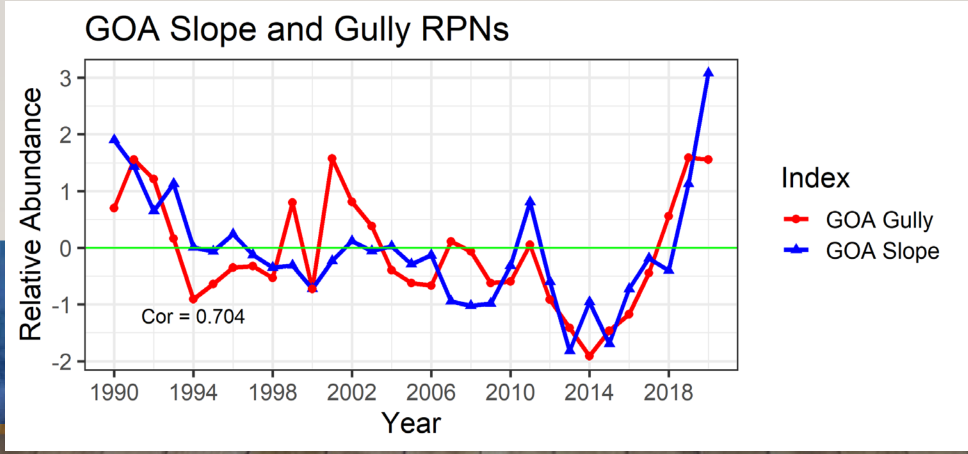
OTHER SURVEYS



OTHER SURVEYS







ADFG

NSEI Assessment

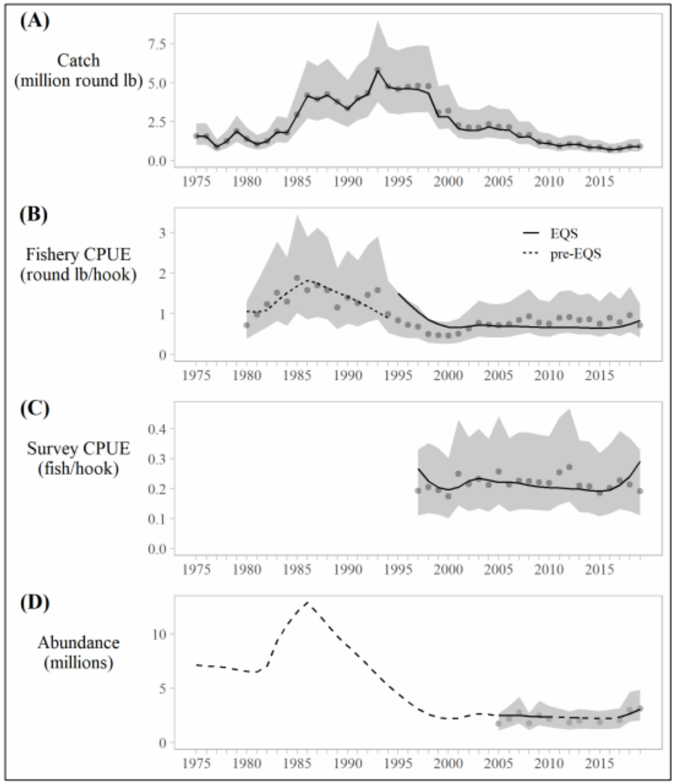
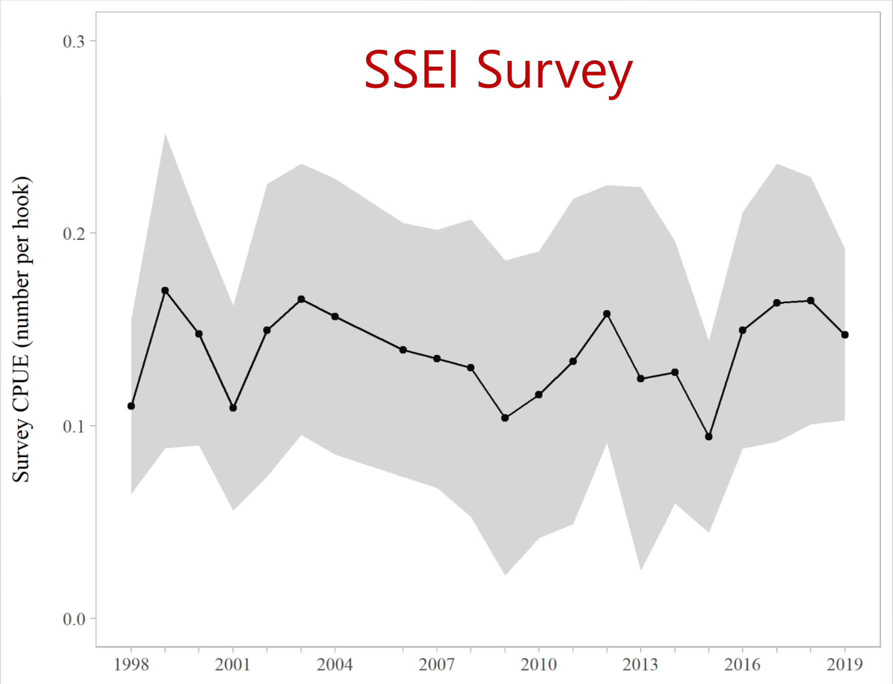
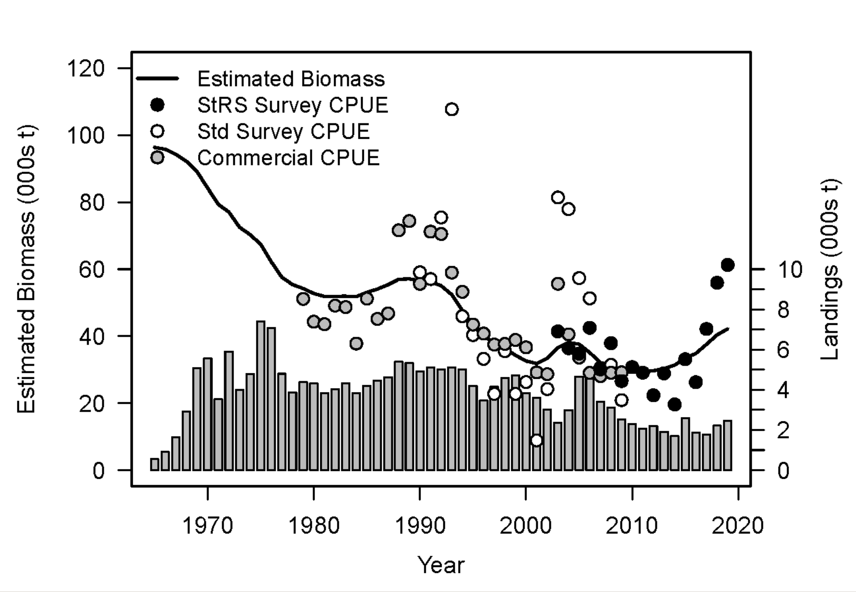


Figure 4.–Fits to indices of catch and abundance with the assumed error distribution shown as shaded grey polygons. Input data are shown as grey points and model fits are shown in black. Indices include (A) harvest (million round lb); (B) fishery CPUE in round lb per hook with separate selectivity and catchability time periods before and after the implementation of the equal quota share (EQS) program in 1994; (C) survey CPUE in number of fish per hook; and (D) mark–recapture abundance estimates in millions. Solid and dashed lines in panel D reflect years for which data were available (solid) and were not available (dashed).

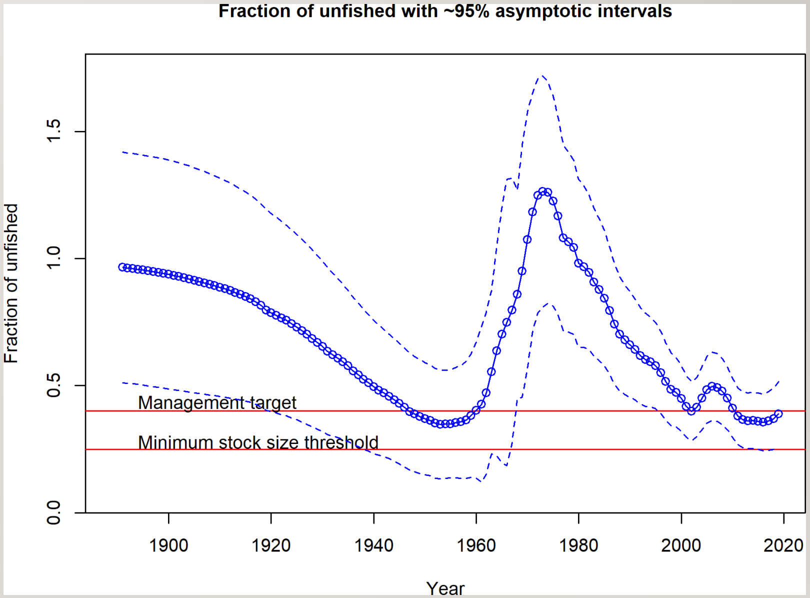


66 # COASTWIDE RESULTS

BC

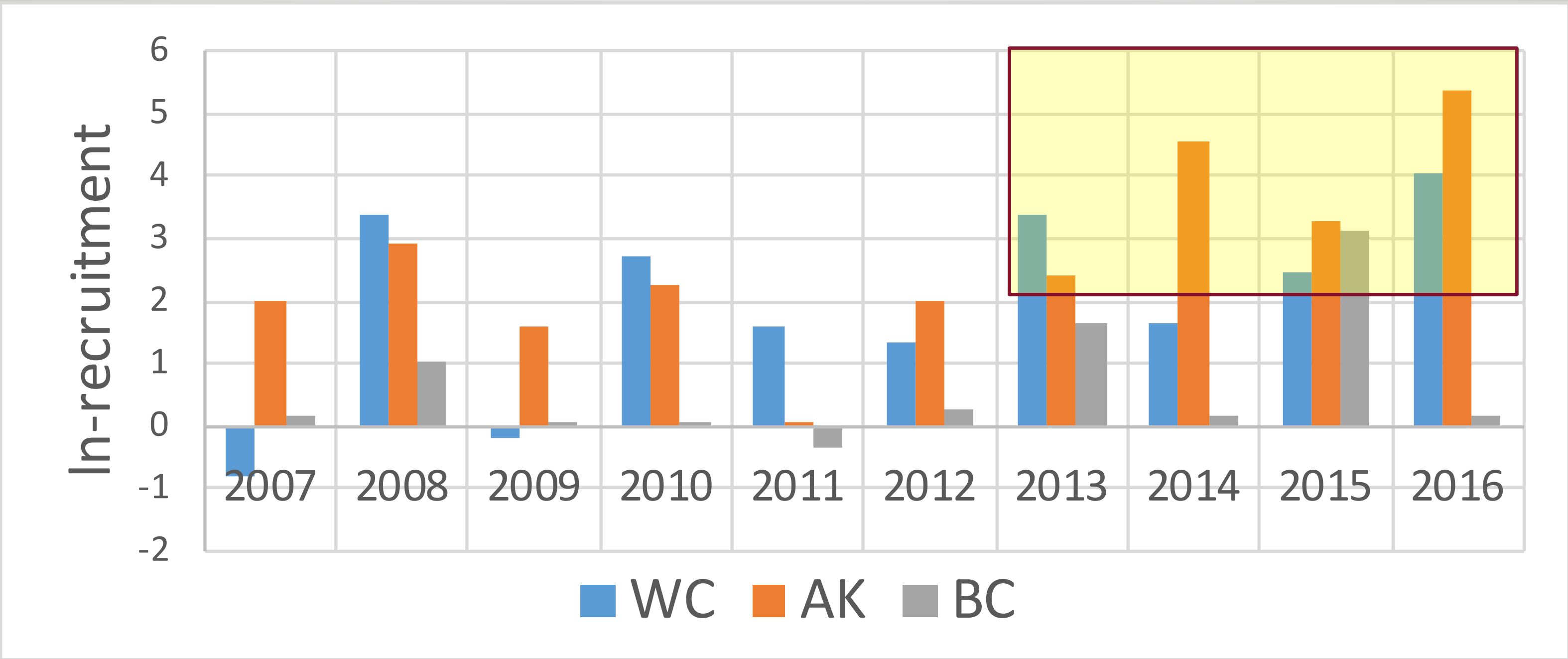


West Coast



67

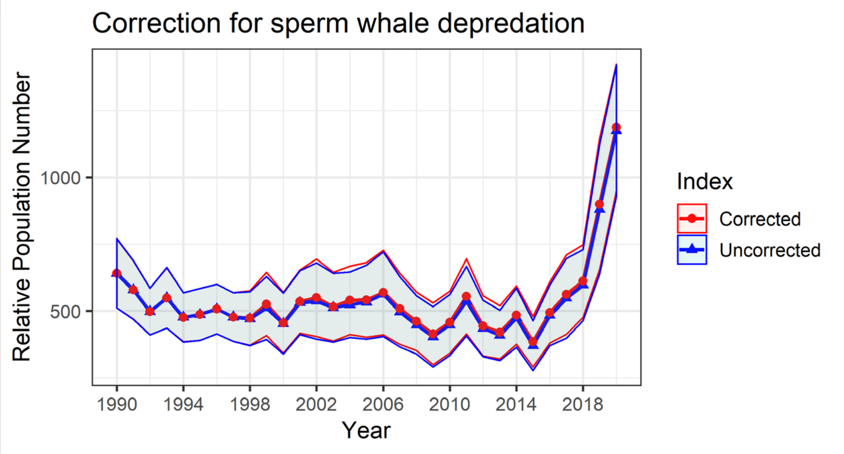
COASTWIDE RESULTS

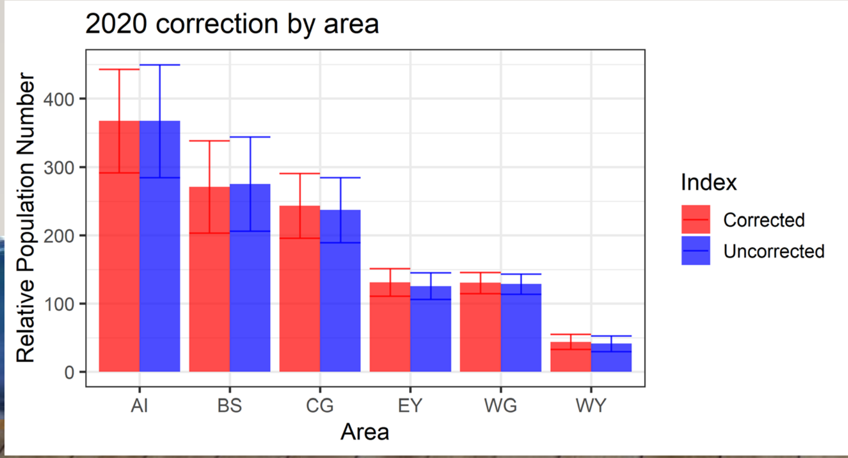


68

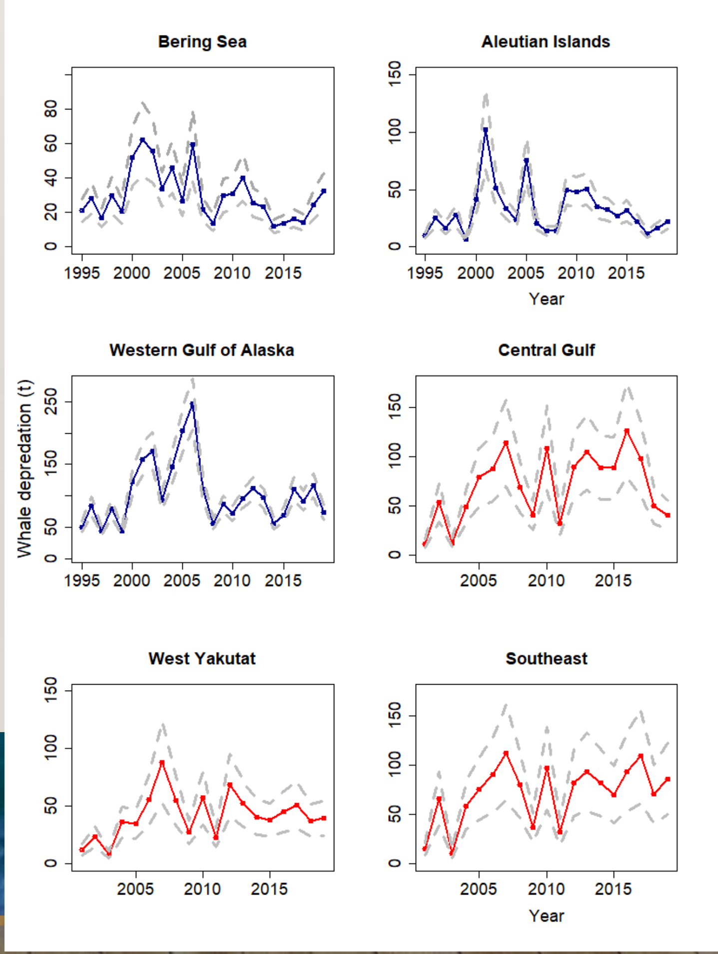
WHALE DEPREDATION

Survey Corrections

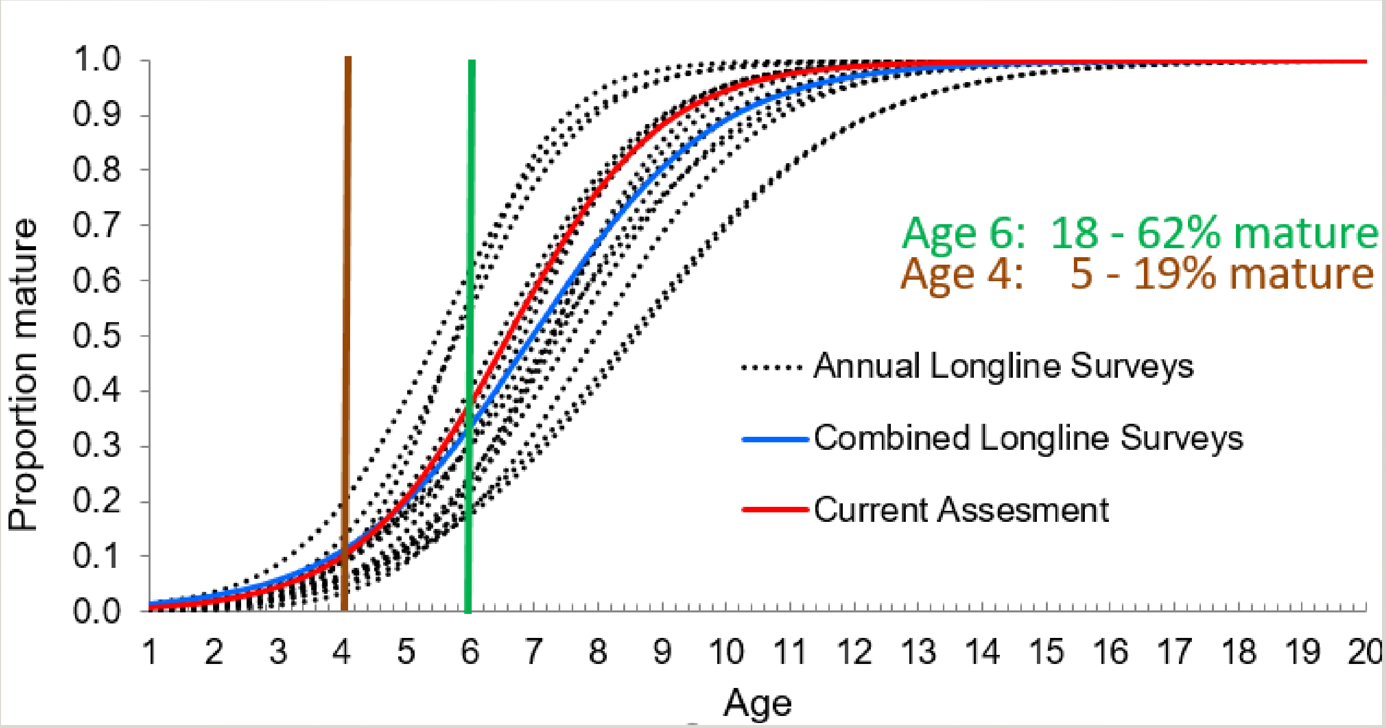




Area Depredation

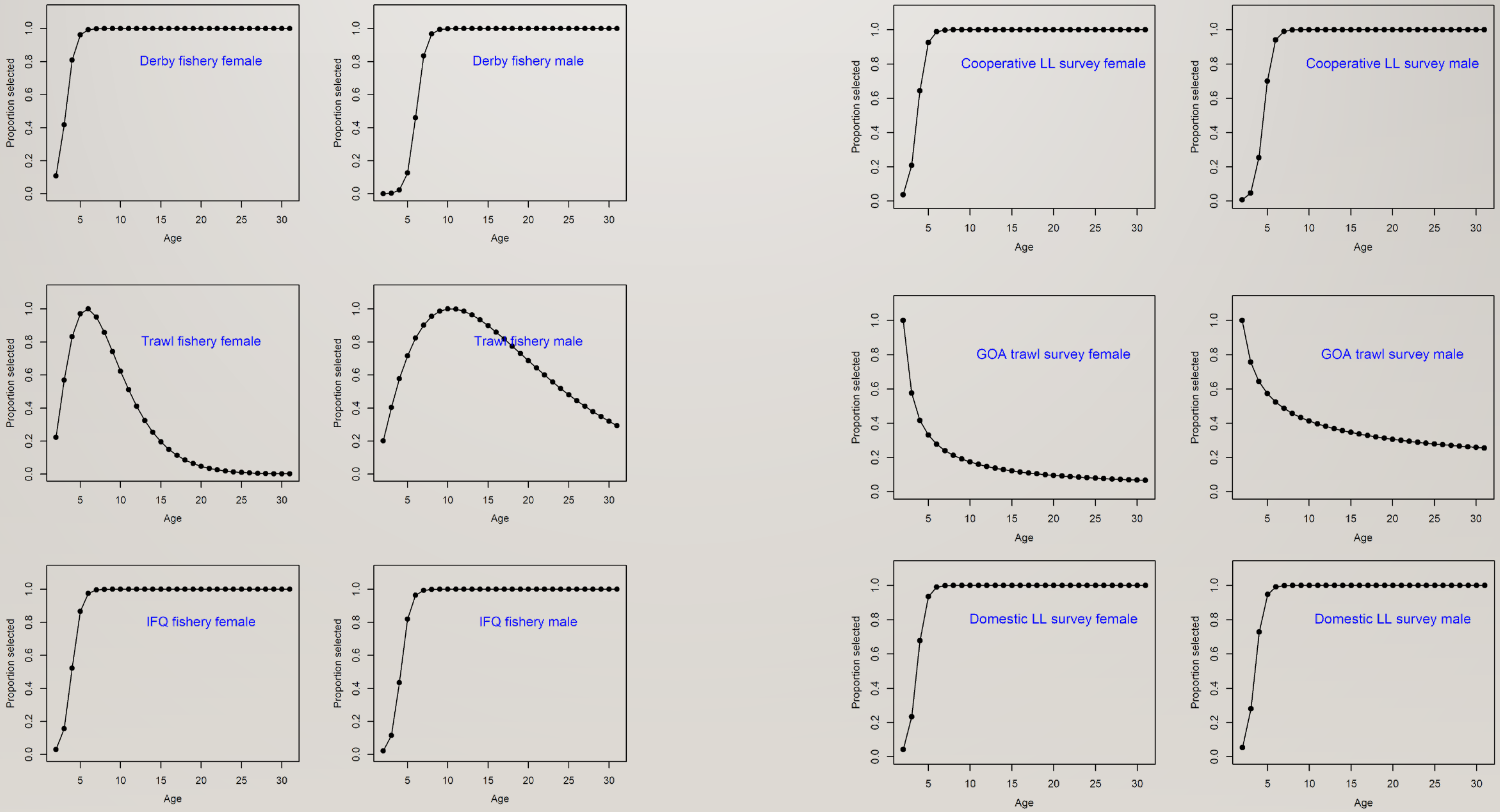


MATURITY

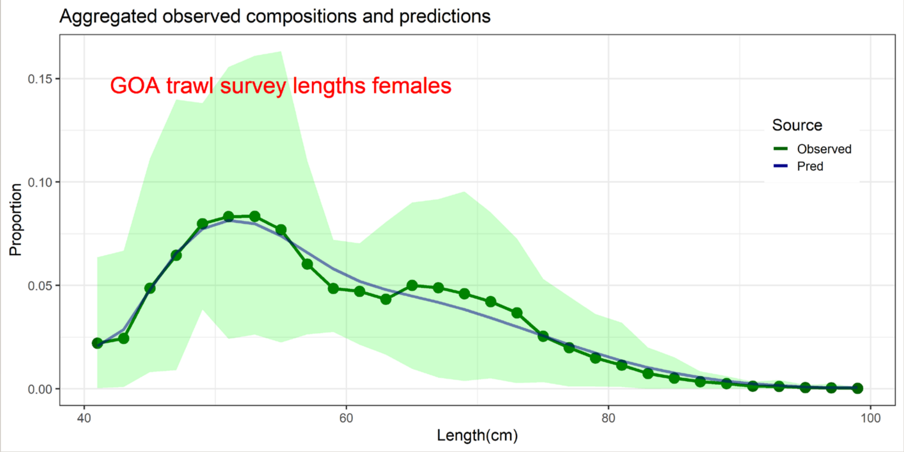


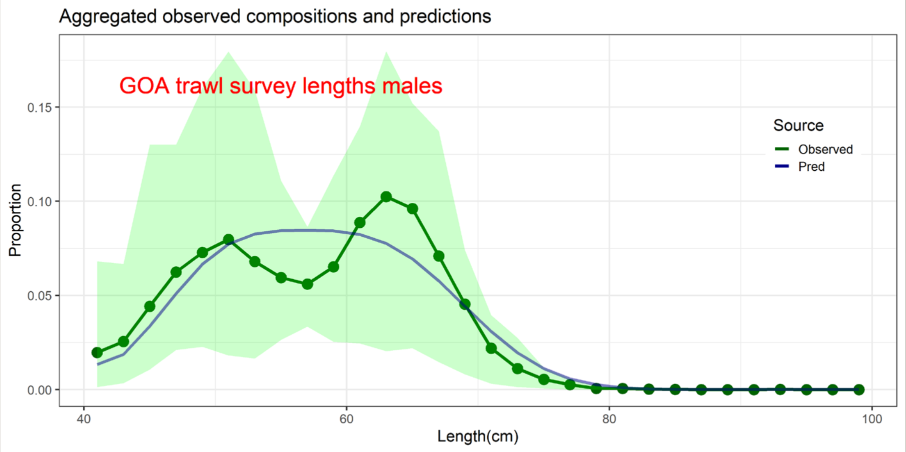
Proportion mature
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Age
Age 6: 18 - 62% mature
Age 4: 5 - 19% mature
Annual Longline Surveys
Combined Longline Surveys
Current Assesment

71 ESTIMATED SELECTIVITY

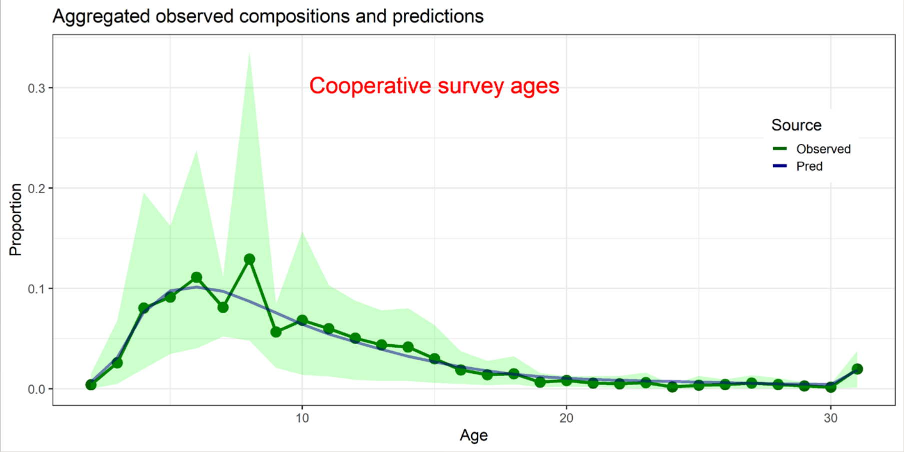


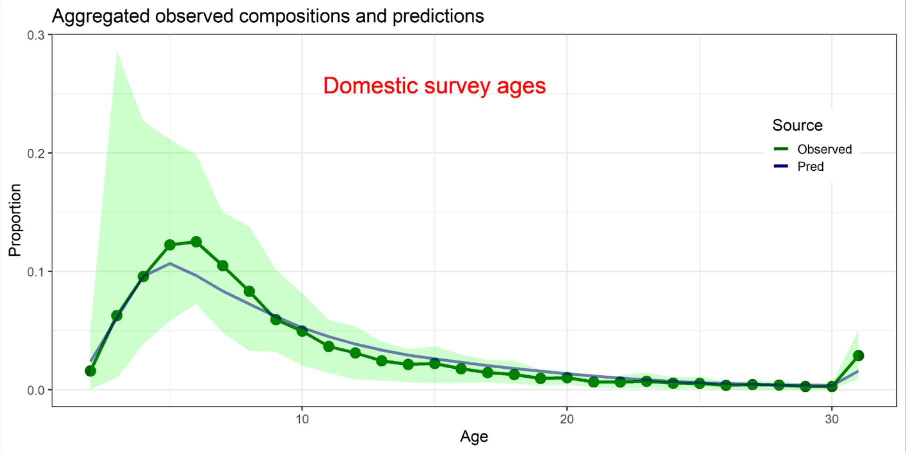
72 FIT TO TRAWL SURVEY LENGTH COMPS



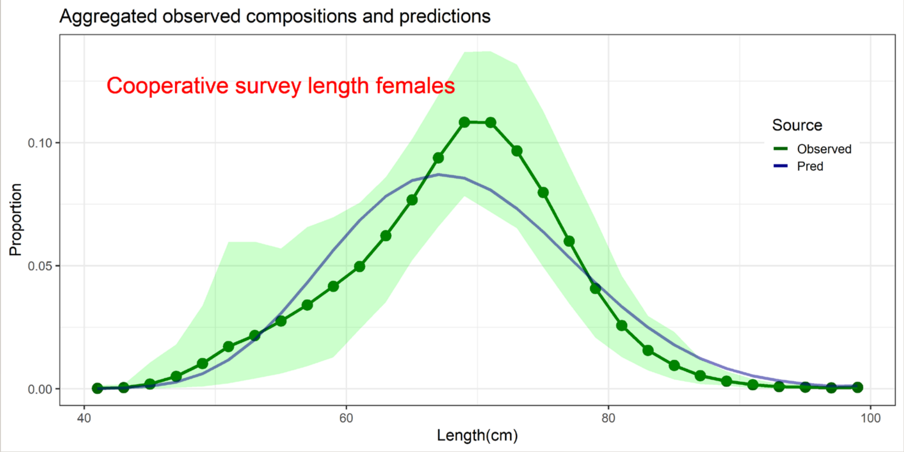


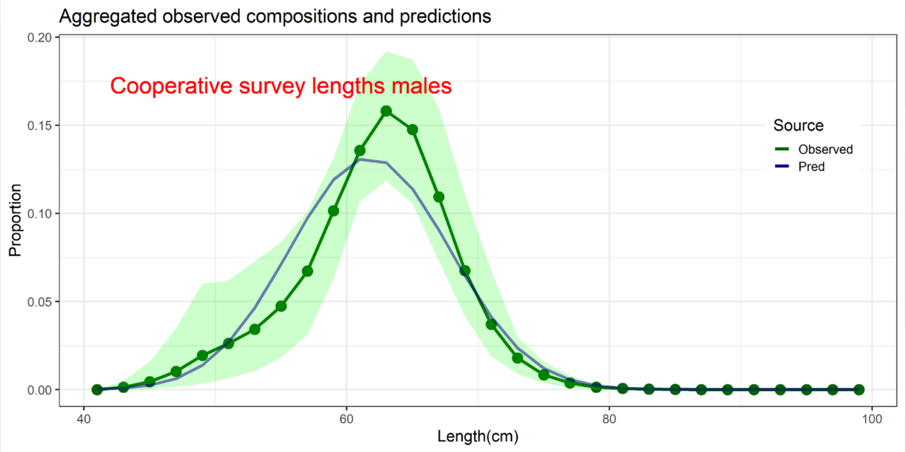
FIT TO LL SURVEY AGE COMPS



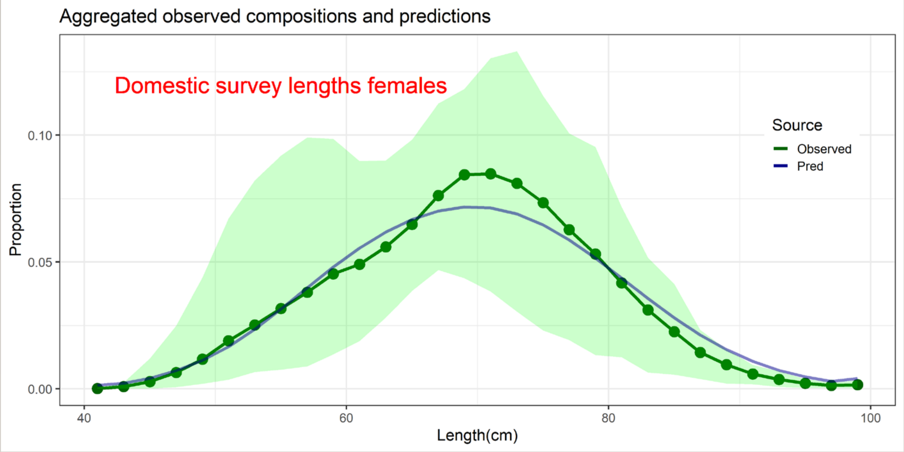


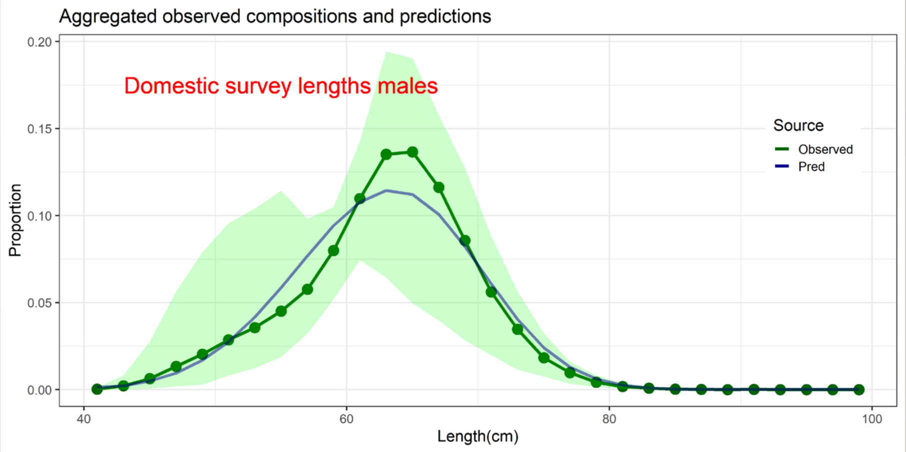
FIT TO COOP LL SURVEY LENGTH COMPS



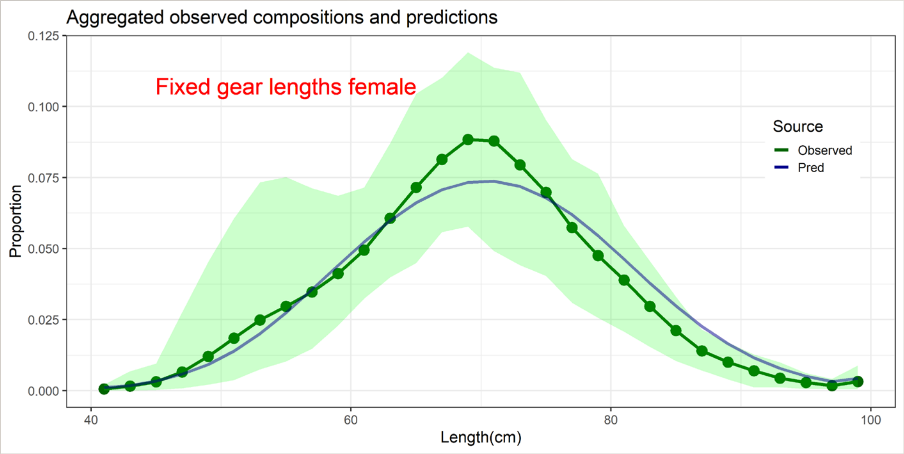


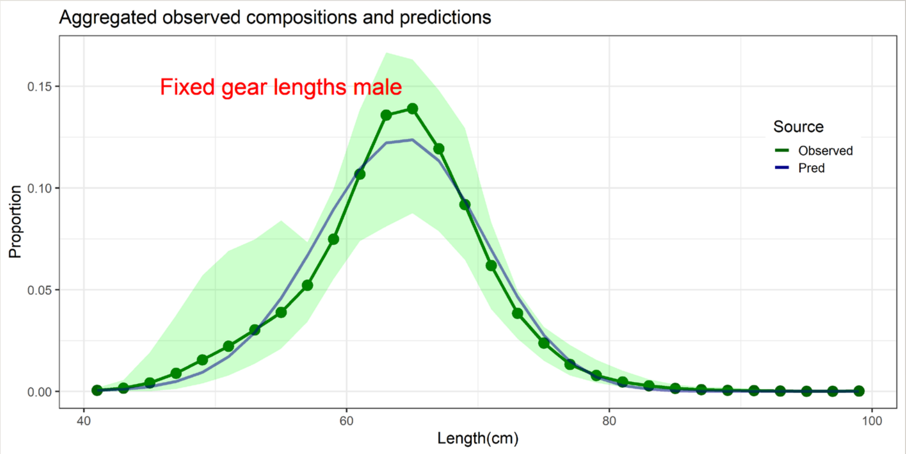
75 FIT TO DOMESTIC LL SURVEY LENGTH COMPS



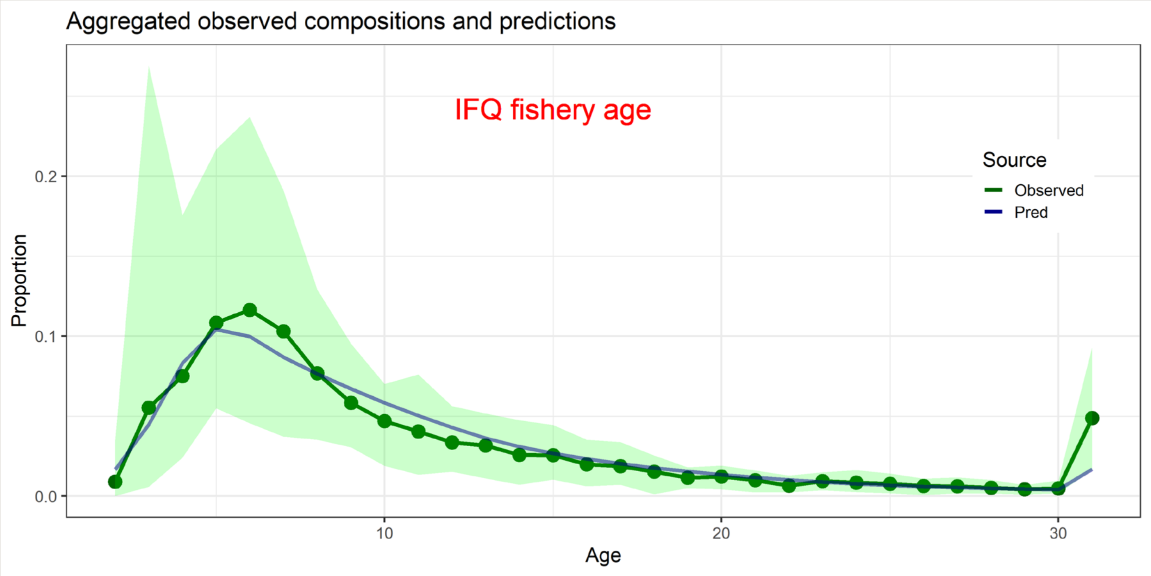


FIT TO FIXED GEAR FISHERY LENGTH COMPS

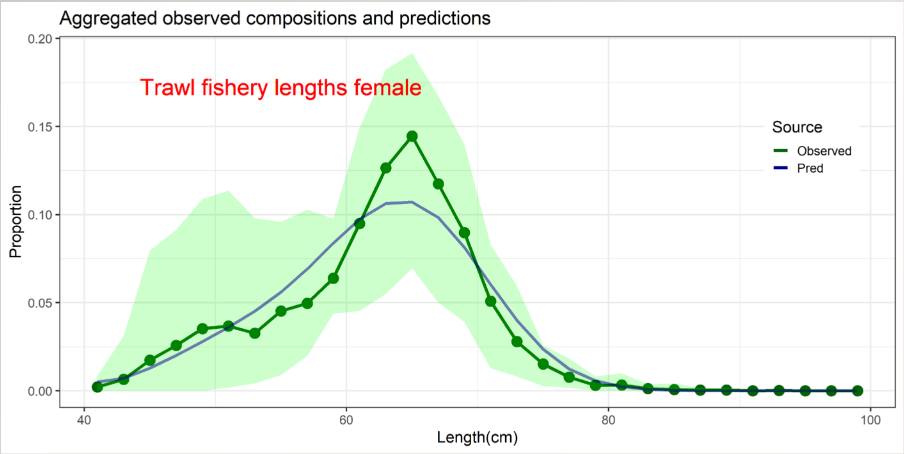


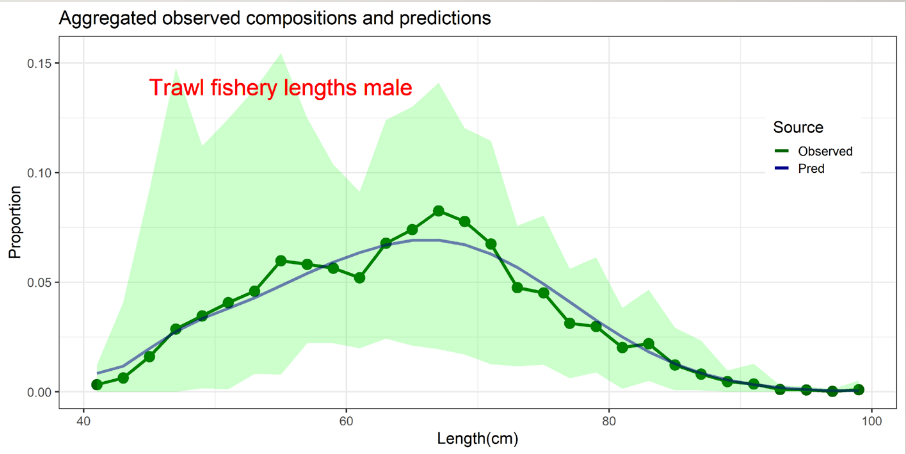


FIT TO FIXED GEAR FISHERY AGE COMPS

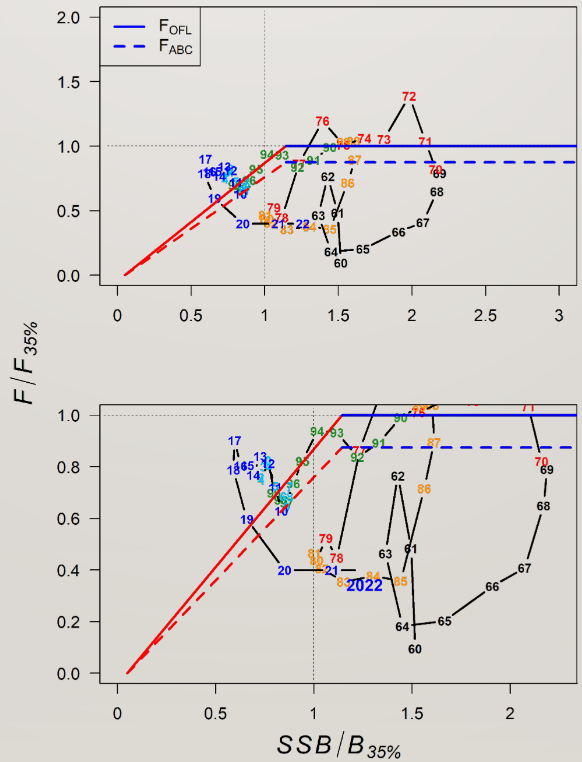


FIT TO TRAWL FISHERY LENGTH COMPS

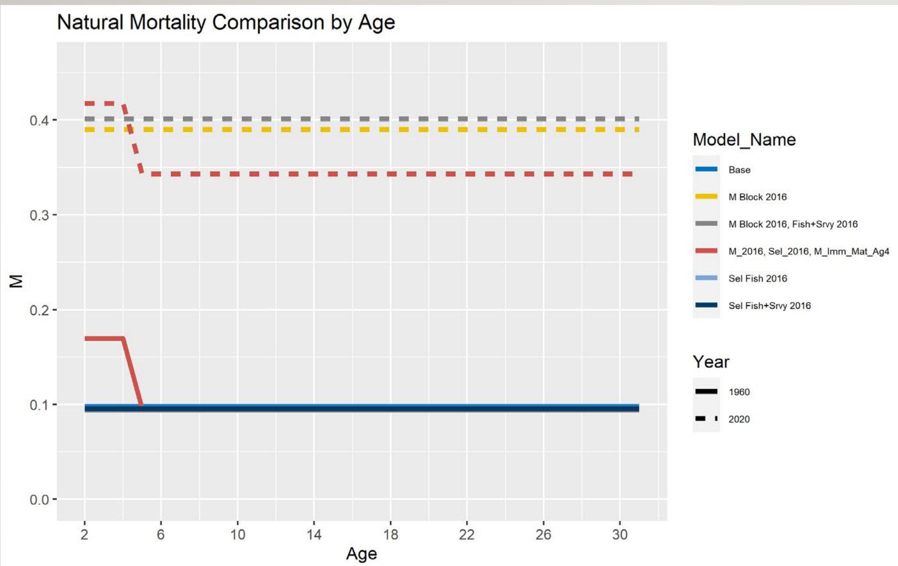


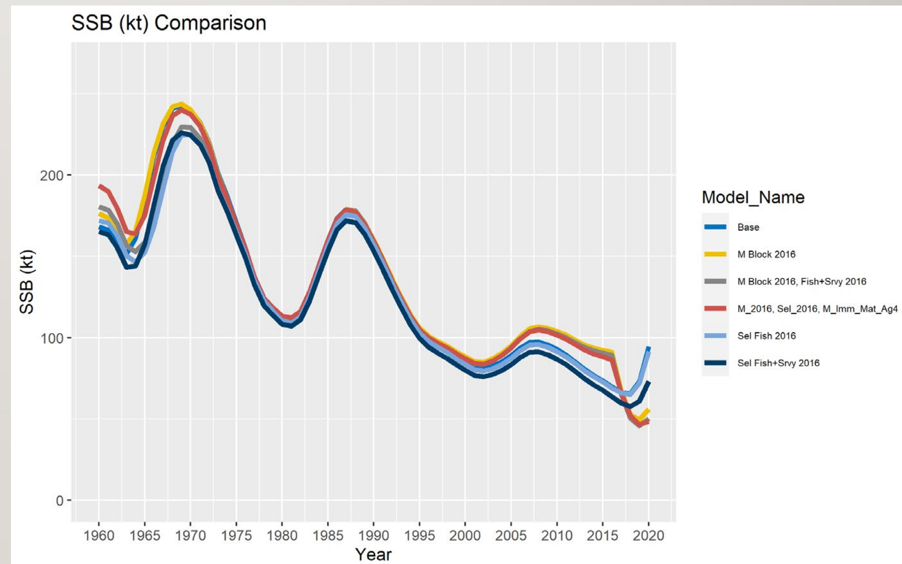


PHASE PLANE DIAGRAM

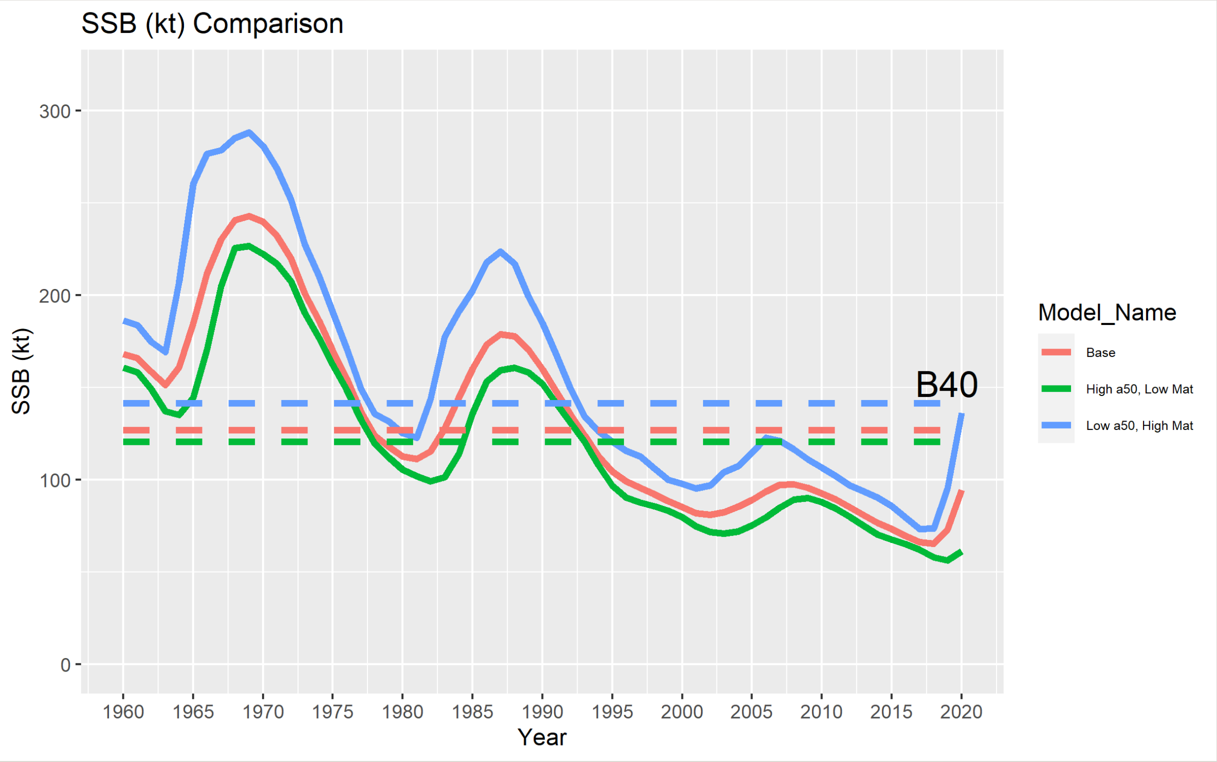


ESTIMATES OF M FOR SENSITIVITY RUNS



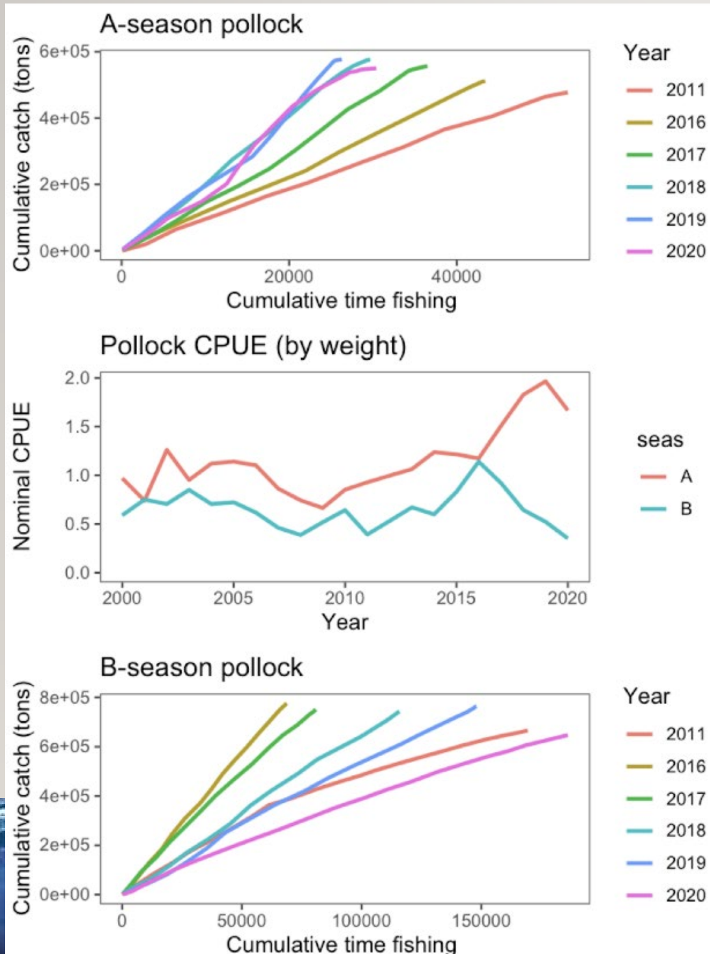


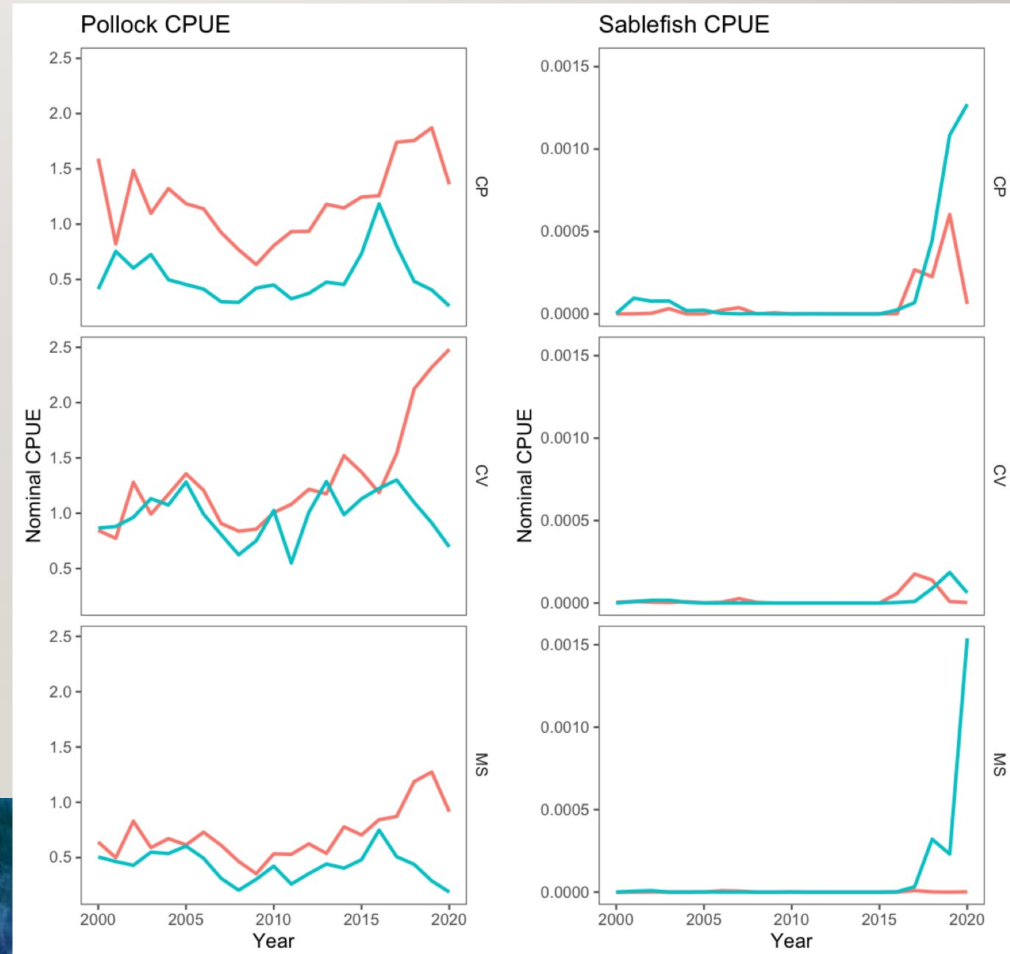
82 SENSITIVITY TO MATURITY RATES



83

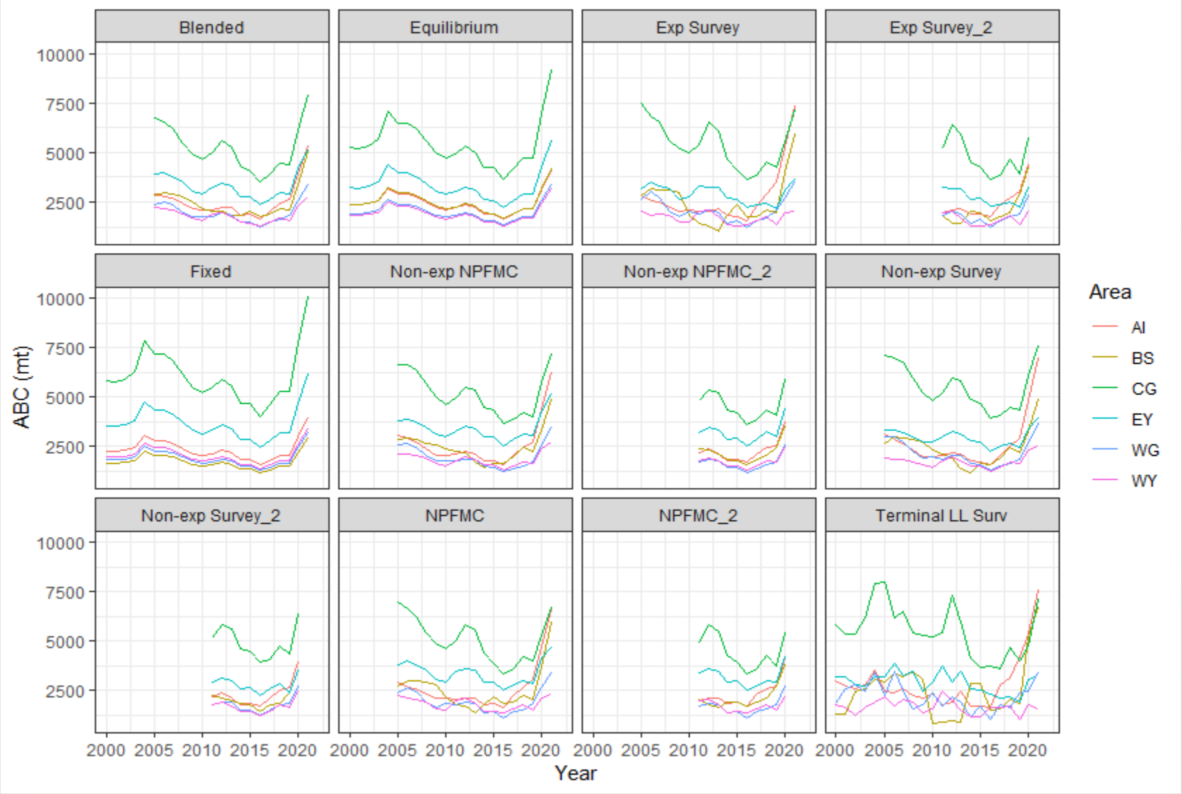
EBS POLLOCK EFFORT AND CPUE





85

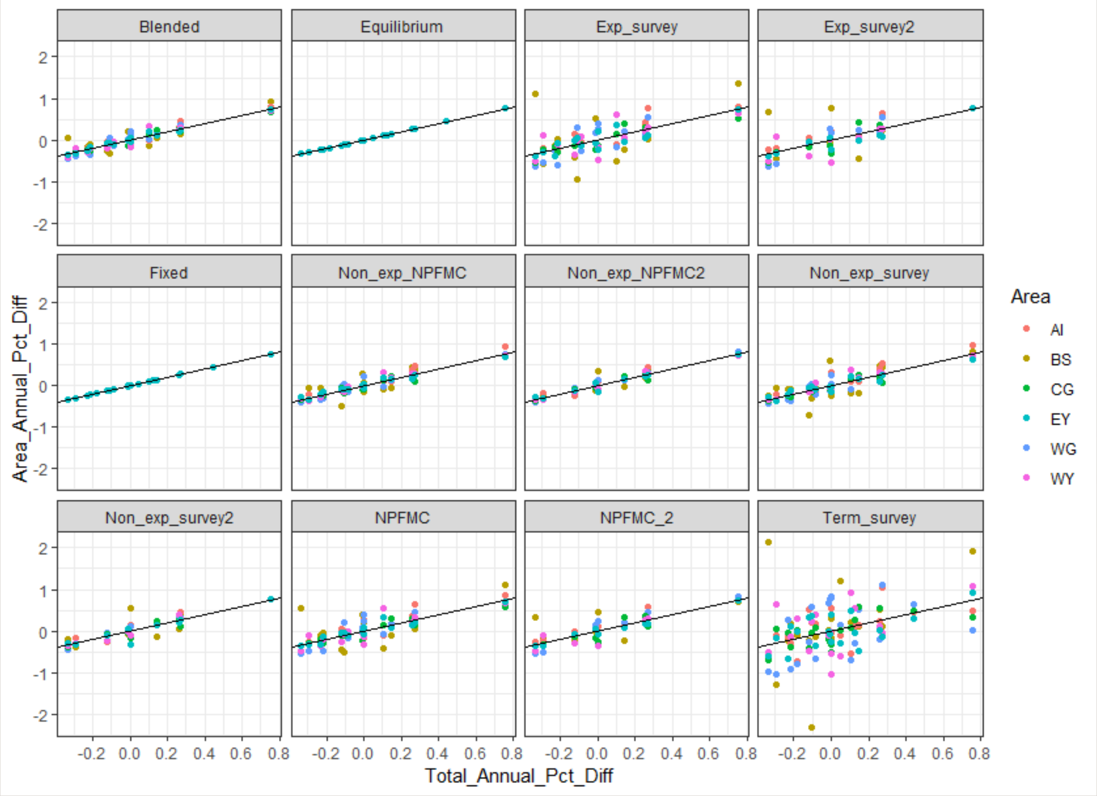
RETROSPECTIVE APPORTIONMENT



87

RETROSPECTIVE APPORTIONMENT

88 RETROSPECTIVE APPORTIONMENT



89 RETROSPECTIVE APPORTIONMENT