



NOAA
FISHERIES

SEFSC

SEDAR 72: US Gulf of Mexico Gag Grouper

Operational Assessment

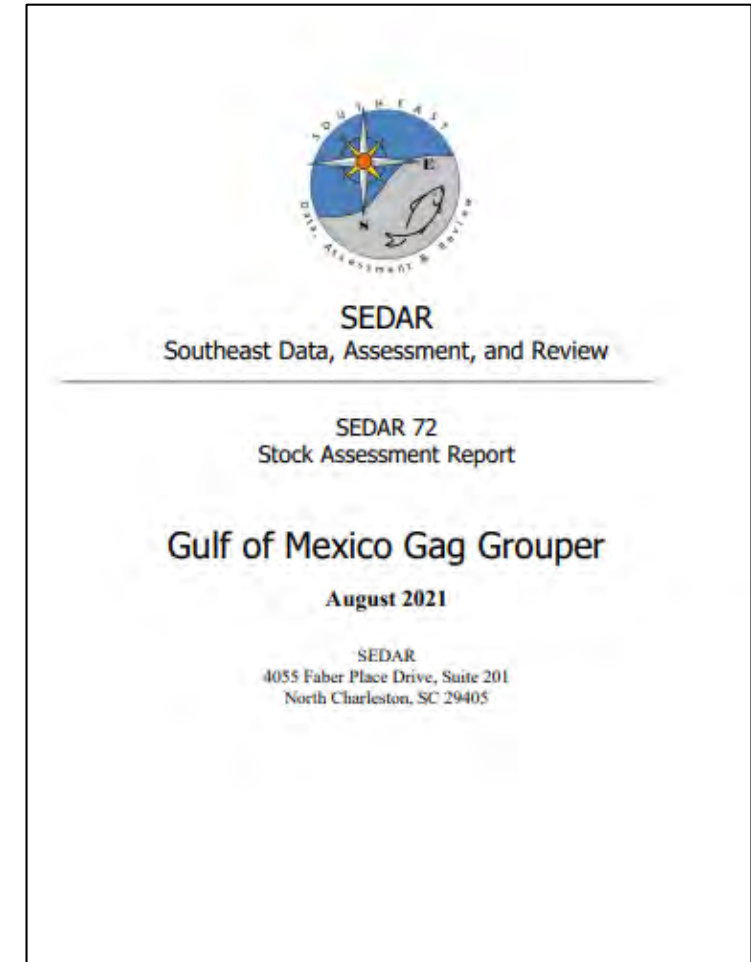
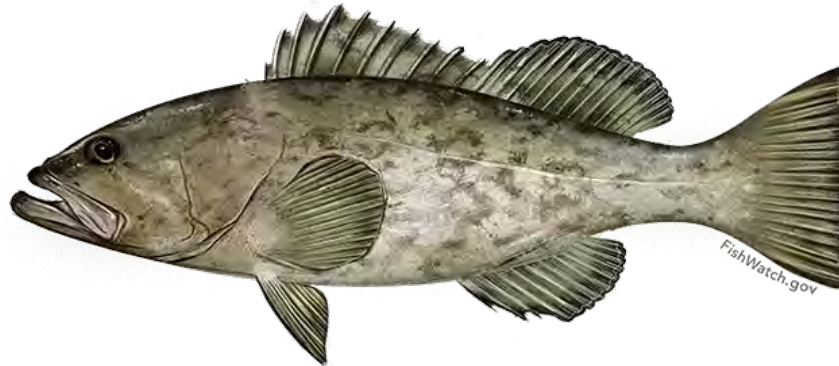
GMFMC SSC Presentation
September 2021



NOAA Fisheries, Southeast Fisheries Science Center,
Sustainable Fisheries Division (SFD)

Outline

- SEDAR 72 Overview
 - SEDAR 72 Data
 - Base Model Run
 - Development
 - Fits
 - Results
 - Base Model Diagnostics
 - Sensitivity runs
 - Conclusions
- Benchmarks, Stock Status & Projections
 - Research recommendations



SEDAR 72 Overview

SEDAR 72 Overview

SEDAR 72: Gulf of Mexico Gag Grouper Operational Assessment Terms of Reference September 2019

1. Update the approved 2016 Update of SEDAR 33 Gulf of Mexico gag grouper base model with data through 2019.
2. Document any changes or corrections made to model and input datasets and provide updated input data tables.
 - Re-evaluate the potential effects of red tide on gag, with consideration of past red tide events through 2018.
 - Document changes in MRIP data, both pre- and post-recalibration, in terms of the magnitude of changes to catch and effort.
 - Reconsider the way the retention and selectivity parameters were specified for recreational fleets based on past work with gag grouper.
 - Consider the SEFSC's improved approach for estimating commercial discards.

SEDAR 72 Overview

- Notable changes compared with the SEDAR 33 Update model include

TOR →

- New **MRIP Fishing Effort Survey (FES)** catch and discard time series

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- Improved **commercial discard** estimates

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- Updated information on **red tide** mortality

TOR →

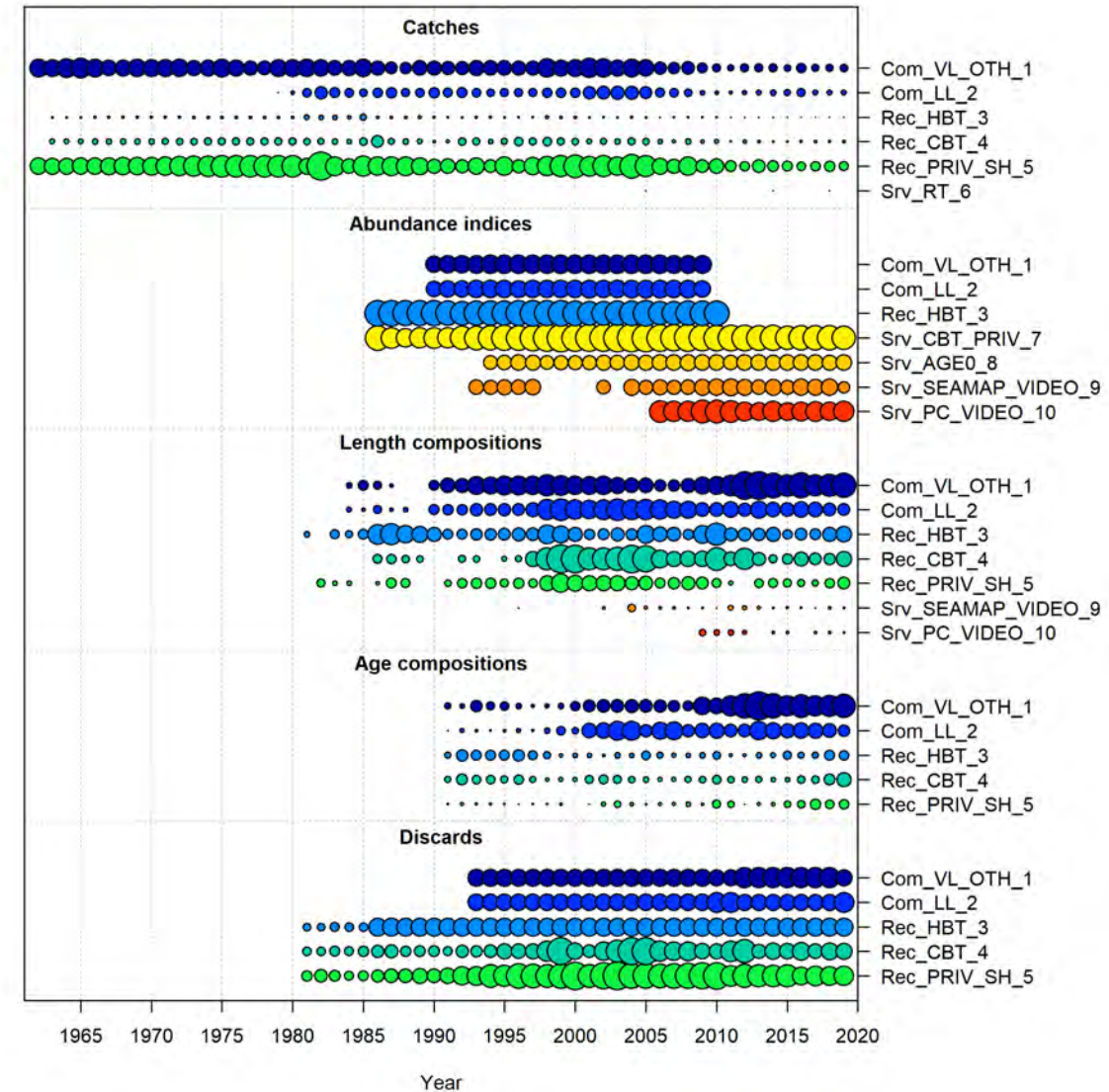
- Refining of the **recreational fleets' selectivity & retention** functions
- Updated information on **maturity** and the **hermaphroditism** transition function
- A new **combined private/charter index** (replacing the individual time series)
- Re-estimation of **growth** and updated variances
- Improved Southeast Region Headboat Survey (**SRHS**) **discard** proxy estimates
- New **black/gag grouper correction factors** for commercial landings and discards
- A new fishery-independent **combined video survey** (*sensitivity run*)

- The Base model results indicate that GOM Gag Grouper is **undergoing overfishing** and is **overfished** under both the female-only SSB and the SSB combined scenarios (<http://sedarweb.org/sedar-72>)

SEDAR 72 Data

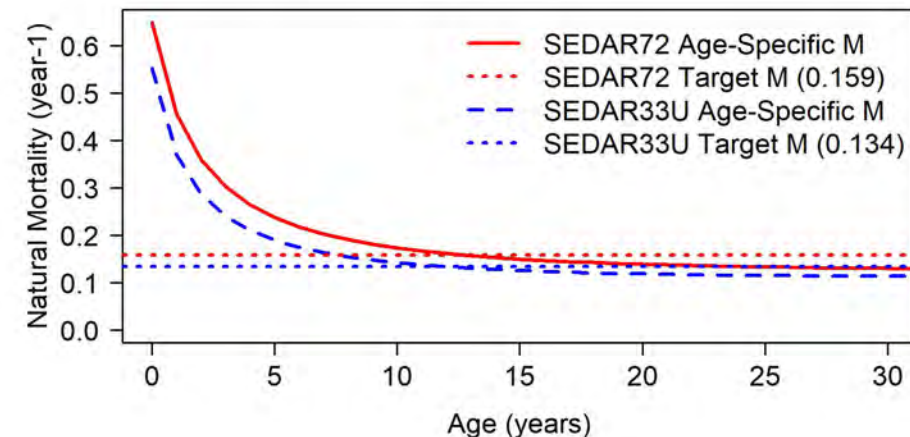
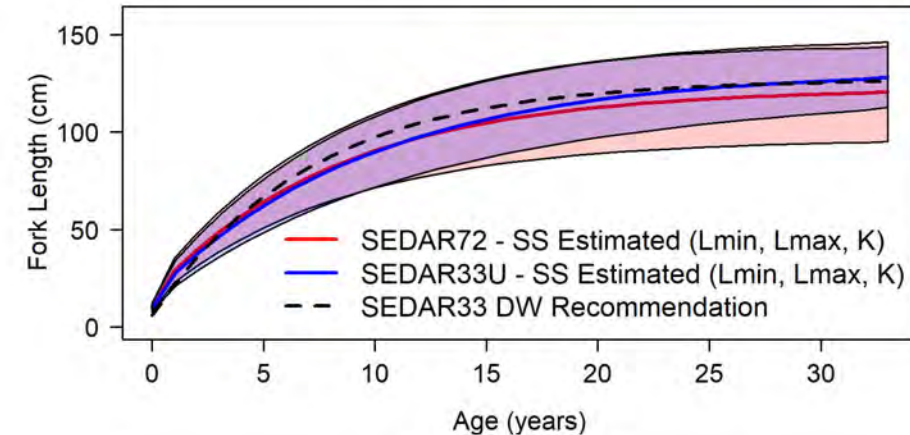
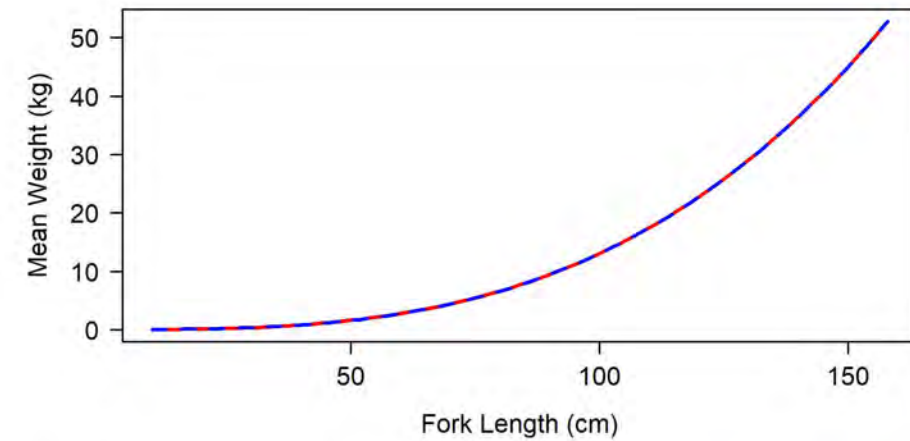
Data – Overall Structure

- Years: 1963-2019
- Fleets
 - Commercial: Vertical Line (VL_OTH) & Longline (LL)
 - Recreational: Headboat (HBT), Charterboat (CBT), Private (PRIV_SH)
- Red tide "bycatch fleet"
- Abundance Indices
 - Fishery-dependent: VL_OTH, LL, HBT, CBT_PRIV
 - Fishery-Independent: SEAMAP video, PC video, Age-0



Data – Life History

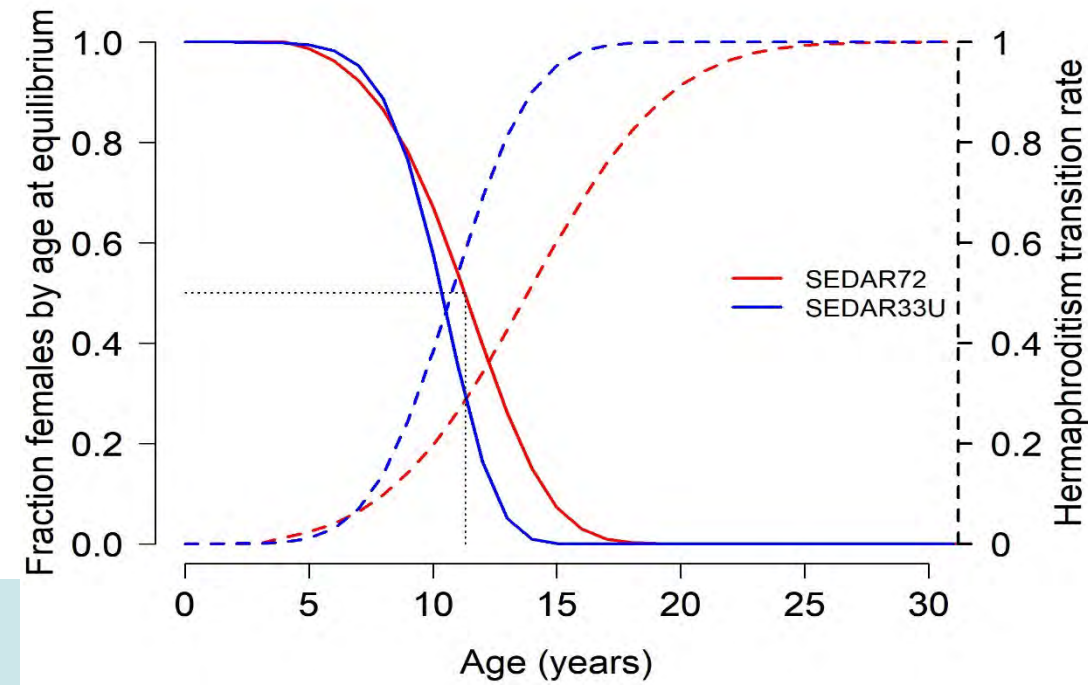
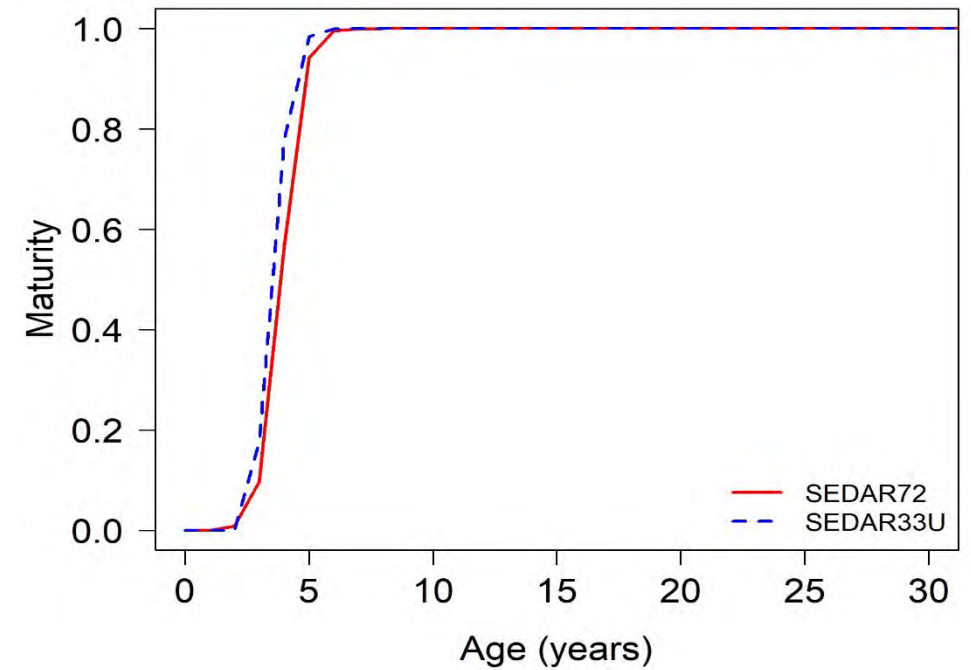
Data Component	Decision
Length-Length and Length-Weight Conversion	Unchanged from SEDAR 33 Update
Age and Growth	Additional age-length pairs made available. Von Bertalanffy growth parameters re-estimated internally to SS. Variability about the growth curve re-estimated externally to SS and fixed in the base model.
Natural Mortality	Maximum age revised from 31 to 33. Target M calculated using the Then et al. (2015) regression using Serranid-only data. Lorenzen scaling using growth curve estimated in the SEDAR 33 Update base model. <i>Sensitivity Run with SEDAR 33 Update M vector</i>



Data – Life History

Data Component	Decision
Maturity	Updated with samples collected through 2019. First age mature lowered from 3 to 2.
Hermaphroditism	Updated using data collected through 2019. Females first transition at age 4.
Fecundity	<p>Equivalent to spawning biomass.</p> <p>Female-only SSB used for the Base Model. An alternative run using combined male and female SSB ("SSB combined") was considered as a sensitivity for calculating benchmarks and reference points.</p>

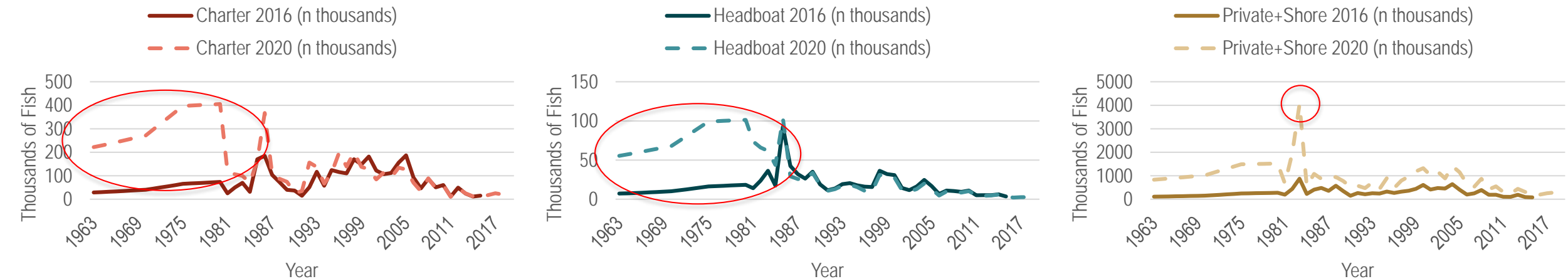
TOR



Data – Recreational Landings

Data Component	Decision
Recreational Landings	<p>Use new fully calibrated (APAIS+FES) MRIP estimates (WP-02) with a CV=0.2. <i>(Sensitivity run with CV=0.05)</i></p> <p>(In SEDAR 33 Update, CV=0.01.)</p> <p>Replaced 1983 private mode landings with geometric mean of 1981, 1982, 1984, and 1985.</p> <p>Recalculated historical catch ratios</p>

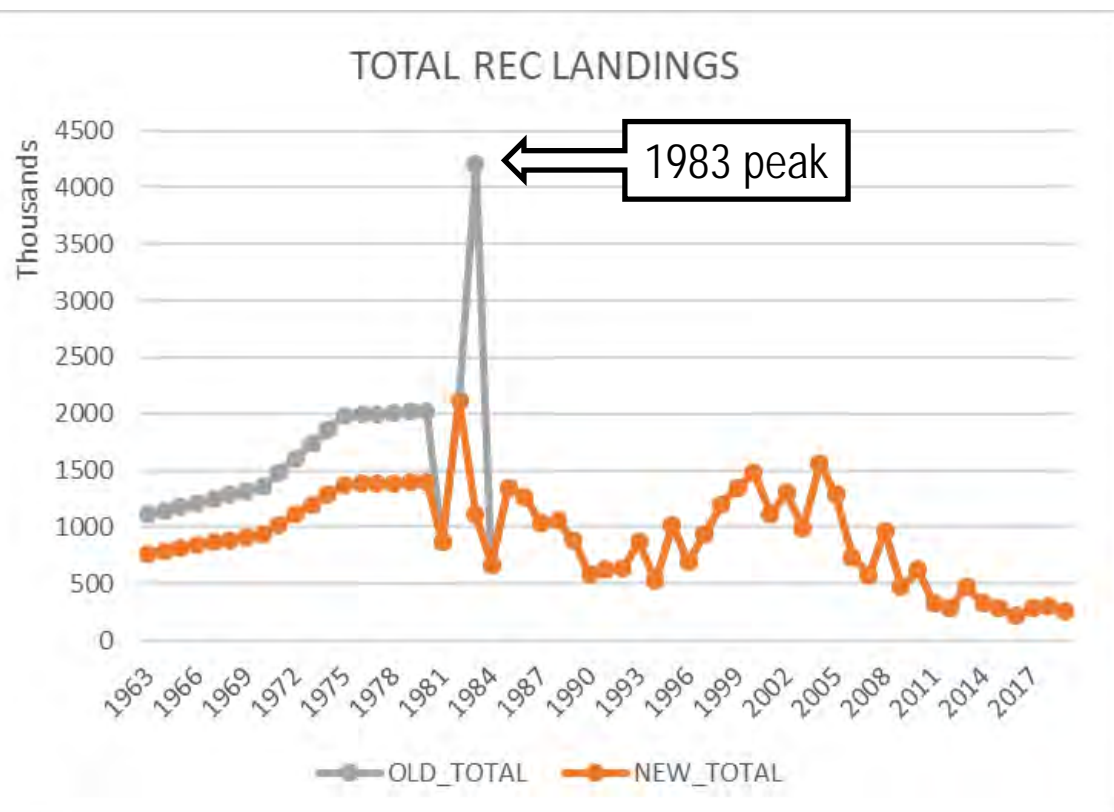
Original attempt :



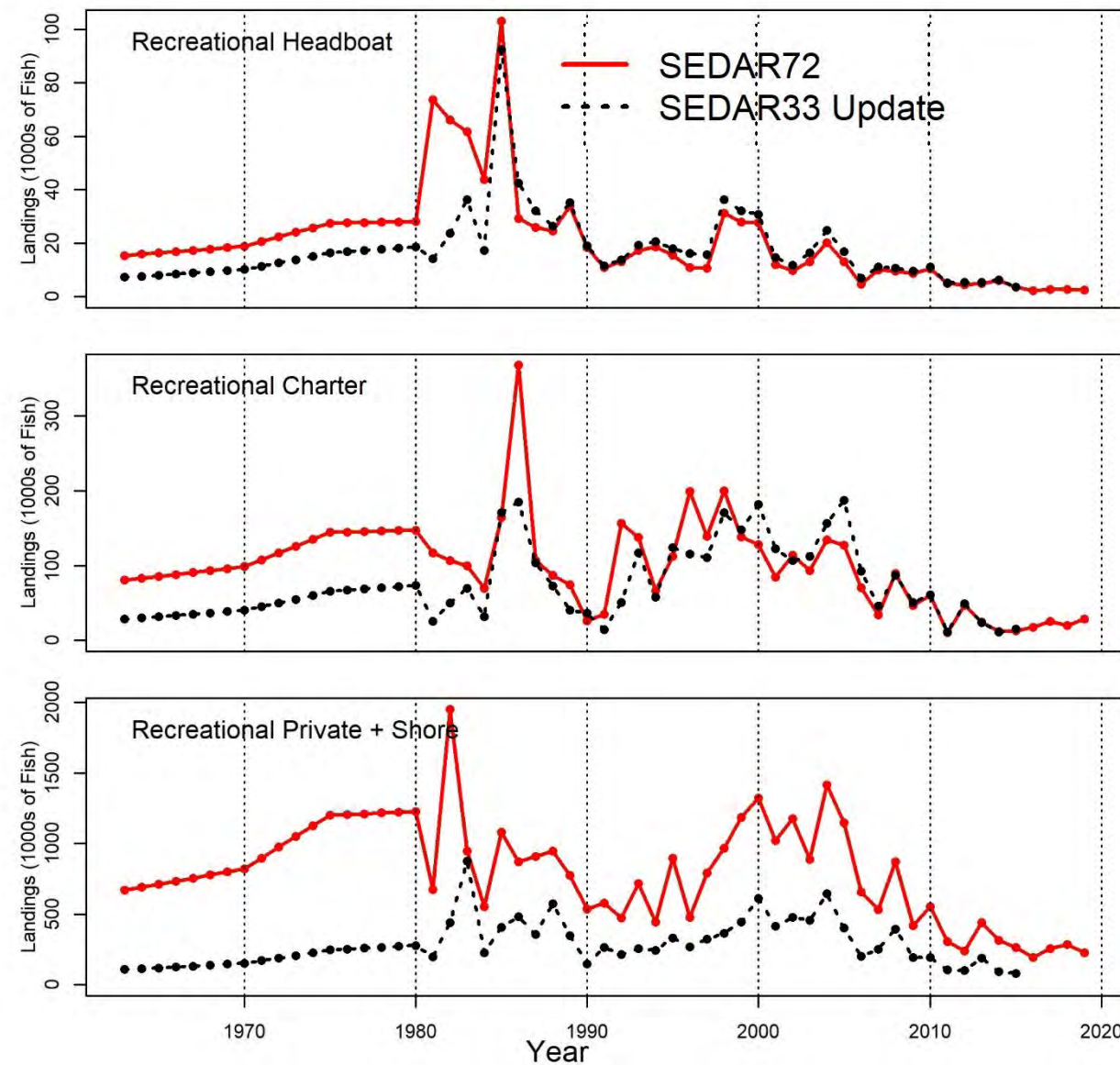
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Document changes in MRIP data, both pre- and post-recalibration, in terms of the magnitude of changes to catch and effort.

Data – Recreational Landings

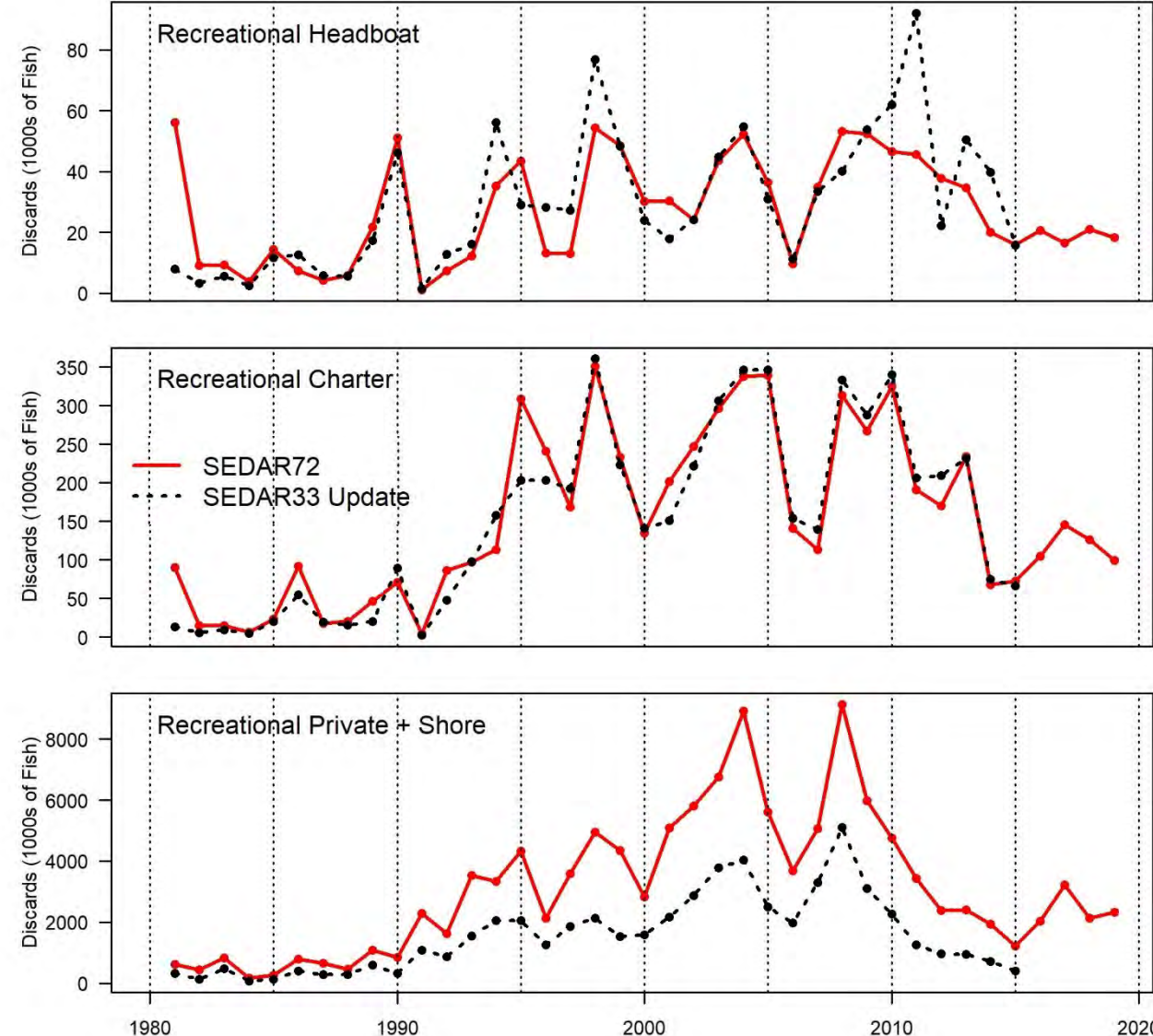


SS inputs



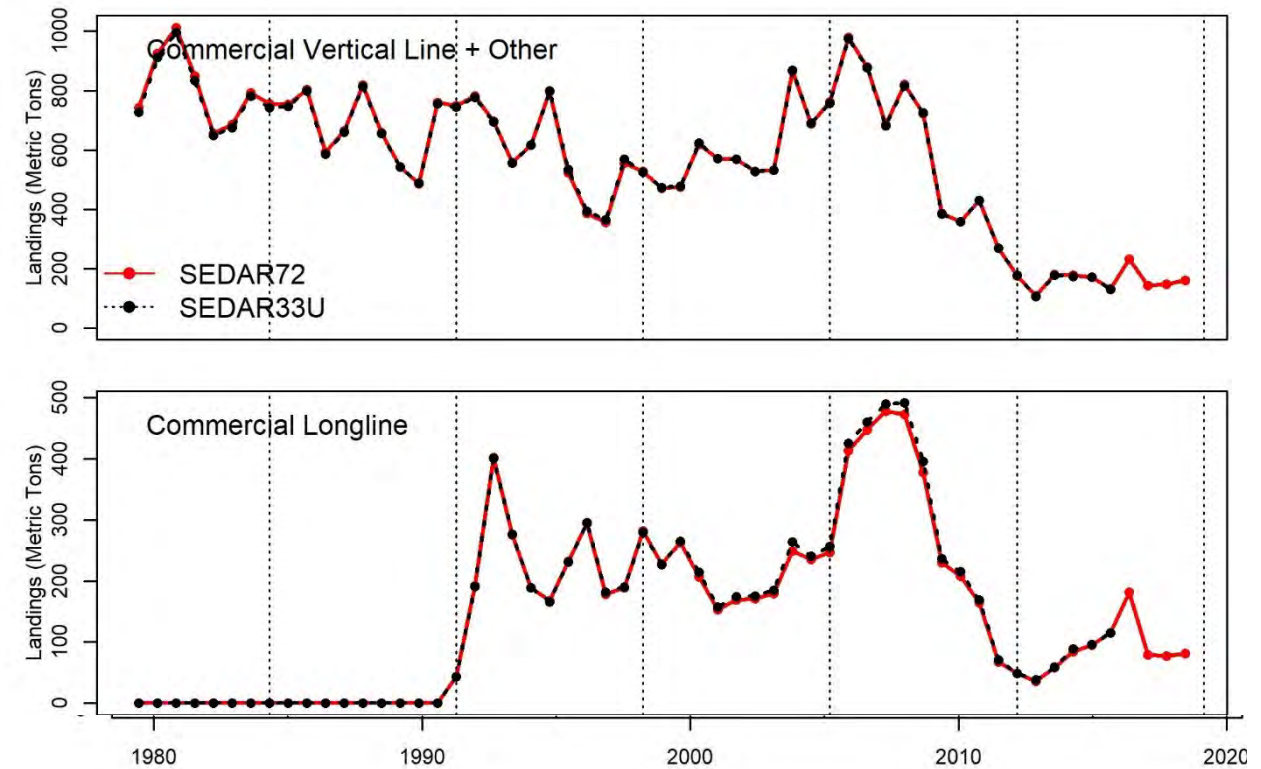
Data – Recreational Discards

Data Component	Decision
Recreational Discards	<p>Use new fully calibrated (APAIS+FES) MRIP estimates (WP-02) with provided CVs.</p> <p>HBT: For the intermediate years where neither MRIP nor SRHS estimates were available (1986-2007), the SEDAR Best Practices method was used (Mean SRHS:MRIP Charter discard ratio (2008-2019), with LA proxy for TX for 2008-2013). CVs set to 0.2 post 1986</p>
Recreational Discard Mortality	12%. Unchanged from SEDAR 33 Update.



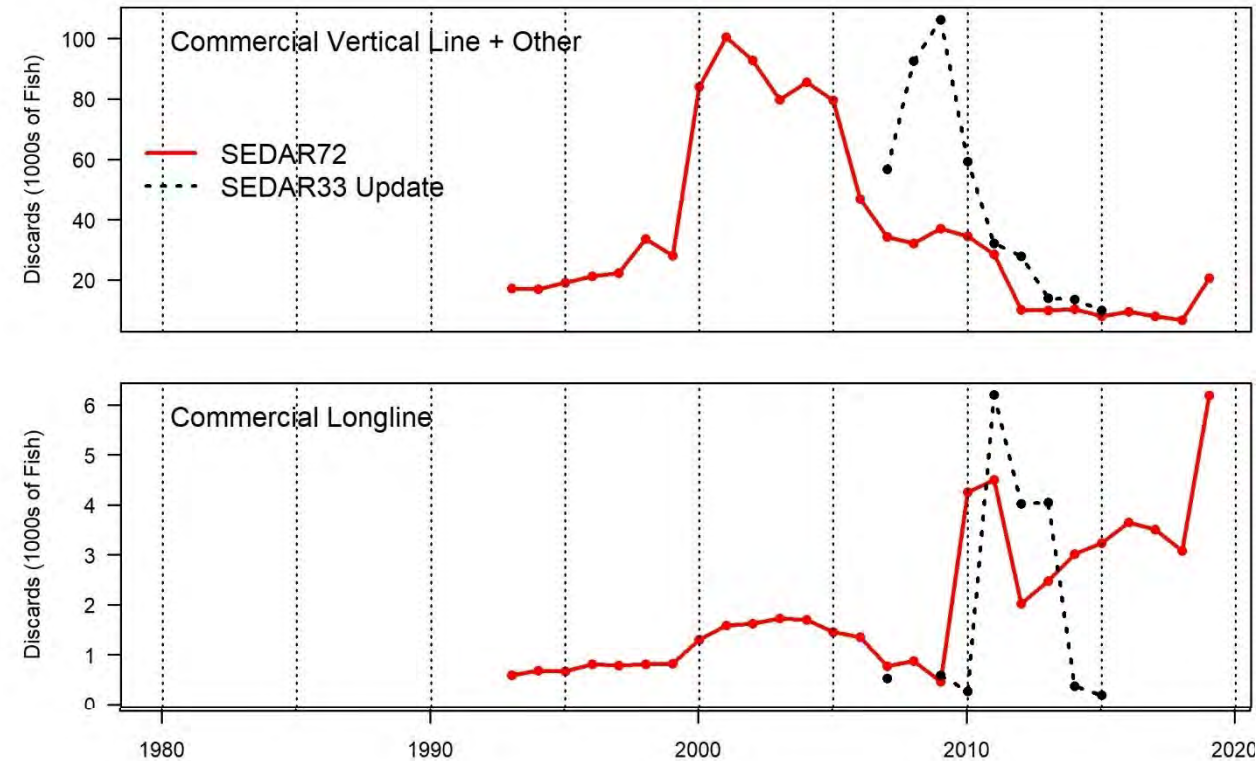
Data – Commercial Landings

Data Component	Decision
Commercial Landings	Use the new set of Gag/Black Grouper correction factors. No CVs provided -- a CV of 0.05 was assigned to landings pre-IFQ, and a tighter CV of 0.01 to landings post-IFQ. (vs. CV=0.01 for entire time series in SEDAR 33 Update)



Data – Commercial Discards

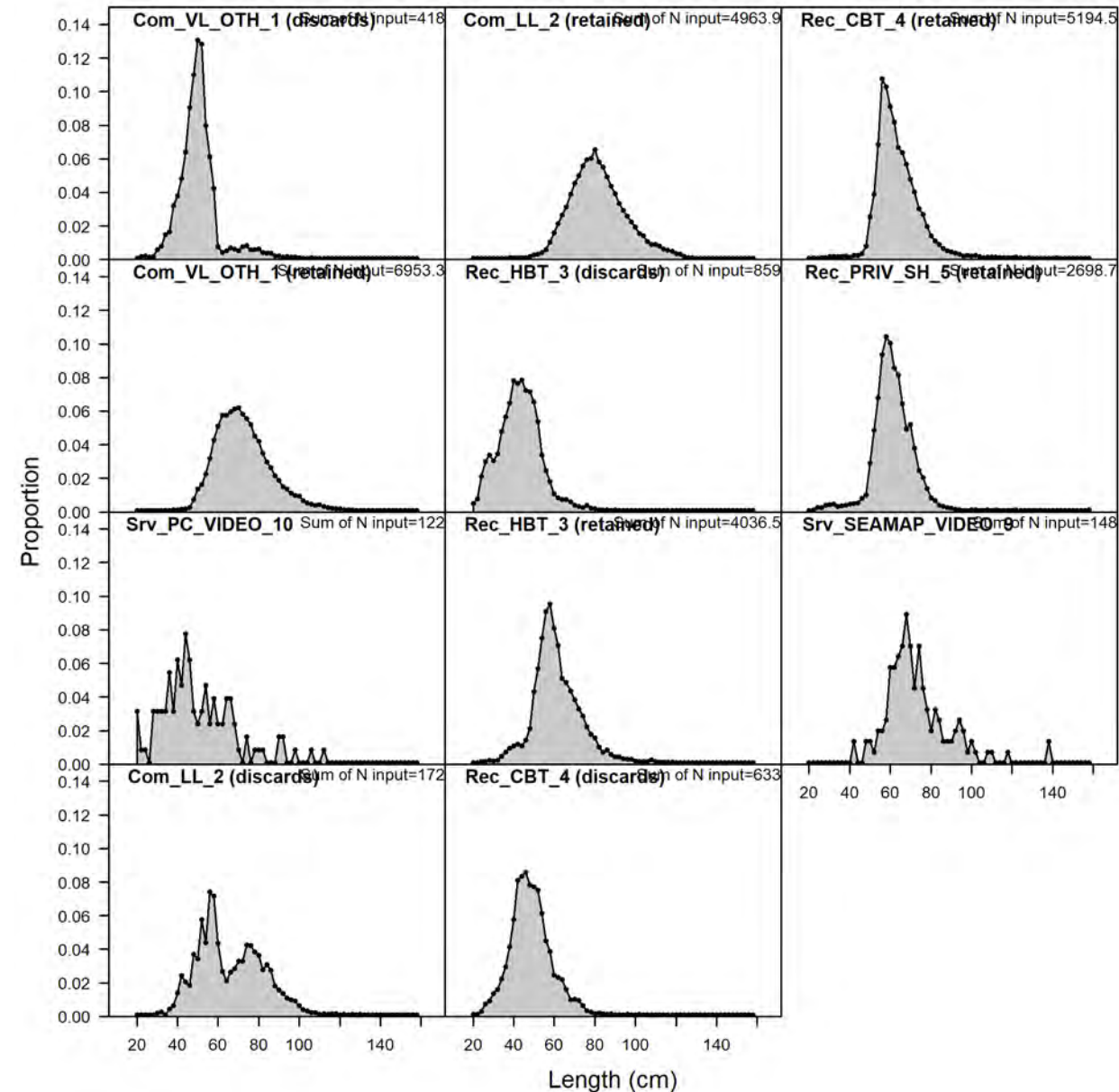
Data Component	Decision
Commercial Discards	Updated methodology and expanded time series. CPUE expansion using coastal observer program in conjunction with total fishing effort from the commercial reef fish logbook program (used consistently in recent reef fish assessments). WP-16
Commercial Discard Mortality	25%. Unchanged from SEDAR 33 Update.



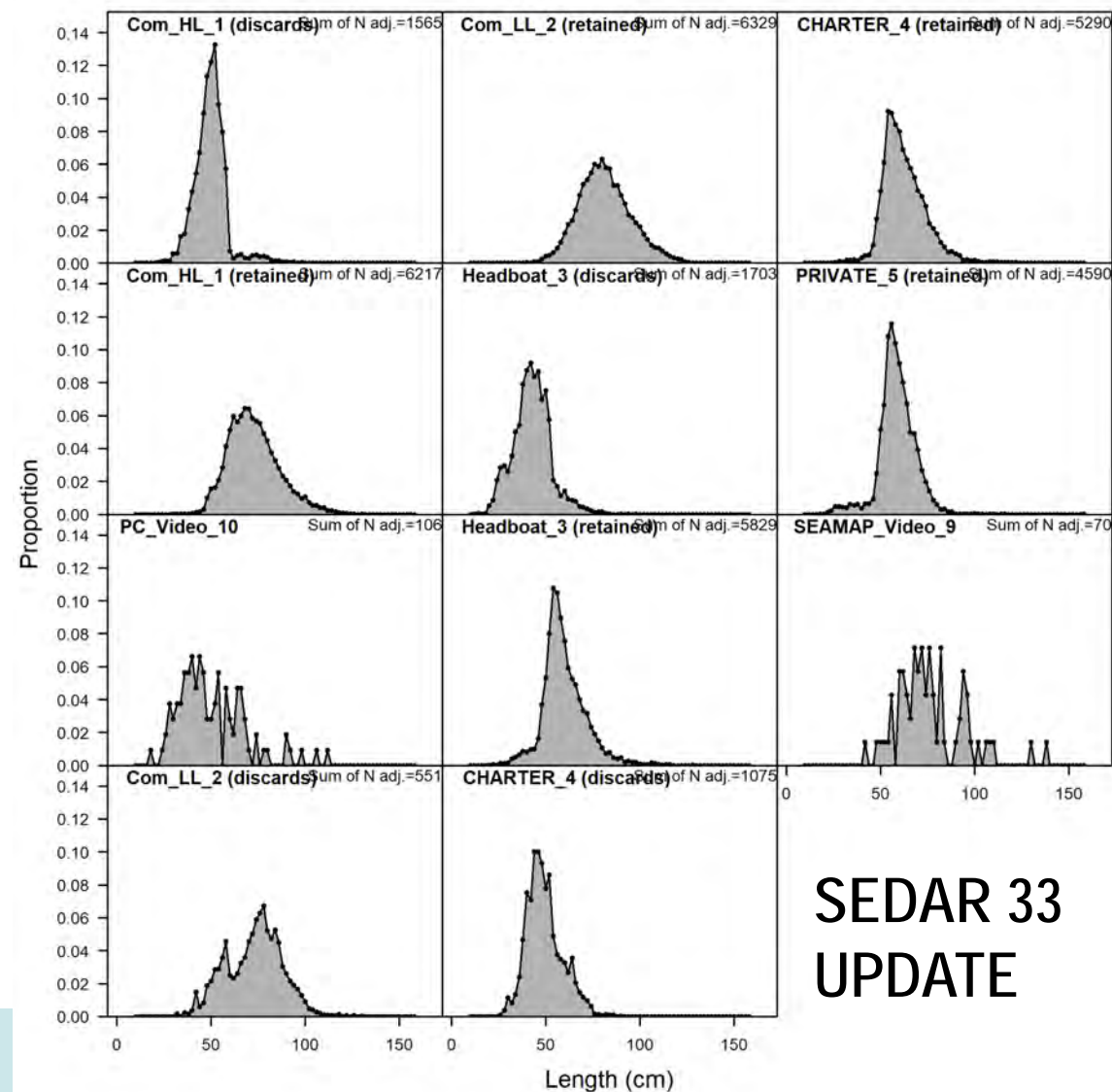
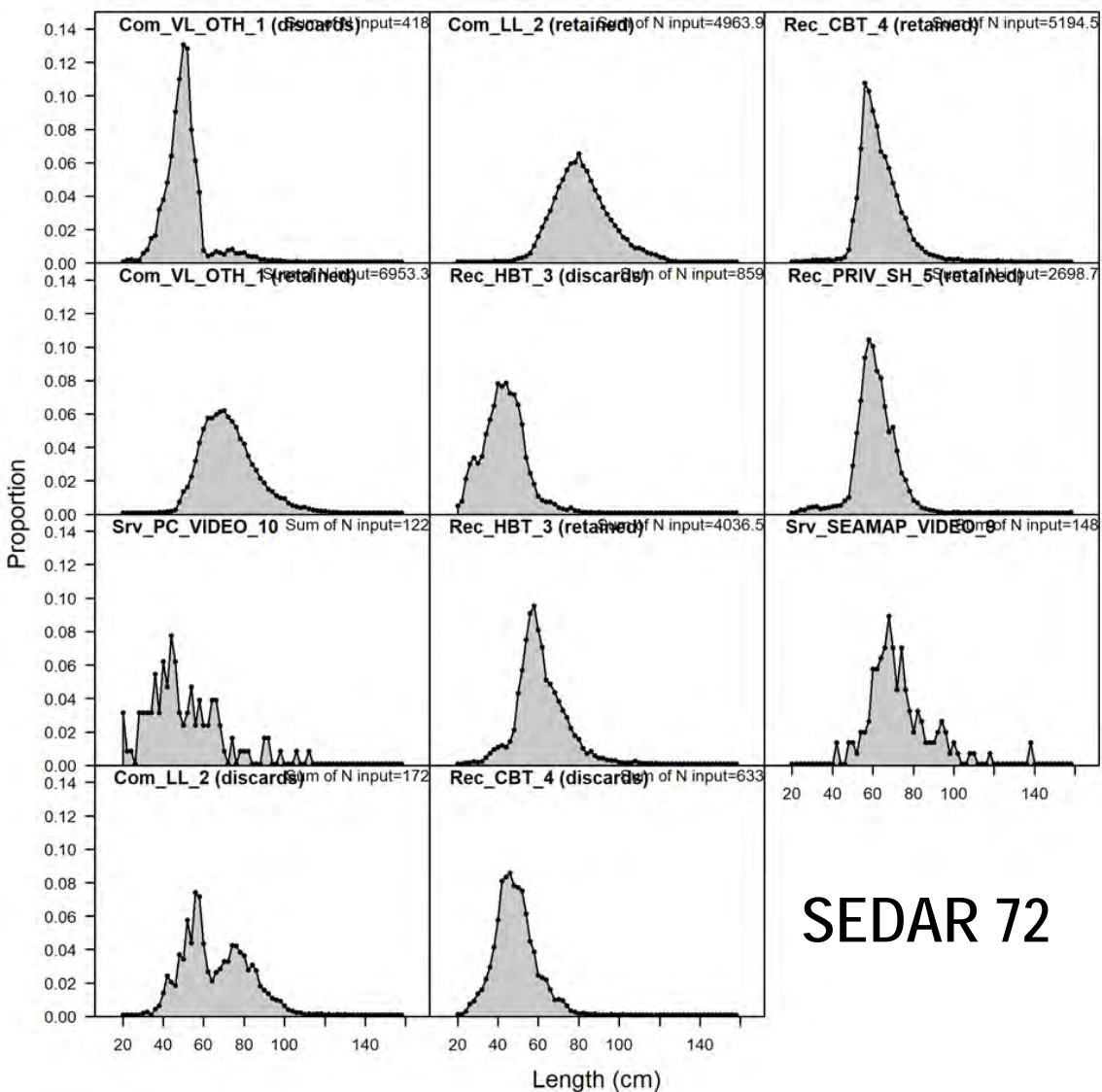
TOR Consider the SEFSC's improved approach for estimating commercial discards.

Data – Length Compositions

Data Component	Decision
Recreational and Commercial Retained Lengths	Same (updated) data source as SEDAR 33 Update Length samples weighted by commercial landings at finest spatial/temporal scale available (WP-17). Input sample sizes: number of trips down-weighted according to percentage of landings represented.
Commercial Discard Lengths	Same (updated) data source as SEDAR 33 Update: Reef Fish Observer Program (RFOP) Input sample sizes: number of trips
Recreational Discard Lengths	Same (updated) data source as SEDAR 33 Update: FWC FWRI At-Sea Observer Program Headboat : weighted by trip length and region (because HBT trips not sampled proportional to fishing effort, WP-13). Charter: Nominal Input sample sizes: number of trips

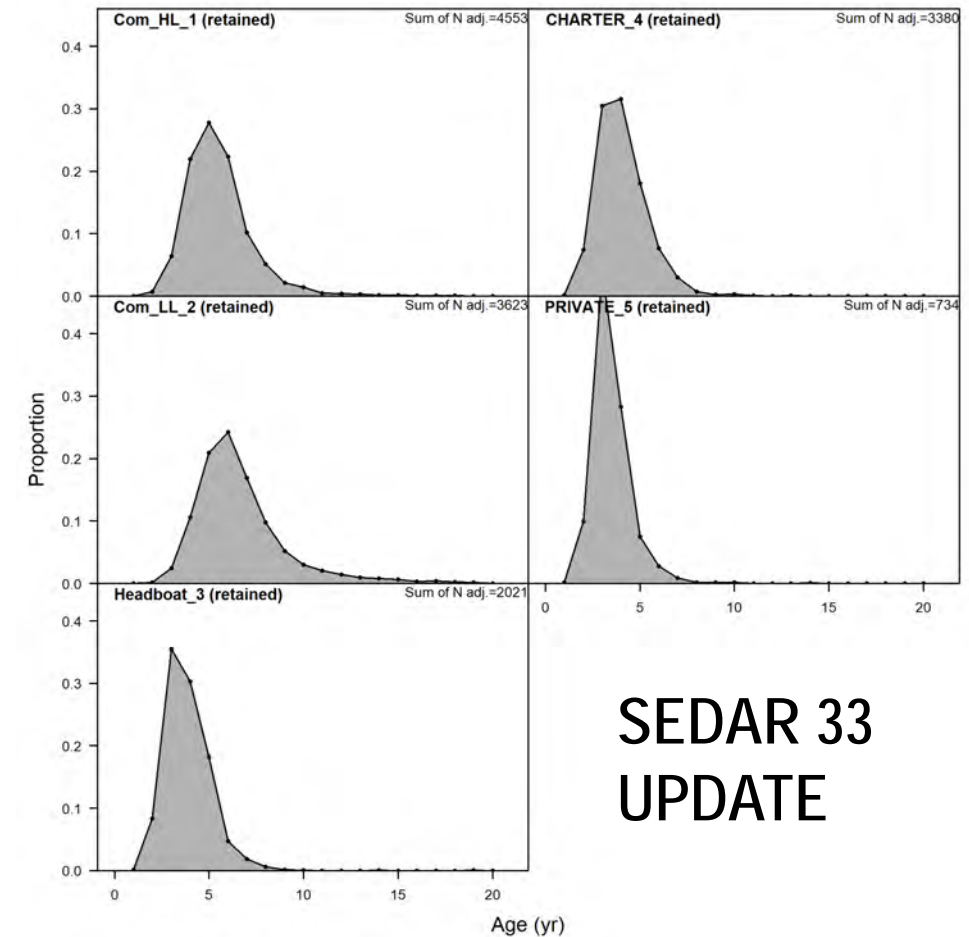
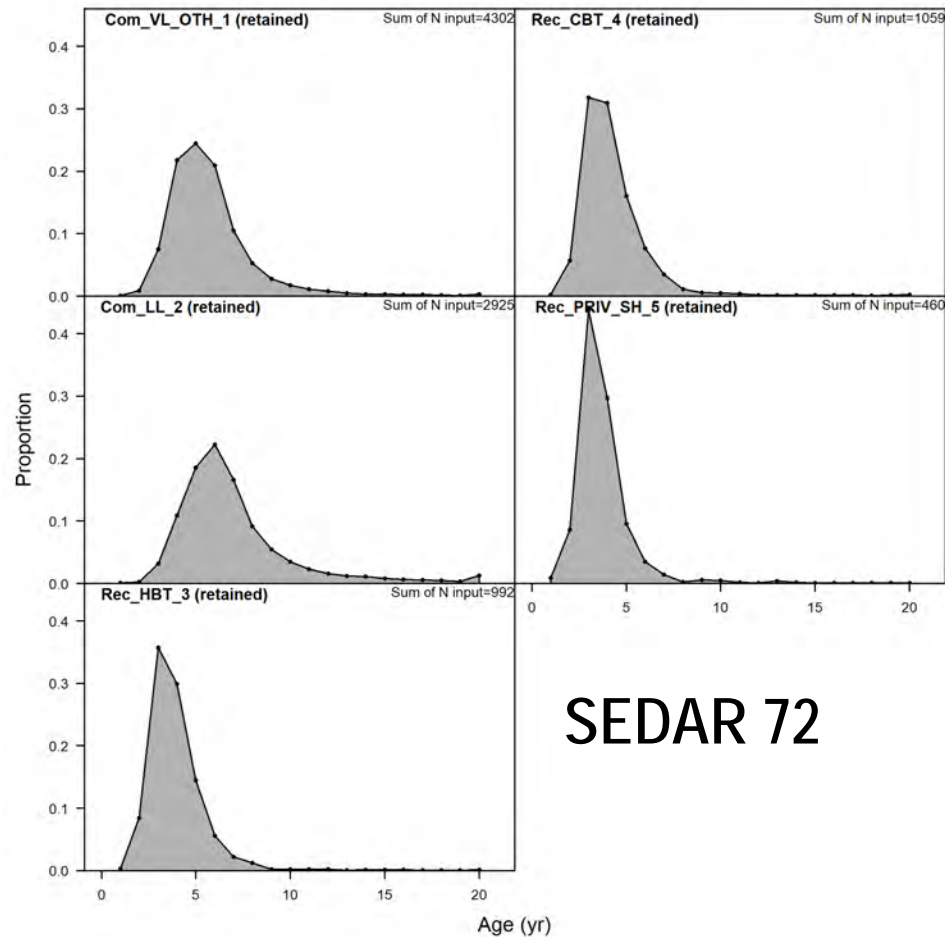


Data – Length Compositions

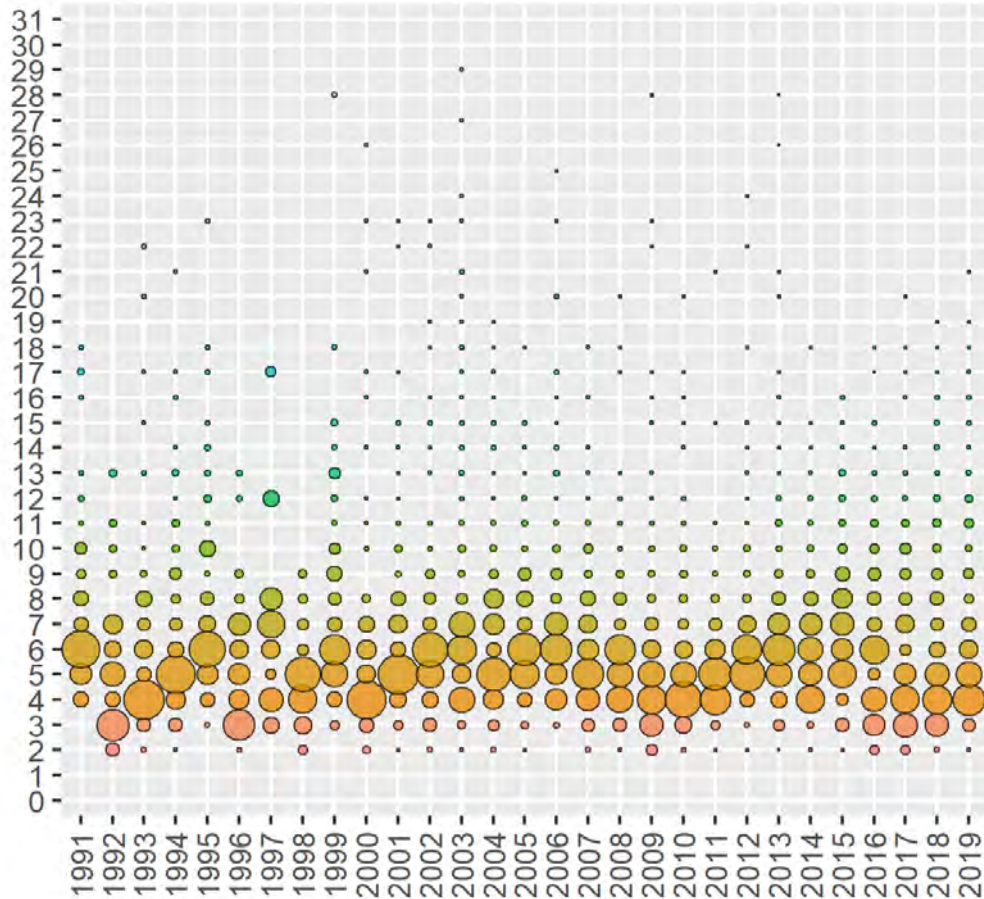


Data – Age Compositions

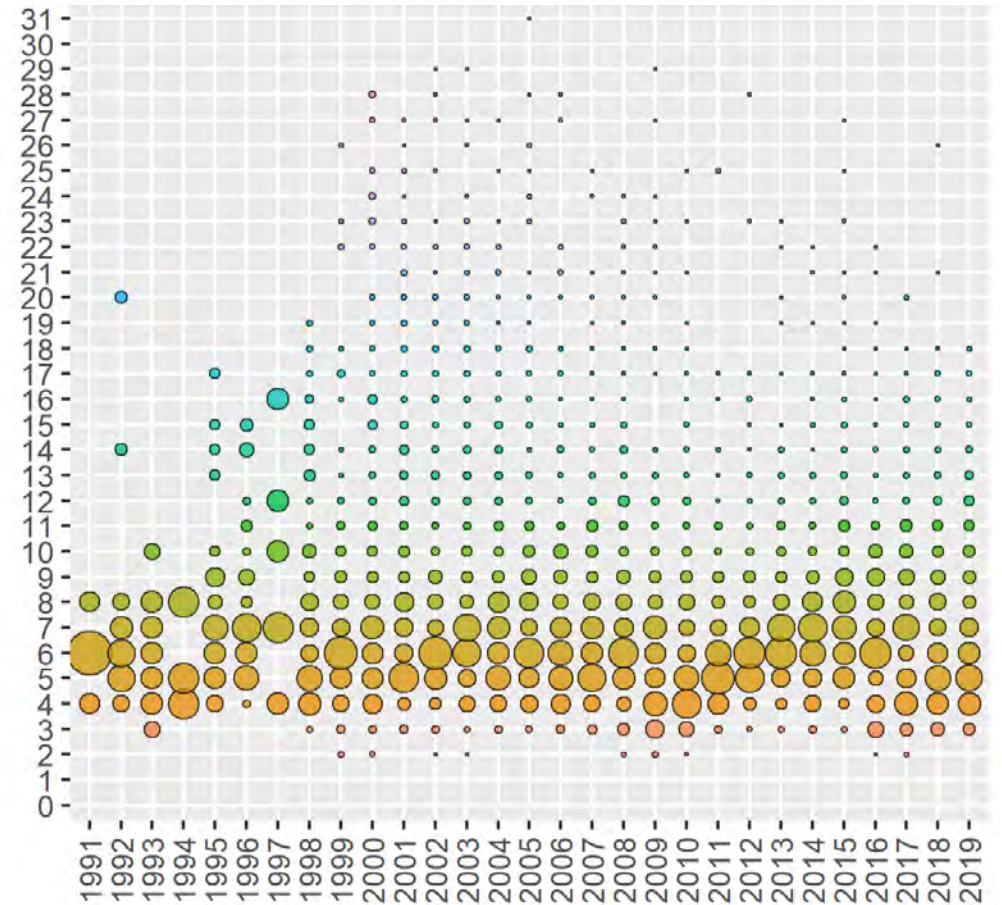
Data Component	Decision
Recreational and Commercial	Nominal Input sample sizes: number of trips



Data – Age Compositions (Commercial)

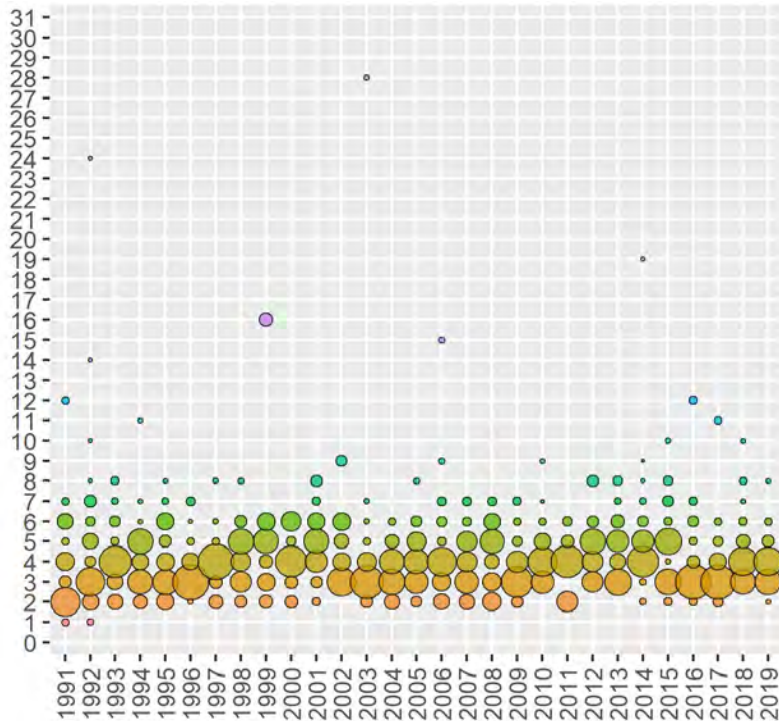


Vertical Line (n=4,302)

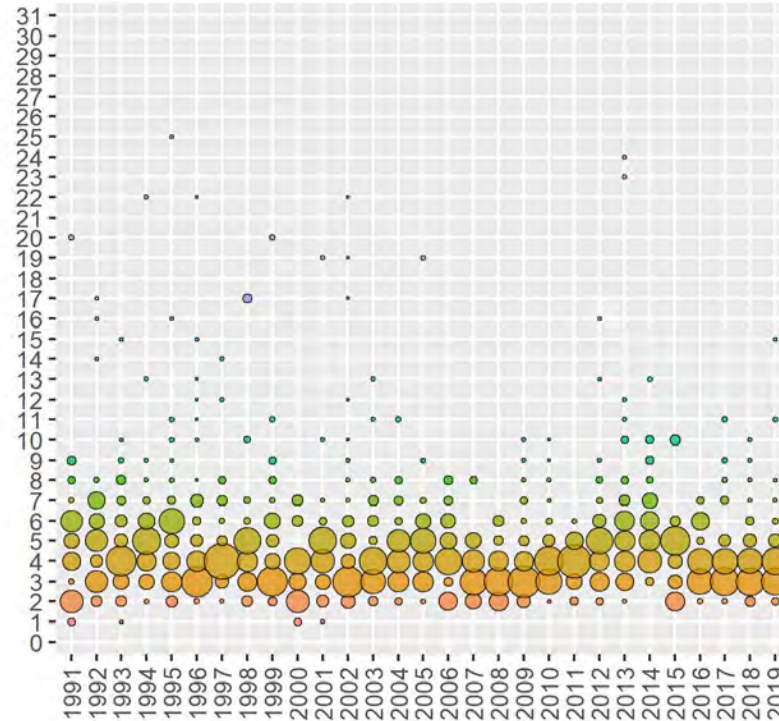


Longline (n=2,925)

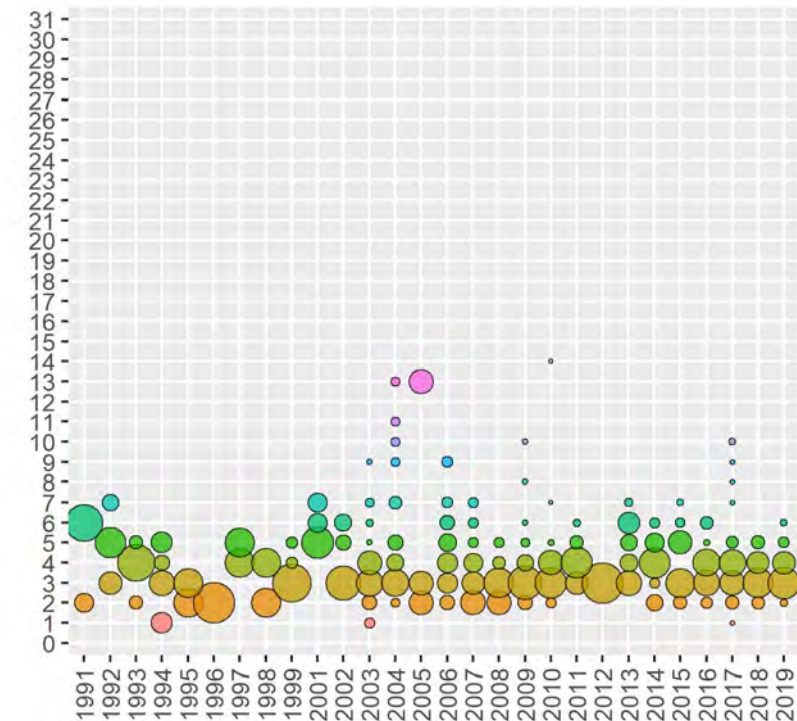
Data – Age Compositions (Recreational)



Headboat (n=992)



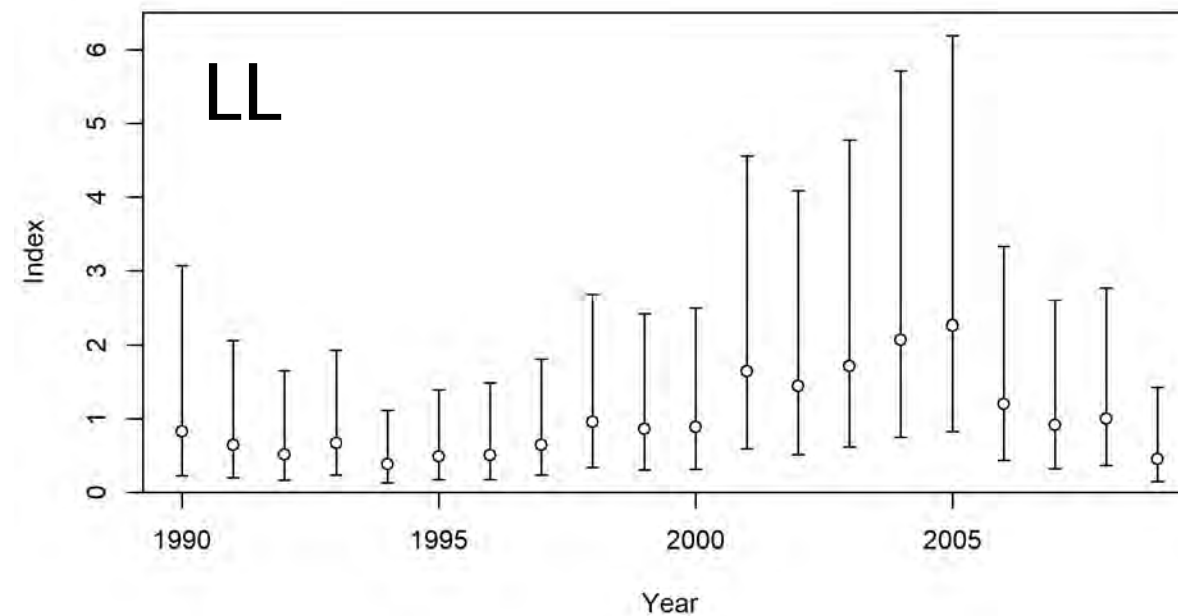
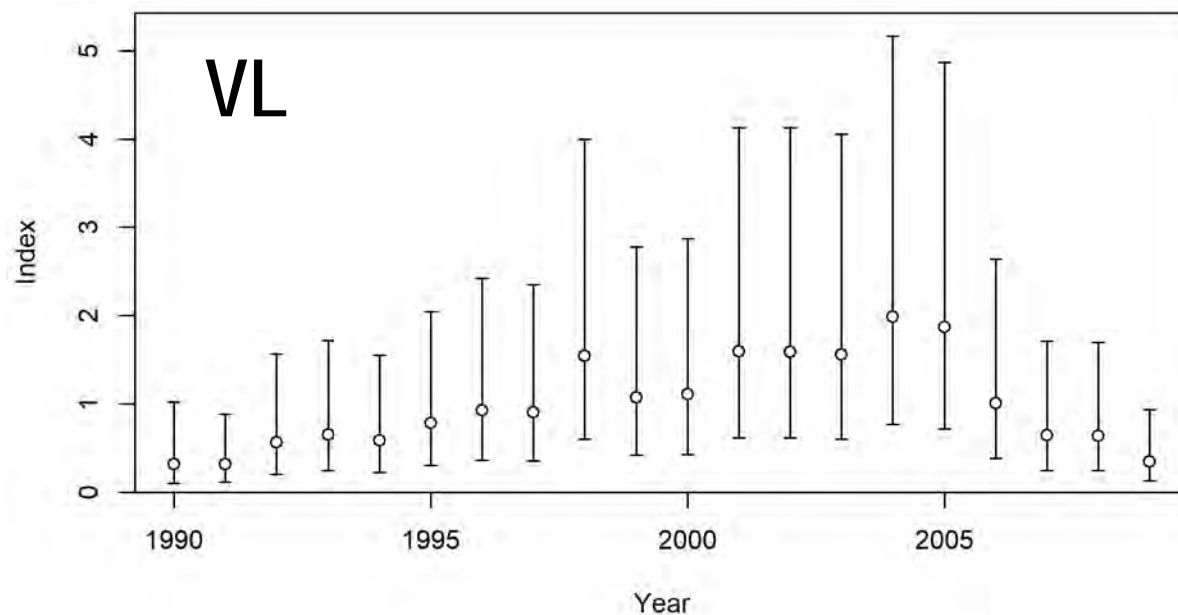
Charterboat (n=1,059)



Private (n=460)

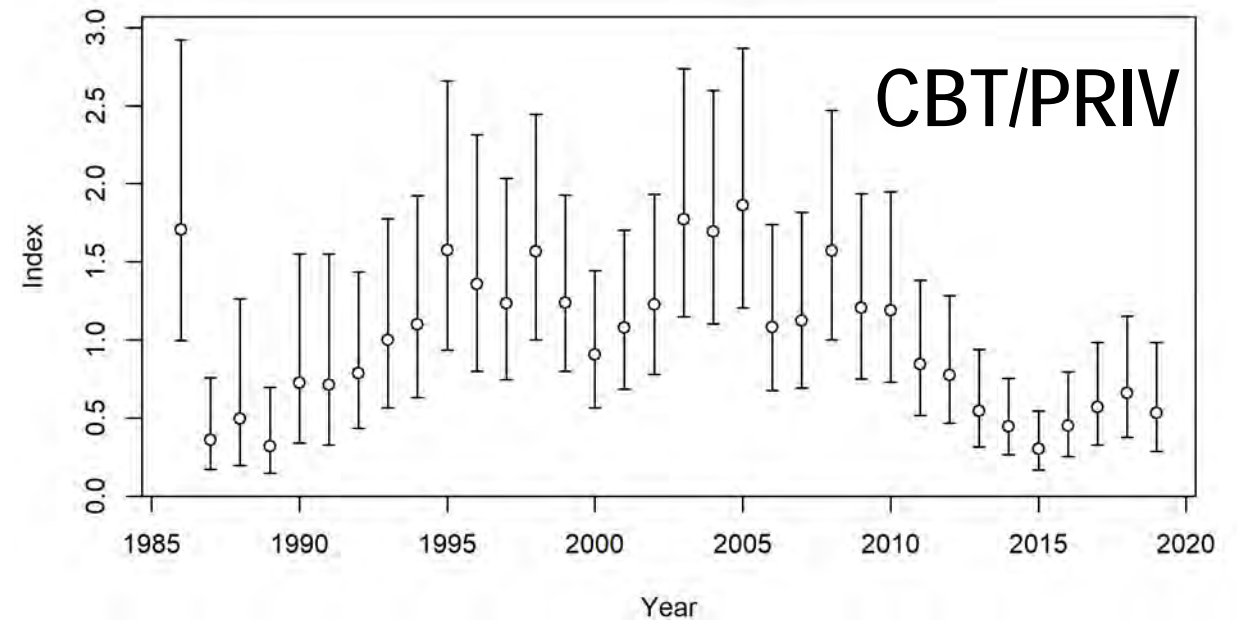
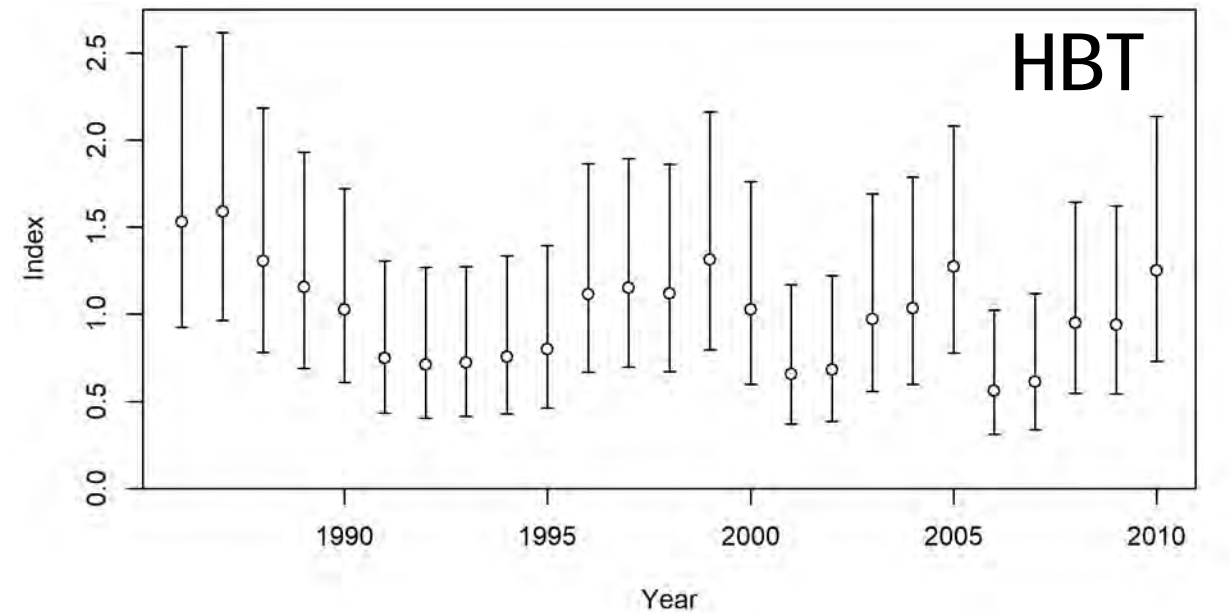
Data – Commercial CPUE

Data Component	Decision
Vertical Line and Longline CPUE	Unchanged from SEDAR33 Update (pre-IFQ). Additional SE estimated as part of the data weighting process.

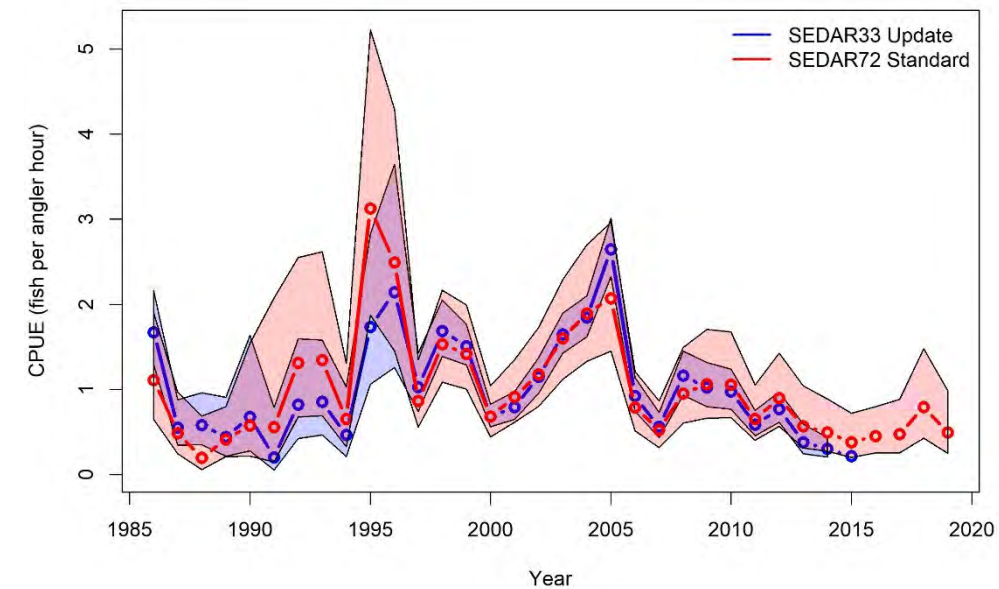
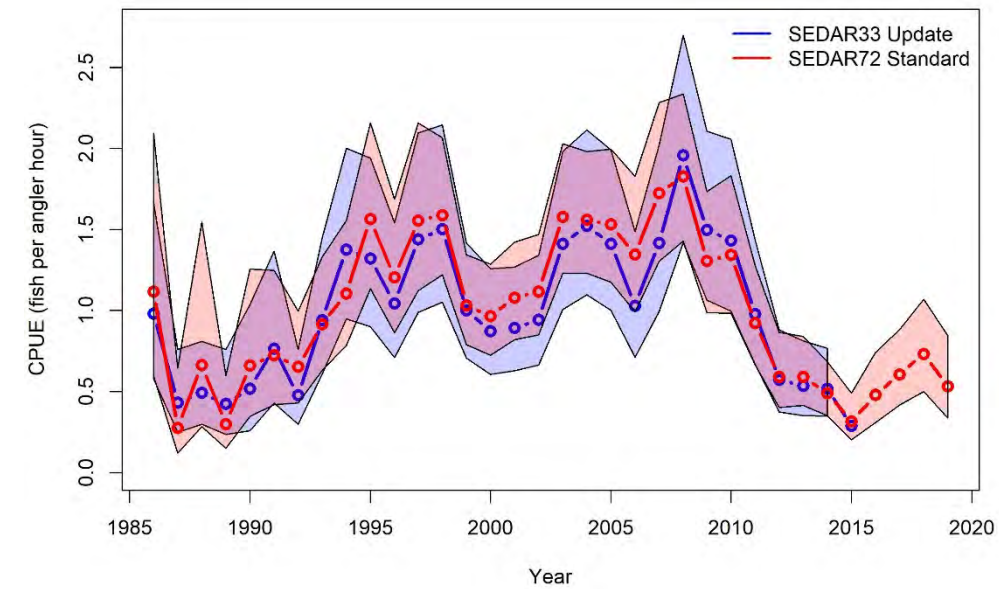
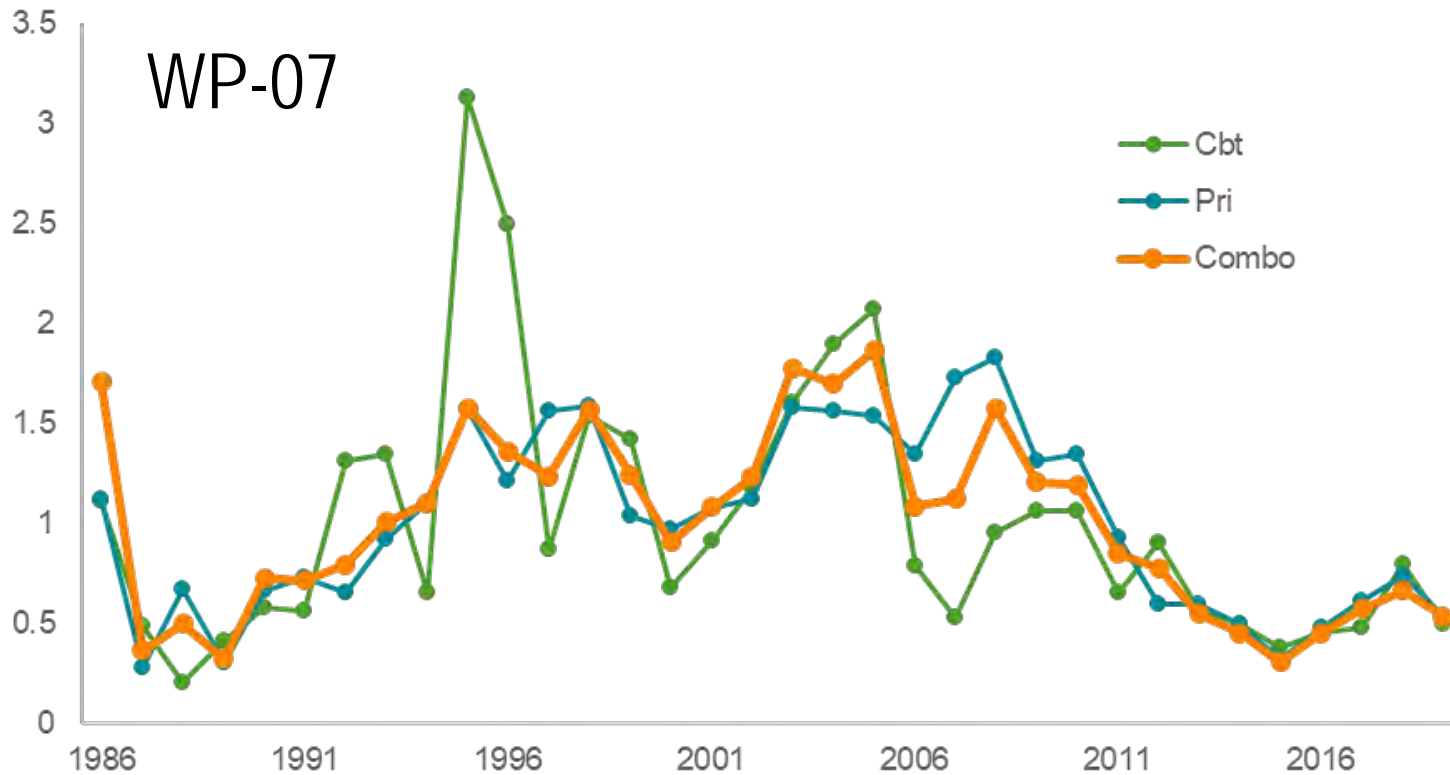


Data – Recreational CPUE

Data Component	Decision
MRIP Charter/Private CPUE	In SEDAR33 Update, separate indices were used for Charter and Private and the guild approach was used for trip selection. During SEDAR72, indices were redeveloped using the Stephens and MacCall (2004) approach and a combined index was selected. Additional SE estimated as part of the data weighting process.
SRHS Heaboat CPUE	Additional QAQC and improvements related to processing the headboat data. Resulted in only minor changes to the index. Additional SE estimated as part of the data weighting process.

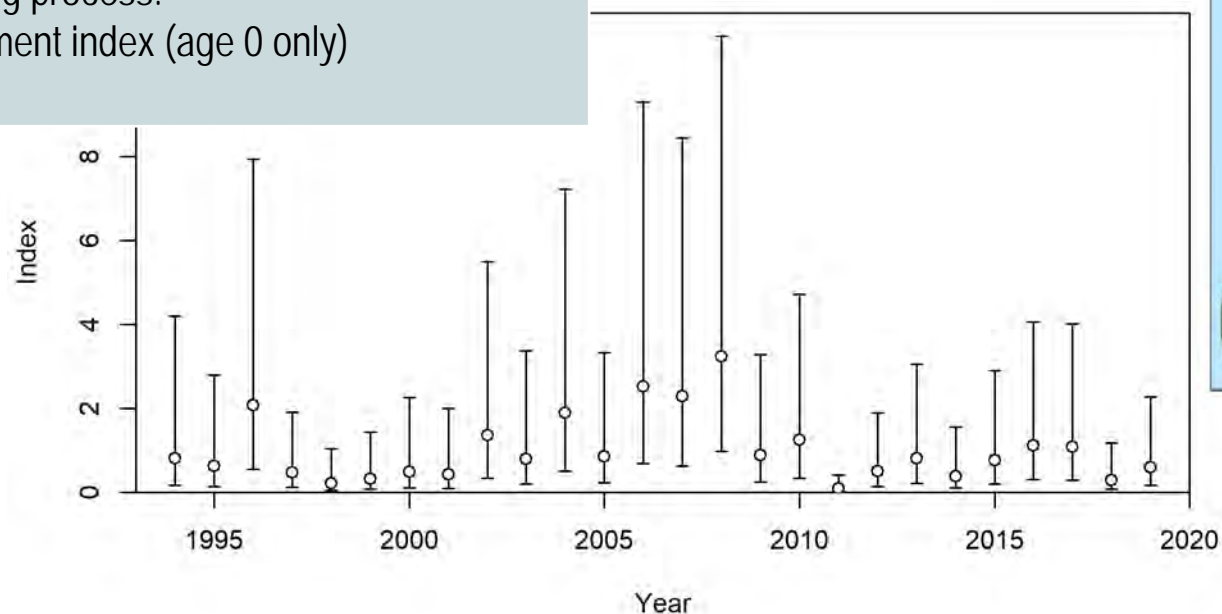


Data – CBT/PRIV CPUE



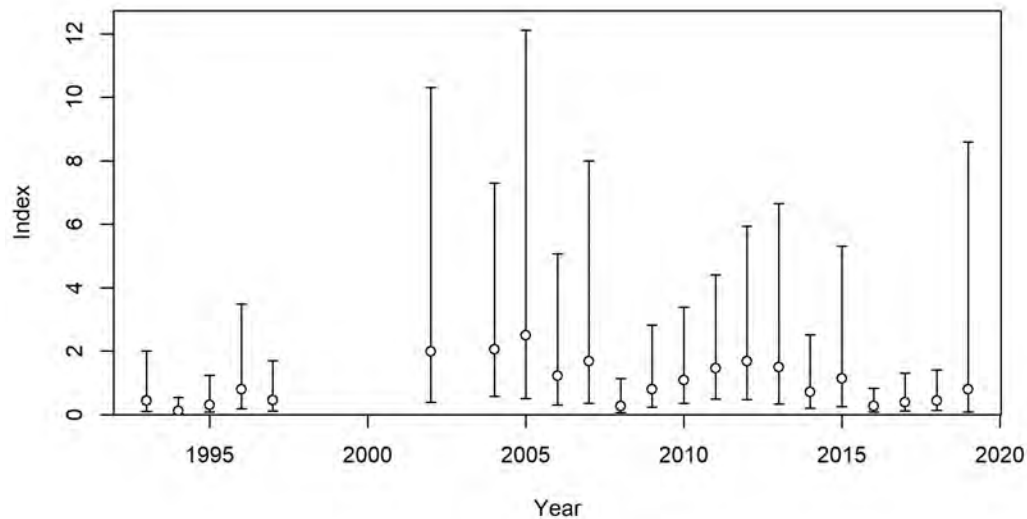
Data – Age-0 Survey

Data Component	Decision
Age-0 CPUE	Methods unchanged from SEDAR33 Update. WP-12 Additional SE estimated as part of the data weighting process. Recruitment index (age 0 only)

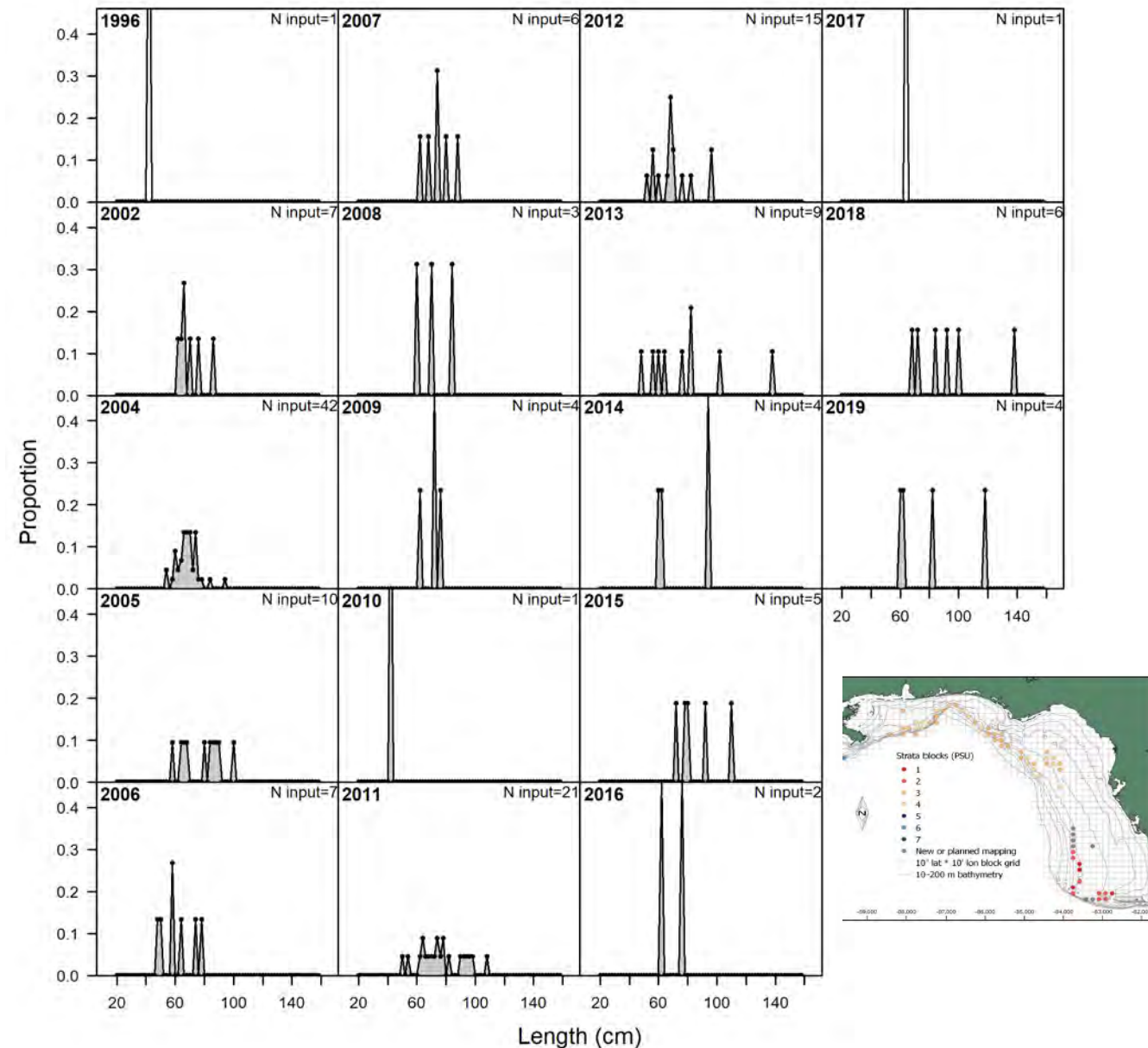


Data – SEAMAP video srvy

Data Component	Decision
SEAMAP CPUE	Negative binomial model instead of delta-lognormal used in SEDAR 33 Update. WP-03 Additional SE estimated as part of the data weighting process.
SEAMAP lengths	Nominal (as in SEDAR 33 Update) Sample size = number of camera drops with successful length measurements.

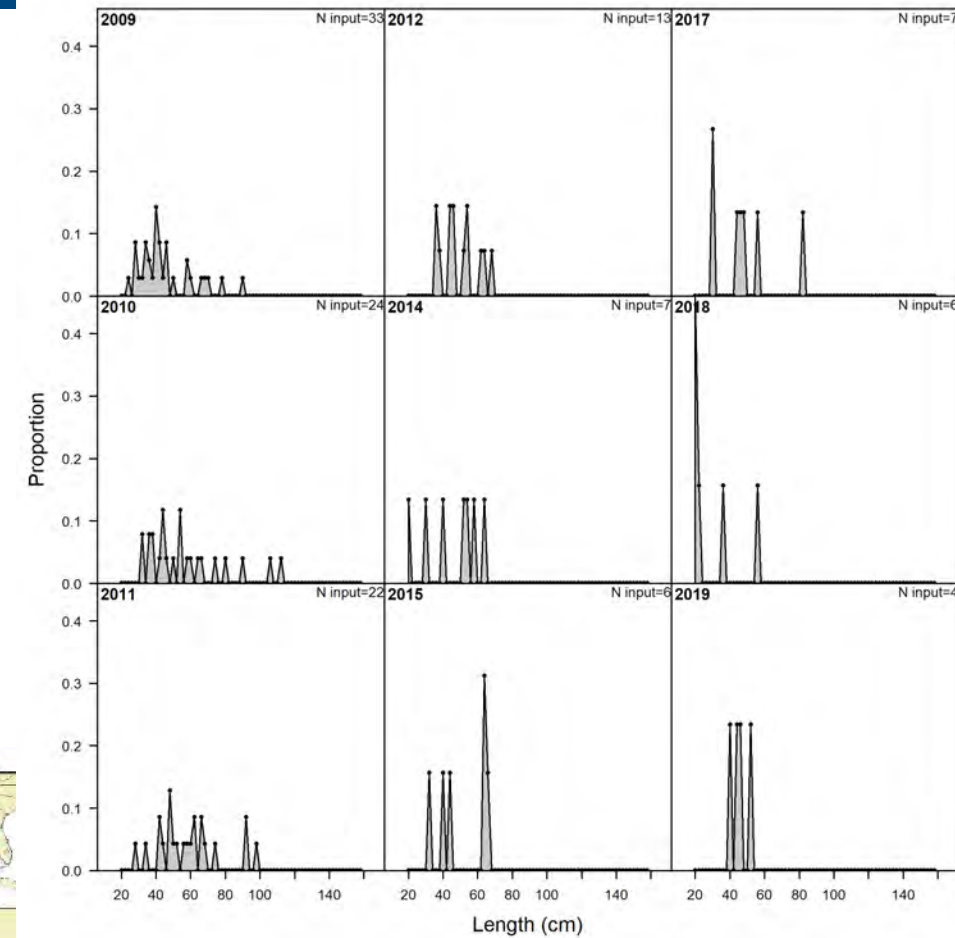
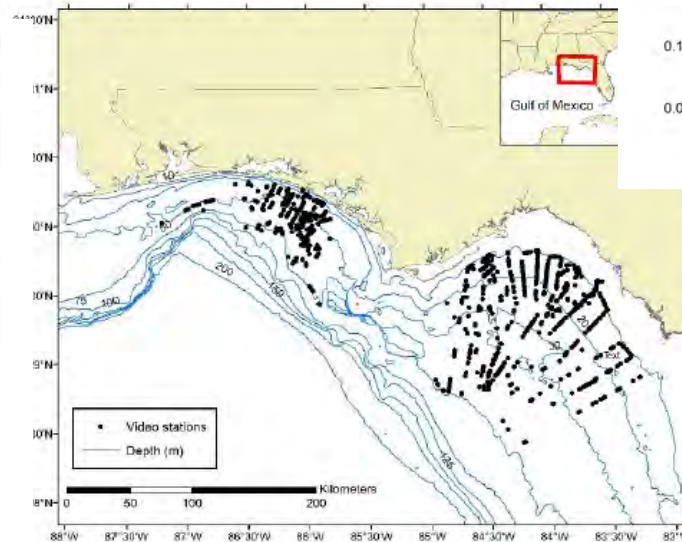
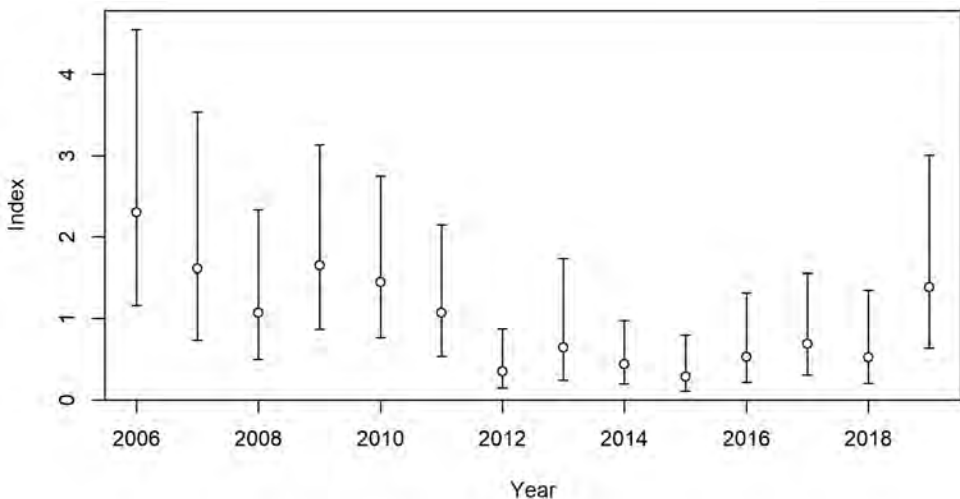


Total 148 individuals measured



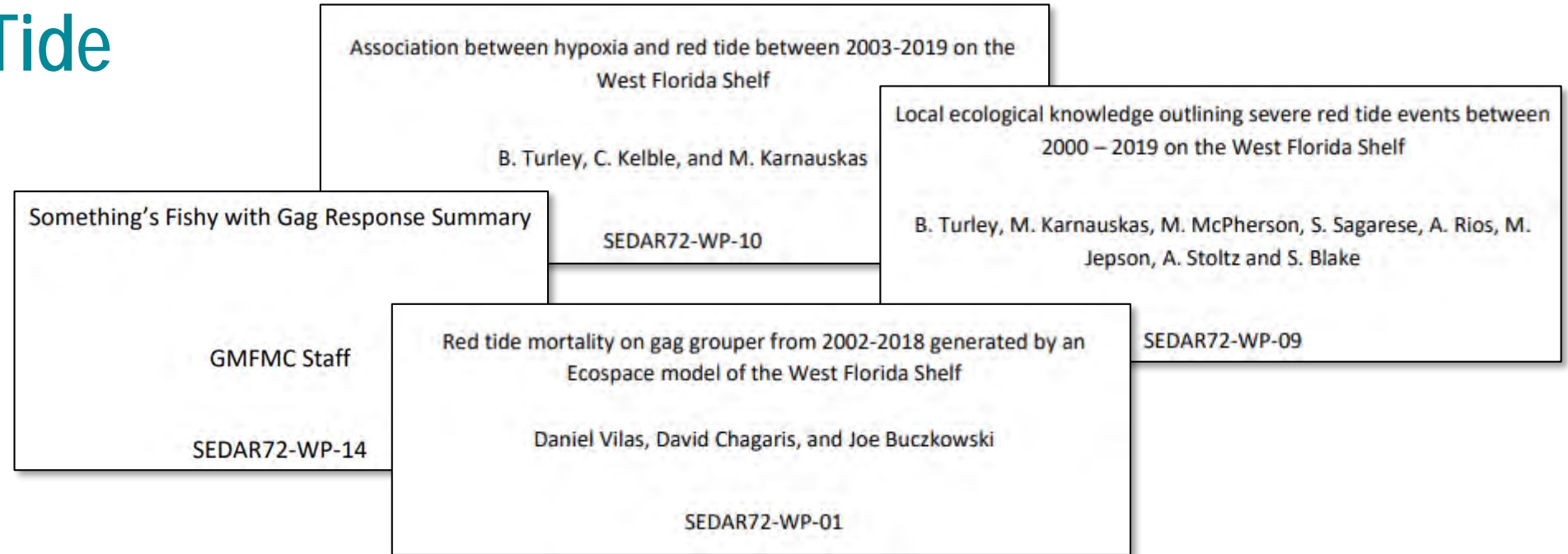
Data – PC video survey

Data Component	Decision
PC CPUE	Methods unchanged from SEDAR33 Update but 2005 dropped from the index. Additional SE estimated as part of the data weighting process.
PC lengths	Nominal (as in SEDAR 33 Update) Sample size = number of camera drops with successful length measurements.



Total 122 individuals measured

Data – Red Tide



Data Component	Decision
Red Tide Mortality	<p>"Bycatch-only fleet" as in SEDAR33 Update</p> <p>Years added : 2014, 2018 (in addition to 2005)</p> <p>Selectivity modified from 1+ to 0+</p> <p>Information from the Ecospace model used in sensitivity runs.</p>

TOR

Re-evaluate the potential effects of red tide on gag, with consideration of past red tide events through 2018.

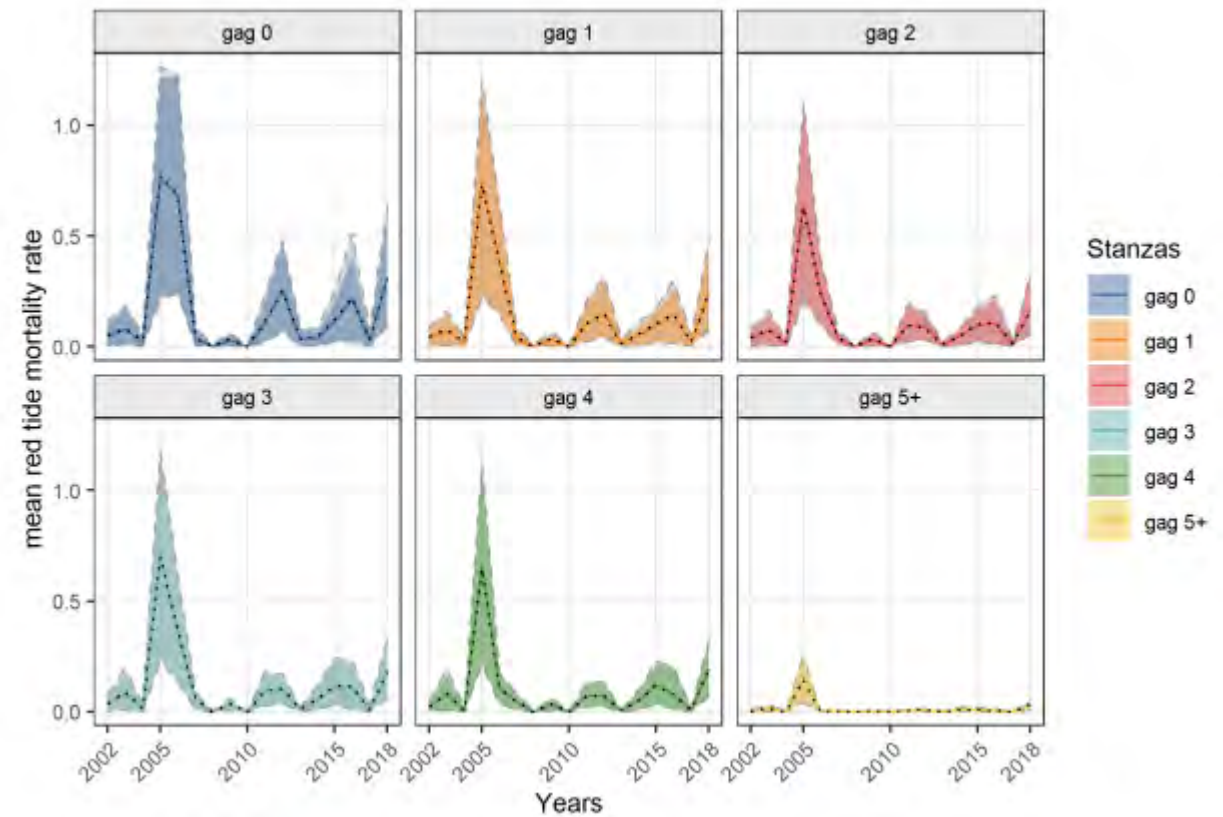
Red Tide Sensitivity Runs

1. Red Tide Selectivity

Empirical selectivity vectors for ages 0-5+ constructed from Ecospace estimated mean red tide mortality estimates for each age in each year

2. Red Tide Time Blocks on M

Set of 1-year time blocks on ages 0-5 (no red tide on ages 6+) using an additive deviation. Prior mean and sd obtained from Ecospace model estimates.



Base Model Run

Base Model - Bridging Analysis

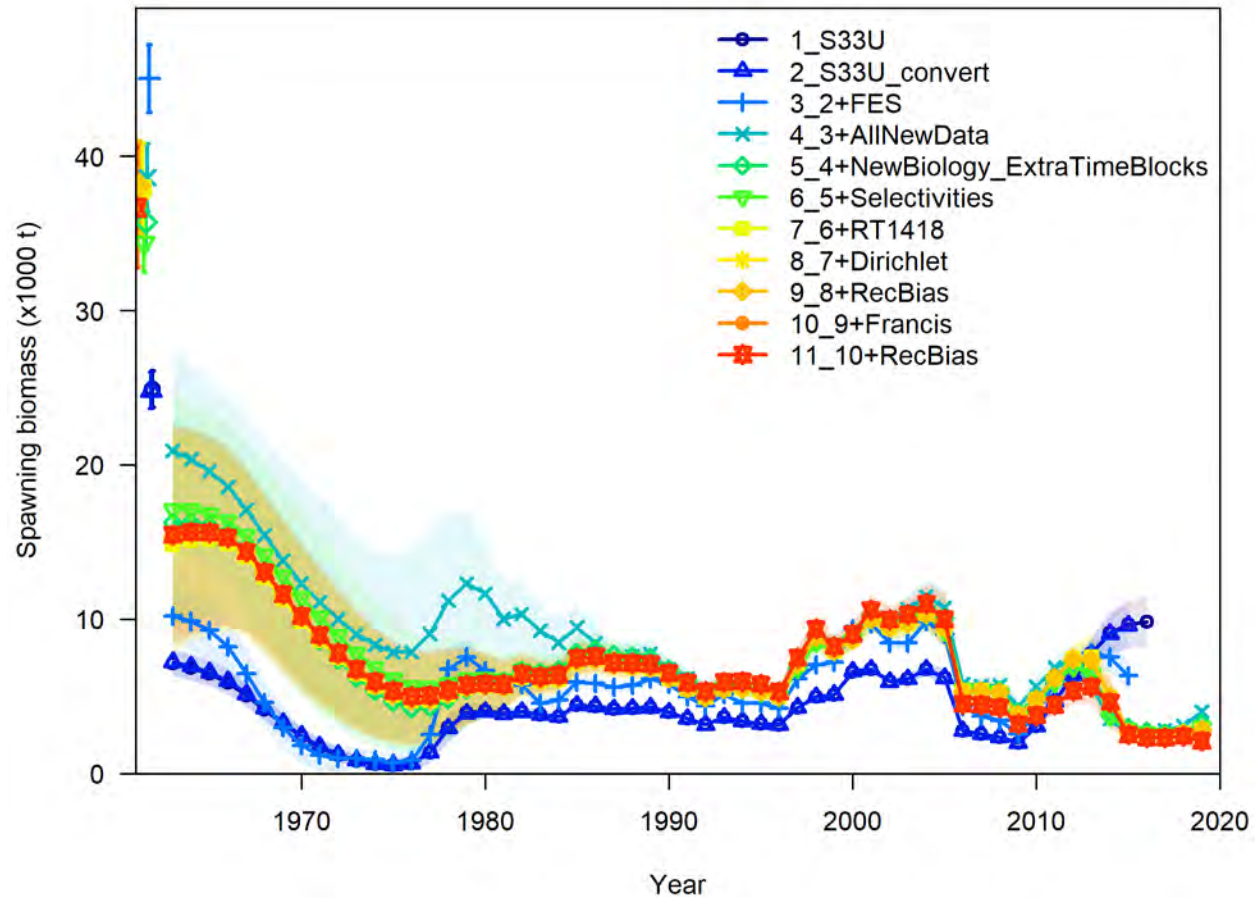
Model Name	Description	SS Version	NLL	Gradient	Bounded Parm
1_S33U	SEDAR 33 Update	3.24	8,630	0.0486	2
2_S33U_convert	SEDAR 33 Update converted to newest SS version	3.30	8,586	0.0012	2
3_2+FES	Step 2 + replace recreational catches and discards with FES estimates, no change to CVs nor end yr	3.30	8,504	0.0064	2
4_3+AllNewData	Step 3 + end year 2019 + fleet structure changes + all new data added catches, discards, indices, length comps, age comps nominal	3.30	5,251	0.2090	0
5_4+NewBiology_ExtraTimeBlocks	Step 4 + new M, maturity, hermaphroditism, growth CVs + time blocks extended and added for new minimum size limit and reduced recreational season	3.30	4,051	0.0002	1
6_5+Selectivities	Step 5 + adjust selectivities, remove prior on initial Fs, extend recruitment deviations to 2019	3.30	4,016	0.0026	1
7_6+RT1418	Step 6 + estimate red tide mortality in 2014 and 2018	3.30	3,951	0.0004	0
8_7+Dirichlet	Step 7 + Dirichlet weighting of length and age compositions	3.30	15,430	0.2970	0
9_8+RecBias	Step 8 + apply recruitment deviations bias adjustment ramp and fix Dirichlet params > 5	3.30	15,423	0.0160	0
10_9+Francis	Step 9 + Francis weighting of indices	3.30	15,182	0.0530	0
11_10+RecBias	Step 10 + apply recruitment deviations bias adjustment ramp	3.30	15,182	0.0312	0

Base Model - Bridging Analysis

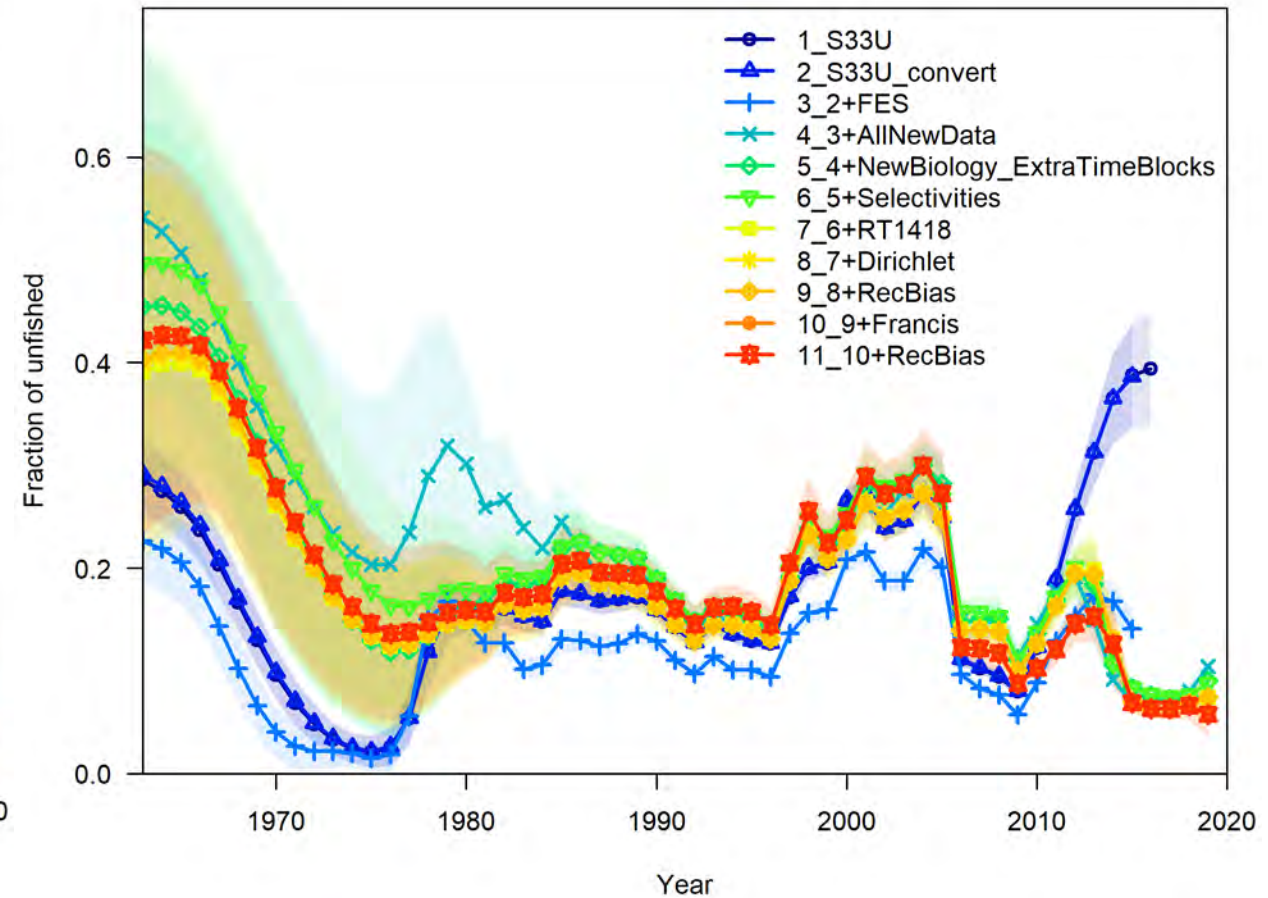
Model Name	Ln(R0)	R1 Offset/ Regime	Target M	Virgin SSB (mt)	Virgin Recr (1000s)	Depletion Start Yr	Depletion End Yr
1_S33U	8.52	-1.07	0.134	24,913	5,032	0.29	0.39
2_S33U_convert	8.52	-1.06	0.134	24,818	5,017	0.29	0.39
3_2+FES	9.13	-0.73	0.134	45,053	9,264	0.23	0.14
4_3+AllNewData	8.98	-0.08	0.134	38,624	7,920	0.54	0.10
5_4+NewBiology_ExtraTimeBlocks	9.27	-0.15	0.159	35,734	10,650	0.45	0.09
6_5+Selectivities	9.24	-0.11	0.159	34,395	10,348	0.50	0.09
7_6+RT1418	9.37	-0.20	0.159	37,932	11,698	0.39	0.07
8_7+Dirichlet	9.36	-0.20	0.159	37,735	11,656	0.40	0.07
9_8+RecBias	9.37	-0.20	0.159	38,097	11,768	0.40	0.07
10_9+Francis	9.35	-0.18	0.159	36,796	11,458	0.42	0.06
11_10+RecBias	9.34	-0.18	0.159	36,666	11,417	0.42	0.06

Base Model - Bridging Analysis

SSB (female-only)

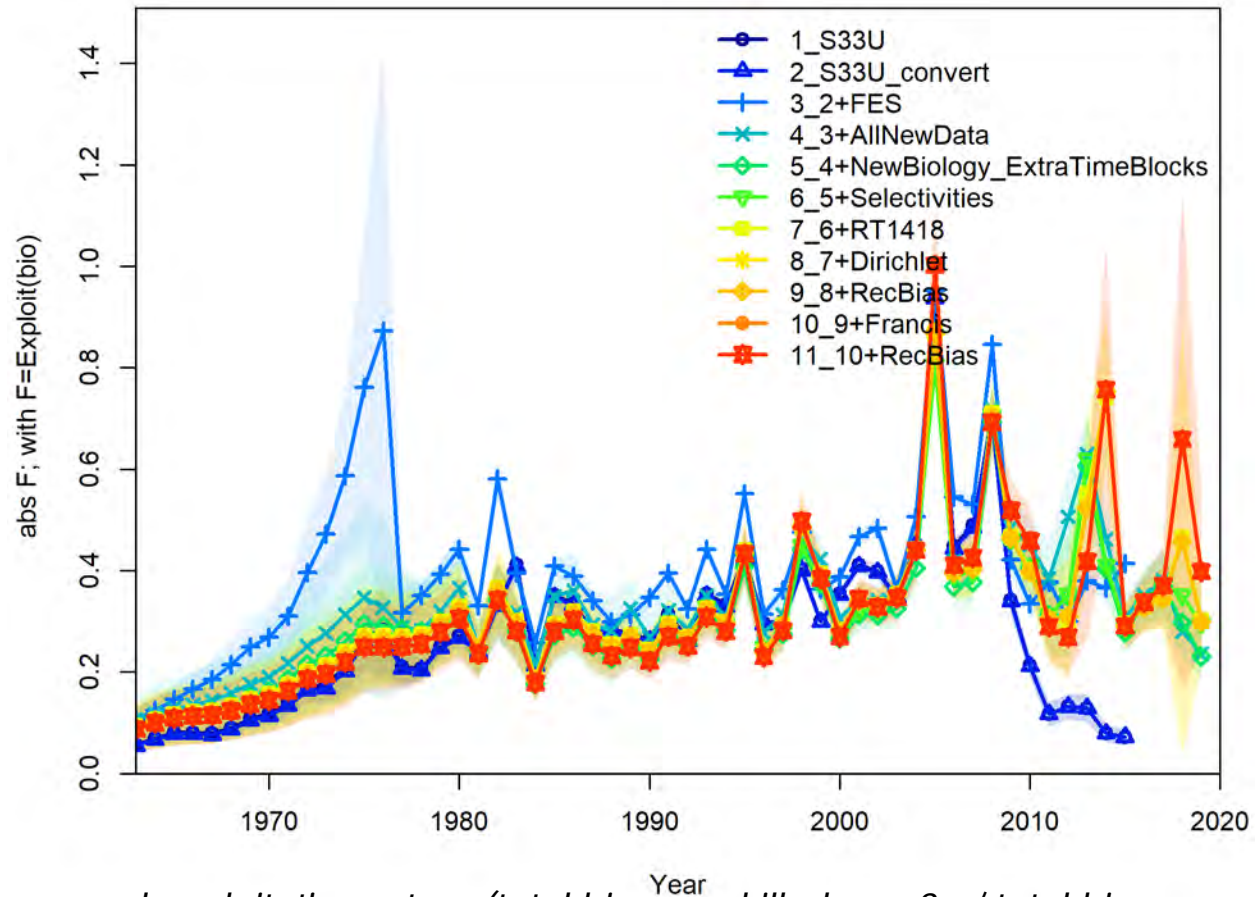


Fraction Unfished



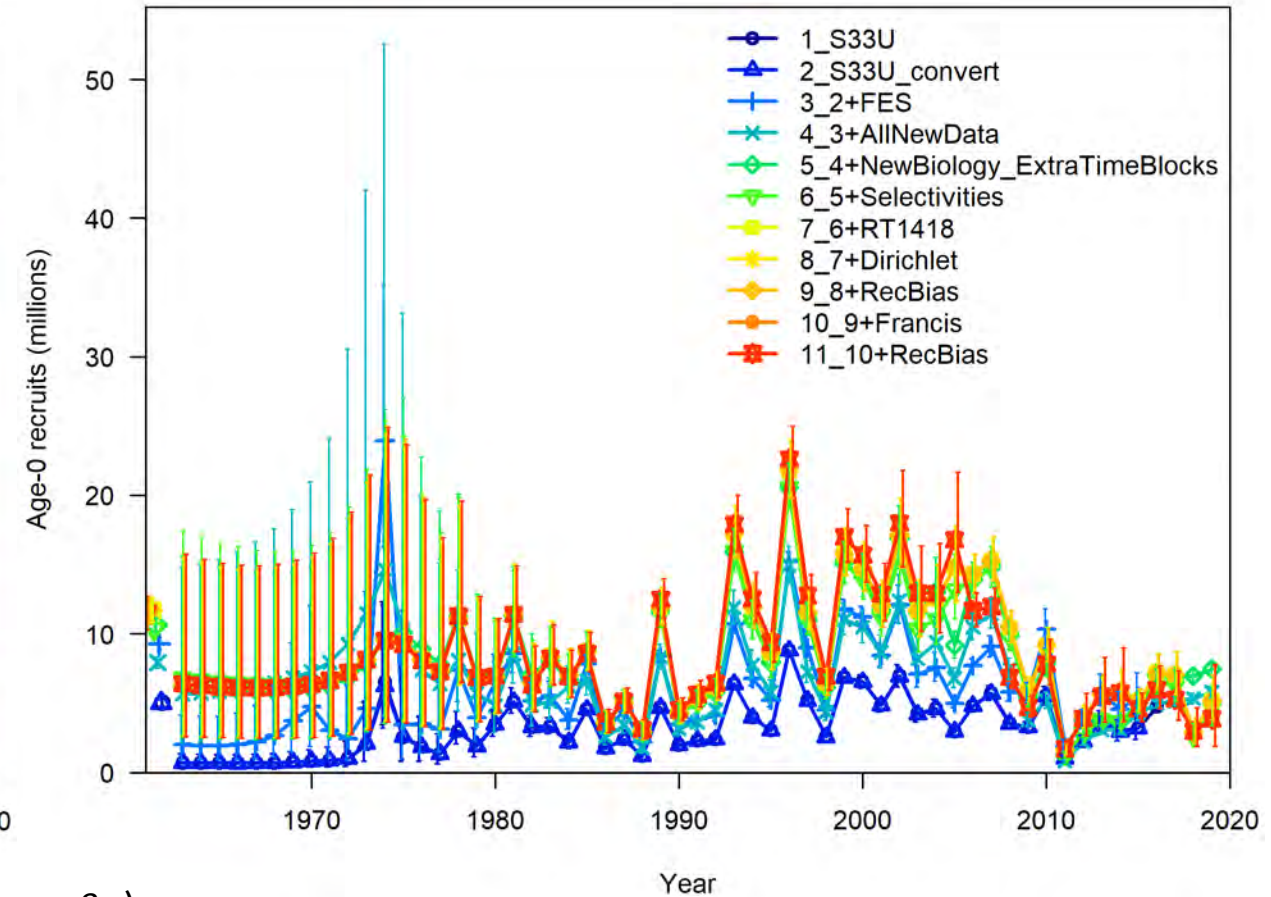
Base Model - Bridging Analysis

Exploitation rate

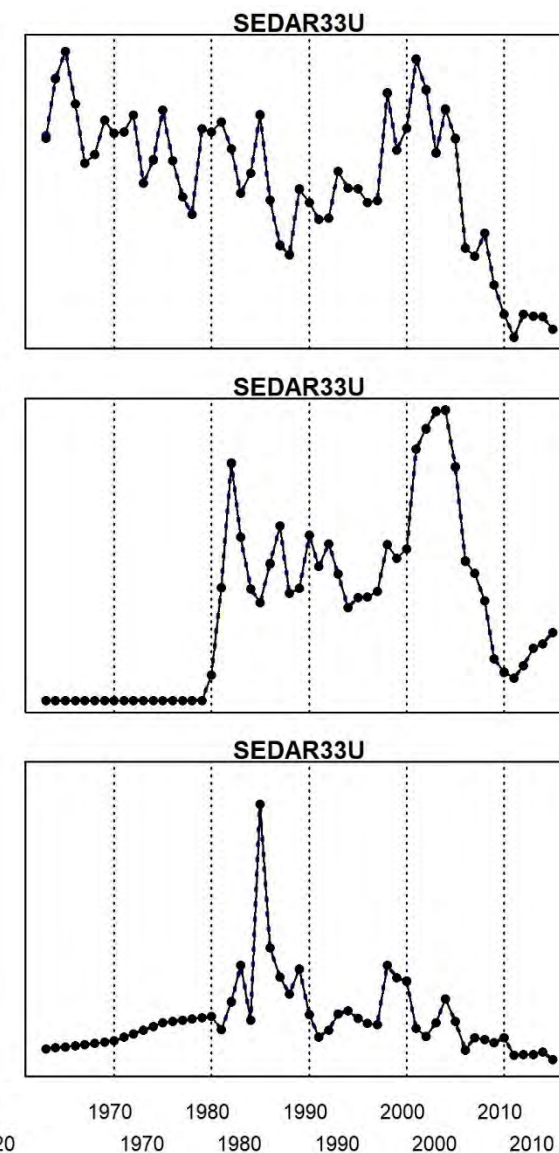
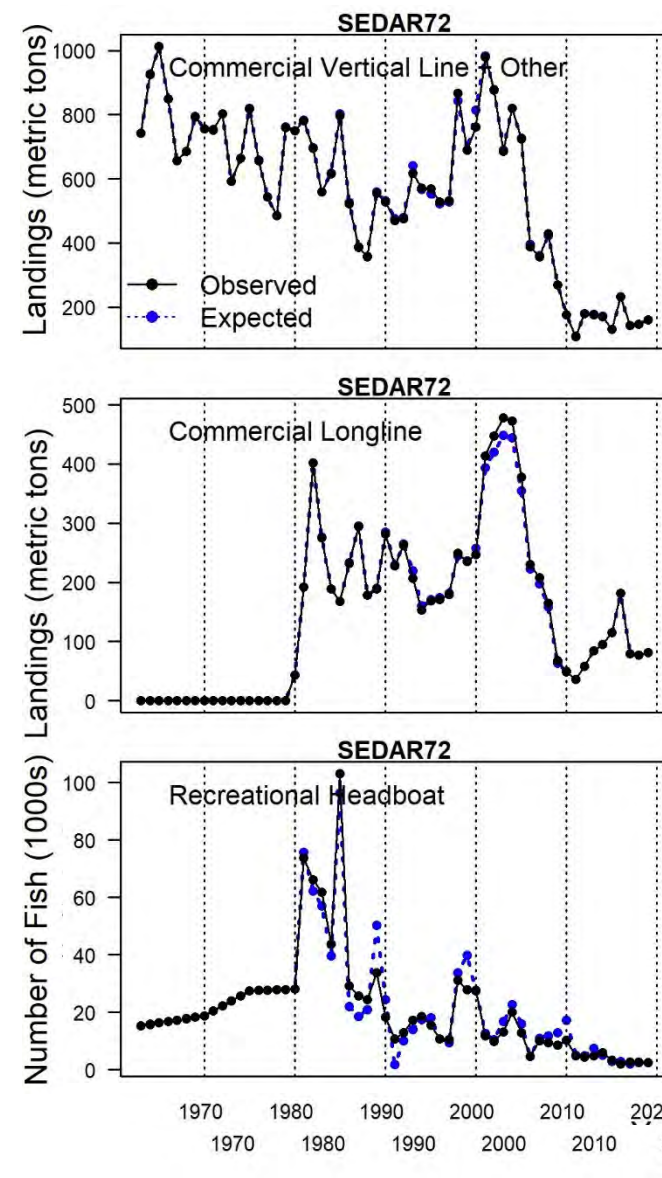
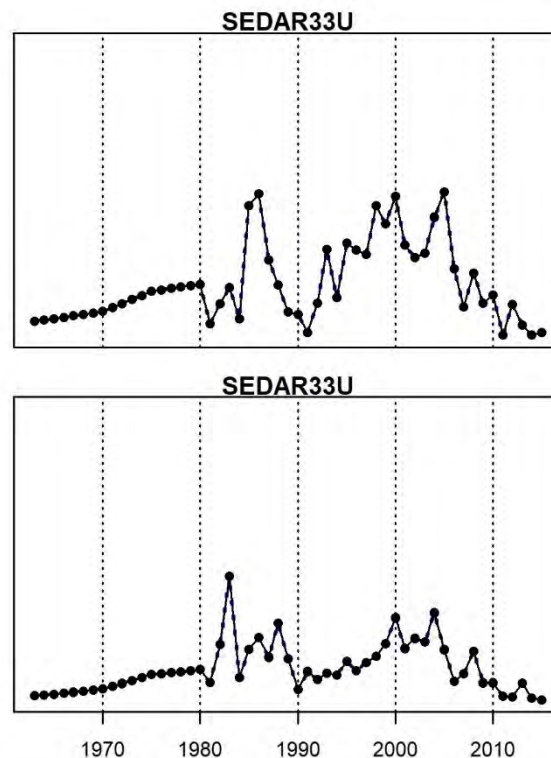
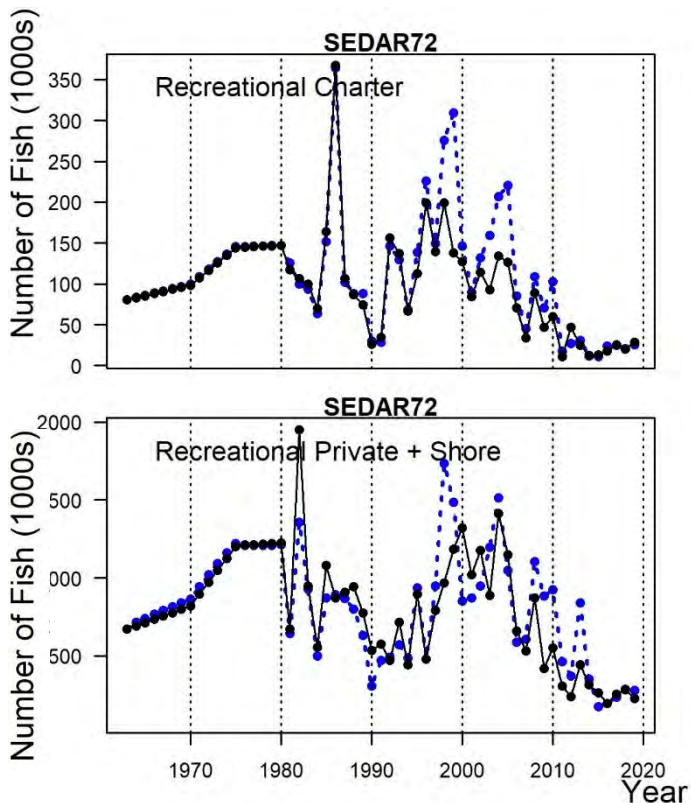


annual exploitation rate = (total biomass killed age 3+ / total biomass age 3+)

Recruitment



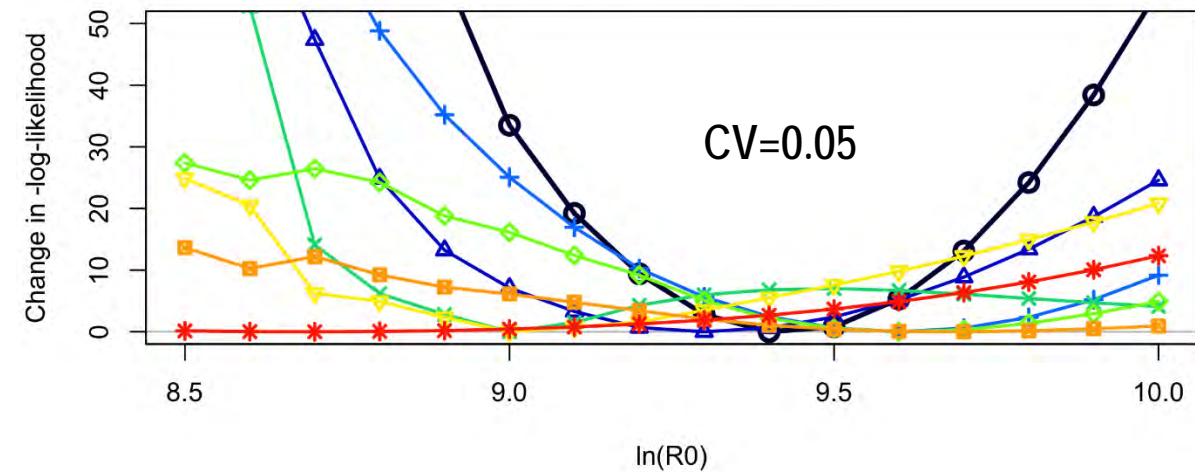
Base Model Fits - Landings



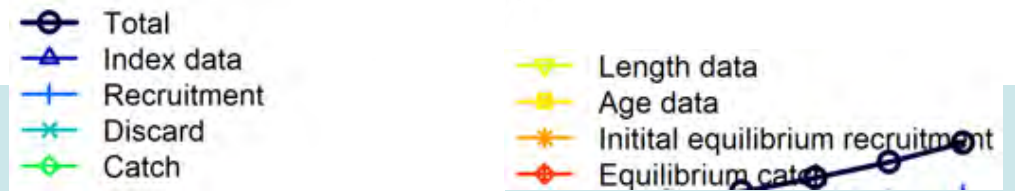
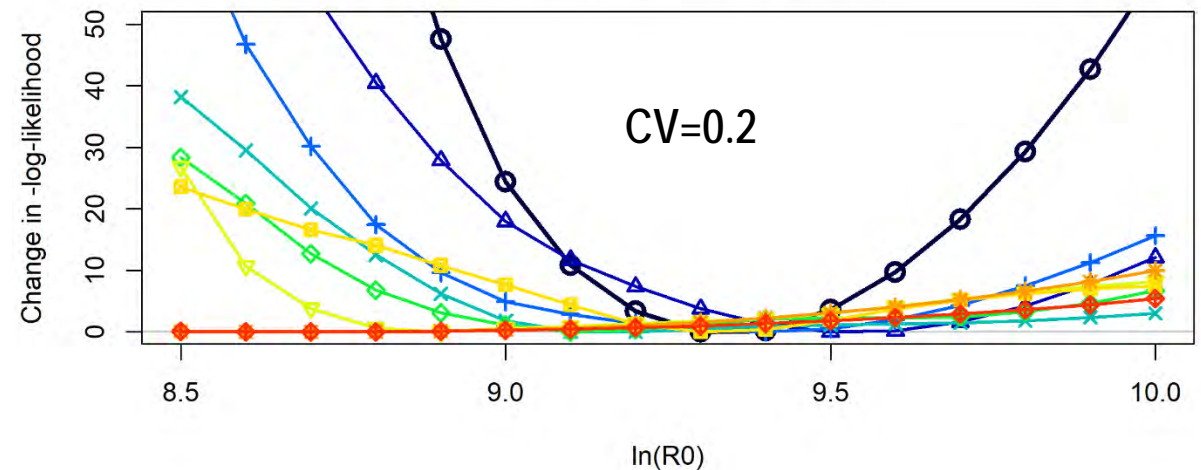
Sensitivity run – CV=0.05 on Recreational Catches

- Worse overall fit
- Tighter fit to the catches degraded fit to the discards
- R_0 profile of the Base Run was indicative of a better behaved model

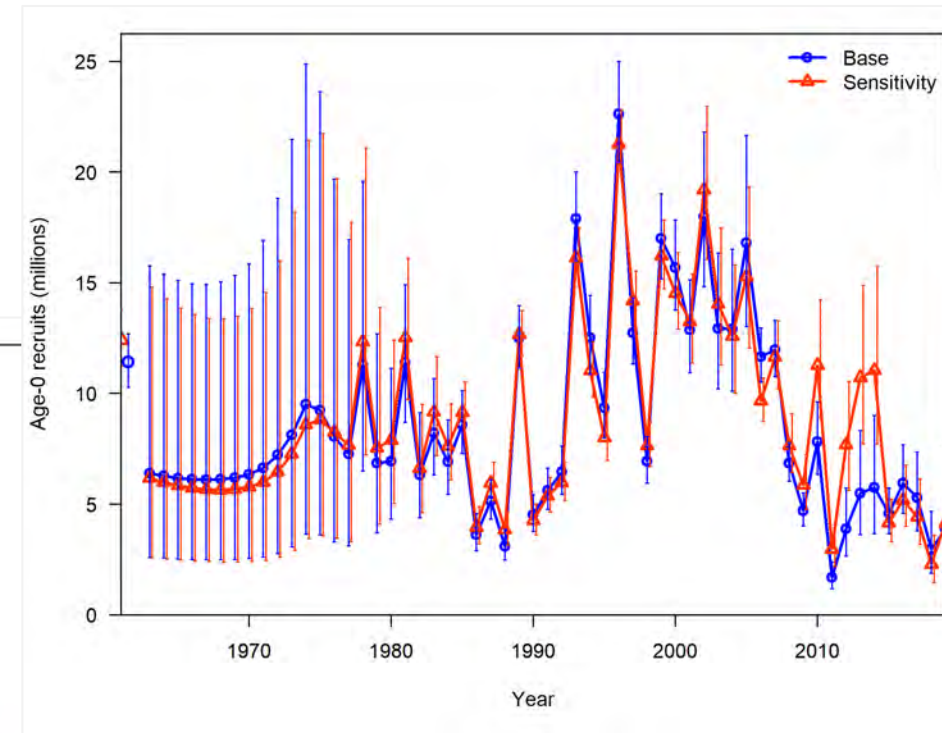
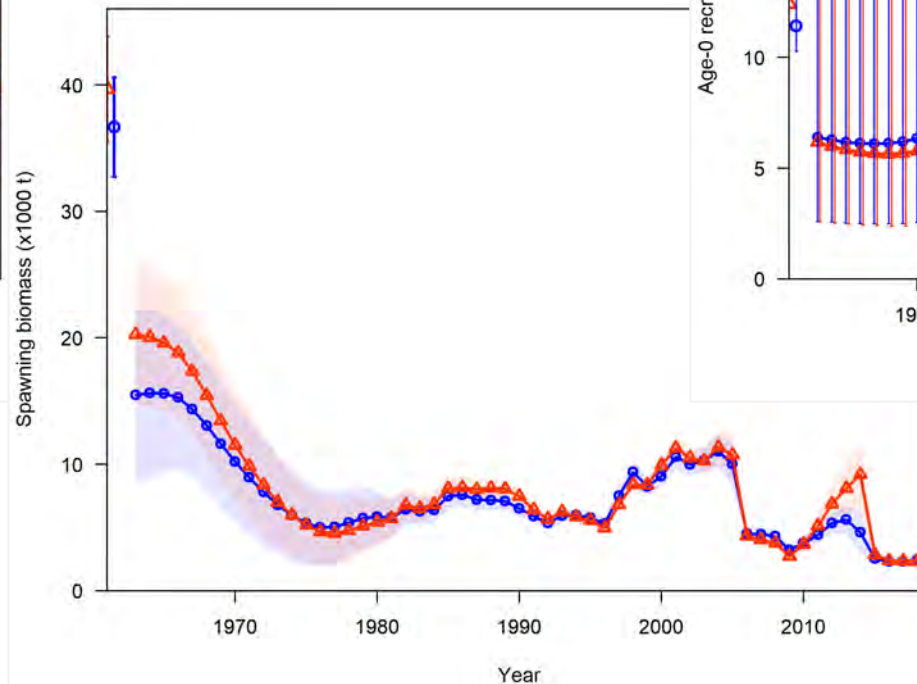
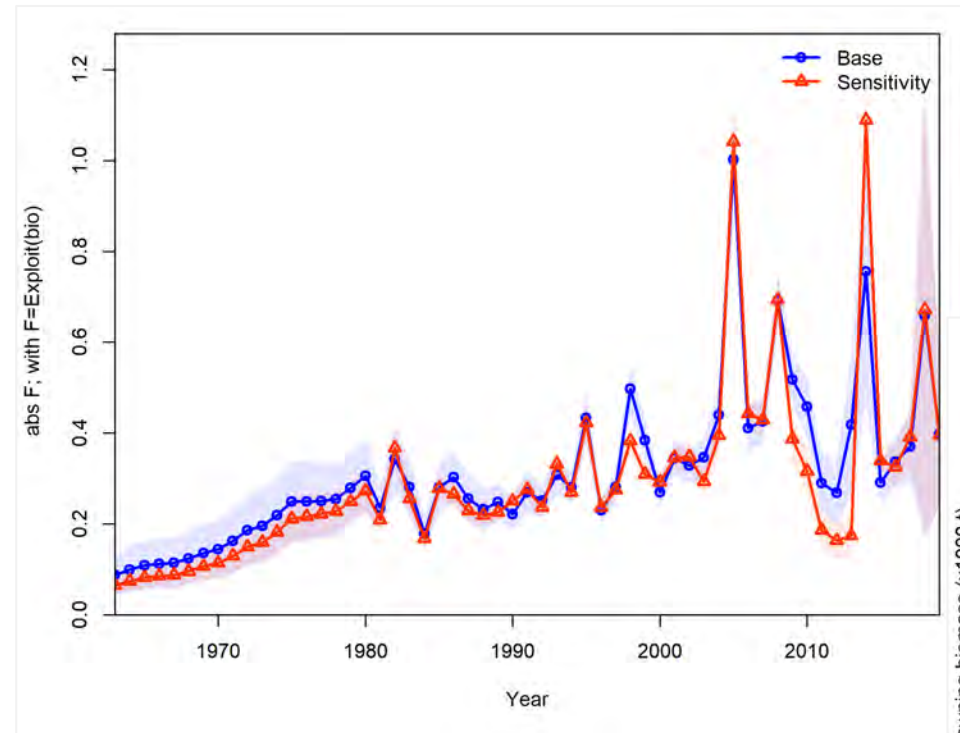
Likelihood Profile -- Zoom



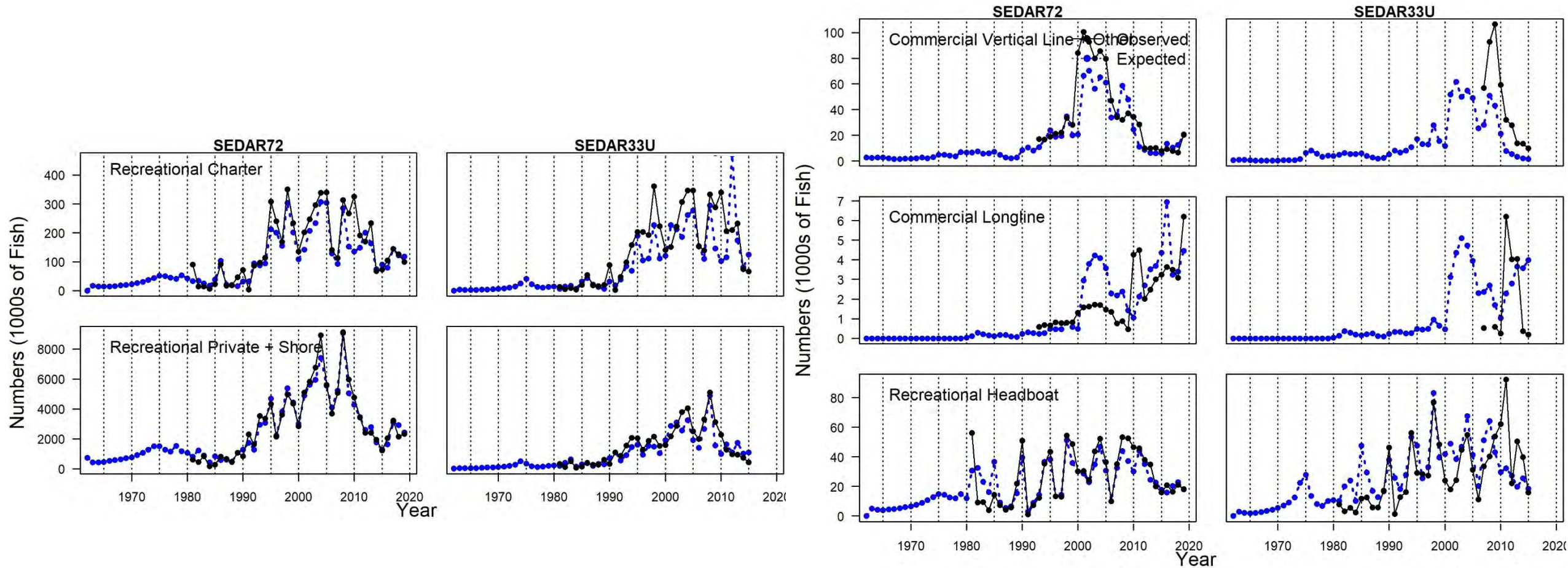
Likelihood Profile -- Zoom



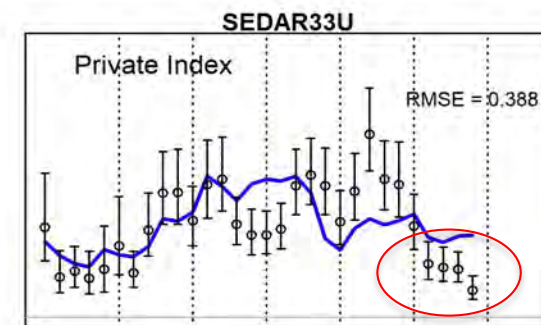
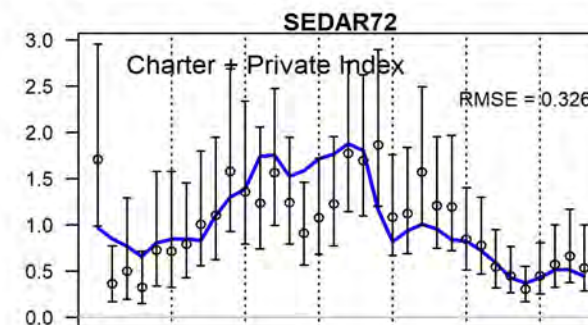
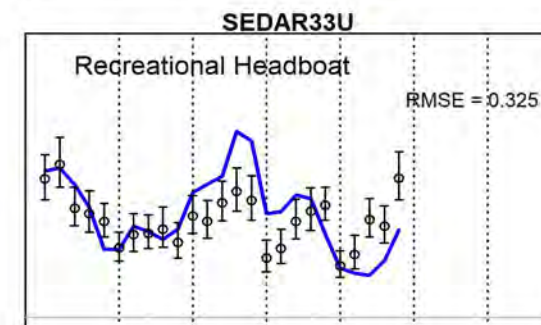
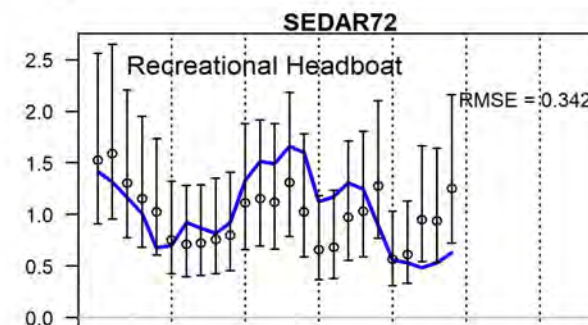
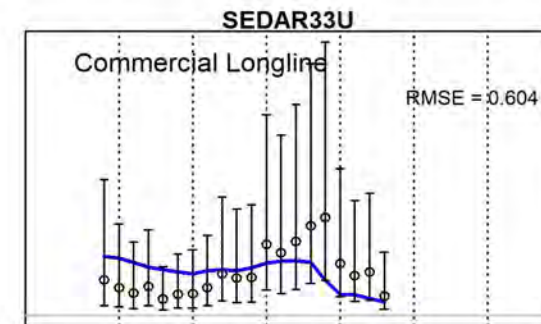
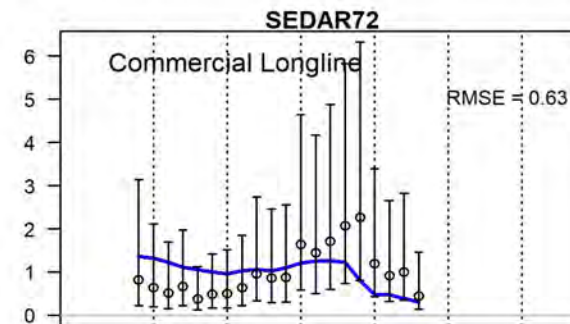
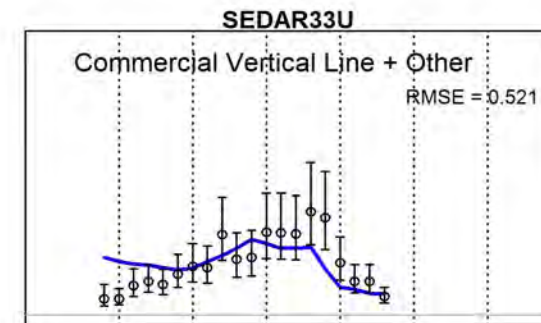
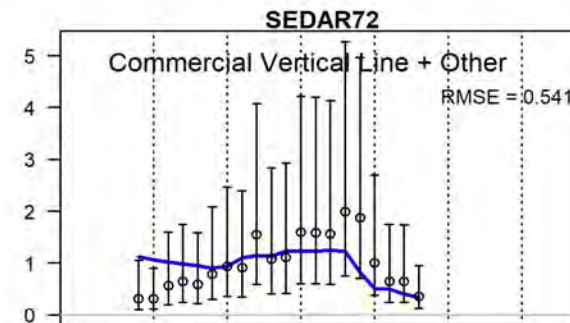
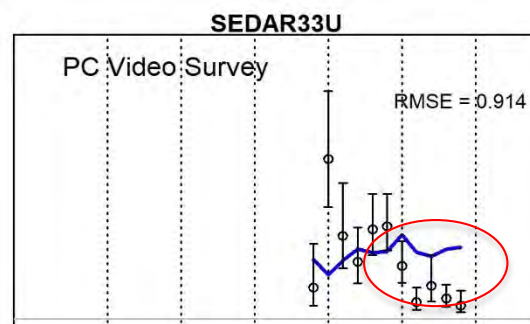
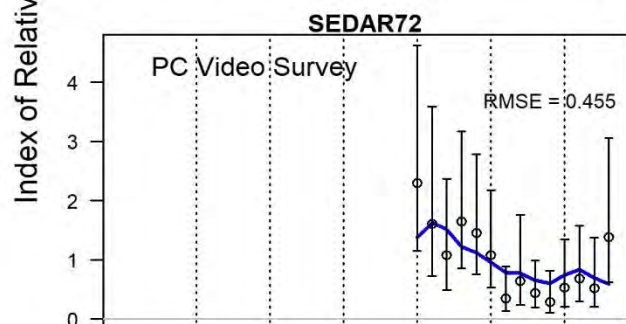
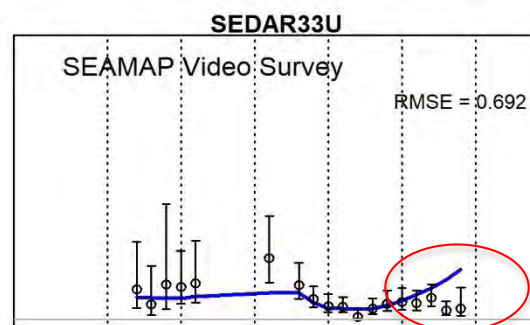
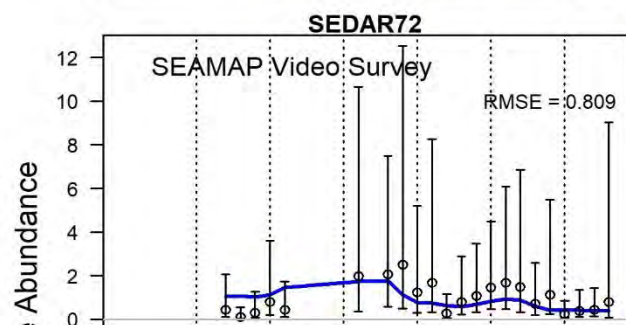
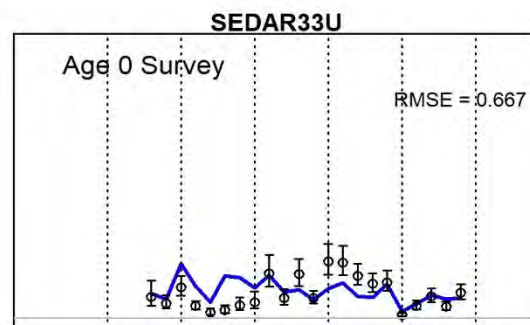
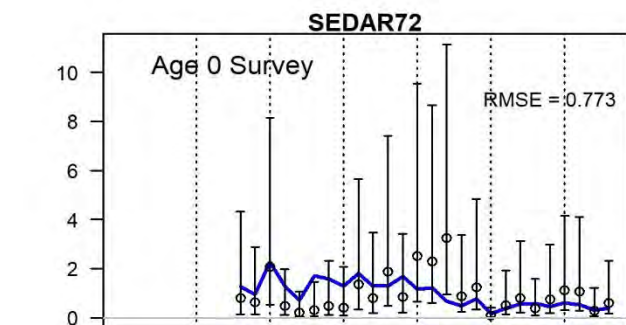
Sensitivity run – CV=0.05 on Recreational Catches



Base Model Fits - Discards



Base Model Fits - Indices



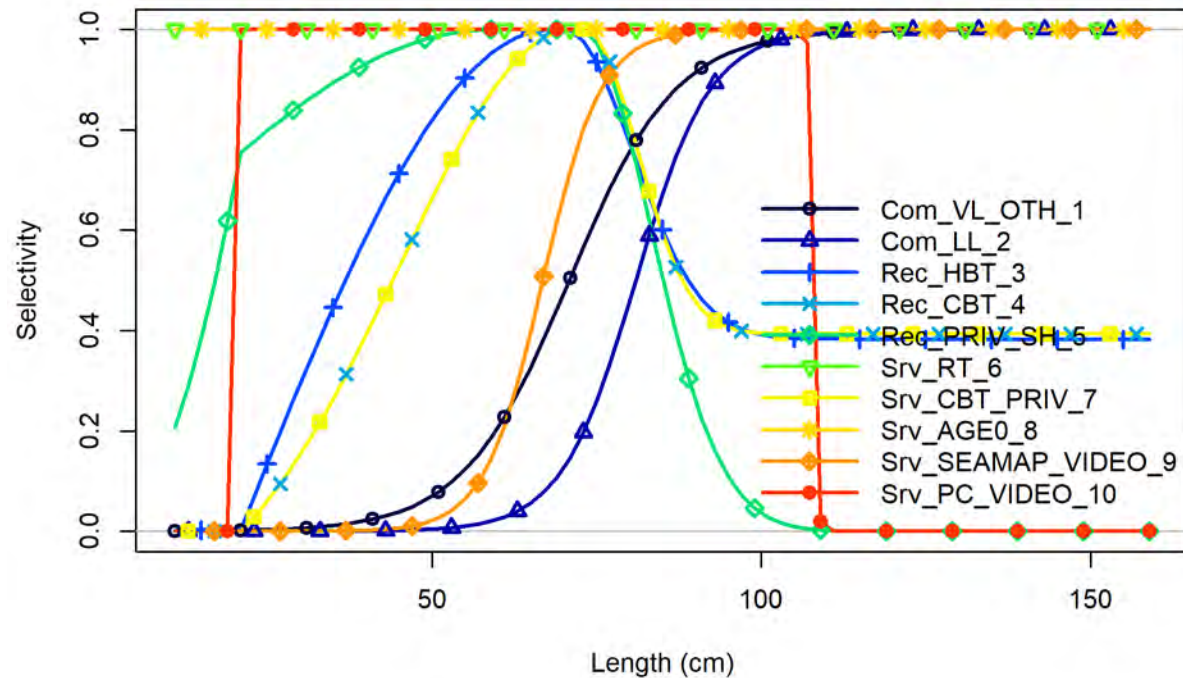
Base Model – Data Weighting

- Francis weighting of indices

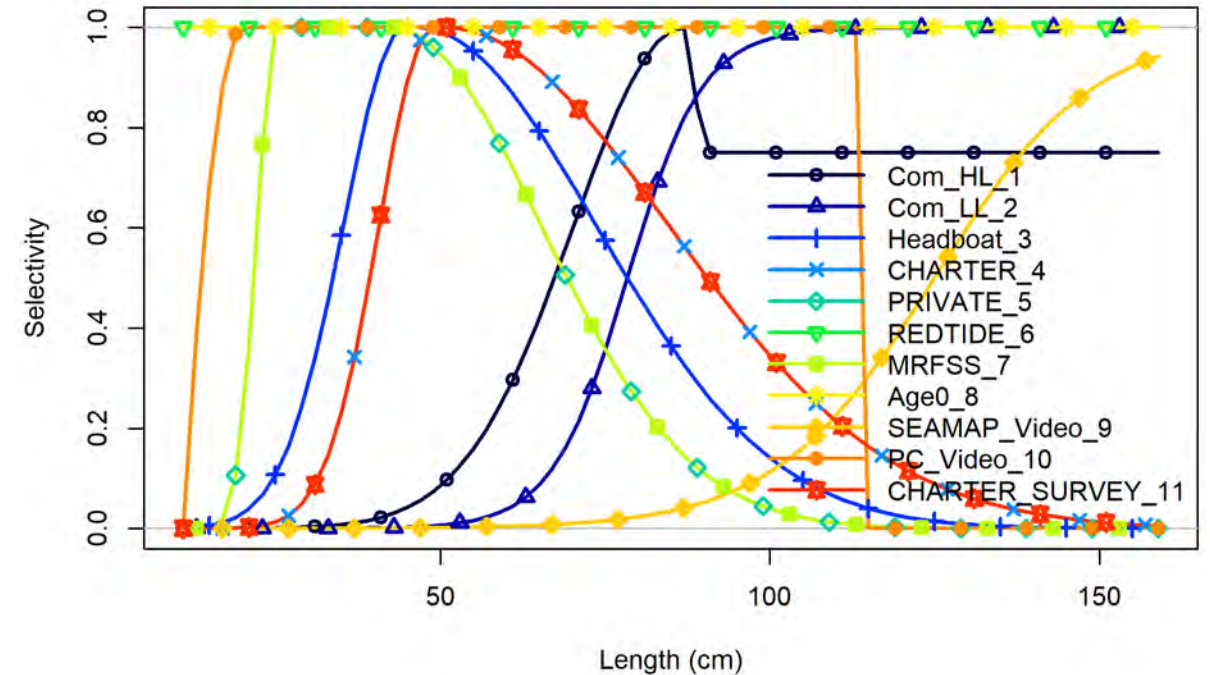
	Input SE	Extra SE	New mean SE
COM HL	0.21	0.42	0.63
COM LL	0.29	0.29	0.59
REC HBT	0.18	0.07	0.25
REC CBT PRIV	0.18	0.06	0.24
AGE 0	0.19	0.91	1.10
SEAMAP	0.34	0.52	0.86
PC VIDEO	0.26	0.10	0.36

Base Model – Selectivity

SEDAR 72



SEDAR 33 Update

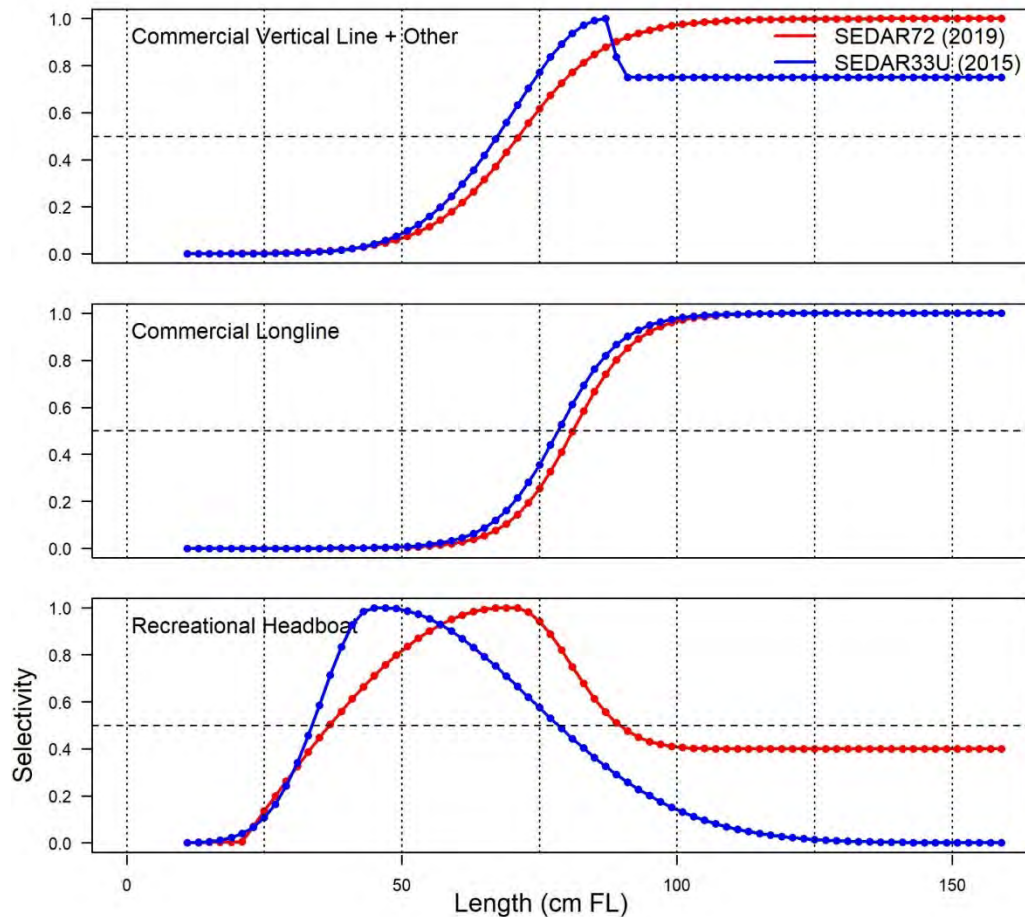


TOR

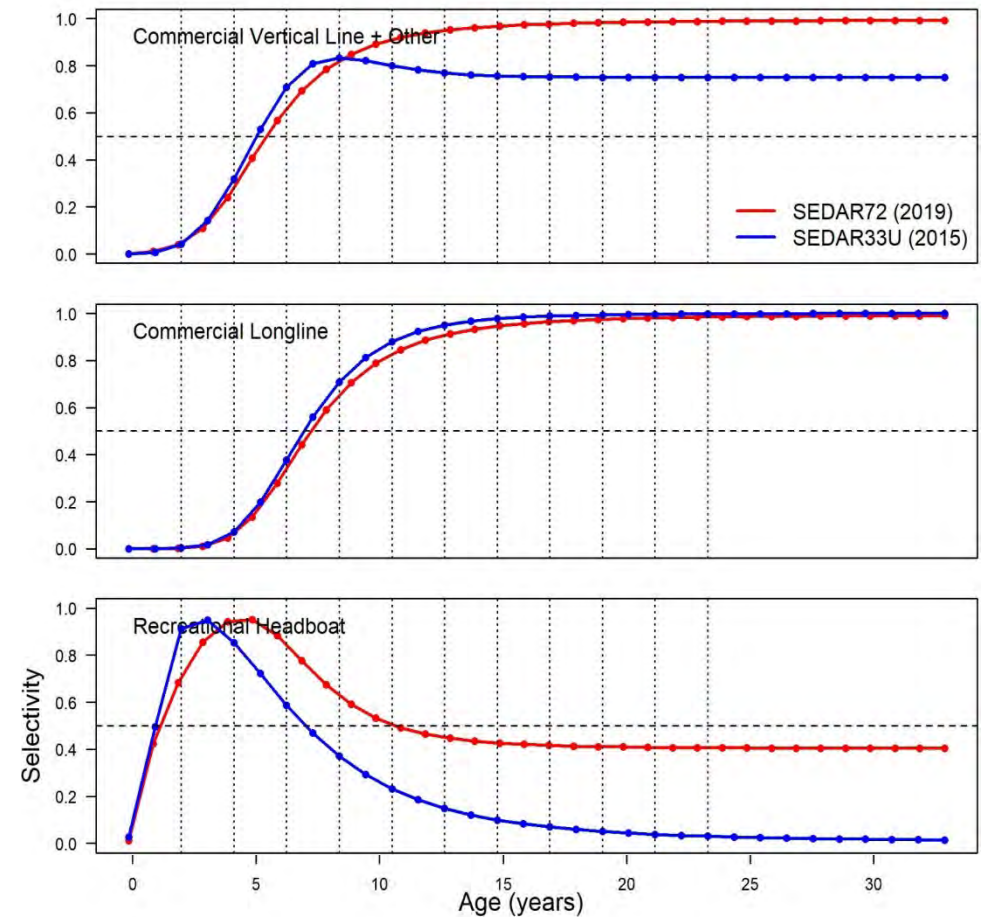
Reconsider the way the retention and selectivity parameters were specified for recreational fleets based on past work with gag grouper.

Base Model – Selectivity of Fleets

Selectivity-at-length

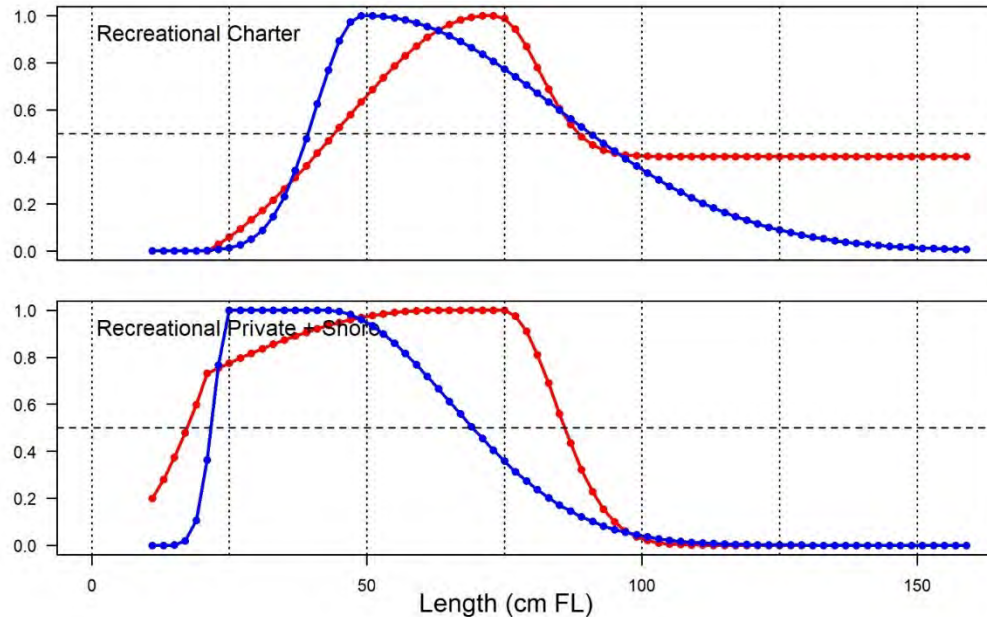


Selectivity-at-age (derived)

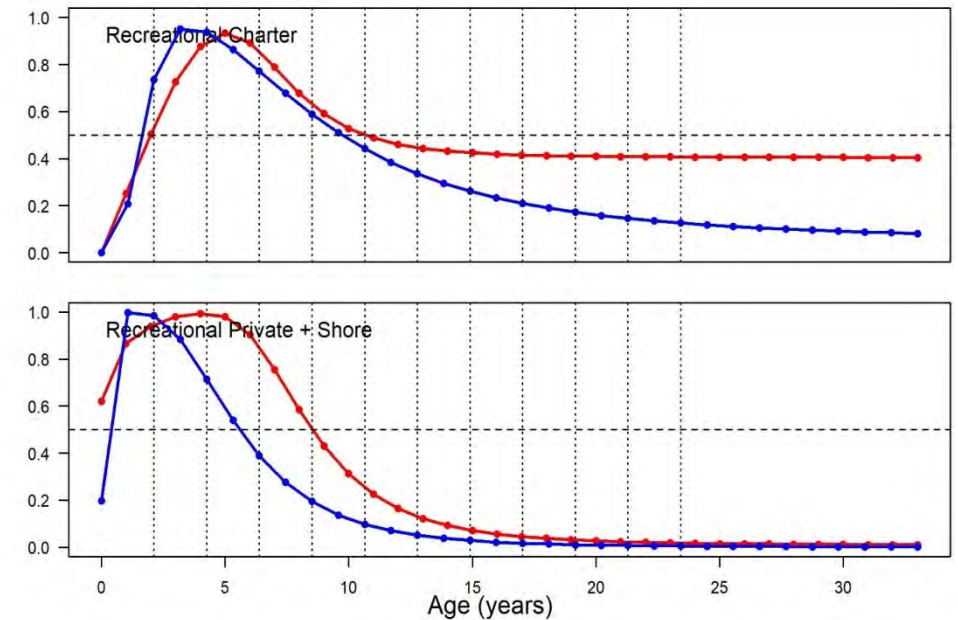


Base Model – Selectivity of Fleets

Selectivity-at-length



Selectivity-at-age (derived)

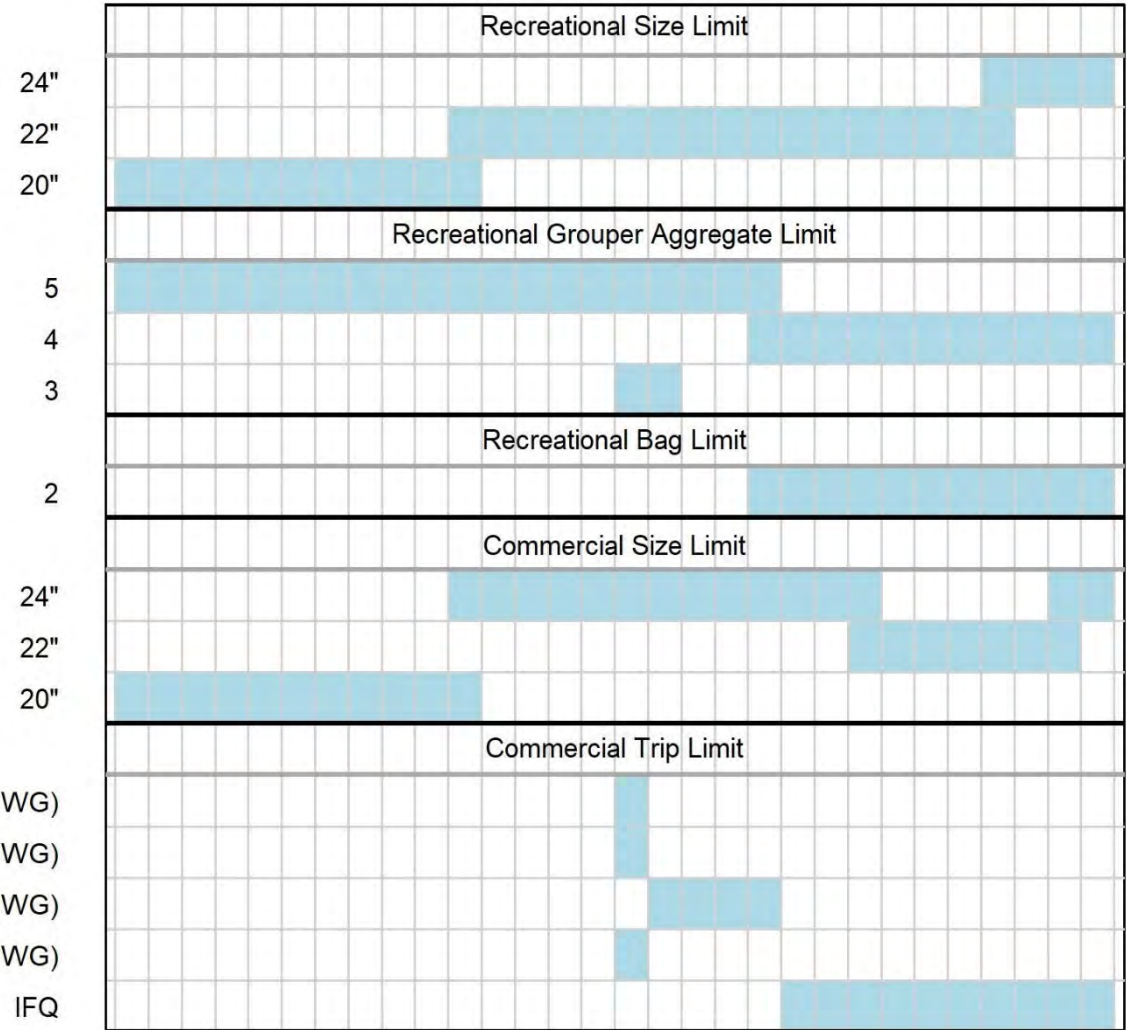


1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

Base Model – Fleet Retention

- Time blocks based on changes in the **minimum size limits**, the implementation of the **IFQ** program in 2010 and post-2011 **restrictions on the recreational fishing season** (2011-12 most restrictive, 2013-15 mildly restrictive, 2016-19 least restrictive).

10,000 lbs gw (D&SWG)
 7,500 lbs gw (D&SWG)
 6,000 lbs gw (D&SWG)
 5,500 lbs gw (SWG)
 IFQ

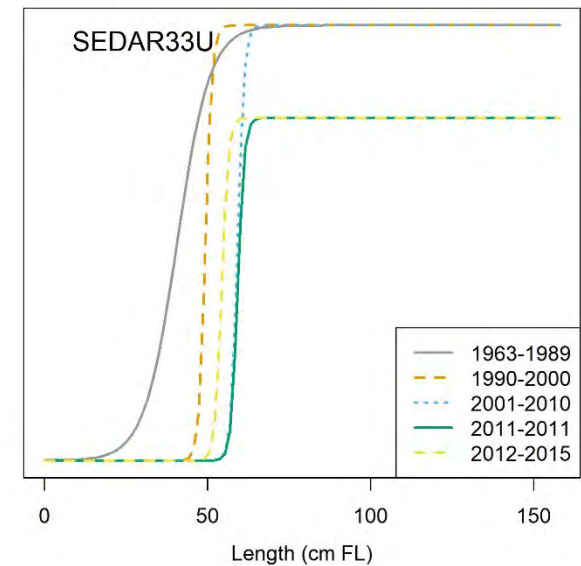
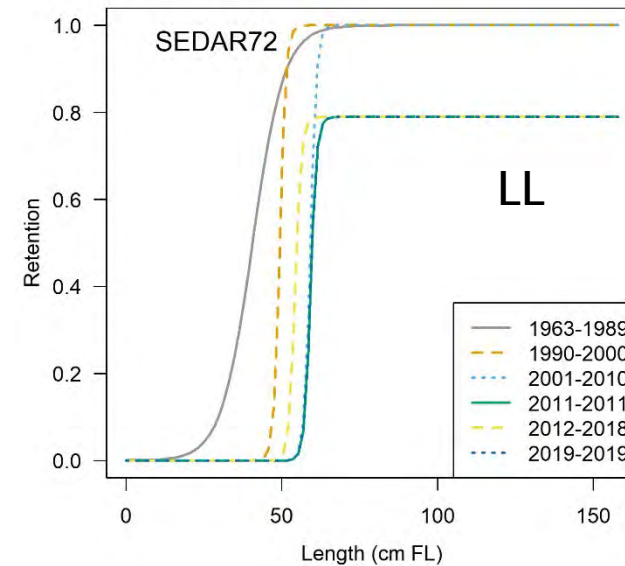
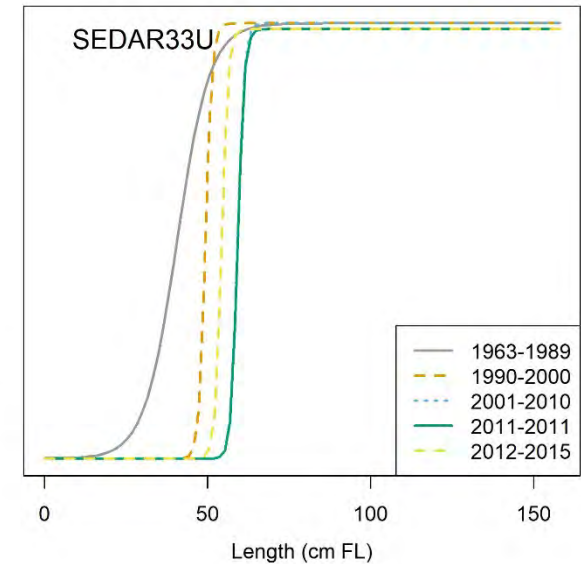
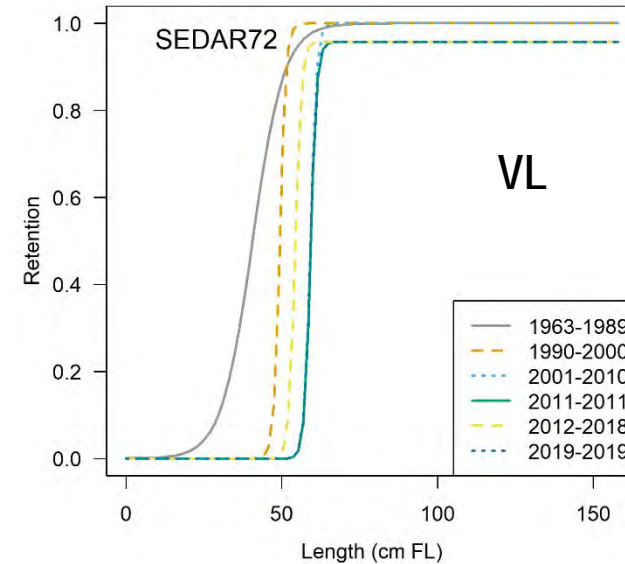


TOR

Reconsider the way the retention and selectivity parameters were specified for recreational fleets based on past work with gag grouper.

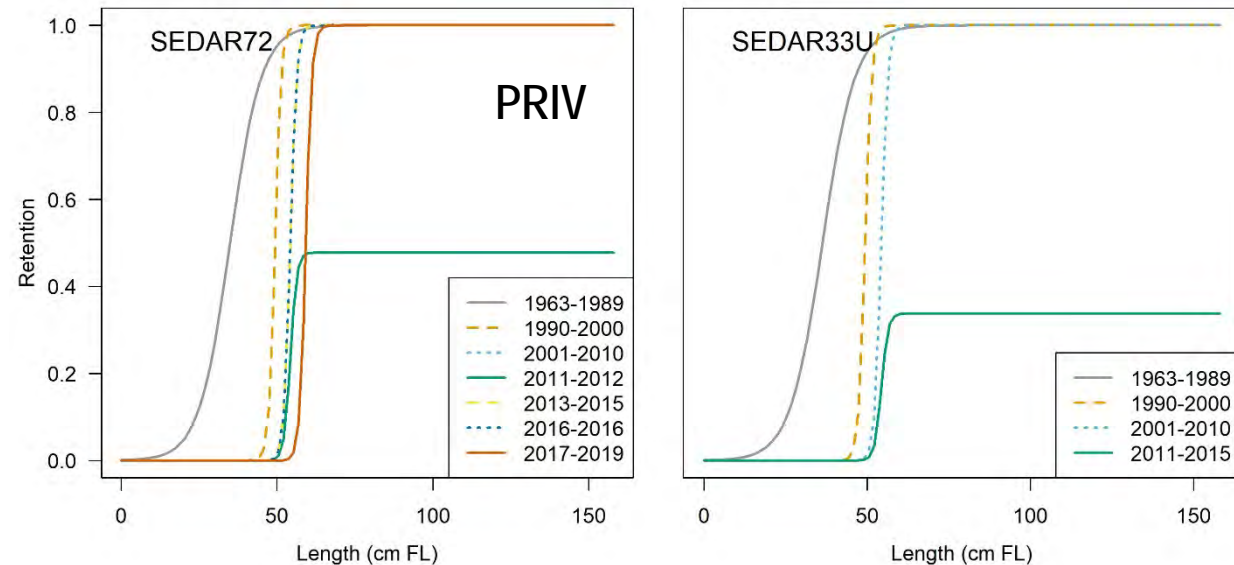
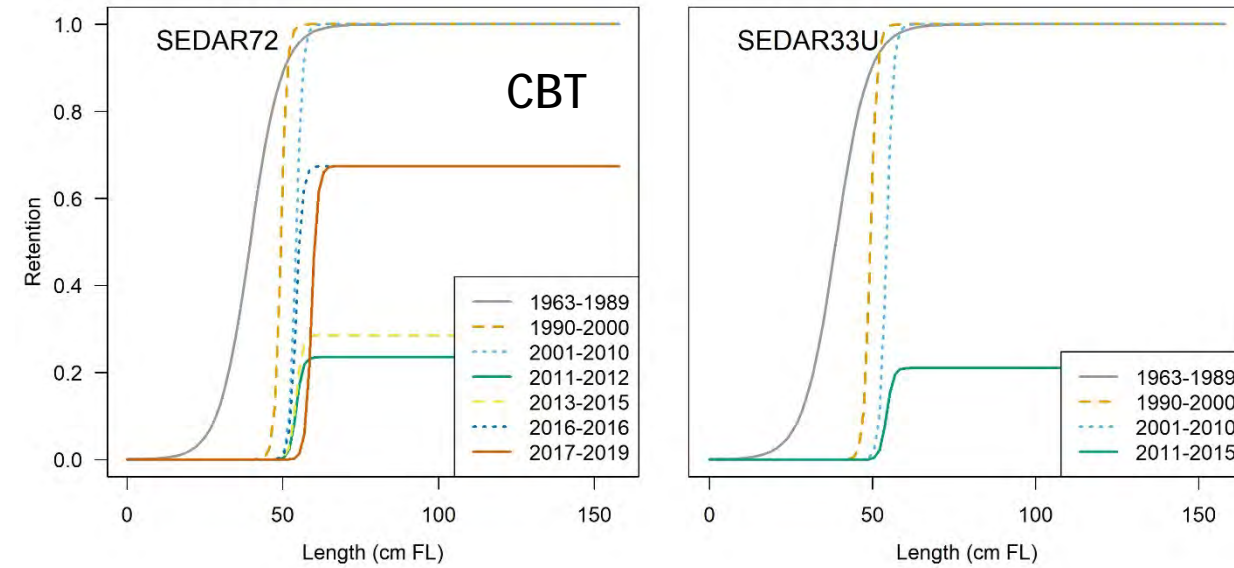
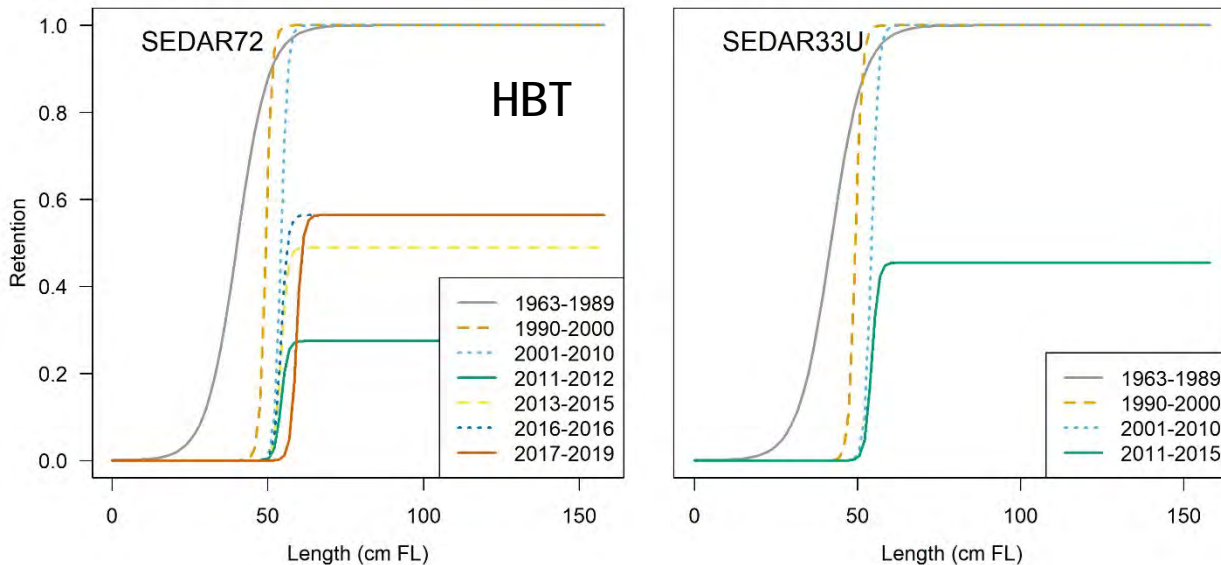
Base Model – Fleet Retention

- Commercial Fleets
 - Slope and inflection fixed pre-minimum size limit (effective msl)
 - Asymptote freely estimated post IFQ
 - Slope (knife-edge) and inflection fixed based on size limit



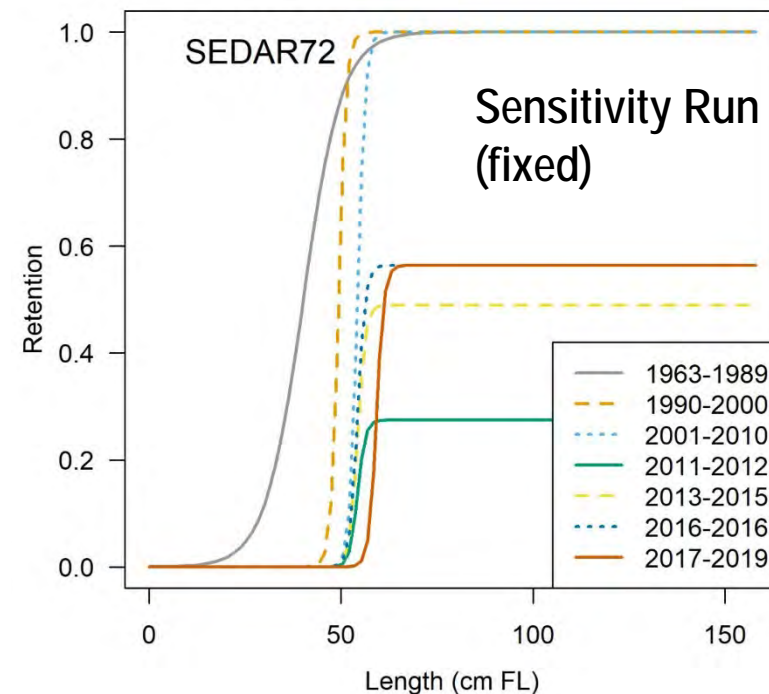
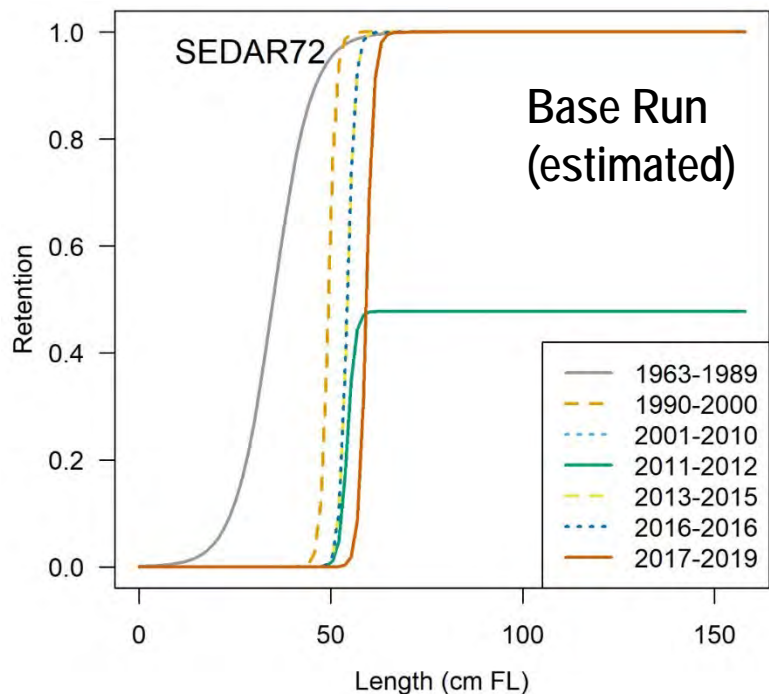
Base Model – Fleet Retention

- Recreational Fleets
 - Slope fixed and inflection estimated pre-minimum size limit
 - 3 asymptotes freely estimated
 - Slope (knife-edge) and inflection fixed based on size limit



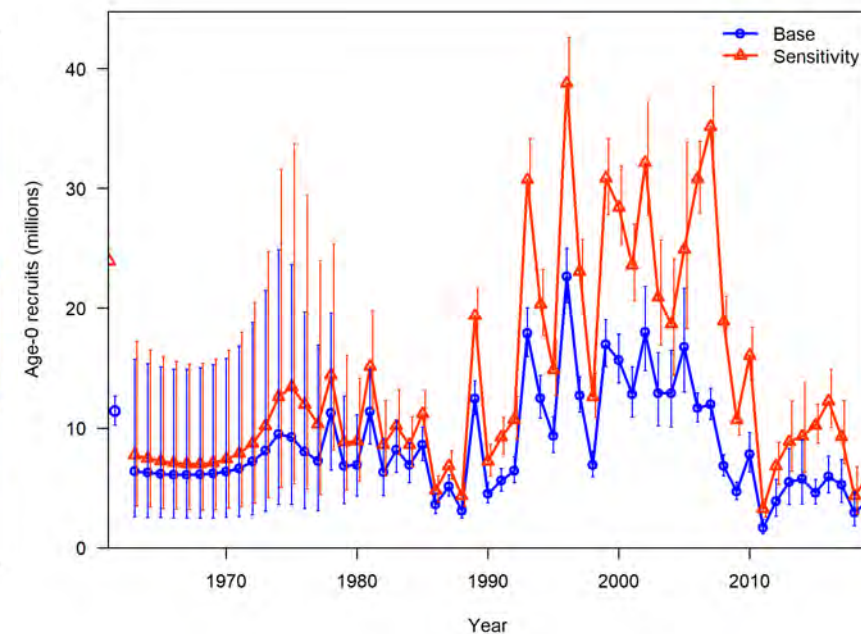
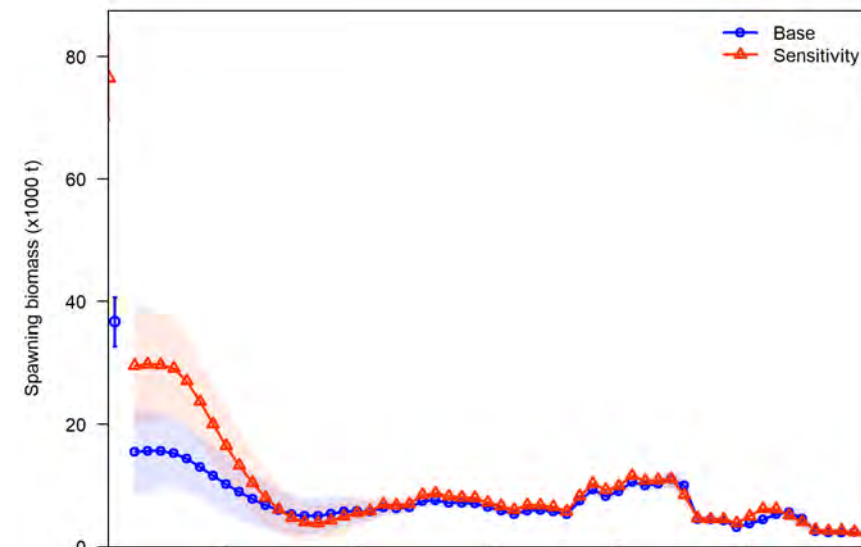
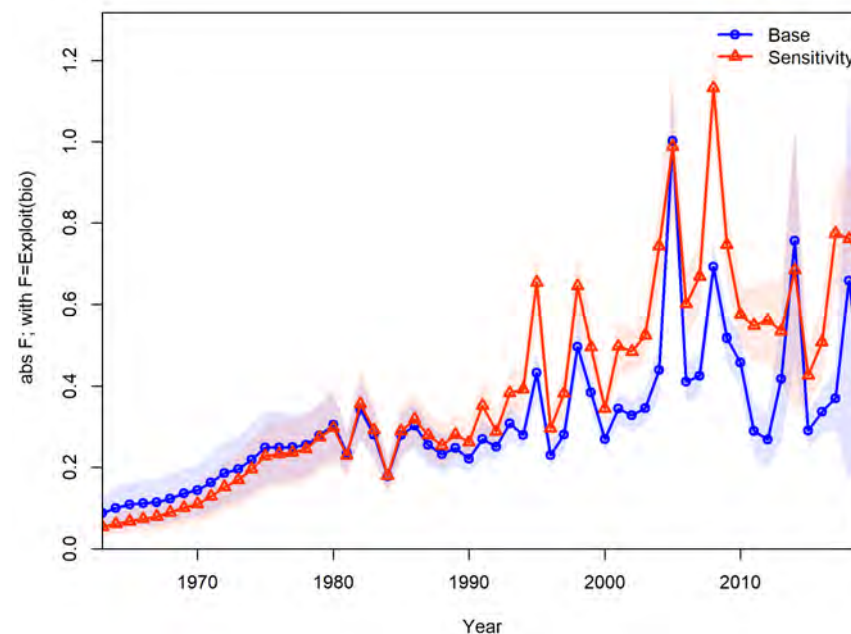
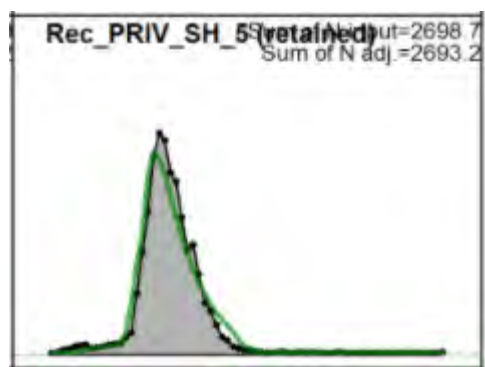
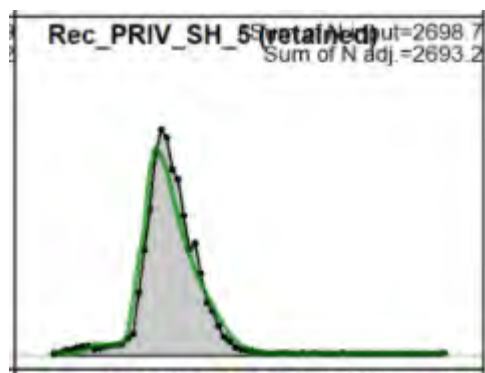
Sensitivity Run – Private Fleet Retention

- No length compositions of discards for Private mode
- Retention asymptote of the Recreational Private + Shore fleet was mirrored after the Recreational Headboat fleet.



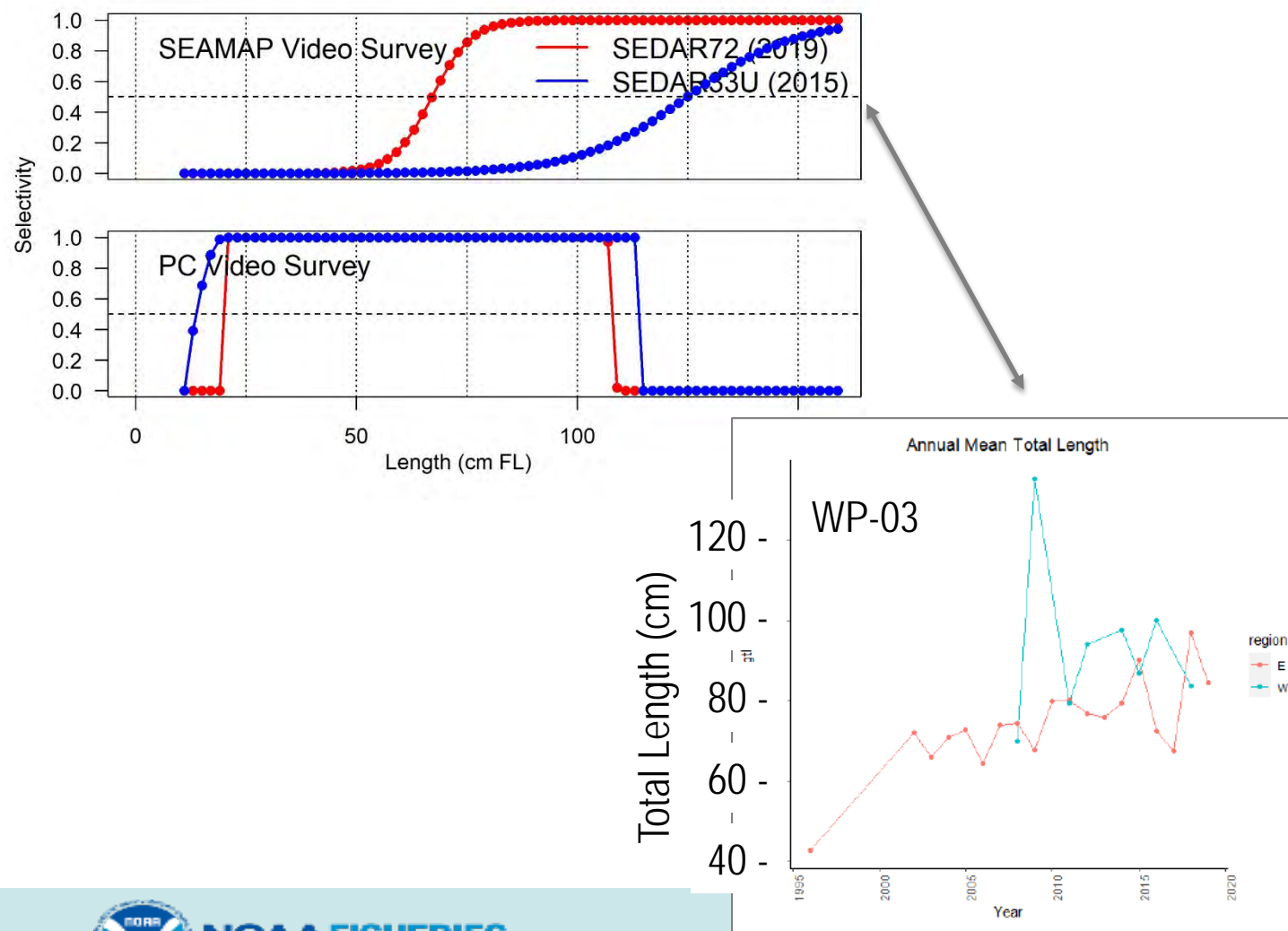
Sensitivity Run – Private Fleet Retention

- Degraded overall fit

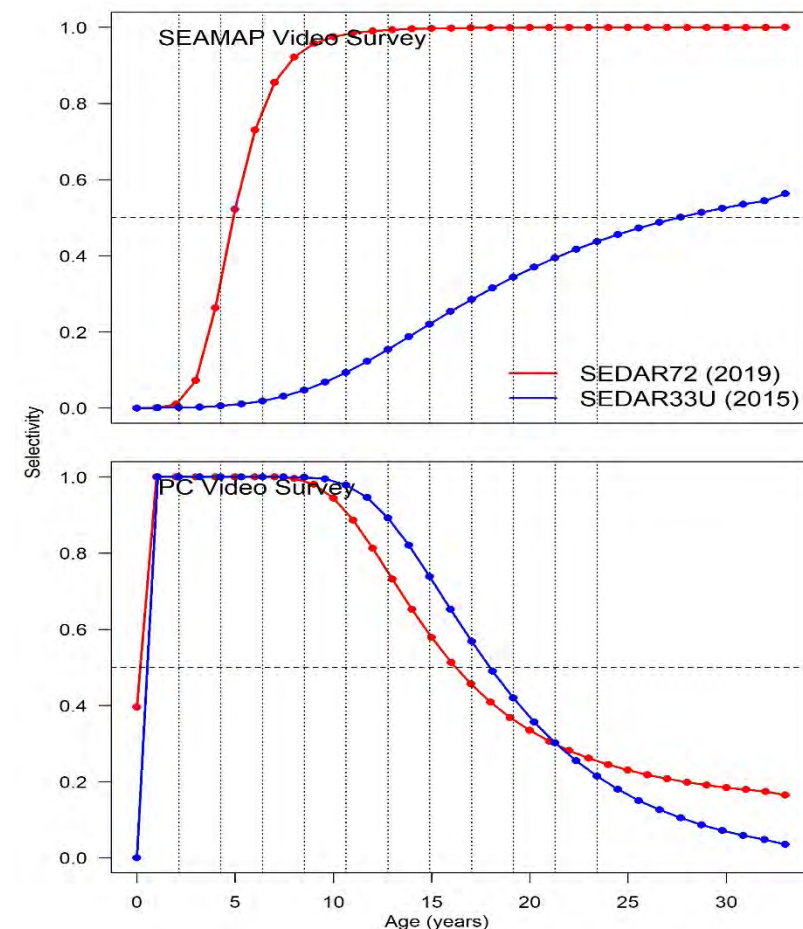


Base Model – Selectivity of Surveys

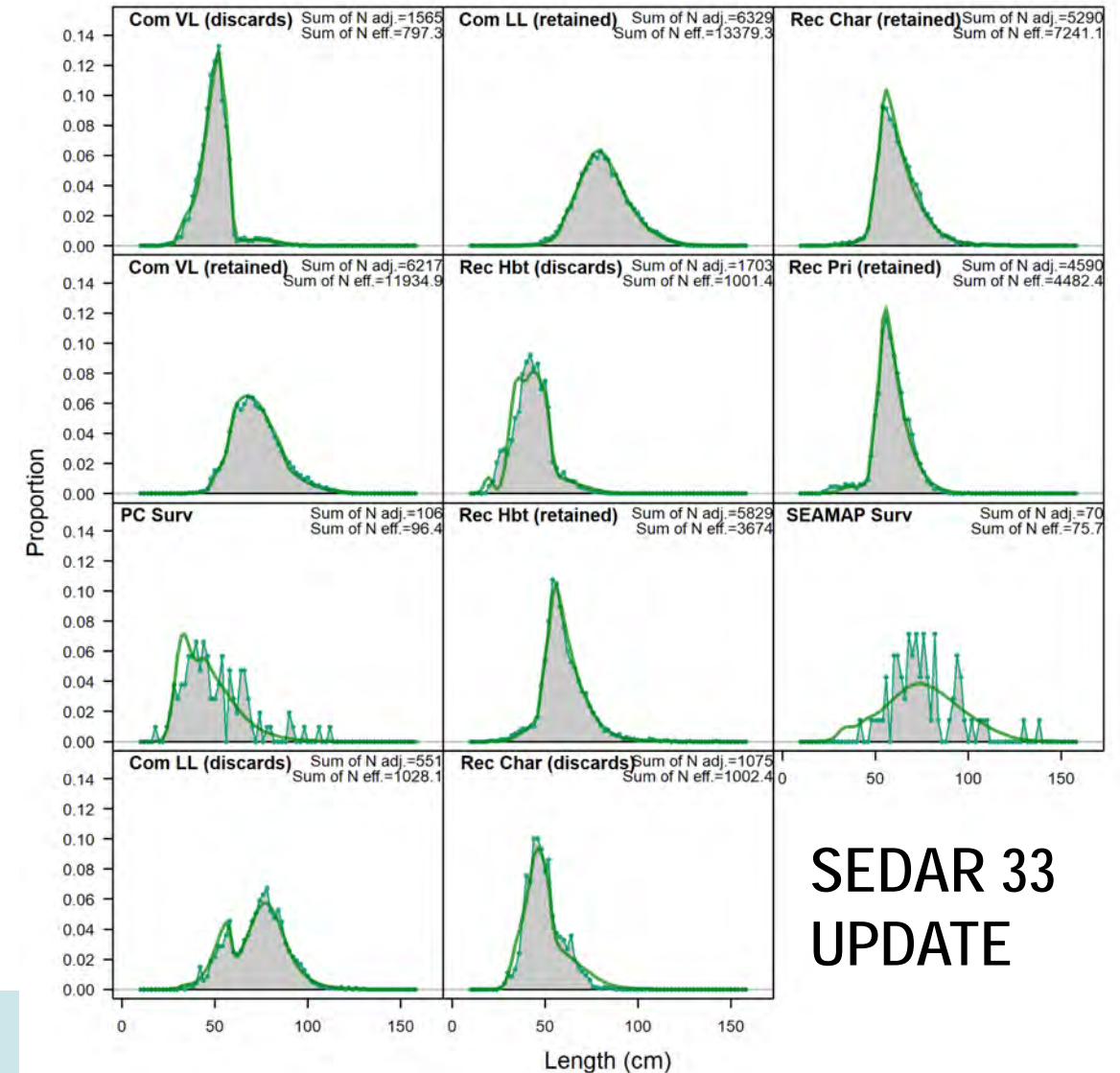
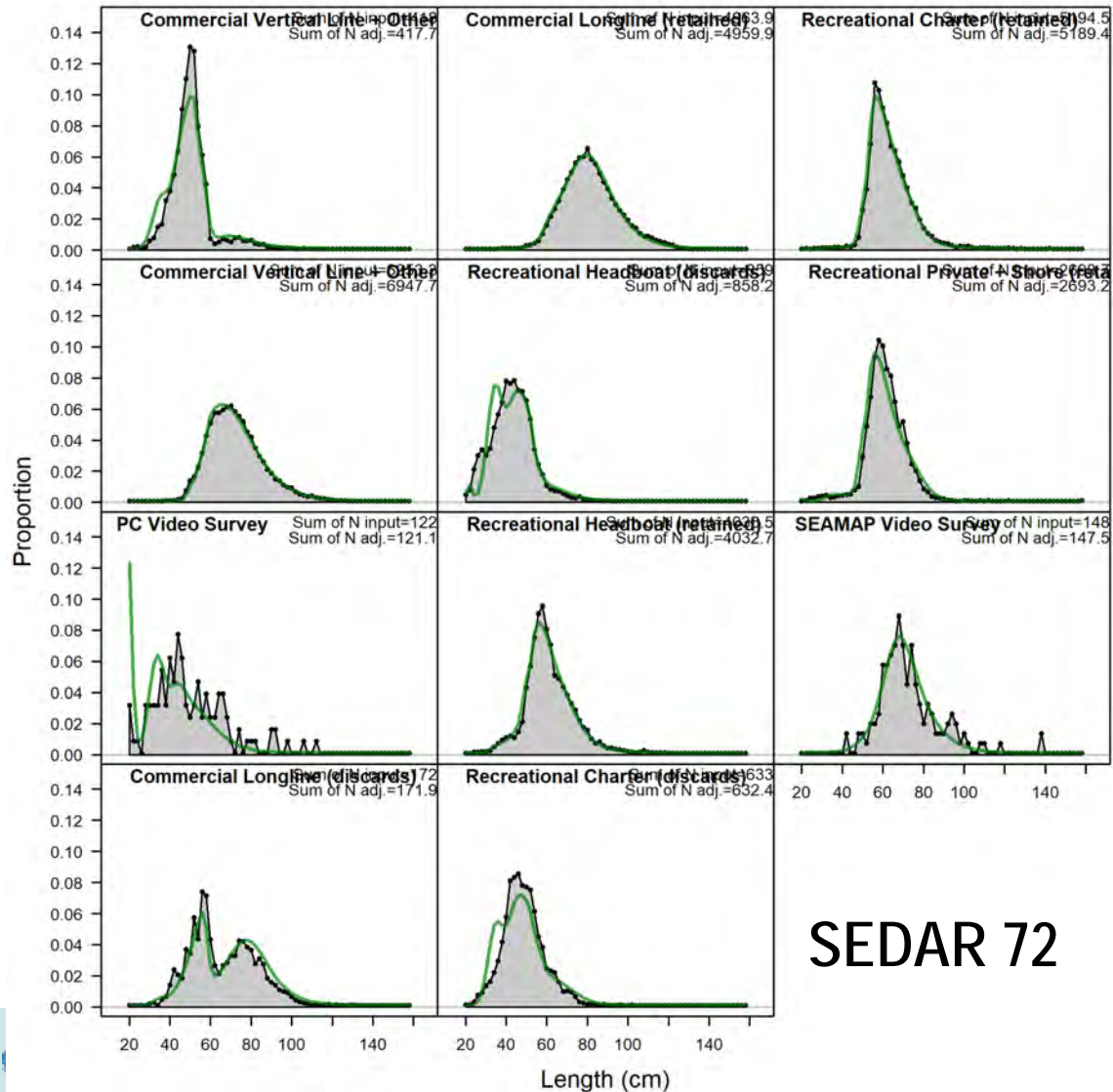
Selectivity-at-length



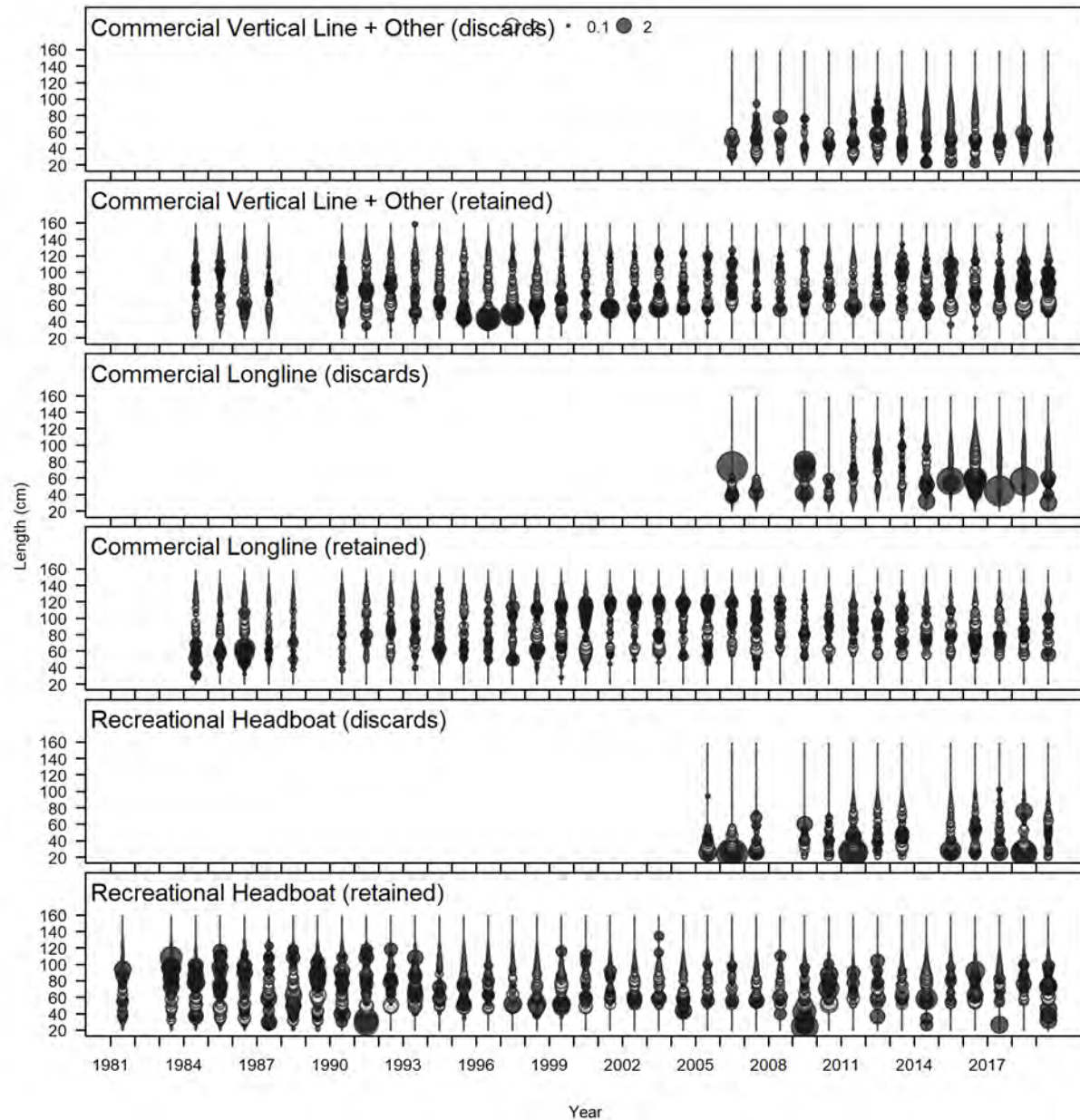
Selectivity-at-age (derived)



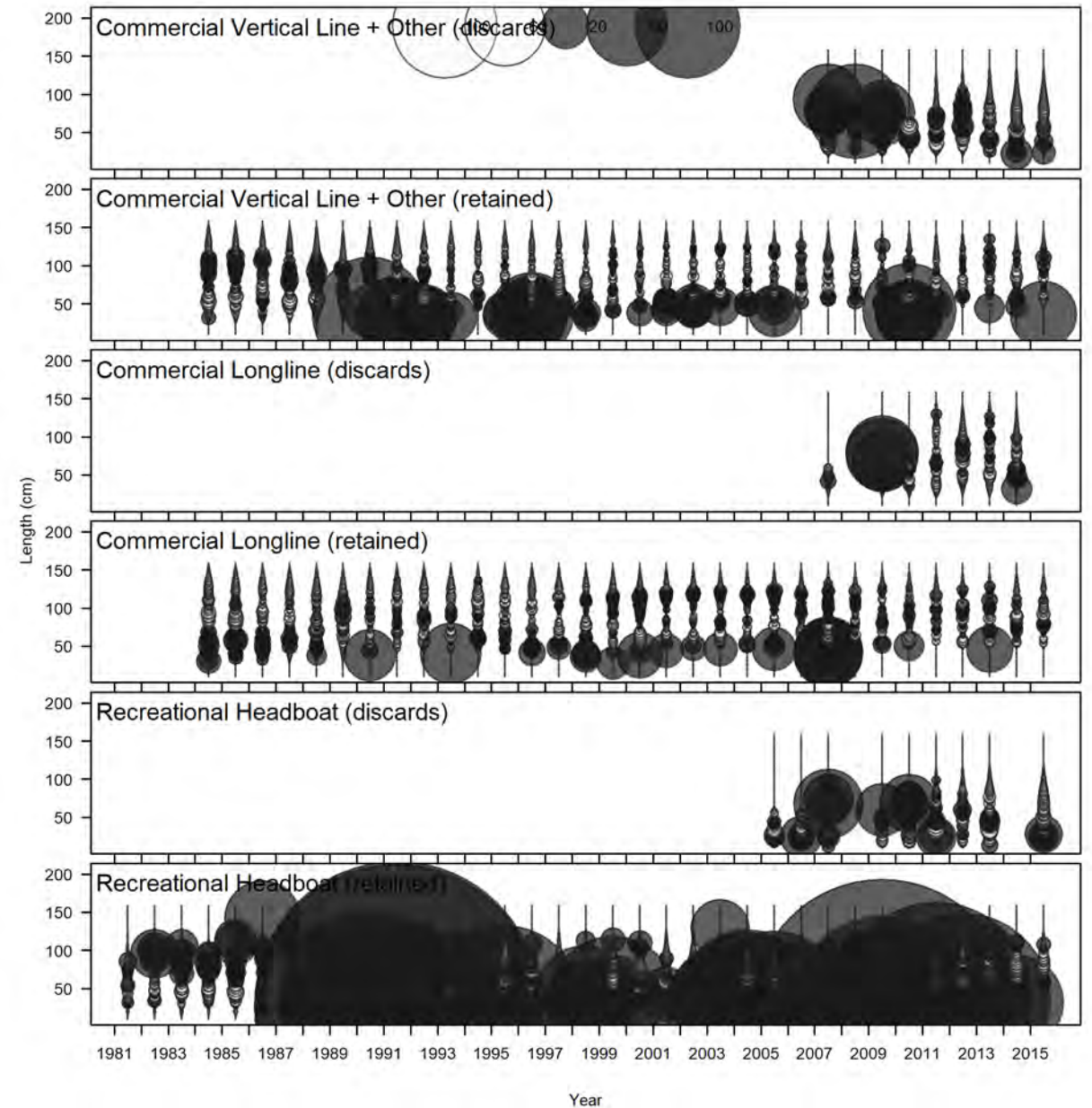
Base Model – Length Composition Fits



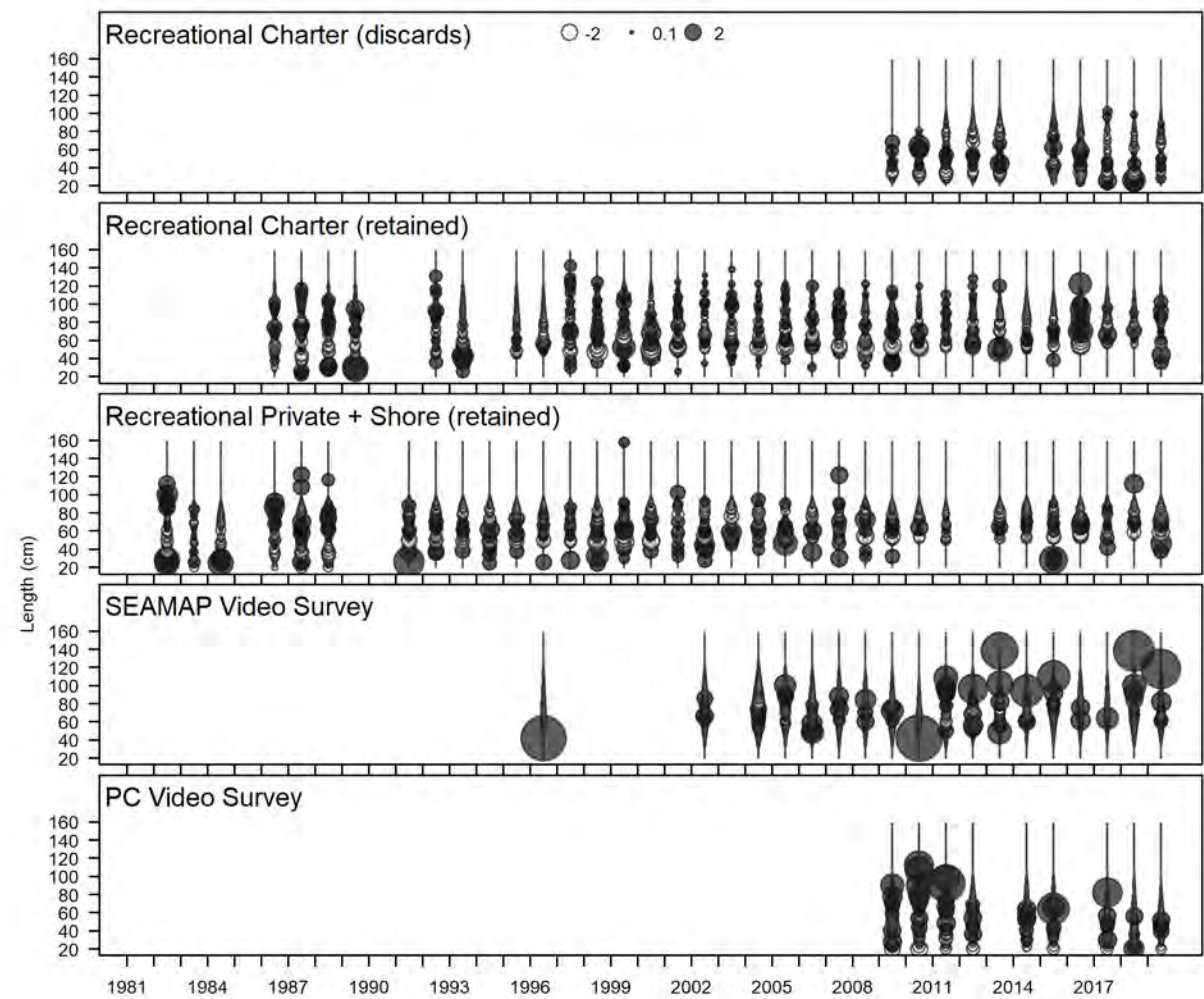
SEDAR 72



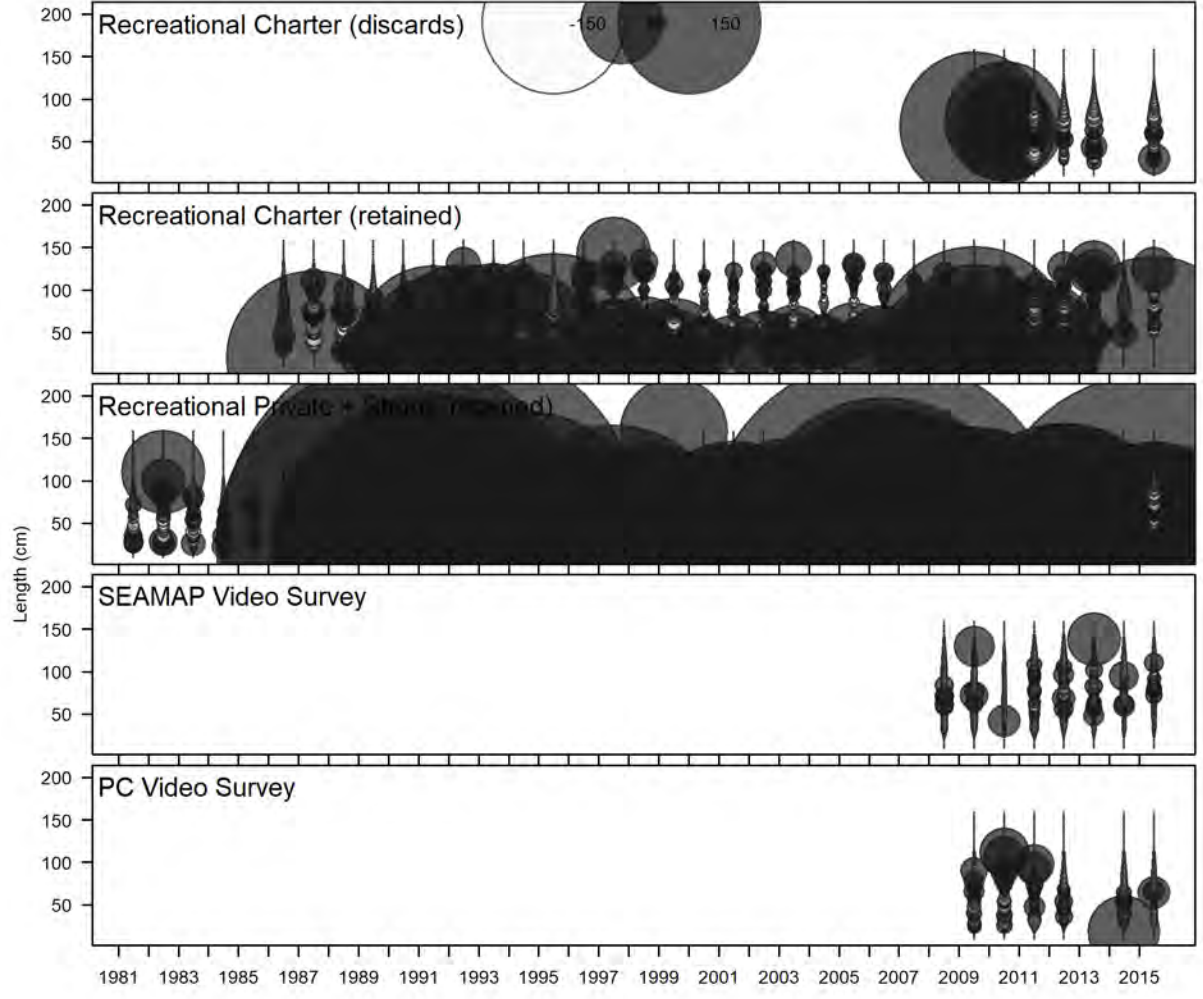
SEDAR33 Update



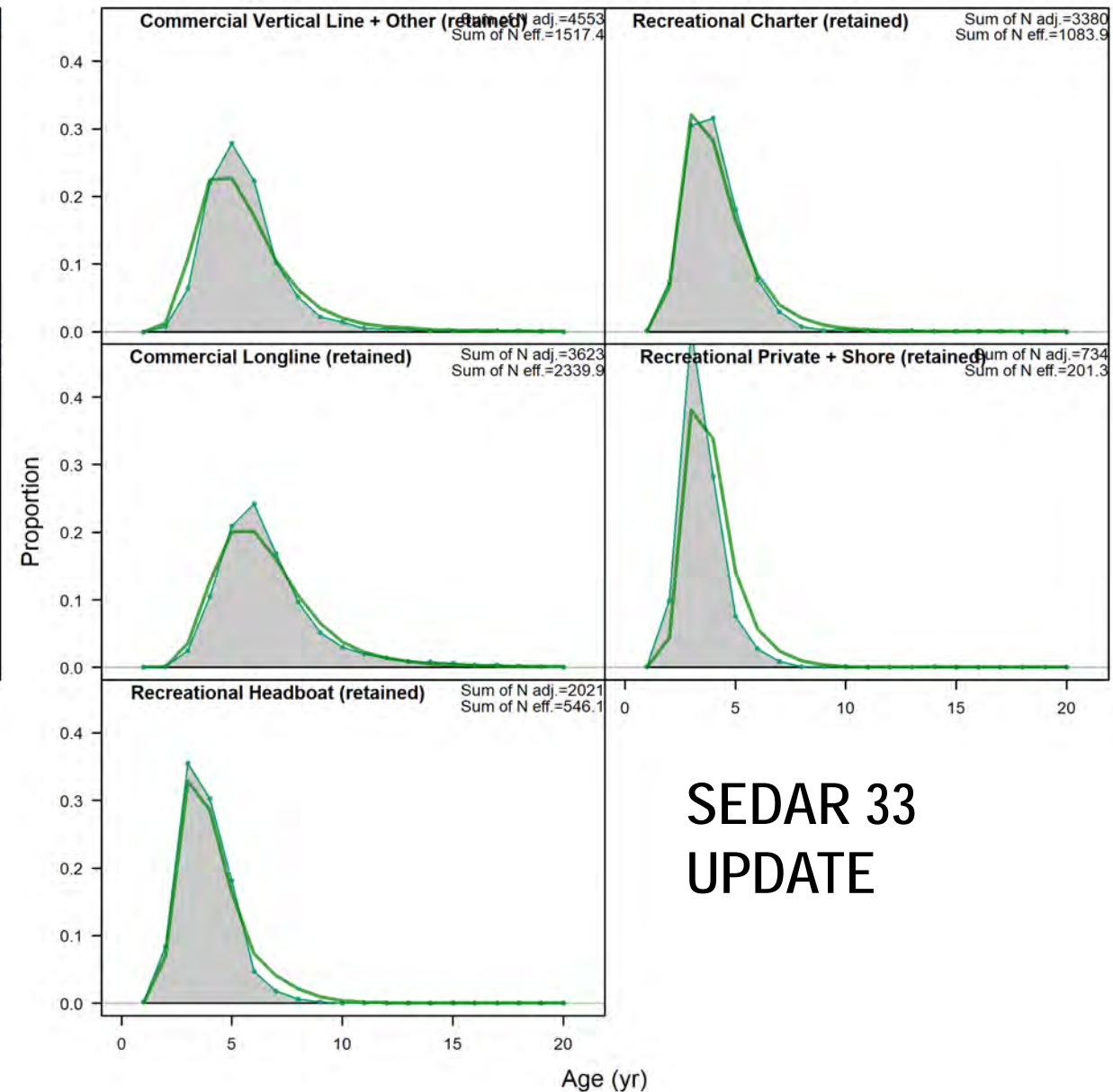
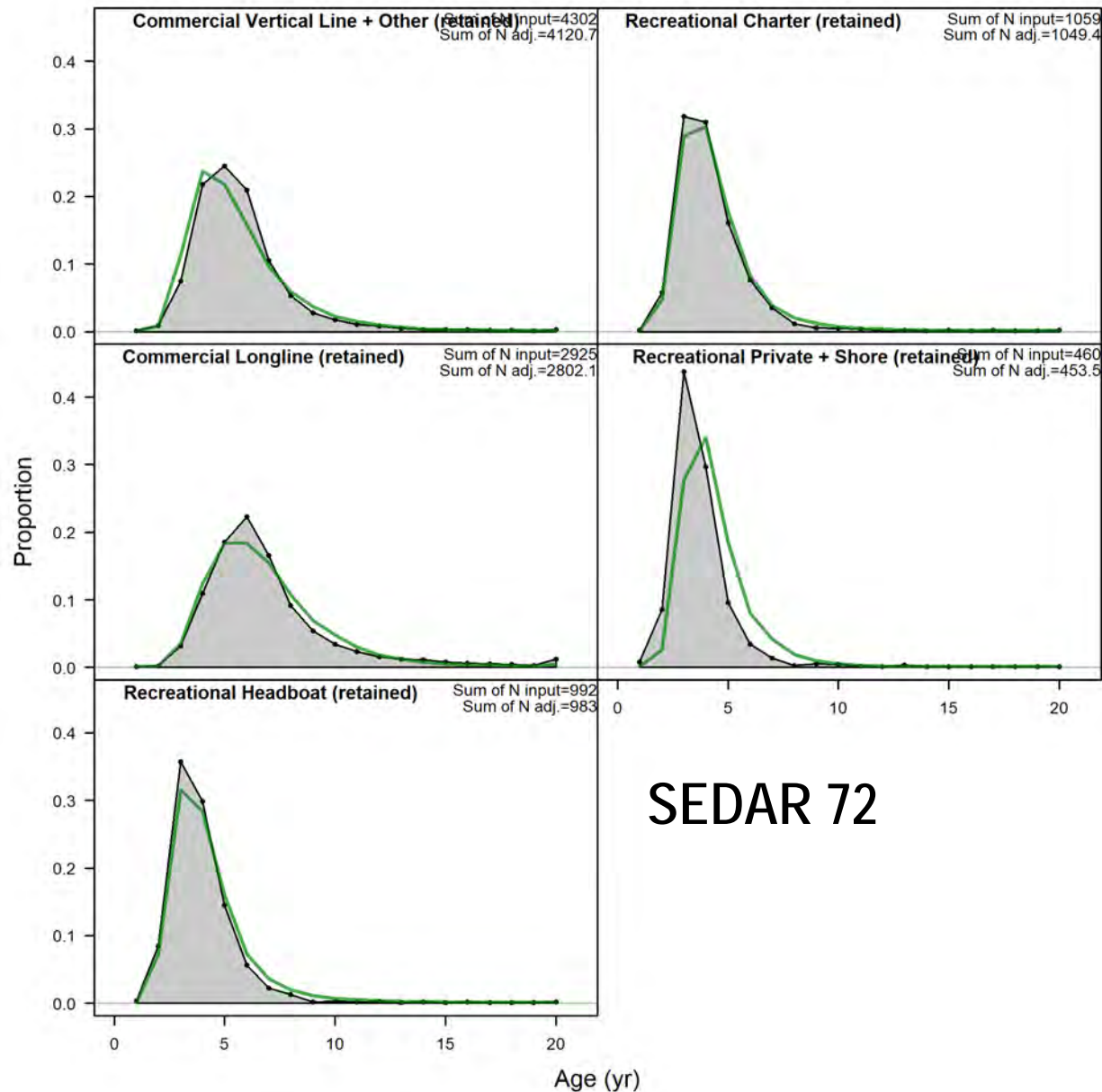
SEDAR 72



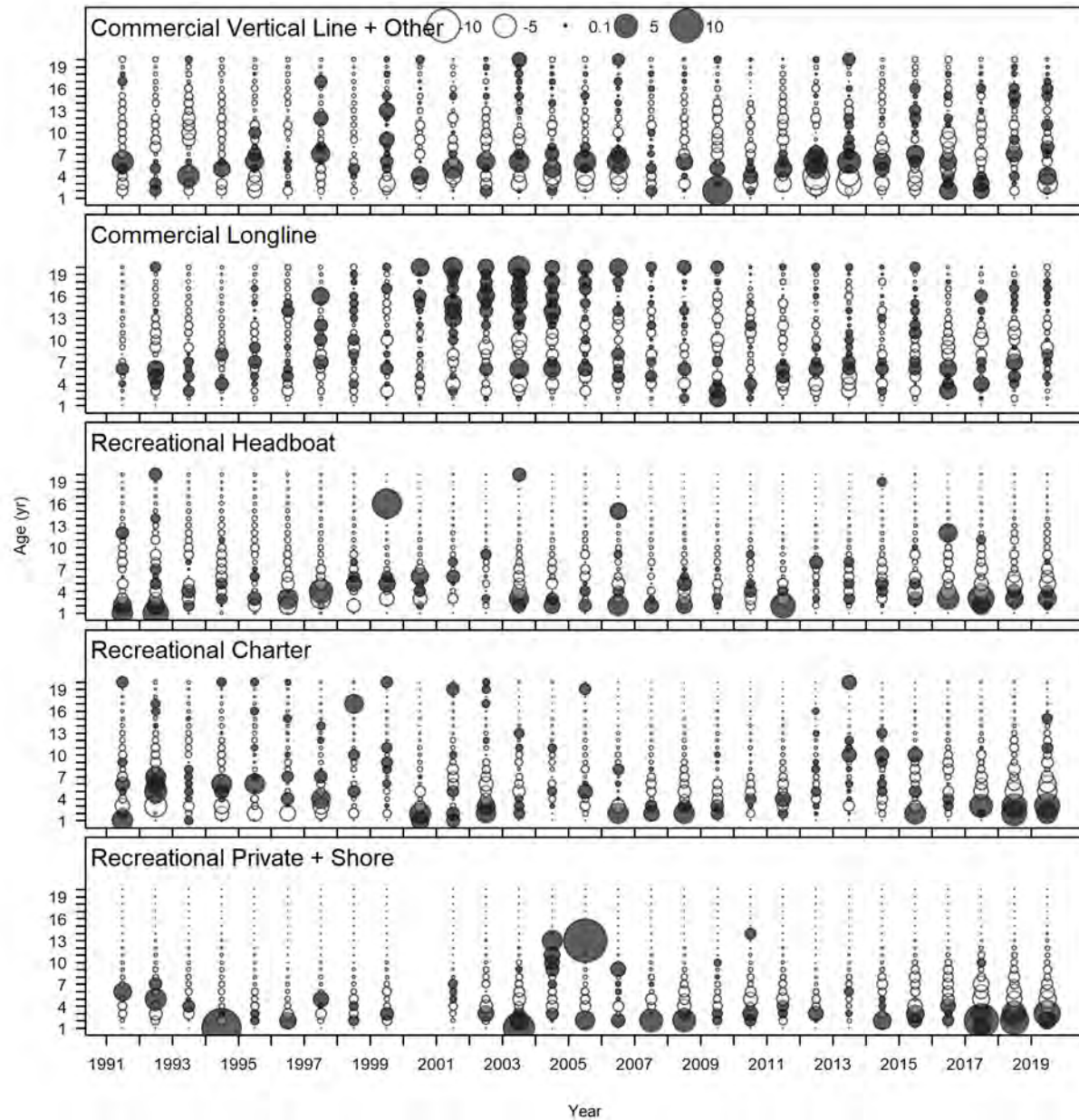
SEDAR33 Update



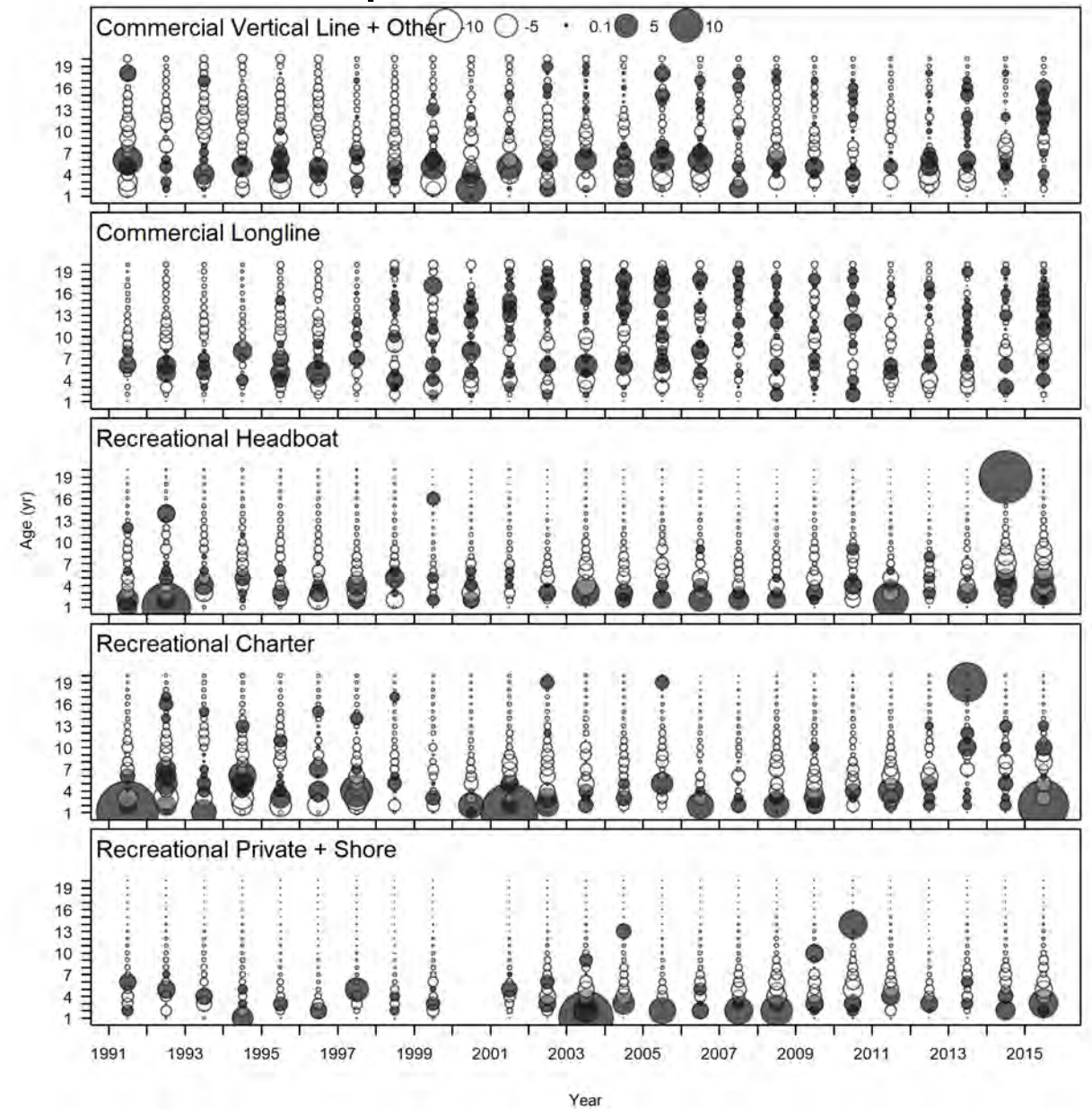
Base Model – Age Composition Fits



SEDAR 72



SEDAR33 Update



Base Model – Data Weighting

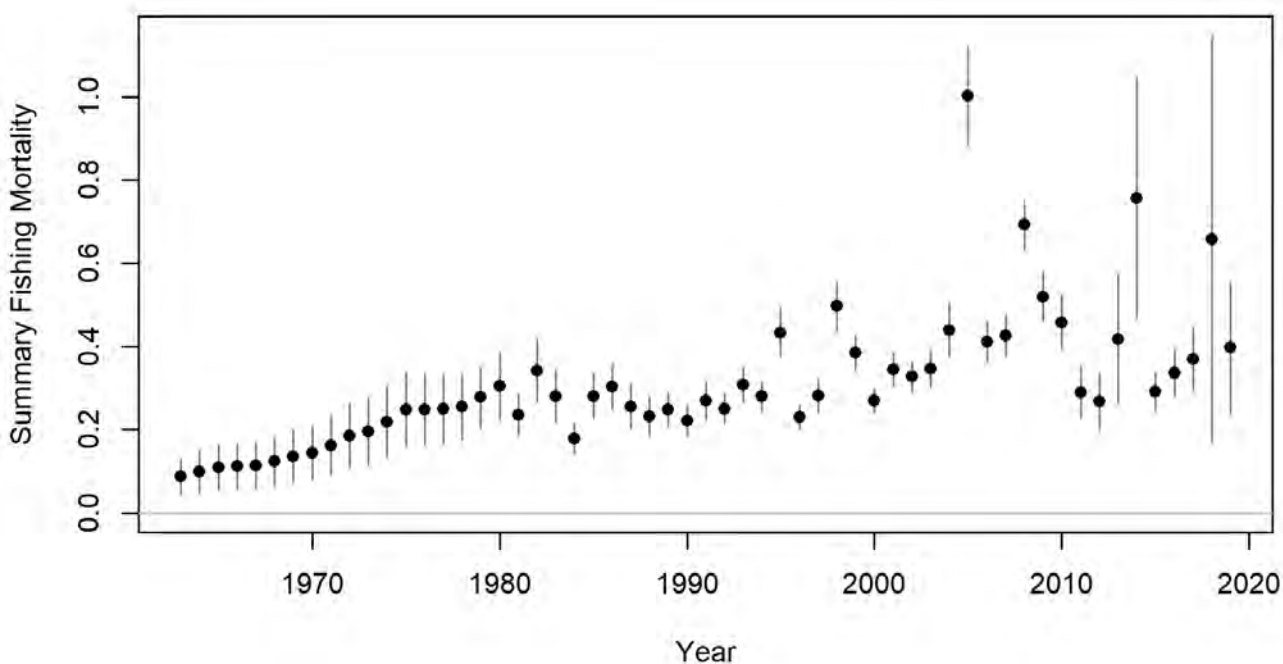
- Dirichlet weighting of compositions

	Fleet/Survey	Parameter	$\ln(\text{DM_theta})$	$\text{DM_theta}/(1+\text{DM_theta})$
Length comps	COM HL, LL	$\ln(\text{DM_theta})_1$	7.11	1.00
	REC HBT, CBT	$\ln(\text{DM_theta})_2$	6.94	1.00
	REC PRIV	$\ln(\text{DM_theta})_3$	6.18	1.00
	SEAMAP SURVEY	$\ln(\text{DM_theta})_4$	5.47	1.00
	PC SURVEY	$\ln(\text{DM_theta})_5$	4.82	0.99
Age comps	COM HL, LL	$\ln(\text{DM_theta})_6$	3.12	0.96
	REC HBT, CBT	$\ln(\text{DM_theta})_7$	4.66	0.99
	REC PRIV	$\ln(\text{DM_theta})_8$	4.19	0.99

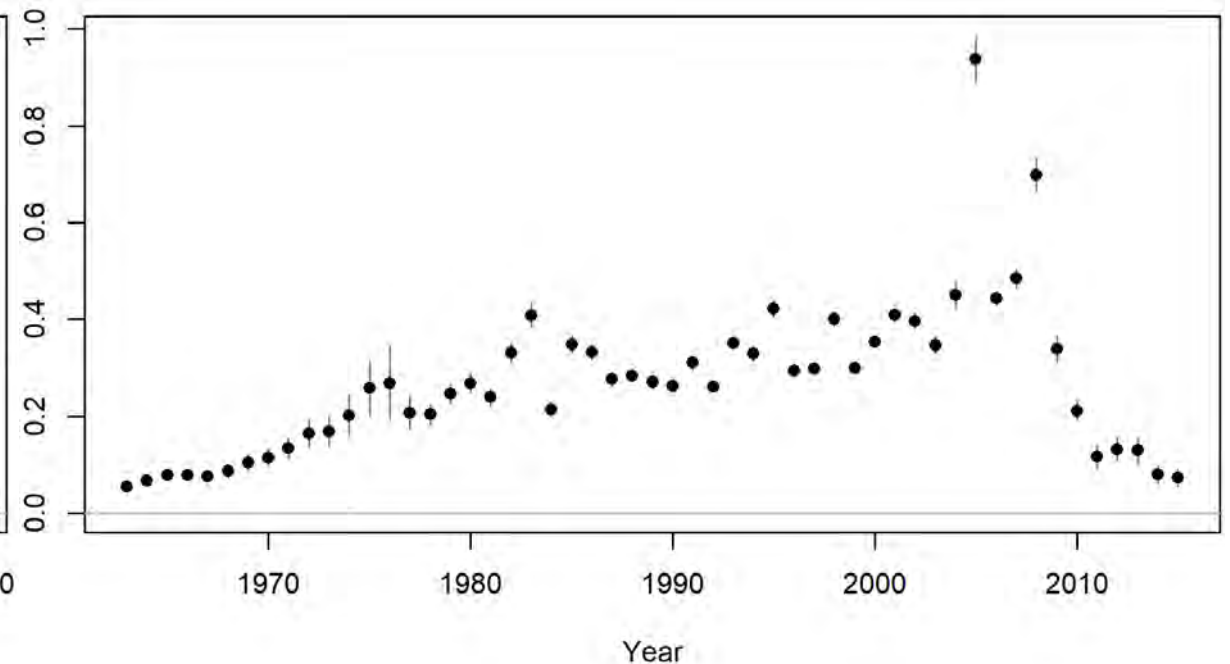
Base Model – Annual Exploitation Rates

- Exploitation rate = total biomass killed age 3+ / total biomass age 3+

SEDAR 72

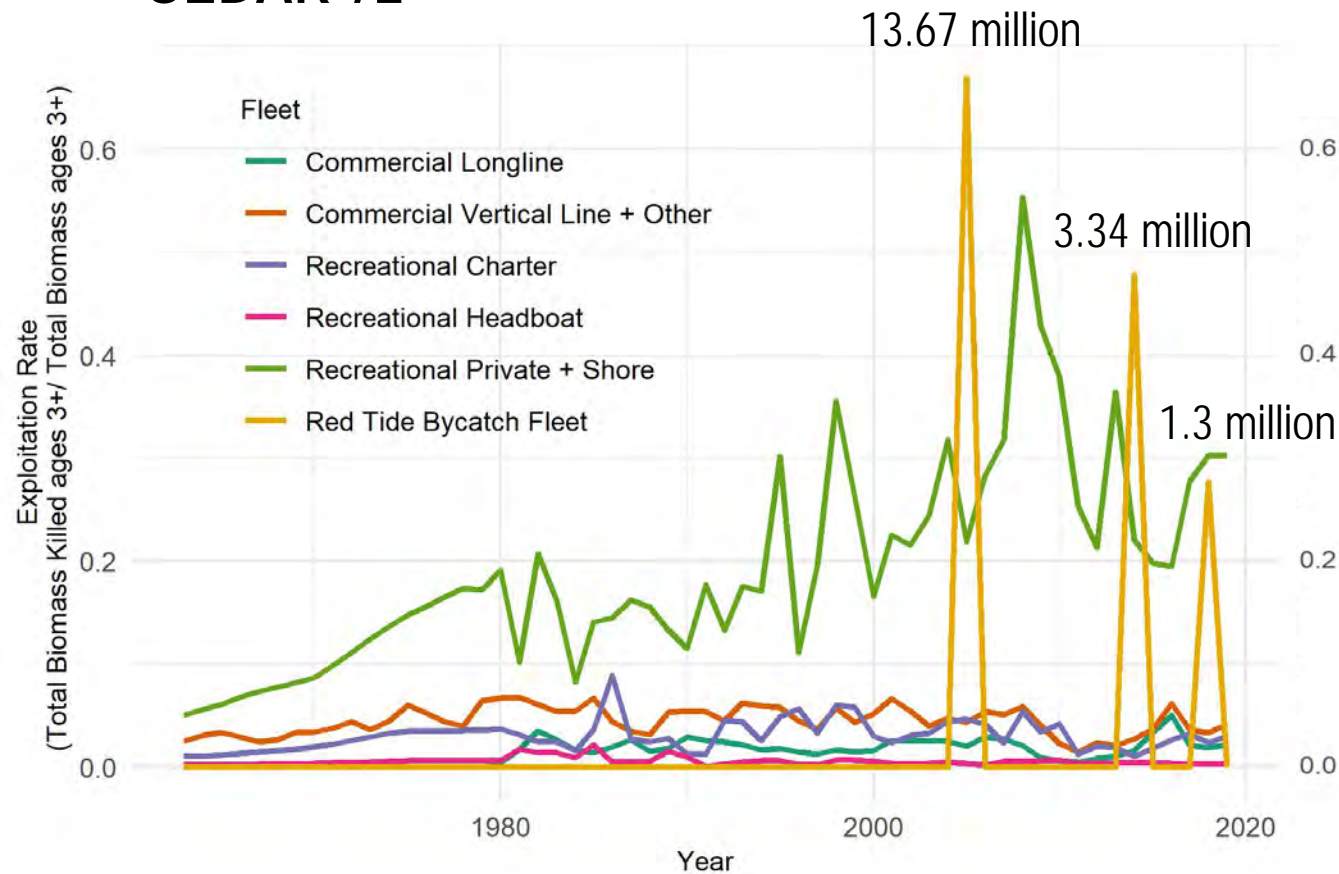


SEDAR33 Update

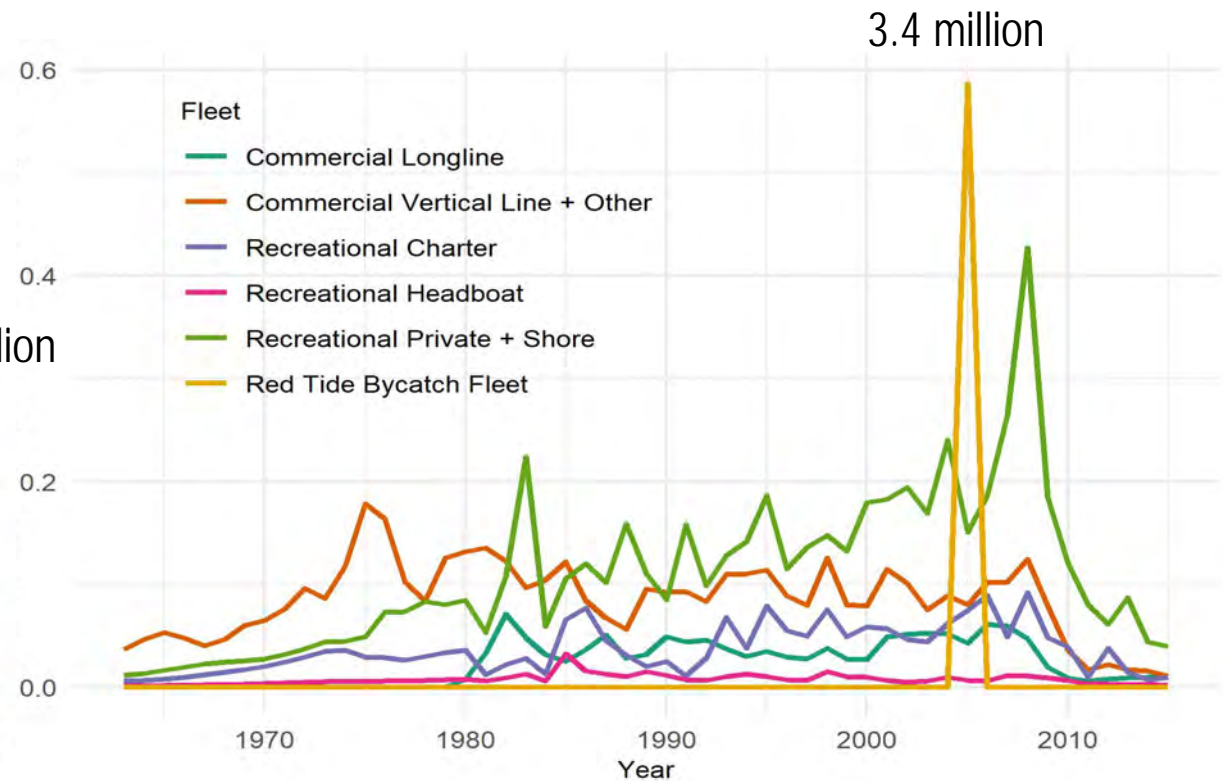


Base Model – Fleet-specific Annual Exploitation Rates

SEDAR 72

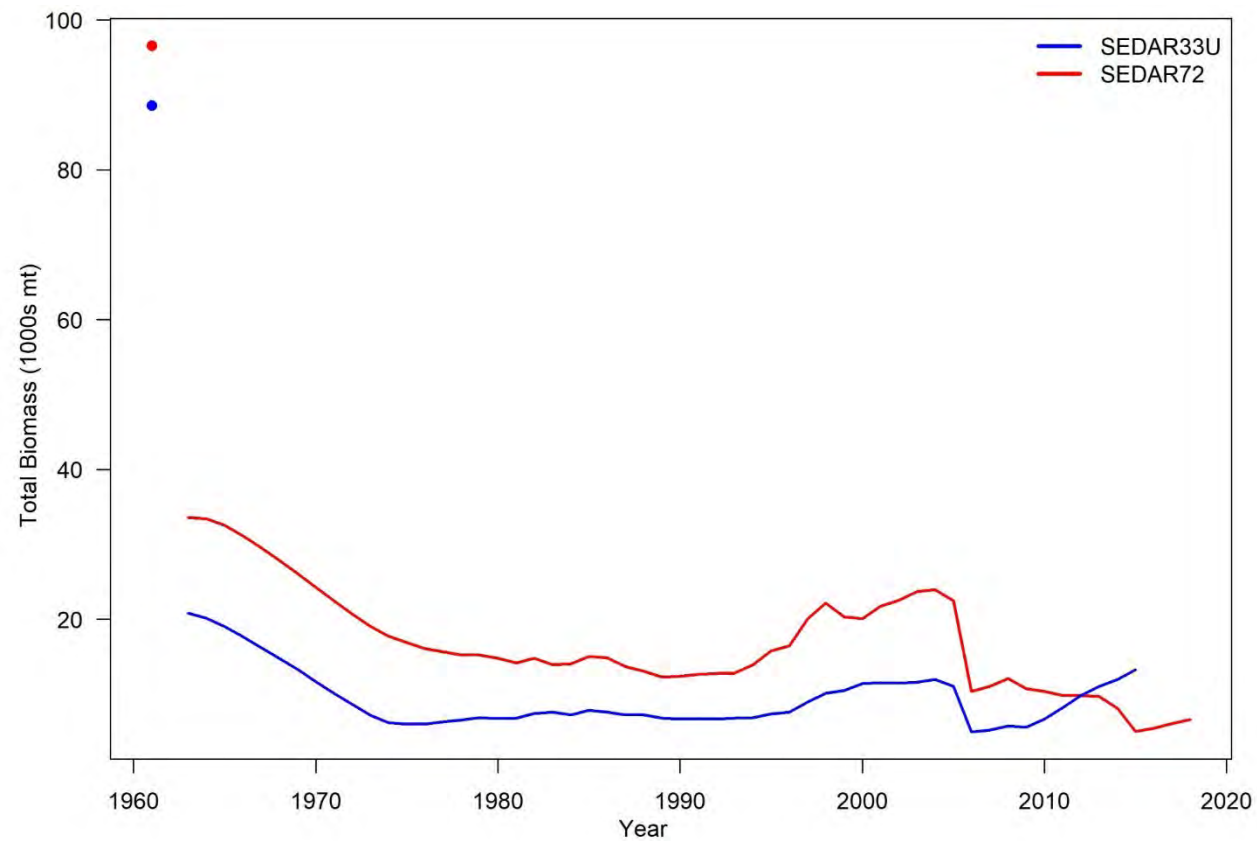


SEDAR33 Update

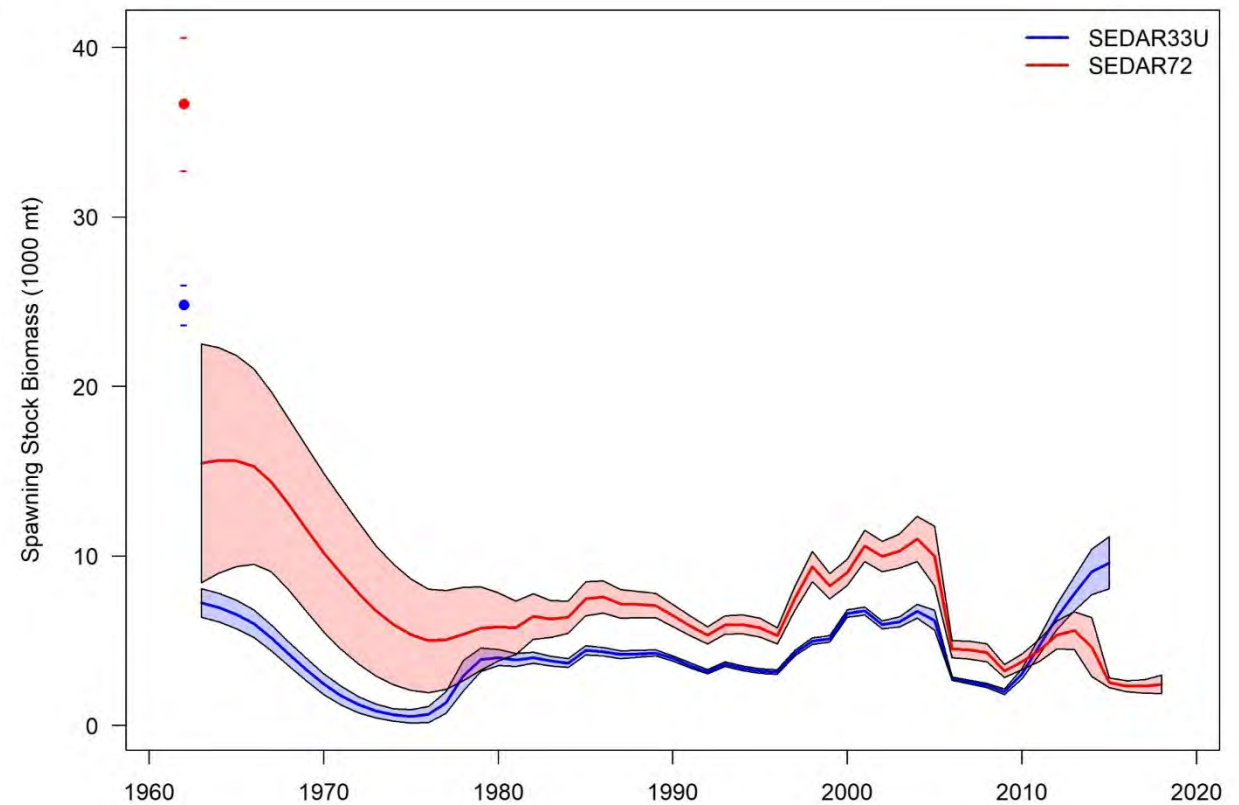


Base Model – Estimated Biomass & SSB

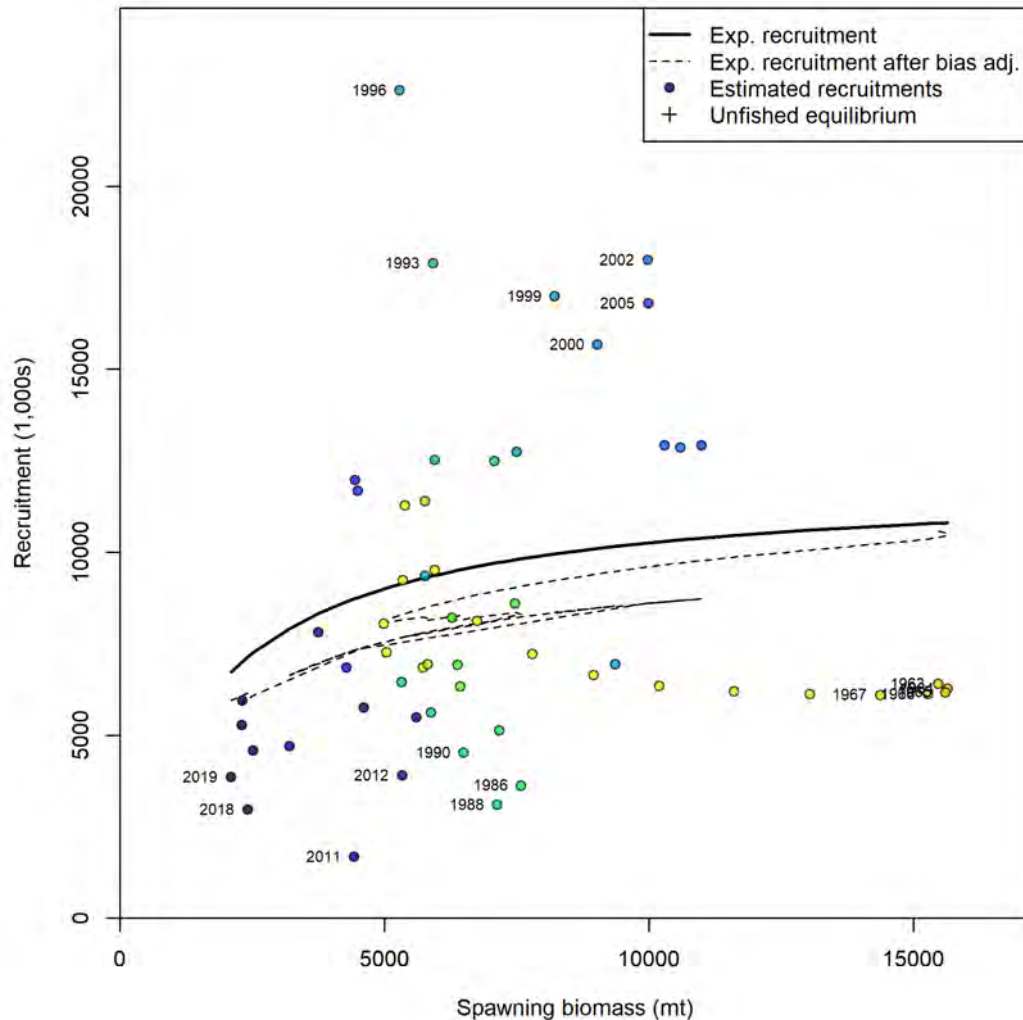
Total Biomass



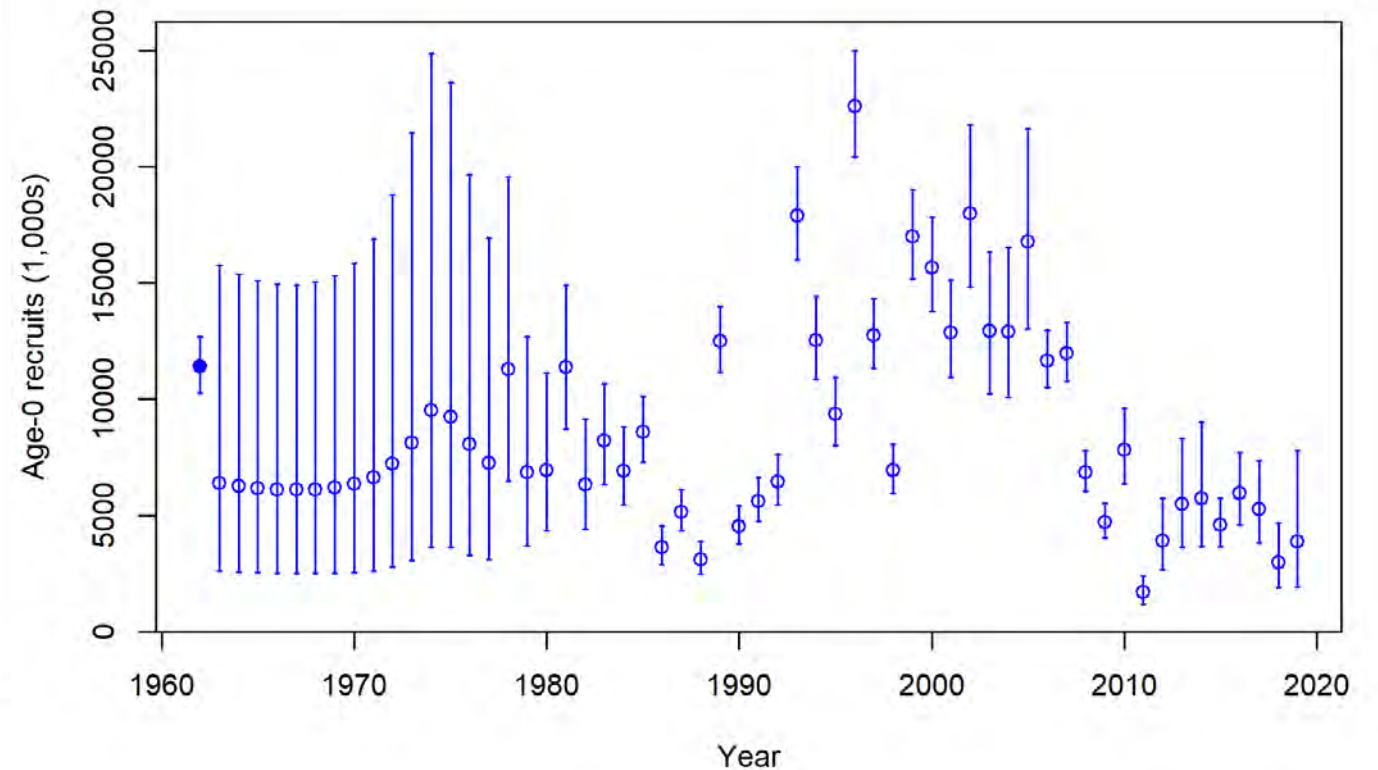
Female-only SSB



Base Model – Stock-Recruitment

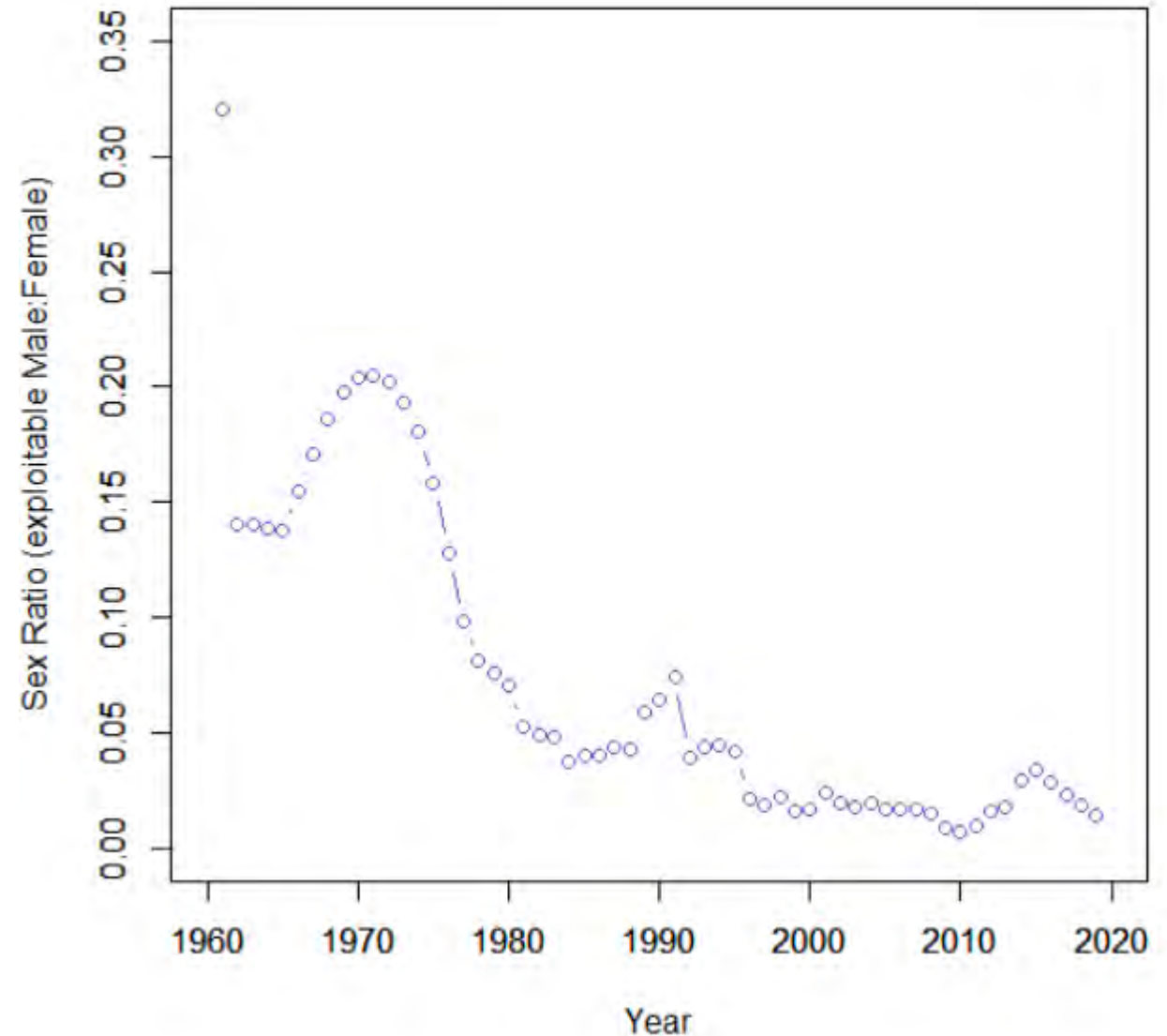


- Fixed parameters:
Steepness $h = 0.855$; $\sigma_r = 0.6$



Base Model – Sex Ratios

- Virgin conditions:
32% male
- Terminal year:
1.4% male

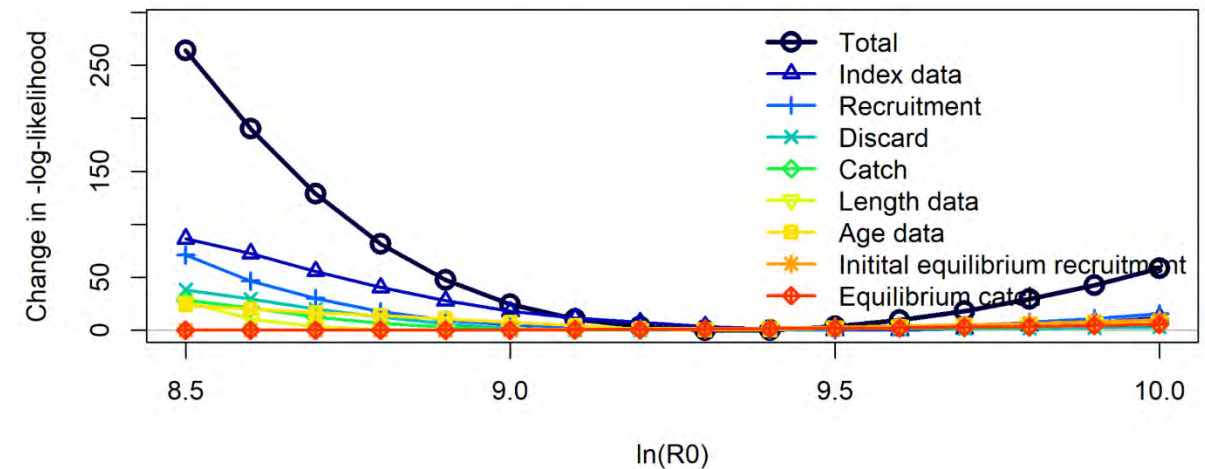


Base Model Diagnostics

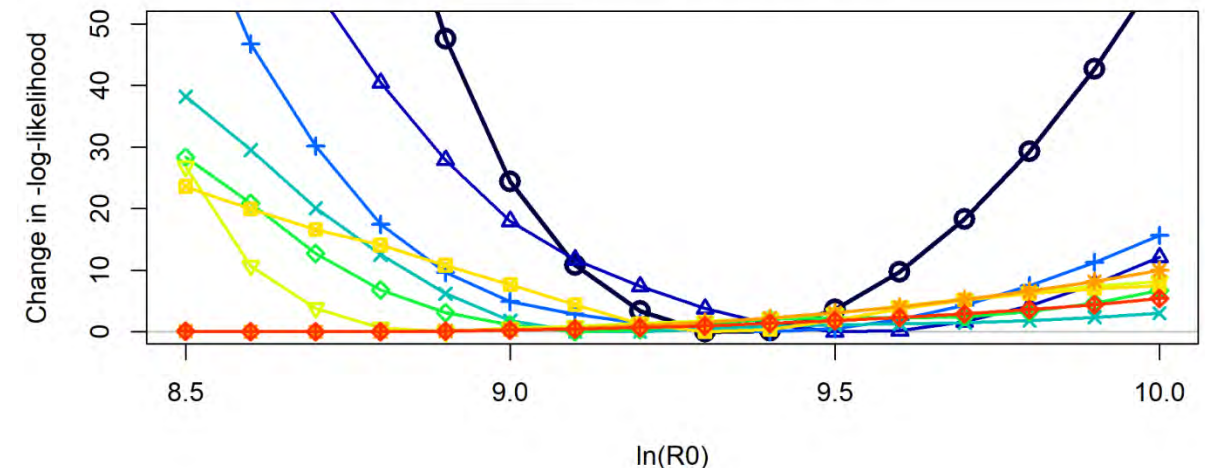
Likelihood Profile on $\ln R_0$

- Fixing $\ln(R_0)$ at different values while maximizing the likelihood over the other parameters.
- The MLE for the base model was 9.343.
- Different data components converge to a similar $\ln(R_0)$

Likelihood Profile

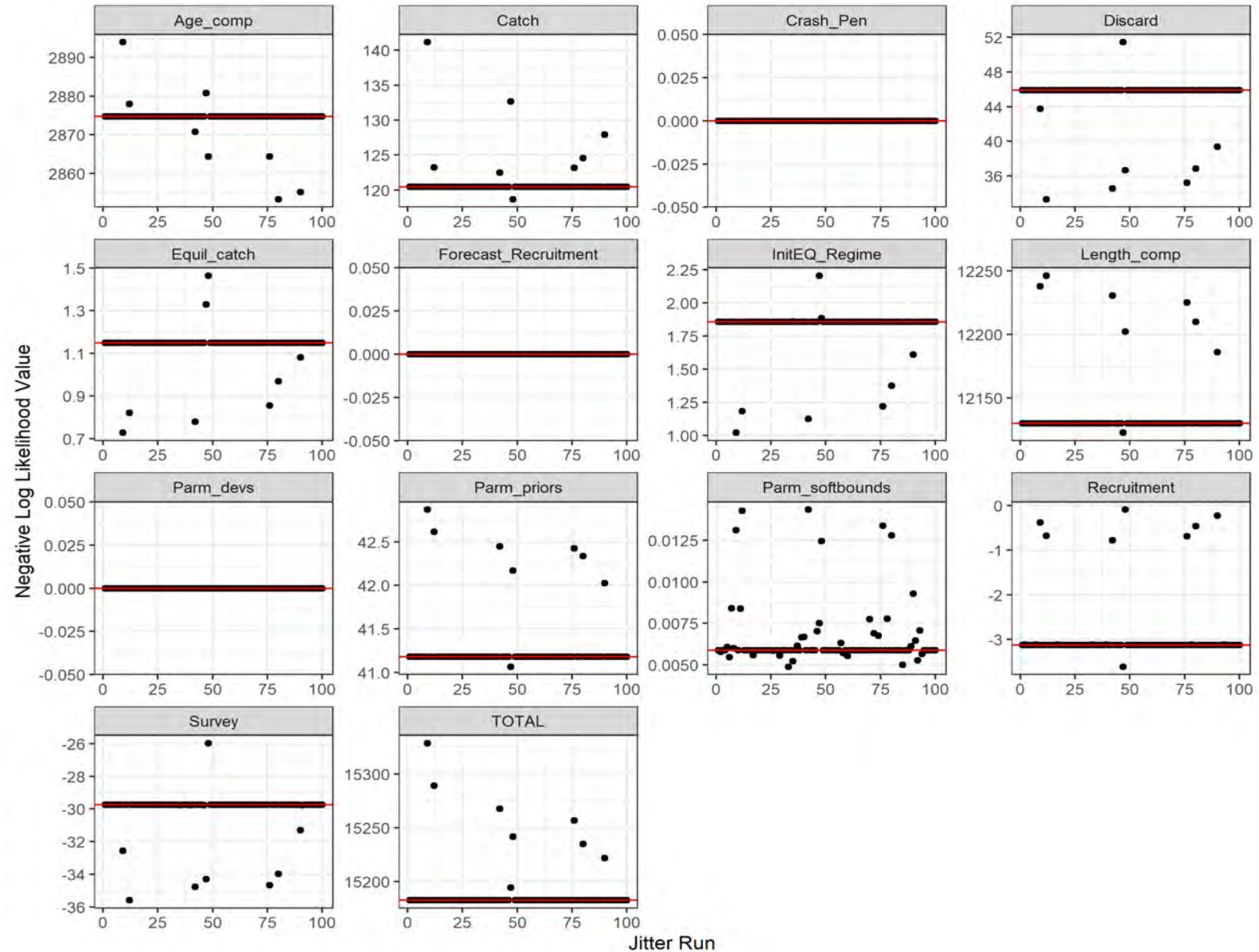


Likelihood Profile -- Zoom



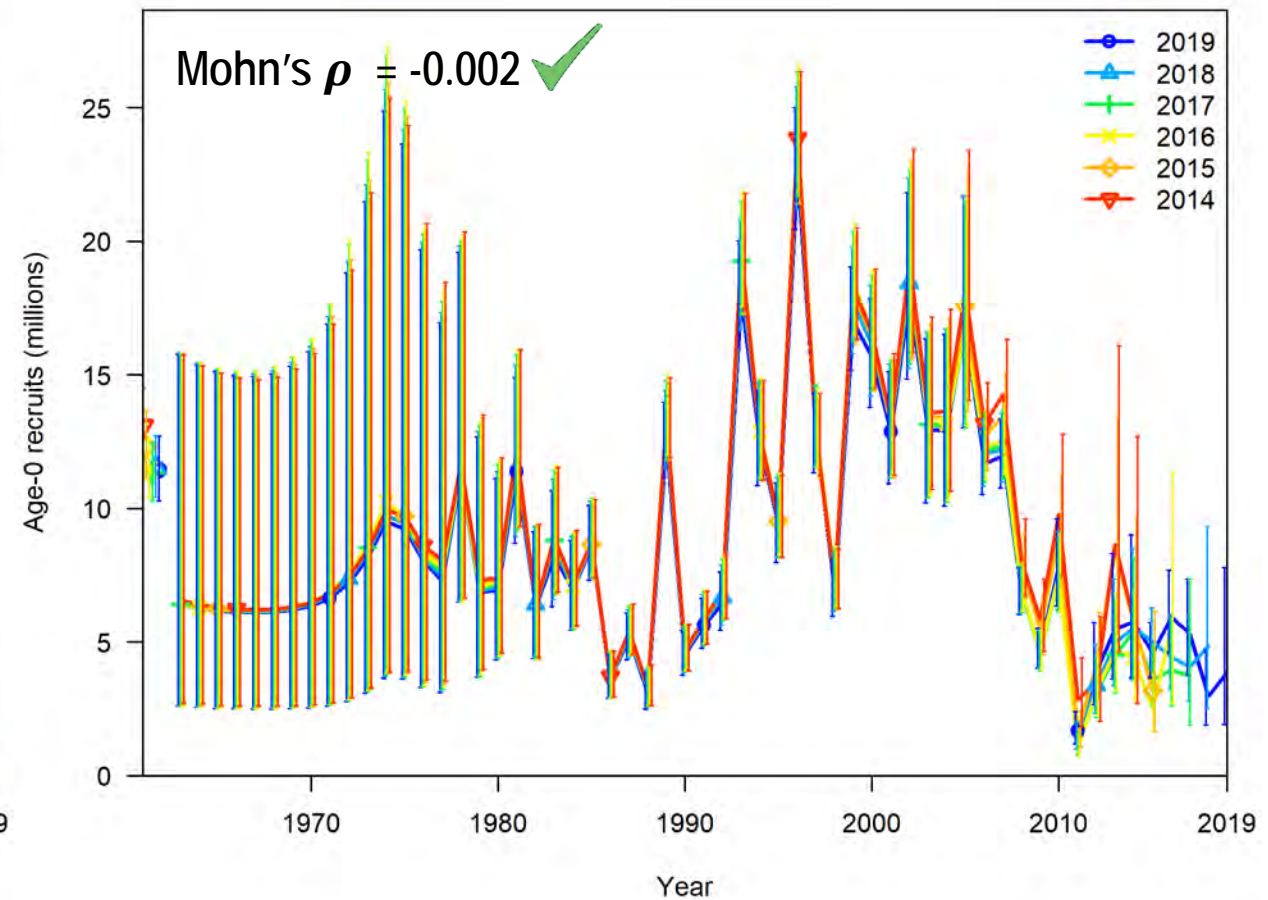
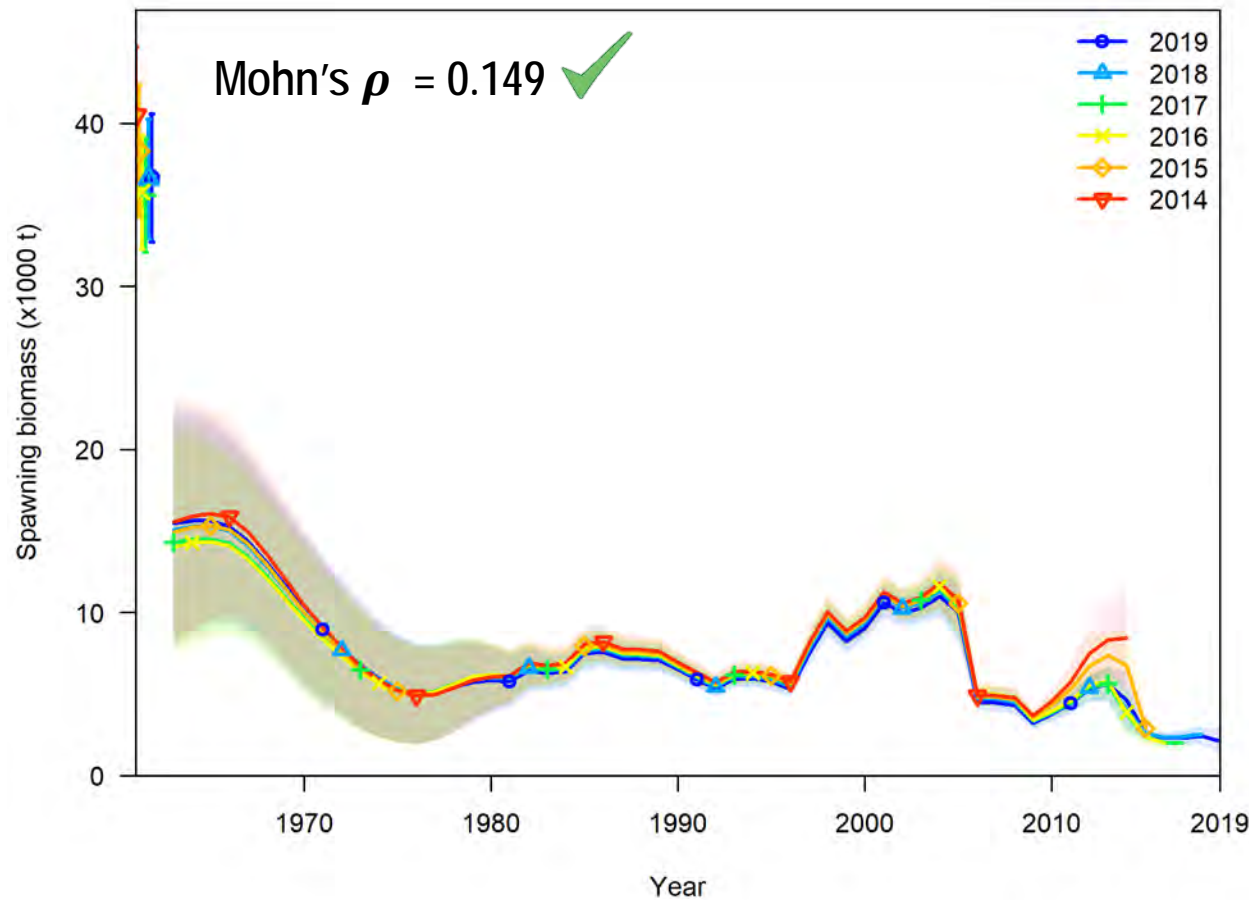
Jitter

- 100 model runs where the starting parameter values were randomly changed ('jittered') by 10% from the base model best fit values.
- The Base Run value for each panel is indicated by a red line.
- Base run = lowest total NLL



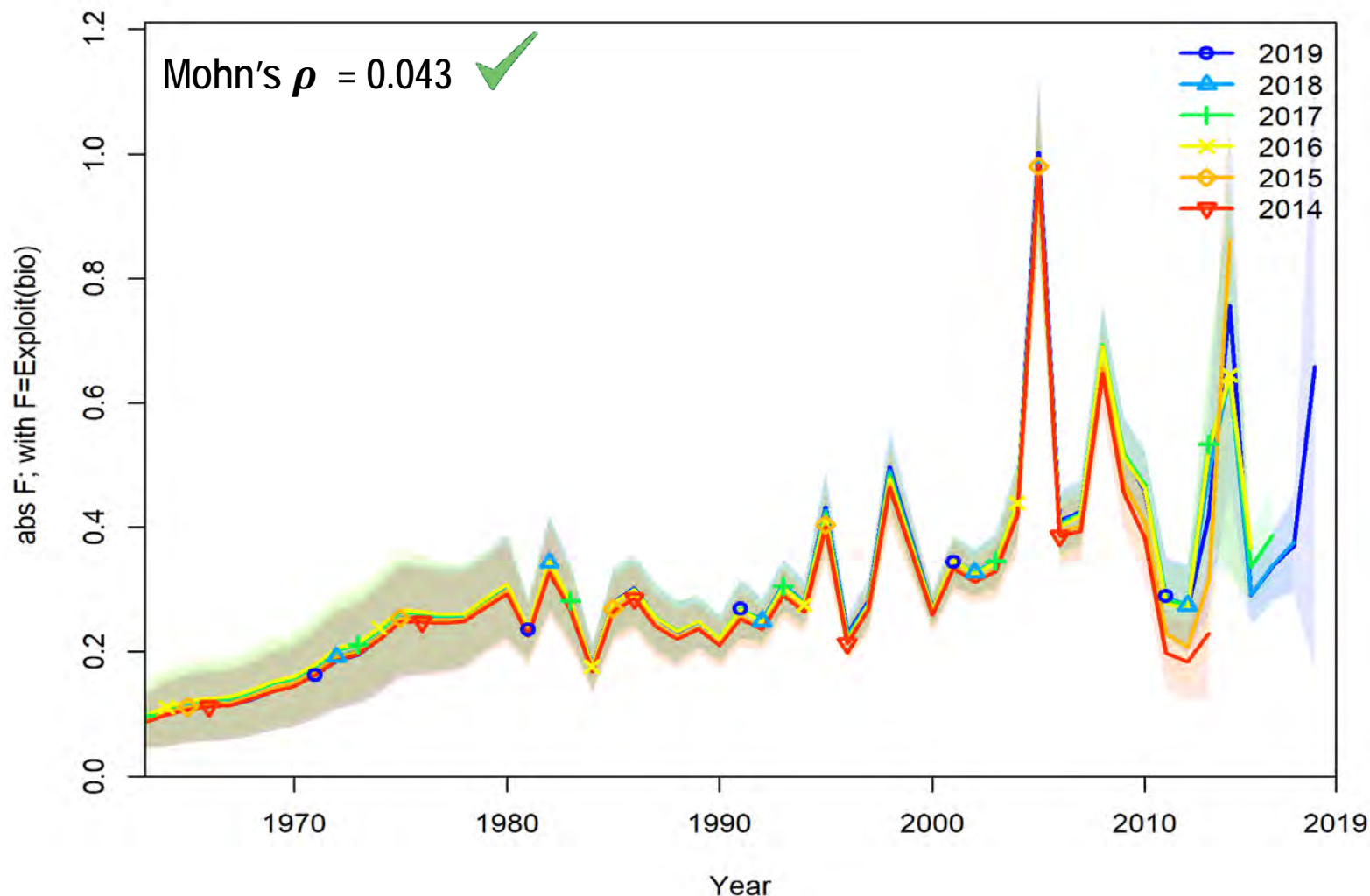
Retrospective Analysis

Mohn's ρ between -0.15 and 0.20 is considered acceptable (i.e. no retrospective pattern) see Hurtadi-Ferro et al. 2015



Retrospective Analysis

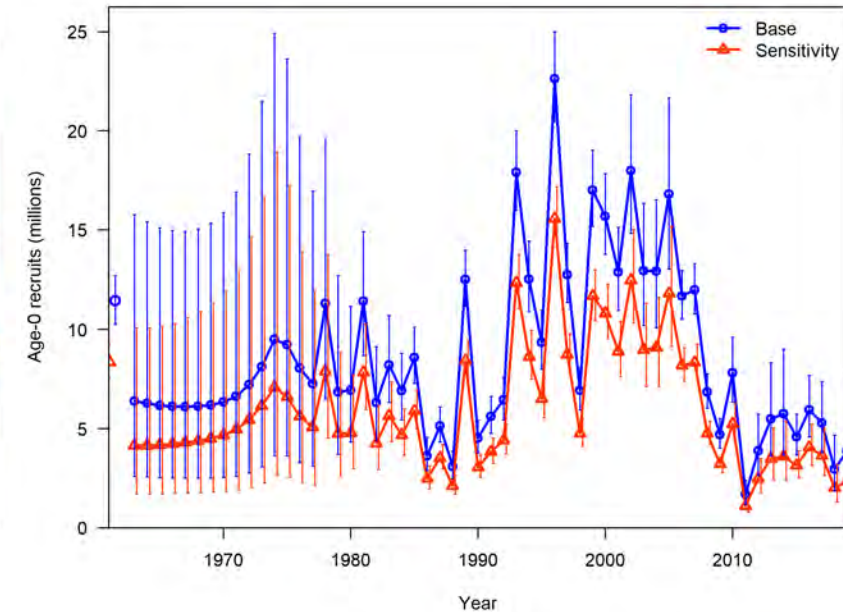
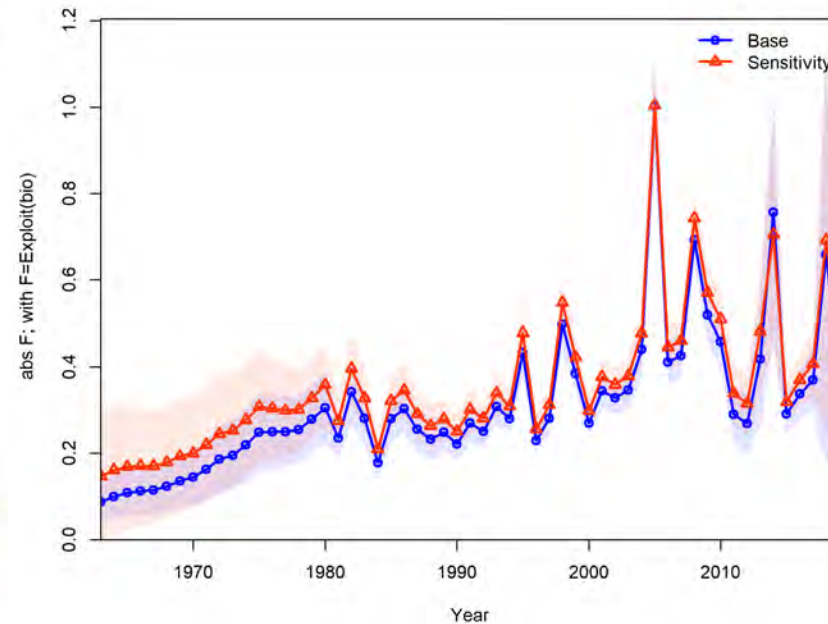
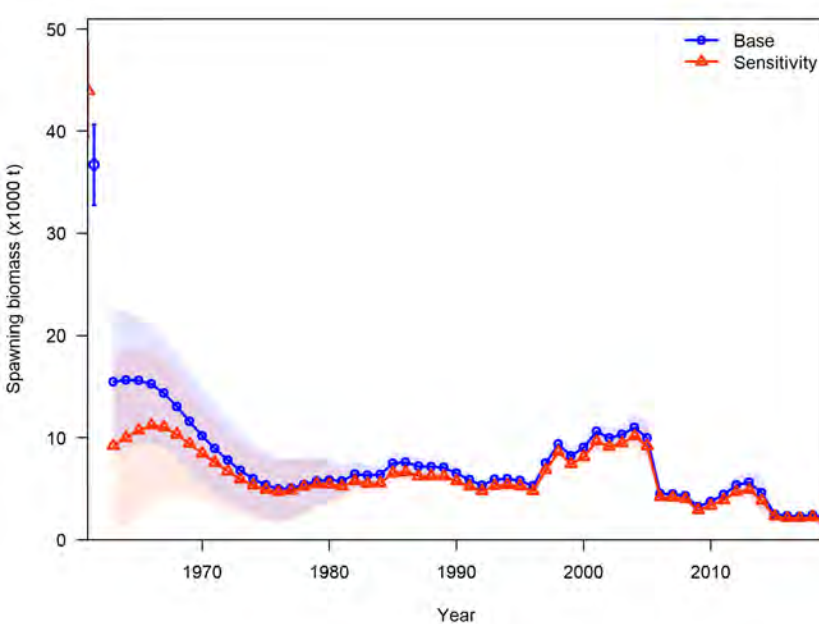
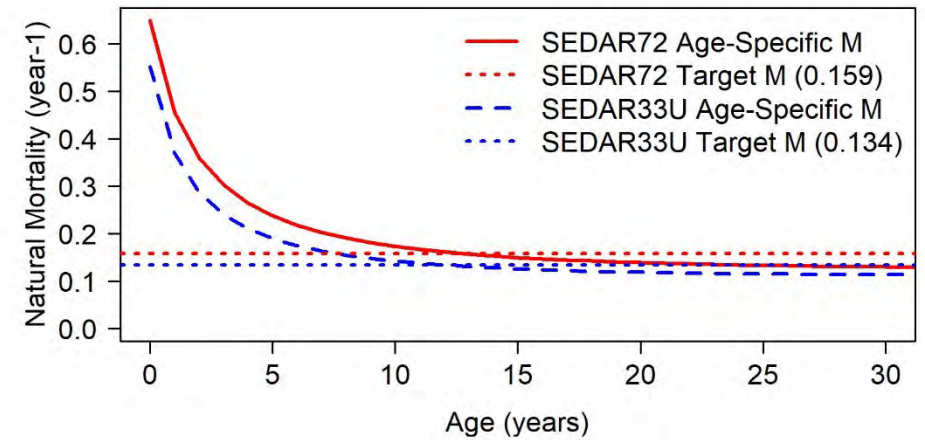
Mohn's ρ between -0.15 and 0.20 is considered acceptable (i.e. no retrospective pattern) see Hurtadi-Ferro et al. 2015



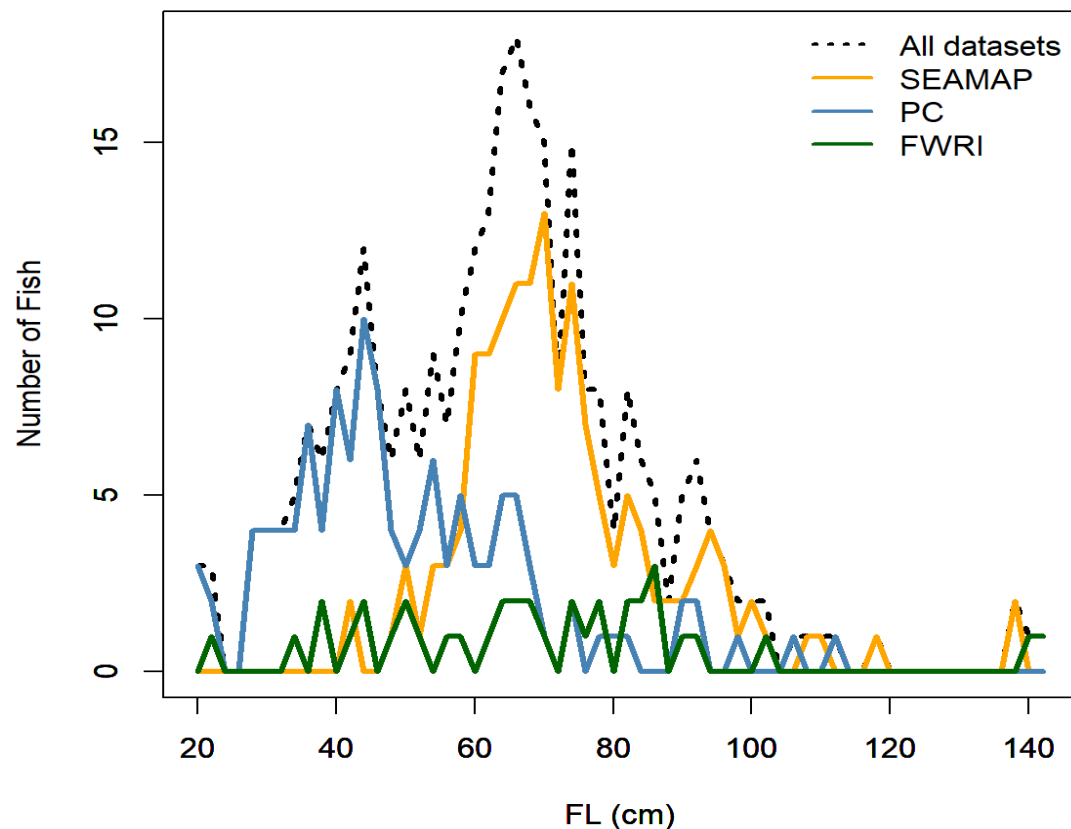
Additional Sensitivity Runs

Sensitivity Run

SEDAR 33 Update M Vector



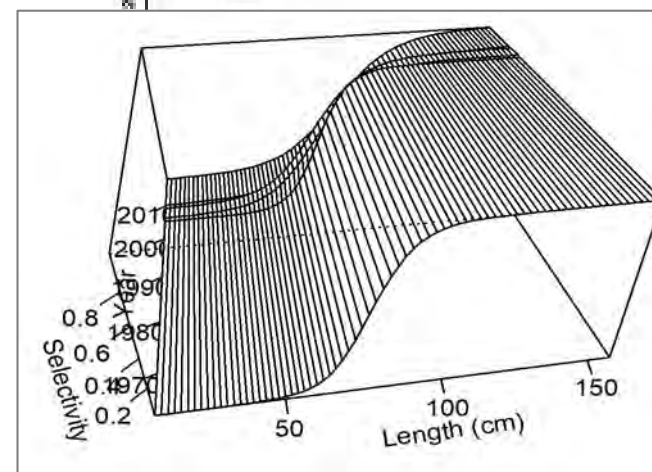
Sensitivity Run Combined video



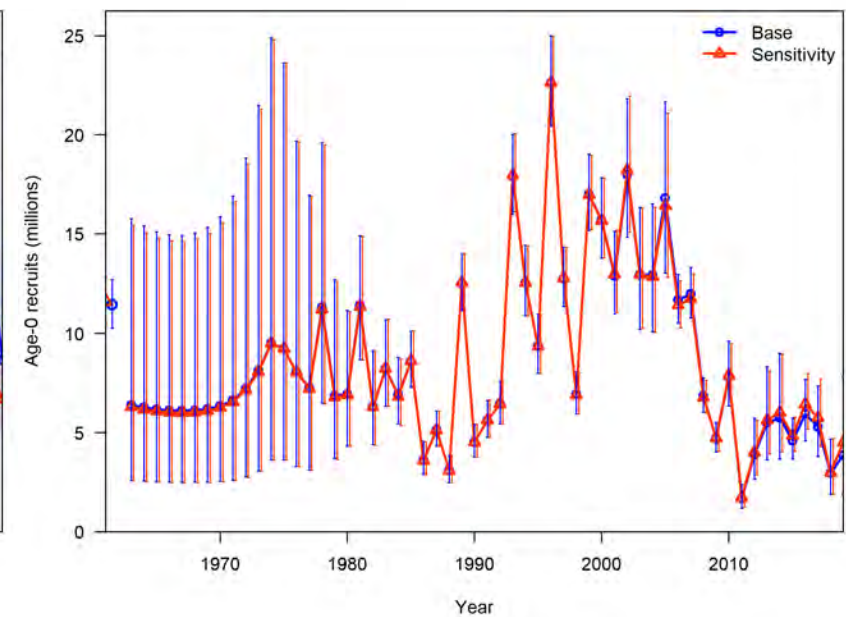
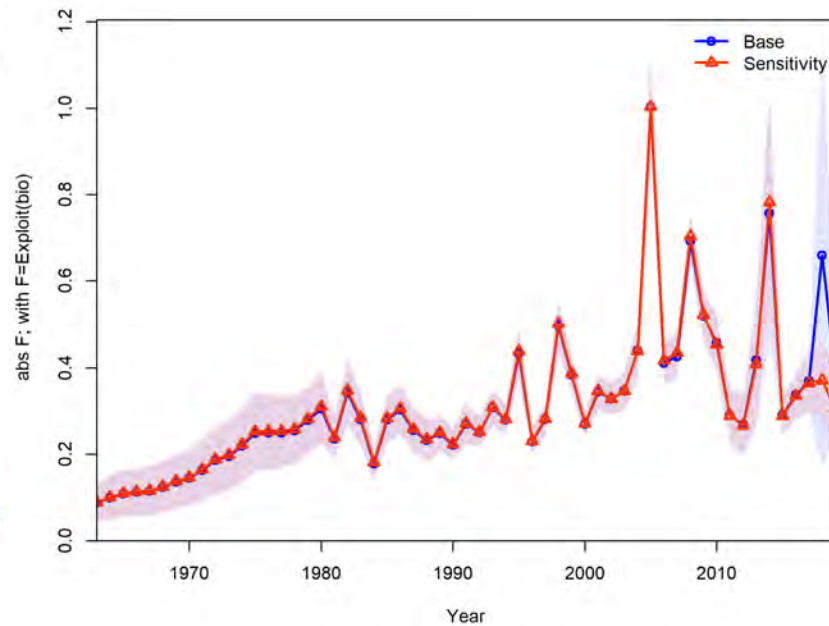
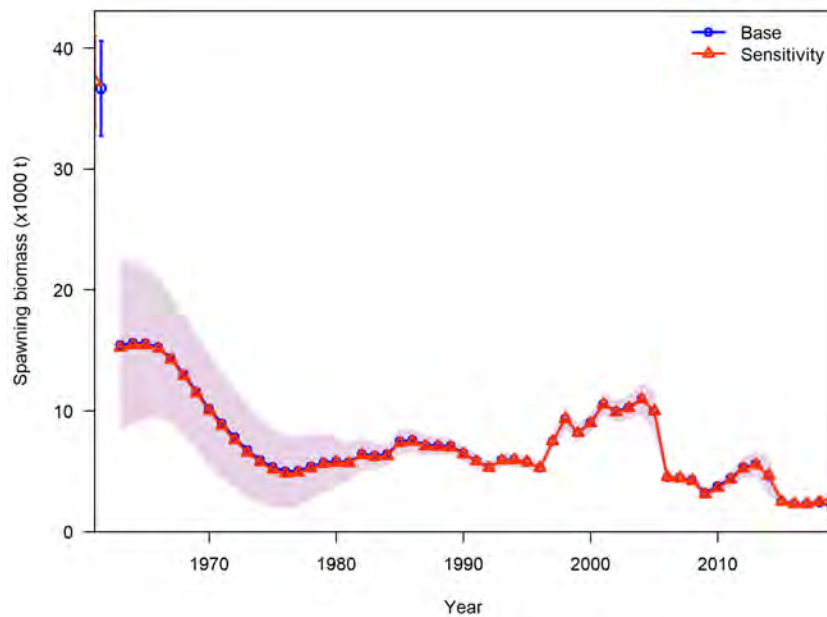
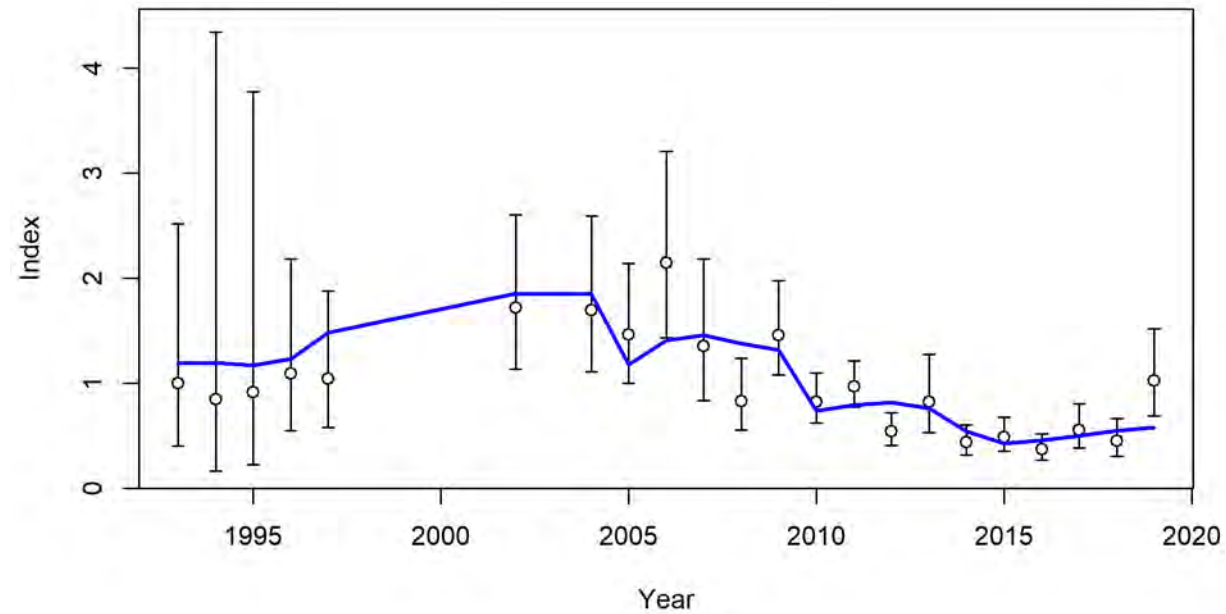
PASC: targets high relief, deep sites
1993-1997; 2002; 2004-2019

PC: targets the inner shelf
2006-2019

FWRI: inshore
and offshore
2010-2019

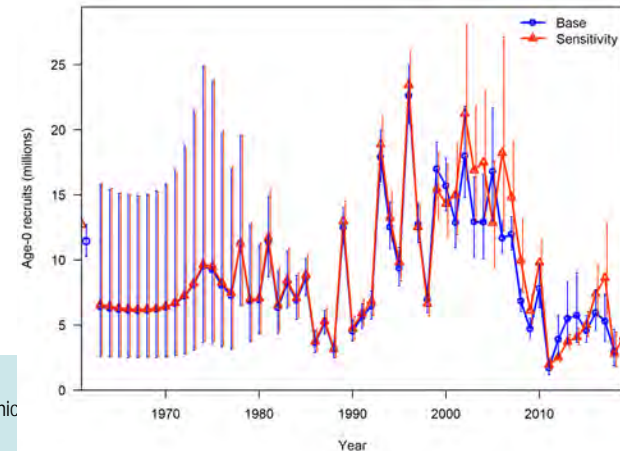
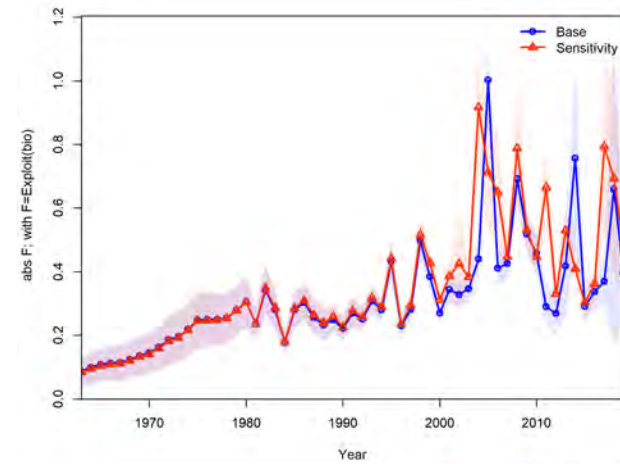
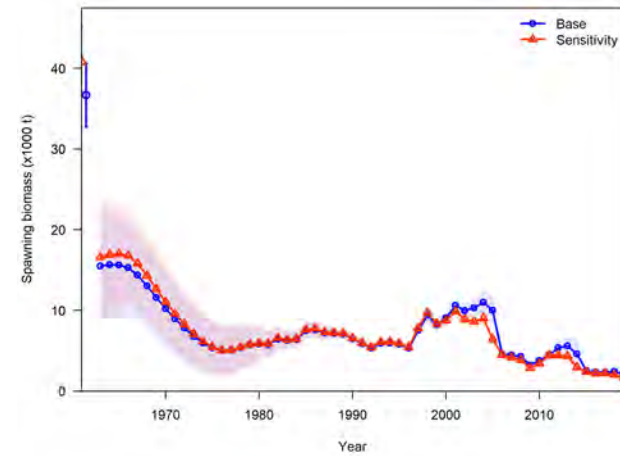
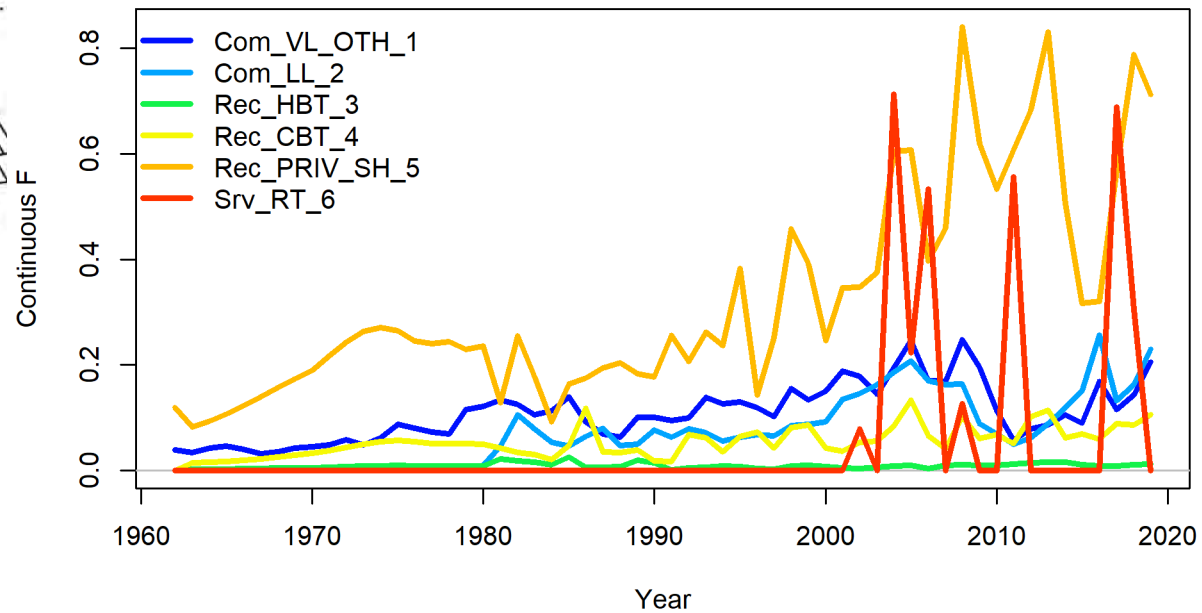
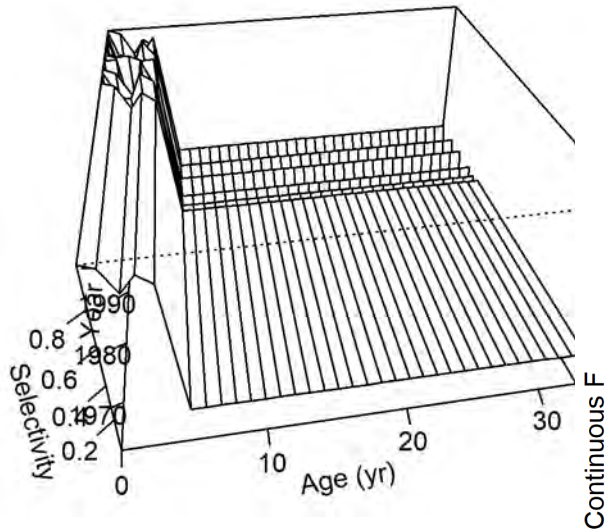


Sensitivity Run Combined video



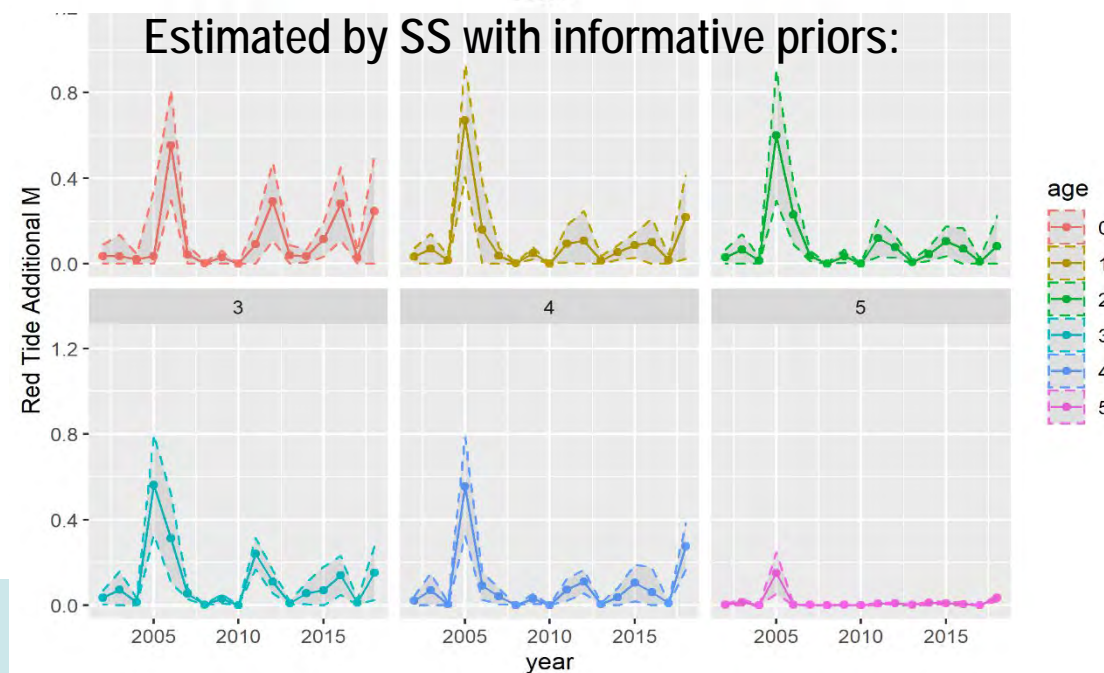
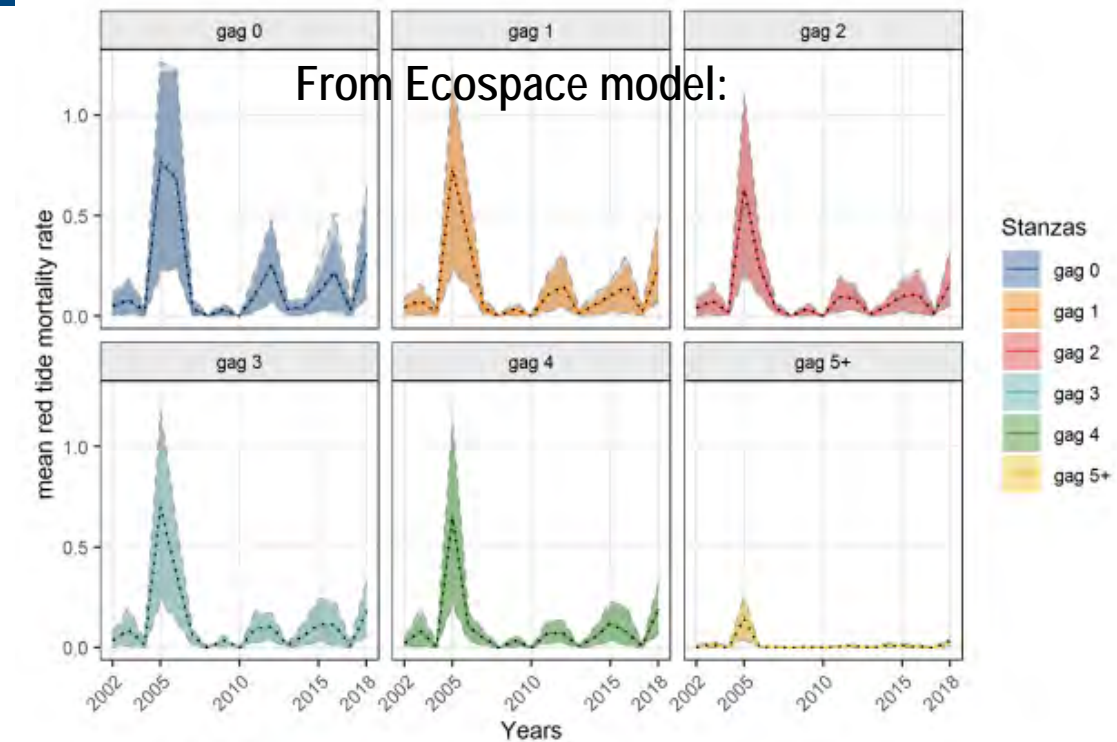
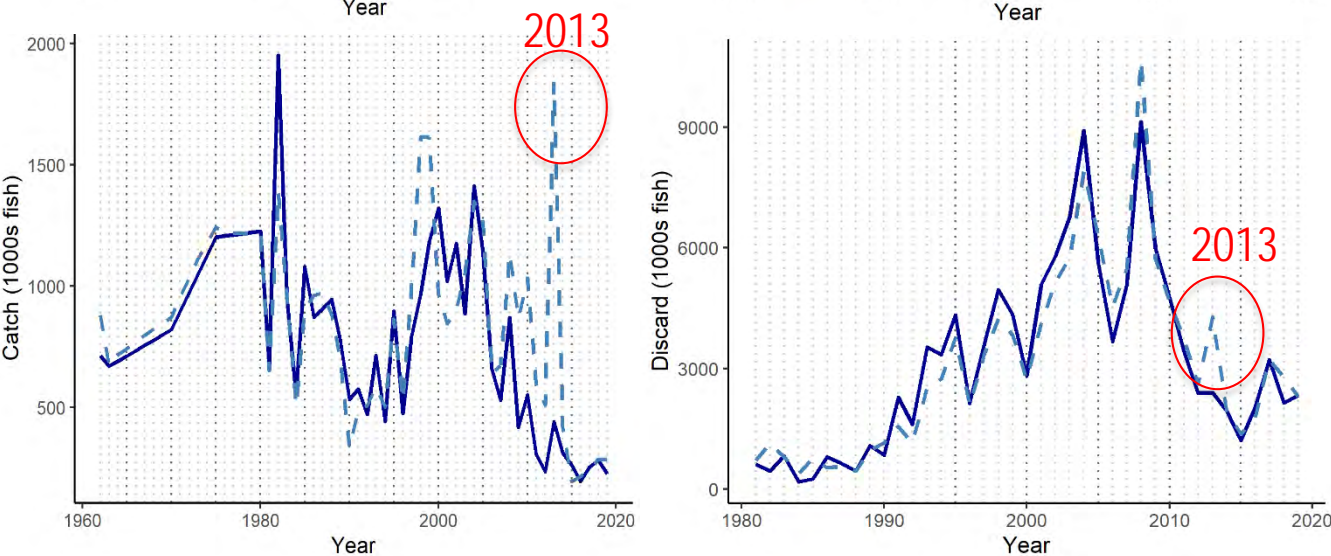
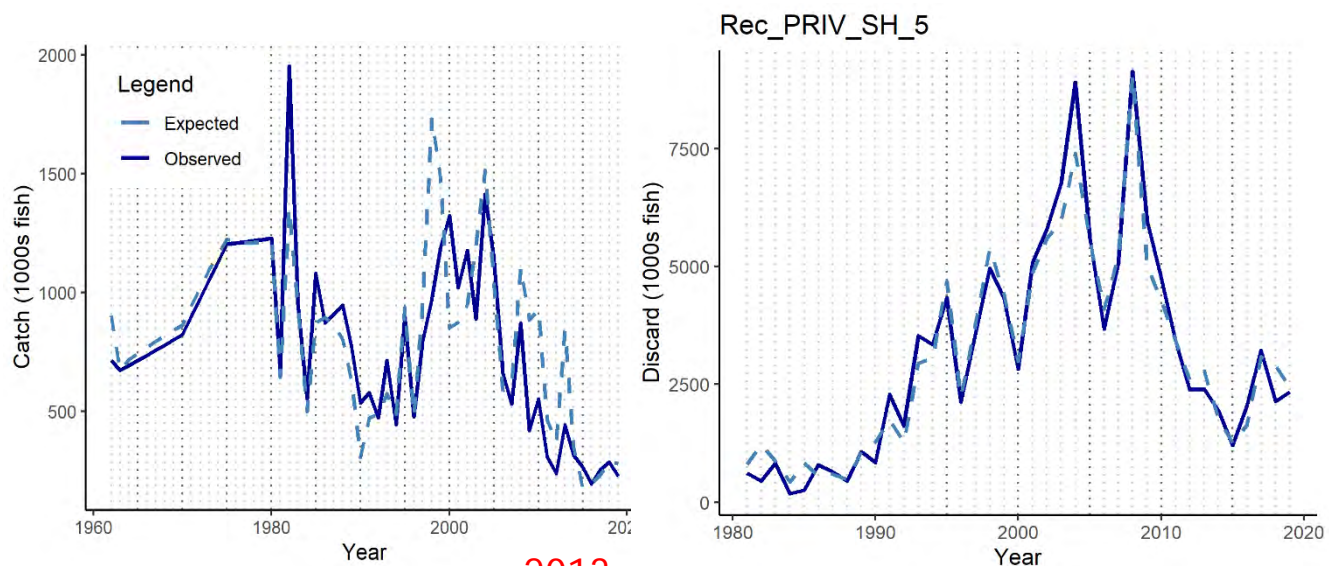
Sensitivity Run

Red Tide – Selectivity-at-age



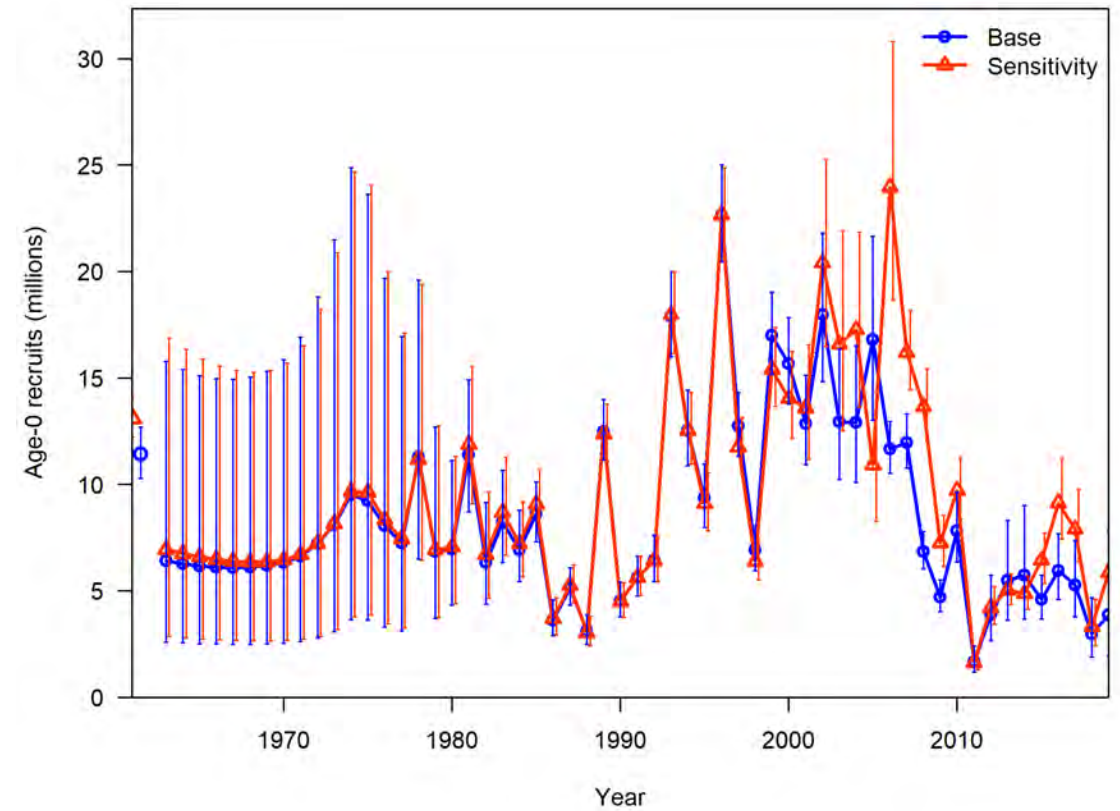
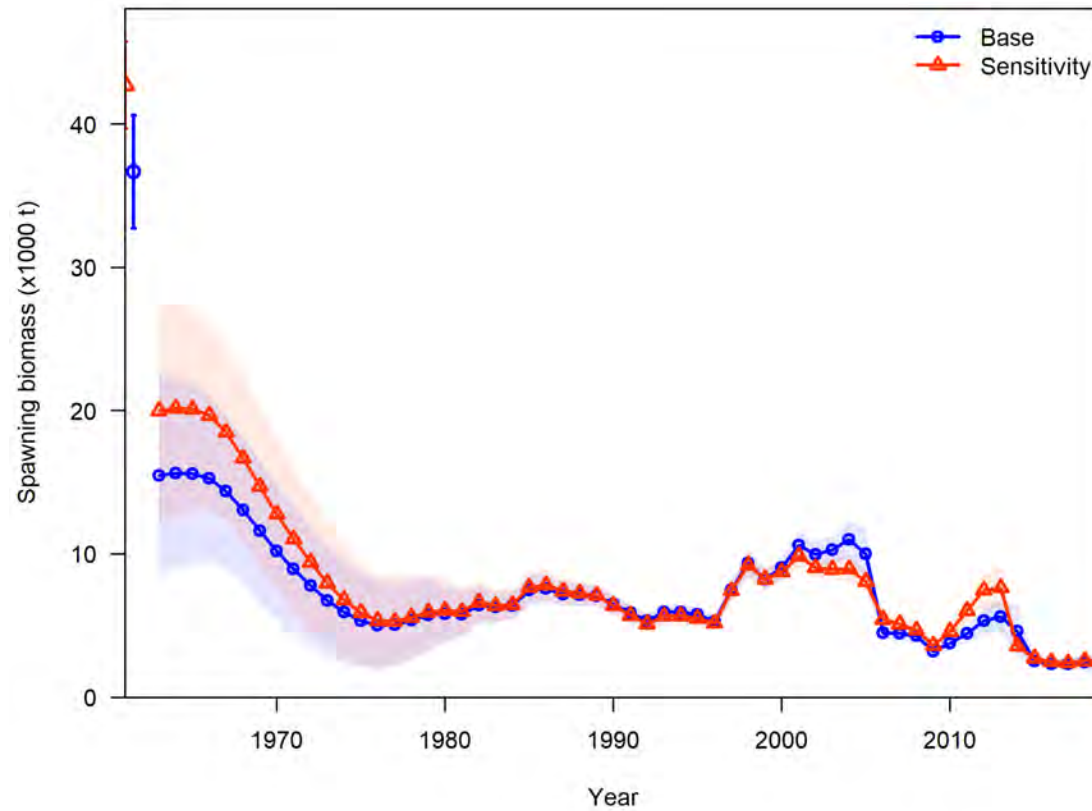
Sensitivity Run

Red Tide – Time blocks on M



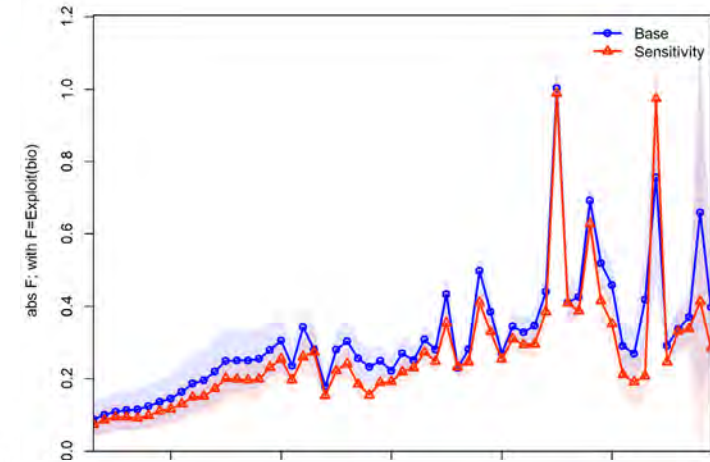
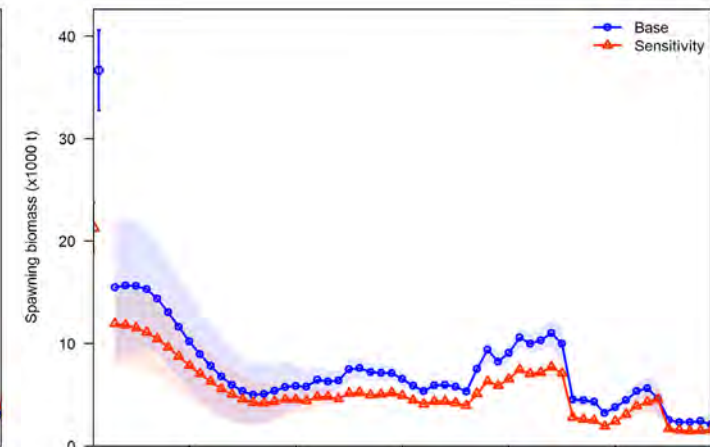
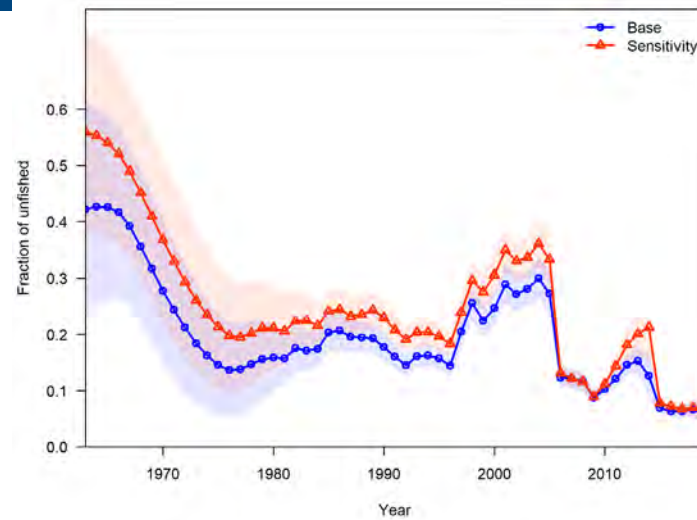
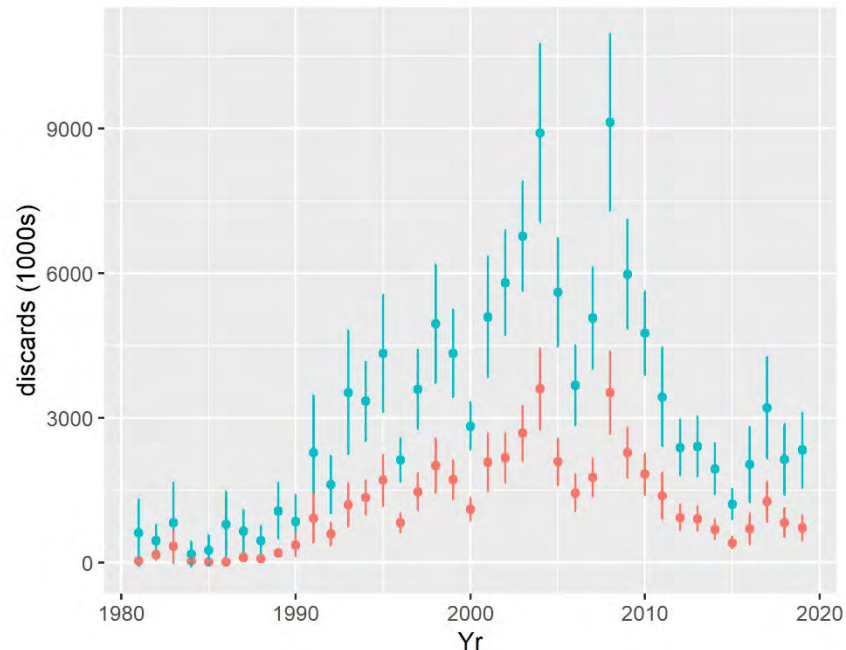
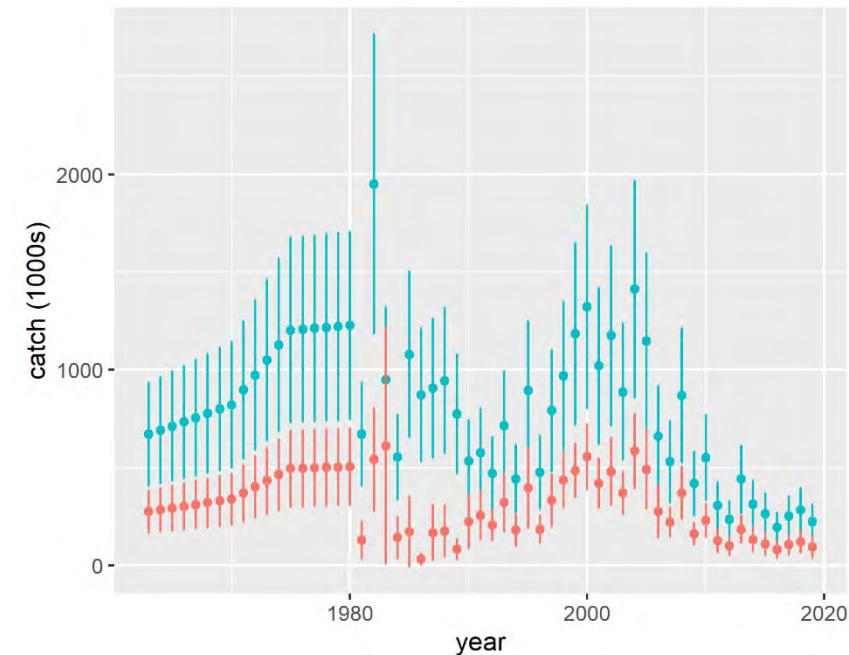
Sensitivity Run

Red Tide – Time blocks on M



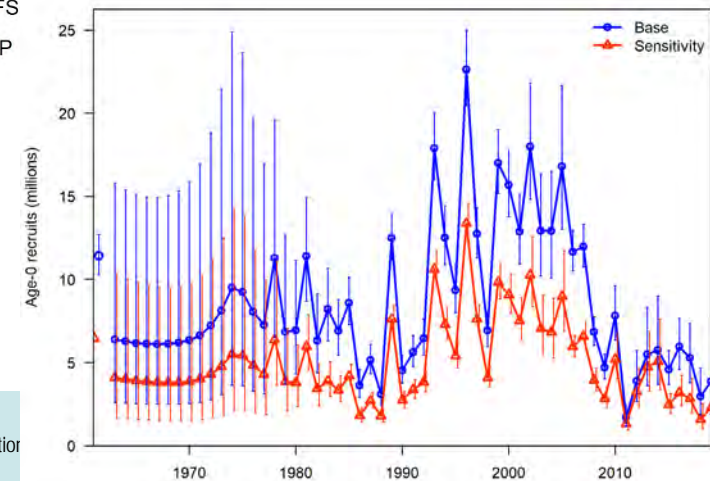
Sensitivity Run GRFS

- Inputted catches/discards and CVs for private fleet
- Adjusted historical time series



source

- GRFS
- MRIP



Base Model Conclusions

SSC Review of the SEDAR 33 Update Assessment:

The SSC felt that there was considerable uncertainty with the results of the gag update assessment for several reasons. Although the update assessment concurred with the SEDAR 33 results that the stock biomass was increasing, the strong retrospective pattern indicated previous management advice may have been optimistic. In addition, there is uncertainty about the level of discards in the private recreational fleet. In the continuity model, retention curves were used to account for private recreational discards. An alternative sensitivity model was run that assumed retention of gag in the recreational private fleet mirrored the retention of the headboat fleet. This simple change resulted in large changes in the model outputs, and would have indicated that the stock was overfished and experiencing overfishing. This indicated that the model is highly sensitive to its inputs.

SEDAR 72 incorporates the **best available data**, addressed the **TORs** and **fixed modeling issues** evident in the prior assessment. Diagnostics show a more **stable model** with **improved fits**.

A number of **research questions** were raised during the SEDAR72 assessment process. While attempts were made to address these questions through sensitivity runs and preliminary data exploration, the Operational nature of this assessment did not leave enough time to thoroughly evaluate each and every one of these questions. The SEFSC **strongly recommends that these topics** (listed in a later slide) **be more thoroughly examined during a future Research Track assessment**.

Benchmarks, Stock Status and Projections

TORs

3. Update model parameter estimates and their variances, model uncertainties, estimates of stock status and management benchmarks, and provide the probability of overfishing occurring at specified future harvest and exploitation levels. Provide commercial and recreational landings and discards in pounds and numbers.
 - Examine spawning stock biomass with respect to females only, and males and females combined, as the data allow.
 - Use the following status determination criteria (SDC) adopted in Amendment 30B:
 - MSY proxy = yield at F_{MAX} or $F_{Rebuild}$ (if overfished)
 - $MSST = 0.5 * B_{MAX}$
 - $MFMT = F_{MAX}$ and $F_{Rebuild}$ (if overfished)
 - If different SDC are recommended, provide outputs for both the current and recommended SDC.
 - Unless otherwise recommended, use the geometric mean of the previous three years' fishing mortality to determine $F_{Current}$. If an alternative approach is recommended, provide justification and outputs for the current and alternative approach.
 - Provide yield streams for the overfishing limit and acceptable biological catch in pounds:
 - Annually for five years
 - Under a "constant catch" scenario for both three and five years
 - For the equilibrium yield at F_{MSY} , when estimable

Male contribution to reproductive potential

- SSB can be characterized by **female-only** mature biomass or **combined** male and female mature biomass
- **Female-only SSB** provides best estimates of biological reference points **if the potential for decreased fertilization is weak**, whereas a **combined SSB** is best **when the potential for decreased fertility is moderate or unknown** (Brooks et al. 2008)
- Increasingly **skewed sex ratios** may result in reduced fertilization rates and, as a consequence, **reduced population growth** (sperm limitation, reduced genetic diversity/resilience)
- Gag Grouper:
 - Recent research estimates **~1%** male sex ratio in the fished stock and **~5%** in Madison Swanson (Barbieri et al. 2021)
 - Last **strong year class** observed 2006/2007
 - Relationship between sex ratio and fertilization success **poorly understood**

TOR

Examine spawning stock biomass with respect to females only, and males and females combined, as the data allow.

Projection Settings

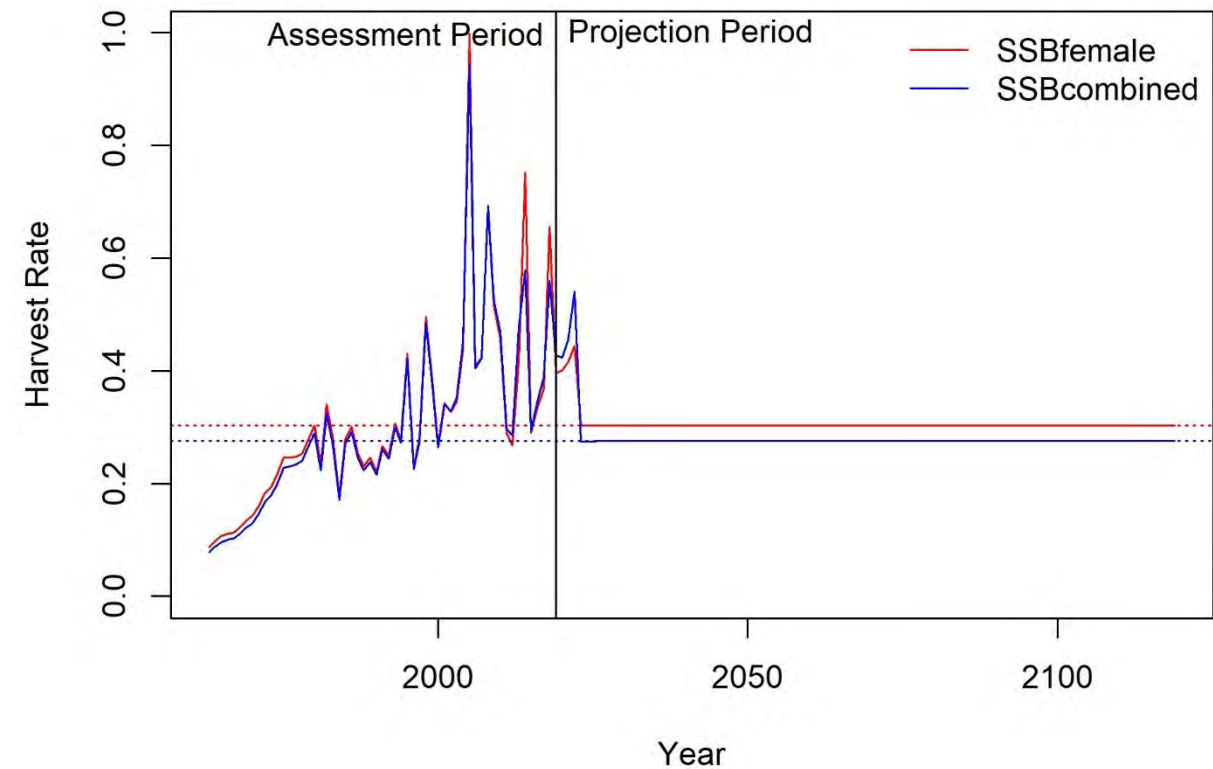
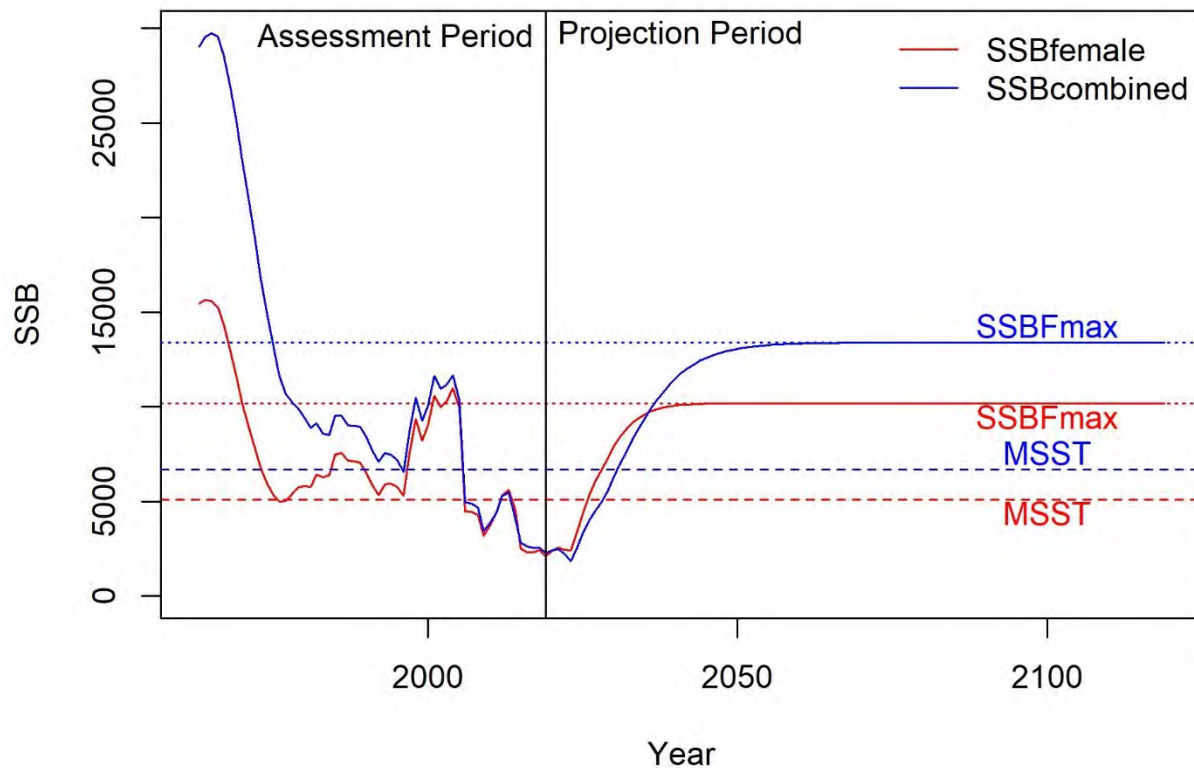
Parameter	Value	Comment
Relative F	Average from 2017 - 2019	Average relative fishing mortality (apical F) over terminal three years of model (Red Tide F excluded)
Selectivity	2019	Fleet specific selectivity estimated in the terminal year of the model
Retention	2019	Fleet specific retention estimated in the terminal year of the model
Recruitment	Beverton-Holt stock-recruitment relationship	Derived from the model estimated Beverton-Holt stock-recruitment relationship
Interim Landings (2020-2022)	73.79/126.72/126.72 mt (Comm. Vertical Line)	Landings provided for 2020; For 2021-2022, used 3-year average of landings (2018-2020)
	133.69/97.41/97.41 mt (Comm. Longline)	
	2.61/2.54/2.54 thousands of fish (Headboat)	
	37.61/28.66/28.66 thousands of fish (Charter)	
	305.4/271.68/271.68 thousands of fish (Private)	
Allocation Ratio	39:61	Commercial:Recreational

Benchmarks & Reference Points

Criteria	Definition	Female-only SSB	SSB combined
R0	Virgin Recruitment (1000s)	11,417	14,292
Generation Time	Fecundity-weighted mean age	7.9	7.9
SSB0	Virgin spawning stock biomass (mt)	36,666	105,978
Fmsy proxy	Fmax - fishing mortality rate that achieves maximum yield per recruit	0.303	0.275
MFMT	Fmax	0.303	0.275
%SPR equivalent of Fmsy proxy	%SPR equivalent of Fmax	31	16
Fcurrent	Geometric mean of the last 3 years of the assessment (F2017-2019), including red tide mortality	0.457	0.453
Fcurrent/MFMT	Current stock status based on MFMT	1.512	1.647
SSBmsy proxy	Equilibrium SSB at Fmax	10,186	13,401
MSST	0.5*SSBFmax	5,093	6,701
SSBcurrent	SSB2019	2,102	2,295
SSBcurrent/SSBFmax	Current stock status based on SSBFmax	0.206	0.171
SSBcurrent/MSST	Current stock status based on MSST	0.413	0.343
SSBcurrent/SSB0	SSB ratio in 2019	0.057	0.022

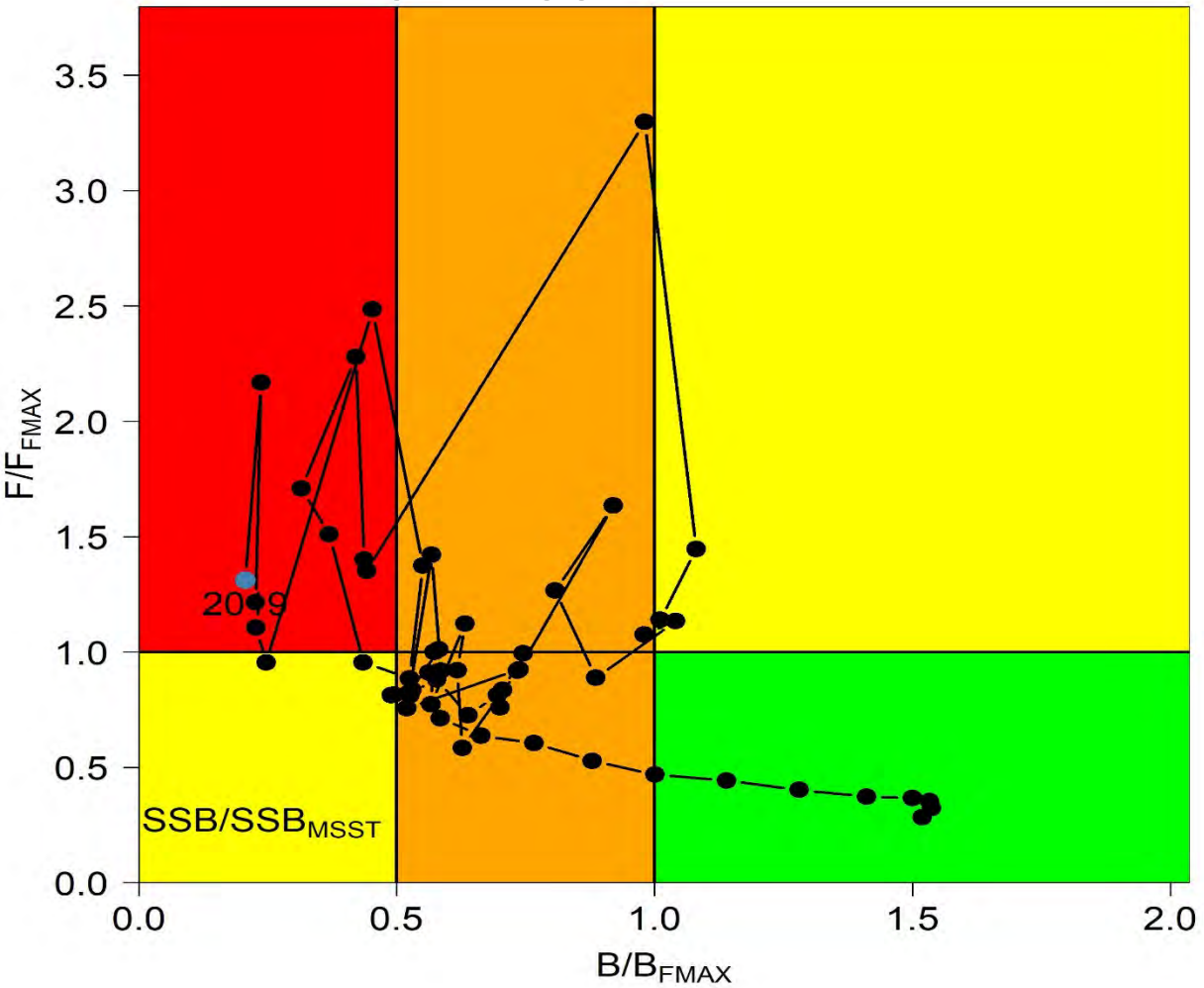
Base Model – Stock Status

- Gulf of Mexico Gag Grouper is overfished and undergoing overfishing under both female-only SSB and SSB combined scenarios

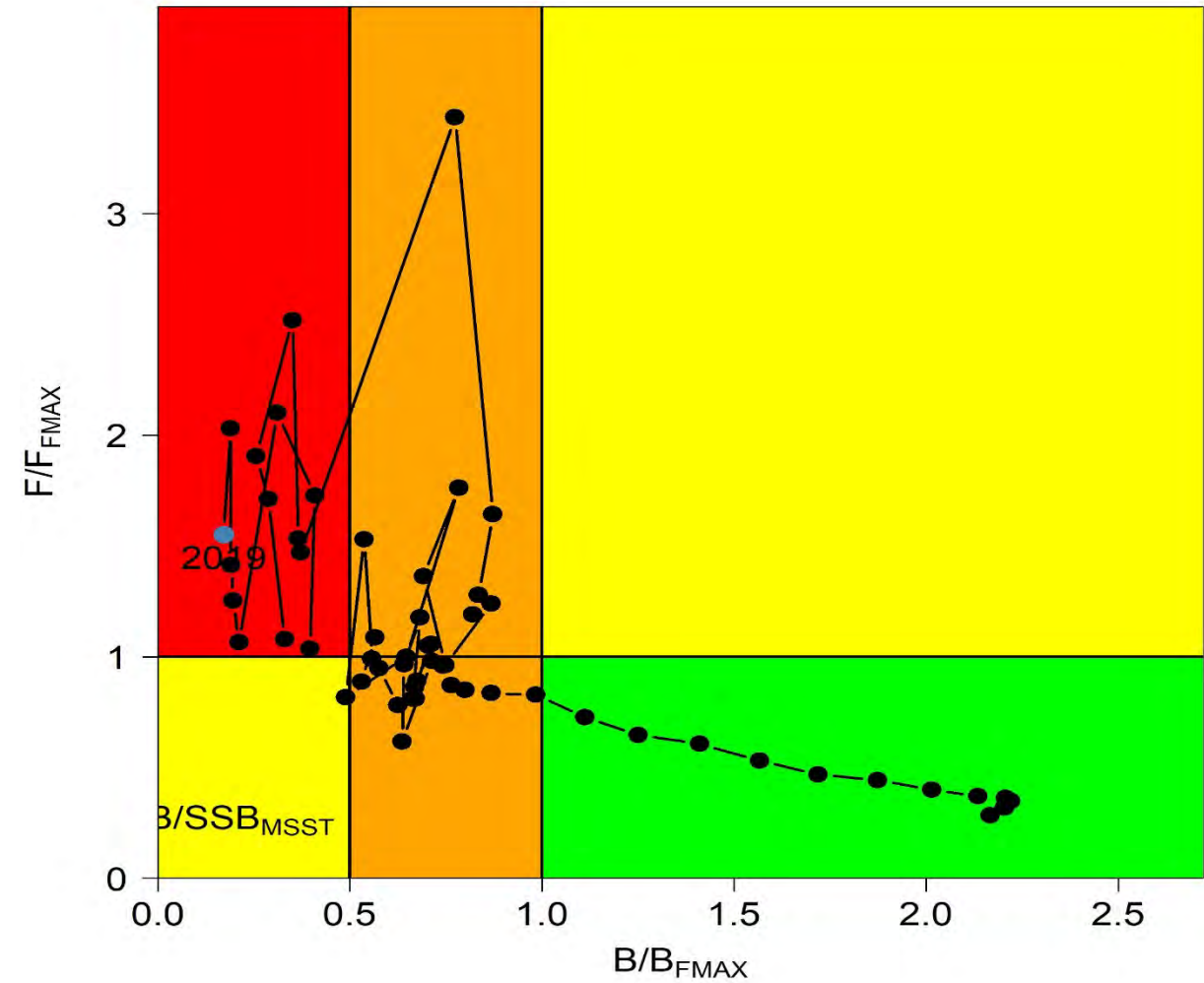


Kobe Plots

FEMALE-ONLY SSB



SSB COMBINED



OFL projections

- Female-only SSB

Year	R	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0	OFL
2023	7,124	0.303	1	2,410	0.237	0.473	0.066	2.715
2024	7,981	0.303	1	3,287	0.323	0.645	0.090	3.641
2025	8,710	0.303	1	4,401	0.432	0.864	0.120	4.466
2026	9,138	0.303	1	5,327	0.523	1.046	0.145	5.109
2027	9,396	0.303	1	6,037	0.593	1.185	0.165	5.731

- SSB Combined

Year	R	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0	OFL
2023	4,217	0.275	1	1,848	0.138	0.276	0.017	1.748
2024	5,177	0.275	1	2,492	0.186	0.372	0.024	2.370
2025	6,188	0.275	1	3,323	0.248	0.496	0.031	2.899
2026	6,877	0.275	1	4,010	0.299	0.598	0.038	3.223
2027	7,307	0.275	1	4,500	0.336	0.672	0.042	3.587

Projections at F=0

- Female-only SSB

mgmt year →

year rebuilt →

Year	R	F	SSB	SSB/SSBFMAX	SSB/MSST	SSB/SSB0	Yield
2020	7,097	0.400	2,388	0.234	0.469	0.065	3.31
2021	7,298	0.415	2,562	0.252	0.503	0.070	3.10
2022	7,189	0.444	2,466	0.242	0.484	0.067	3.16
mgmt year → 2023	7,124	0.000	2,410	0.237	0.473	0.066	0.00
2024	7,980	0.000	4,288	0.421	0.842	0.117	0.00
2025	8,709	0.000	6,899	0.677	1.355	0.188	0.00
2026	9,137	0.000	9,731	0.955	1.911	0.265	0.00
year rebuilt → 2027	9,395	0.000	12,582	1.235	2.471	0.343	0.00

- SSB Combined

mgmt year →

year rebuilt →

Year	R	F	SSB	SSB/SSBFMAX	SSB/MSST	SSB/SSB0	Yield
2020	5,090	0.424	2,428	0.181	0.362	0.023	3.31
2021	5,161	0.455	2,480	0.185	0.370	0.023	3.10
2022	4,813	0.541	2,233	0.167	0.333	0.021	3.17
mgmt year → 2023	4,216	0.000	1,847	0.138	0.276	0.017	0.00
2024	5,177	0.000	3,206	0.239	0.479	0.030	0.00
2025	6,187	0.000	5,115	0.382	0.763	0.048	0.00
2026	6,877	0.000	7,199	0.537	1.074	0.068	0.00
2027	7,306	0.000	9,298	0.694	1.388	0.088	0.00
2028	7,671	0.000	11,707	0.874	1.747	0.110	0.00
year rebuilt → 2029	8,099	0.000	14,750	1.101	2.201	0.139	0.00

Questions regarding projection settings

- Red Tide
 - Include/Exclude Red Tide in $F_{current}$ calculations?
 - Magnitude of 2021 Red Tide in projections?
- Recruitment
 - Average of data rich period? (1984-2019)
- SSB
 - Female-only SSB vs. SSB combined?

Research Recommendations

Research Recommendations

Recreational Landings and Discards data

- Further develop best practices for correcting for prominent peaks and troughs in the earlier part of the time series where uncertainty is high and catch/discard estimates are driven by few but influential intercept records.
- Develop estimates of uncertainty around Headboat discard estimates.
- Develop estimates of uncertainty around estimates of Recreational landings in weight.

Age and length composition

- Quantify and evaluate appropriate modeling and weighting procedures of length and age compositions to ensure age and length composition inputs are representative of the segment of the population being modeled.

Research Recommendations Continued

Selectivity and catchability of the commercial fleets

- Further investigate and quantify changes in selectivity/catchability through time to improve fit to the discards and length compositions in recent years.
- Attempt to model changes in fishing behavior caused by the implementation of the IFQ through the use of time-varying selectivity and retention.
- Continue data collection from observer programs or electronic monitoring programs.

Selectivity and retention of the recreational fleets

- Further investigate and quantify changes in selectivity/catchability through time to improve fit to the length compositions across the time series.

Research Recommendations Continued

Combined Video Index

- Continue the development of the Gulf of Mexico Gag Grouper Combined Video Index. Particularly, exploring ways to account for the survey and habitat effects. One possibility discussed during SEDAR72 would be to develop a separate index for the shallow/inshore and deep/offshore components of the surveys to better represent and track the various segments of the Gulf of Mexico Gag Grouper population through time.

Landings and Discards

- Explore approaches for assigning uncertainty estimates to commercial landings and revisit estimation of historic landings.
- Further investigate best practices for converting historical recreational landings from numbers to weight.

Research Recommendations Continued

Recreational CPUE indices

- Additional research is needed to investigate if assumptions are appropriate across full time series (e.g., targeting, trip length, effects of various regulations, red snapper).

Natural mortality

- Explore ways to better reflect uncertainty about the mortality at age vector.

Red Tide and other sources of episodic mortality

- Continue to improve the way red tide mortality is modeled inside SS (e.g., extending the blocks-on-M method to older ages, including a vector of biomass loss), explore whether additional historical red tide years should also be modelled, and investigate other potential sources of episodic mortality (e.g. cold snaps) on the Gulf of Mexico Gag Grouper population.

Thank You