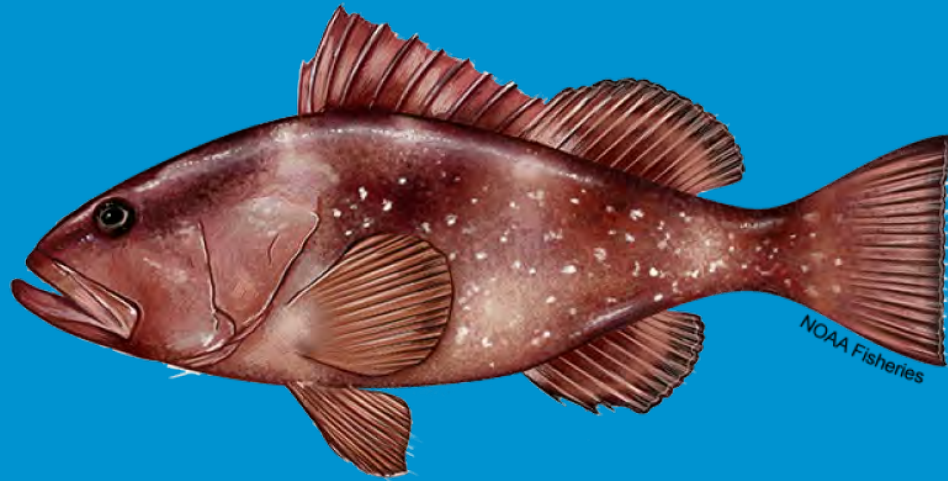




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SEFSC

Gulf Fisheries Branch



# SEDAR 88: Gulf of Mexico Red Grouper

Operational Assessment  
Gulf SSC Review

February 26, 2025

# Outline

- Overview
- Updates to data inputs
- Updates to model specification
- Results
- Diagnostics
- Sensitivity Runs
- Conclusions and Recommendations
- Benchmarks, Stock Status and Projections



# Overview



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# ToRs

- Two Topical Working Groups:
  - Florida's State Reef Fish Survey (SRFS) data
    - October 2023
    - March 2024
  - Red Tide Mortality
    - November 2023
    - January, May and November 2024
    - January 2025



# SEDAR

*SouthEast Data, Assessment, and Review*

4055 Faber Place Drive #201  
North Charleston SC 29405

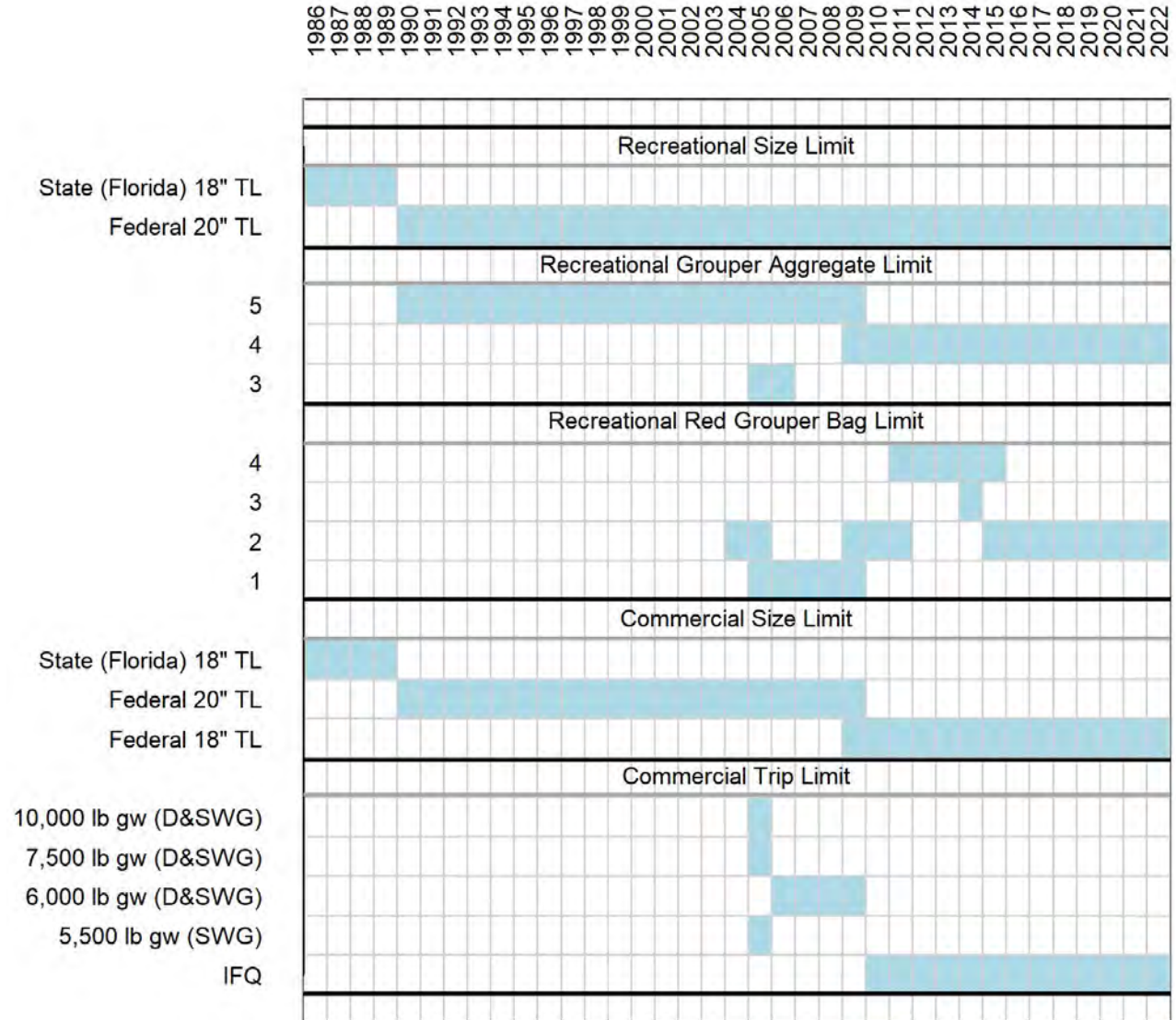
Phone (843) 571-4366  
Fax (843) 769-4520  
www.sedarweb.org

## **SEDAR 88 Gulf of Mexico Red Grouper Operational Assessment Terms of Reference April 2023**

1. Update the approved SEDAR 61 Gulf of Mexico red grouper base model with data through 2022.
  - Use the State of Florida's State Reef Fish Survey (SRFS) to inform private recreational landings data, if historical SRFS landings have been calibrated and SRFS has been certified by the NOAA Office of Science and Technology.
  - Document any changes or corrections made to model and input datasets and provide updated input data tables.
  - Update life history data (e.g., growth, reproduction, mortality) if warranted.
  - Provide a means to model projected discards in a manner that relaxes the assumption that discards would increase/decrease in proportion to changes in the landings.
  - Consider the treatment of recreational harvest:
    - Consider inputting recreational catch in weight (i.e., pounds) instead of in numbers of fish.
    - Re-evaluate error estimates for recreational landings.
    - Explore the effects of the changes in the mean weight estimation procedure between SEDAR 61 and the 2021 red grouper interim analysis
      - If using numbers of fish as the input unit for recreational catch, compare the mean weights estimated by the model with that reported by the SERO ACL Monitoring Dataset, or explore fitting to the SERO mean weights.
2. Explore the potential effects of red tide with consideration of past red tide events, and more recent events in 2018 and thereafter. Explore age-specific episodic mortality of red grouper due to red tide.

# Management

- Time blocks in model to account for changes in regulations
- Commercial:
  - 1986-1989: Florida size limit
  - 1990-2009: State and Federal size limits
  - 2010-2022: IFQ period
- Recreational:
  - 1986-1989: Florida size limit
  - 1990-2022: Federal size limit



# Working Papers

Document #	Title	Authors
SEDAR88-WP-01	Headboat Data for Red Grouper in the US Gulf of Mexico	Robin T. Cheshire, Kenneth Brennan, and Matthew E. Green
SEDAR88-WP-02	General Recreational Survey Data for Red Grouper in the Gulf of Mexico	Matthew A. Nuttall and Samantha Binion-Rock
SEDAR88-WP-03	Commercial Landings of Gulf of Mexico Red Grouper ( <i>Epinephelus morio</i> ) from 1986-2022	Micki Pawluk and Sarina Atkinson
SEDAR88-WP-04	CPUE Expansion Estimation for Commercial Discards of Gulf of Mexico Red Grouper ( <i>Epinephelus morio</i> )	Sarina Atkinson & Kevin Thompson
SEDAR88-WP-05	Proxy Discard Estimates of Red Grouper ( <i>Epinephelus morio</i> ) from the US Gulf of Mexico Headboat Fishery	Matthew A. Nuttall
SEDAR88-WP-06	Gulf of Mexico Red Grouper ( <i>*Epinephelus morio*</i> ) length and age compositions from the recreational fishery	Samantha M. Binion-Rock
SEDAR88-WP-07	Size and age information Red Grouper, <i>Epinephelus morio</i> , collected in association with fishery-dependent projects along Florida's Gulf of Mexico coast	Maria McGirl, Jessica Carroll, and Bridget Cermak
SEDAR88-WP-08	Descriptions of Florida's Gulf of Mexico Red Grouper Recreational Fishery Assessed Using Fishery-Dependent Survey Data	Maria McGirl
SEDAR88-WP-09	Gulf of Mexico Red Grouper ( <i>Epinephelus morio</i> ) Commercial Landings Length and Age Compositions	Michaela Pawluk
SEDAR88-WP-10	Standardized Catch Per Unit Effort for Gulf of Mexico Red Grouper from the Southeast Region Headboat Survey	Matthew A. Nuttall, Kevin Thompson, and Michaela Pawluk

# Working Papers Cont.

Document #	Title	Authors
SEDAR88-WP-11	A Review of the Gulf of Mexico Red Grouper ( <i>Epinephelus morio</i> ) Age-Length Data, 1978-2022	Chris Palmer, Laura Thornton, Steve Garner, and Beverly Barnett
SEDAR88-WP-12	An Index of Relative Abundance for Red Grouper Captured During the NMFS Bottom Longline Survey in the Northern Gulf of Mexico	Adam G. Pollack, Kristin Hannan, William Driggers, and David S. Hanisko
SEDAR88-WP-13	Red Grouper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack and David S. Hanisko
SEDAR88-WP-14	Electronic Monitoring Documentation of Red Grouper ( <i>Epinephelus morio</i> ) in the Eastern Gulf of Mexico Bottom Longline Fishery	Max Lee, Katie Harrington, Carole Neidig, and Ryan Schloesser
SEDAR88-WP-15	A Summary of Gulf of Mexico Red Grouper Discard Length Data Collected from At-Sea Observers in Recreational Fishery Surveys in Florida	Ellie Corbett
SEDAR88-WP-16	Combined indices of abundance for Red Grouper ( <i>Epinephelus morio</i> ) in the eastern Gulf of Mexico using data from three historic video surveys and unified G-FISHER program	Justin P. Lewis, Heather M. Christiansen, Theodore S. Switzer, Sean F. Keenan, Kate E. Overly, Matthew D. Campbell
SEDAR88-WP-17	A ratio-based method for calibrating estimates of total landings (numbers and pounds of fish), releases (numbers of fish), and total trips from MRIP-FCAL to SRFS for Red Grouper ( <i>Epinephelus morio</i> ) in the Gulf of Mexico	Chloe Ramsay, Tiffanie A. Cross, Colin P. Shea, and Beverly Sauls

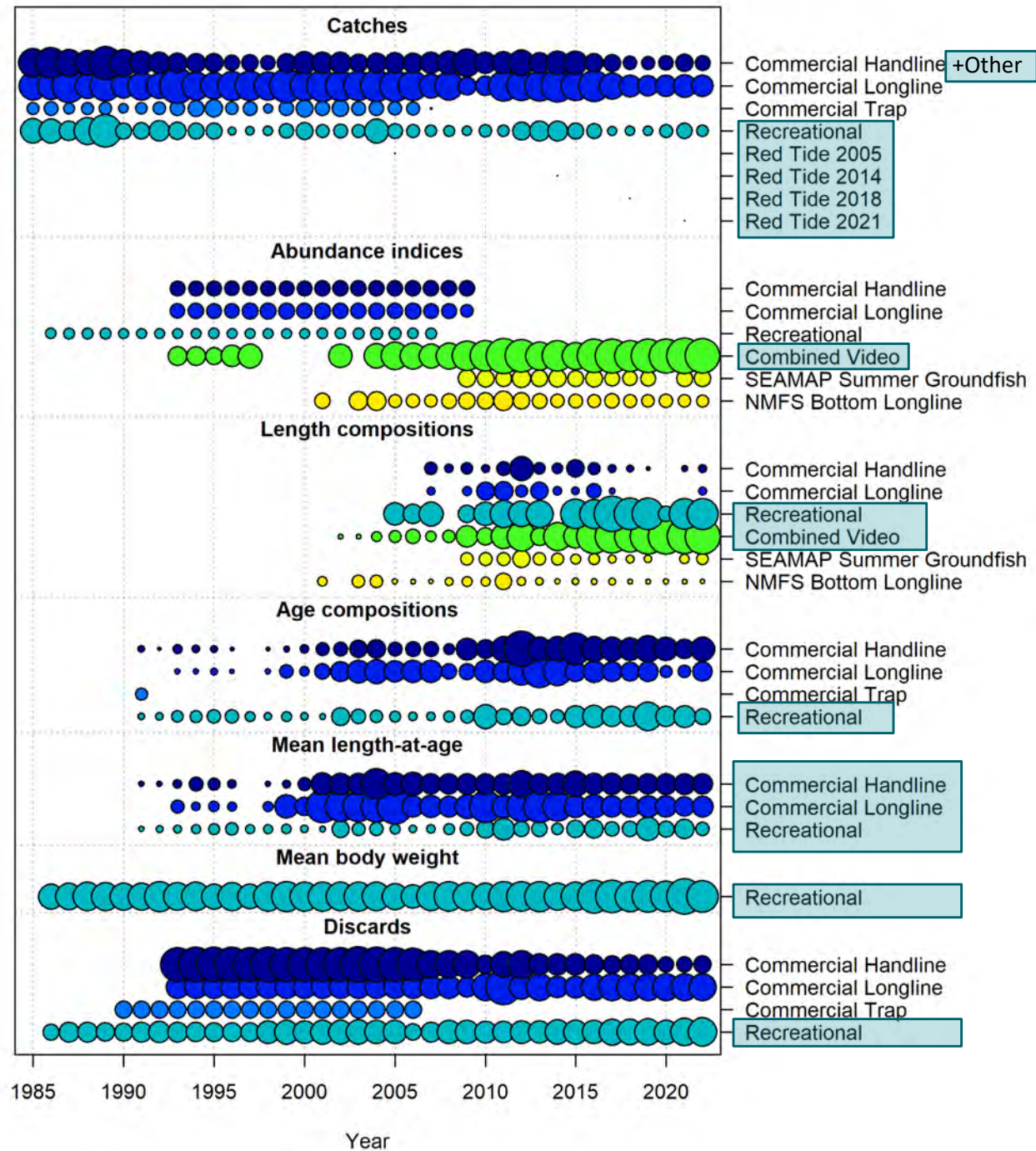
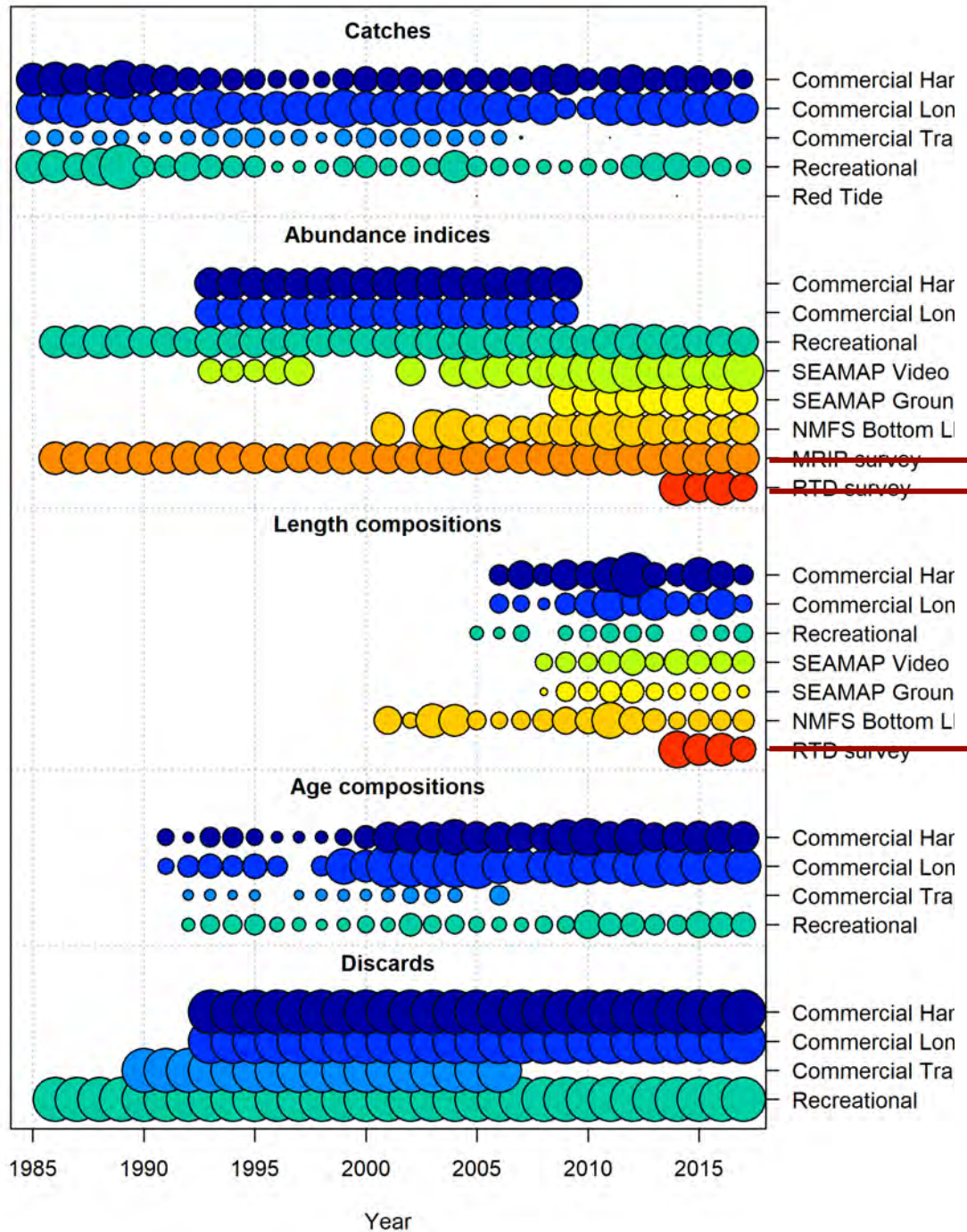


# SEDAR 88 Overview

Current best practice  
TORs

Notable **changes** compared with the SEDAR 61 Standard assessment model (TY 2017):

- Year specific **commercial and recreational landings and discards standard errors**
- Improved **commercial discards** using the catch per unit of effort (CPUE)-expansion approach
- Recreational landings and discards changed from Marine Recreational Information Program Fishing Effort Survey (**MRIP-FES**) to Florida's State Reef Fish Survey (**SRFS**) data (for private mode only)
- Updated **weighted age compositions** methodologies for both commercial and recreational compositions
- Fit to **mean weight of landings** for recreational fleet
- **Dirichlet-Multinomial** approach for age and length compositions
- Included **mean length at age** for three fishing fleets (lightly fit in model)
- Updated **combined video index**
- Removed **MRIP index** and **Repetitive Time Drop Survey**
- Updated **natural mortality** point estimate to current best practices
- **Age selectivity** for commercial handline, longline and recreational fleets
- **Asymptotic** longline selectivity
- Estimated **steepness**
- Estimated growth ( $L_{\infty}$  and  $K$ )
- Empirical **selectivity-at-age** for Red Tide years



# Data Review

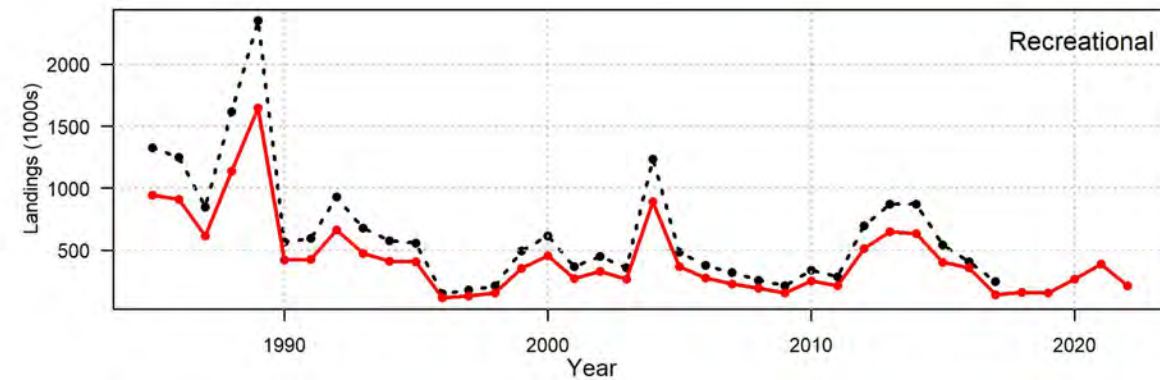
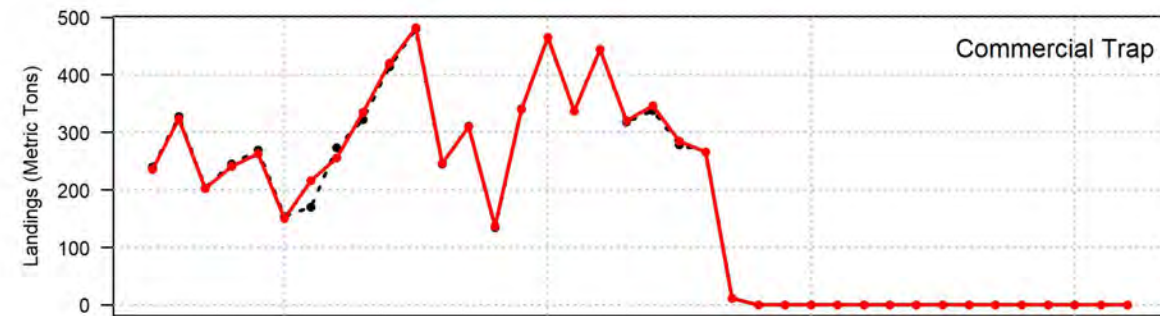
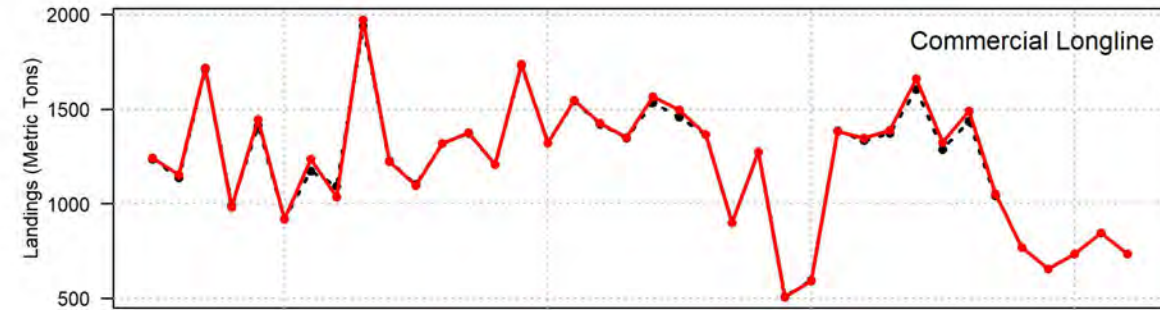
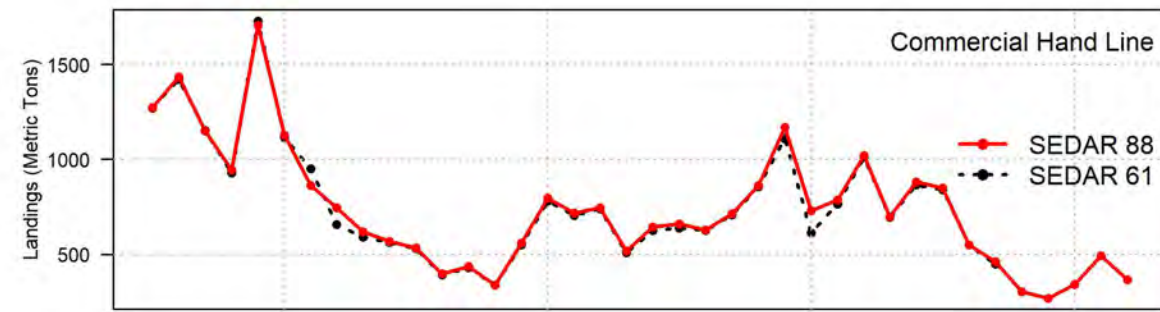
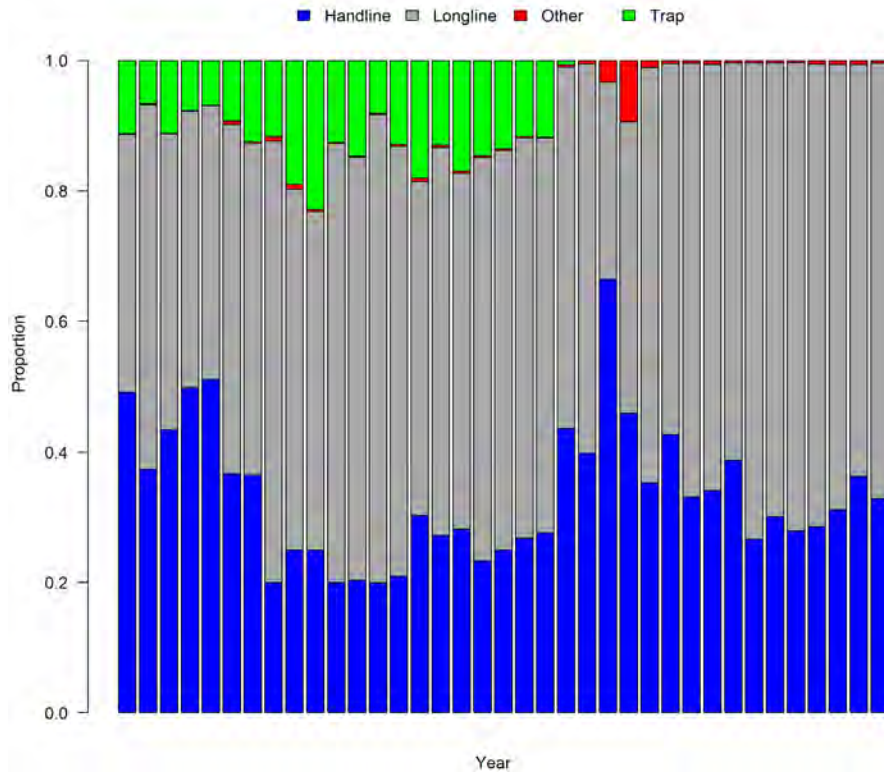


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# Landings

Notable change:

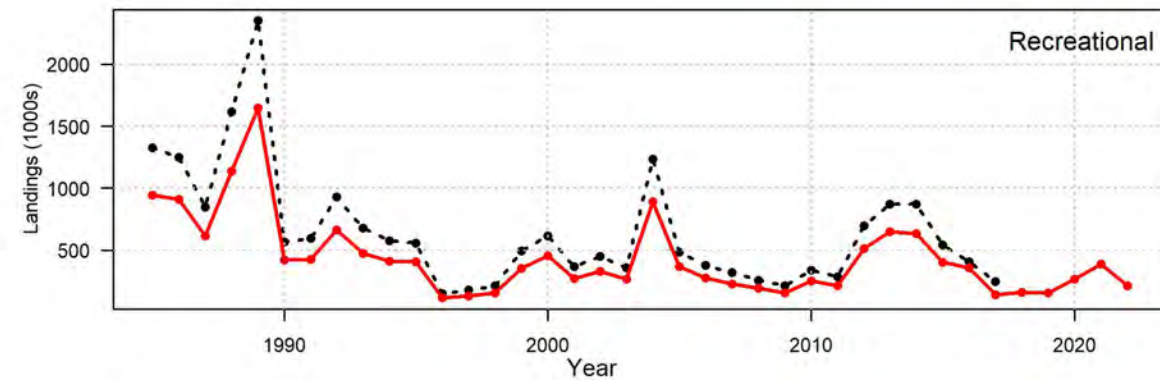
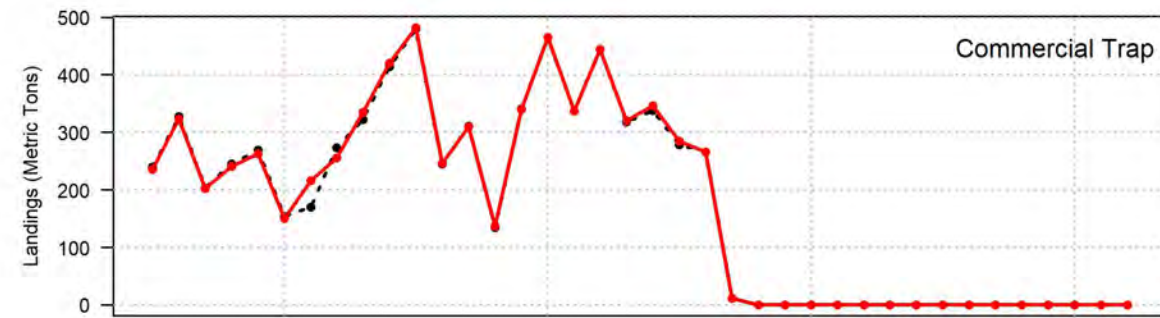
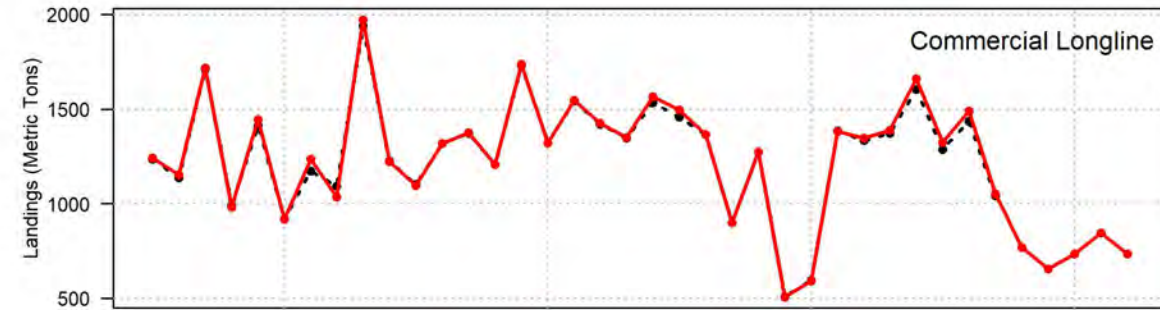
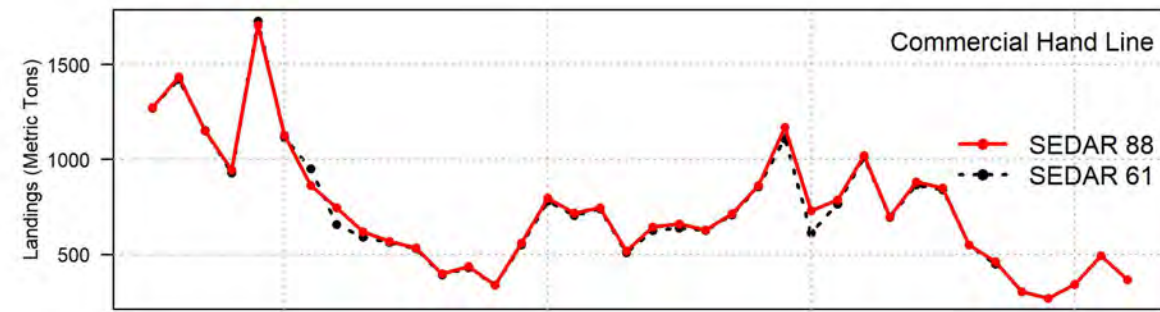
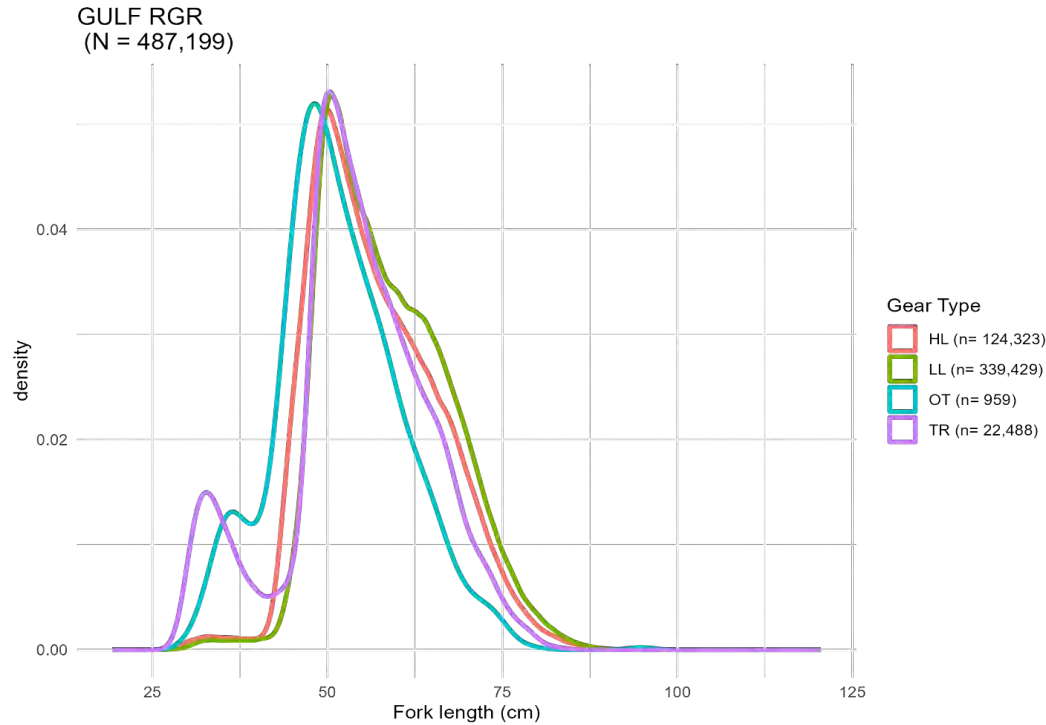
- S61 did not include 'Other' landings
- Added to Handline for S88



# Landings

Notable change:

- S61 did not include 'Other' landings
- Added to Handline for S88

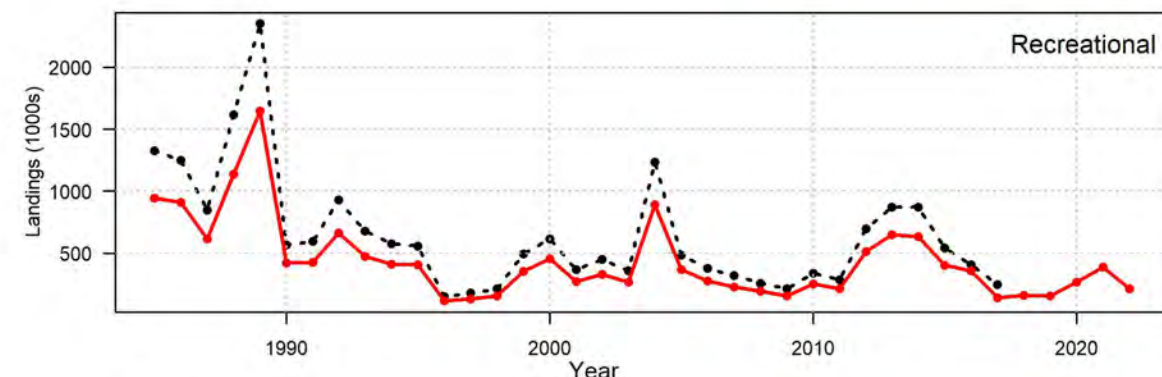
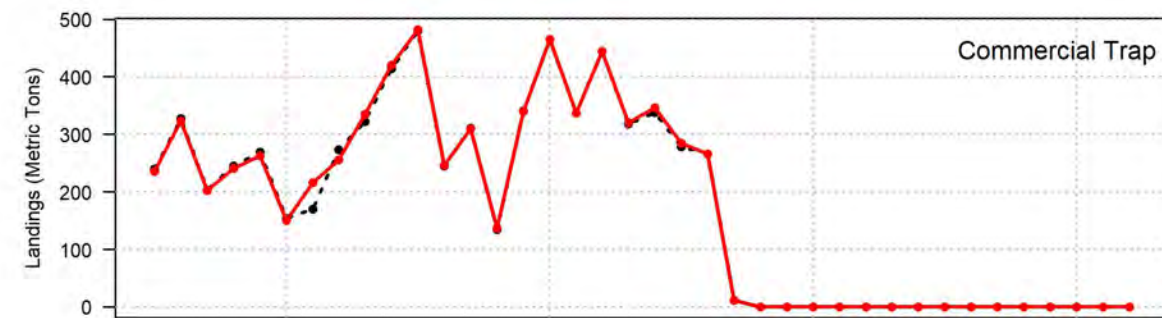
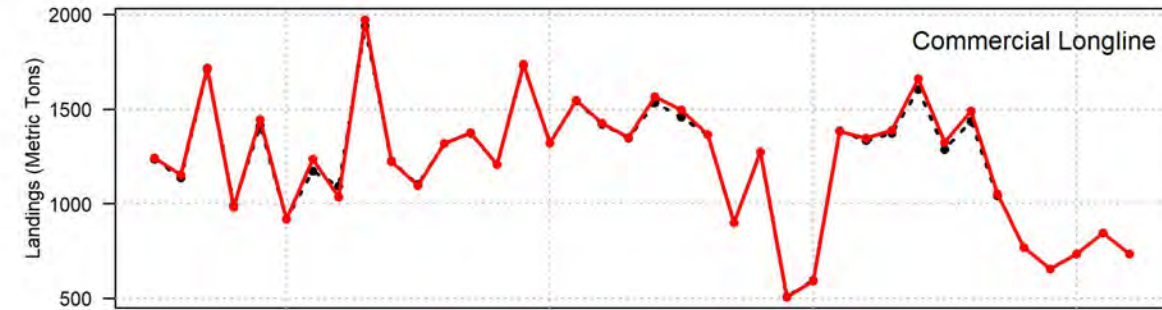
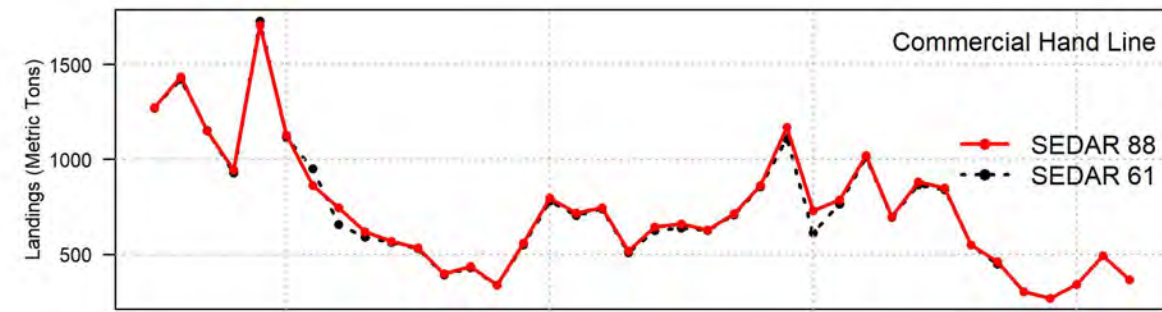


# Landings

Notable change:

- Some Gear Group designations changed between S61 and S88 ([WP-03](#))

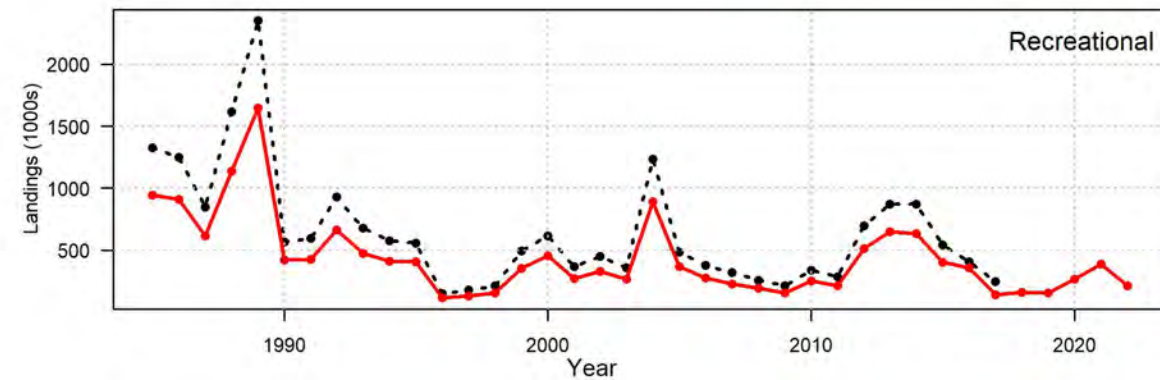
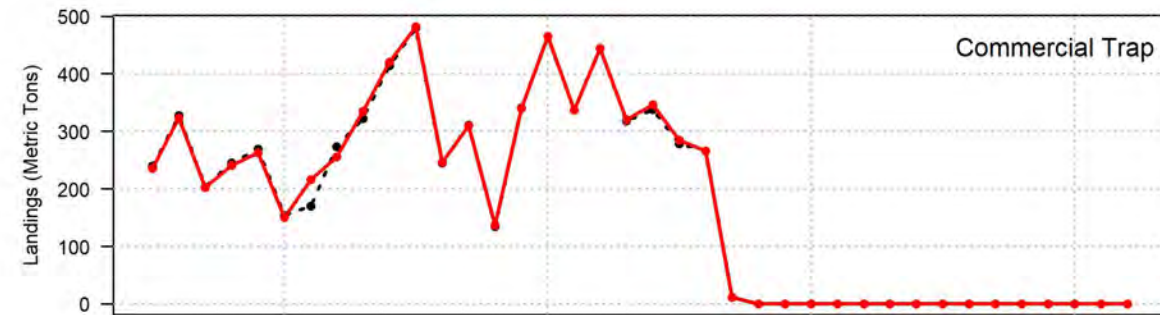
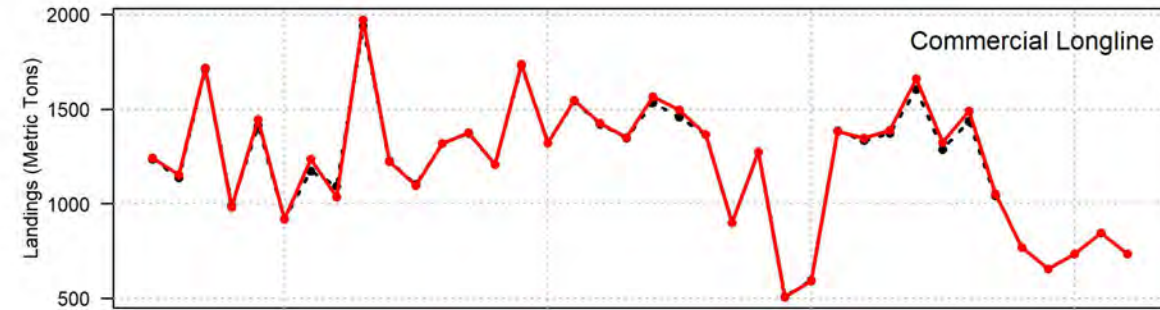
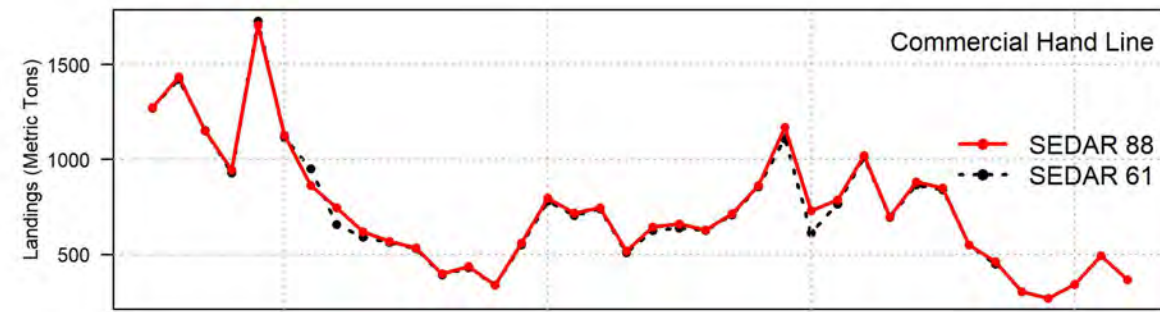
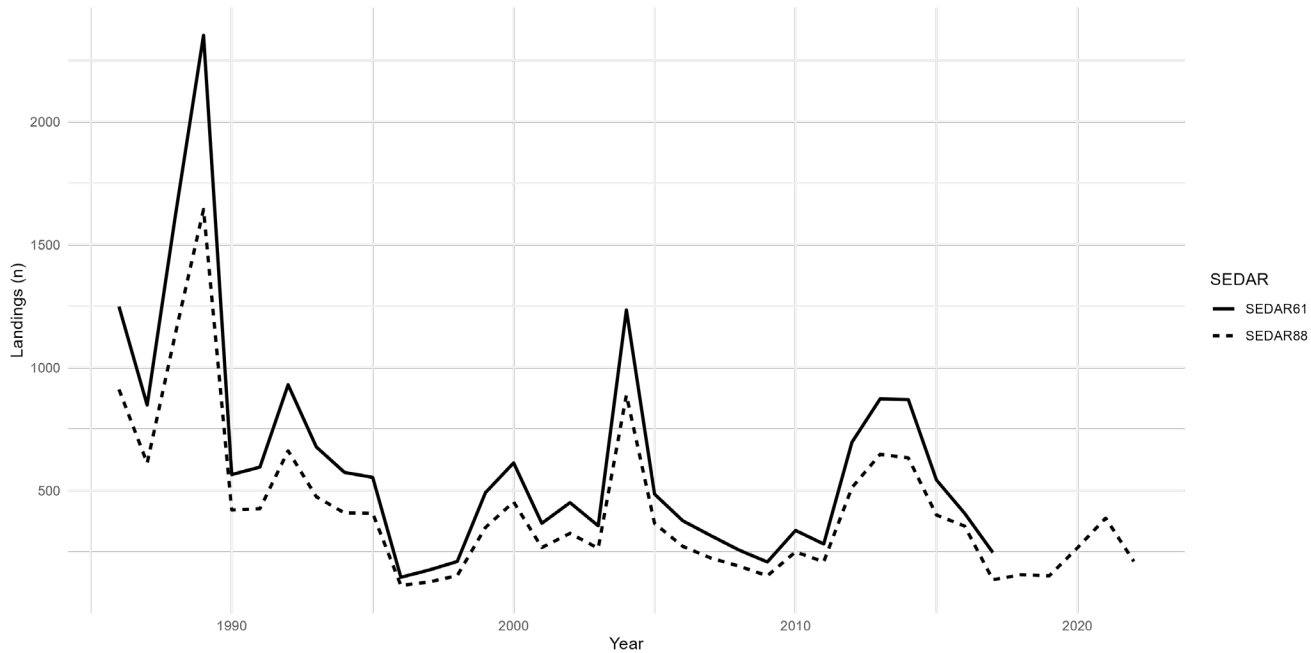
FIN Gear Code	FIN Gear Name	SEDAR 61 Gear Group	SEDAR 88 Gear Group
130	POTS AND TRAPS	Other	Trap
132	POTS AND TRAPS, BLUE CRAB	Other	Trap
145	POTS AND TRAPS, STONE CRAB	Other	Trap
164	POTS AND TRAPS, COLLAPSIBLE CRAB	Other	Trap
180	POTS AND TRAPS, OTHER	Other	Trap
320	TROLL LINES	Other	Handline
321	TROLL LINE, MANUAL	Other	Handline
322	TROLL LINE, ELECTRIC	Other	Handline
408	BUOY GEAR	Handline	Longline



# Landings

Notable change:

- SRFS replaced MRIP for Florida private mode landings estimates ([WP-17](#))

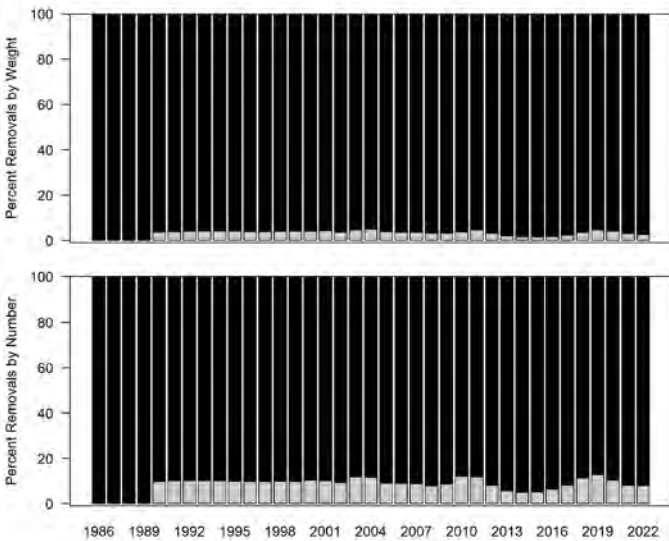


# Discards

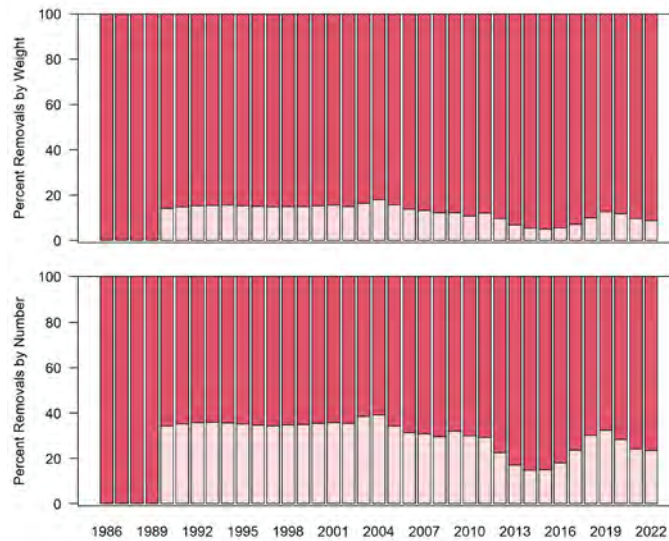
Notable change:

- CPUE expansion estimation methodology updated from SEDAR61 for commercial discards (WP-04)

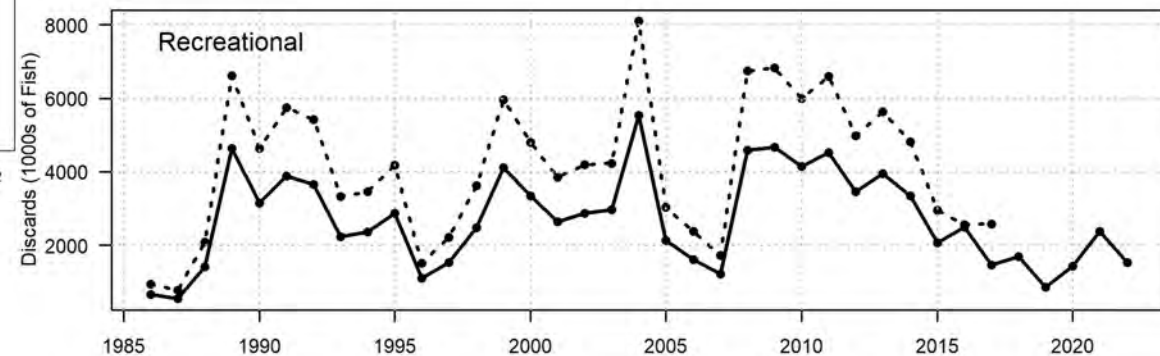
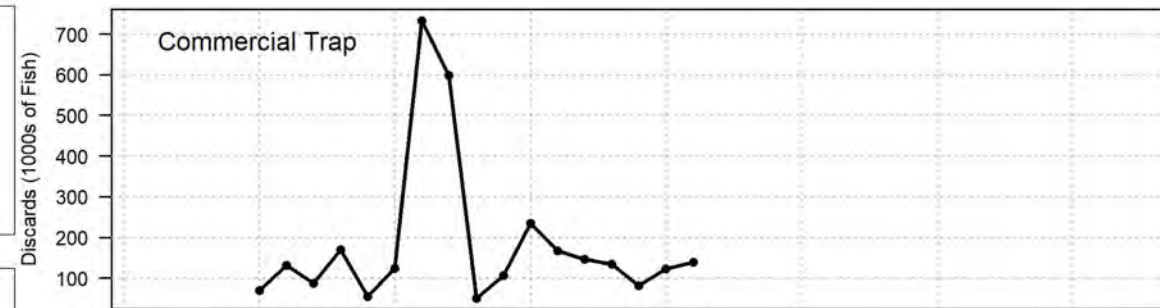
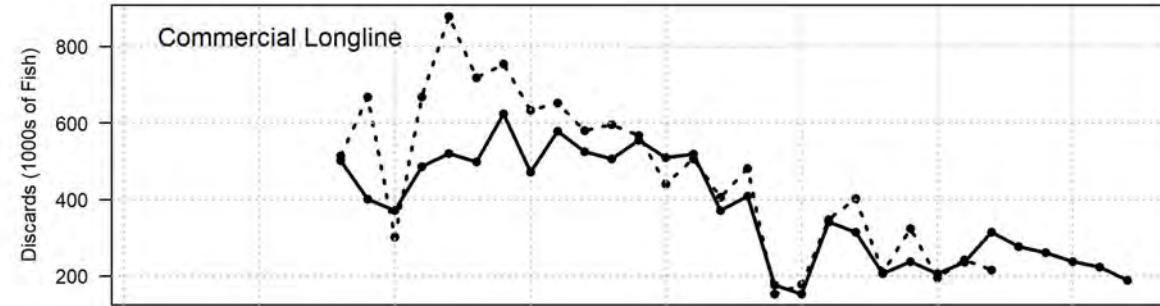
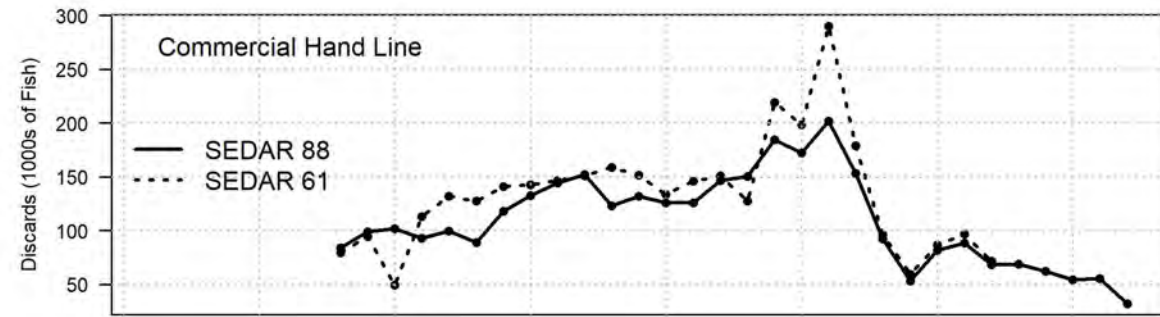
## Handline



## Longline



\* light colors = discards

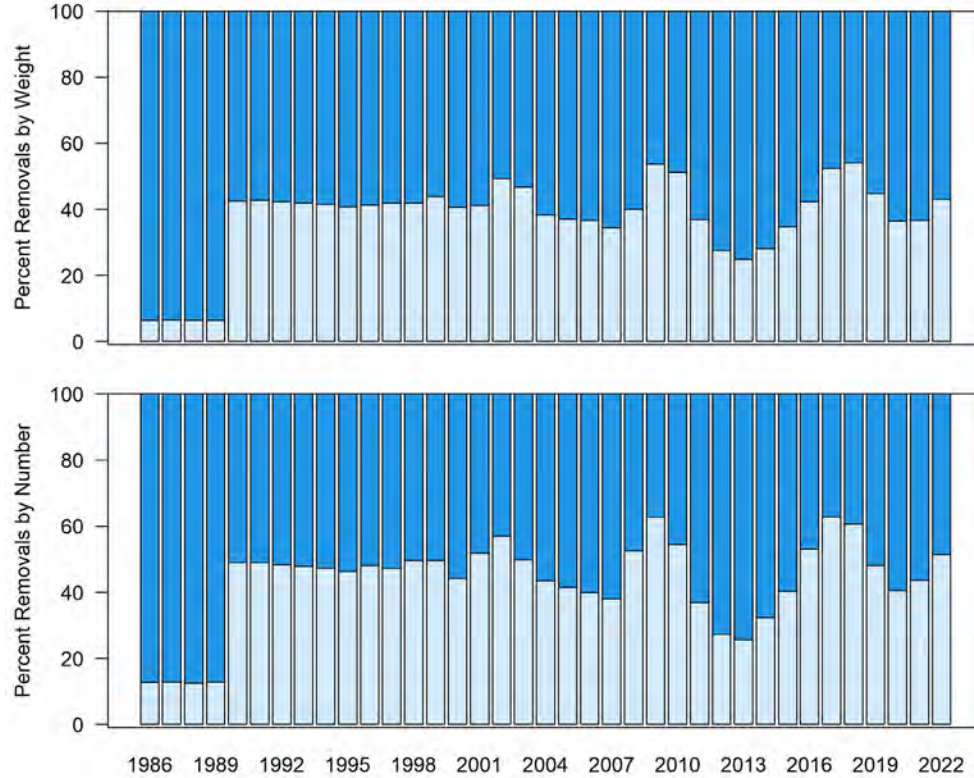


# Discards

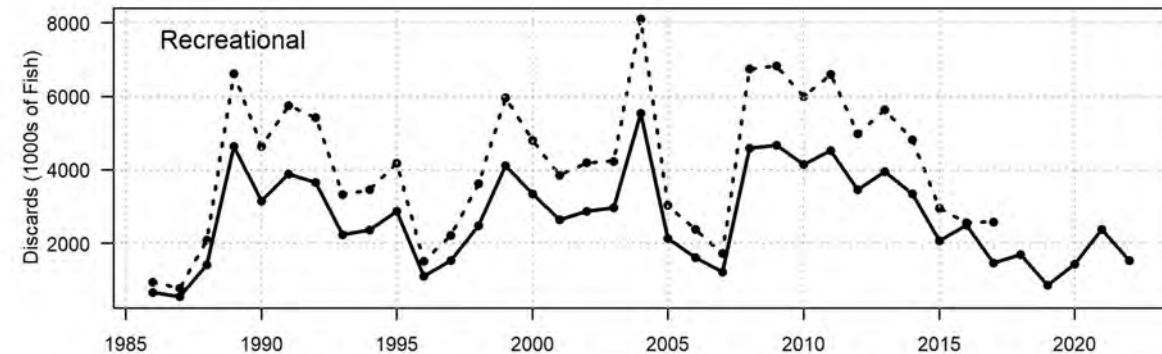
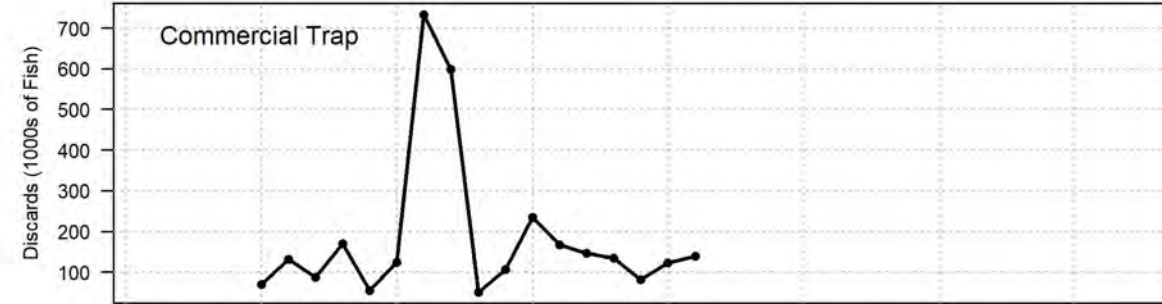
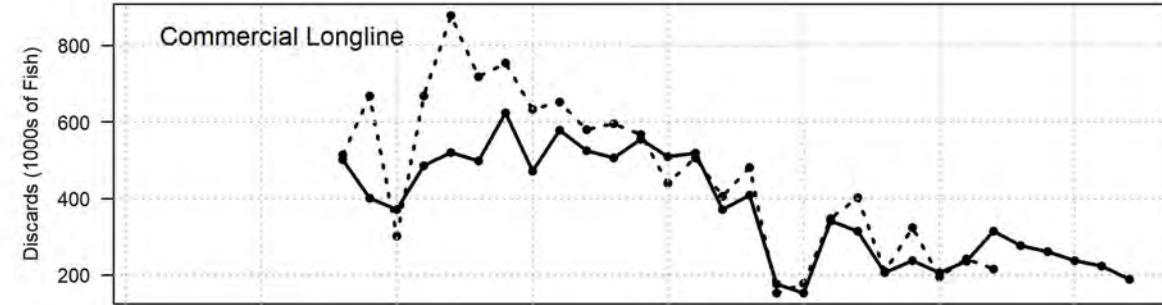
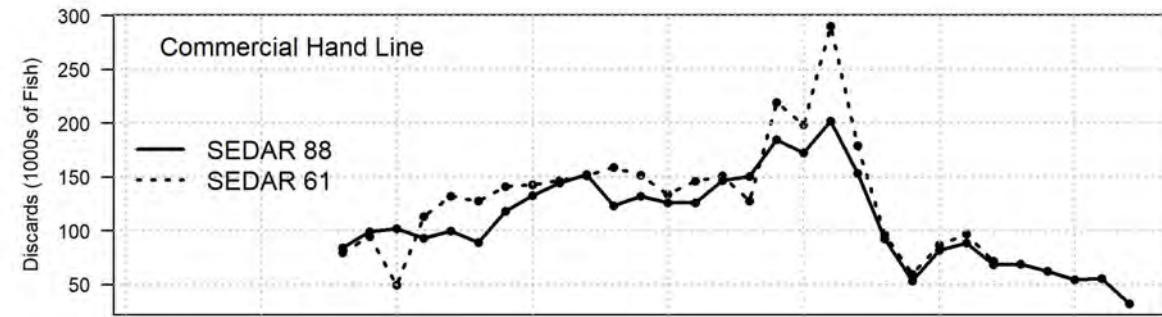
Notable change:

- SRFS replaced MRIP for Florida private mode discards estimates (**WP-17**)

## Recreational



\* lighter color = discards



# Landings: Uncertainties

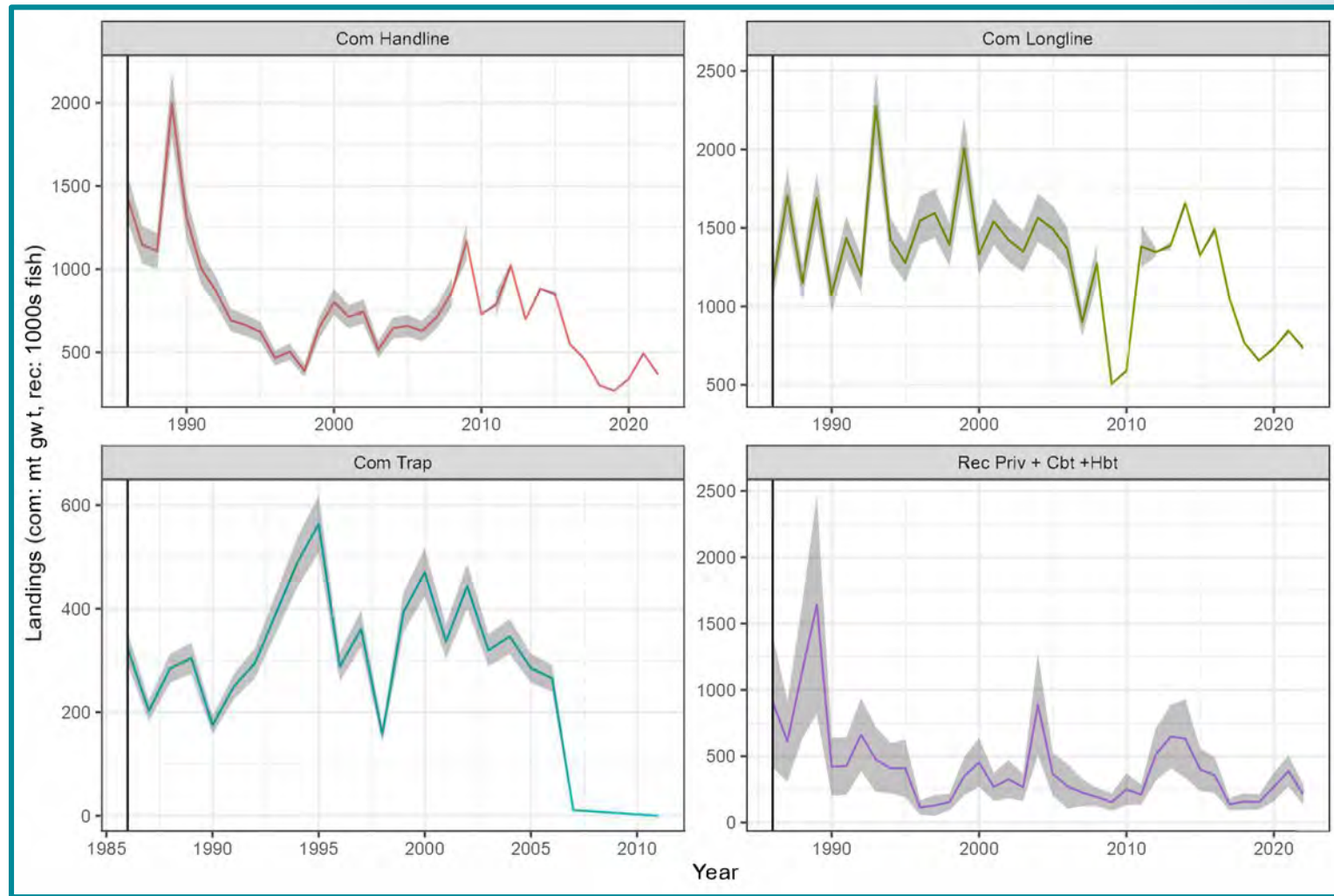
- Commercial Landings:
  - Year-specific obtained from expert opinion and IFQ program

Year	Texas	Louisiana	Mississippi	Alabama	Florida	Comments
1962-1976	0.2	0.2	0.2	0.2	0.2	Annual state summaries
1977-1985	0.1	0.1	0.1	0.1	0.1	Monthly state summaries
1986-1999	0.1	0.1	0.1	0.1	0.05	Florida starts state trip ticket, used in ALS 1986
2000-2001	0.1	0.05	0.1	0.1	0.05	Louisiana starts state trip ticket 1997; used in ALS 2000
2002-2009	0.1	0.05	0.1	0.05	0.05	Alabama starts state trip ticket, used in ALS 2002
2010-present	0.1	0.05	0.1	0.05	0.05	Deep Water Grouper IFQ starts 2010 (use 0.01 as done for scamp and gag)
2014-present	0.05	0.05	0.05	0.05	0.05	Texas (2008) and Mississippi (2012) state trip tickets begin; used in ALS 2014 [MS may change to 2015]

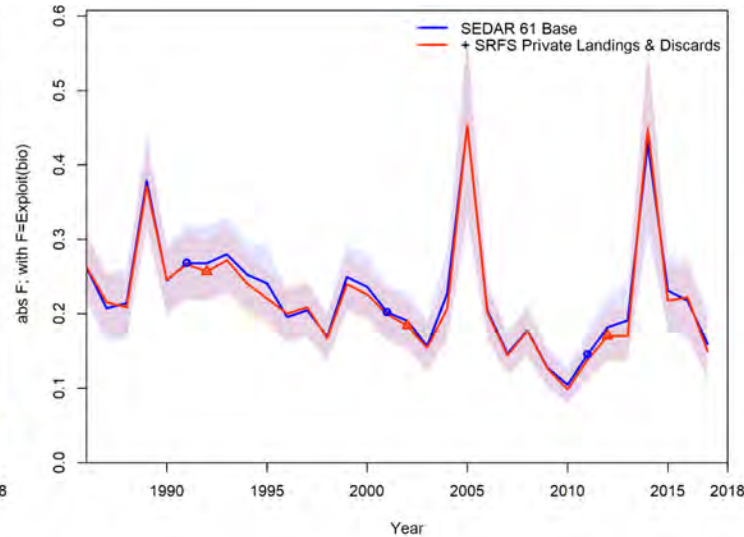
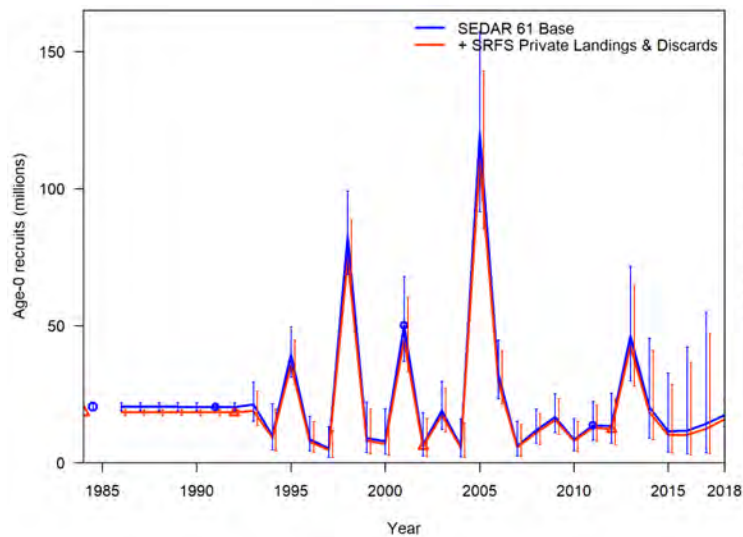
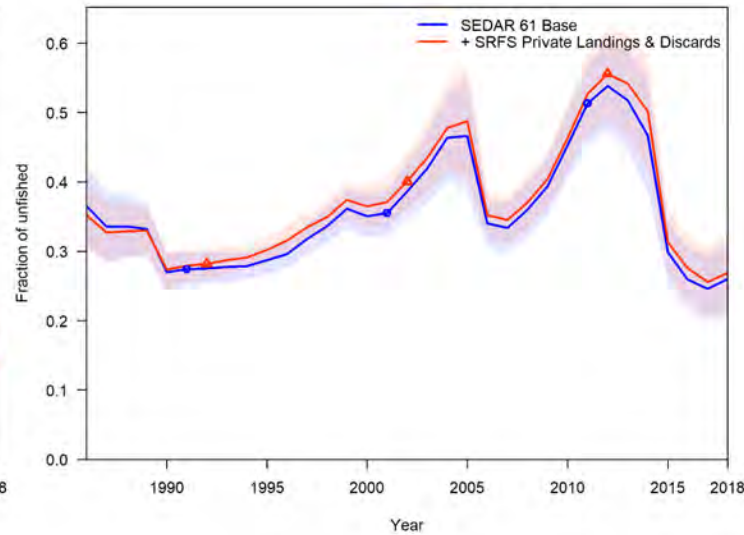
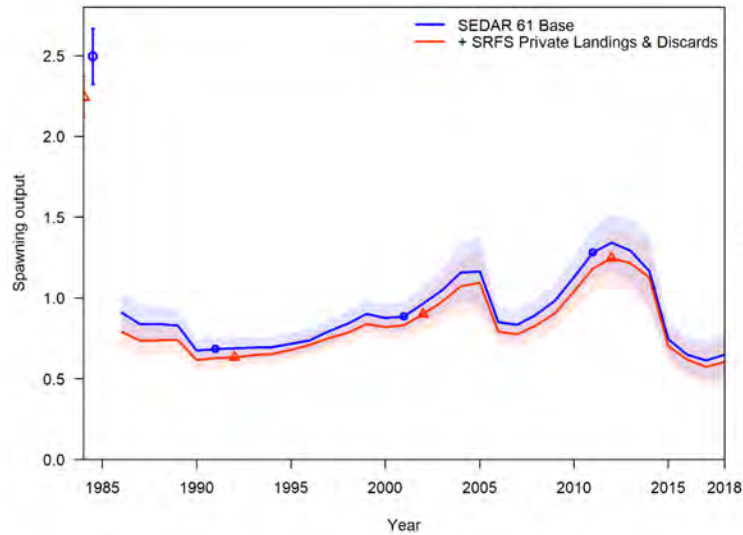


# Landings: Uncertainties

- Recreational Landings:
  - Constant SE of 0.3 used in S61
  - Yearly SEs available for AB1 (landings) for S88
  - Variance estimates from different modes/surveys additively combined using the Variance Sum Law
- Overall:
  - Commercial SE decreased from S61 (SE = 0.15)
  - Recreational yearly SEs decreased from 0.3



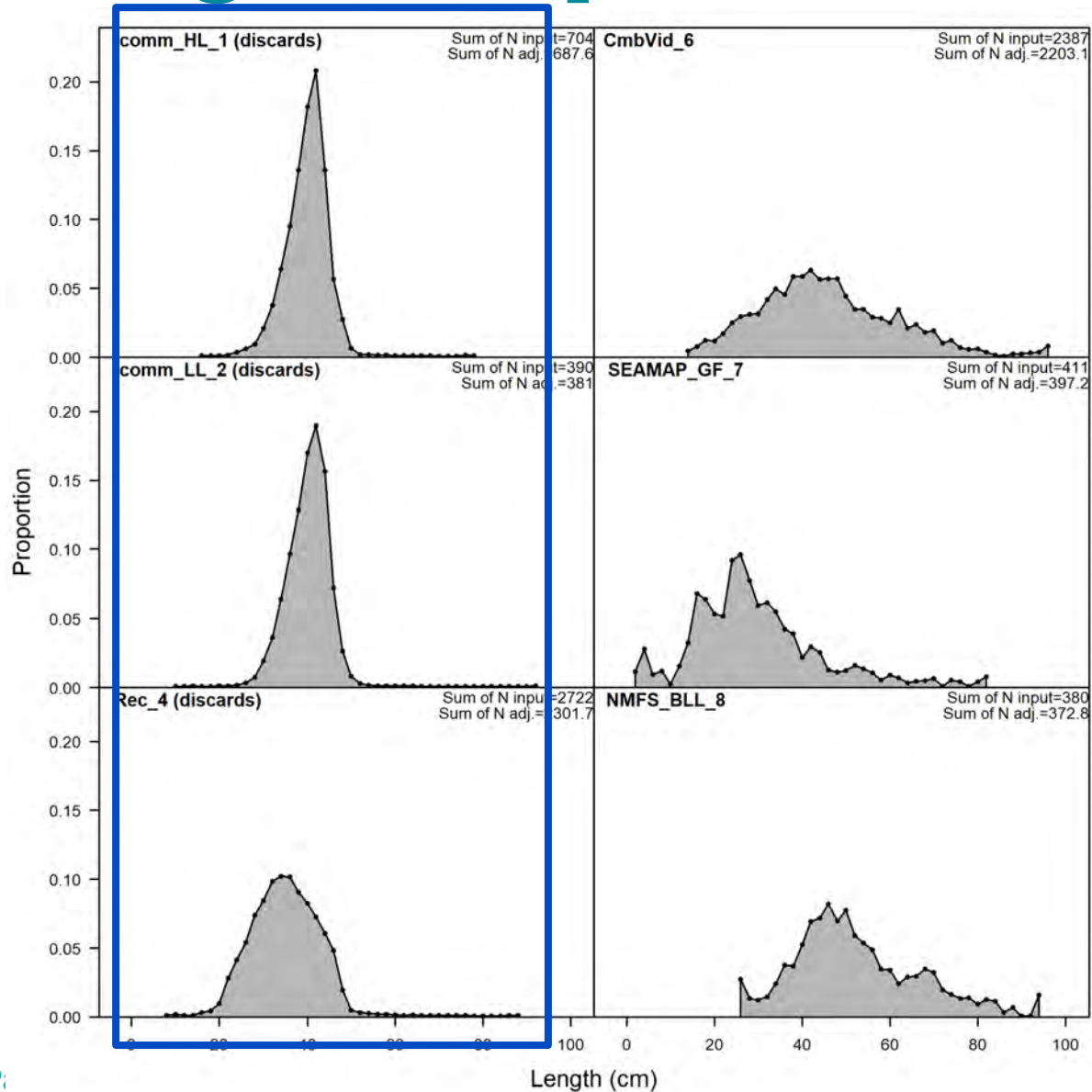
# Effects of Data Changes: SRFS



- Recreational landings and discards replaced with SRFS data for Florida private mode estimates
- Length and age compositions not updated in these plots



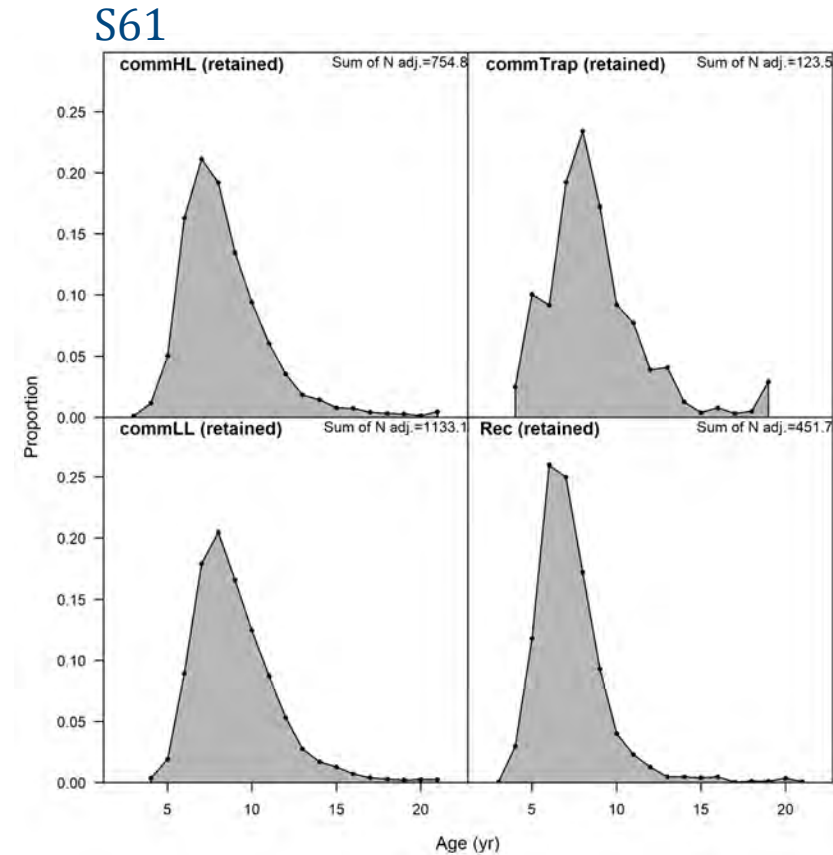
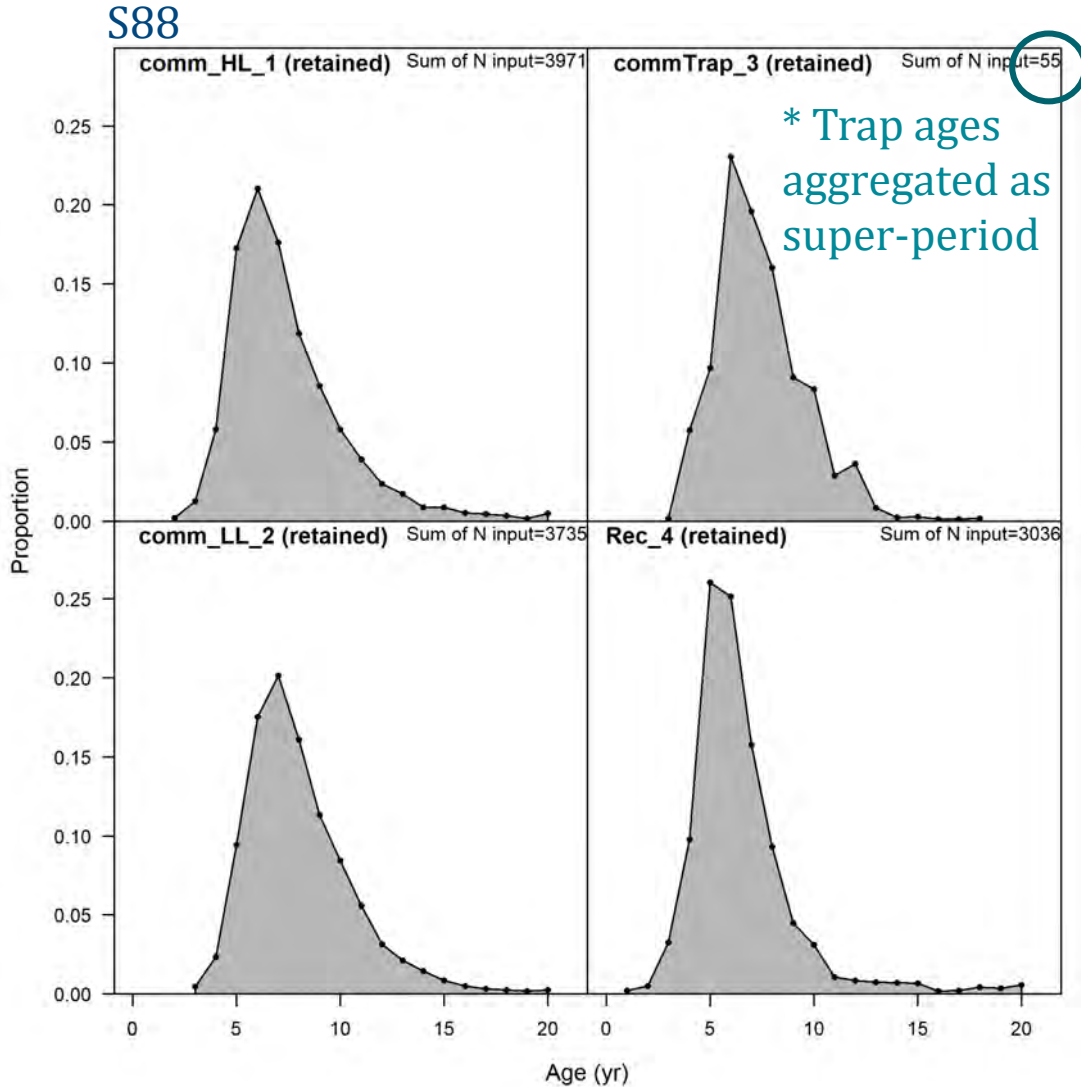
# Length Compositions



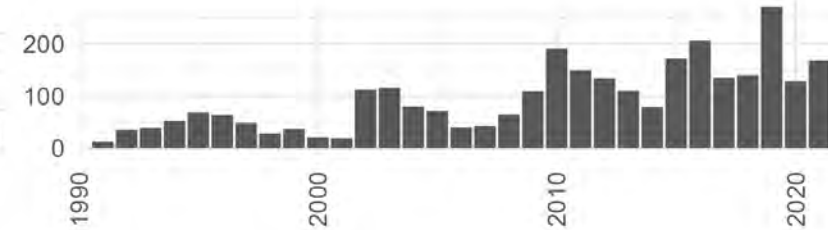
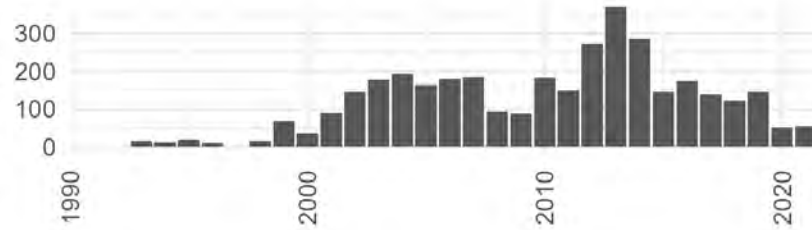
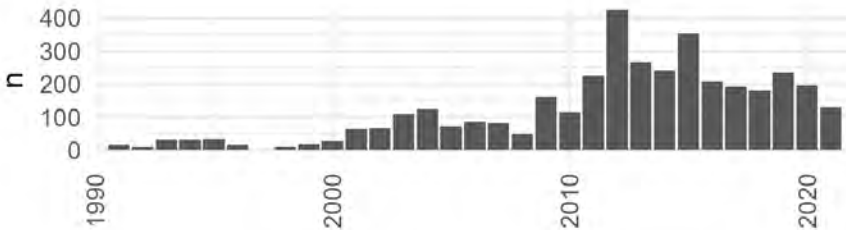
- Compositions for landings (retained) used to weight age compositions
- Length composition for **fleets** represent discards
- For S61, sample sizes =  $\sqrt{\text{number of fish}}$  with Francis re-weighting
- For S88, sample sizes = number of trips/stations with Dirichlet-multinomial re-weighting

# Age Compositions

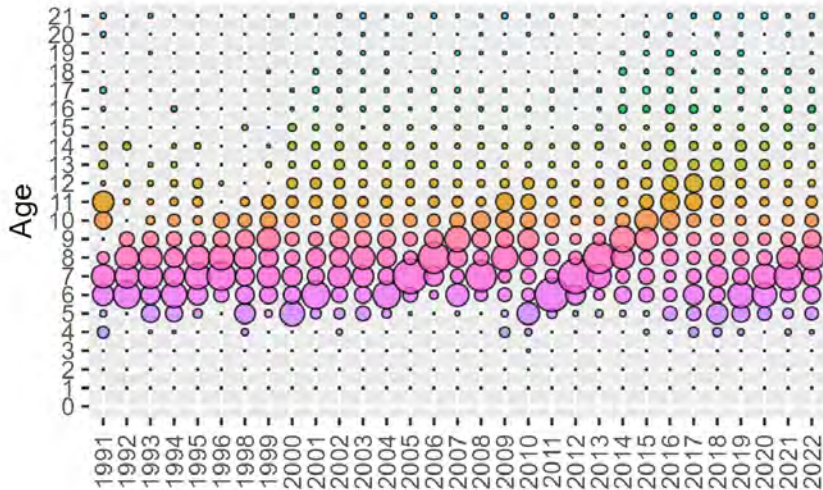
- Weighted age compositions for retained fish
- Weighting methodology updated from S61
- For S88, number of trips/stations with Dirichlet-multinomial re-weighting



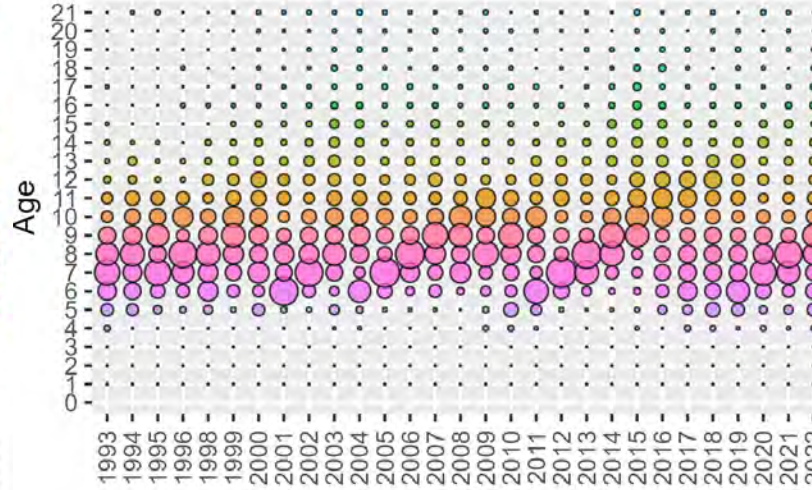
# Age Compositions



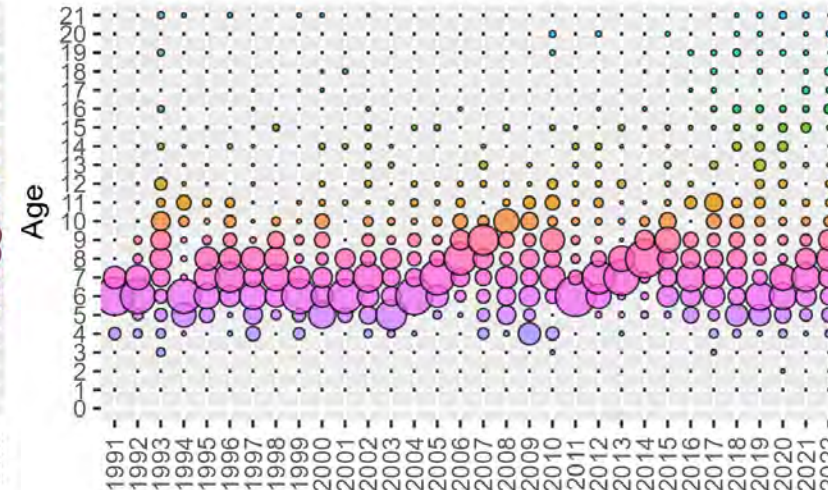
Commercial Handline



Commercial Longline



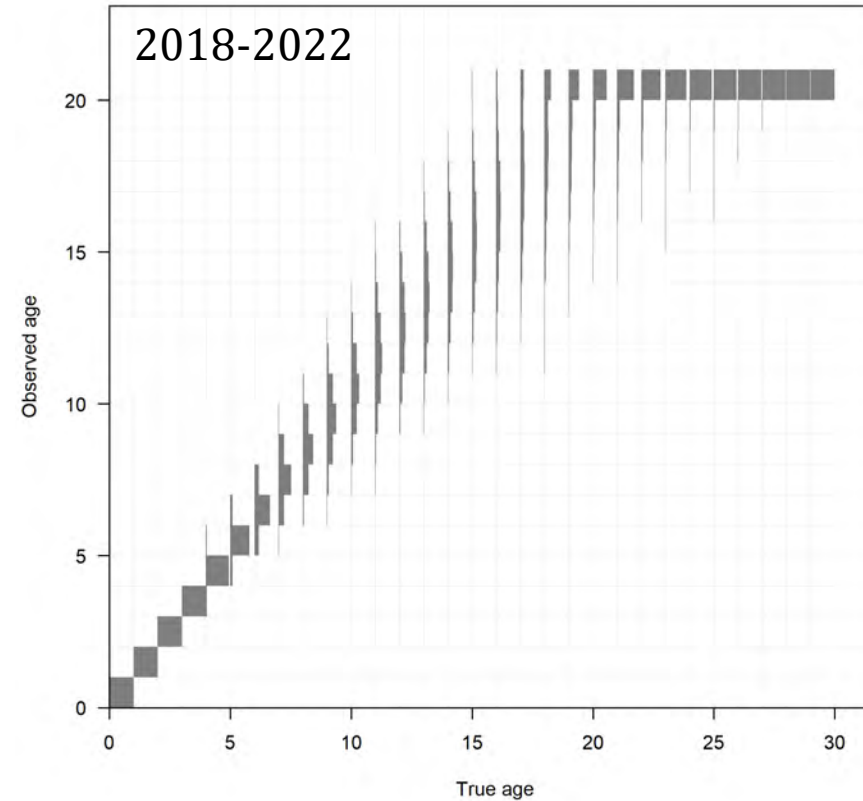
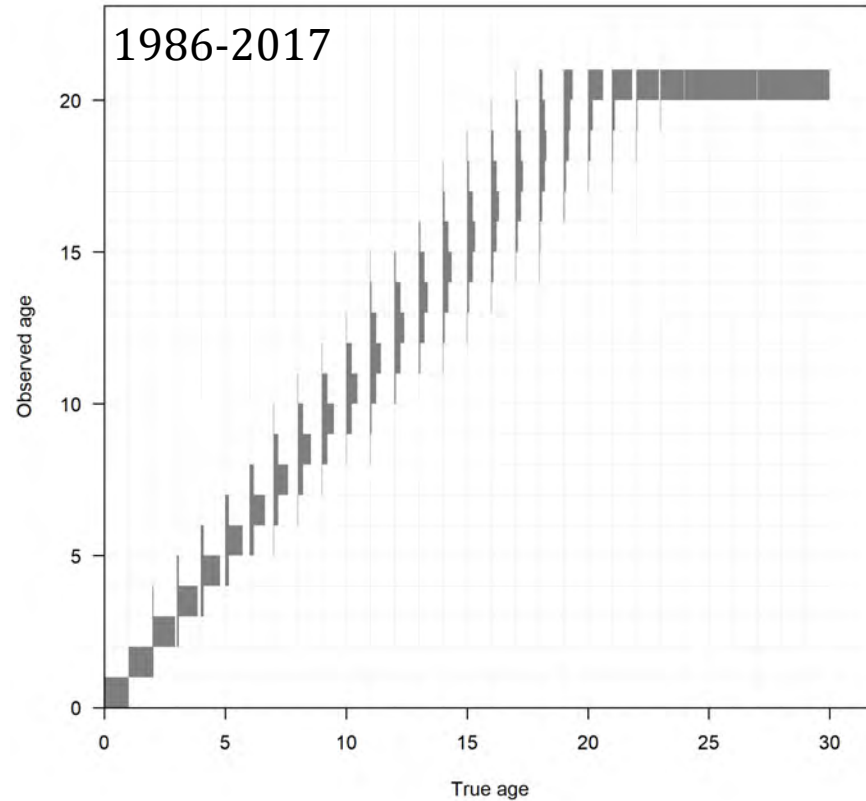
Recreational



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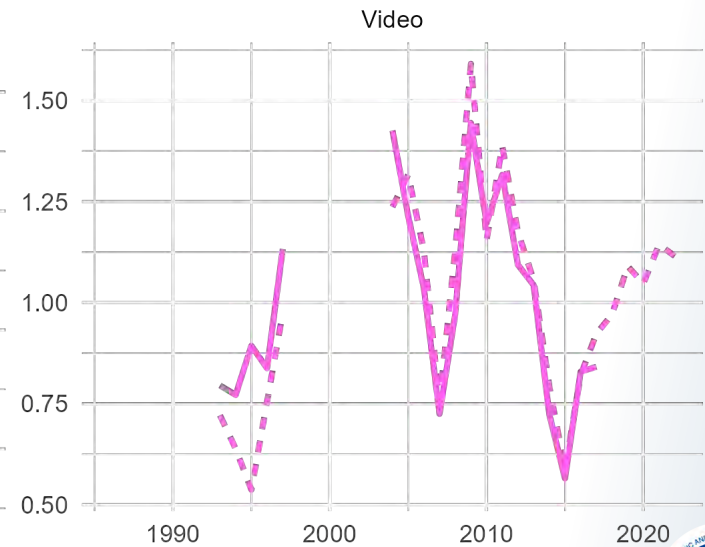
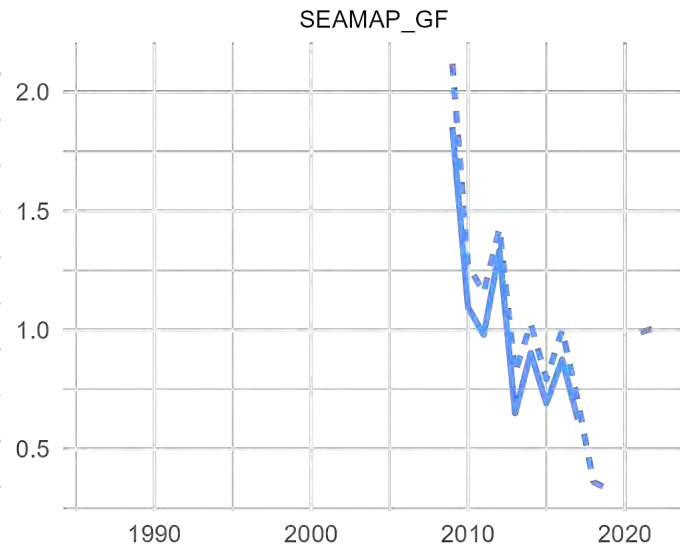
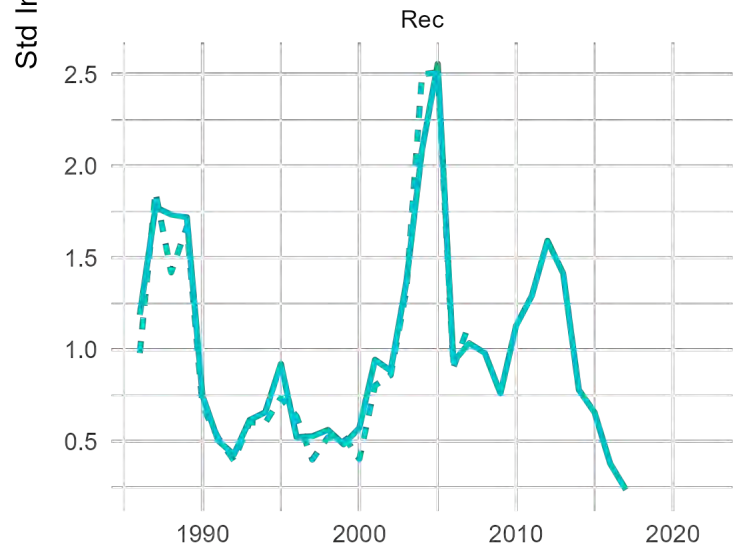
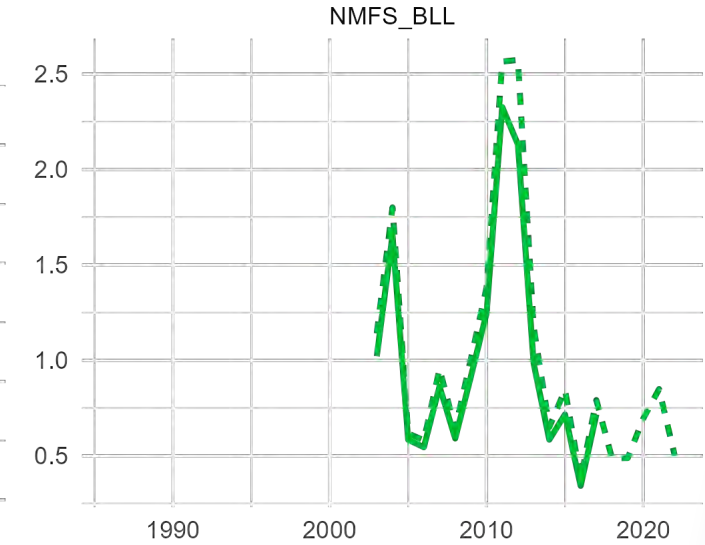
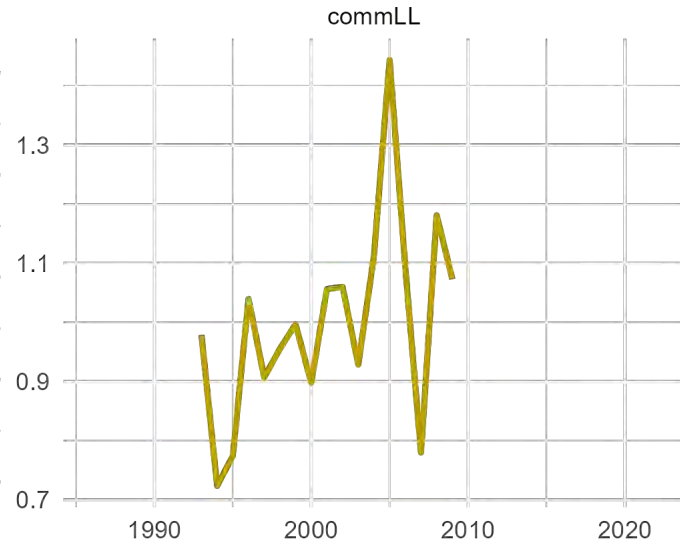
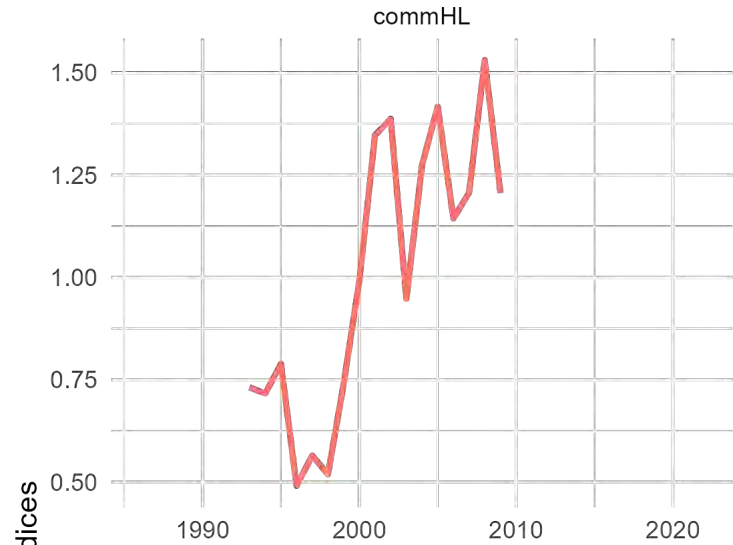
# Aging Error Matrix

- Accounts for aging error between readers
- Second matrix applied to recent age compositions



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# Indices



SEDAR  
— SEDAR61  
- - SEDAR88



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# Indices

- Notable changes:
  - MRIP index dropped as it does not adequately track population abundance due to:
    - changes in regulations and targeting
    - advances in fishing technology (Fitzpatrick and Williams, 2021)
  - FWRI RTD Survey dropped as no longer in operation
  - Southeast Regional Headboat Survey truncated to end in 2007
    - Influence of switch to circle hooks on catchability ([WP-10](#))
    - Regulatory changes since 2007 have likely changed fishing behavior
  - Combined Video Survey
    - Updated methodology to integrate three surveys ([WP-16](#)) to G-FISHER survey
  - SEDAR61 scaled all indices to have a mean SE to 0.3



# Combined Video Survey

- Habitat-based approach to combining relative abundance data (WP-16)
- G-FISHER survey 2020 start

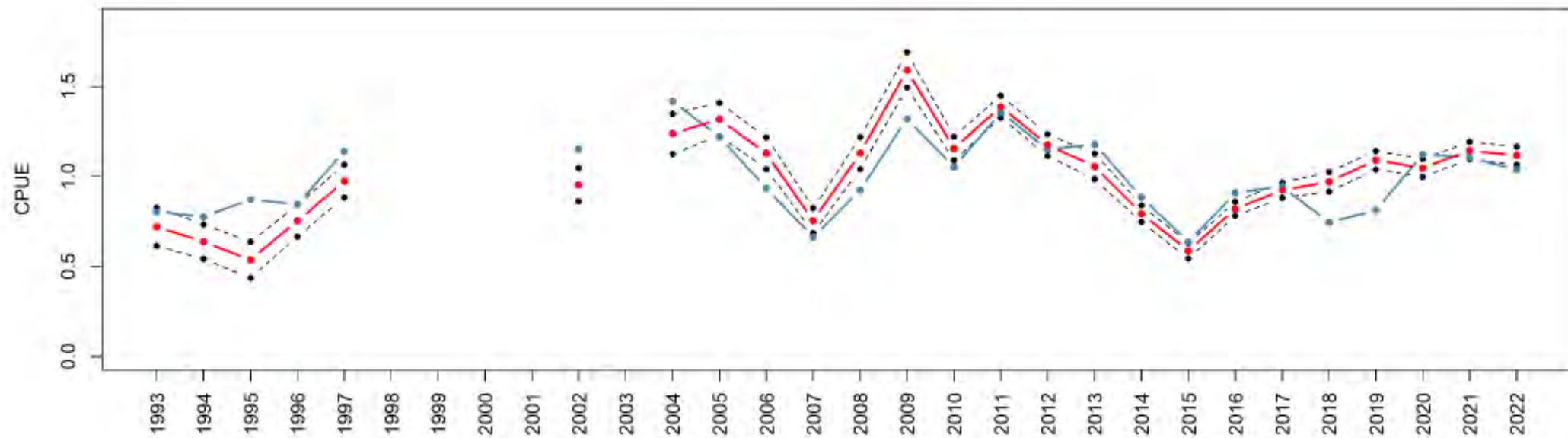
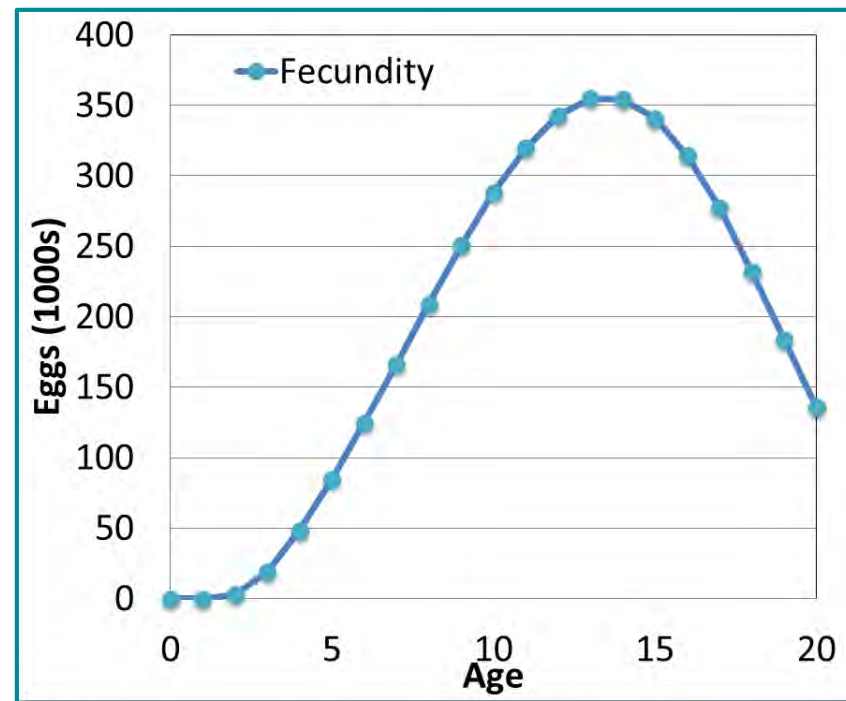


Figure 10. Standardized index of abundance (solid red line) with 2.5% and 97.5% confidence intervals (black dotted lines) and nominal CPUE (solid blue line) for Red Grouper in the eastern Gulf of Mexico.

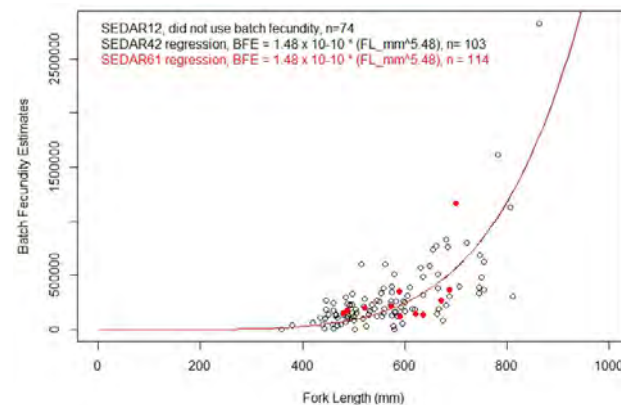
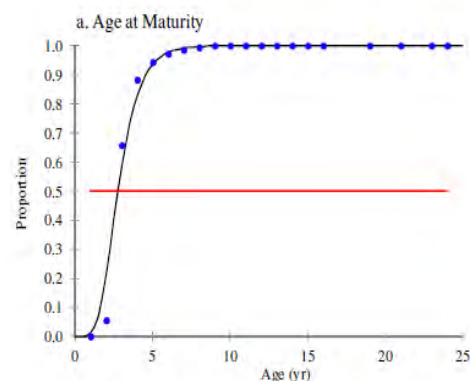
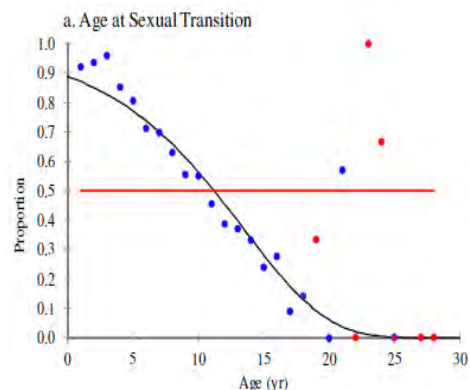
# Fecundity

- Unchanged from S61
- Fecundity vector fixed in SS
- Female SSB in relative number of eggs, not absolute number of eggs



Per Capita Fecundity =

proportion female  $\times$  proportion mature  $\times$  batch fecundity at age (\*converted from length)



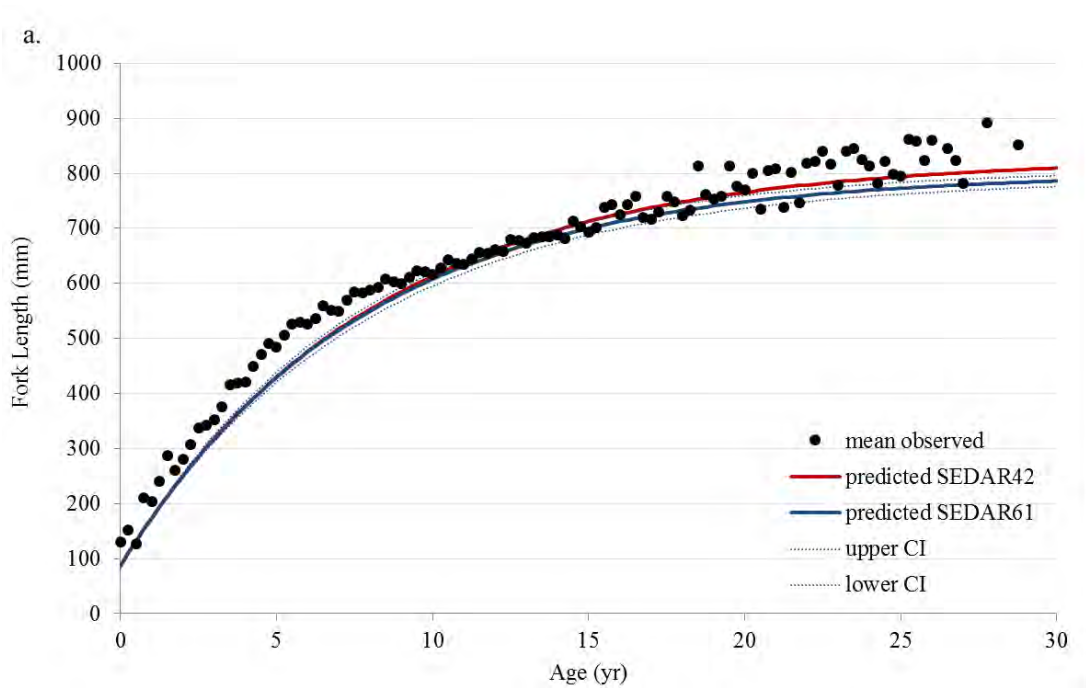
NOAA  
FISHERIES

# Updates to model specification

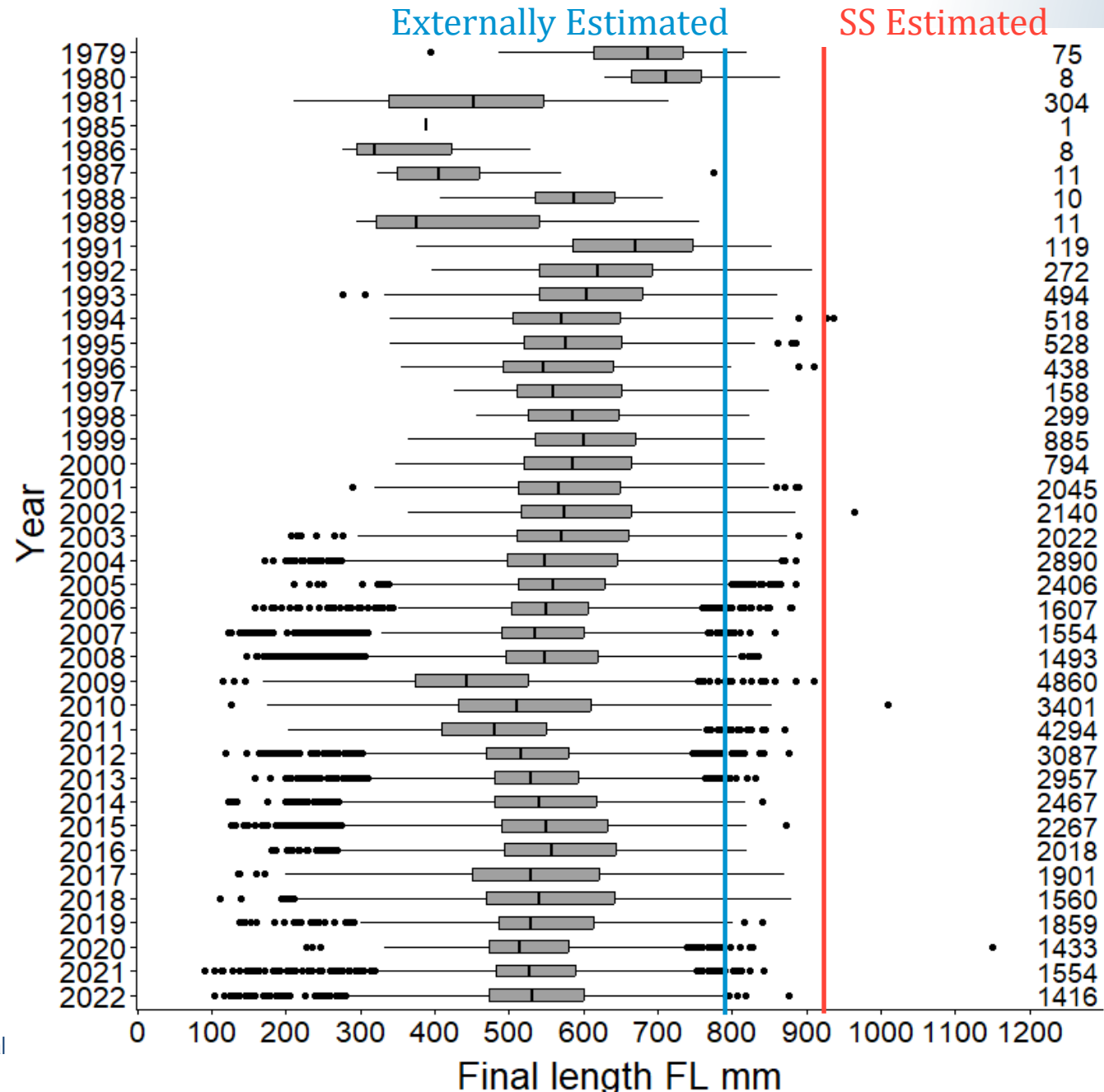
# Growth

Parameter	SEDAR42	SEDAR61
$L_{\infty}$	82.719	79.995
k	0.124	0.131
$t_0$	-0.899	-0.875

Data from 1991-2017 (SEDAR 61)



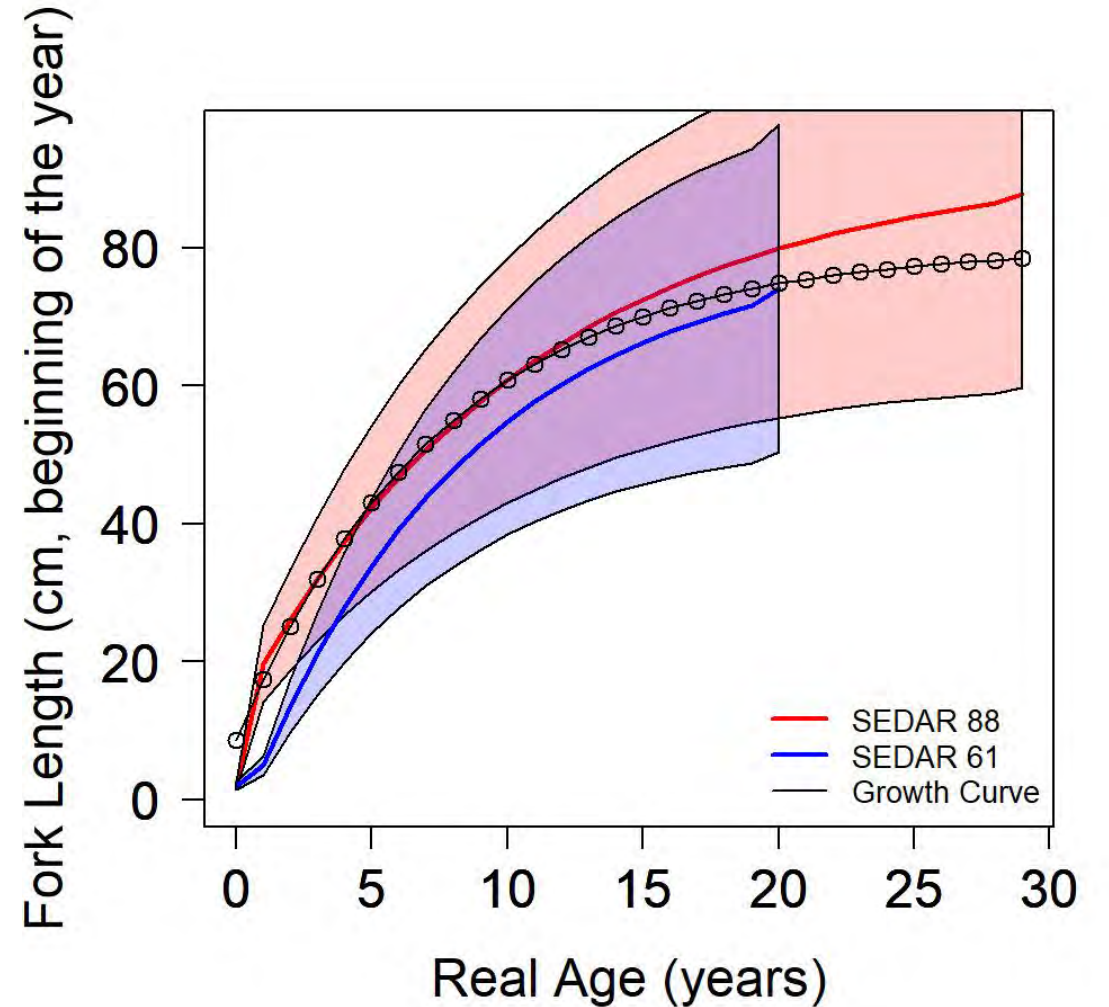
Data from 1978-2022 (WP-88-11)



# Growth

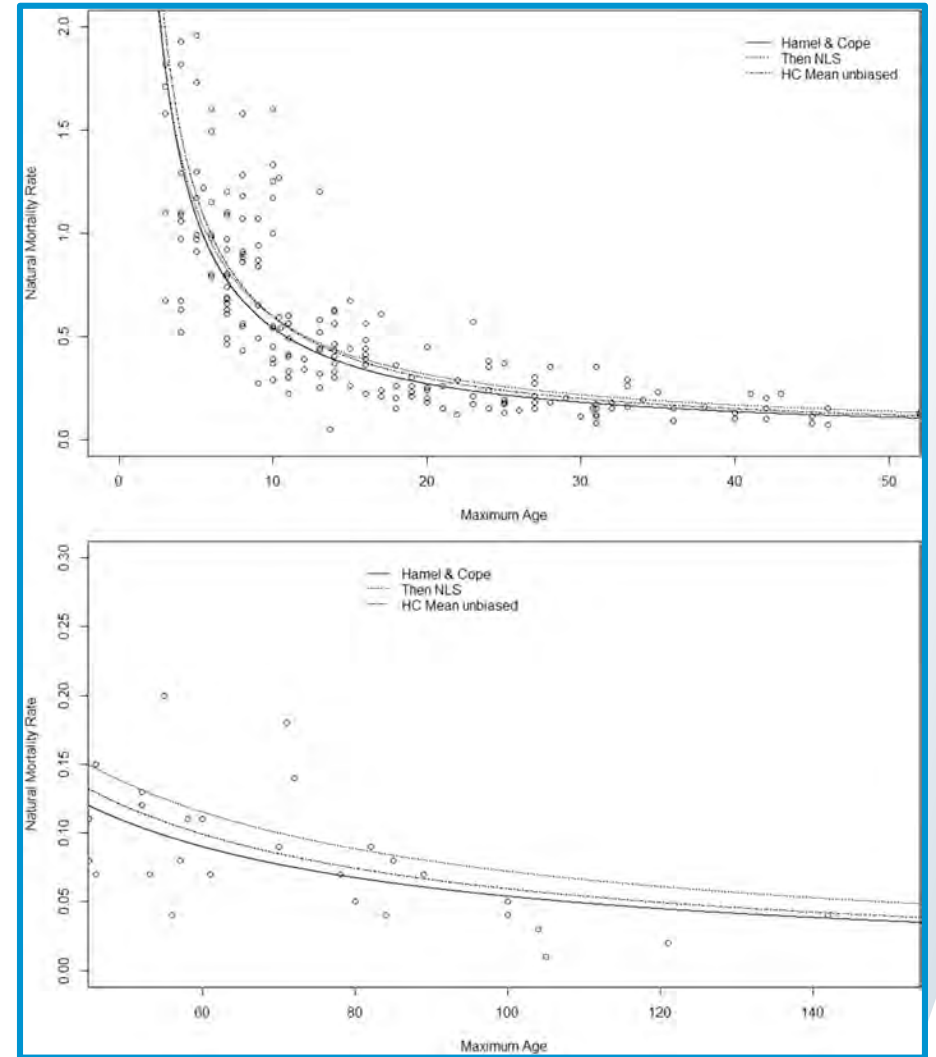
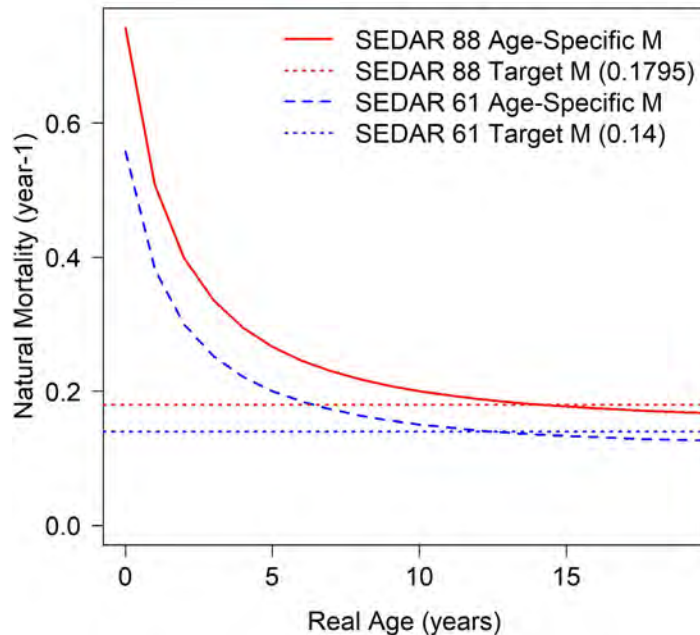
- External growth curve not updated from S61
- S61 estimated  $L_{amin}$  and  $k$
- Estimated  $L_{\infty}$  in SEDAR 88

Parameter	SEDAR42	SEDAR61	SEDAR88
$L_{\infty}$	82.719	79.995	92.41 (0.036)
$k$	0.124	0.121 (0.017)	0.092 (0.066)
$t_0$	-0.899	-0.875	-0.875
$L_{amin}$	17.29	5.016 (0.137)	19.724 (0.02)



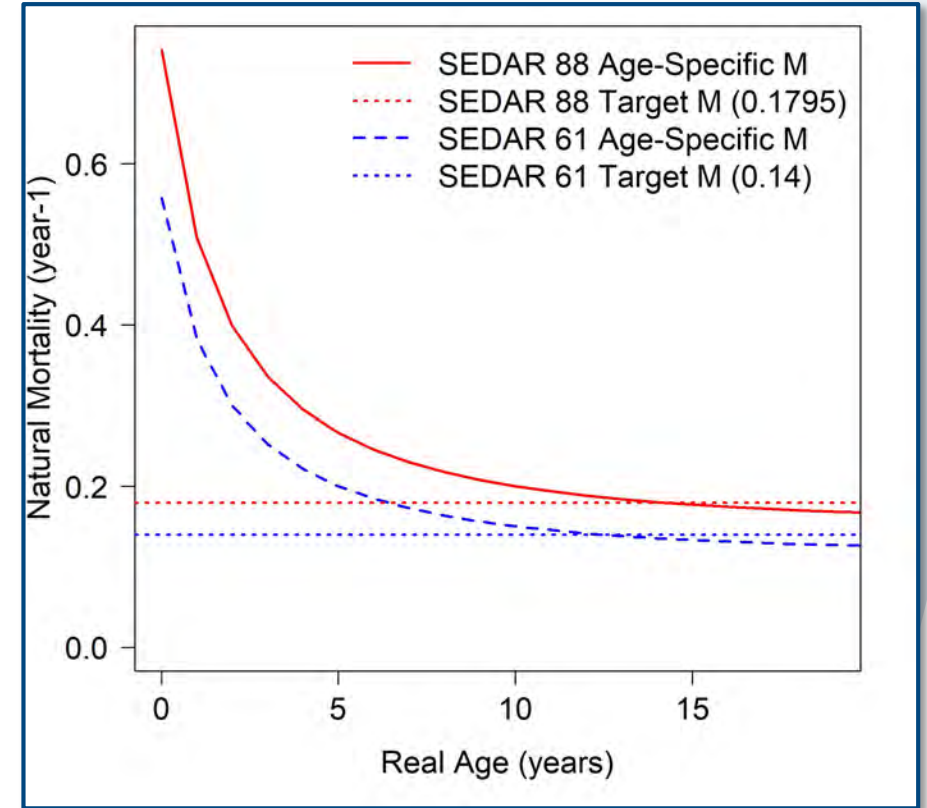
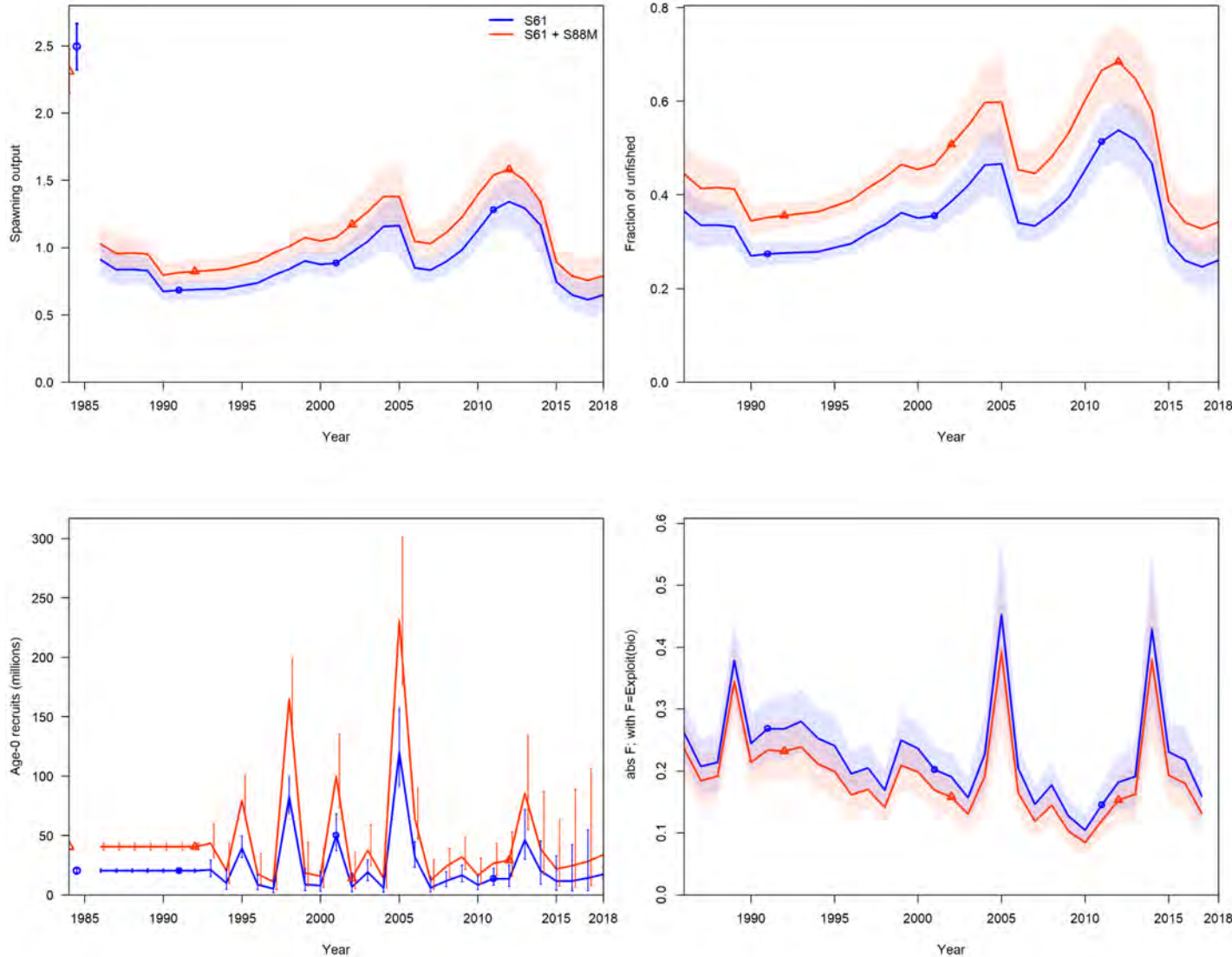
# Natural Mortality

- Hamel and Cope (2022)
  - Estimate M from max age
  - Updated point estimate of M from 0.1795 (Then et al) to 0.1862
- Lorenzen M curve calculated internally from point estimate



Hamel, Owen S., and Jason M. Cope. "Development and considerations for application of a longevity-based prior for the natural mortality rate." *Fisheries Research* 256 (2022): 106477.

# Effects of Model Changes: Updating M



\*Hamel & Cope point estimate

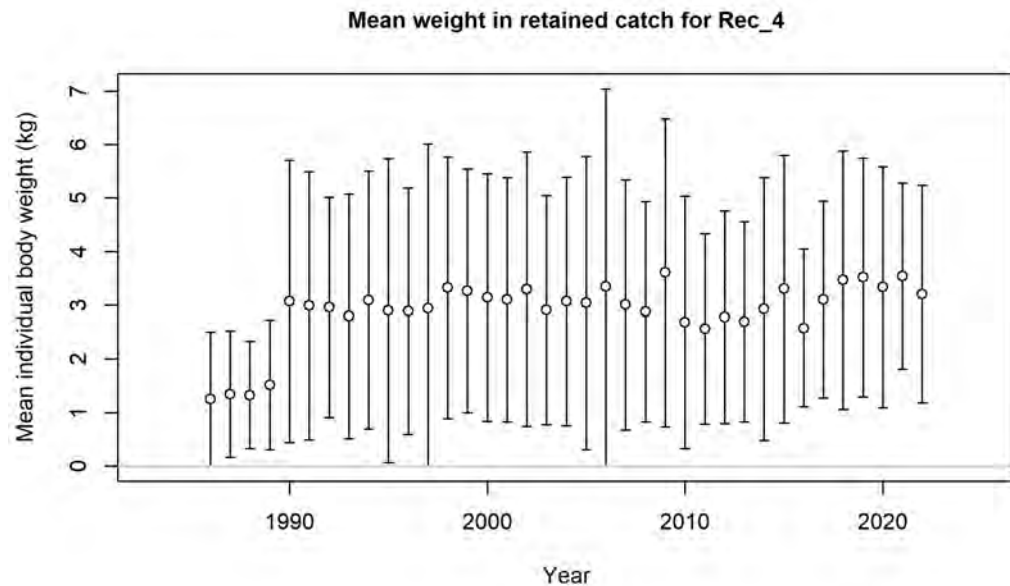
# Beverton-Holt SR Model

- Estimated:
  - Virgin recruitment ( $R_0$ ): unexploited equilibrium recruitment on log-scale
  - Recruitment deviations from 1993-2022
  - Recruitment variability ( $\sigma_R$ )
- Steepness:
  - Estimable (0.66) with low CV and clear profile (discussed in Diagnostic section)
  - Sensitivities:
    - Fixed at biologically plausible estimate obtained from FishLife (0.786)
    - Fixed at 0.99 in S61 (fixing at 0.99 no longer recommended unless we are not modeling a S/R relationship)
      - Has implications for the value of  $R_0$



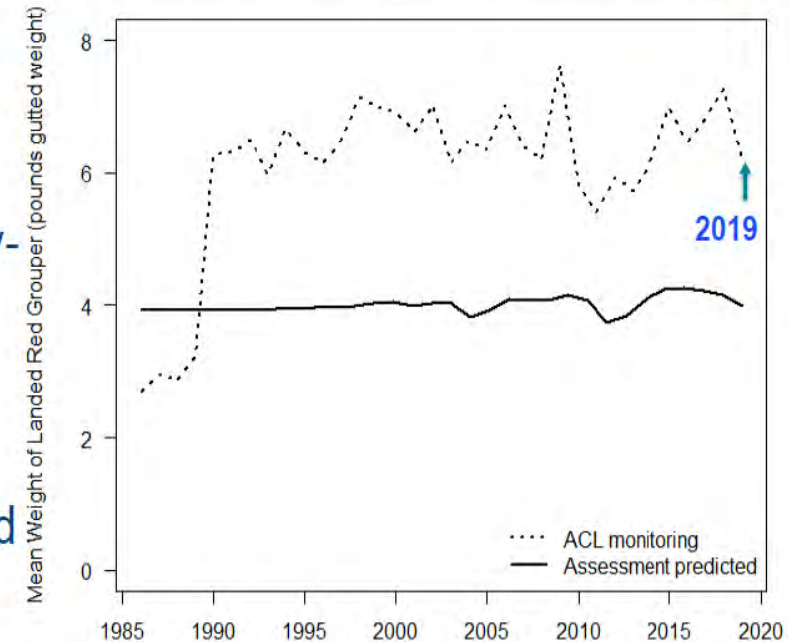
# Changes to Model Specification

- Fit to mean weight of recreational landings (not used as a data input for S61)



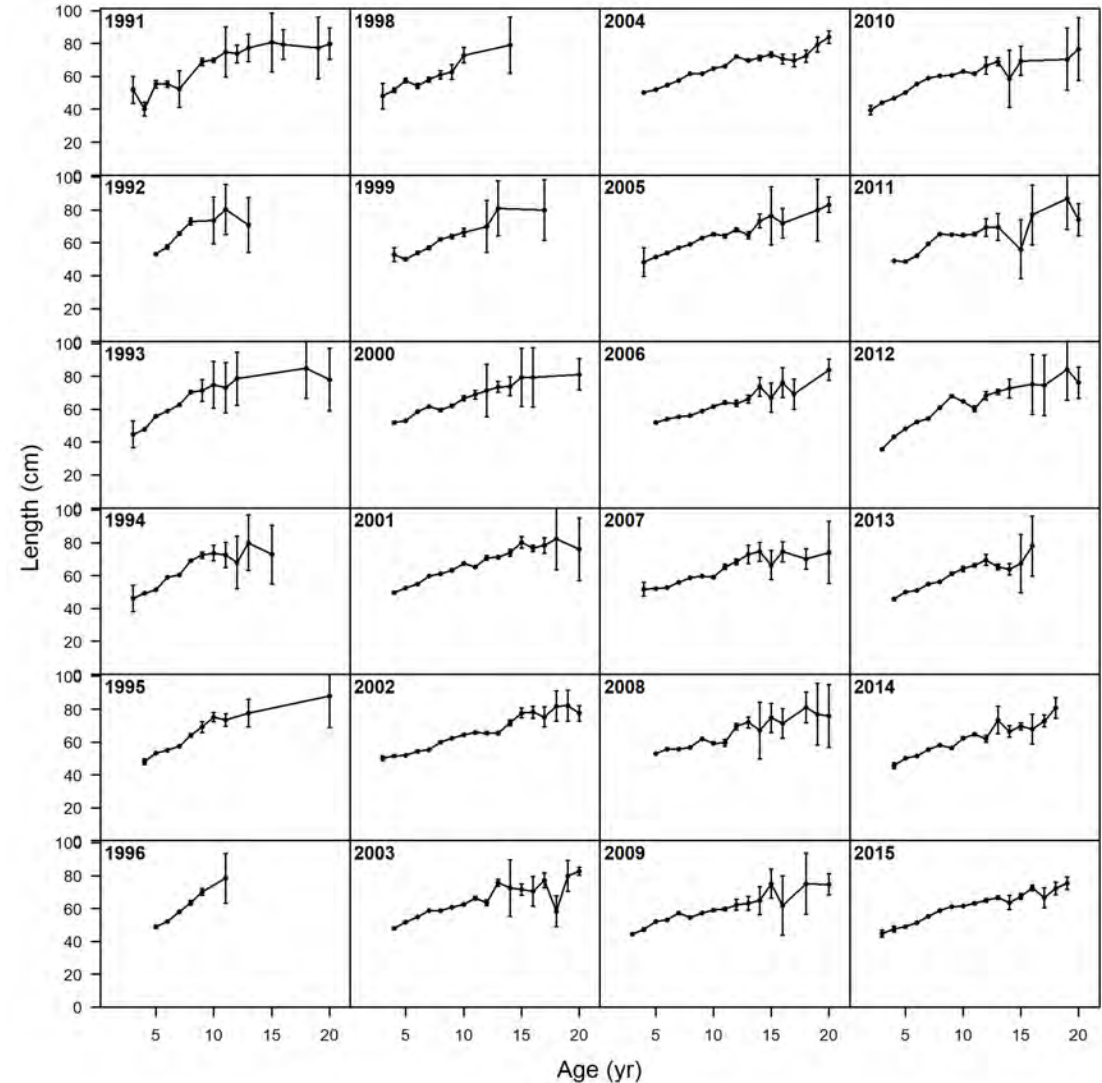
## SEDAR61 mean weight of Red Grouper

- Assessment model underestimated mean weight landed by the recreational fishery
- External growth curve (i.e., assumed distribution of variability-at-length [CV])
- Length-weight conversion
- No weight data included in assessment model



# Changes to Model Specification

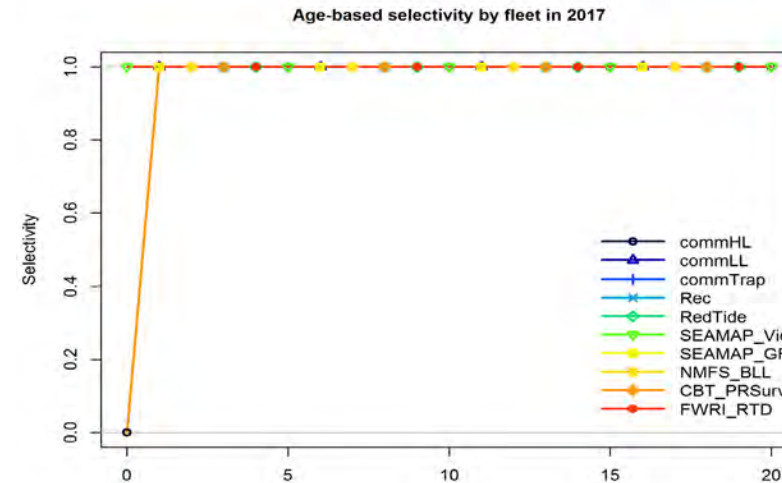
- Input mean length at age for model checking, light lambda applied during model building
- MLAA data: handline, longline and recreational



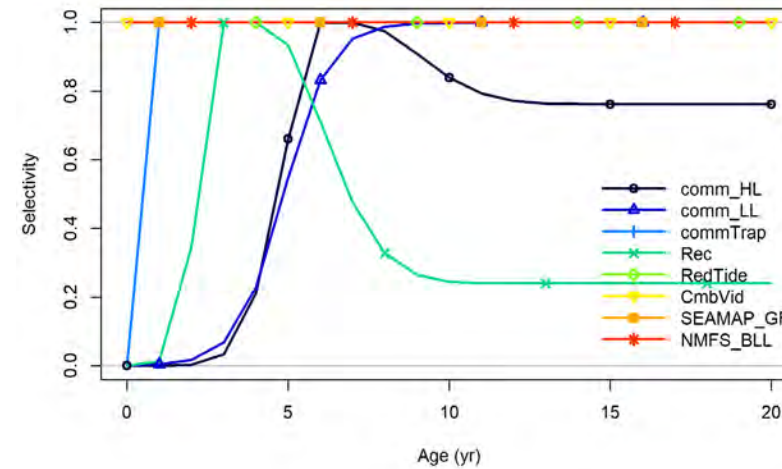
# Changes to Model Specification

- Age selectivity for three of the fishing fleets
  - Com HL, Com LL and Rec

S61



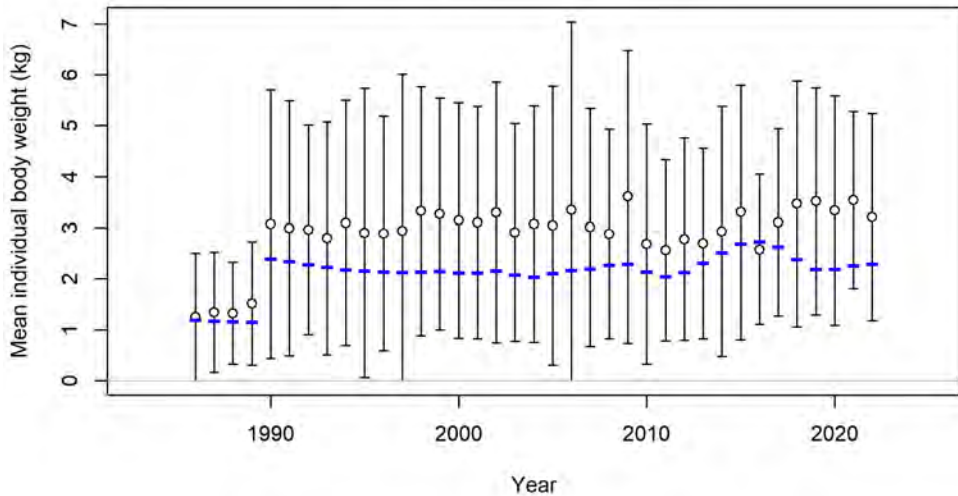
S88



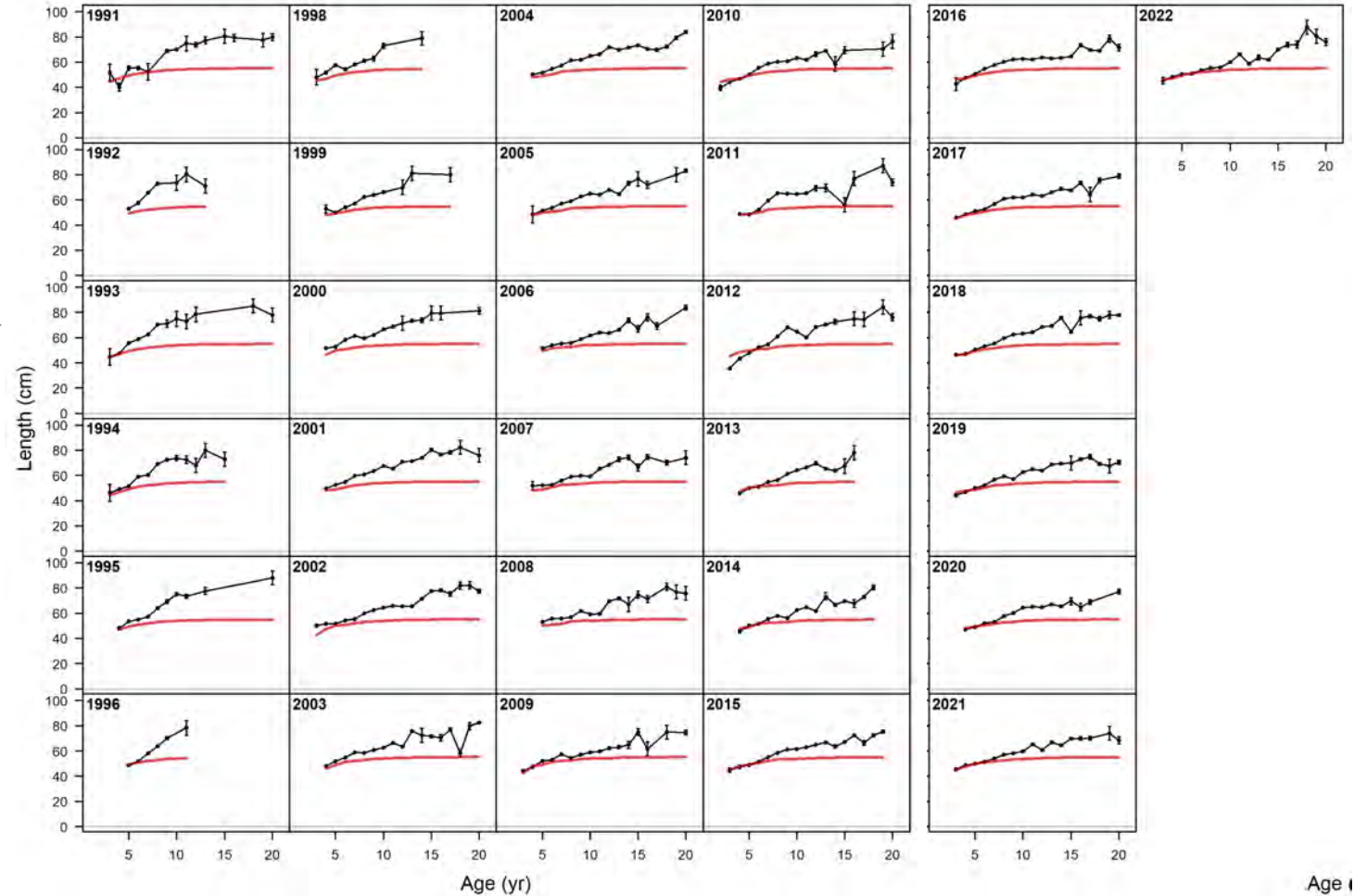
# Age Selectivity vs. Length Selectivity

- Model building runs with length-based selectivity underestimated mean weight for recreational landings and MLAA for HL, LL and Rec
- Corrected with age-based selectivity

Mean weight in retained catch for Rec



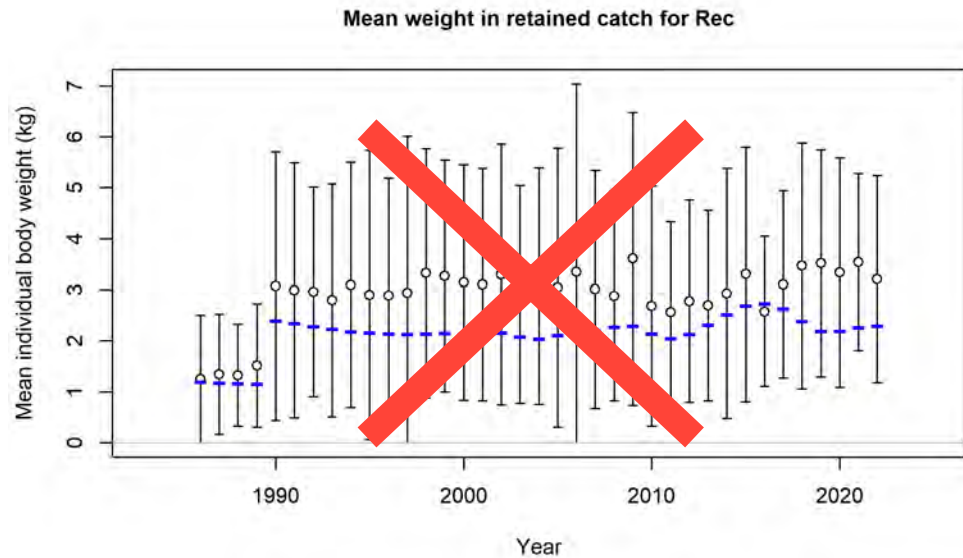
Example: Longline



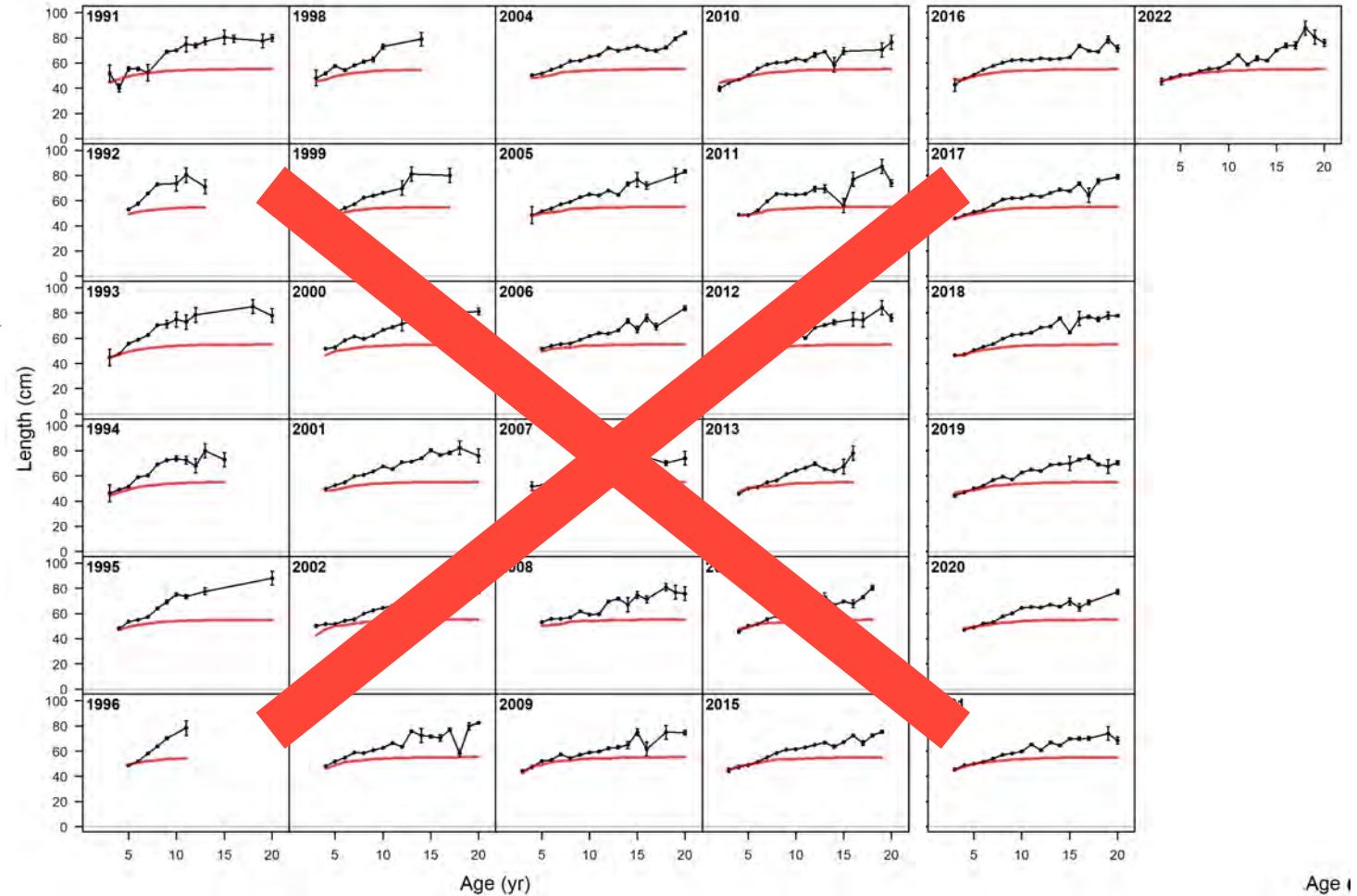
Age (yr)

# Age Selectivity vs. Length Selectivity

- Model building runs with length-based selectivity underestimated mean weight for recreational landings and MLAA for HL, LL and Rec
- Corrected with age-based selectivity



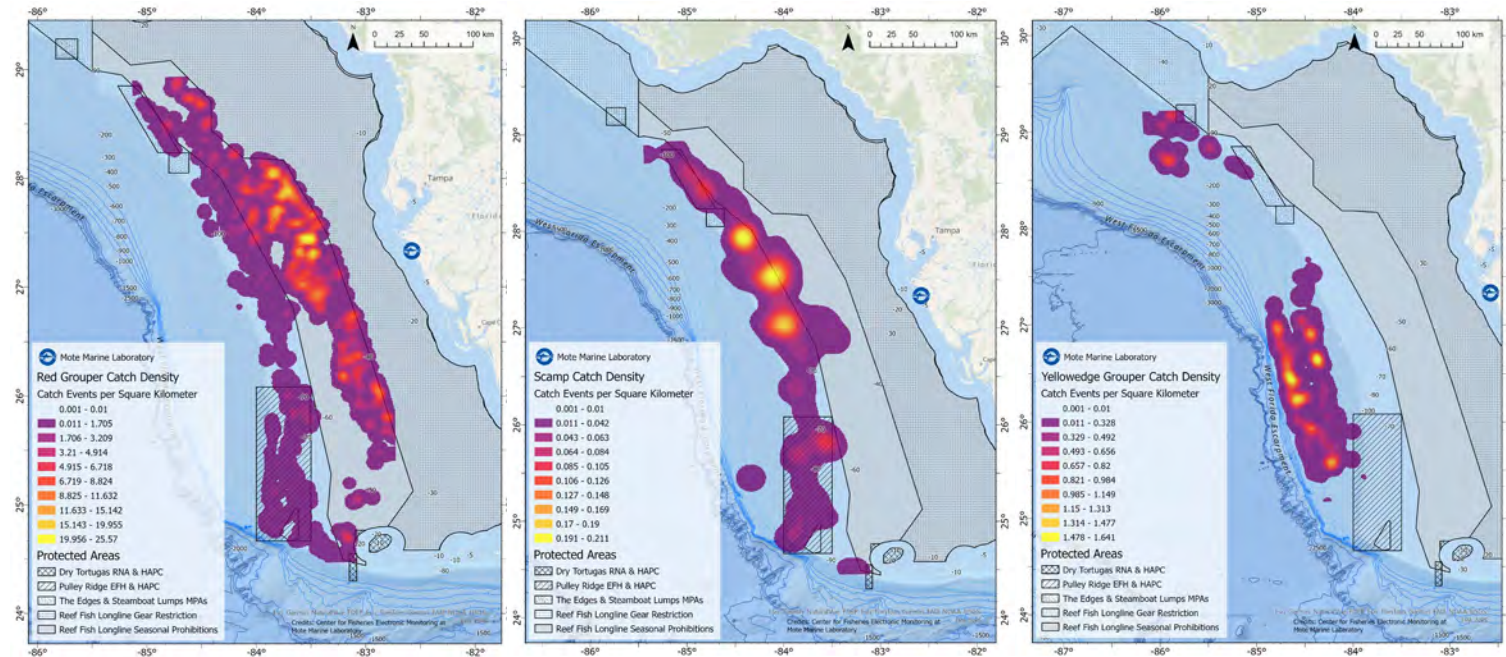
Example: Longline



Age (yr)

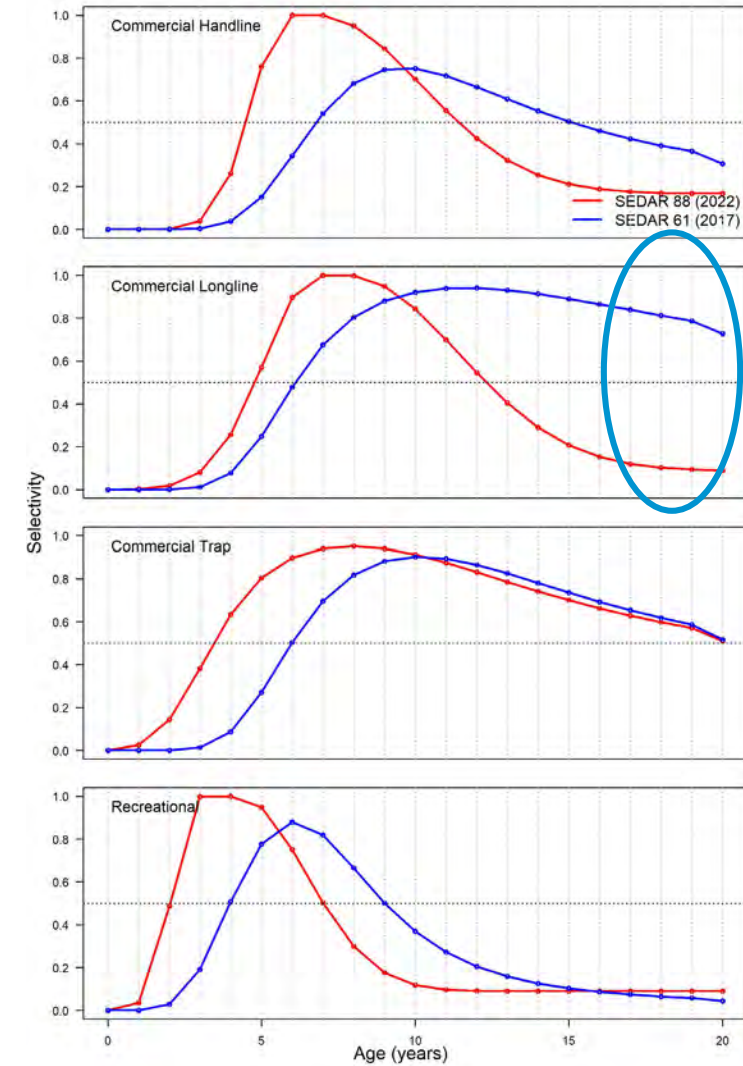
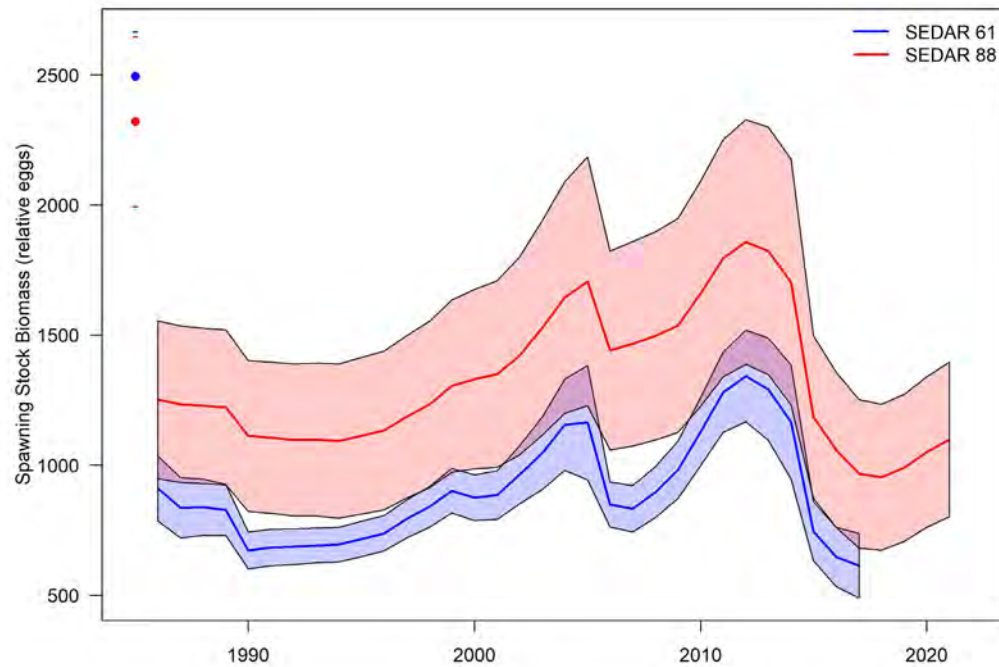
# Changes to Model Specification

- Longline Selectivity:
  - Modeled as dome-shaped in SEDARs 42 and 61
    - Functionally dome-shaped in SEDAR12
  - Bottom Longline Survey modeled as logistic
  - Logistic selectivity used for Longline in other grouper species in Gulf:
    - Yellowedge
    - Gag
    - Scamp



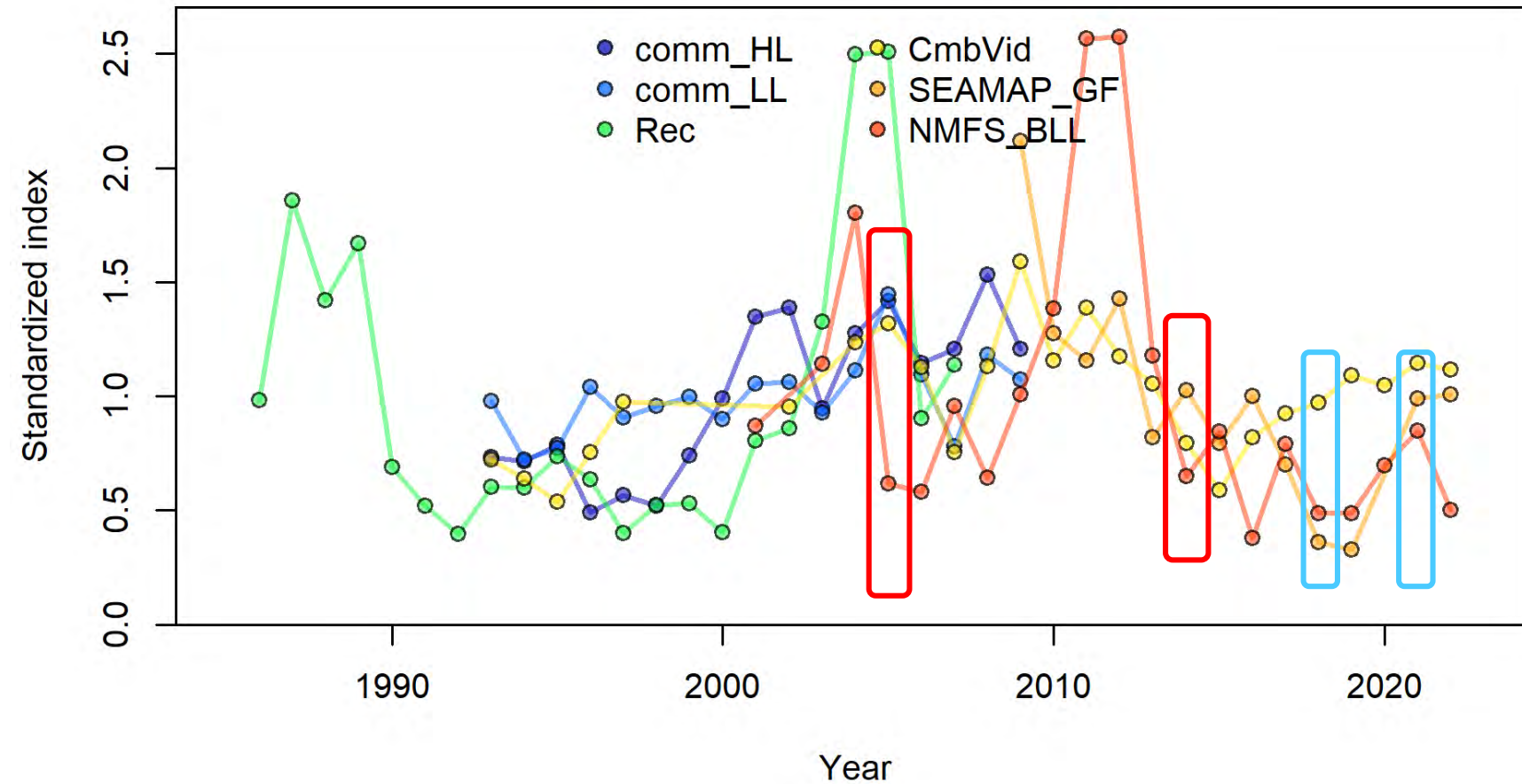
# Longline Selectivity

- Freely estimated dome-shaped yielded unrealistic SSB and fishing mortality (selectivity at oldest/largest fish)



**\* Results from model building, not final proposed base**

# Red Tide Years

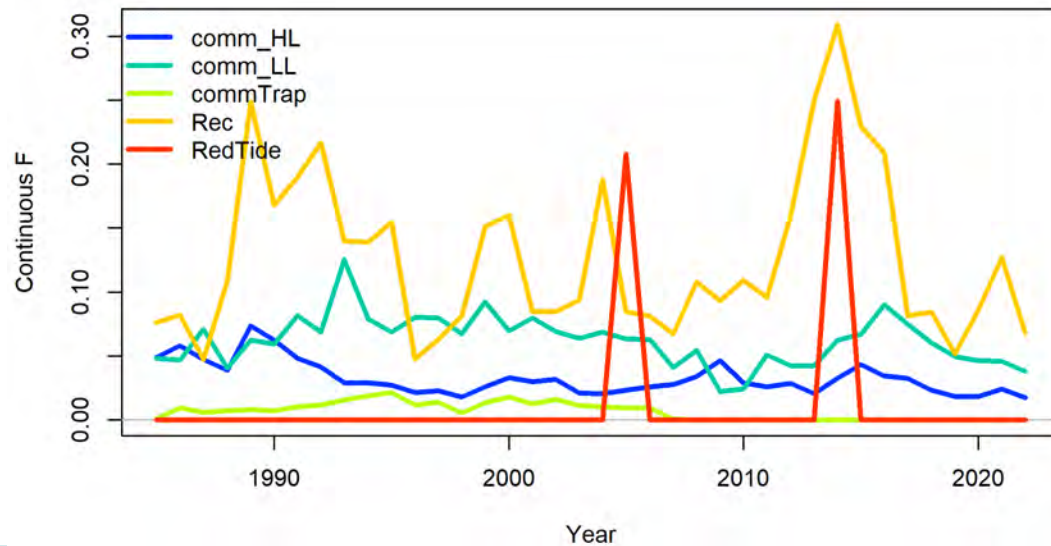


- 2005 and 2014 outlined in red
- 2018 and 2021 outlined in blue

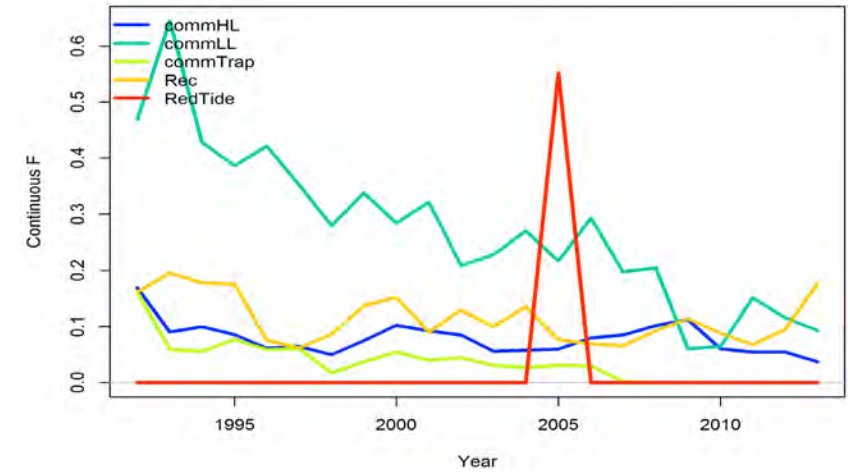
# Issues with Red Tide during model building

- Concerns identified during model building around observed red tide mortality in model
- 2014 larger F due to red tide than 2005
- Opposite of what was estimated in S61 and what was observed on the water.
- 2018 and 2021 no discernable mortality due to red tide and mortality parameter highly uncertain

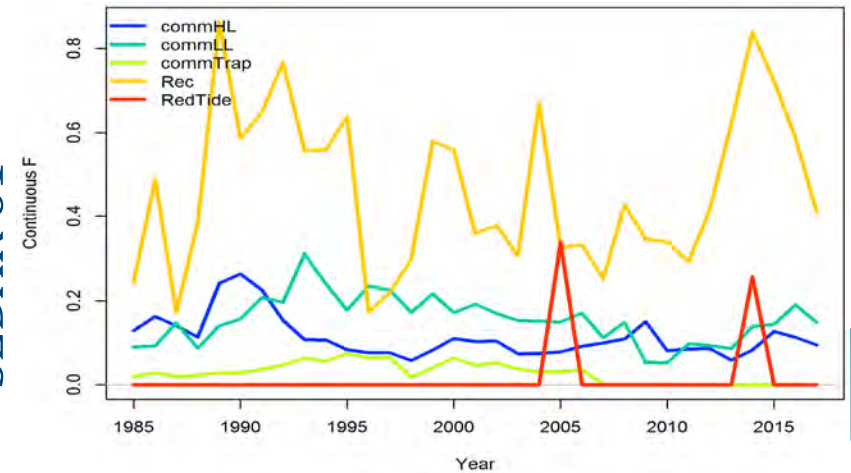
Model building run S88



SEDAR 42



SEDAR 61



# Empirical Selectivity-at-Age

Outputs from WFS EwE model:

Scale to max						
Age	y2005	y2006	y2014	y2018	y2021	
0	0.924	1.000	0.342	1.000	0.916	
1	0.951	0.639	0.422	0.976	1.000	
2	0.940	0.541	0.516	0.764	0.776	
3	1.000	0.552	0.623	0.725	0.507	
4	0.884	0.301	1.000	0.865	0.471	
5+	0.869	0.186	0.810	0.568	0.339	



Scaled to input into SS

Age	y2005	Selectivity Input	
0	0.924	2.503	
1	0.951	2.973	
2	0.940	2.757	
3	1.000	#NUM!	9
4	0.884	2.028	
5+	0.869	1.888	

Age	y2014	Selectivity Input	
0	0.342	-0.655	
1	0.422	-0.315	
2	0.516	0.063	
3	0.623	0.502	
4	1.000	#NUM!	9
5+	0.810	1.447	

$$S_a = -LN \left( \frac{1}{RT\_scaled} - 1 \right)$$

\* Where RT\_scaled is the value from WFS model scaled to the maximum value within a year

# Red Tide

- Modeled as four bycatch fleets, one each for 2005, 2014, 2018, and 2021.
- Selectivity curves fixed at values obtained from outputs from WFS EwE model
- SEDAR 61: Red tide mortality modeled as single bycatch fleet that only operated in years with significant red tide events (2005 and 2014)
  - Full selectivity assumed (i.e., = 1) and constant at age



# Results



**NOAA**  
**FISHERIES**

# Bridging: Data Changes

1: SEDAR 61 Base Model

2: replace REC catches and discards with SRFS data same CV, TY S61

3: remove RTD survey

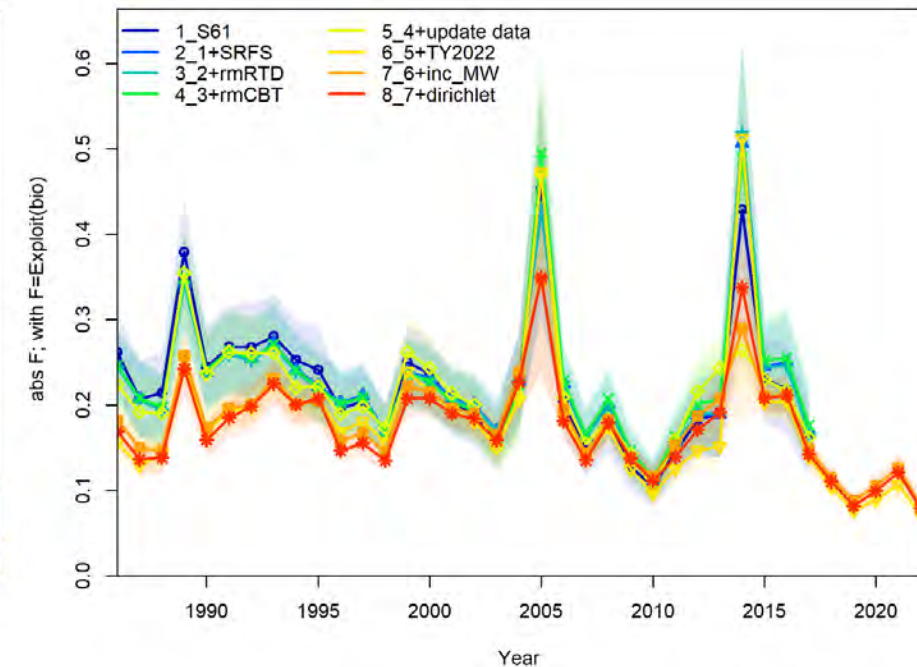
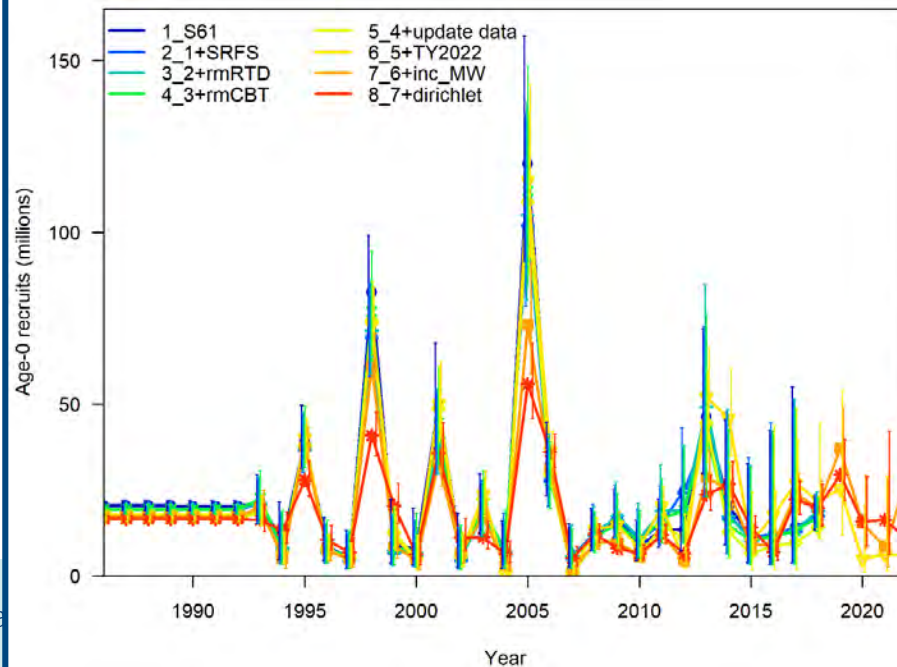
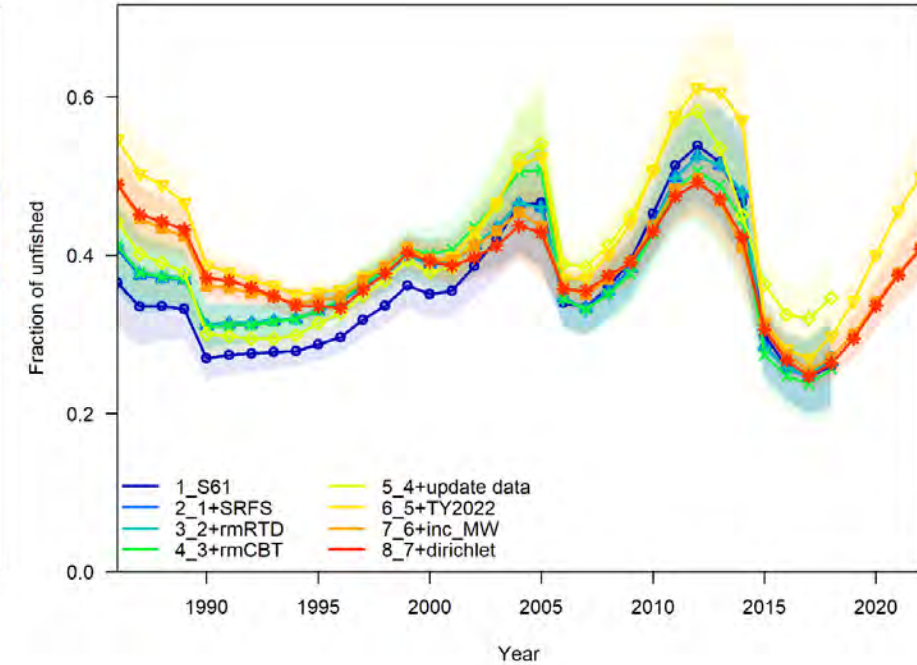
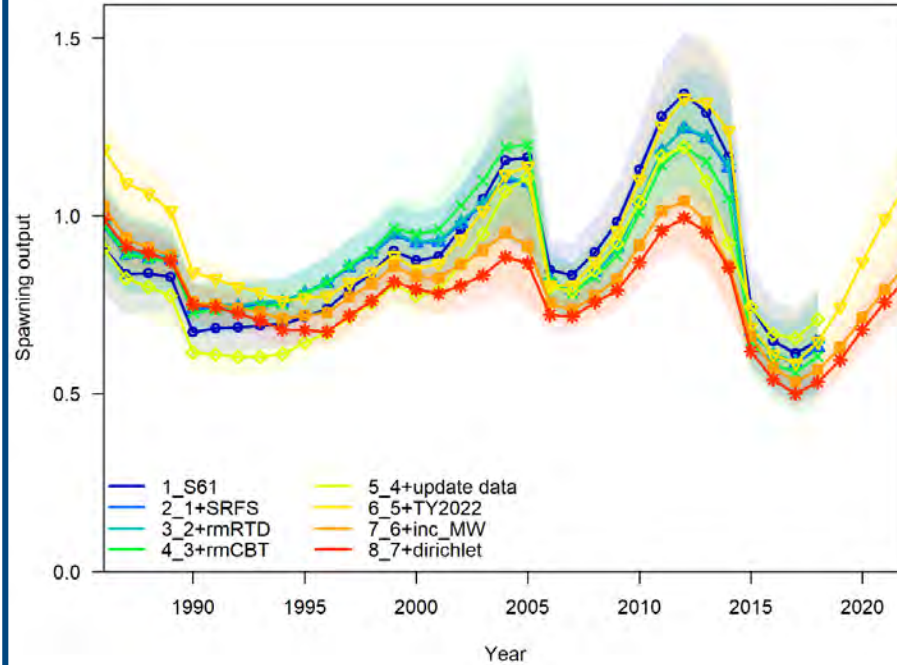
4: + remove MRIP index

5: updated data

6: end year 2022

7: MW of private mode landings included

8: DM on comps



# Bridging: Model Changes

1: SEDAR 61 Base Model

9: Free sel parms

10: update M point estimate

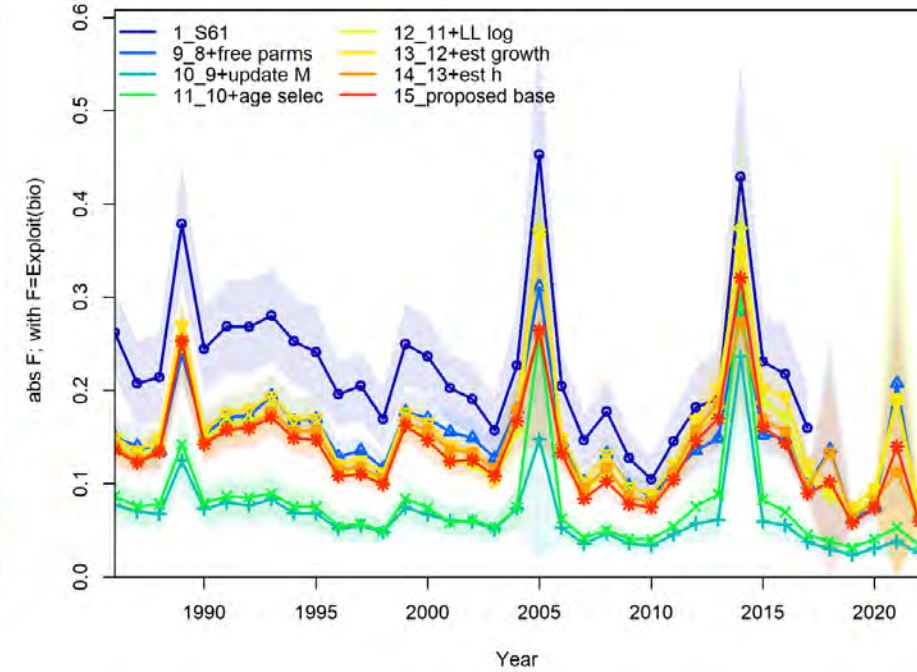
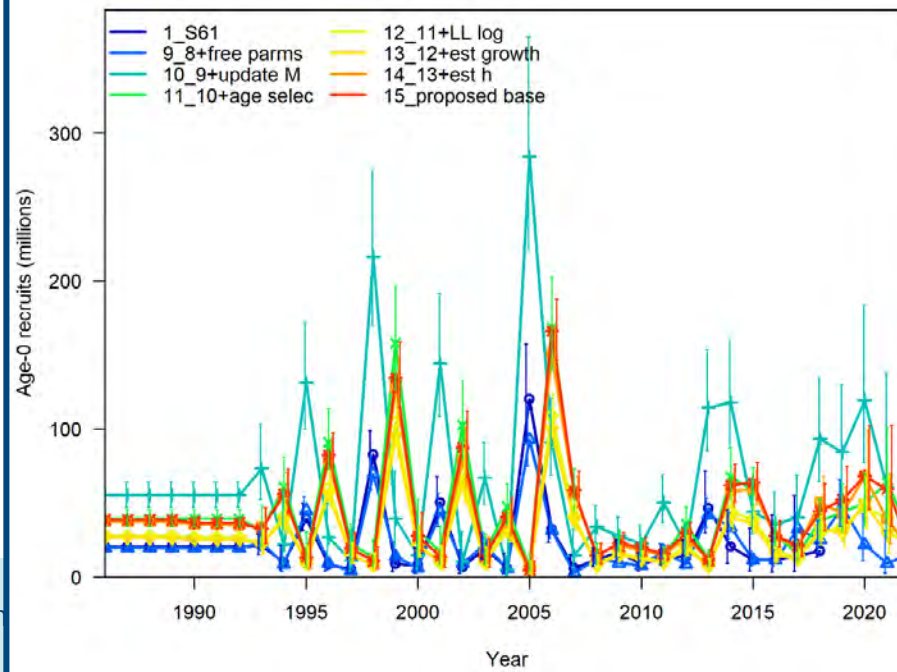
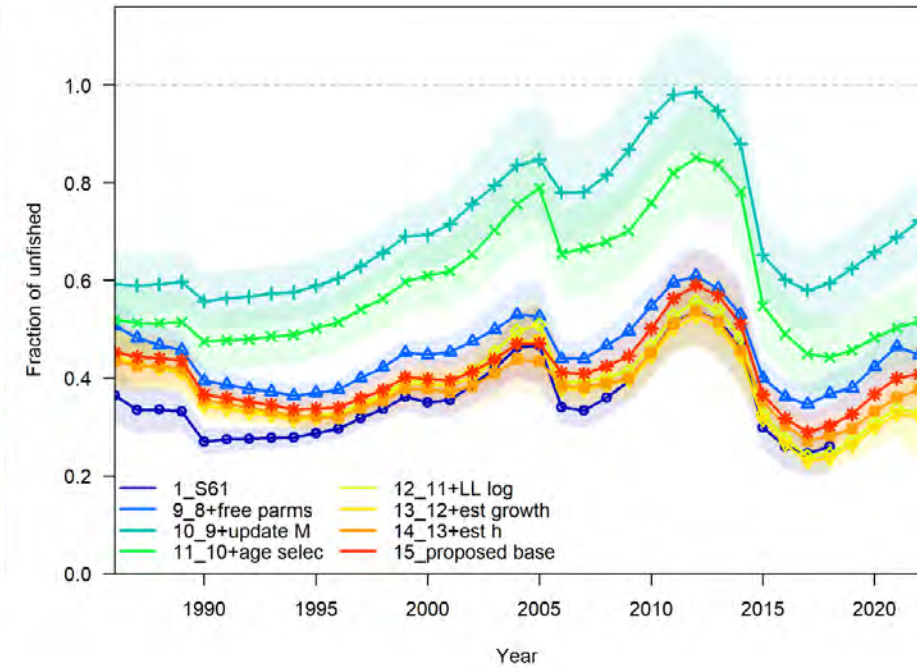
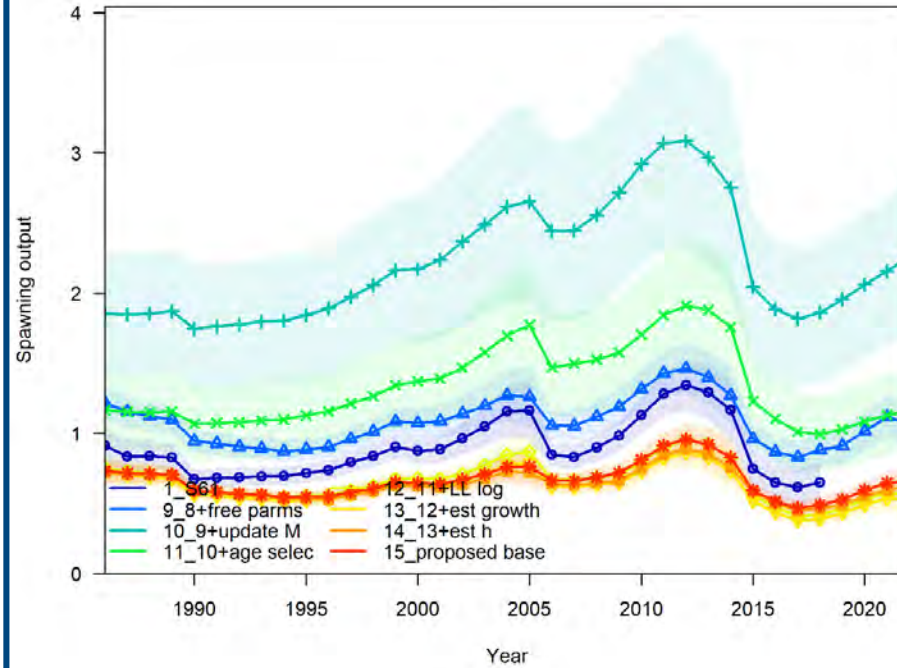
11: Age select

12: Logistic Sel LL

13: Estimate Linf

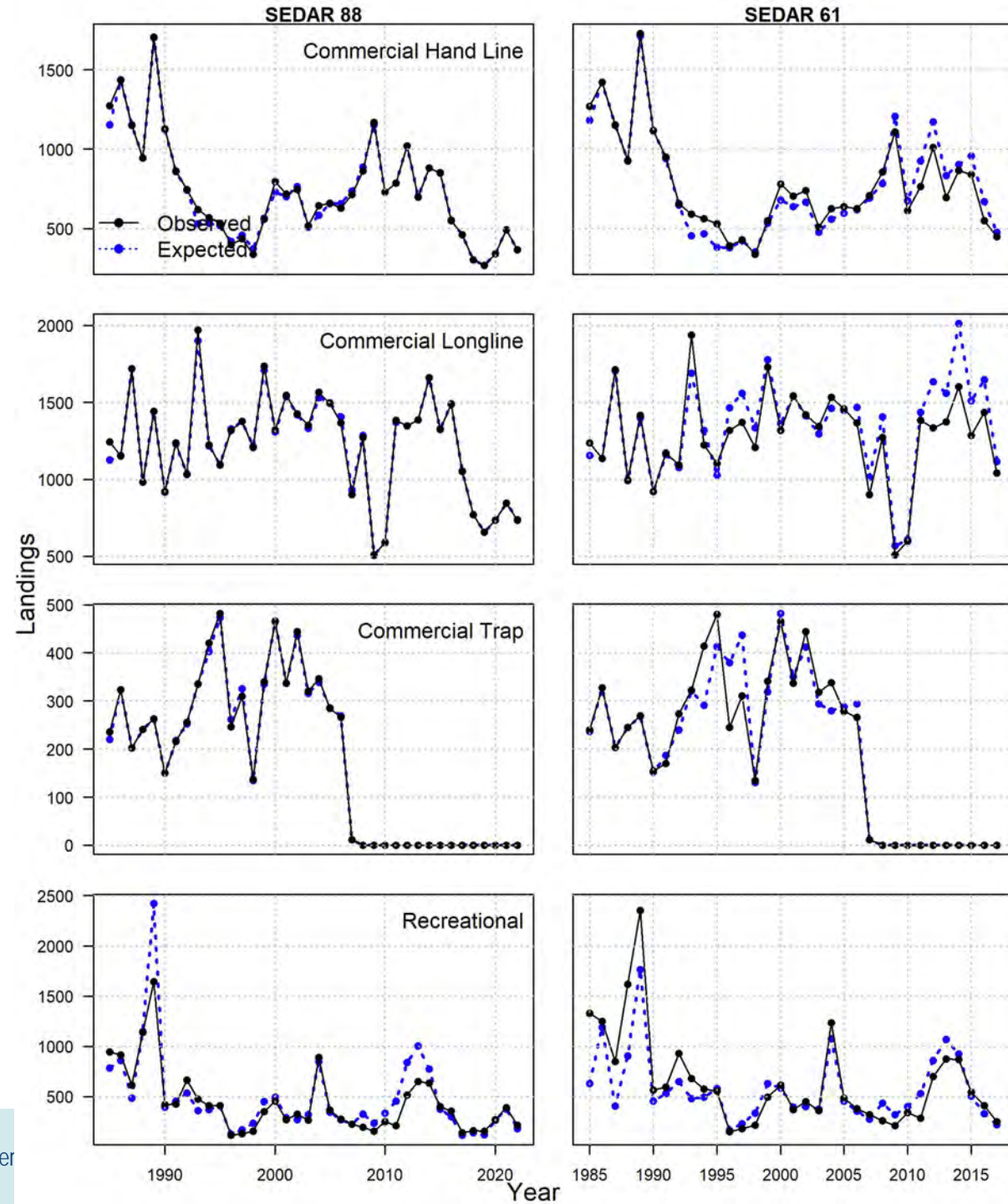
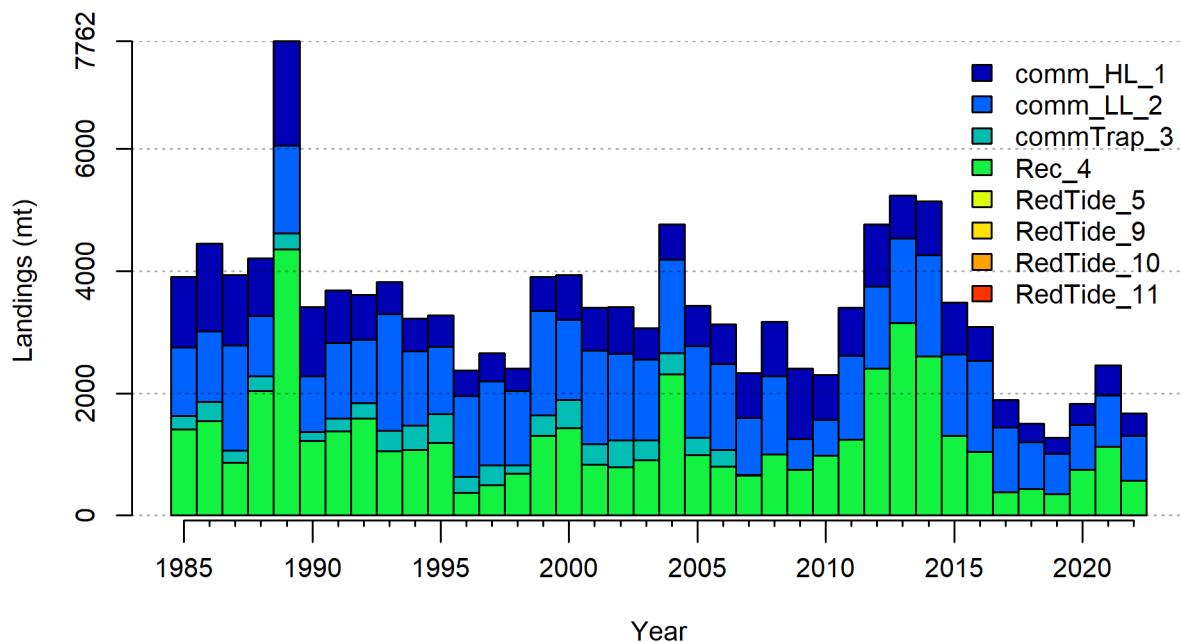
14: Estimate steepness

15: Proposed Base

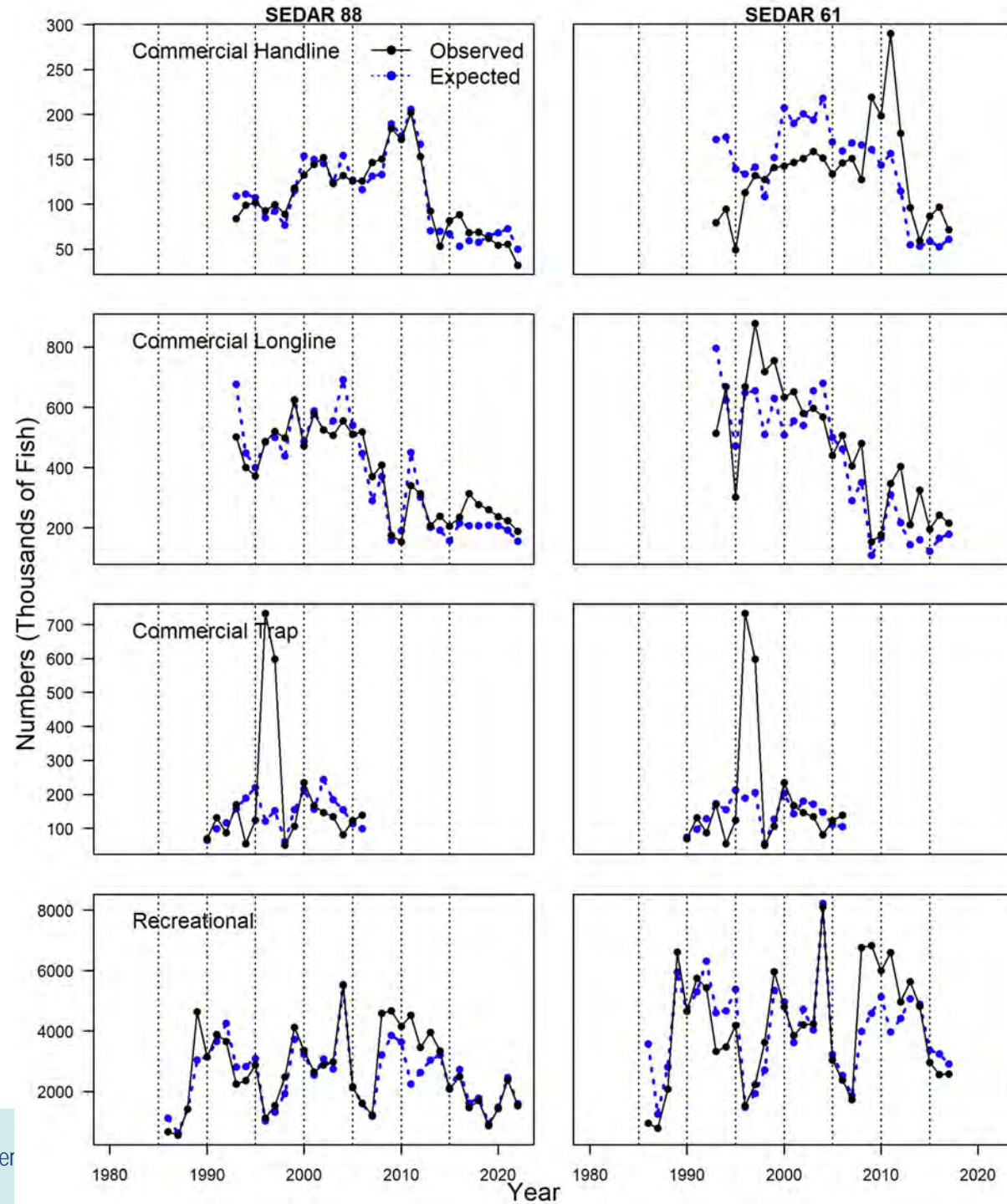
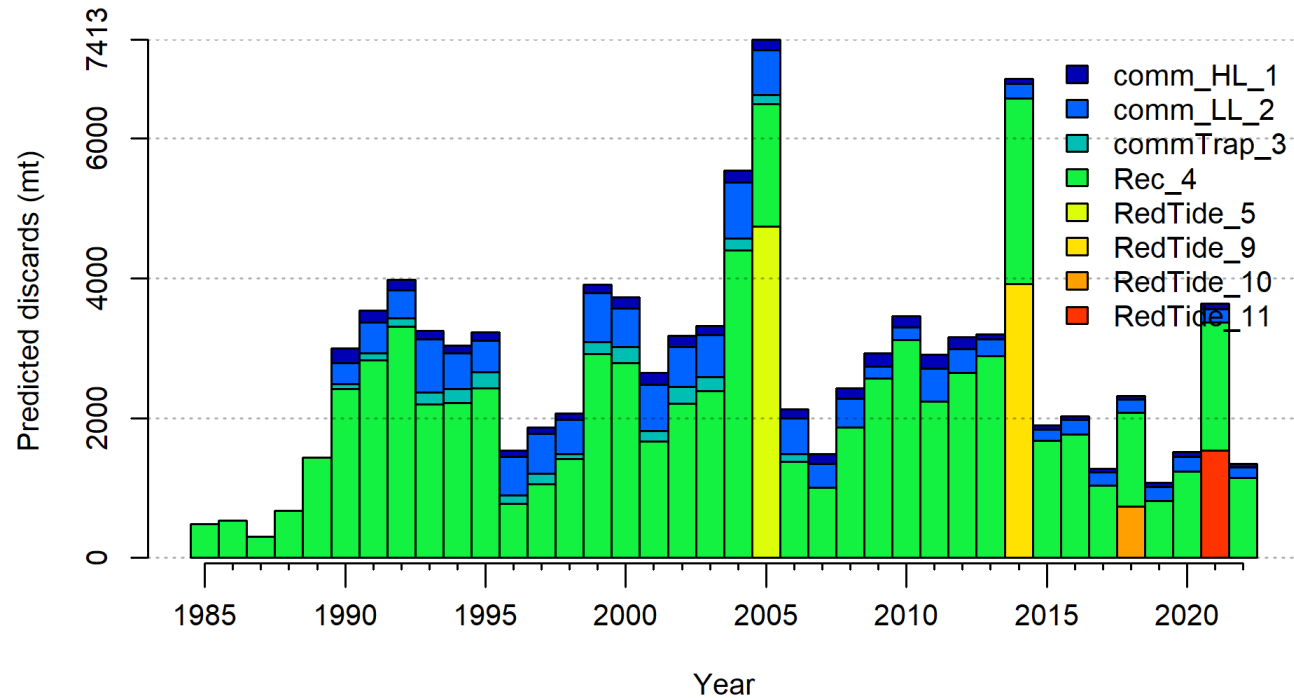


# Landings

- Tighter SE for both commercial and recreational fleets
- Tight fits from 2010+ (IFQ years log-scale SE = 0.01)

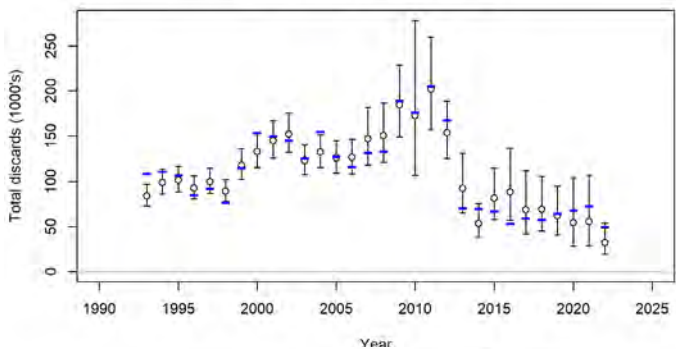


# Discards

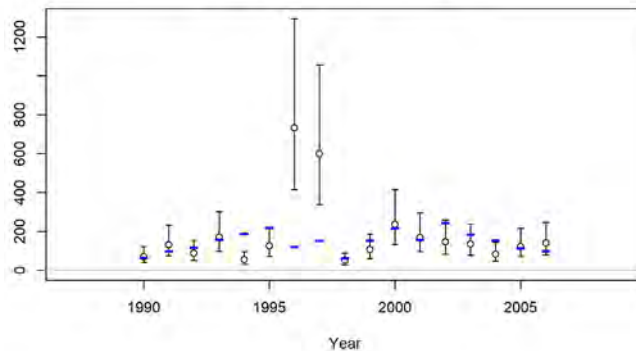


# Discards

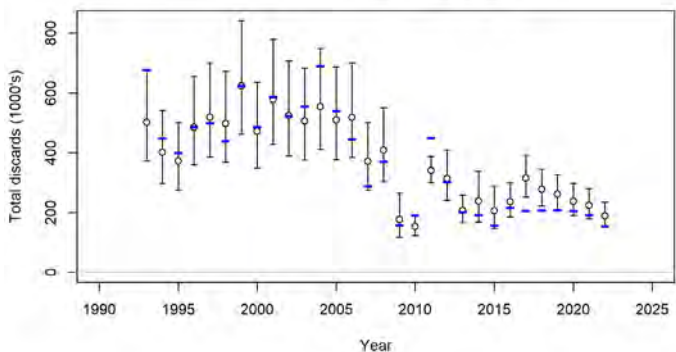
Total discard for comm\_HL\_1



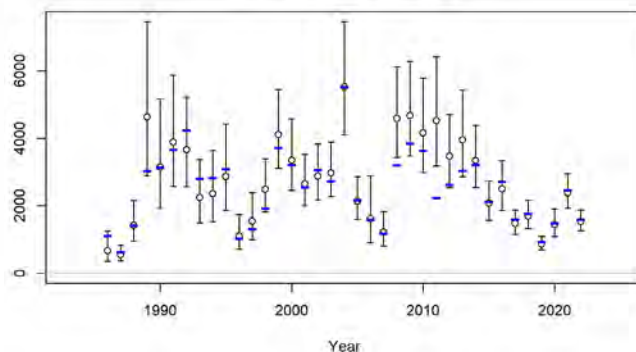
Total discard for commTrap\_3



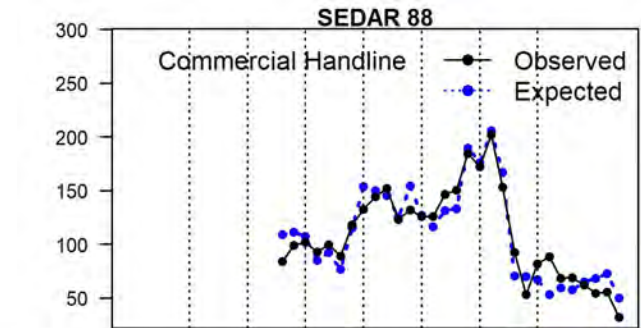
Total discard for comm\_LL\_2



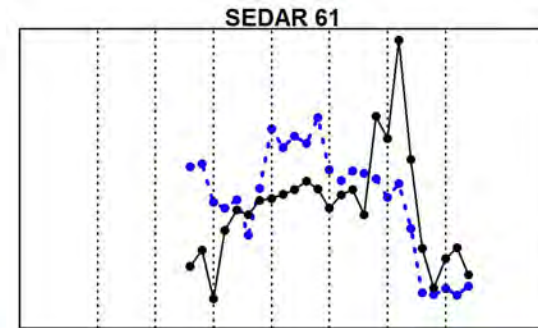
Total discard for Rec\_4



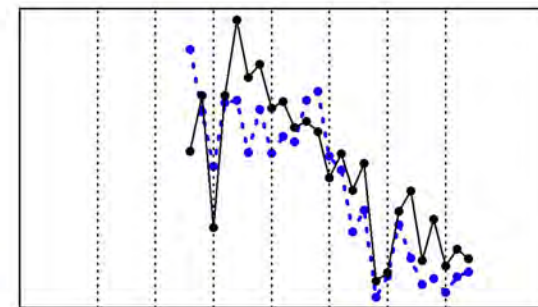
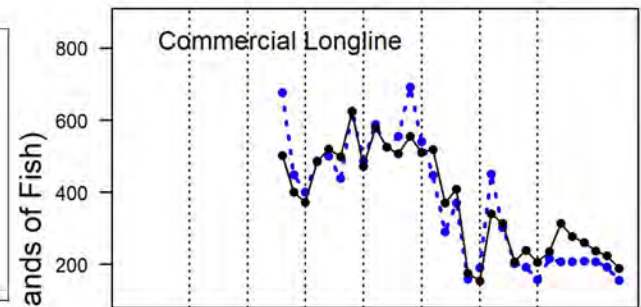
SEDAR 88



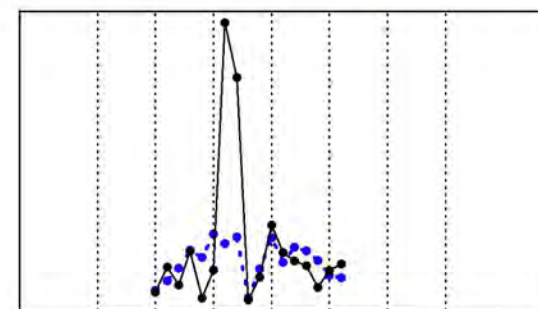
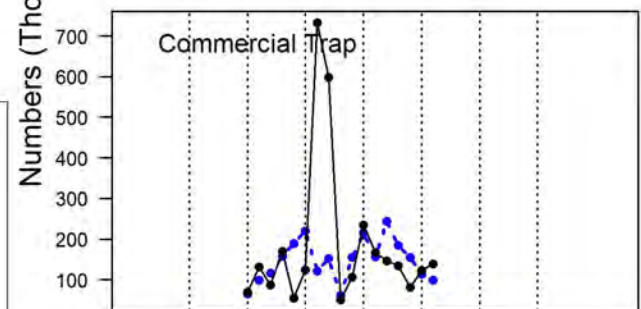
SEDAR 61



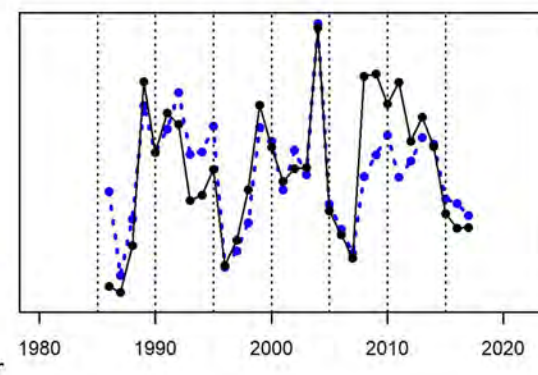
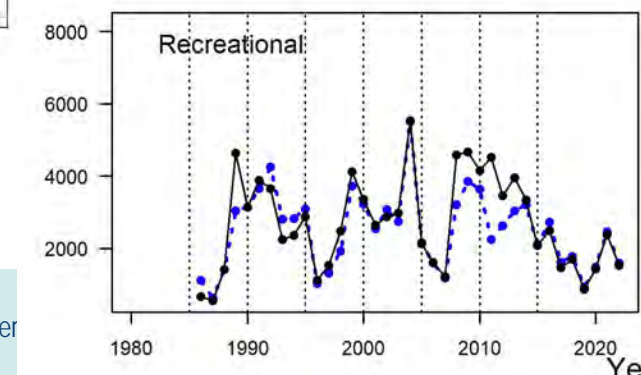
Commercial Longline



Commercial Trap

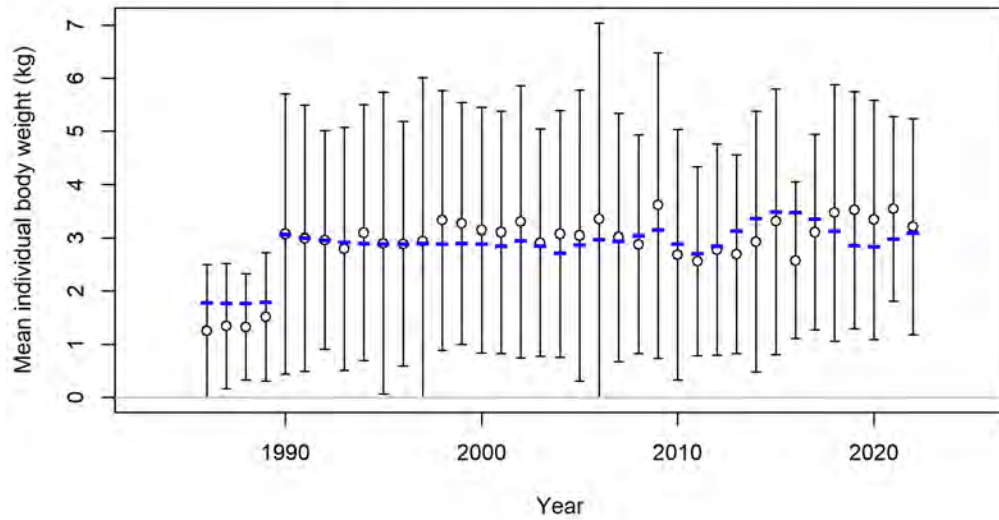


Recreational

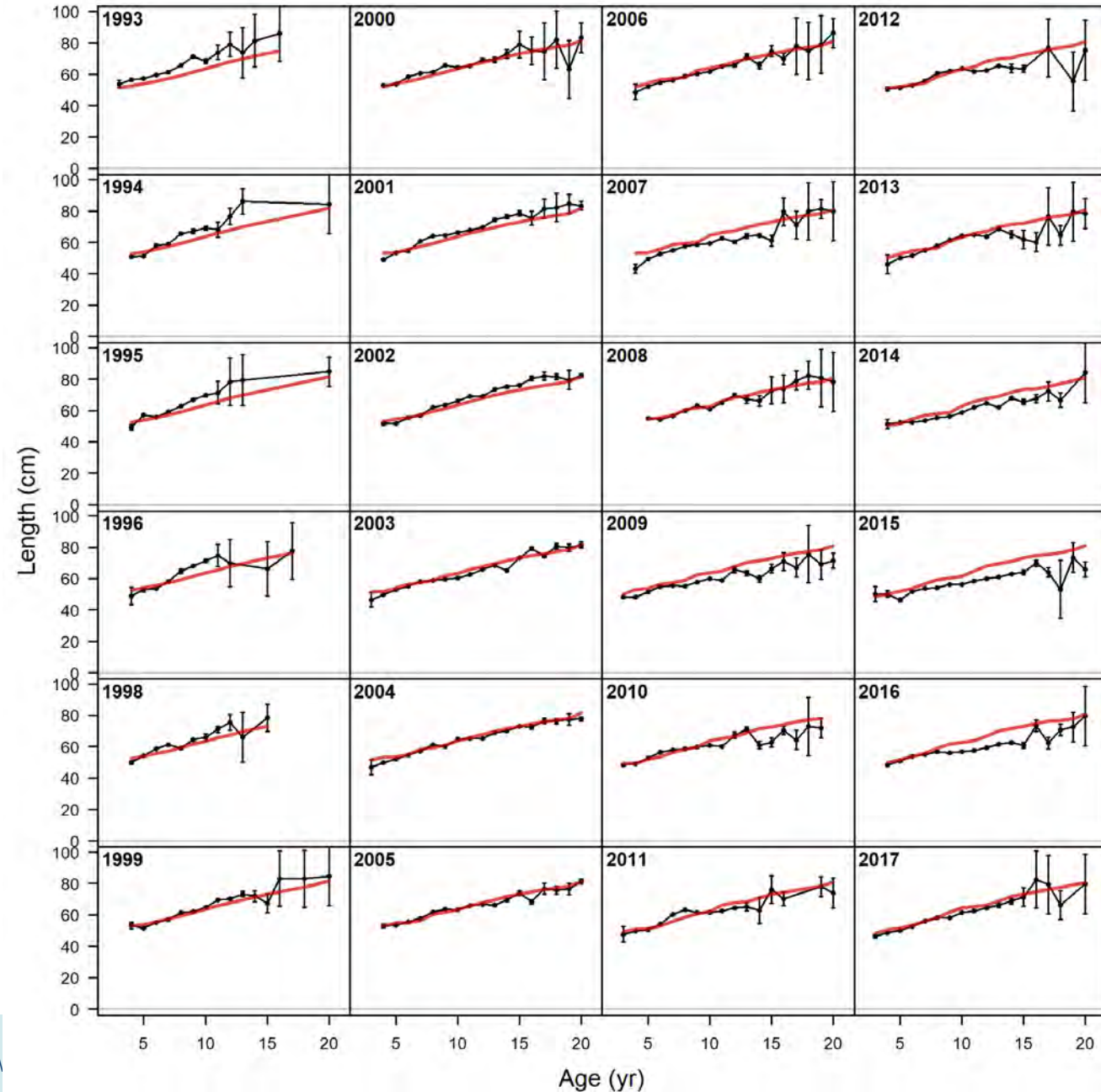


# Mean Weight & MLAA

Mean weight in retained catch for Rec\_4



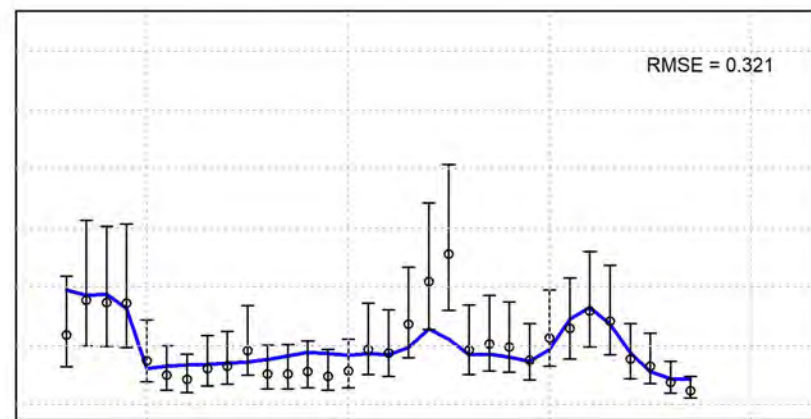
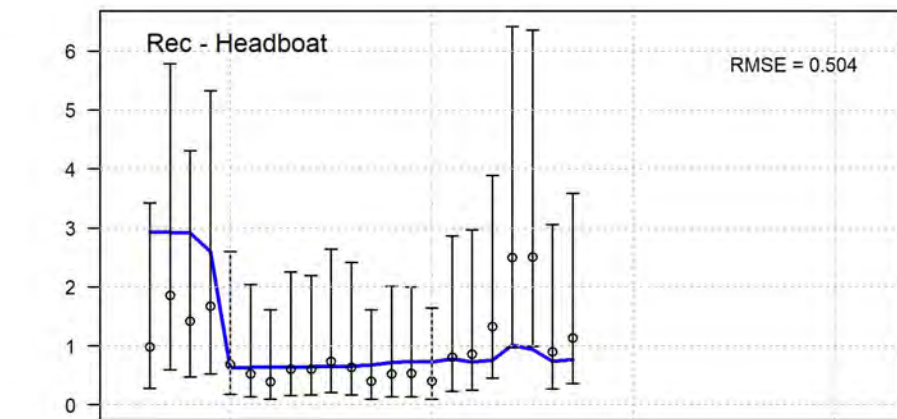
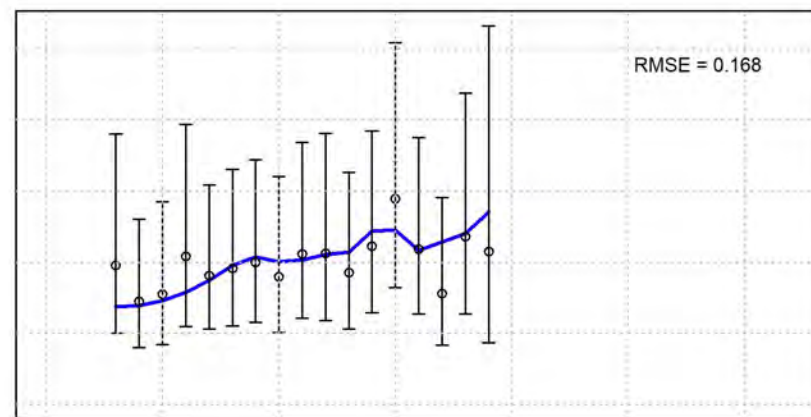
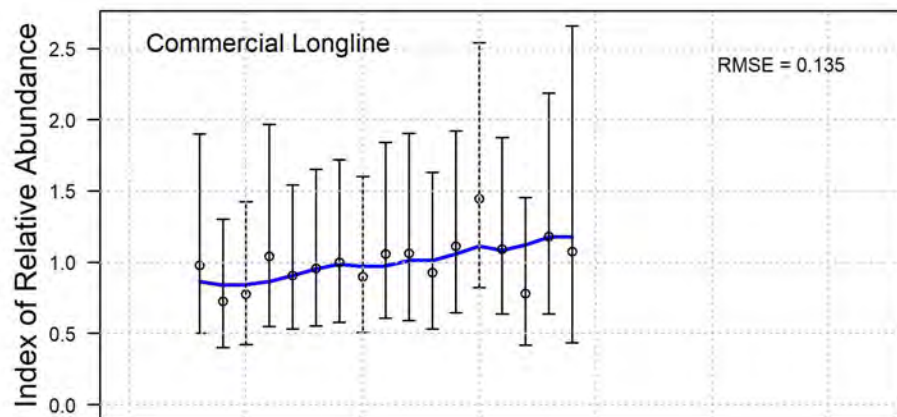
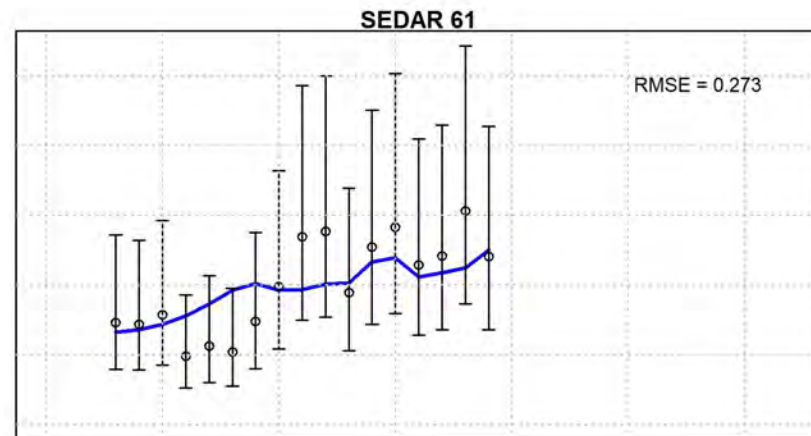
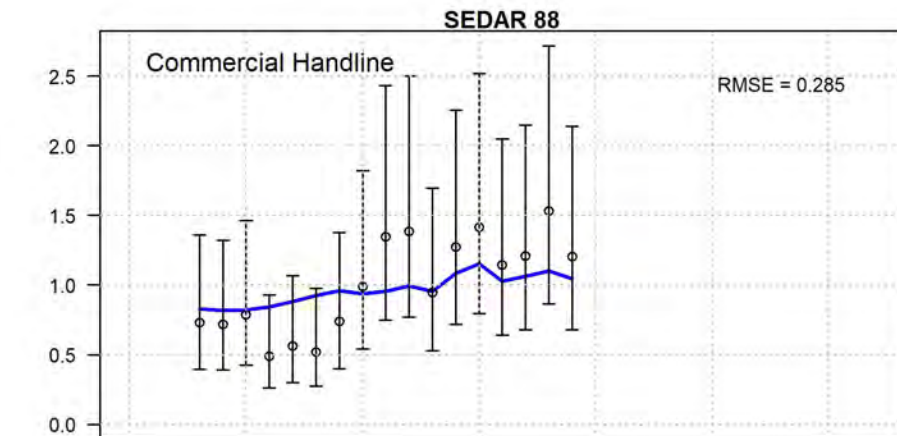
## Example: Longline



# Indices

## Fishery Dependent:

- Handline and Longline unchanged from S61
- Recreational – SRHS
  - Truncated in 2007

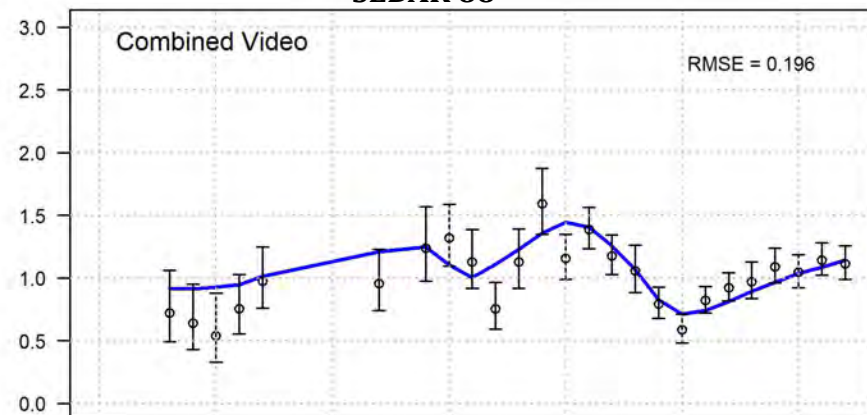


# Indices

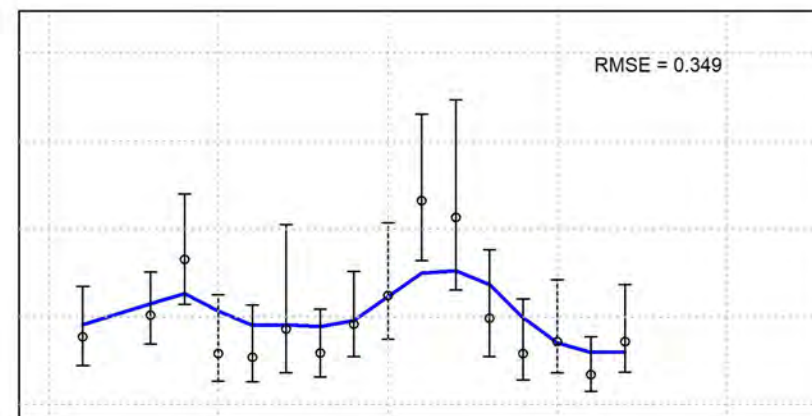
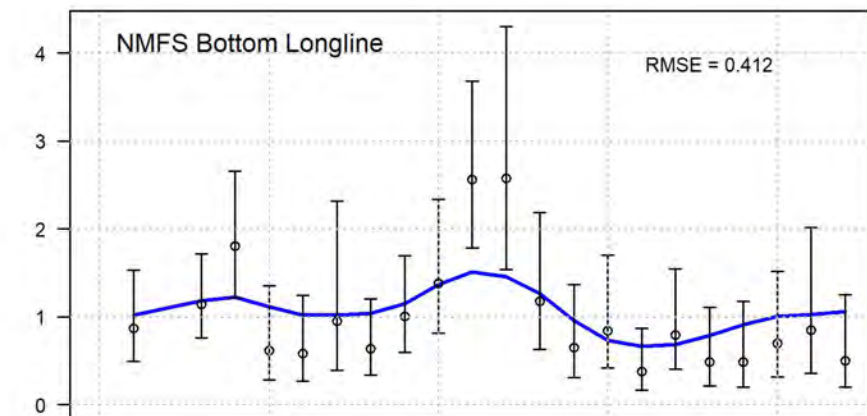
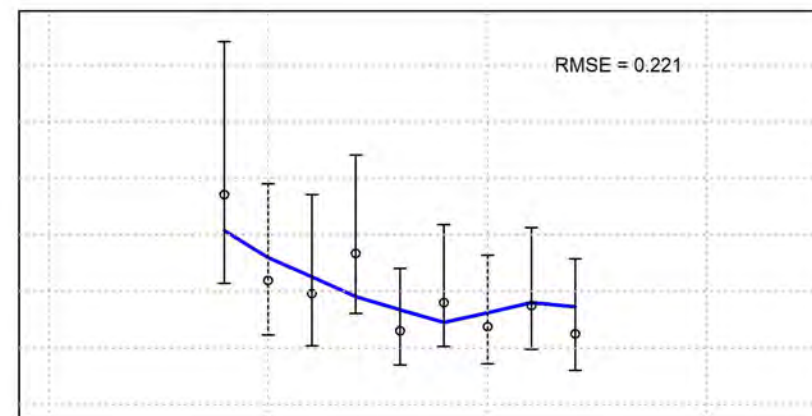
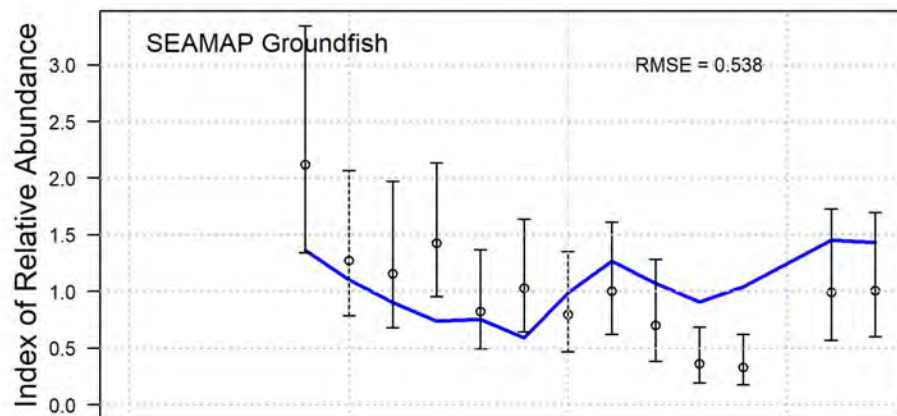
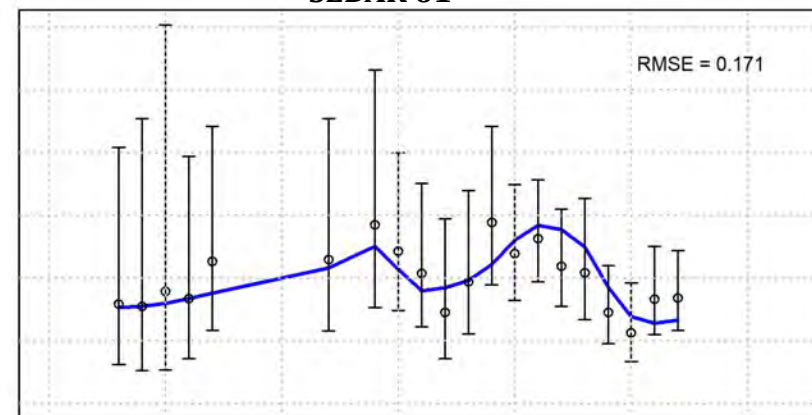
Fishery Independent:

- G-FISHER begins 2020 for Combined Video
- SEAMAP GF: 2020 dropped due to COVID

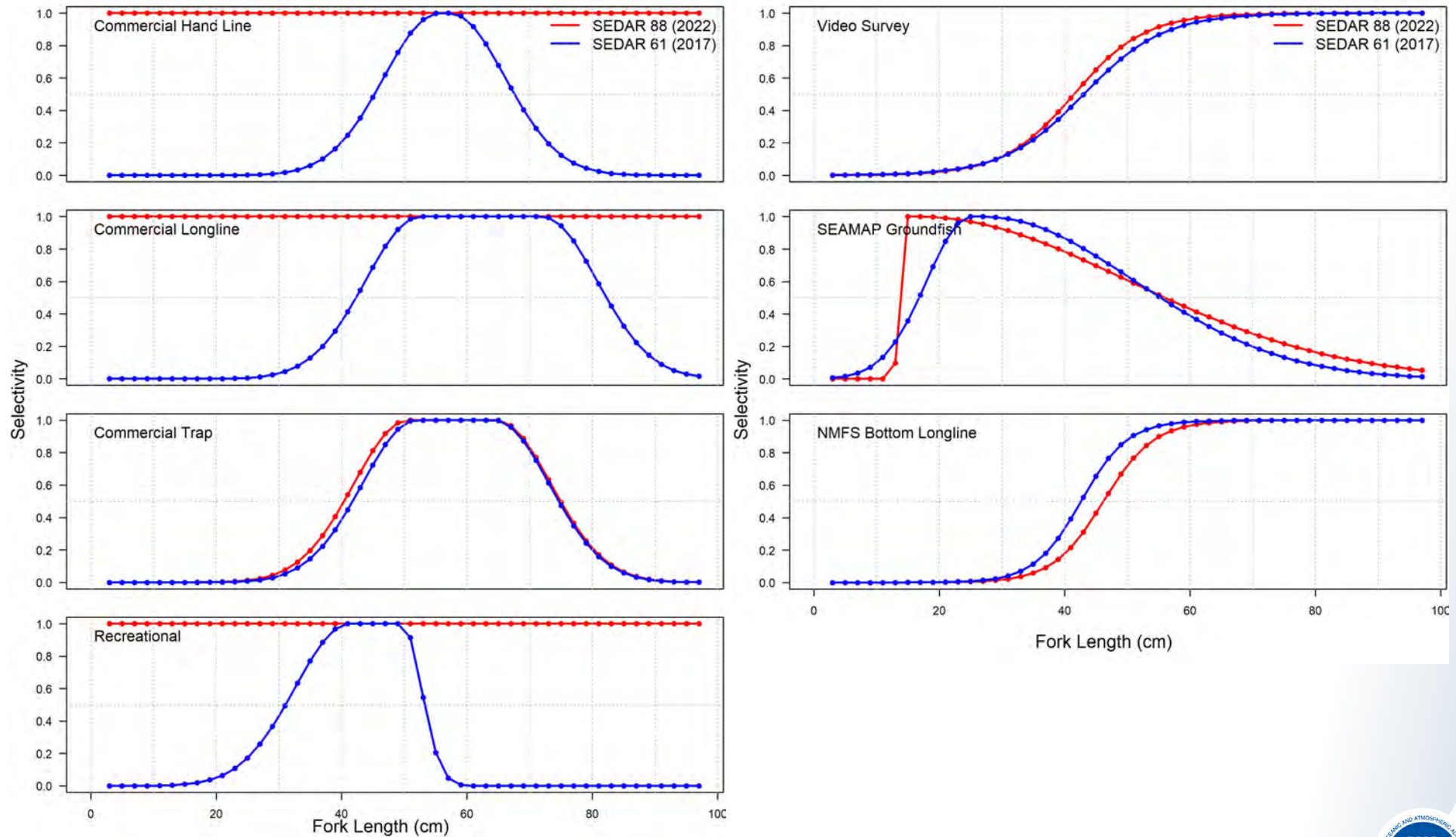
SEDAR 88



SEDAR 61

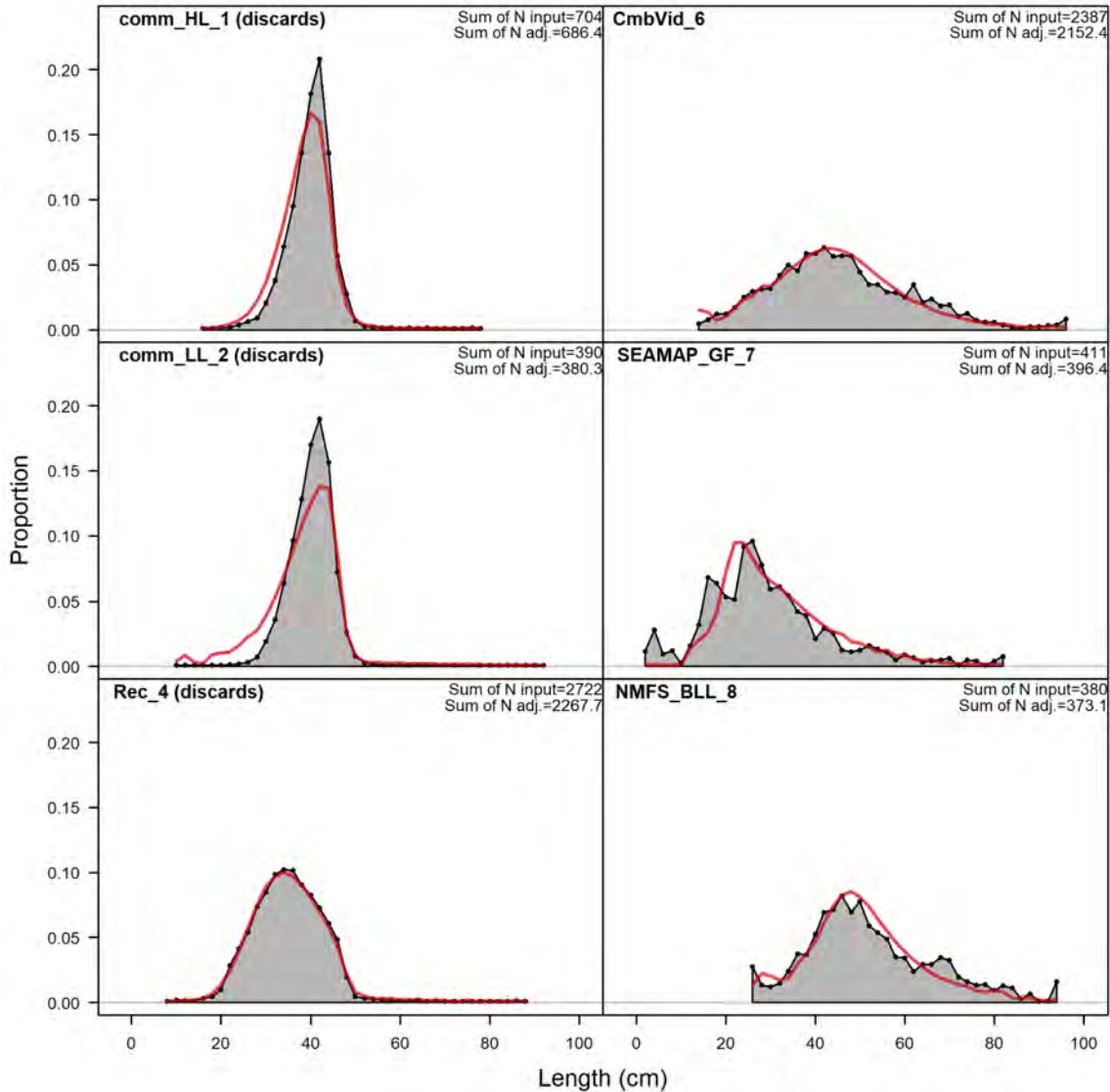


# Length Selectivity

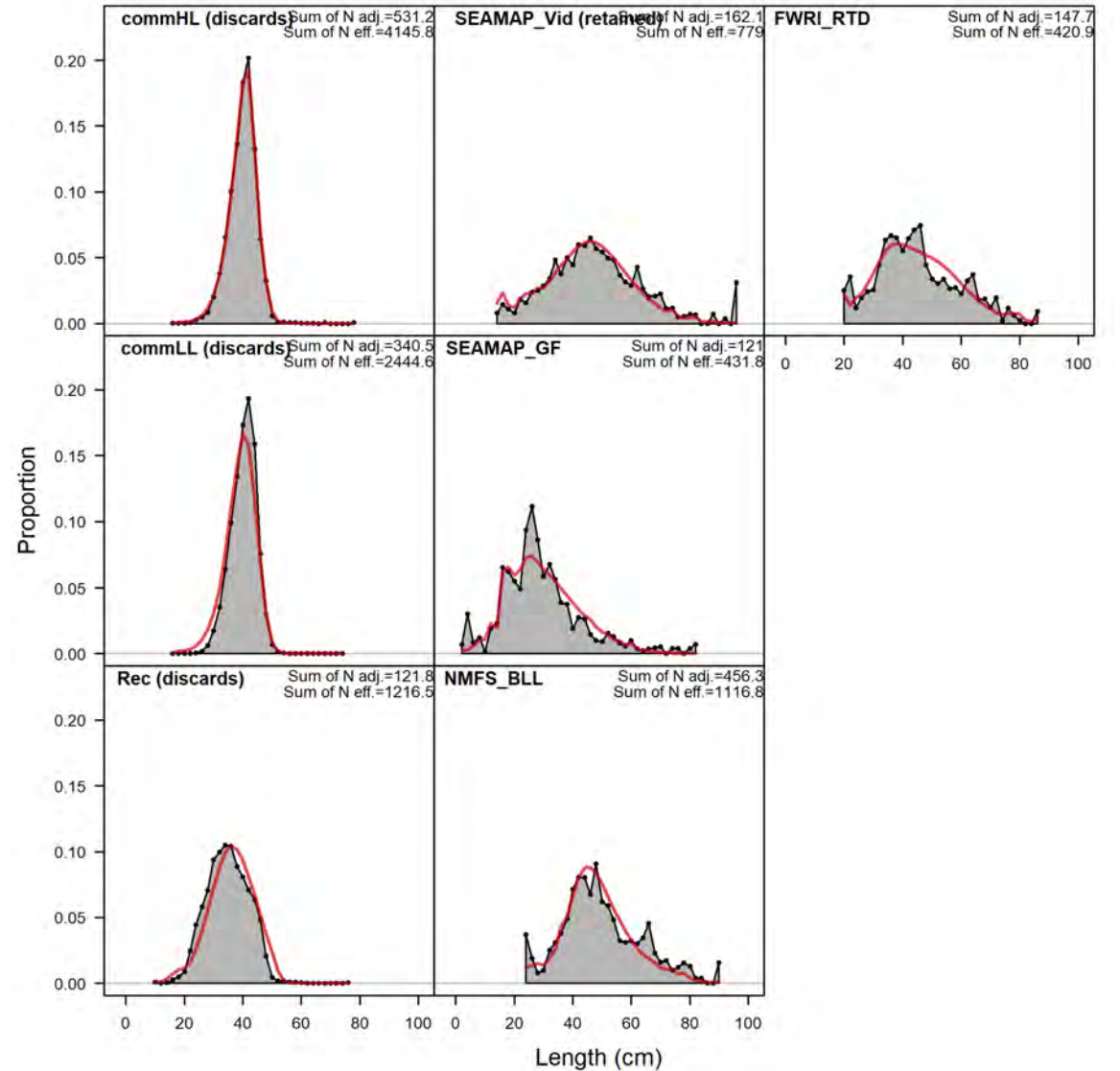


# Length Composition Fits

SEDAR 88

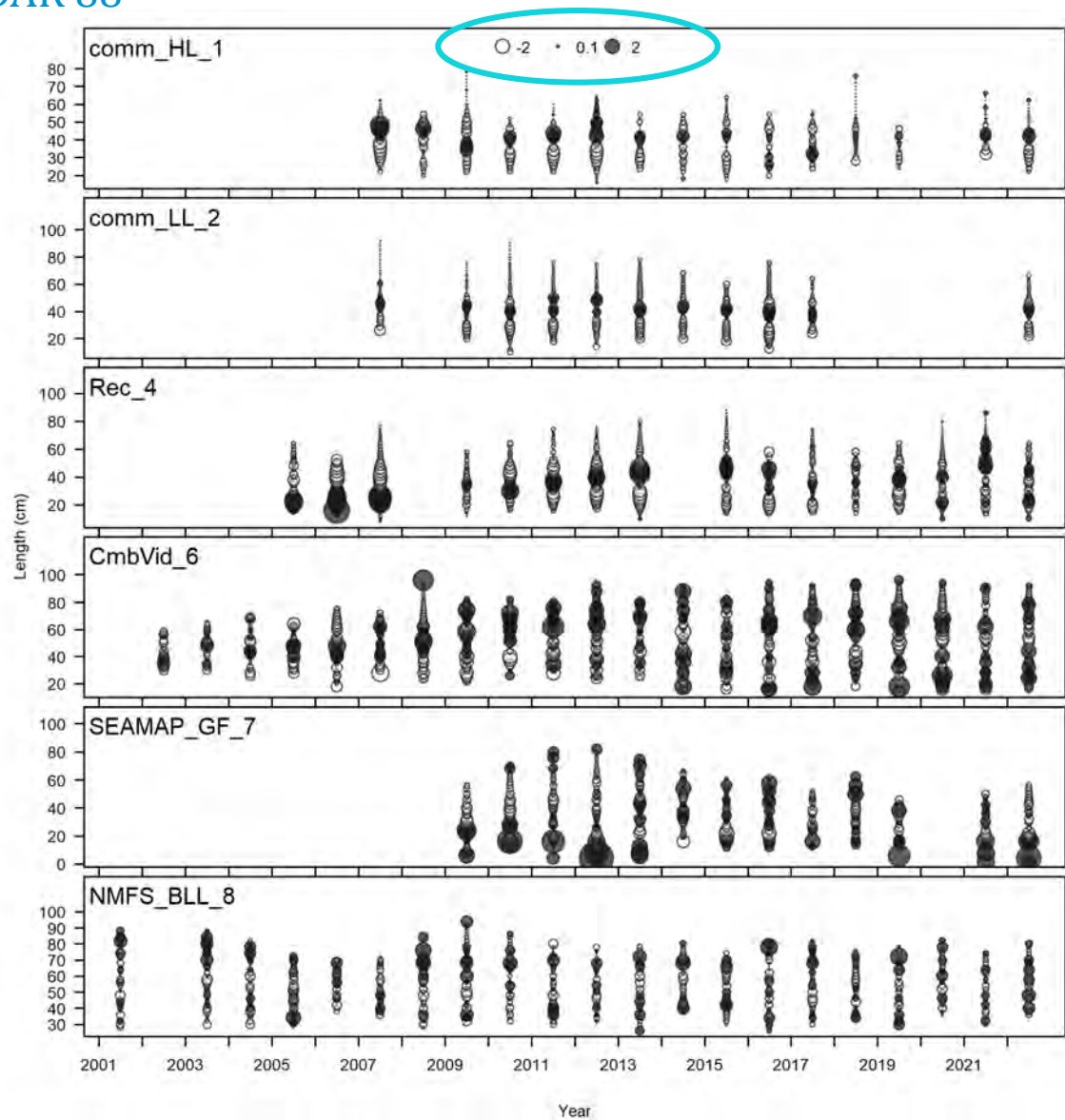


SEDAR 61

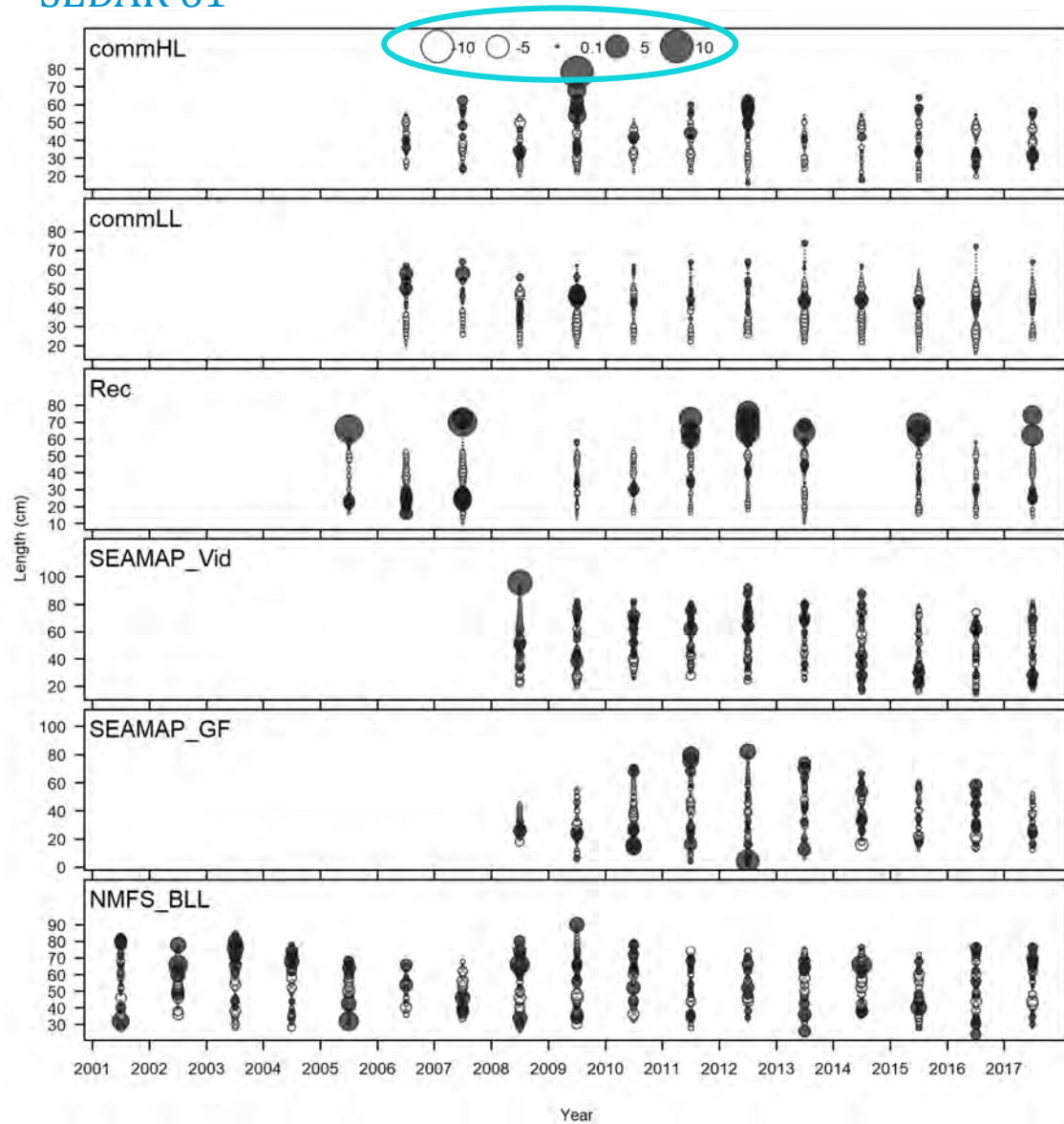


# Length Composition Fits

SEDAR 88

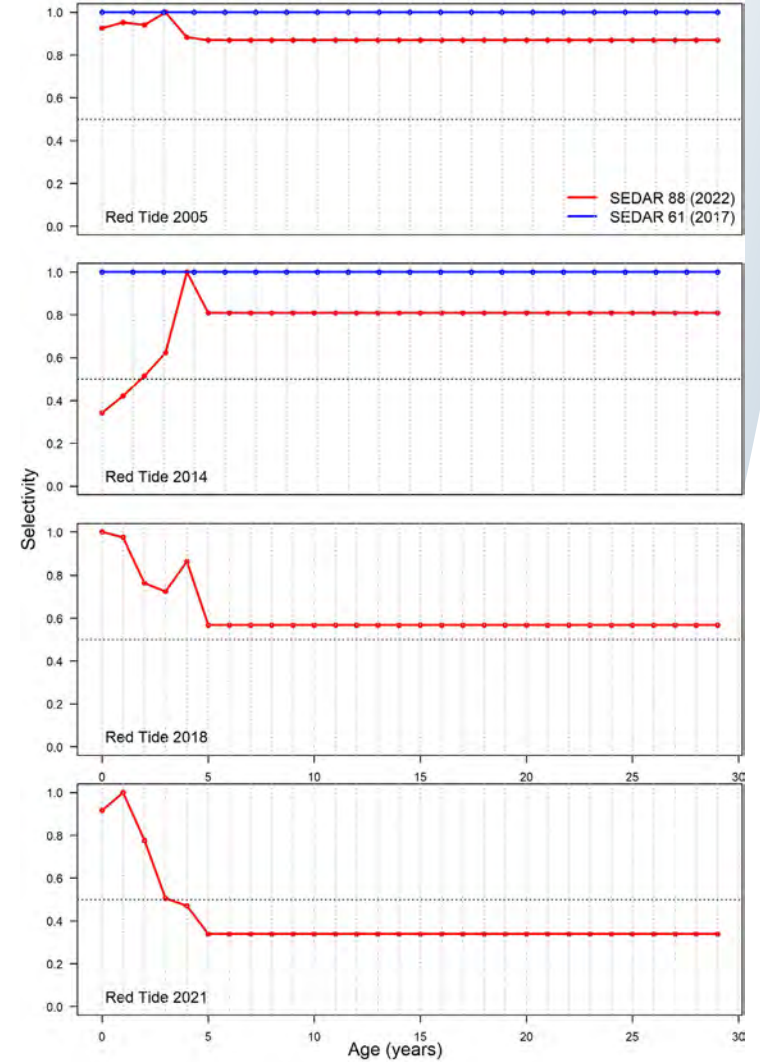
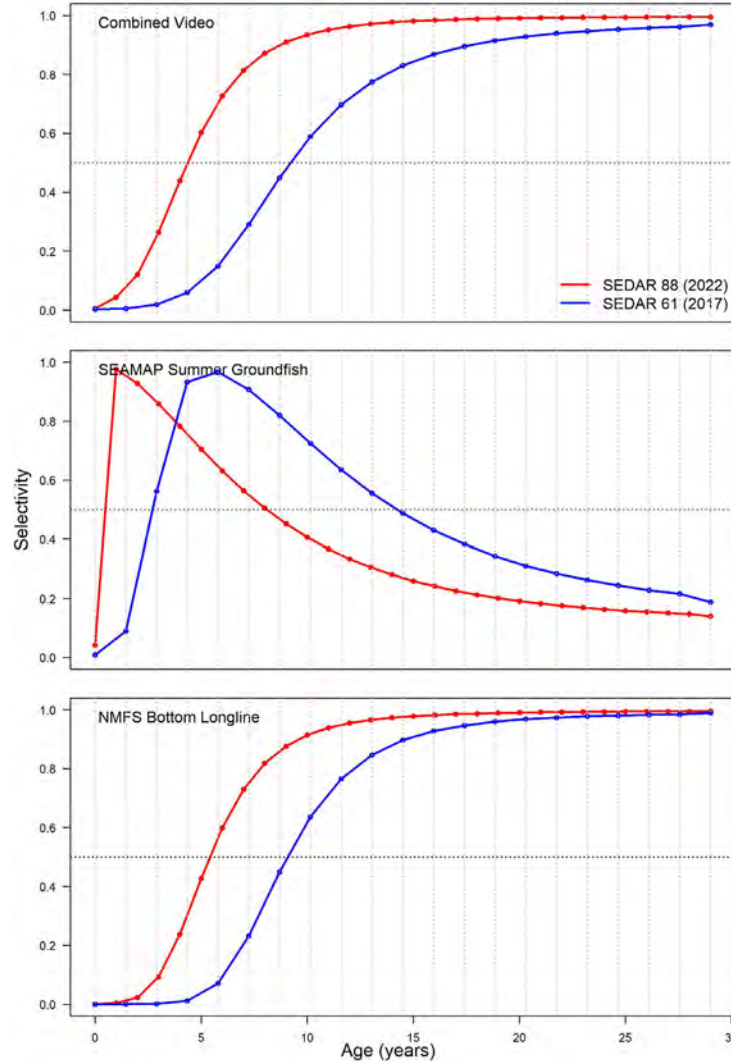
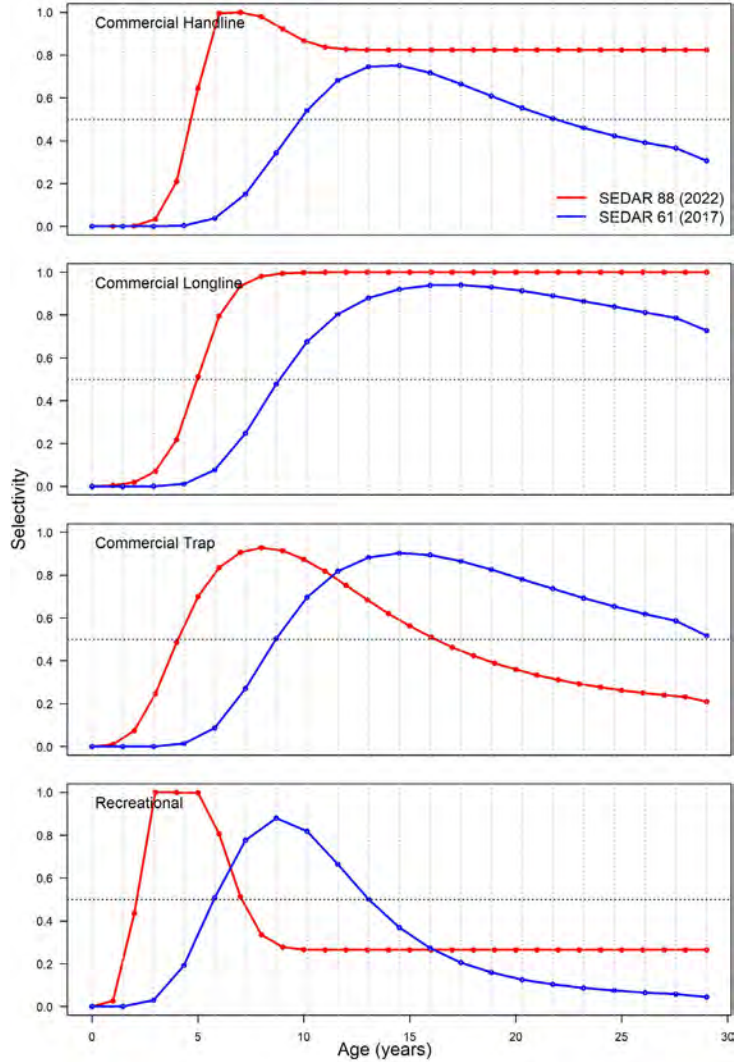


SEDAR 61



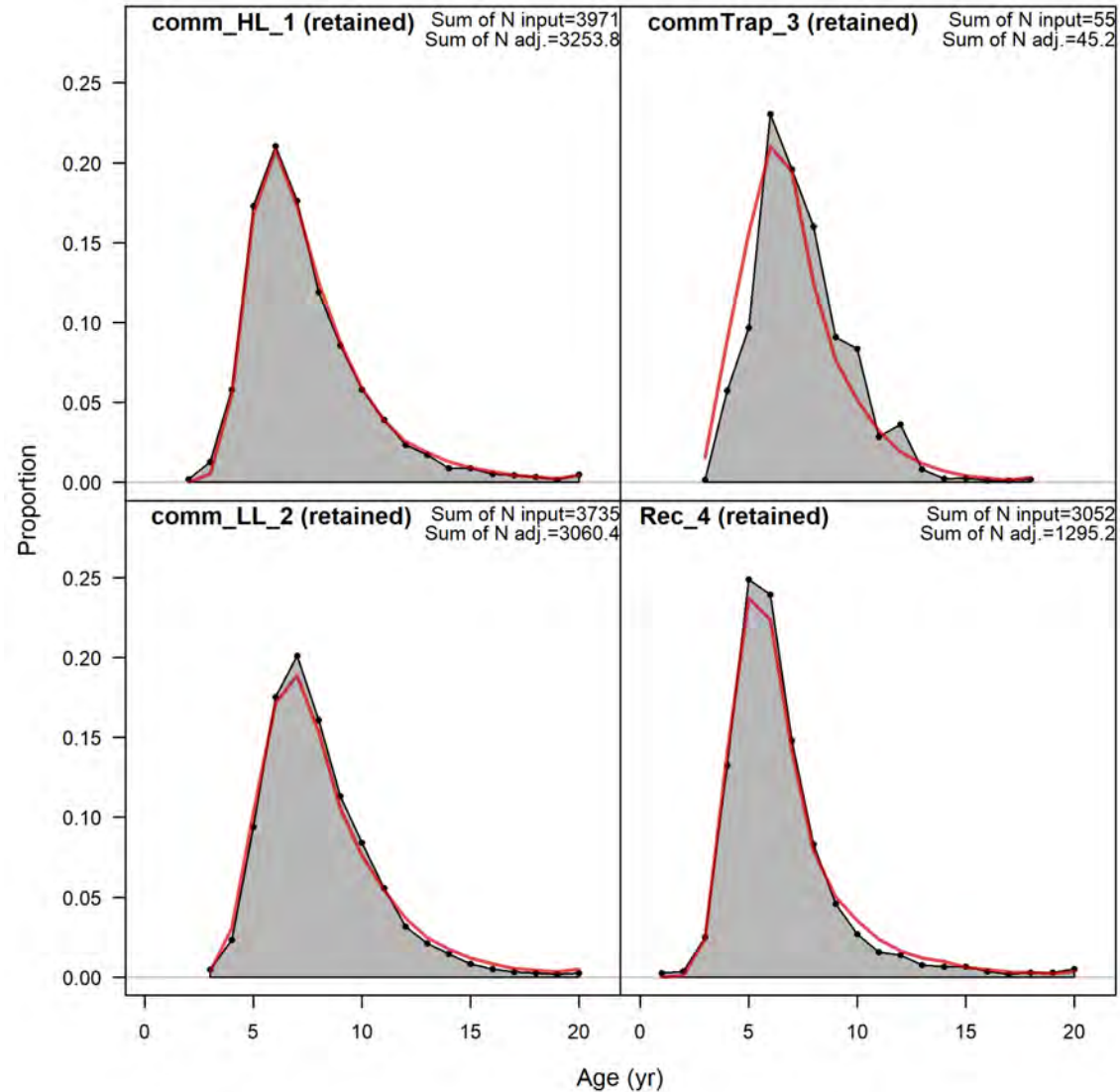
# Age Selectivity

\* Derived age selectivity for comparison purposes (S61 length base only)

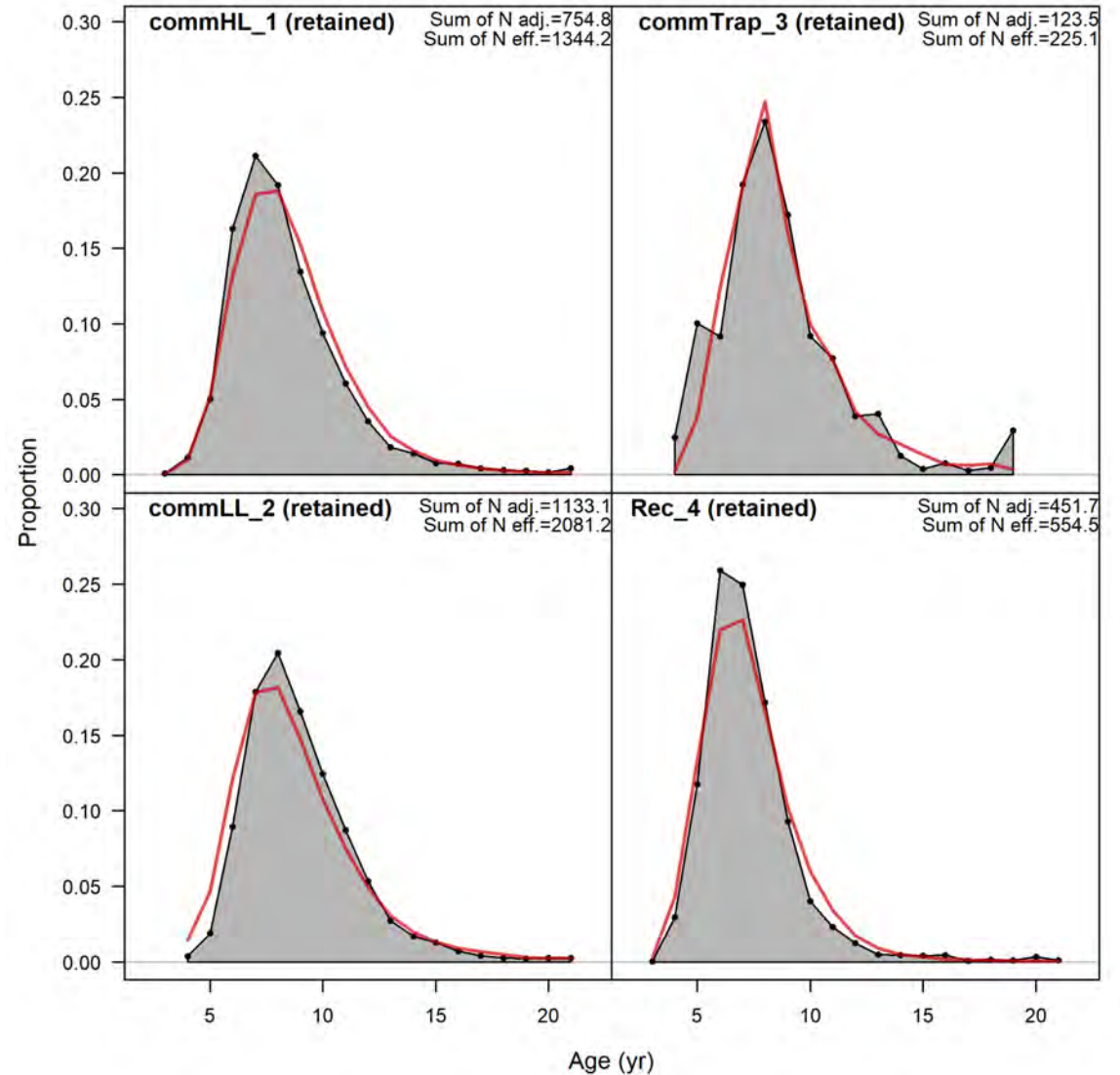


# Age Composition Fits

SEDAR 88

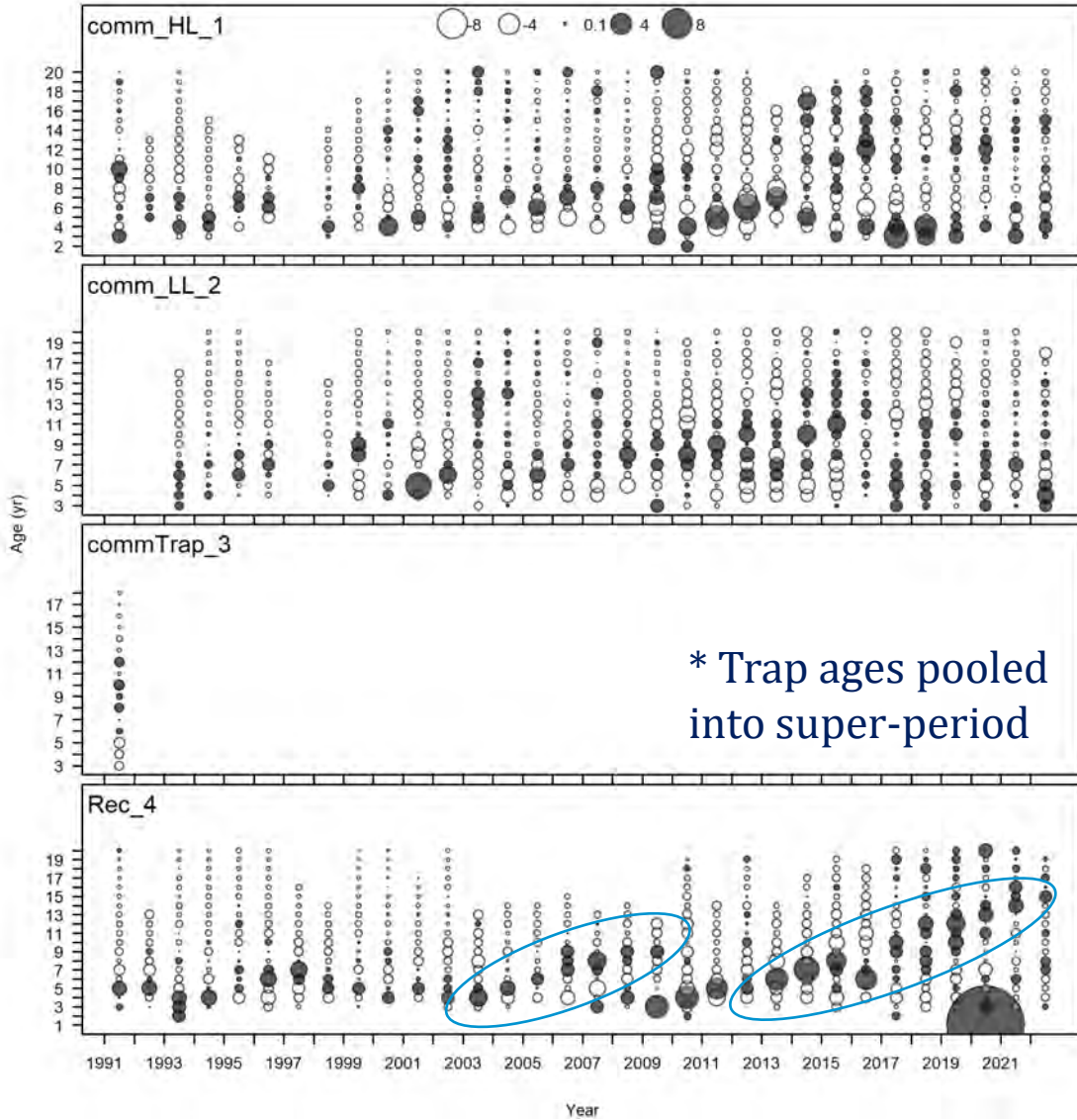


SEDAR 61

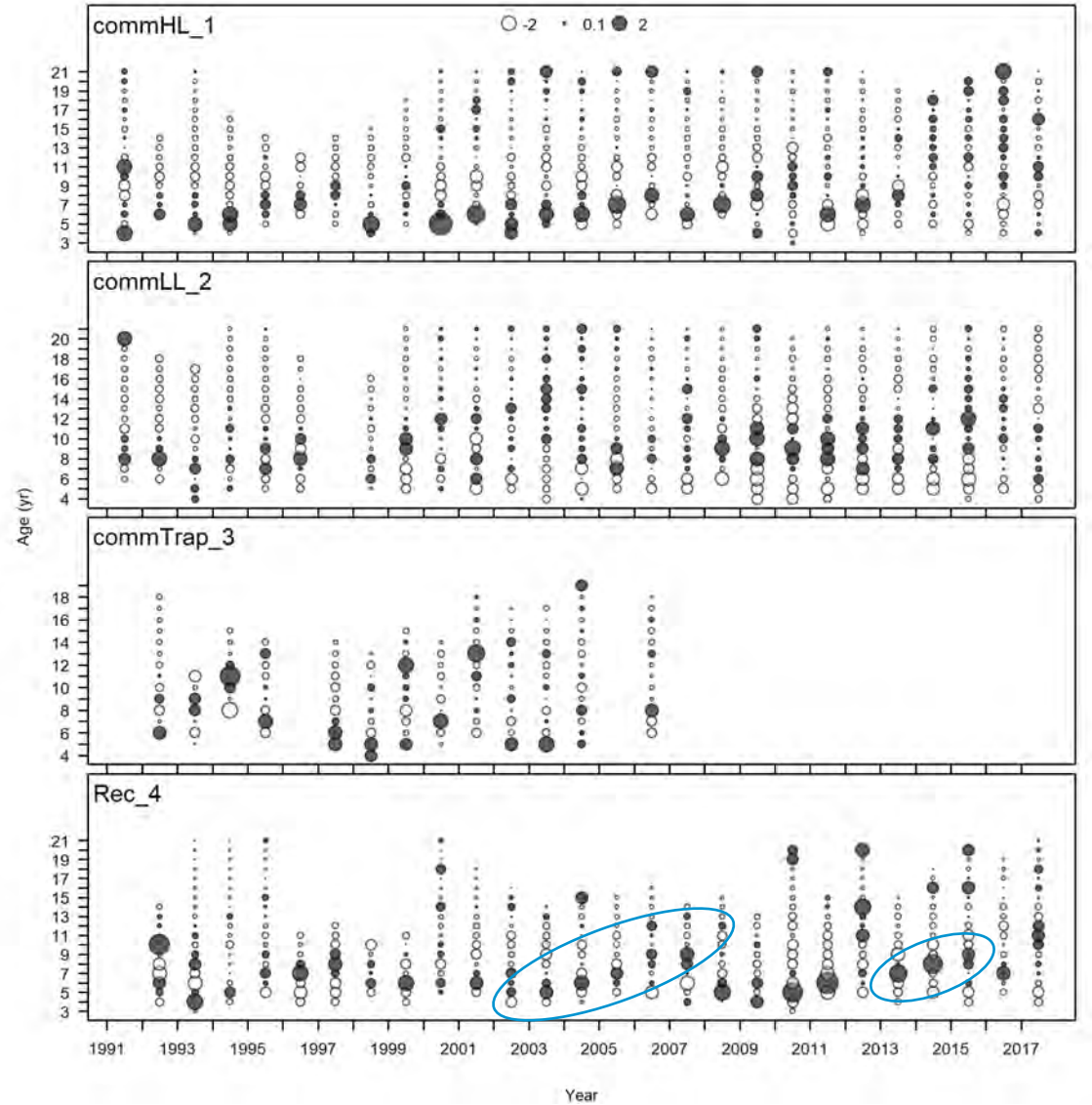


# Age Compositions Fits

## SEDAR 88

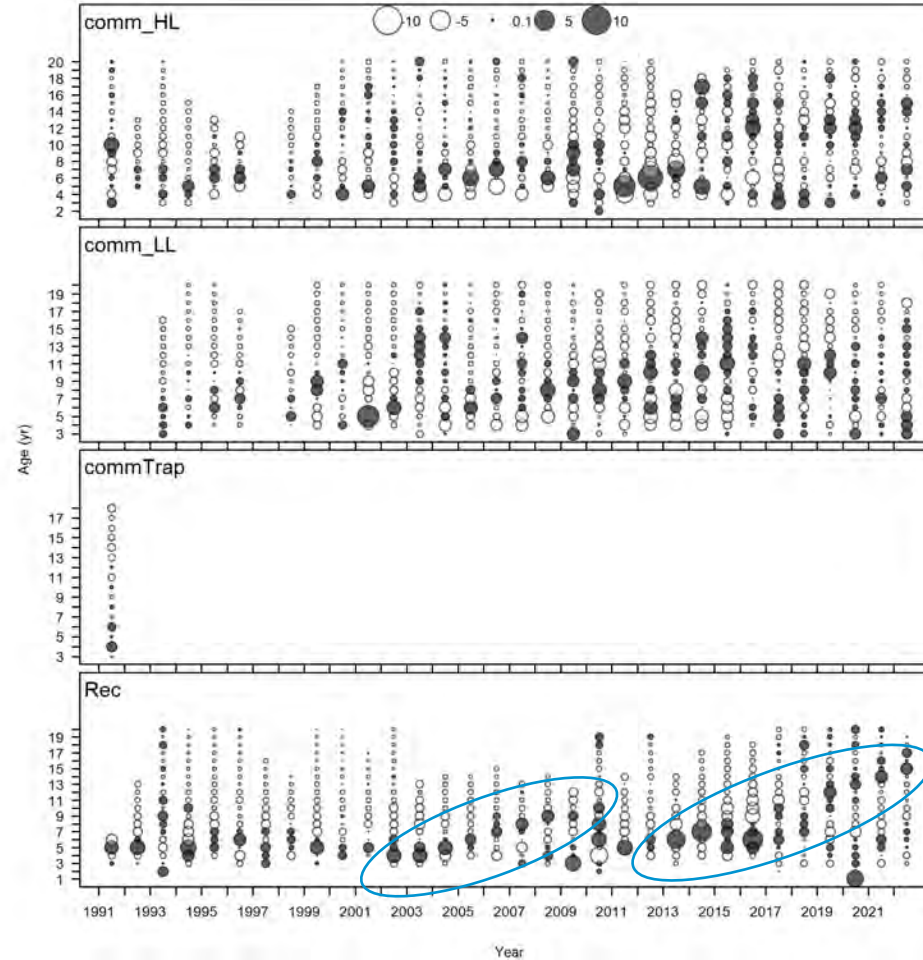
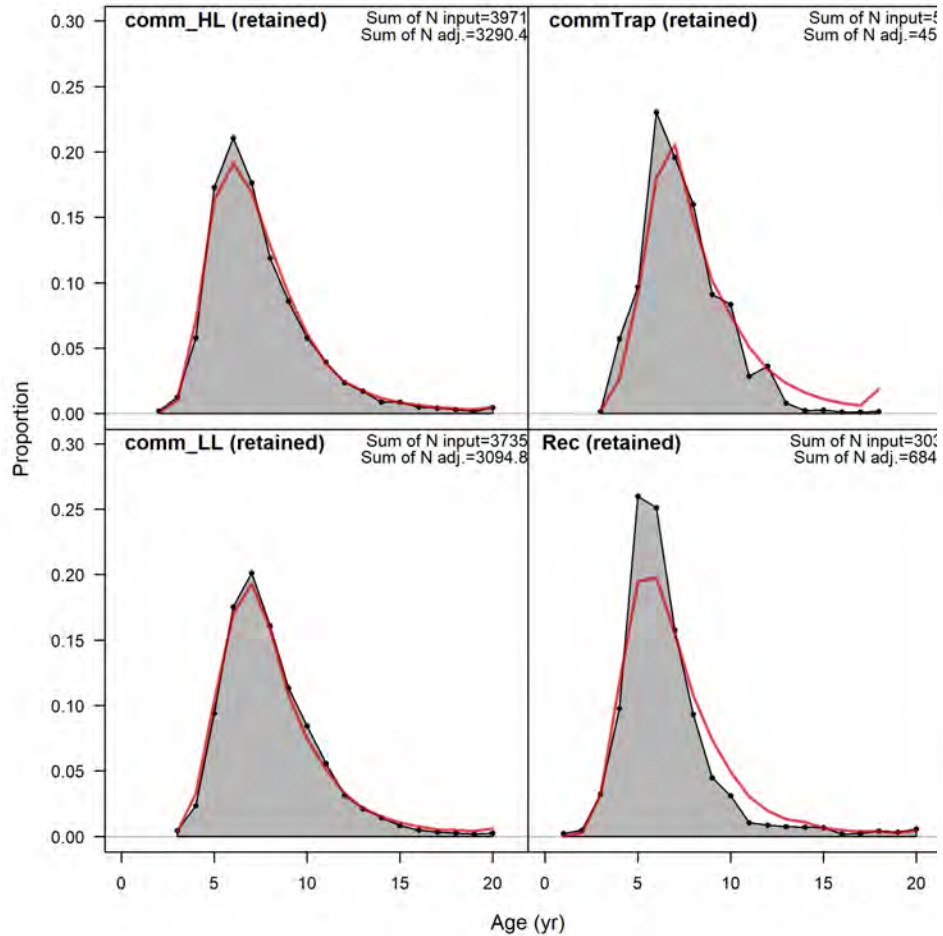


## SEDAR 61



# Recreational Residual Pattern

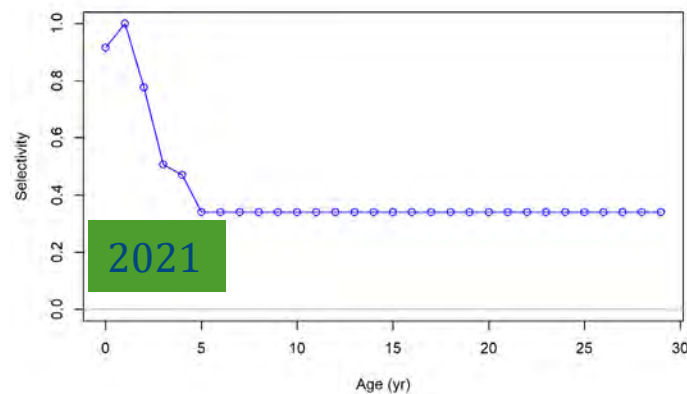
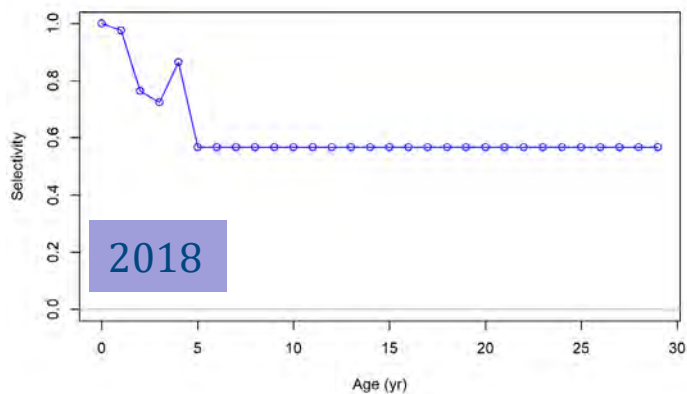
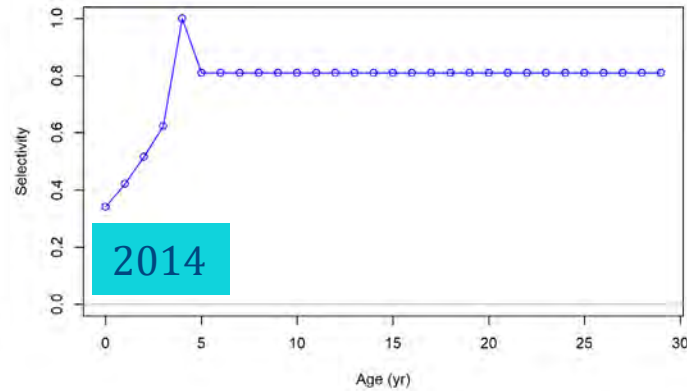
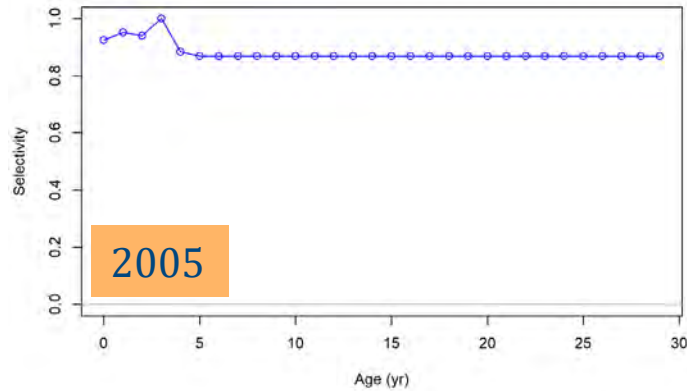
Length-based selectivity run from model building



**NOAA**  
FISHERIES

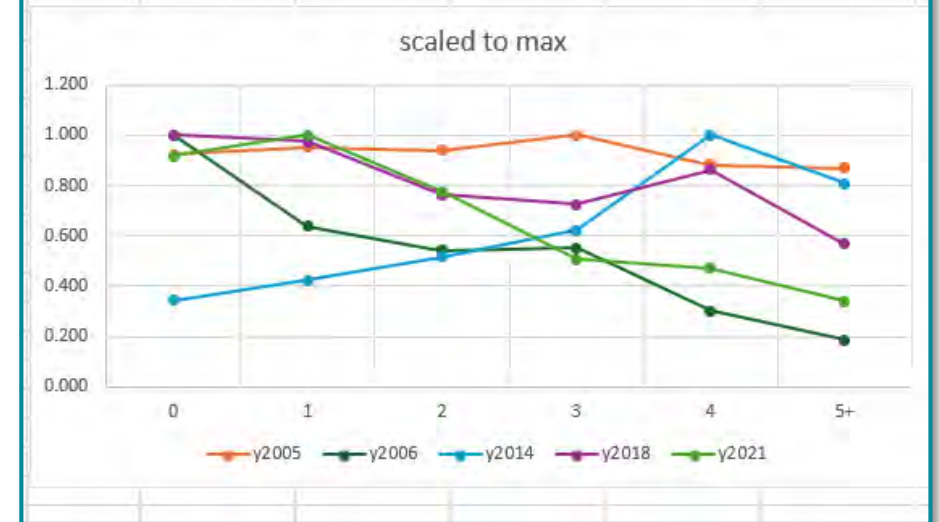
# Red Tide: Empirical Selectivity-at-Age

Selectivity curve from SS:



Outputs from WFS EwE model:

Scale to max	2005	2006	2014	2018	2021
Age 0	0.924	1.000	0.342	1.000	0.916
1	0.951	0.639	0.422	0.976	1.000
2	0.940	0.541	0.516	0.764	0.776
3	1.000	0.552	0.623	0.725	0.507
4	0.884	0.301	1.000	0.865	0.471
5+	0.869	0.186	0.810	0.568	0.339



# Red Tide

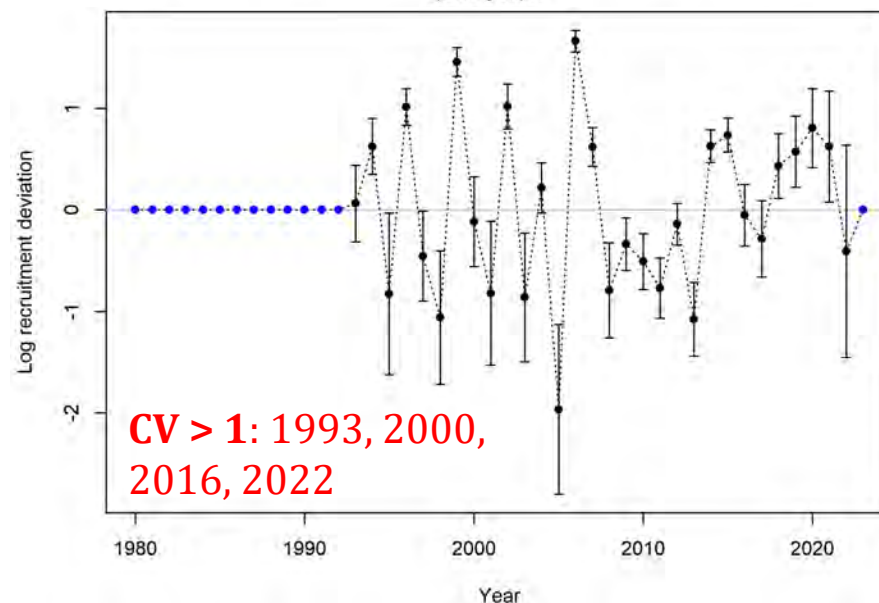
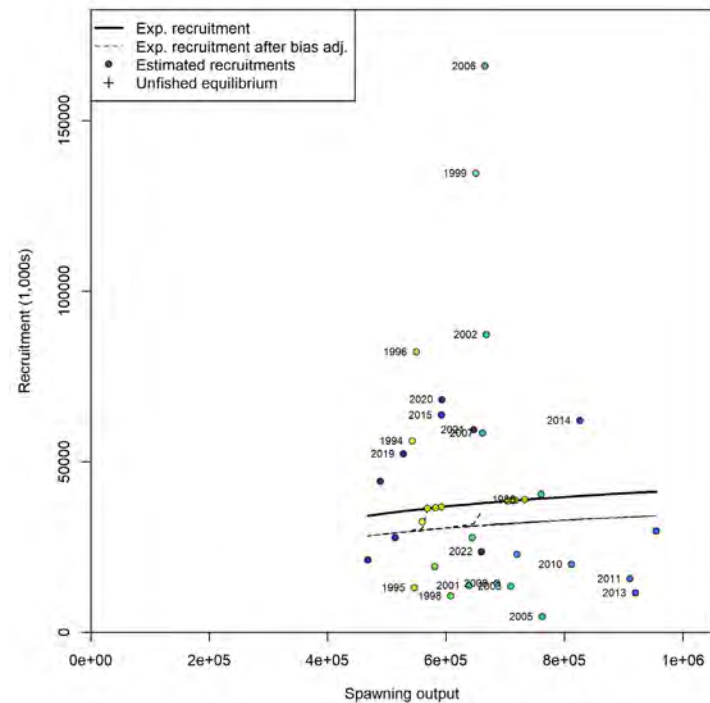
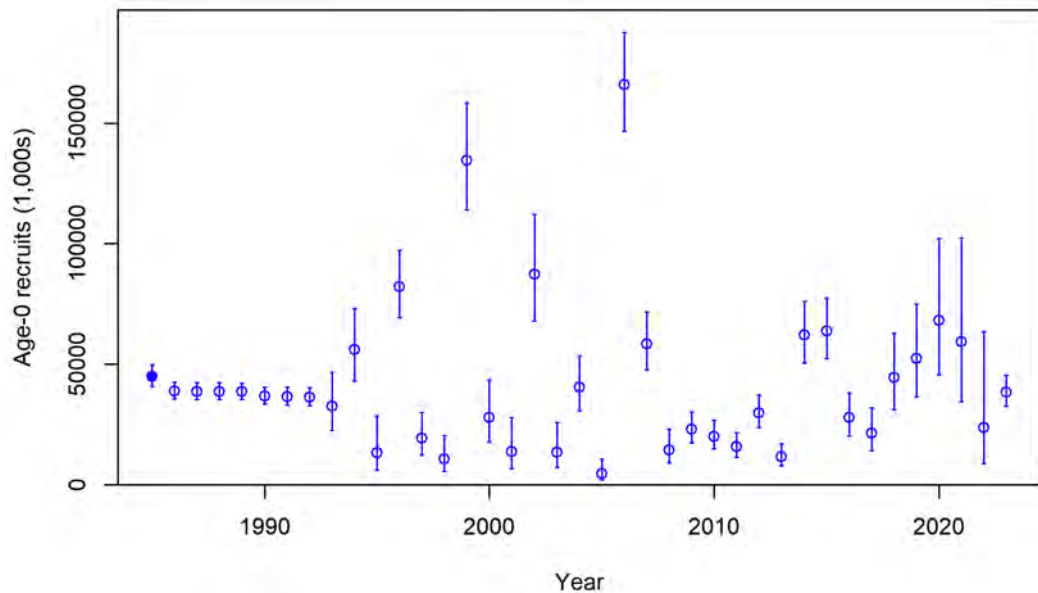
- Red tide mortality in 2018 and 2021 consistently uncertain during model building
- True magnitude of recent red tide mortality may only be estimated with additional years of data

Years	S88	S61
F values (CV)		
2005	0.174 (0.533)	0.339 (0.309)
2014	0.196 (0.455)	0.257 (0.429)
2018	0.042 (2.04)	
2021	0.099 (1.606)	
Biomass killed		
2005	4,741 (14%)	7,137 (29.5%)
2014	3,918 (13%)	5,292 (21.3%)
2018	733 (3%)	
2021	1,539 (5%)	
Numbers killed		
2005	5,936 (12%)	35,926 (22.9%)
2014	5,042 (6%)	13,039 (18.6%)
2018	2,129 (3%)	
2021	6,682 (6%)	



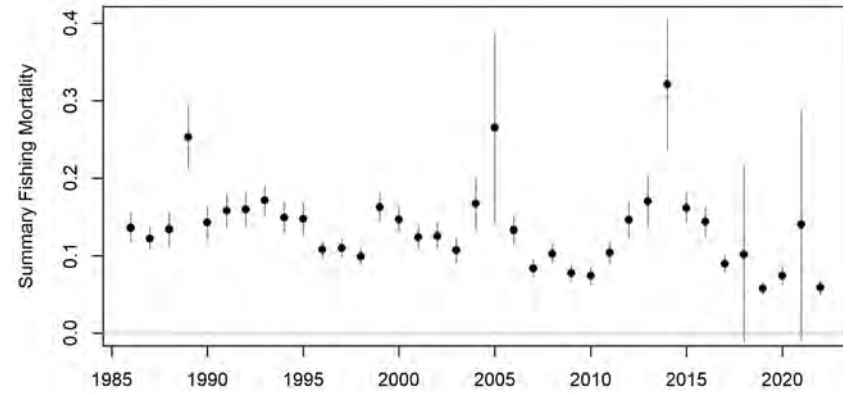
# Recruitment

Parameter	Value
Ln(R0)	10.713 (0.005)
Steepness	0.661 (0.086)
SigmaR	0.647 (0.094)

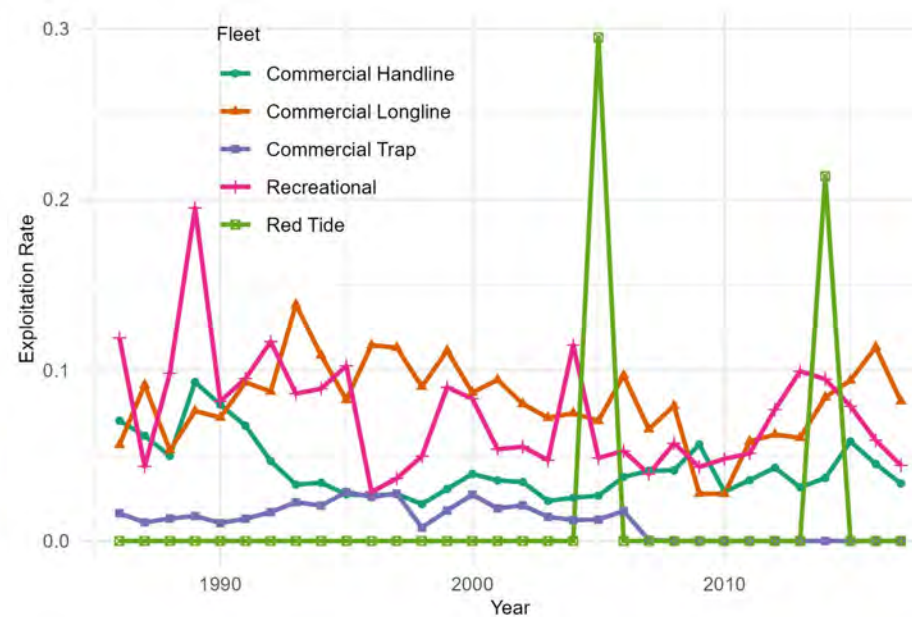
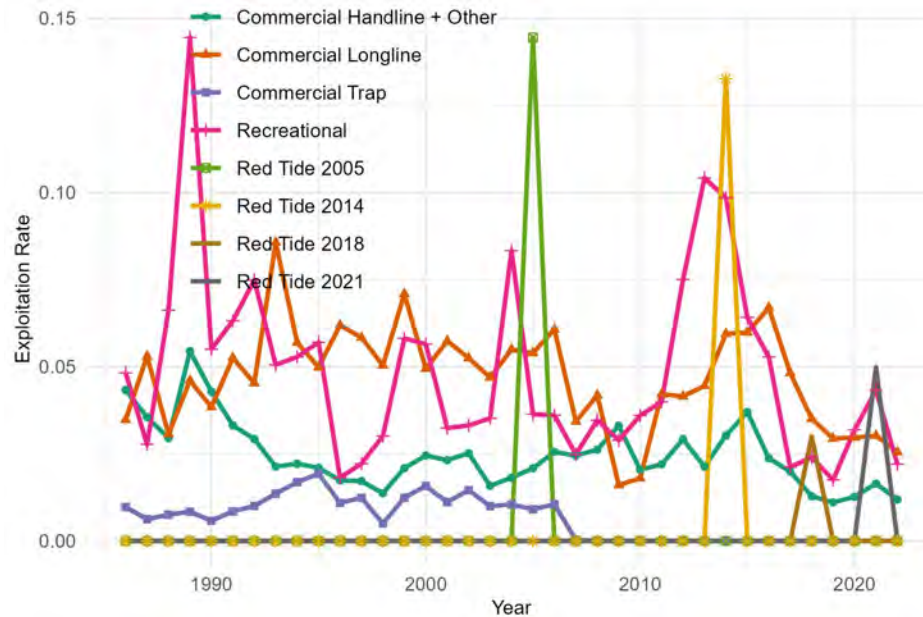
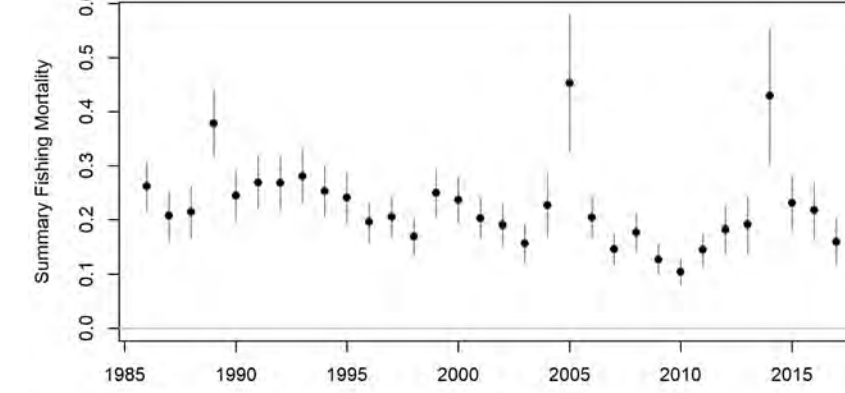


# Exploitation Rate

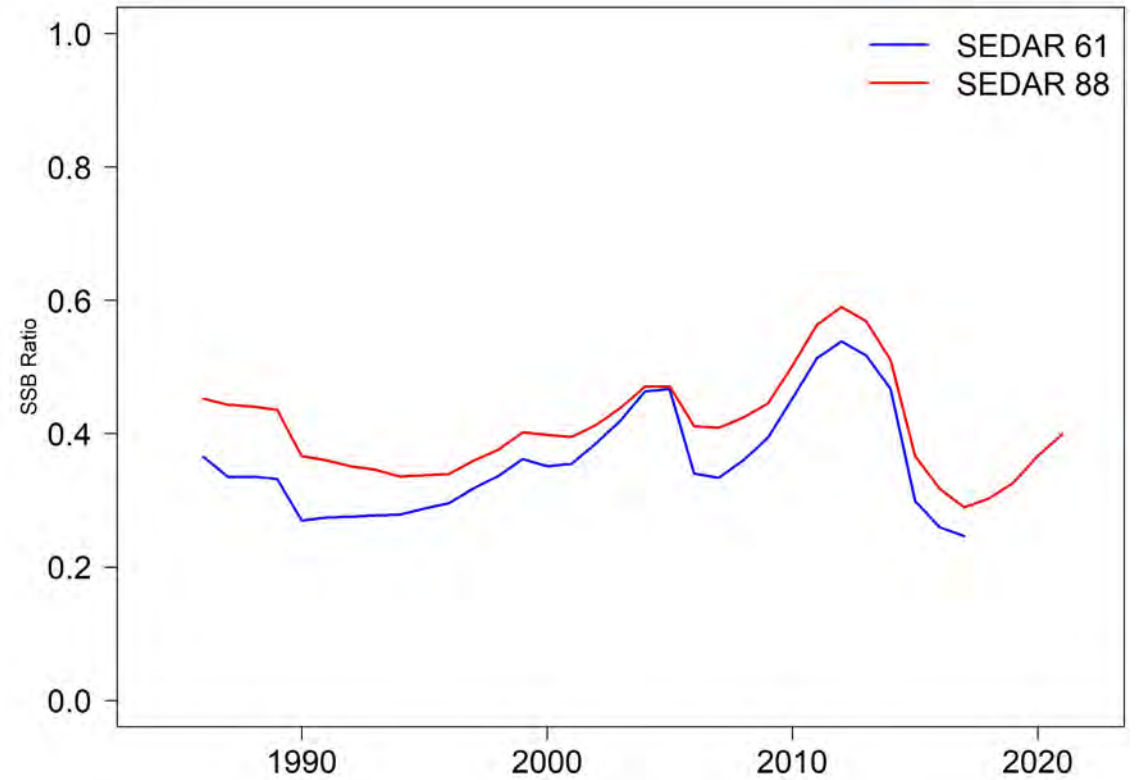
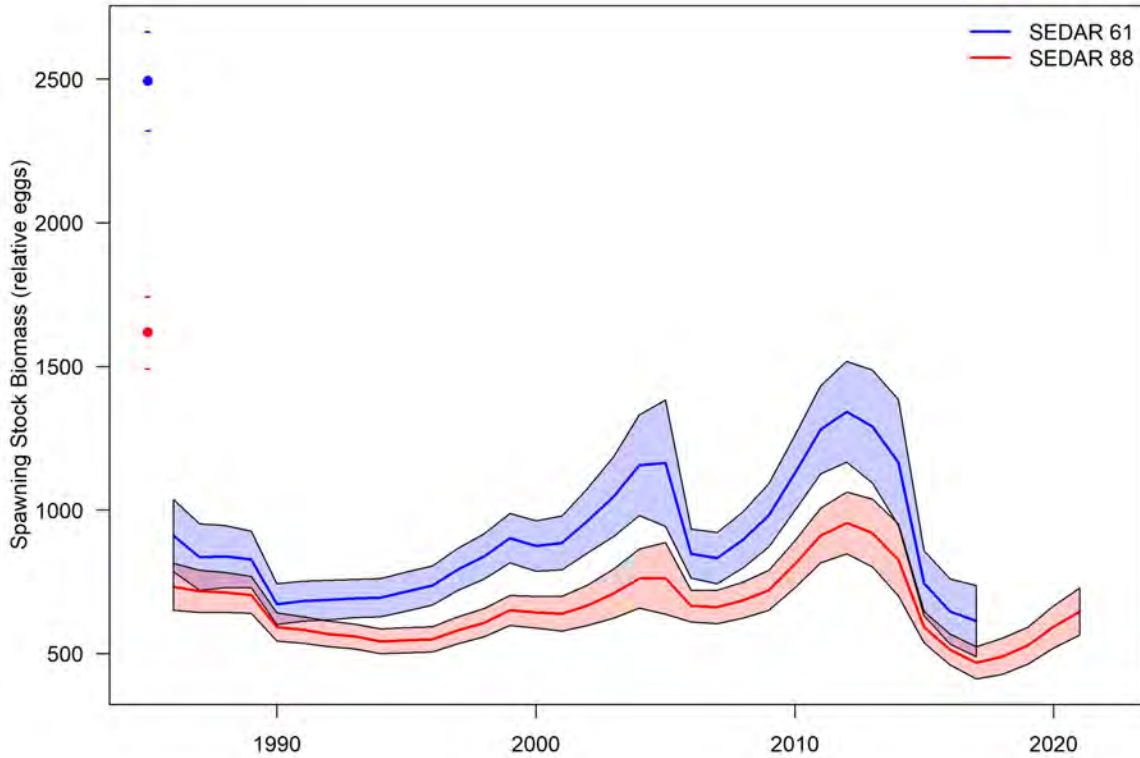
SEDAR 88



SEDAR 61



# SSB and SSB/SSB0 trajectories



# Diagnostics

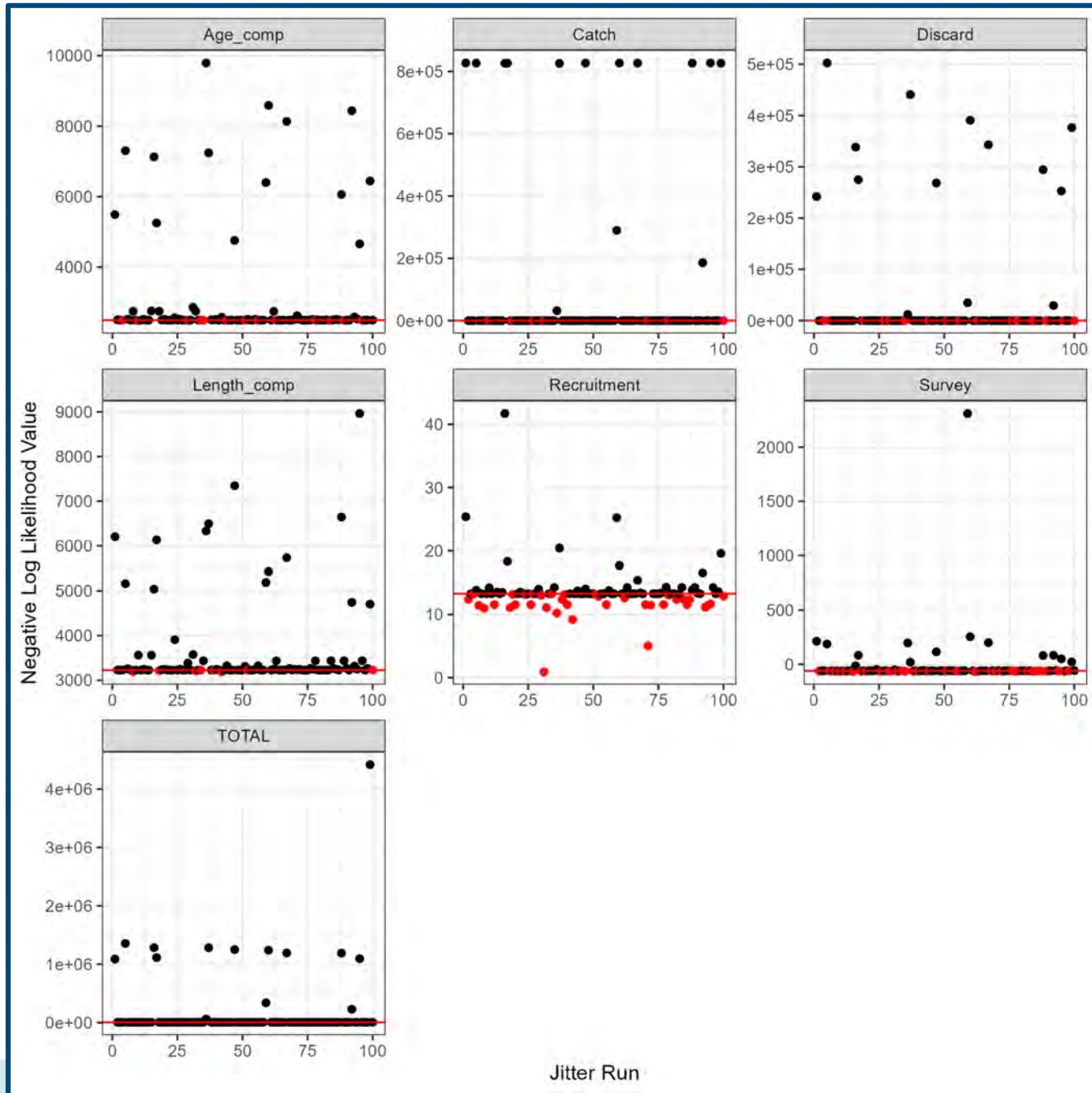


**NOAA**  
**FISHERIES**

# Jitter

- No runs revealed a lower negative log-likelihood (NLL) than the base
- Recruitment component did have lower NLL

	Percent
Same NLL	34
Within1 NLL	34
Within5 NLL	37
Within10 NLL	42
Within25 NLL	48
Within50 NLL	62

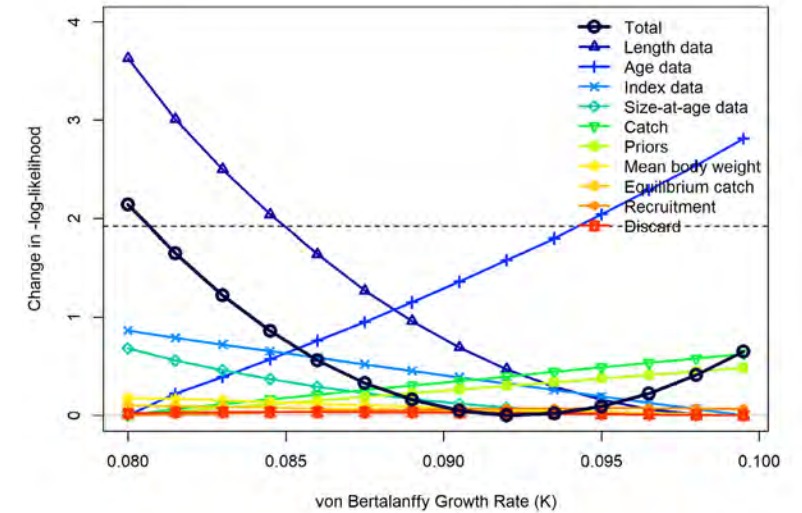
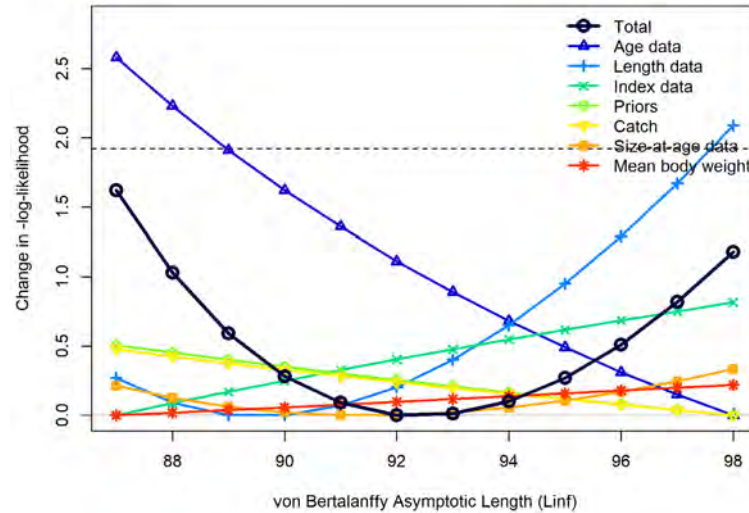
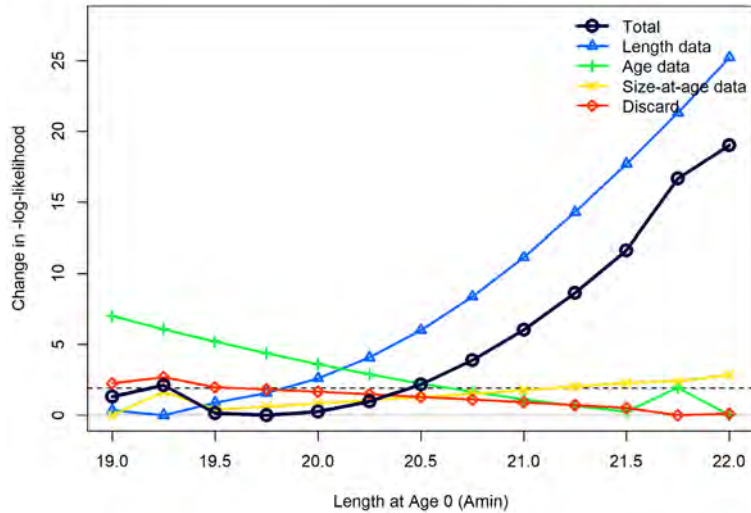


# Likelihood Profiles: Growth

Label	Value
$L_{Amin}$	19.72 (0.02)

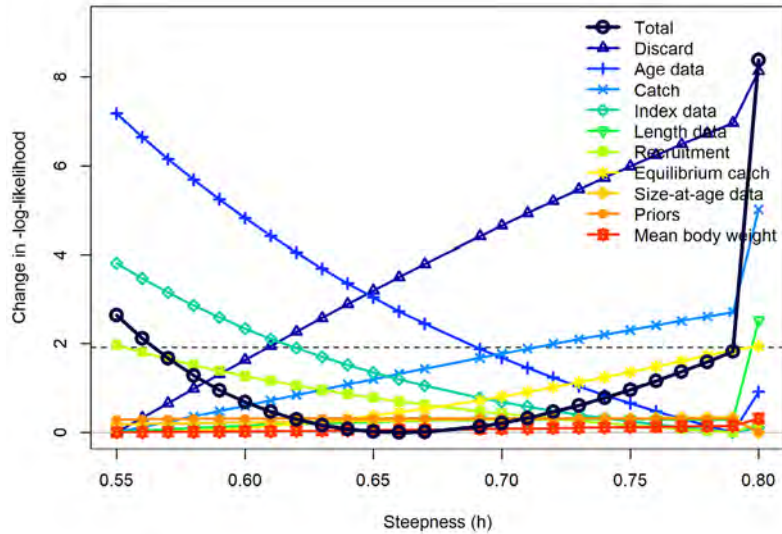
Label	Value
$L_{inf}$	92.41 (0.036)

Label	Value
K	0.092 (0.066)

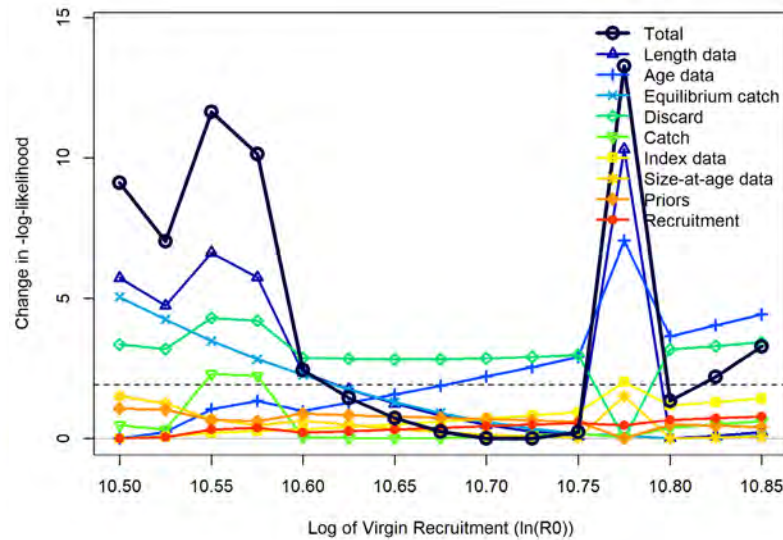


# Likelihood Profiles: Recruitment

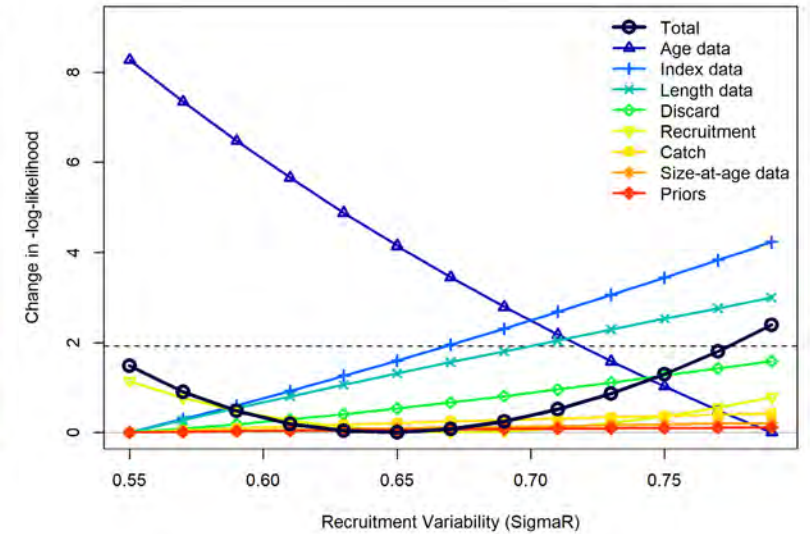
Label	Value
Steepness	0.661 (0.086)



Label	Value
Ln(R0)	10.713 (0.005)

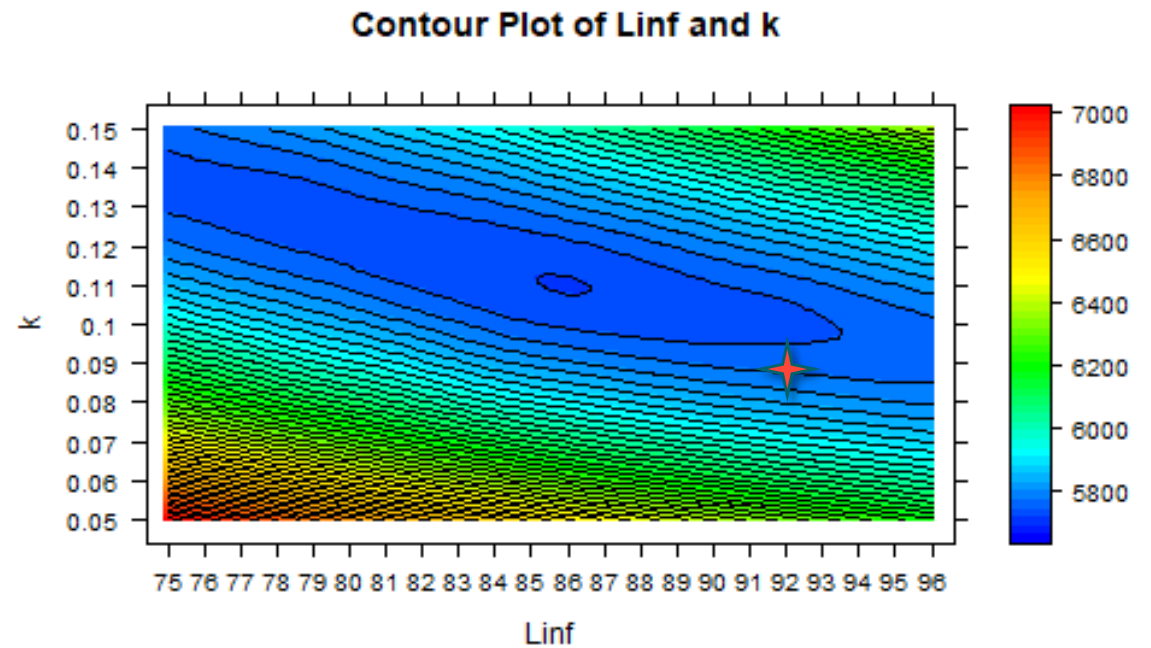
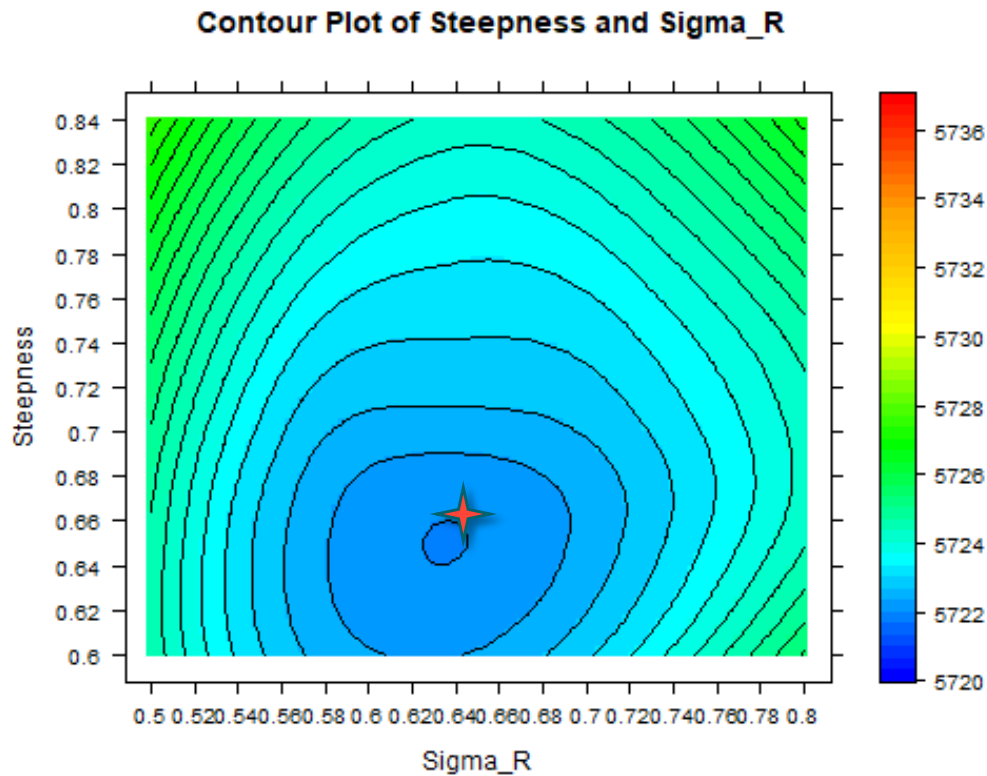


Label	Value
SigmaR	0.647 (0.094)



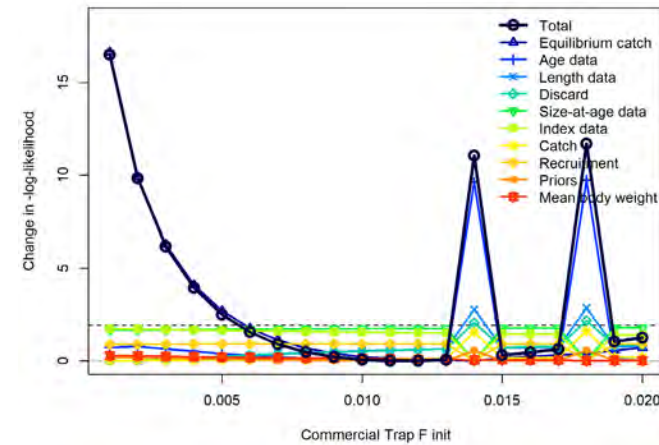
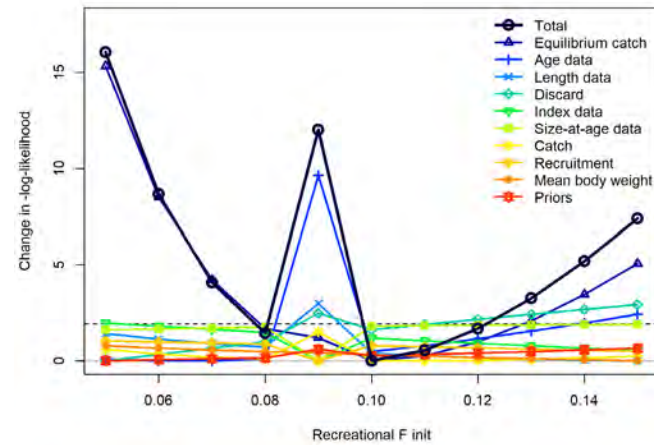
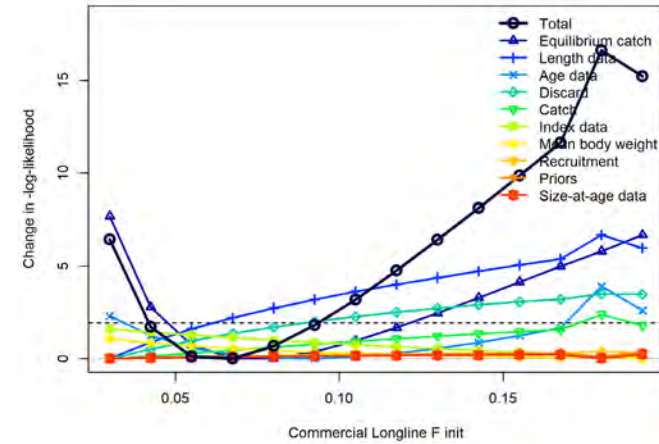
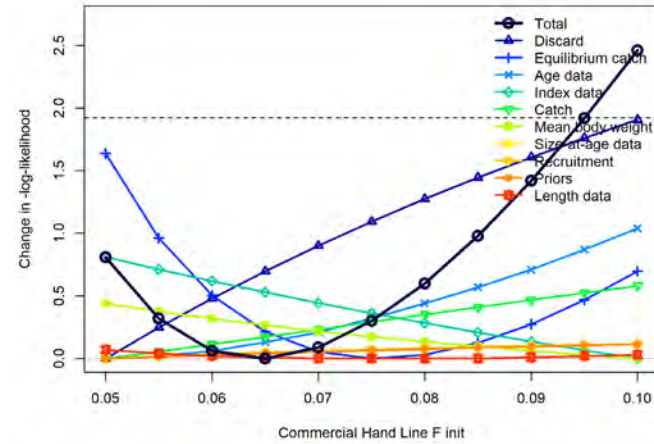
# Contour Likelihood

- Likelihood profiles across two parameters:



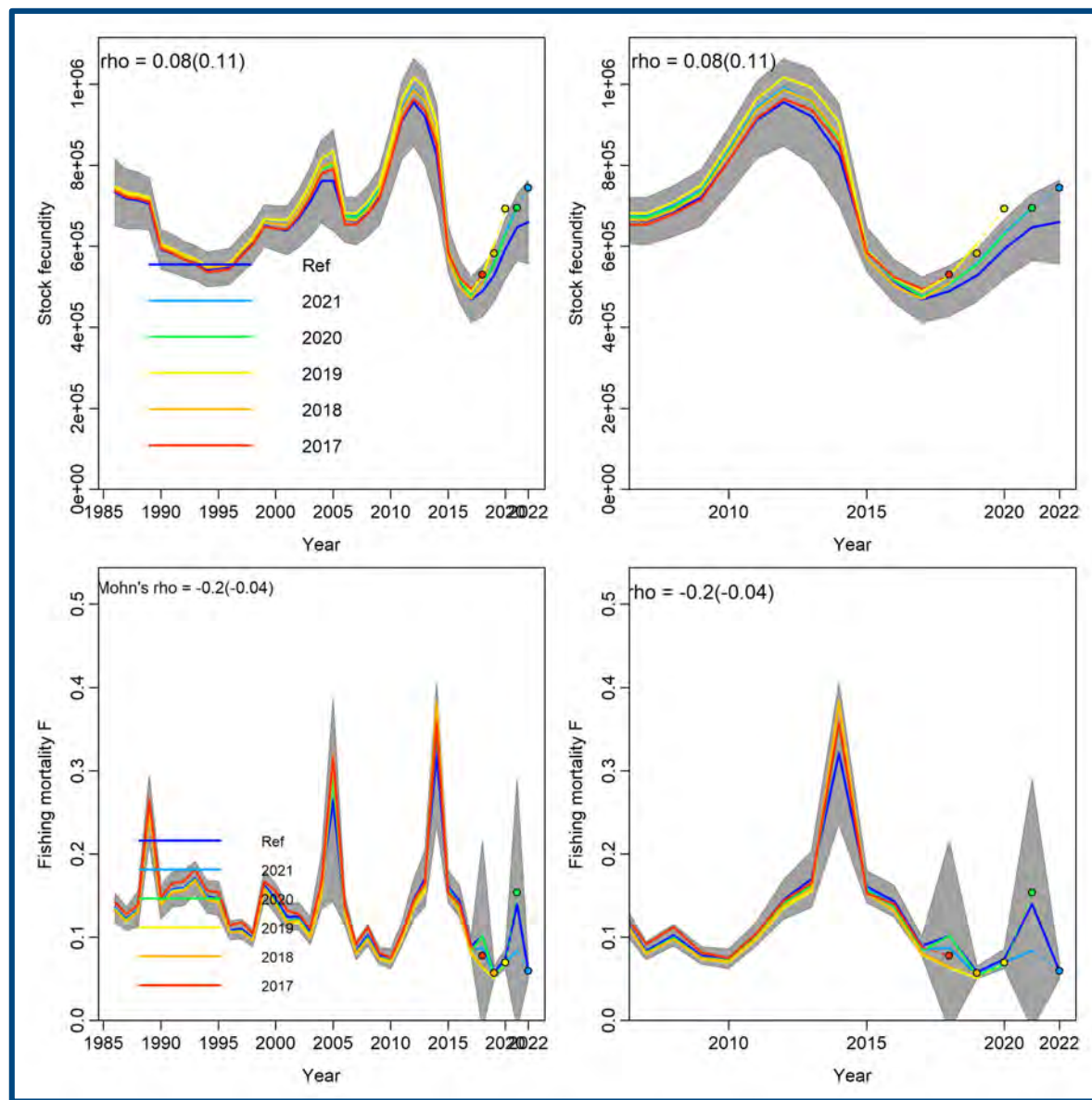
# Likelihood Profiles: Finit

Label	Value
Comm HL	0.064 (0.199)
Comm LL	0.062 (0.203)
Comm TR	0.011 (0.356)
Recreational	0.097 (0.114)



# Retrospectives

- Acceptable range for long-lived species (-0.15 to 0.2; Hurtado et al. 2015):
  - SSB = **0.075**
  - Recruitment = **-0.614**
  - F = **-0.198**
- Recruitment and F potentially interact with red tide years of 2018 and 2021



# Additional diagnostics

- Hindcast: **Poor predictive skill** remains for some data

Data Source	Com HL	Com LL	Rec	Cmd Vid	SEAMAP	BLL
Index	-	-	-	X	X	X
Age	X	X	X	-	-	-
Length	X	X	X	X	X	X

# Sensitivity Runs

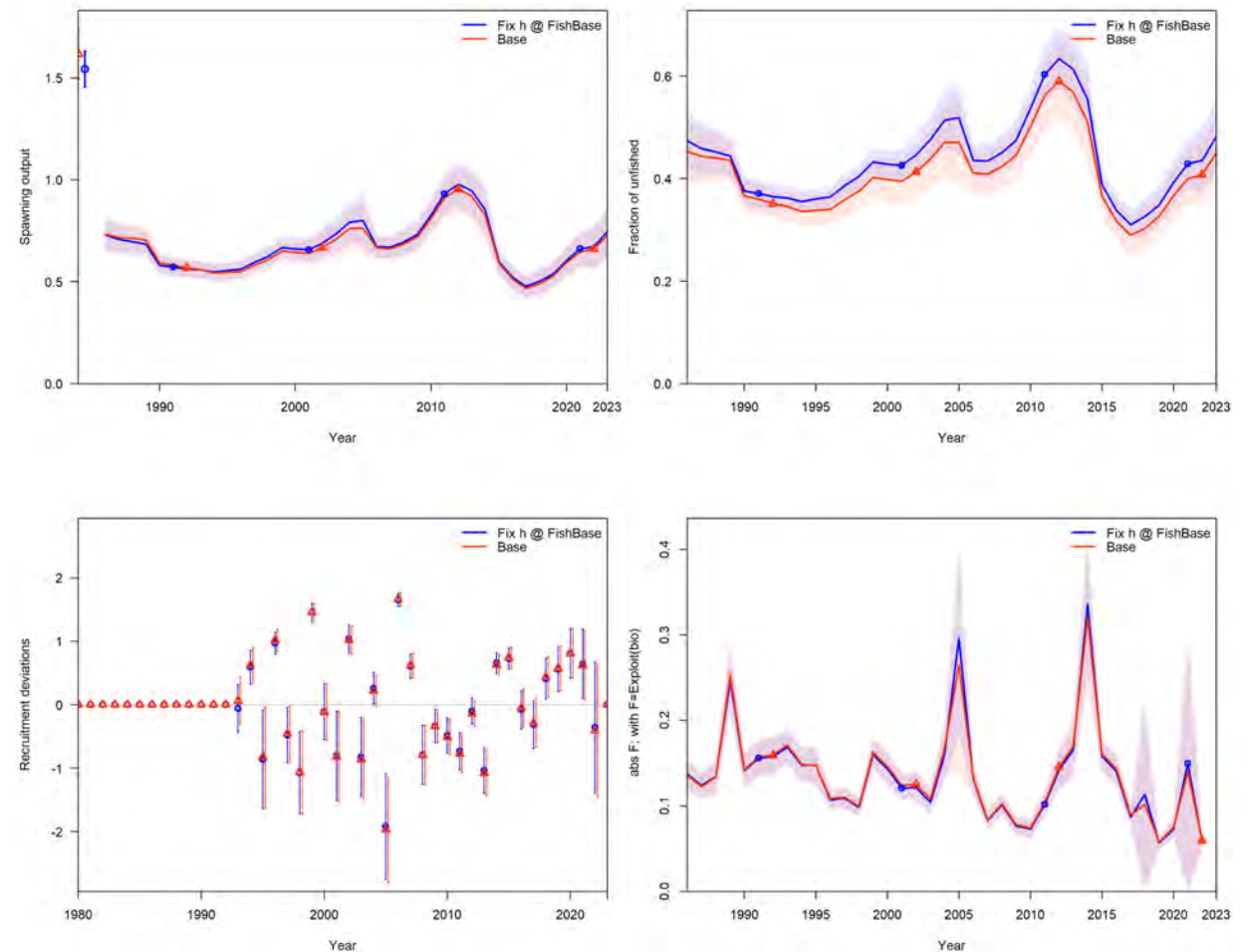


**NOAA**  
**FISHERIES**

# Steepness: Fix at 0.78

	Depletion Start Yr	Depletion End Yr
Base	0.453	0.408
Fixed at 0.78	0.474	0.435

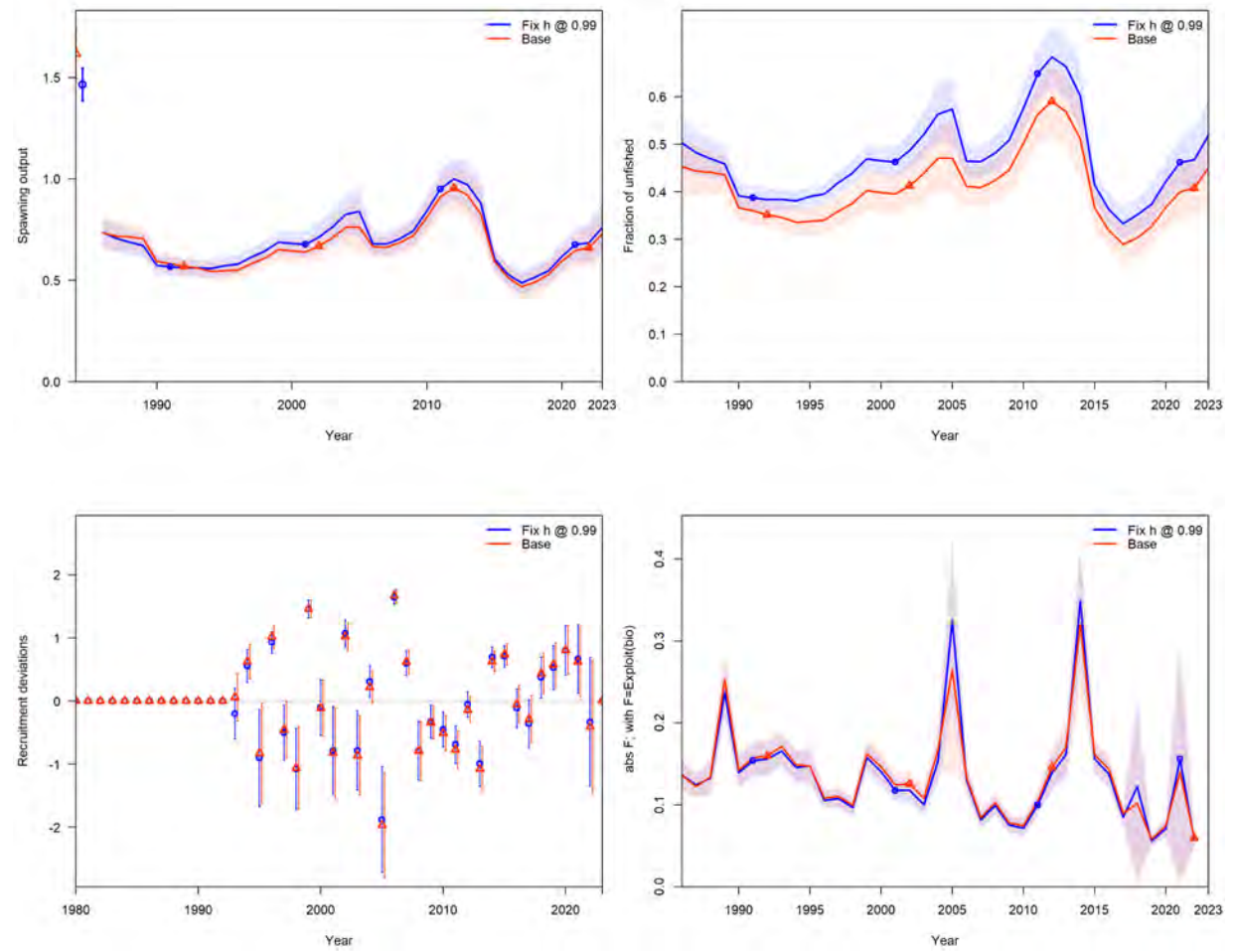
- Fixed at 0.78:
  - Higher fraction of unfished SSB/SSB0 (within confidence interval of base)



# Steepness: Fix at 0.99

	Depletion Start Yr	Depletion End Yr
Base	0.453	0.408
Fixed at 0.99	0.503	0.467

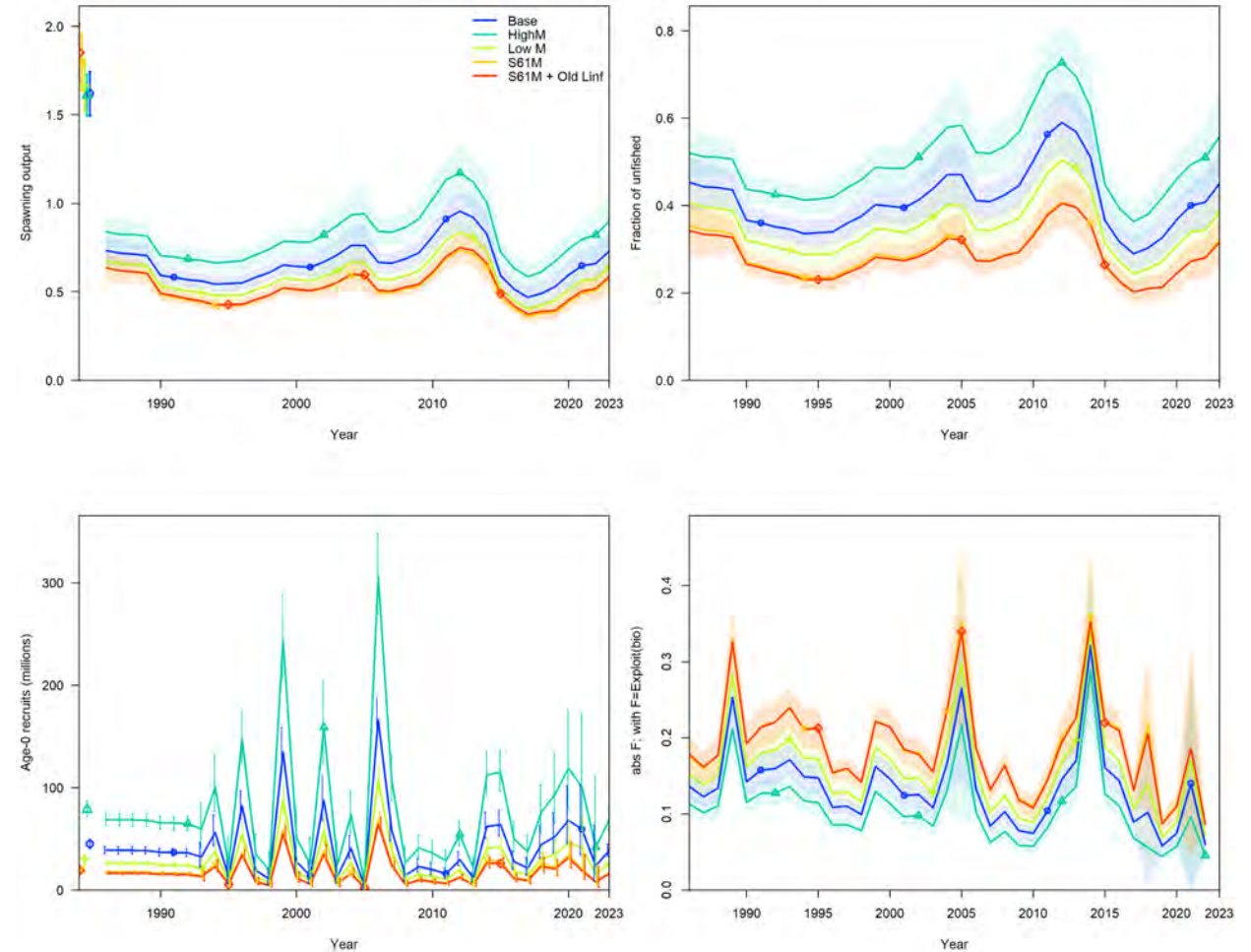
- Fixed at 0.99:
  - Higher fraction of unfished SSB/SSB0 (outside confidence interval of base)



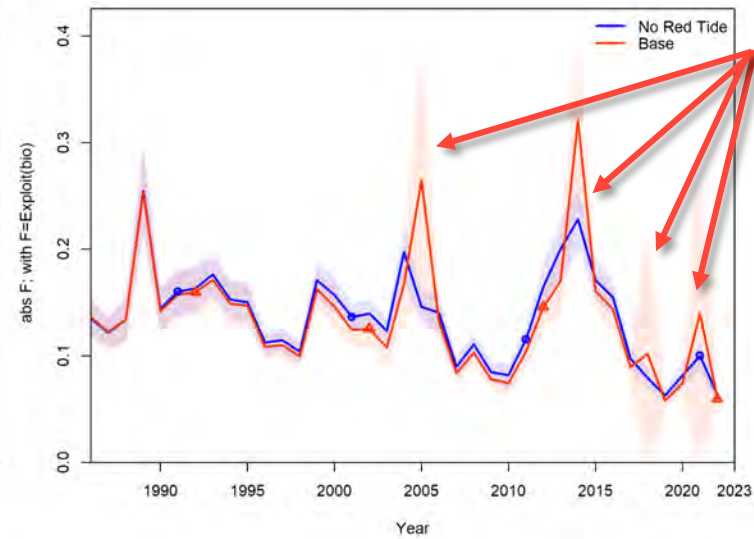
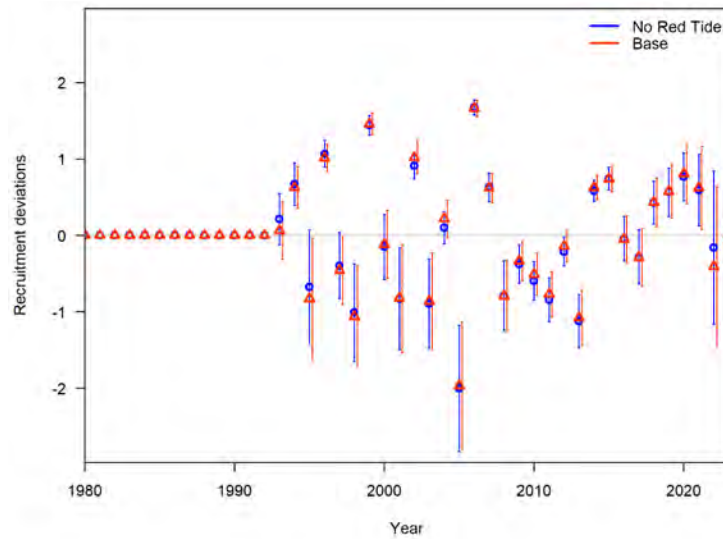
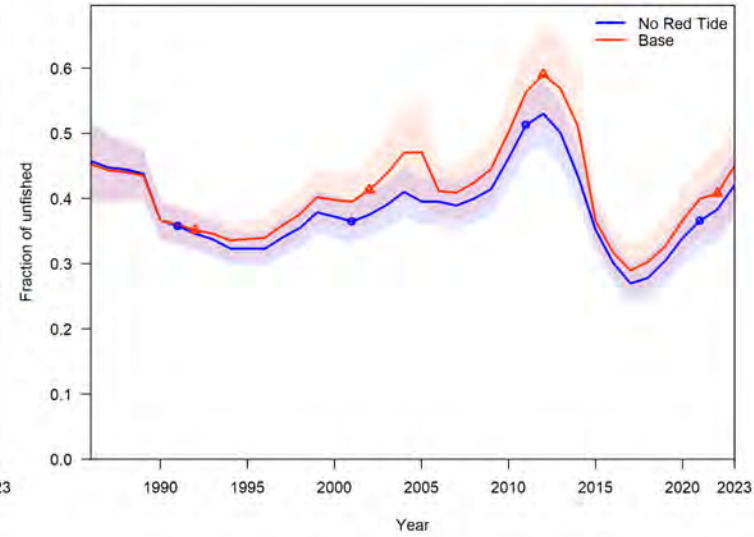
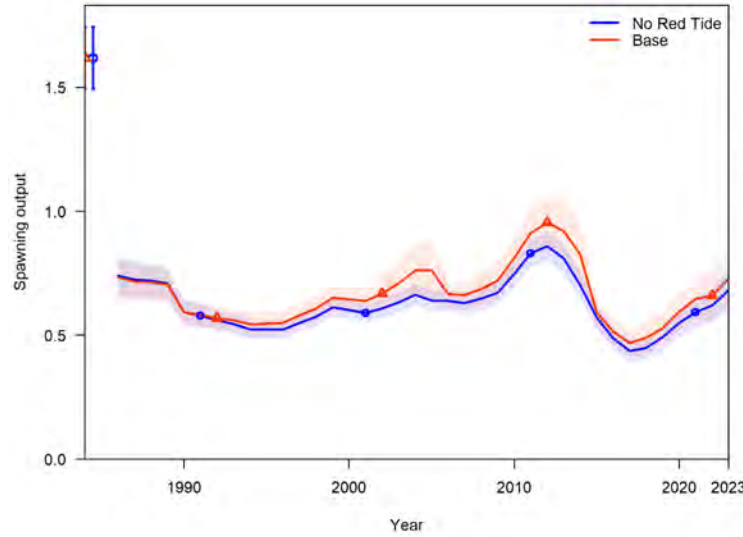
# Natural Mortality

	Target M	Linf	End Yr
Base	0.186	92.41	0.408
Low M	0.158	93.06	0.344
High M	0.225	91.38	0.510
S61 M	0.140	80.00	0.282
S61 Est Linf	0.140	87.61	0.280

\* Lorenzen M curve calculated internally in S88



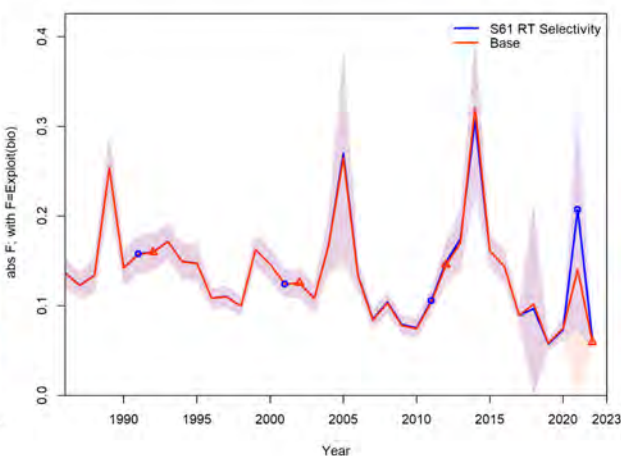
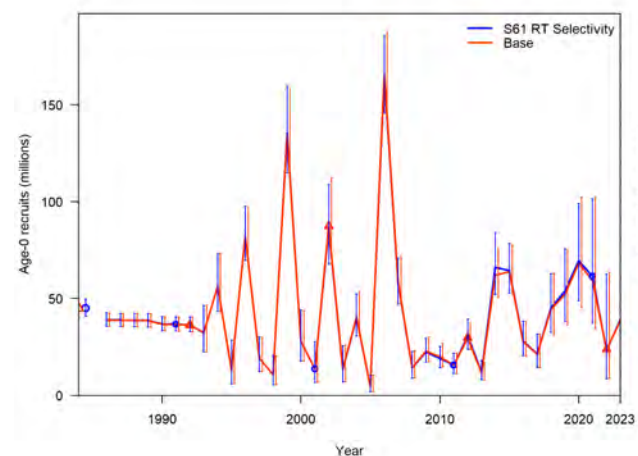
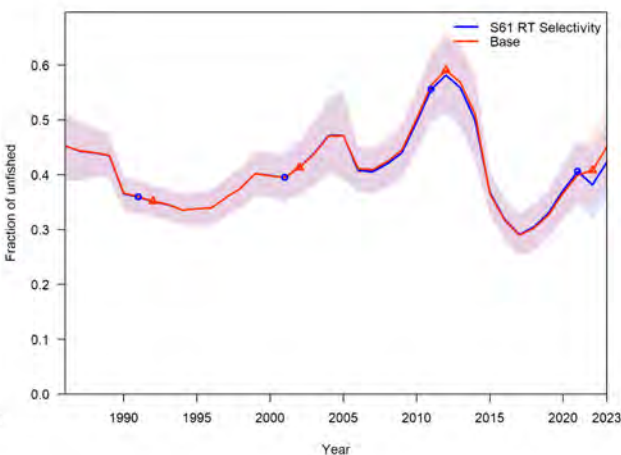
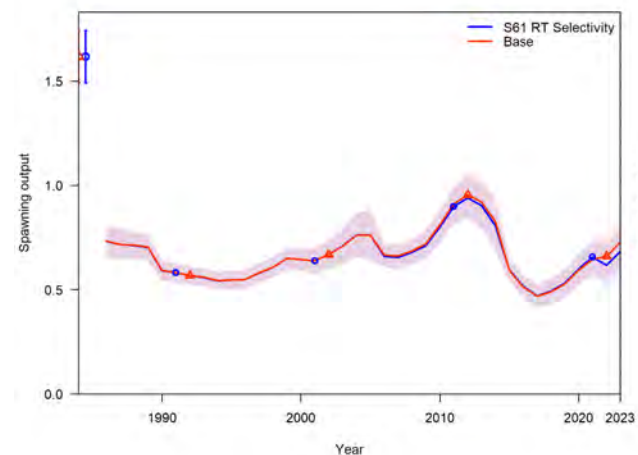
# Red Tide



\* Red tide mortality included as part of fishing mortality (F)

# Red Tide

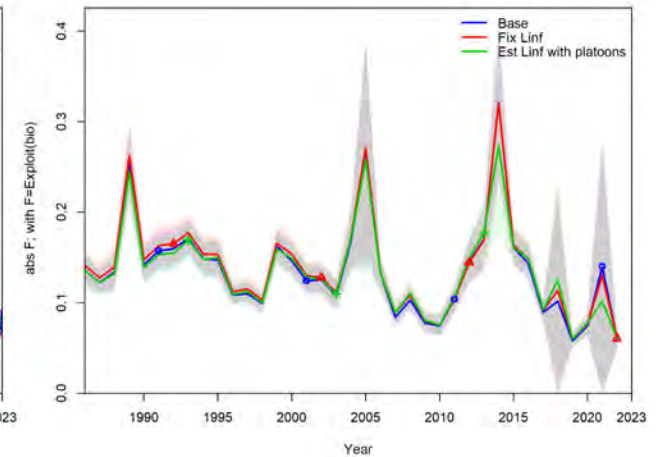
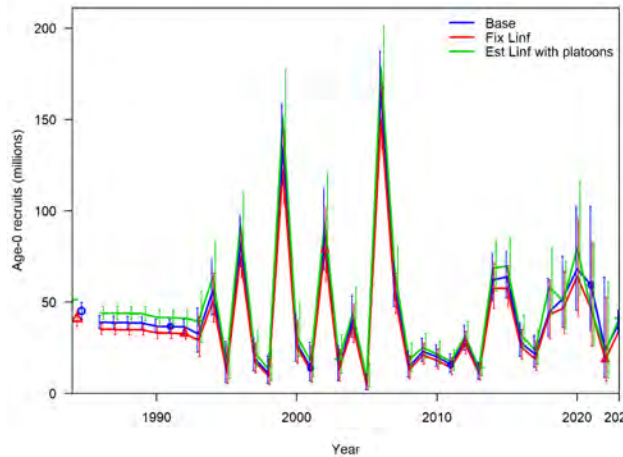
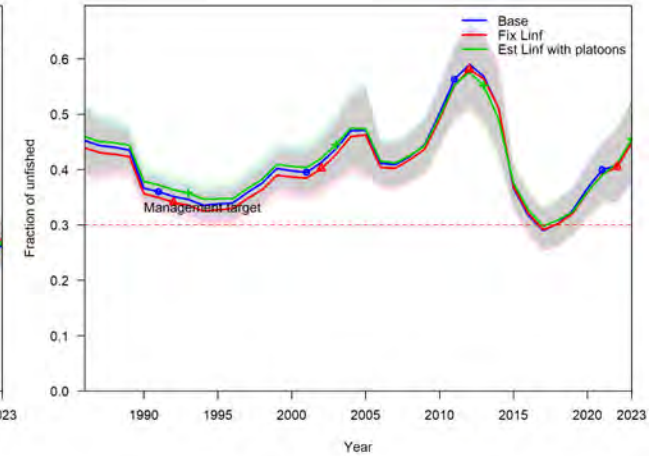
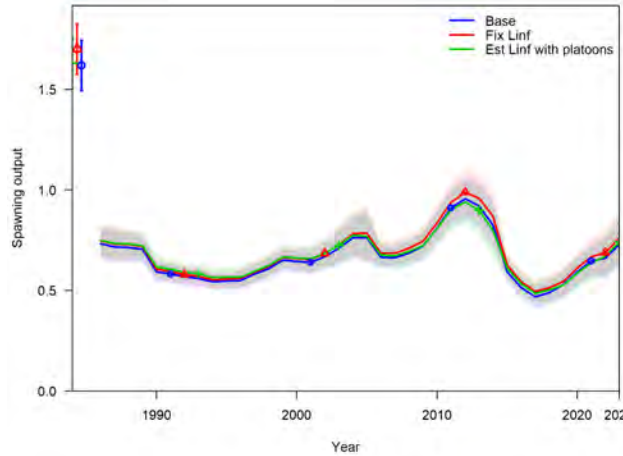
Years	Emp Sel@age	Full Sel@age 0
<b>F values (CV)</b>		
2005	0.174 (0.533)	0.163 (0.506)
2014	0.196 (0.455)	0.128 (0.545)
2018	0.042 (2.04)	0.025 (2.519)
2021	0.099 (1.606)	0.122 (0.634)
<b>Biomass killed (%)</b>		
2005	4,741 (14%)	4,870 (15%)
2014	3,918 (13%)	3,289 (11%)
2018	733 (3%)	618 (2.5%)
2021	1,539 (5%)	3,751 (12%)
<b>Numbers killed (%)</b>		
2005	5,936 (12%)	5,853 (12%)
2014	5,042 (6%)	7,624 (8%)
2018	2,129 (3%)	1,425 (2%)
2021	6,682 (6%)	10,046 (8%)



# Growth

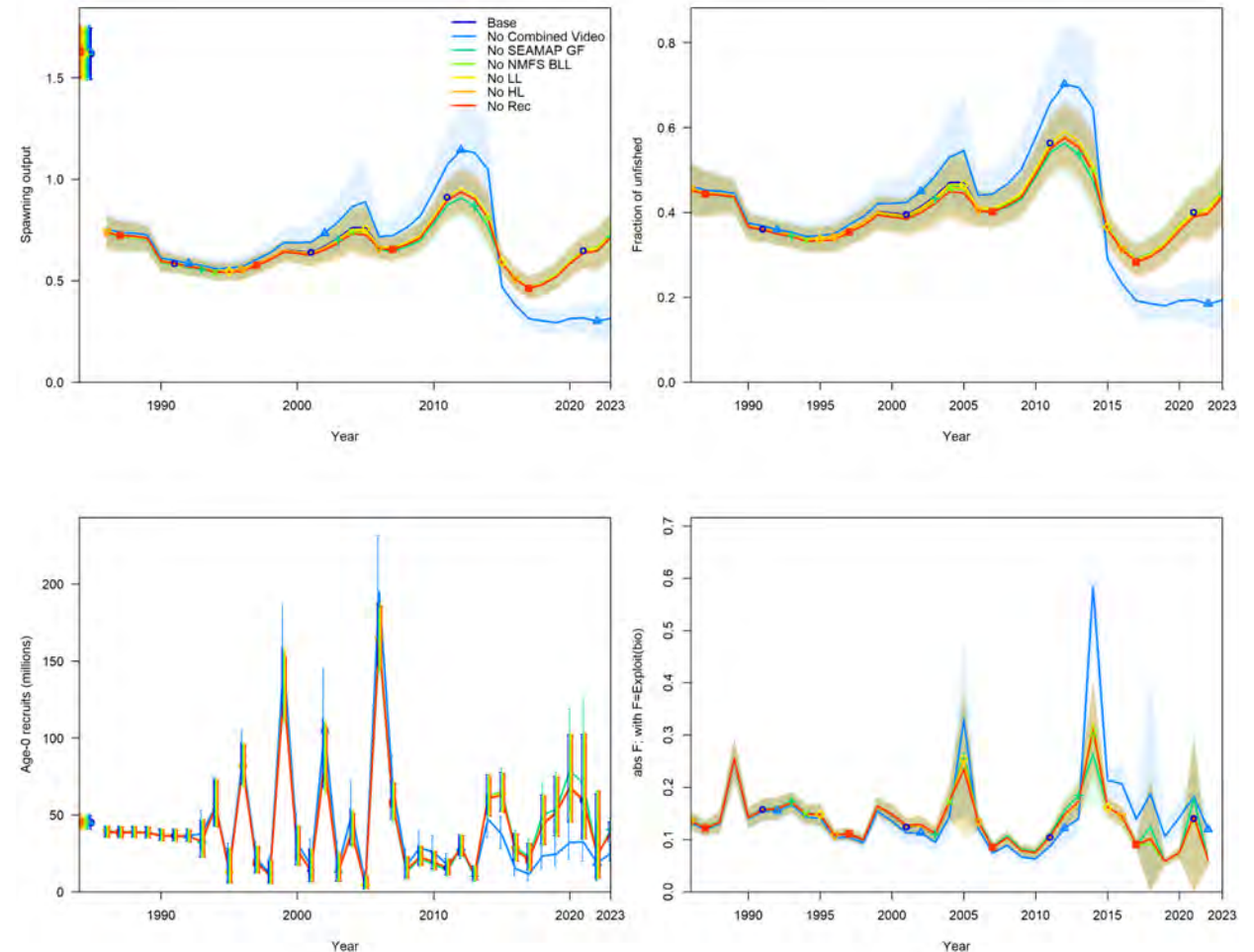
- Use of platoons mimics the effect of size selectivity on the distribution of size-at-age fish surviving the fishery (i.e. Rose Lee Phenomenon)

	NLL	Linf	Ending Yr Depl
Base	5,721	92.41	0.408
Estimate Linf with platoons	5,742	91.22	0.411
Fix Linf	5,732	80.00	0.405



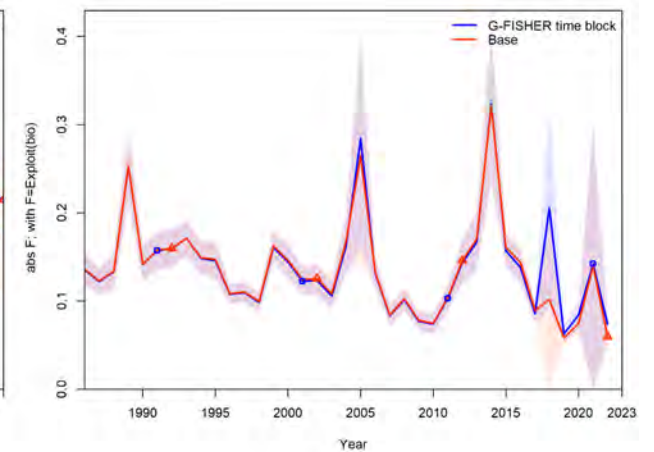
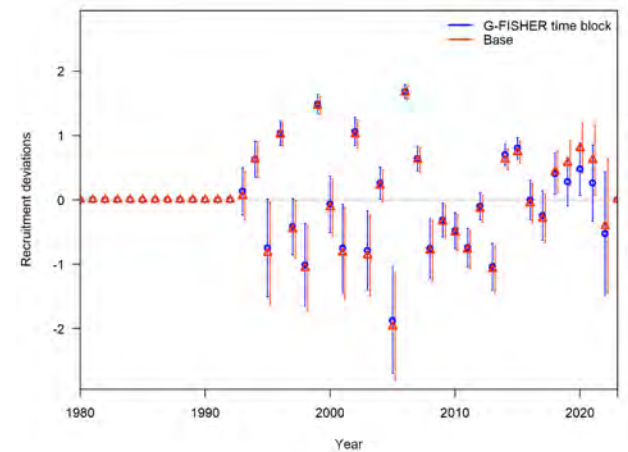
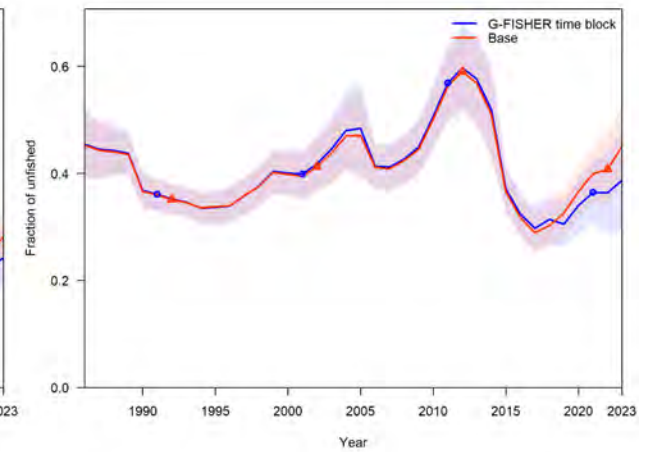
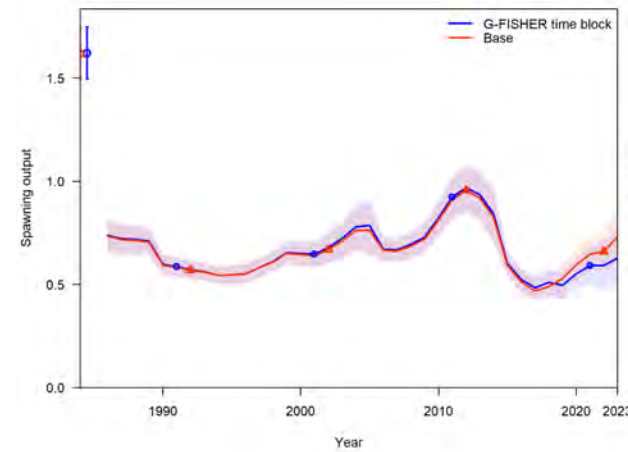
# Jack-knife

- Purpose: determine which index or indices were most influential on derived quantities
- Removal of Combined Video Index has strong effect on time series trends



# G-FISHER

- Time block placed on Combined Video Index in 2020
- G-FISHER survey design implemented



# Conclusions

- SEDAR 88 OA Base Model incorporated the best available data, addressed the TORs, and showed an improved model with better fits and diagnostics

## Improvements

- Data inputs from best practices methods
- Fit to mean weight recreational landings
- Fit to age compositions

## Outstanding Issues

- Poor fits to indices
- Recruitment uncertainty
- Red tide mortality uncertainty in recent years



# Benchmark, Stock Status and Projections



**NOAA**  
**FISHERIES**

# Projection Settings

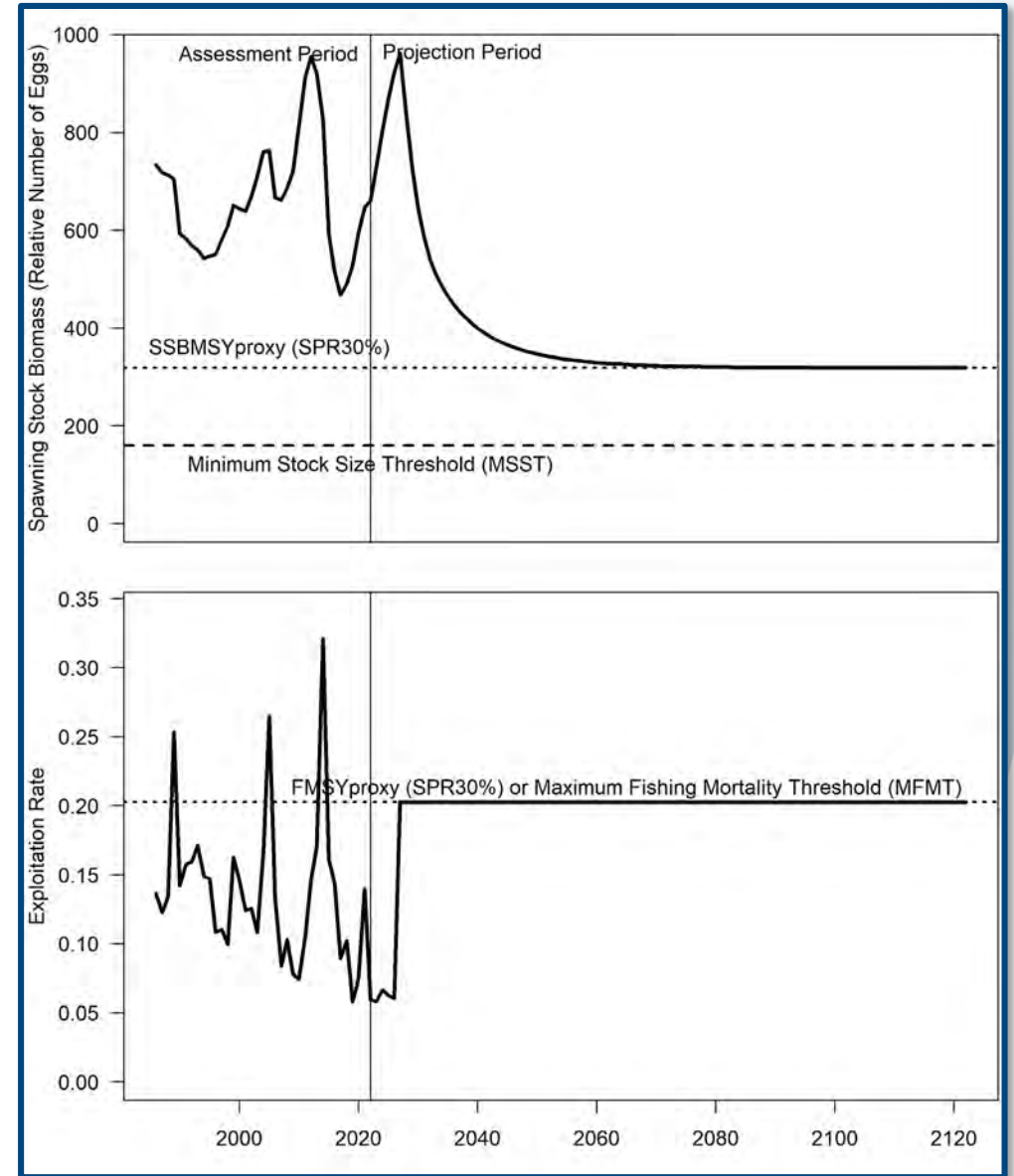
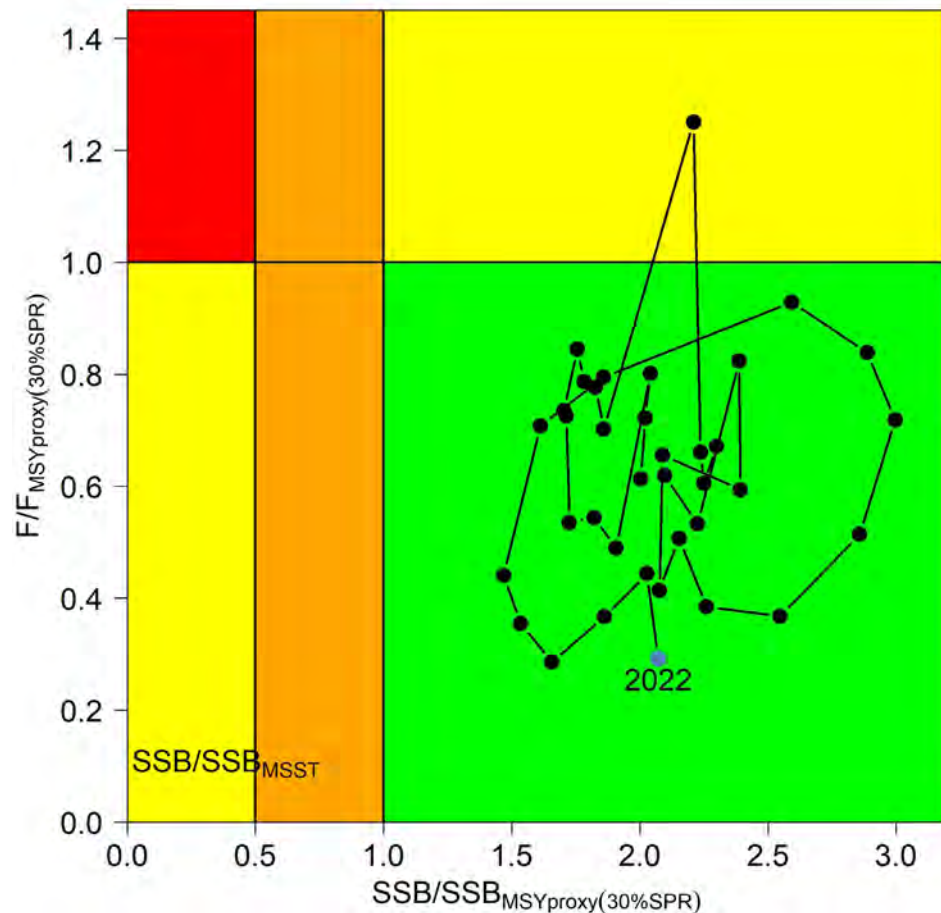
Parameter	Value	Comment
Relative F	-	Not used due to allocations below
Selectivity	Average from 2020-2022	Fleet specific selectivity estimated over terminal three years of model
Retention	Average from 2020-2022	Fleet specific retention estimated over terminal three years of model
Recruitment	Beverton-Holt stock-recruitment relationship	Derived from the model estimated Beverton-Holt stock-recruitment relationship
Interim Landings (2023-2026)	383.68/400.48 metric tons (Commercial Handline); 740.8/770.99 metric tons (Commercial Longline); 185.72/289.27 numbers (Recreational)	Landings provided for 2023; For 2024, 2025 and 2026 used 3-year average of landings (2021-2023)
Allocation Ratio	59.3:40.7	Commercial: Recreational

# MSRA Benchmarks & Reference Points: 30%SPR

Criteria	Definition	Value
Base M	Target M for fully selected ages in the Lorenzen (2000) scaling	0.186
Steepness	Steepness of the Beverton-Holt stock-recruit relationship	0.661
Unfished Recruitment (R0)	Unfished recruitment (1,000s)	44,927
Generation Time	Fecundity-weighted mean age	9.78
Unfished SSB (SSB0)	Unfished spawning stock biomass (Relative number of eggs)	1,618,300
<b>Mortality Rate Criteria</b>		
$F_{MSYproxy}$	Equilibrium F that achieves SPR30%	0.203
MFMT	$F_{MSYproxy}$	0.203
Fcurrent	Geometric mean of the last 3 years of the assessment (F2020-2022)	0.073
Fcurrent/MFMT	Current stock status based on MFMT	<b>0.363</b>
<b>Biomass Criteria</b>		
$SSB_{MSYproxy}$	Equilibrium SSB at FSPR 30 %	318,790
MSST	0.5 * SSBSPR30%	159,395
$SSB_{current}$	SSB in 2022	660,063
$SSB_{current}/SSB_{FMSYproxy}$	Current stock status based on SSBSPR30% (Equilibrium)	2.07
$SSB_{current}/MSST$	Current stock status based on MSST	<b>4.14</b>
$SSB_{current}/SSB0$	SSB ratio in 2022	0.41

# Stock Status: 30% SPR

- Gulf of Mexico Red Grouper is **not overfished** nor undergoing overfishing at 30% SPR

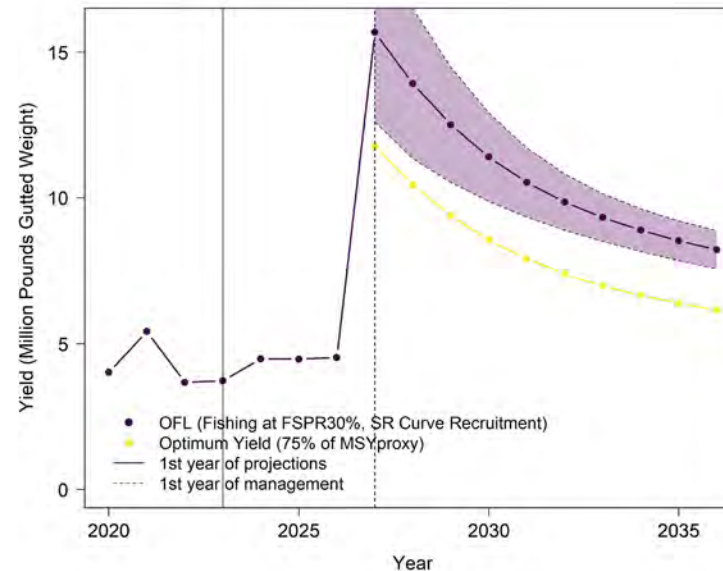


# OFL Projections: $F=F_{30\%SPR}$

Year	Recr	F	F/ $F_{30\%SPR}$	SSB	SSB/ $SSB_{30\%SPR}$	SSB/MSST	SSB ratio	OFL (mp gw)
2027	41,306	0.203	1	961,572	3.016	6.033	0.594	15.683
2028	40,101	0.203	1	835,153	2.620	5.240	0.516	13.928
2029	38,842	0.203	1	728,675	2.286	4.572	0.450	12.508
2030	37,658	0.203	1	646,185	2.027	4.054	0.399	11.397
2031	36,629	0.203	1	585,145	1.836	3.671	0.362	10.528

- Assuming recruitment from stock-recruit curve throughout projections

Years	Constant Catch
Three (2027-2029)	14.04 mp gw
Five (2027-2031)	12.81 mp gw

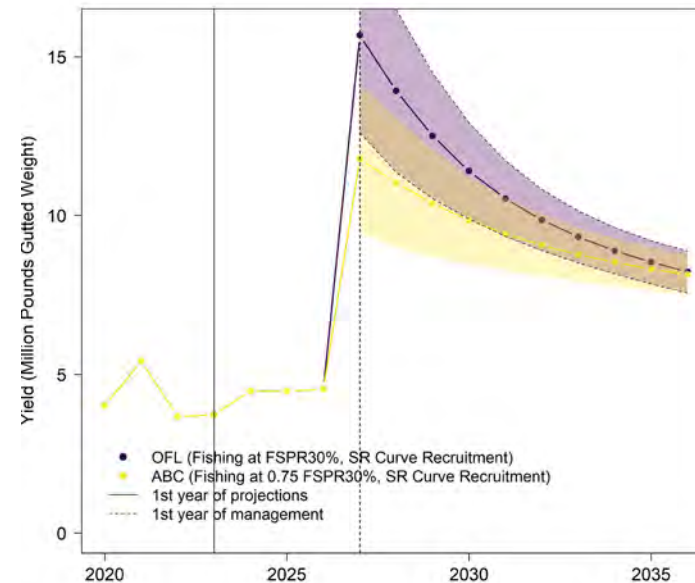


# ABC Projections: $F=0.75 * F_{30\%SPR}$

Year	Recr	F	F/ $F_{30\%SPR}$	SSB	SSB/ $SSB_{30\%SPR}$	SSB/MSST	SSB ratio	Yield
2027	41,306	0.152	0.75	961,572	3.016	6.033	0.594	11.777
2028	40,647	0.152	0.75	888,979	2.789	5.577	0.549	11.025
2029	39,952	0.152	0.75	821,322	2.576	5.153	0.508	10.379
2030	39,295	0.152	0.75	764,465	2.398	4.796	0.472	9.849
2031	38,718	0.152	0.75	719,304	2.256	4.513	0.444	9.413

- Assuming recruitment from stock-recruit curve throughout projections

Years	Constant Catch
Three (2027-2029)	11.06 mp gw
Five (2027-2031)	10.49 mp gw

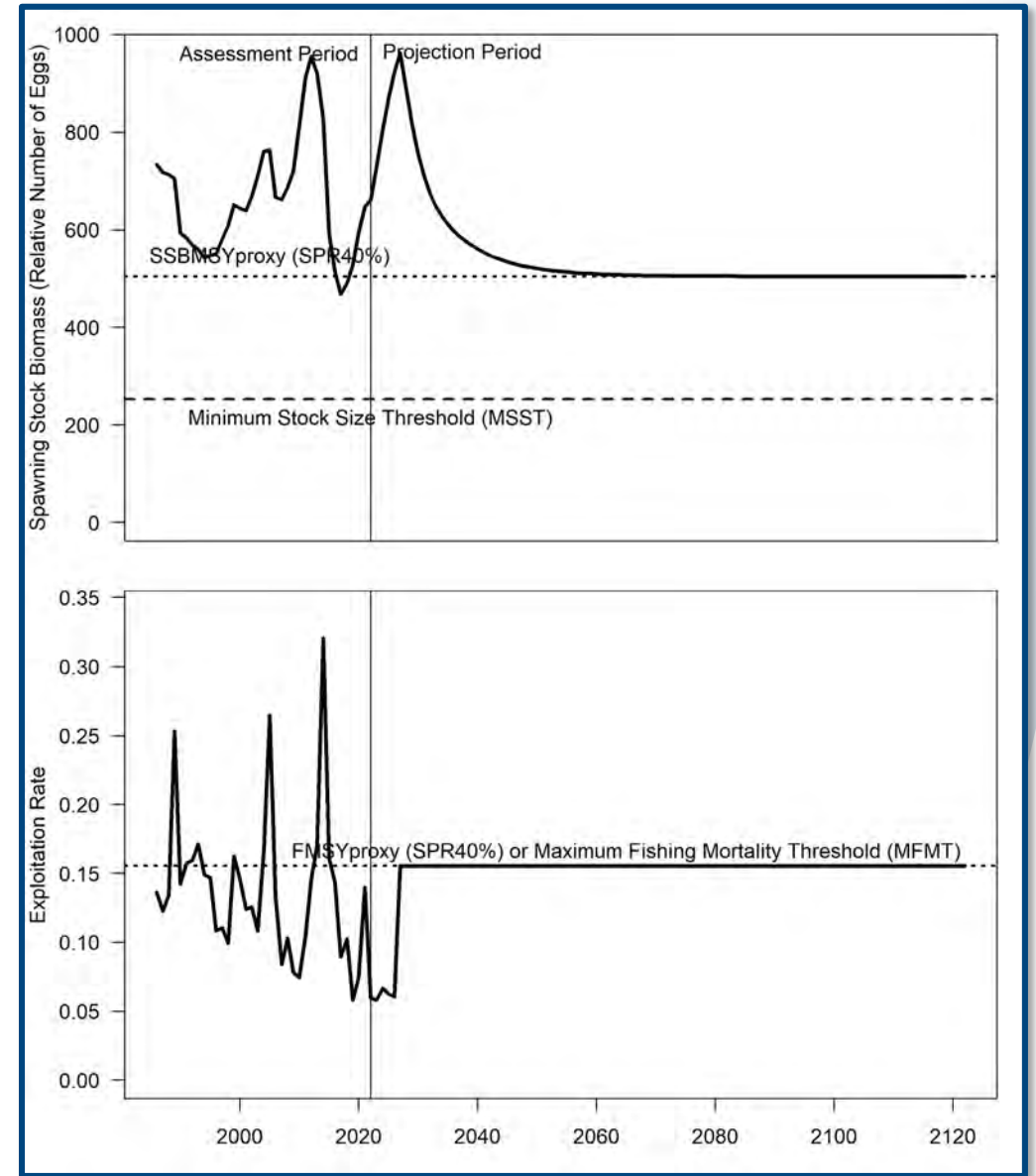
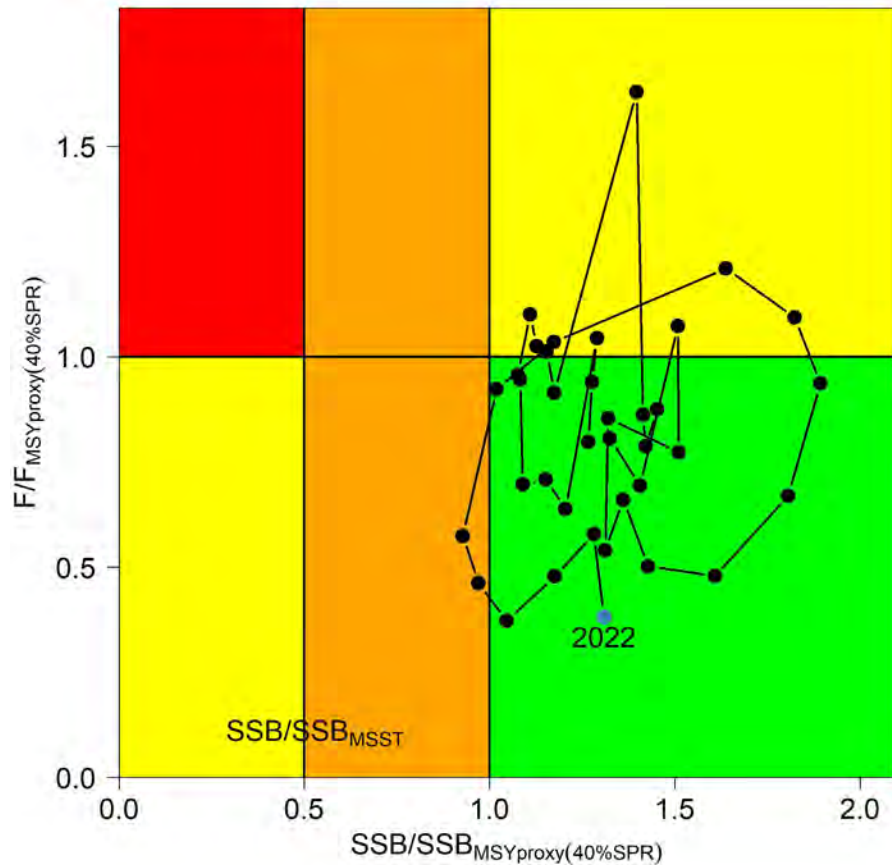


# MSRA Benchmarks & Reference Points: 40%SPR

Criteria	Definition	Value
Base M	Target M for fully selected ages in the Lorenzen (2000) scaling	0.186
Steepness	Steepness of the Beverton-Holt stock-recruit relationship	0.661
Unfished Recruitment (R0)	Unfished recruitment (1,000s)	44,927
Generation Time	Fecundity-weighted mean age	9.78
Unfished SSB (SSB0)	Unfished spawning stock biomass (Relative number of eggs)	1,618,300
<b>Mortality Rate Criteria</b>		
$F_{MSYproxy}$	Equilibrium F that achieves SPR40%	0.156
MFMT	$F_{MSYproxy}$	0.156
Fcurrent	Geometric mean of the last 3 years of the assessment (F2020-2022)	0.073
Fcurrent/MFMT	Current stock status based on MFMT	<b>0.473</b>
<b>Biomass Criteria</b>		
$SSB_{MSYproxy}$	Equilibrium SSB at FSPR 40 %	504,435
MSST	0.5 * SSBSPR40%	252,218
$SSB_{current}$	SSB in 2022	660,063
$SSB_{current}/SSB_{FMSYproxy}$	Current stock status based on SSBSPR40% (Equilibrium)	1.31
$SSB_{current}/MSST$	Current stock status based on MSST	<b>2.62</b>
$SSB_{current}/SSB0$	SSB ratio in 2022	0.41

# Stock Status: 40% SPR

- Gulf of Mexico Red Grouper is **not overfished** nor undergoing overfishing at 40% SPR

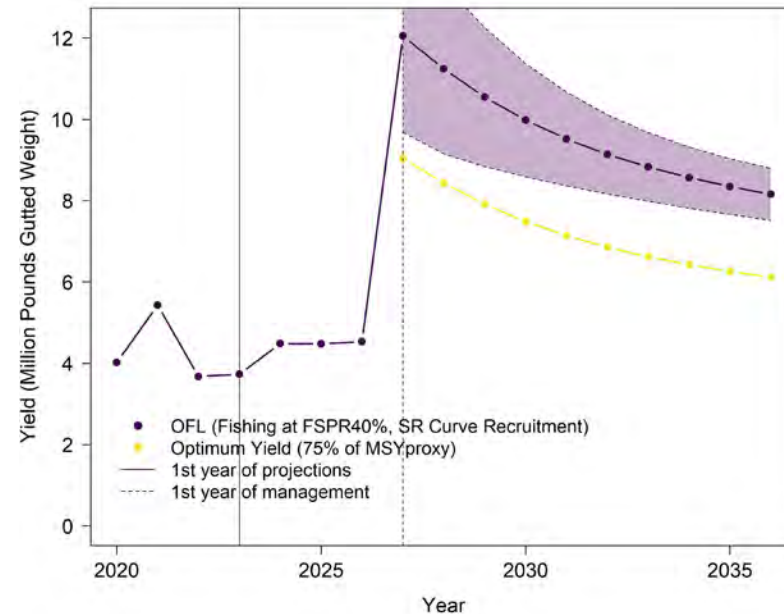


# OFL Projections: $F=F_{40\%SPR}$

Year	Recr	F	$F/F_{40\%SPR}$	SSB	$SSB/SSB_{40\%SPR}$	SSB/MSST	SSB ratio	OFL (mp gw)
2027	41306.6	0.156	1	961572	1.906	3.812	0.594	12.054
2028	40610.8	0.156	1	885160	1.755	3.51	0.547	11.243
2029	39878.2	0.156	1	814583	1.615	3.23	0.503	10.55
2030	39187	0.156	1	755661	1.498	2.996	0.467	9.983
2031	38580.1	0.156	1	709113	1.406	2.812	0.438	9.518

- Assuming recruitment from stock-recruit curve throughout projections

Years	Constant Catch
Three (2027-2029)	11.28 mp gw
Five (2027-2031)	10.66 mp gw

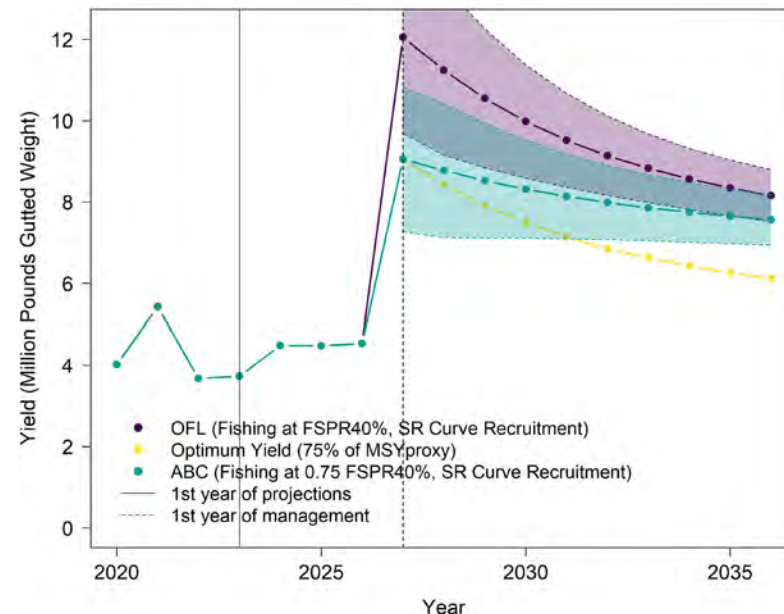


# ABC Projections: $F=0.75 * F_{40\%SPR}$

Year	Recr	F	F/ $F_{40\%SPR}$	SSB	SSB/ $SSB_{40\%SPR}$	SSB/MSST	SSB ratio	Yield
2027	41306.6	0.117	0.75	961572	1.906	3.812	0.594	9.049
2028	40999.9	0.117	0.75	926645	1.837	3.674	0.573	8.773
2029	40649.4	0.117	0.75	889150	1.763	3.525	0.549	8.524
2030	40307.1	0.117	0.75	854783	1.695	3.389	0.528	8.316
2031	39999.7	0.117	0.75	825662	1.637	3.274	0.51	8.138

- Assuming recruitment from stock-recruit curve throughout projections

Years	Constant Catch
Three (2027-2029)	8.78 mp gw
Five (2027-2031)	8.56 mp gw



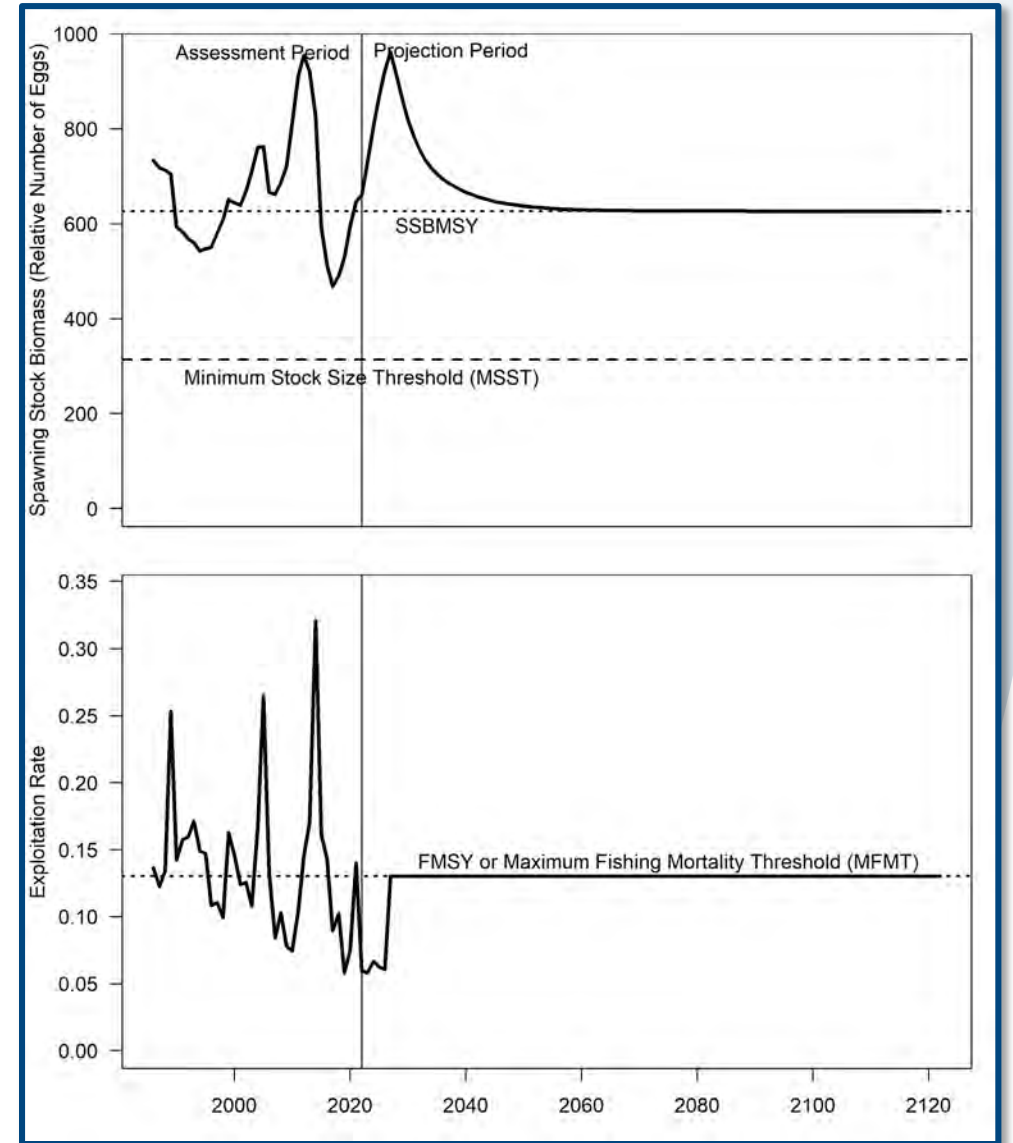
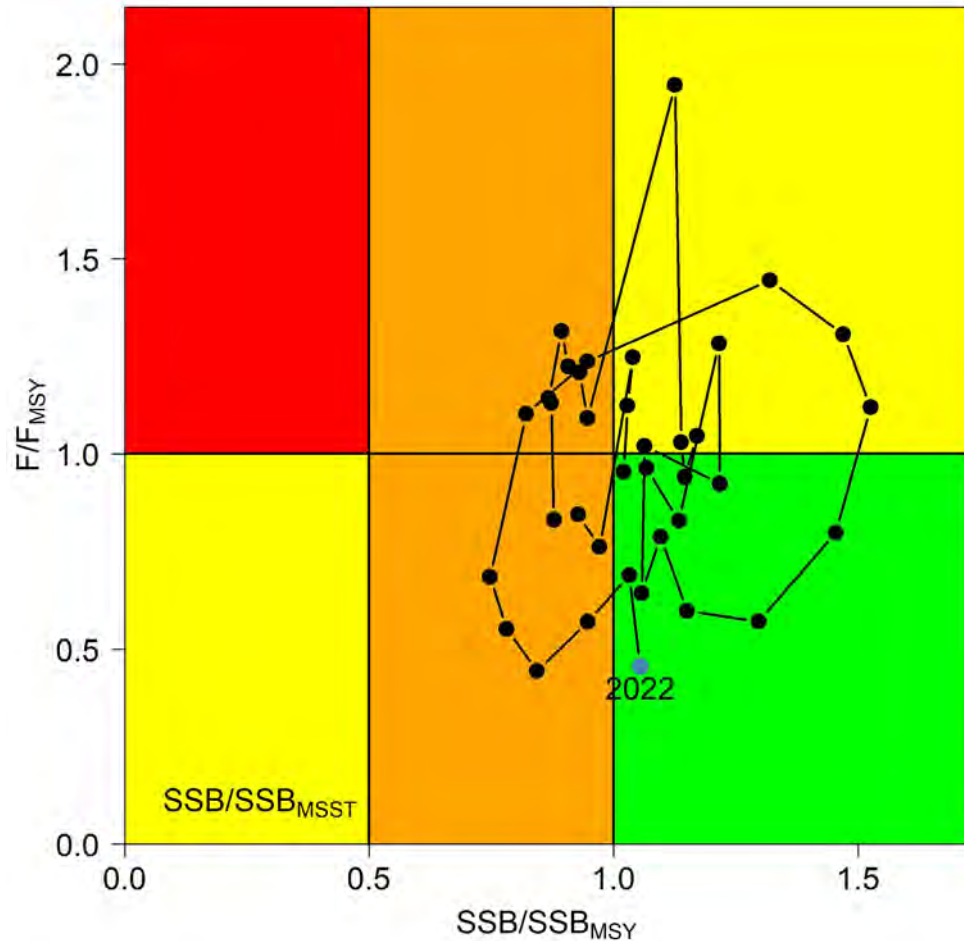
# MSRA Benchmarks & Reference Points: MSY

Criteria	Definition	Value
Base M	Target M for fully selected ages in the Lorenzen (2000) scaling	0.186
Steepness	Steepness of the Beverton-Holt stock-recruit relationship	0.661
Unfished Recruitment (R0)	Unfished recruitment (1,000s)	44,927
Generation Time	Fecundity-weighted mean age	9.78
Unfished SSB (SSB0)	Unfished spawning stock biomass (Relative Number of Eggs)	1,618,300
<b>Mortality Rate Criteria</b>		
FMSY	Equilibrium F that achieves MSY	0.13
MFMT	FMSY	0.13
Fcurrent	Geometric mean of the last 3 years of the assessment (F2020-2022)	0.073
Fcurrent/MFMT	Current stock status based on MFMT	<b>0.565</b>
<b>Biomass Criteria</b>		
SSBMSY	Equilibrium SSB at FMSY	626,411
MSST	0.5 * SSBMSY	313,206
SSBcurrent	SSB in 2022	660,063
SSBcurrent/SSBFMSY	Current stock status based on SSBMSY (Equilibrium)	1.05
SSBcurrent/MSST	Current stock status based on MSST	<b>2.11</b>
SSBcurrent/SSB0	SSB ratio in 2022	0.41
SPR at MSY	Equivalent SPR (%) at MSY	46.6



# Stock Status: MSY

- Gulf of Mexico Red Grouper is **not overfished** nor undergoing overfishing at MSY



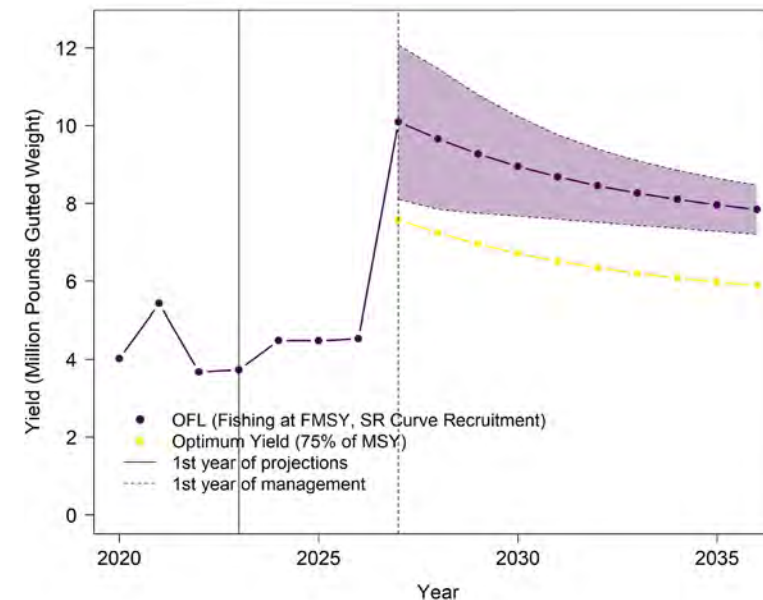
# OFL Projections: $F=F_{MSY}$

Year	Recr	F	F/ $F_{MSY}$	SSB	SSB/ $SSB_{MSY}$	SSB/MSST	SSB ratio	OFL
2027	41,306	0.13	1	961,572	1.535	3.070	0.594	10.092
2028	40,867	0.13	1	912,232	1.456	2.913	0.564	9.656
2029	40,389	0.13	1	862,905	1.378	2.755	0.533	9.271
2030	39,932	0.13	1	819,472	1.308	2.616	0.506	8.950
2031	39,525	0.13	1	783,694	1.251	2.502	0.484	8.679

- Assuming recruitment from stock-recruit curve throughout projections

\* OFL equilibrium (2122) = 7.019 mp gw

Years	Constant Catch
Three (2027-2029)	9.67 mp gw
Five (2027-2031)	9.33 mp gw



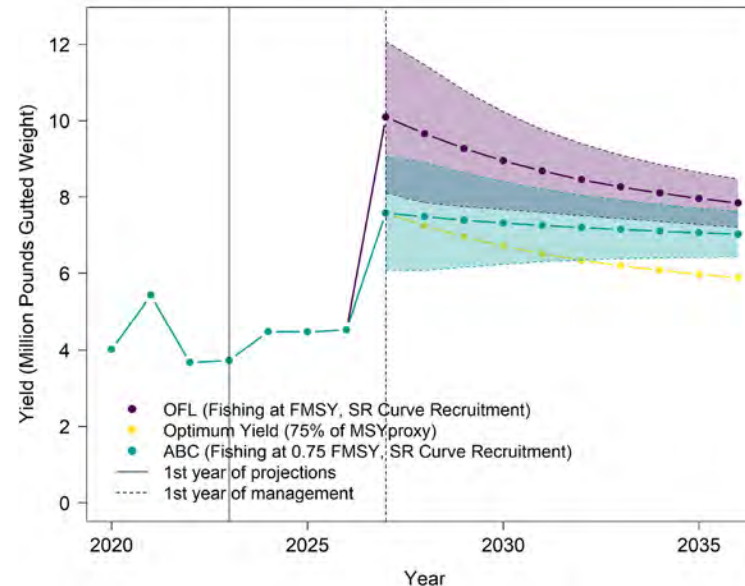
# ABC Projections: $F=0.75 * F_{MSY}$

Year	Recr	F	F/ $F_{MSY}$	SSB	SSB/ $SSB_{MSY}$	SSB/MSST	SSB ratio	Yield
2027	41,306	0.098	0.75	961,572	1.535	3.070	0.594	7.575
2028	41,180	0.098	0.75	947,005	1.512	3.024	0.585	7.481
2029	41,001	0.098	0.75	926,837	1.480	2.959	0.573	7.391
2030	40,812	0.098	0.75	906,276	1.447	2.894	0.560	7.317
2031	40,635	0.098	0.75	887,725	1.417	2.834	0.549	7.252

- Assuming recruitment from stock-recruit curve throughout projections

\* ABC equilibrium (2122) = 6.748 mp gw

Years	Constant Catch
Three (2027-2029)	7.48 mp gw
Five (2027-2031)	7.40 mp gw

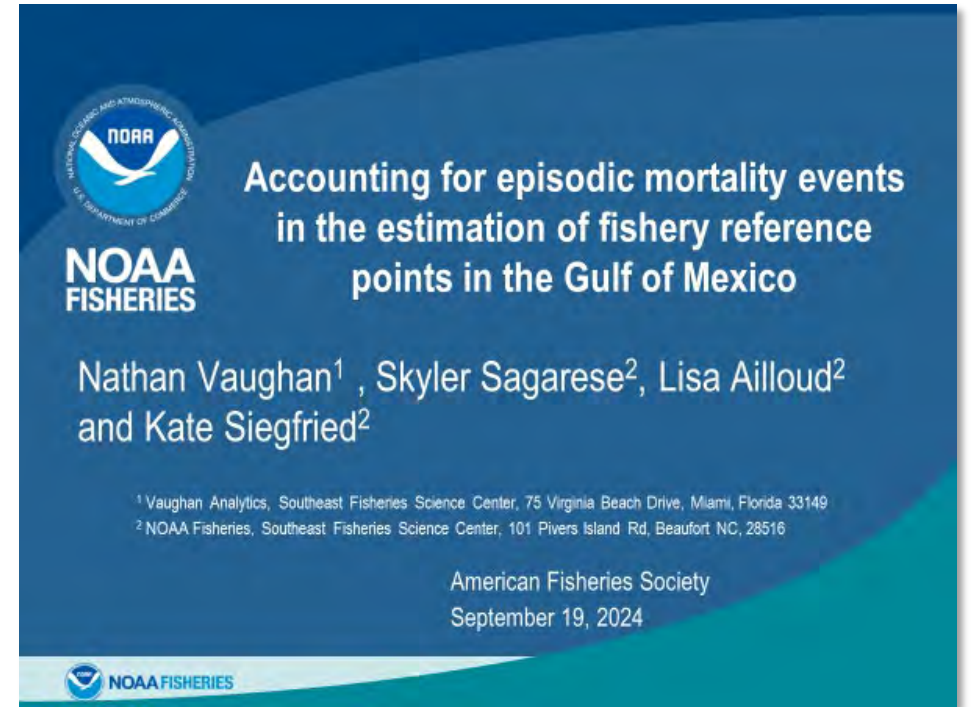


# Red Tide Projections (Sensitivities)

# Projection approach for benchmarks

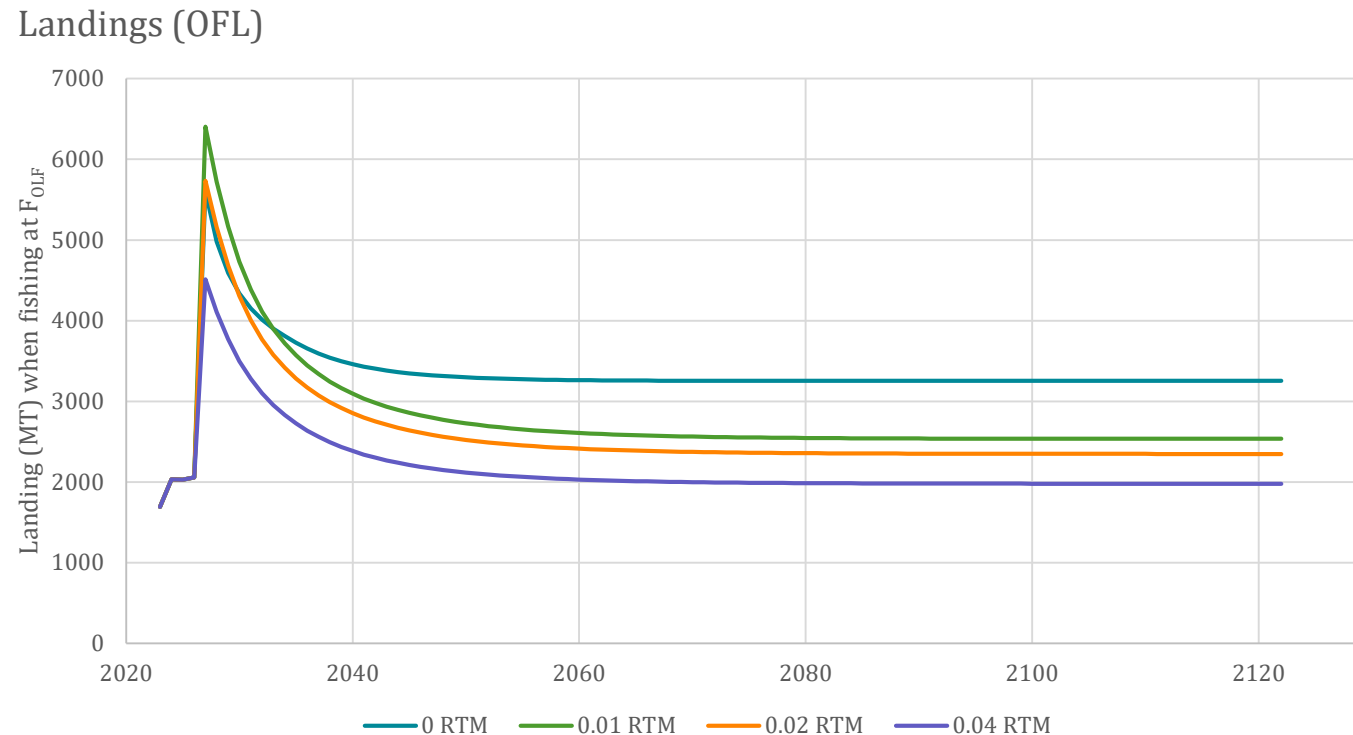
- Red tide mortality assumed zero
- Simulating future red tides using mean mortality levels observed in past red tides

Year Range	S61 Mean	Year Range	S88 Mean
1998-2017	0.030	1998-2022	0.020
2000-2009	0.034	2000-2009	0.017
2010-2017	0.033	2010-2022	0.026
2013-2017	0.052	2013-2022	0.034



# Sensitivity Projection Runs

- No red tide mortality and assuming 0.01, 0.02, 0.04 annual rate of red tide mortality at 2005 selectivity curve (at 30% SPR)
- Assuming some level of red tide mortality allows for uncertainty around future red tide events



# Thank you!

The SEDAR 88 Operational Assessment for Gulf of Mexico Red Grouper would not have been possible without the efforts of the numerous SEFSC, SERO, and GMFMC staff along with the many state, academic, and research partners involved throughout the Gulf of Mexico. The following agencies contributed to the assessment and deserve notable attention and thanks for efforts extended to developing data inputs: NOAA SEFSC Fisheries Statistics Division (FSD), NOAA SEFSC Panama City Laboratory, NOAA SEFSC Mississippi Laboratories, NOAA Southeast Regional Office (SERO), Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, NOAA SEFSC Beaufort Laboratory, and the Gulf States Marine Fisheries Commission.



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