



NOAA
FISHERIES

SEFSC

SEDAR 100: US Gulf of America Gray Triggerfish (*Balistes capriscus*)

Review Workshop
Assessment Model



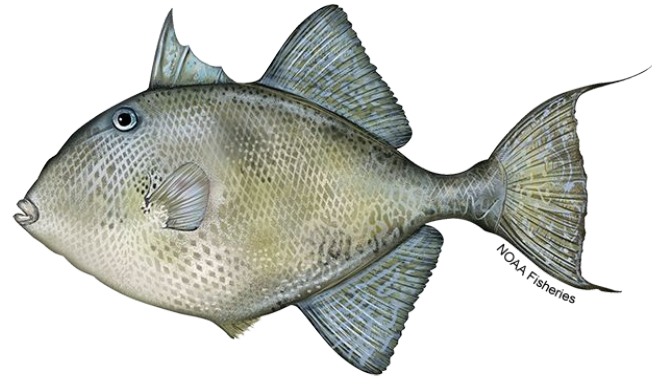
August 11, 2026

Photo courtesy of F. Forrestal

Outline

- Data Review
 - Stock definition
 - Assessment history
 - Regulations
 - Key data decisions
 - Life history
 - Removals
 - Size compositions
 - Age compositions
 - Indices of abundance
 - Survey length composition

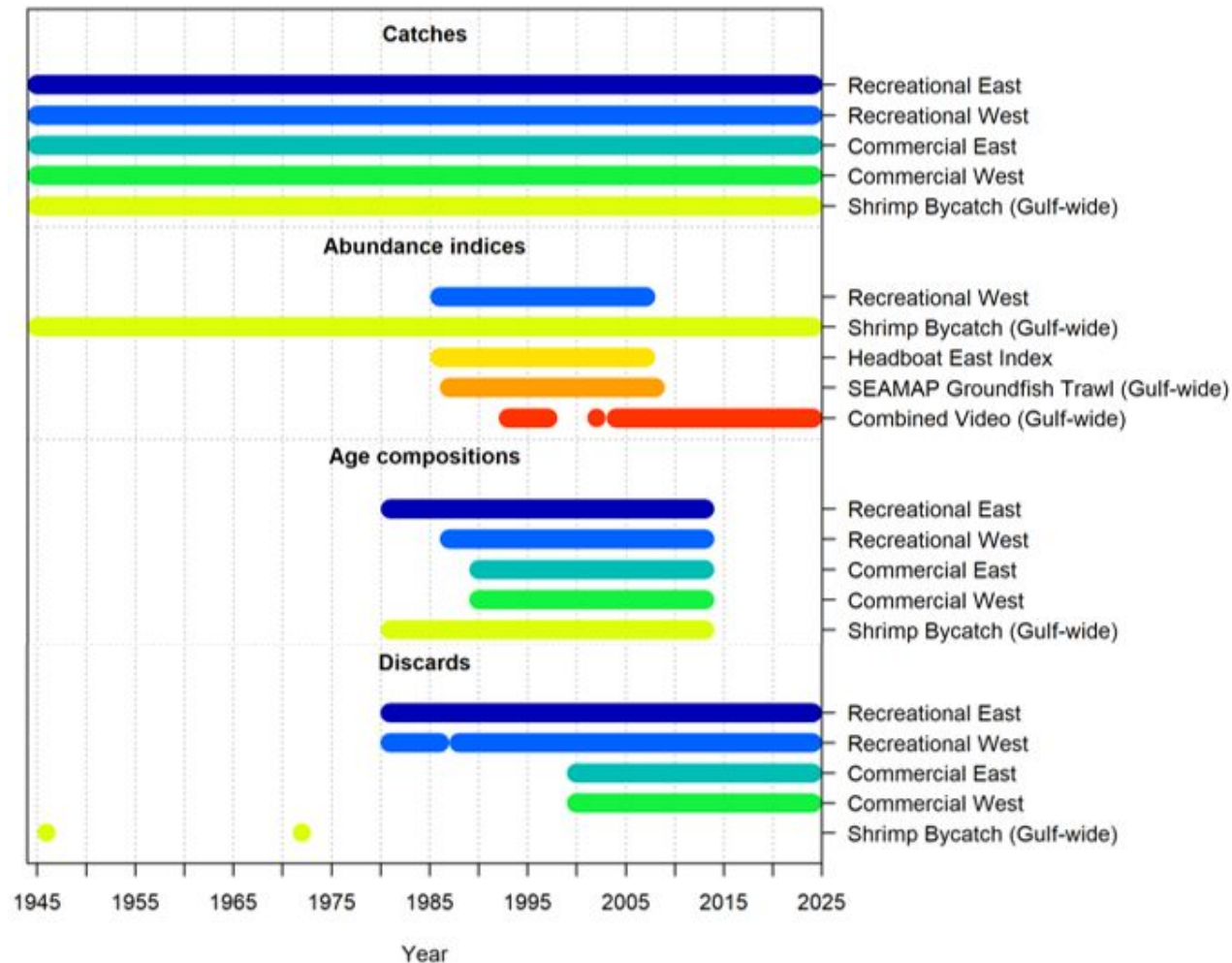
Gray Triggerfish: *Balistes capriscus*



- Assessment model
 - Model building
 - AP Model configuration
 - AP Model results
 - AP Model diagnostics
 - AP Model sensitivities
 - AP Model projections

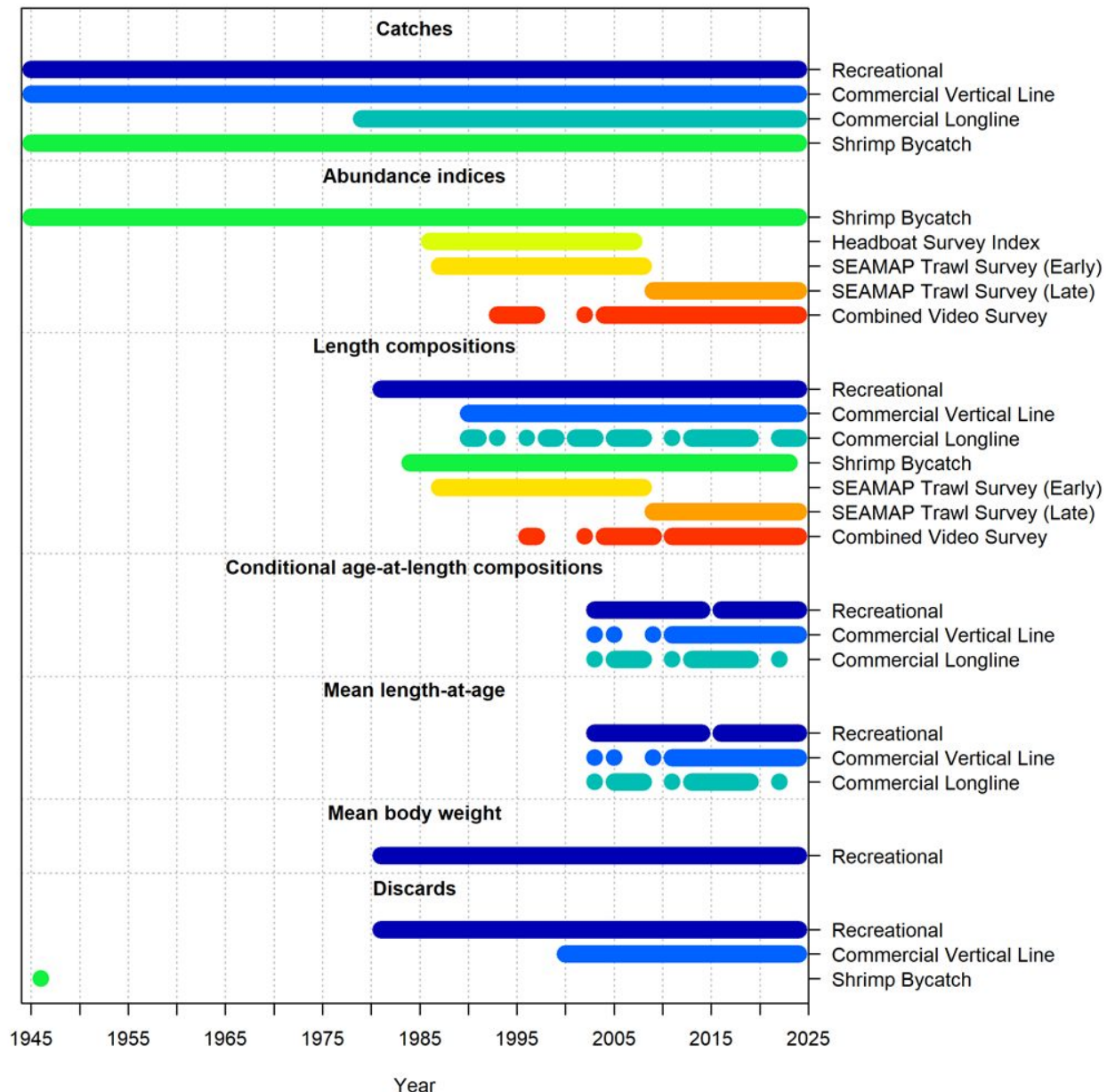
Starting data structure (SEDAR 43)

- Fleets-as-areas approach for fishing fleets
- Shrimp bycatch and fishery-independent surveys Gulf-wide



SEDAR 100 data structure

- All data streams Gulf-wide
- Separated commercial longline from vertical line

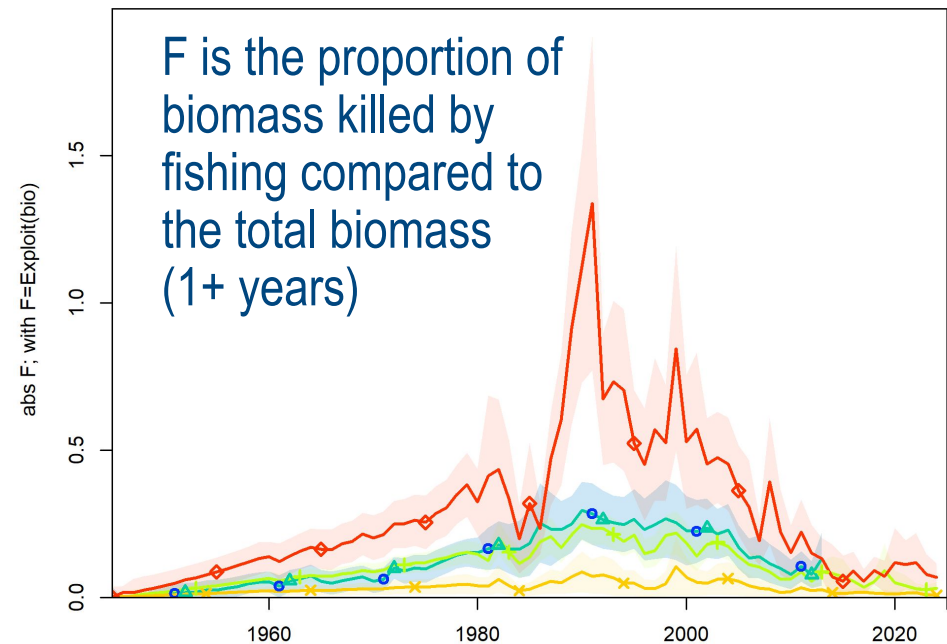
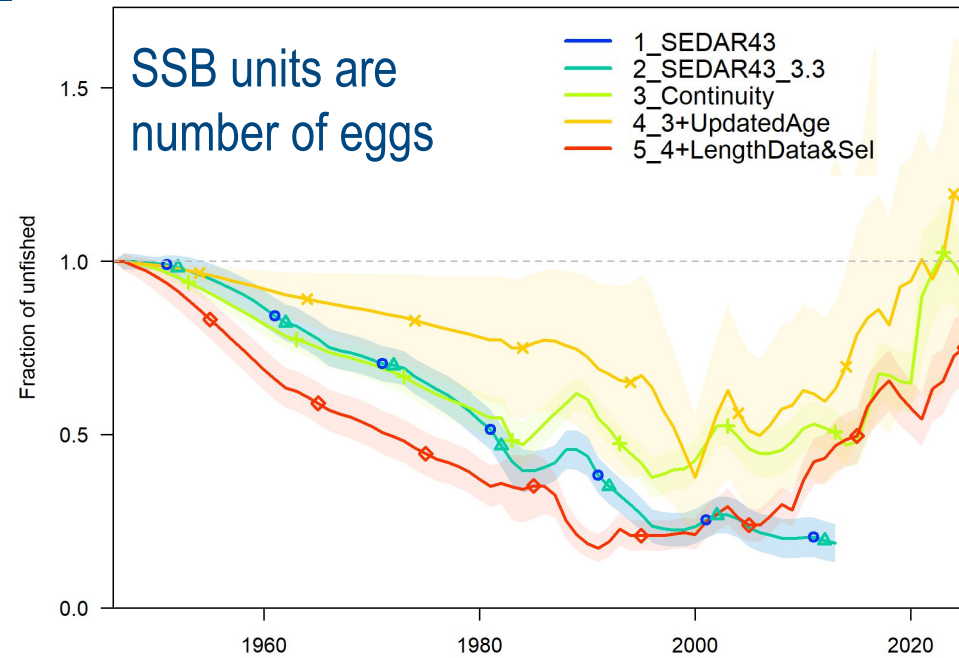
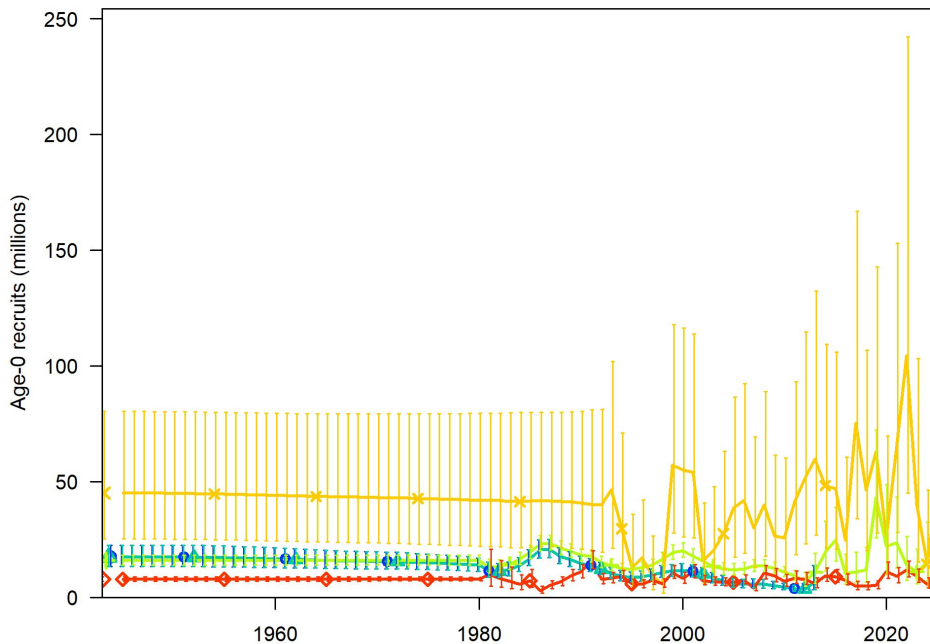


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Phase 1 Comparison

- “Continuity” not possible
- “Revamped Continuity” based on length data, nominal age comps (from otoliths), and length-based selectivity



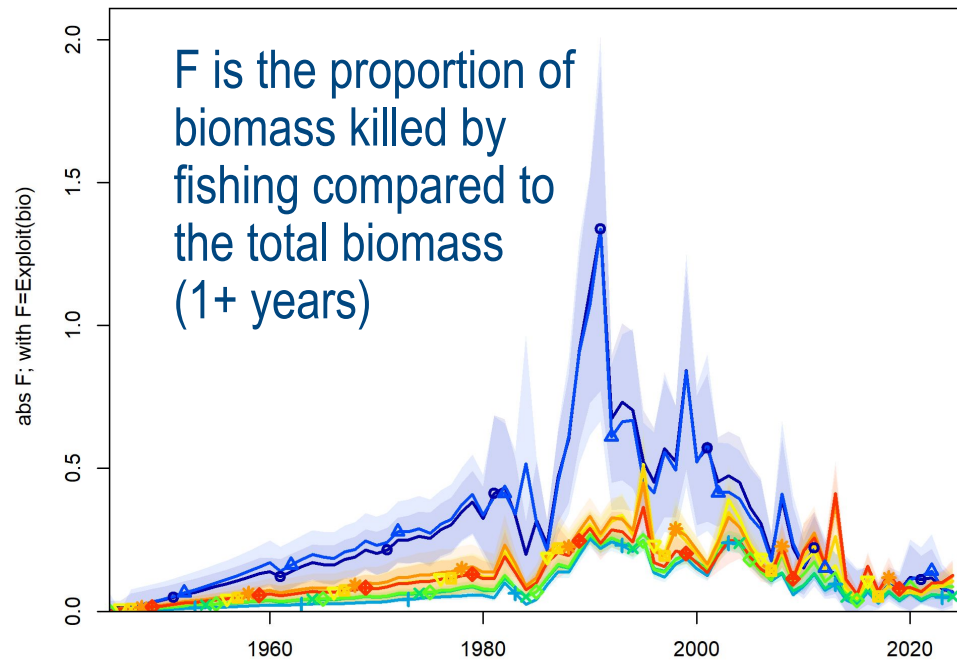
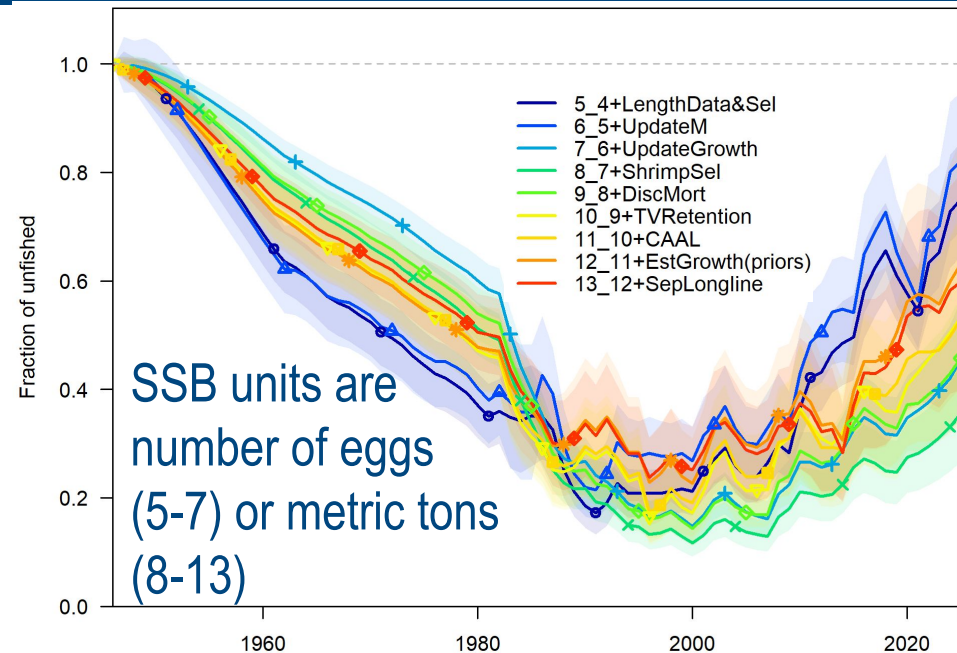
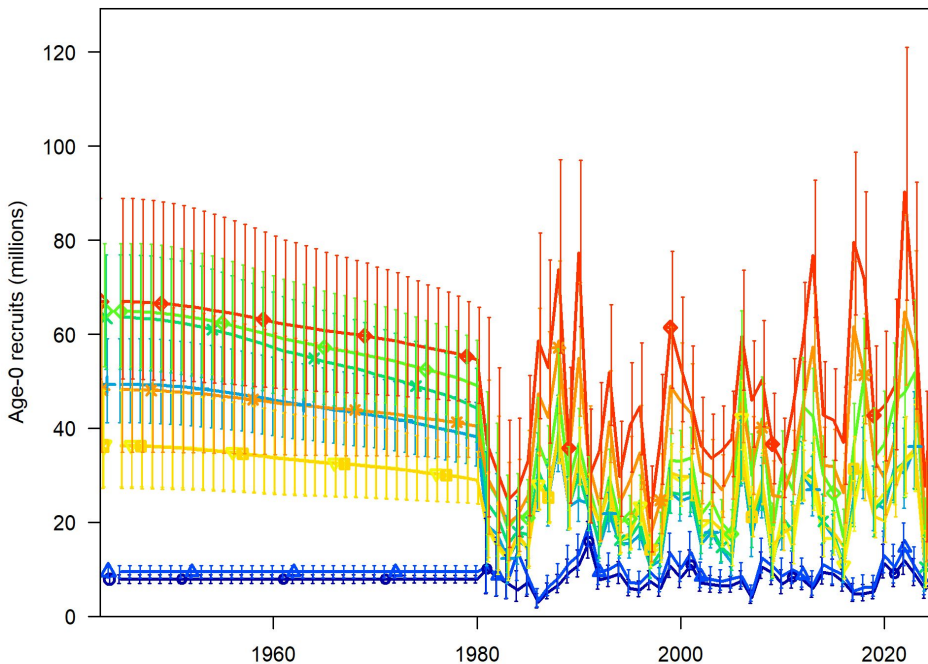
Phase 1 Comparison

Model Details	NLL	Gradient	Estimated Parameters (Bounded)	Parameters with CVs > 1	steepness	<i>SigmaR</i>	$\text{Ln}(R_0)$
1. SEDAR 43 Base Model	225	0.0331	410 (0)	28	0.46	0.36	9.76
2. SEDAR 43 Base Model converted to 3.30.21	225	0.0035	411 (0)	28	0.46	0.36	9.76
3. Step 2 + update all data streams (except age composition)	313	0.0019	477 (1)	22	1	0.4	9.67
4. Step 3 + updated age data	920	11.473	467 (3)	24	0.48	0.81	10.72
5. Step 4 + use length data & length-based selectivity	12,679	247.005	489 (3)	34	0.99	0.42	8.97

- Life history parameters and age-0 based selectivity for shrimp causing really poor fits to compositions

Phase 2 Comparison

- Updated life history, selectivity, retention, switched to conditional age-at-length, and separated Commercial Longline from Vertical Line

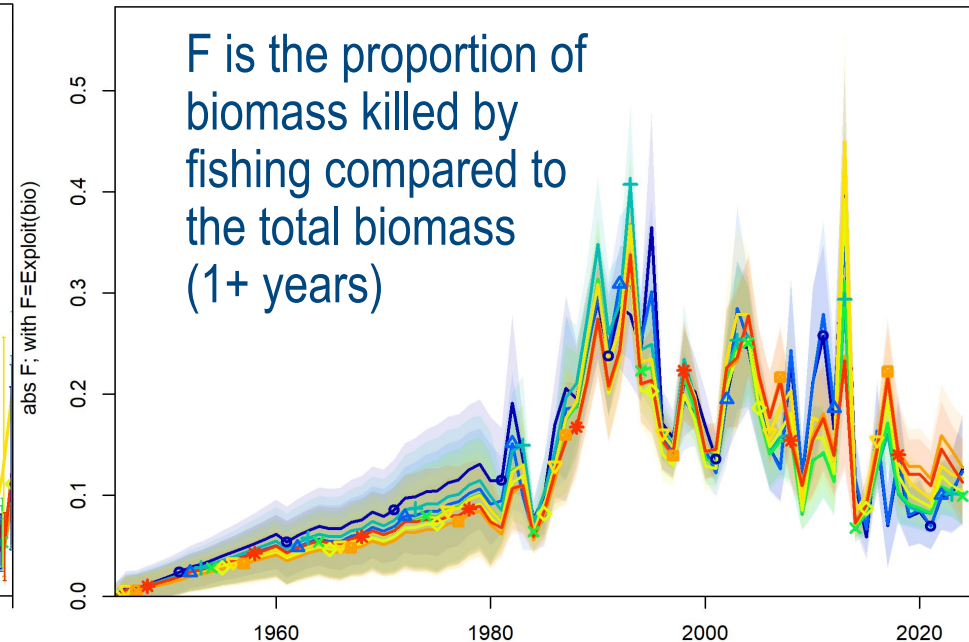
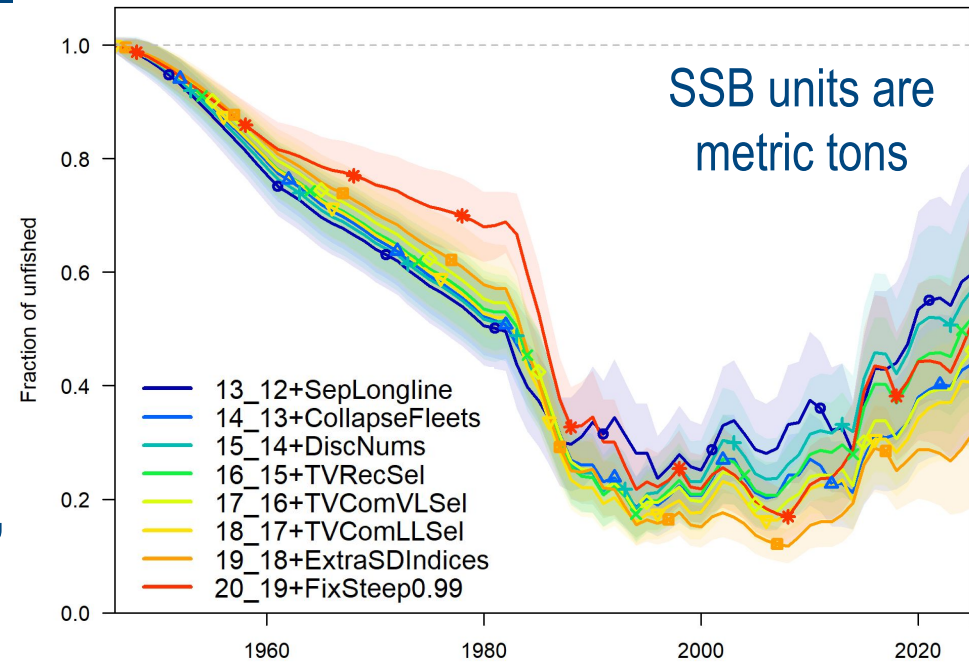
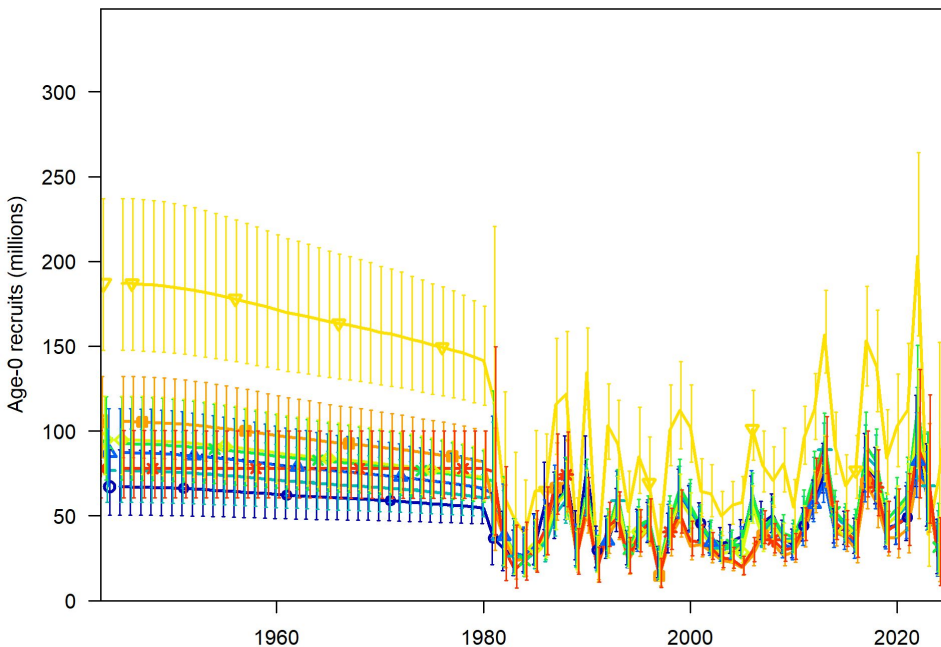


Phase 2 Comparison

Model Details	NLL	Gradient	Estimated Parameters (Bounded)	Parameters with CVs > 1	steepness	<i>SigmaR</i>	$\text{Ln}(R_0)$
6. 5 + update natural mortality	12,647	0.4127	489 (1)	36	1	0.42	9.15
7. 6 + update growth	10,880	0.0403	489 (2)	26	0.36	0.57	10.81
8. 7 + estimate length-based selectivity for shrimp	10,630	0.6675	495 (2)	32	0.35	0.45	11.06
9. 8 + update discard mortality to 40%	10,643	0.3269	495 (2)	31	0.4	0.43	11.08
10. 9 + allow time-varying retention parameters	9,287	0.2434	515 (2)	30	0.52	0.44	10.5
11. 10 + switch to conditional age-at-length	15,696	0.6513	515 (2)	25	0.52	0.38	10.5
12. 11 + estimate growth (priors on L_{Amin} , L^∞ , & K)	14,820	0.2044	520 (0)	25	0.59	0.36	10.78
13. 12 + separate commercial longline	15,922	0.0660	568 (0)	26	0.52	0.39	11.11

Phase 3 Comparison

- Collapsed fleets-as-areas, fit discards in numbers, allowed time-varying fleet selectivity, estimated extra SD for indices, and fixed steepness

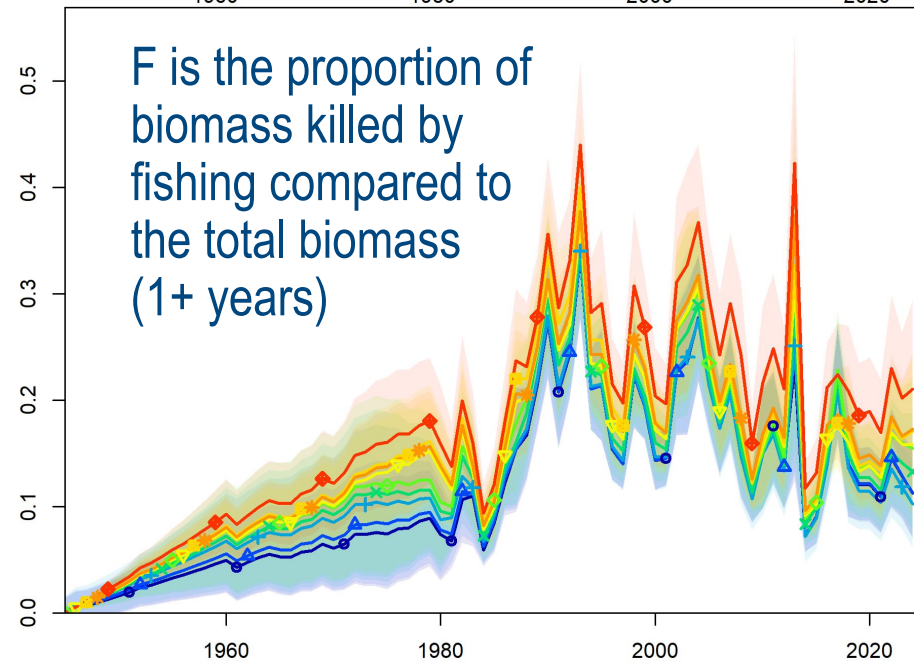
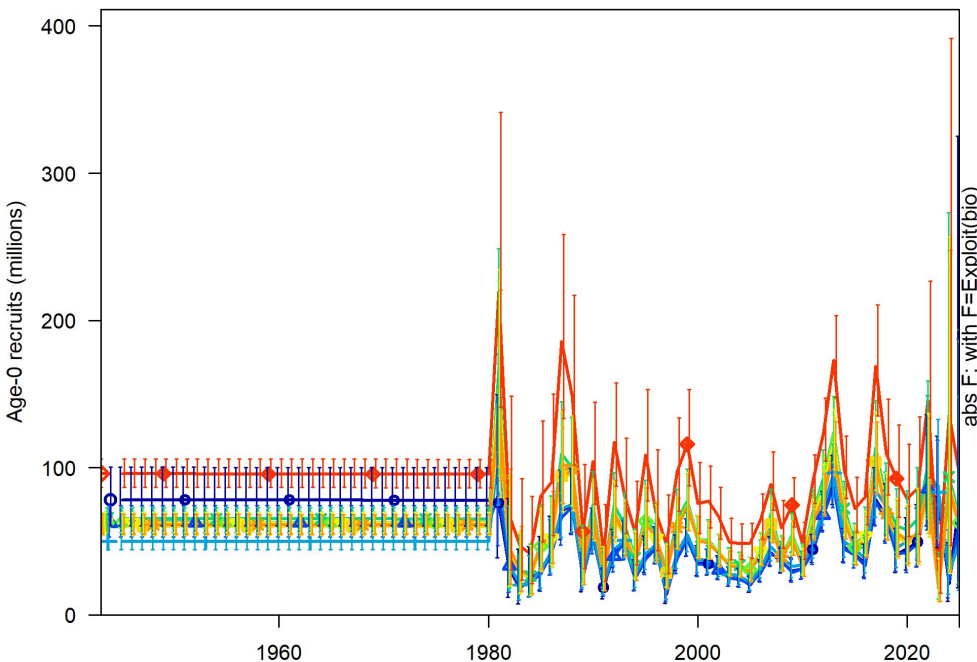
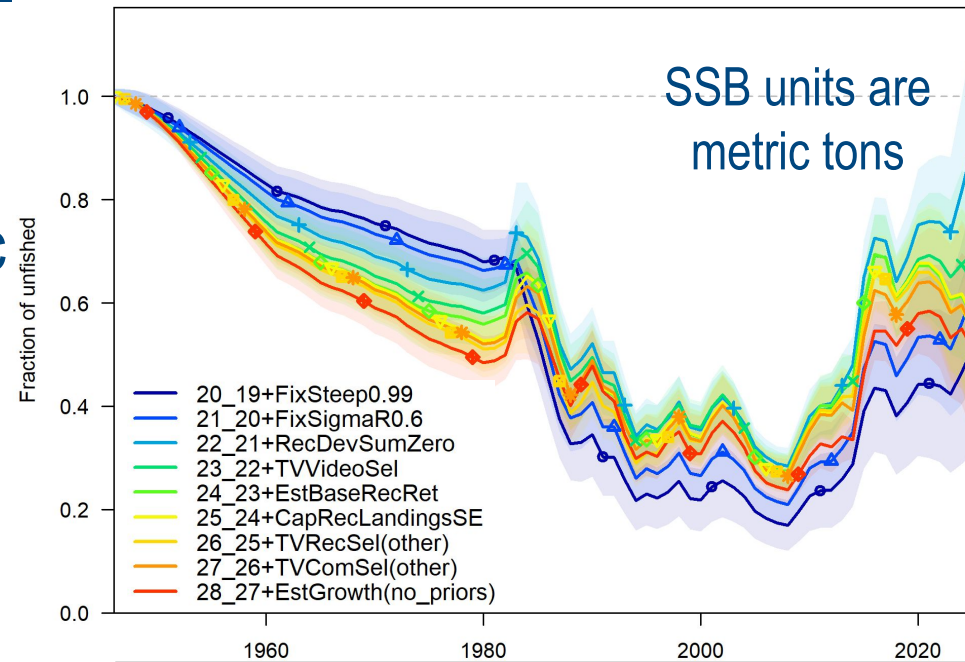


Phase 3 Comparison

Model Details	NLL	Gradient	Estimated Parameters (Bounded)	Parameters with CVs > 1	steepness	<i>SigmaR</i>	$\text{Ln}(R_0)$
14. 13 + collapse fleets-as-areas	13,819	0.0203	382 (0)	22	0.42	0.43	11.38
15. 14 + fit to discards in numbers	14,112	0.028	382 (1)	20	0.47	0.42	11.25
16. 15 + fit time-varying recreational selectivity (peak)	14,074	0.0413	383 (2)	18	0.43	0.46	11.43
17. 16 + fit time-varying commercial vertical line selectivity (inflection)	13,987	0.1617	380 (1)	21	0.4	0.46	11.46
18. 17 + fit time-varying commercial longline selectivity (inflection)	13,892	0.0152	381 (2)	18	0.41	0.54	12.14
19. 18 + estimate extra SD for indices of abundance	13,536	0.0253	384 (0)	22	0.39	0.5	11.57
20. 19 + fix steepness as 0.99	13,543	0.0617	383 (0)	18	0.99	0.83	11.26

Phase 4 Comparison

- Fixed $\text{Sigma}R$, constrained rec devs, allowed time-varying video selectivity, refined selectivities and retention, freely estimated growth



Phase 4 Comparison

Model Details	NLL	Gradient	Estimated Parameters (Bounded)	Parameters with CVs > 1	steepness	<i>SigmaR</i>	$\text{Ln}(R_0)$
21. 20 + fix <i>SigmaR</i> at 0.6	13,551	0.038	382 (0)	15	0.99	0.6	11.05
22. 21 + constrain recruitment deviations to sum to 0	13,654	0.101	382 (0)	23	0.99	0.6	10.82
23. 22 + time-varying video selectivity (peak)	13,503	0.0384	256 (0)	18	0.99	0.6	11.09
24. 23 + estimate base recreational retention	13,768	0.0023	261 (0)	19	0.99	0.6	11.04
25. 24 + cap large recreational landings SE	13,788	0.0858	261 (0)	18	0.99	0.6	11.04
26. 25 + time-varying recreational retention (estimate other parameters)	13,715	0.0127	270 (1)	20	0.99	0.6	11
27. 26 + time-varying commercial retention (estimate other parameters)	13,652	0.0055	272 (0)	21	0.99	0.6	11.02
28. 27 + estimate growth without priors (SEDAR 100 AP Model)	13,582	0.0054	268 (0)	20	0.99	0.6	11.47

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Modeling approach

- Using Stock Synthesis (Methot and Wetzel 2013), an integrated assessment modeling platform
 - Statistical catch-at-age model
- Advantages
 - Do not have to split time series
 - Time varying selectivity or retention
 - Can use both length and age composition data
 - Can link parameters to environmental series
 - Explicitly incorporates imprecision of observation processes (e.g., ageing imprecision)

Model configuration

- 1945 (unfished) – 2024
 - Re-evaluated start year (TOR)

Assessment Process

- Evaluate the start year and initial Fs used in the assessment model.
- Ultimately retained SEDAR 43/62 start year of 1945 which assumed the stock was at virgin conditions (negligible removals prior)
- Sensitivity analyses undertaken to evaluate different start years and the specification of initial conditions

Model configuration

- 1 area (Gulf-wide), 1 season model
 - Re-evaluated spatial structure (**TOR**)
- 1 gender model (combined sexes; 50:50 sex ratio at birth)
- Maturity a function of length
 - Switched from maturity-at-age due to **ageing issues**
- Reproductive potential based on female-only SSB
 - Switched from fecundity as a function of length due to **data limitations and lack of uncertainty**
 - Decision also reversed for Gulf red snapper (**SEDAR 74**)

Model configuration

- von Bertalanffy growth
 - Estimated internally in SS due to revised age data
- Lorenzen natural mortality
 - Updated with Hamel and Cope (2022) approach for specifying target M and estimated Lorenzen scaling internally in SS
 - Adjusted age-0 for peak spawning in July
- Ageing error matrix
 - Updated based on revised age data
- Ages 1-15 modeled, with plus group of 10+ (< 1.3% of data)

Model configuration

- Beverton-Holt stock-recruitment relationship
 - Estimated $\ln(R_0)$: unexploited equilibrium recruitment on log-scale
 - Fixed steepness at 0.99 to enable mean recruitment in projections
 - Fixed $\text{Sigma}R$ at 0.6 to reflect realistic standard deviation in recruitment estimates
 - Recruitment deviations estimated in main period (1981-2024), full bias adjustment from 1998-2022
 - No early estimates (high uncertainty)

Model configuration

- Fishing mortality specified using fleet-specific continuous/hybrid approach (F method 4)
 - Annual F s estimated for Recreational and Shrimp Bycatch fleets
 - Commercial fleets switched to hybrid (for parsimony) after results were nearly identical
 - F is a tuned factor where the tuning is based on the retained catch for each fishing fleet
- Sensitivity run conducted for F as a parameter approach (F method 2) which is used in SEFSC projections

Model configuration

- 3 fishing fleets with landings, discards, and composition inputs as available
 1. Recreational
 2. Commercial Vertical Line (+ other gears)
 3. Commercial Longline
- Shrimp bycatch included as a discard-only bycatch fleet
- 1 fishery-dependent index: Recreational (SRHS) CPUE
 - Commercial Vertical Line CPUE and Recreational MRIP index no longer recommended for use

Model configuration

- Length-based selectivity for fishing fleets and shrimp bycatch fleet
 - Time-varying selectivity for fishing fleets to account for switch from J-hooks to circle hooks (among other regulations) in 2008
 - SEDAR 43 estimated age-based selectivity using age composition (derived from length compositions and Age-Length Keys)
- Time-varying length-based retention to account for changes in regulations for fishing fleets

Model configuration

- 3 fishery-independent surveys with indices and length compositions
 1. SEAMAP Trawl Early
 2. SEAMAP Trawl Late
 3. Combined Video
 - Fall Plankton Survey no longer recommended for use as index of SSB and not recommended for juveniles
- Length-based selectivity for surveys
 - Time-varying selectivity for video to account for different surveys
 - Age-based selectivity fixed in SEDAR 43

Model configuration

- Catchability coefficient associated with each index
 - Estimated parameter for Effort Index for Shrimp Bycatch fleet
 - Floated in Stock Synthesis for indices of relative abundance, analytical solution used
- Constant catchability assumed for all indices
- Extra Standard Deviation (SD) estimated for each index of relative abundance

Estimated parameters

Type	Parameters	Notes
Growth	3	L_{Amin} , L^∞ , K
Annual F_s for Recreational fleet and Shrimp Bycatch fleet	160	80 parameters per fleet
Recruitment	1	$\ln(R_0)$
Recruitment deviations	44	1981-2024
Selectivity	34	
Retention	14	
Dirichlet-multinomial parameters	6	1 per fleet/survey and data type
Catchability coefficient	1	Shrimp Effort index
Extra SD	4	1 per index of relative abundance
Total	267	

Likelihood components

- **Landings:** Lognormal with commercial SE ~ 0.05 (as provided in sensitivity run) and recreational SE capped at 0.25 (as provided in sensitivity runs)
- **Mean weight of landings:** t -distribution with 30 degrees of freedom
- **Indices of relative abundance:** Lognormal with annual SEs from catch rate standardization for surveys or CPUE
- **Shrimp Effort Index:** Lognormal with annual SEs = 0.2
- **Discards:** Lognormal with SEs as provided
- **Length Composition:** Dirichlet multinomial with annual N = number of sampled trips (fishing fleets) or stations (surveys)
- **Conditional age-at-length composition:** Dirichlet multinomial with N = number of ages within a length bin
- **Recruitment deviations:** Lognormal with estimated variance = $\text{Sigma}R$
- **Parameter priors:** Extra SD, Dirichlet parameters

Length-based selectivity – fishing fleets

Pattern	Parameters	Fleet
Double normal	1*. Peak (beginning size for the plateau) 2. Top (width of plateau) 3. Ascending width (parameter describing incline to plateau) 4*. Descending width (parameter describing decline from plateau to final size bin) 5. Initial (selectivity of first size bin) 6*. Final (selectivity of final size bin)	Recreational
Logistic	1*. Size at inflection 2*. Width for 95% selection $S_l = \frac{1.0}{1 + \exp(-\ln(19)(L_l - p1)/p2)}$	Commercial Vertical Line & Longline

- *Time-varying selectivity estimated for fishing fleets to account for change to circle hooks

Length-based selectivity – surveys

Pattern	Parameters		Fleet
Double normal	1. Peak 3. Ascending width 5. Initial	2. Top 4. Descending width 6. Final	SEAMAP Trawl Early/Shrimp Bycatch, SEAMAP Trawl Late, and Combined Video

- Time-varying selectivity estimated (peak only) for video survey to account for changes in surveys

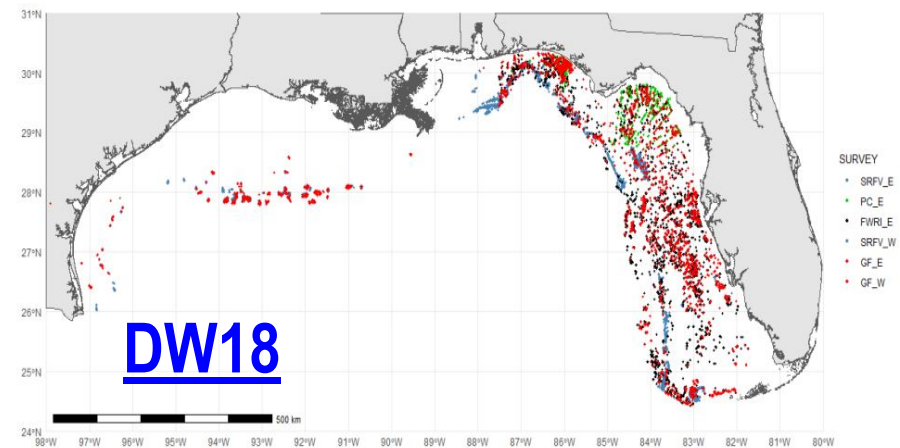
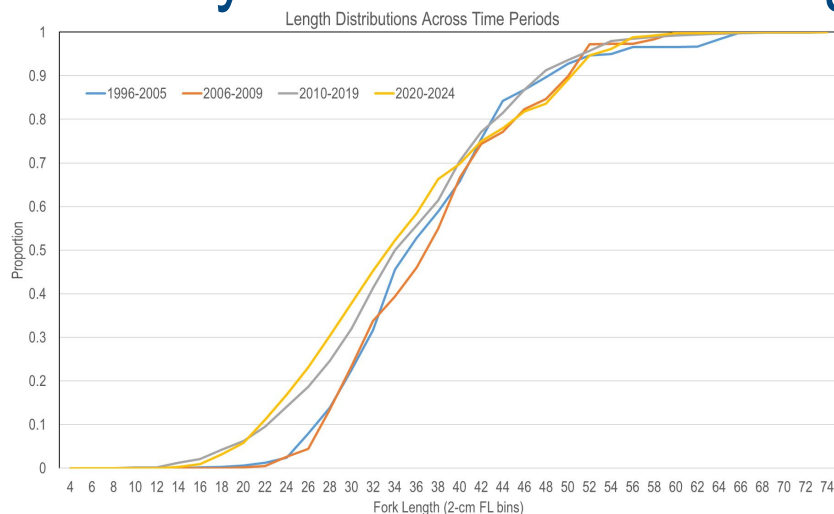


Figure 1. Map of all video sites included in the GOA Index for each survey across all years 1993-2023.

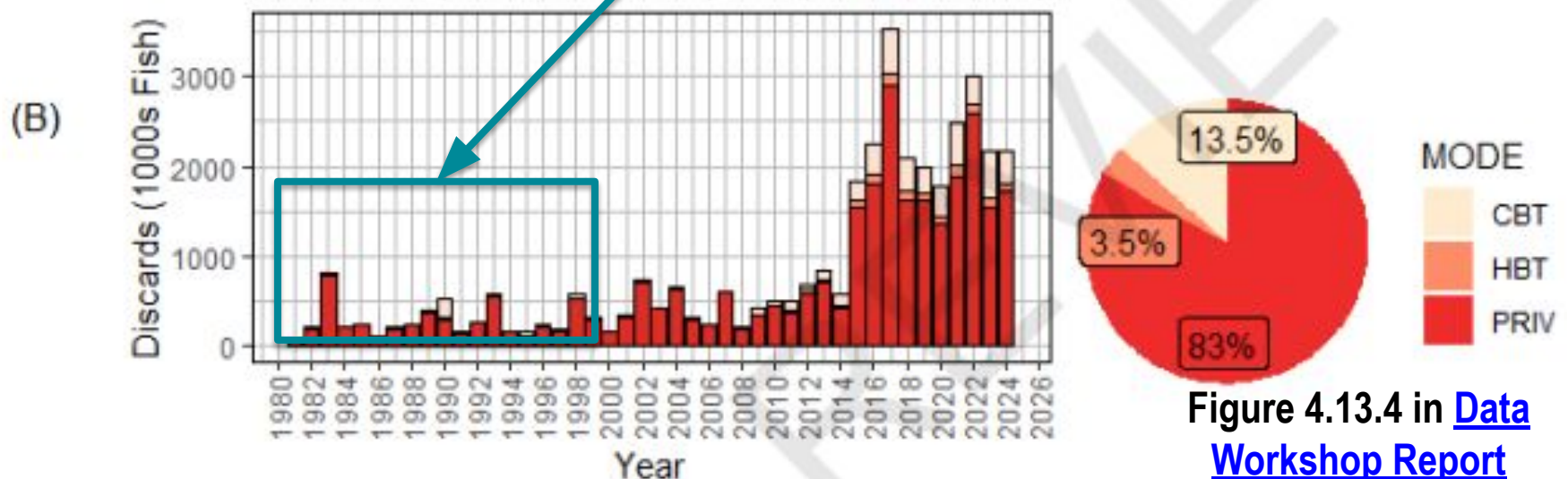
Length-based retention

- Modeled time-varying retention to account for changes in management regulations
 - Size limits, bag limits, trip limits, closed seasons
- Retention was modeled as a logistic relationship
 - P1 = ascending inflection
 - P2 = ascending slope
 - P3 = maximum retention
 - P4 = male offset to ascending; set to 0

$$\text{Retention} = \left(\frac{P3}{1 + e^{\frac{-(L - (P1 + P4 * \text{male}))}{P2}}} \right)$$

Retention

- Estimated retention prior to size limit in 1999 for:
 - Recreational
 - Commercial Vertical Line
- Discards occurred prior to size limit in 1999
 - Not a target species (DW20, DW10)
 - Hard to filet (DW10)



Commercial retention

- All parameters estimated, but base (1945-1998) inflection point and width parameters were fixed at model estimates

Time Block	Inflection	Width	Asymptote
pre-1999	Fixed at model estimate	Fixed at model estimate	Estimated (due to low desirability)
1999-2007	Estimated; initially started at size limit of 12 inches TL (26 cm FL)	Estimated	
2008-2011	Estimated; initially started at size limit of 14 inches FL (36 cm FL)	Estimated	
2012-2024			Estimated (due to regulations)

Recreational retention

- All parameters estimated, but base (1945-1998) inflection point and width parameters were fixed at model estimates

Time Block	Inflection	Width	Asymptote
pre-1999	Fixed at model estimate	Fixed at model estimate	Estimated (due to low desirability)
1999-2007	Estimated; initially started at size limit of 12 inches TL (26 cm FL)	Estimated	
2008-2011	Estimated; initially started at size limit of 14 inches FL (36 cm FL)	Estimated	
2012-2017			Estimated (due to regulations)
2018-2024	Estimated; initially started at size limit of 15 inches FL (38 cm FL)	Estimated	

Discard Mortality

$$\text{Mortality} = \left(1 - \frac{1 - P3}{1 + e^{\frac{-(L - (P1 + P4 * male))}{P2}}} \right)$$

- P1 = descending inflection
- P2 = descending slope
- P3 = maximum discard mortality

Fleet	P3
Recreational	0.4
Commercial Vertical Line	0.4

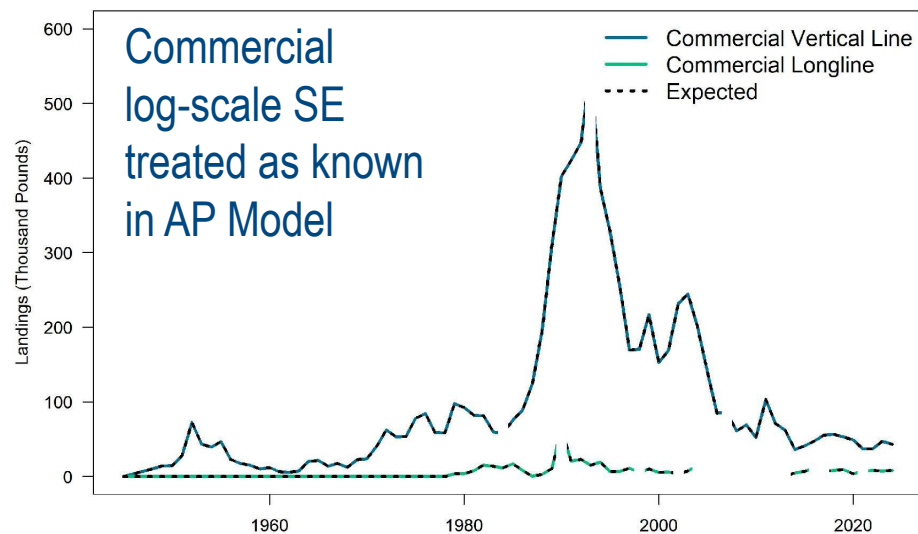
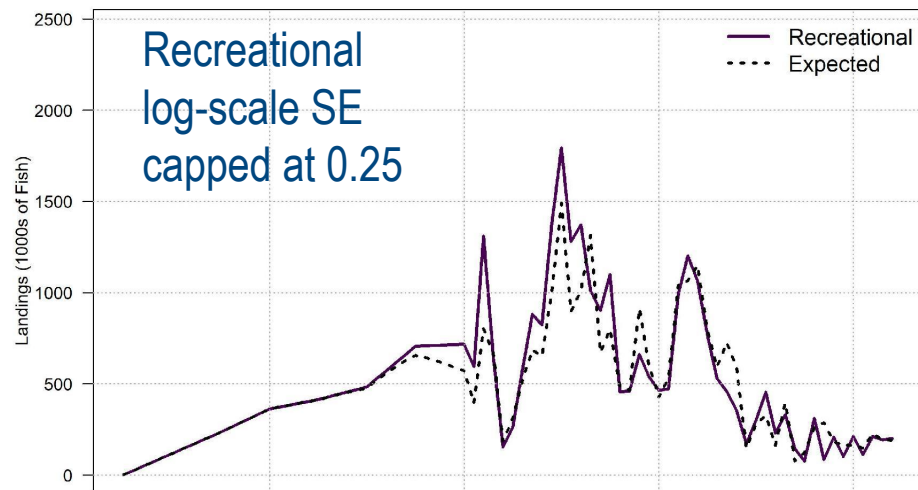
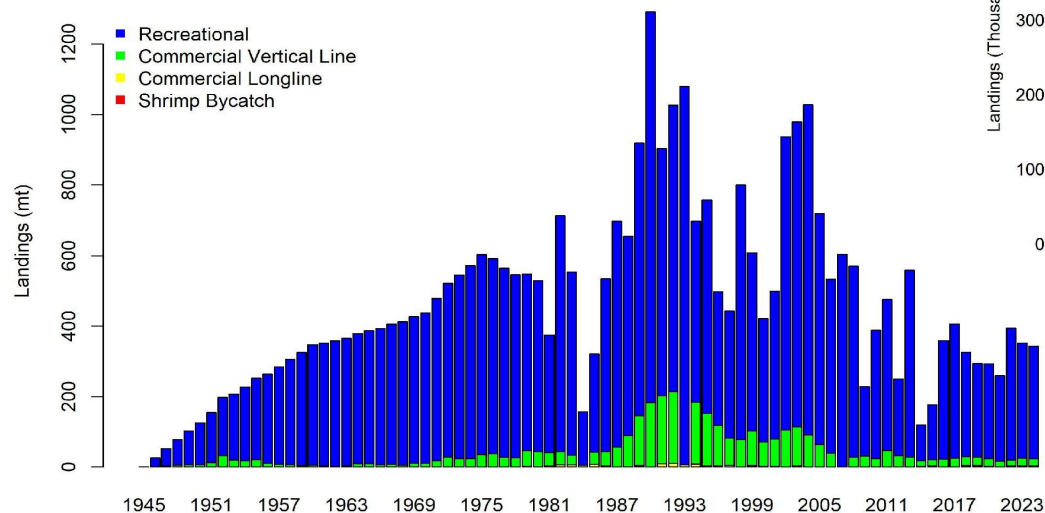
- P4 = male offset to descending; set to 0

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Landings

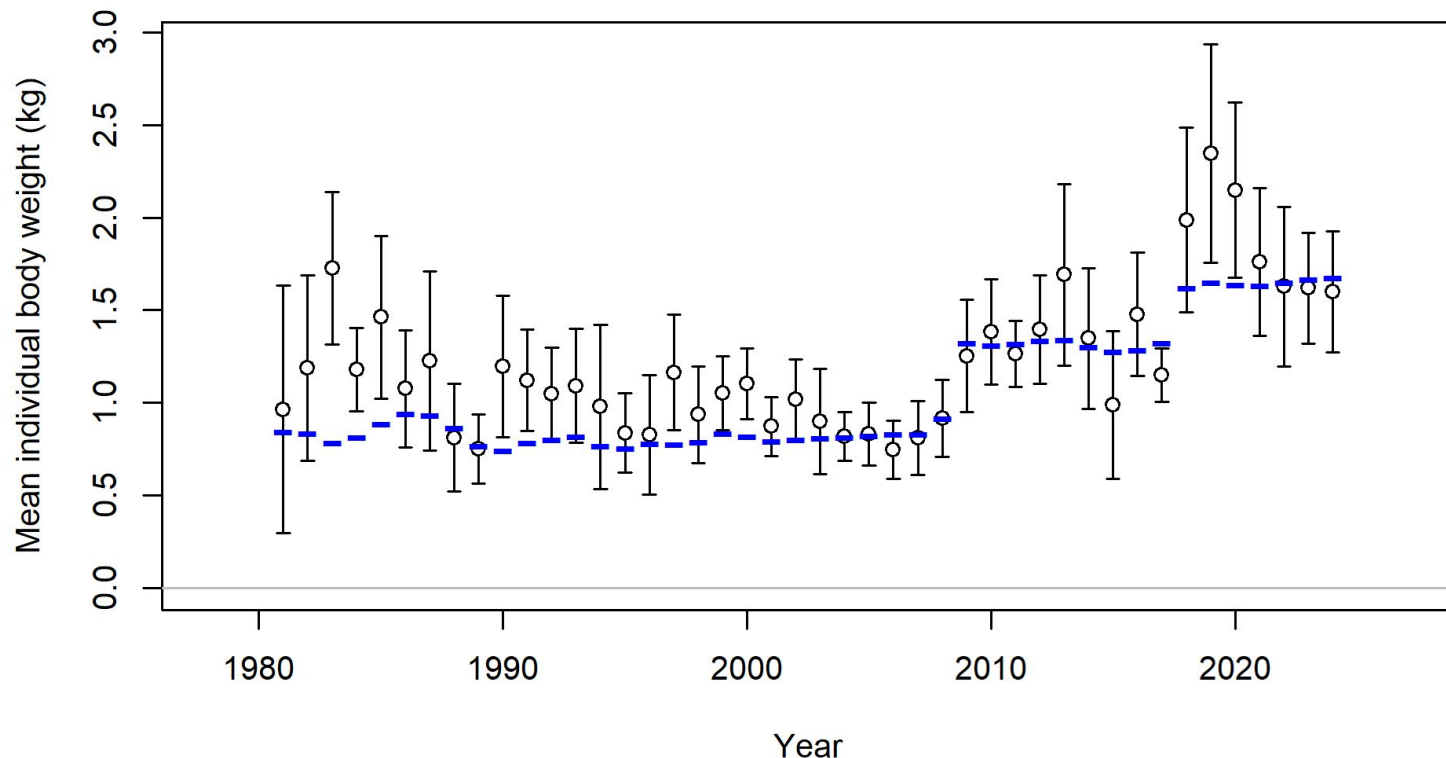
- Highly variable recreational landings through time, commercial landings relatively low
- Sensitivity runs explored uncertainty and magnitude



Confidential commercial
data excluded

Mean weight of recreational landings

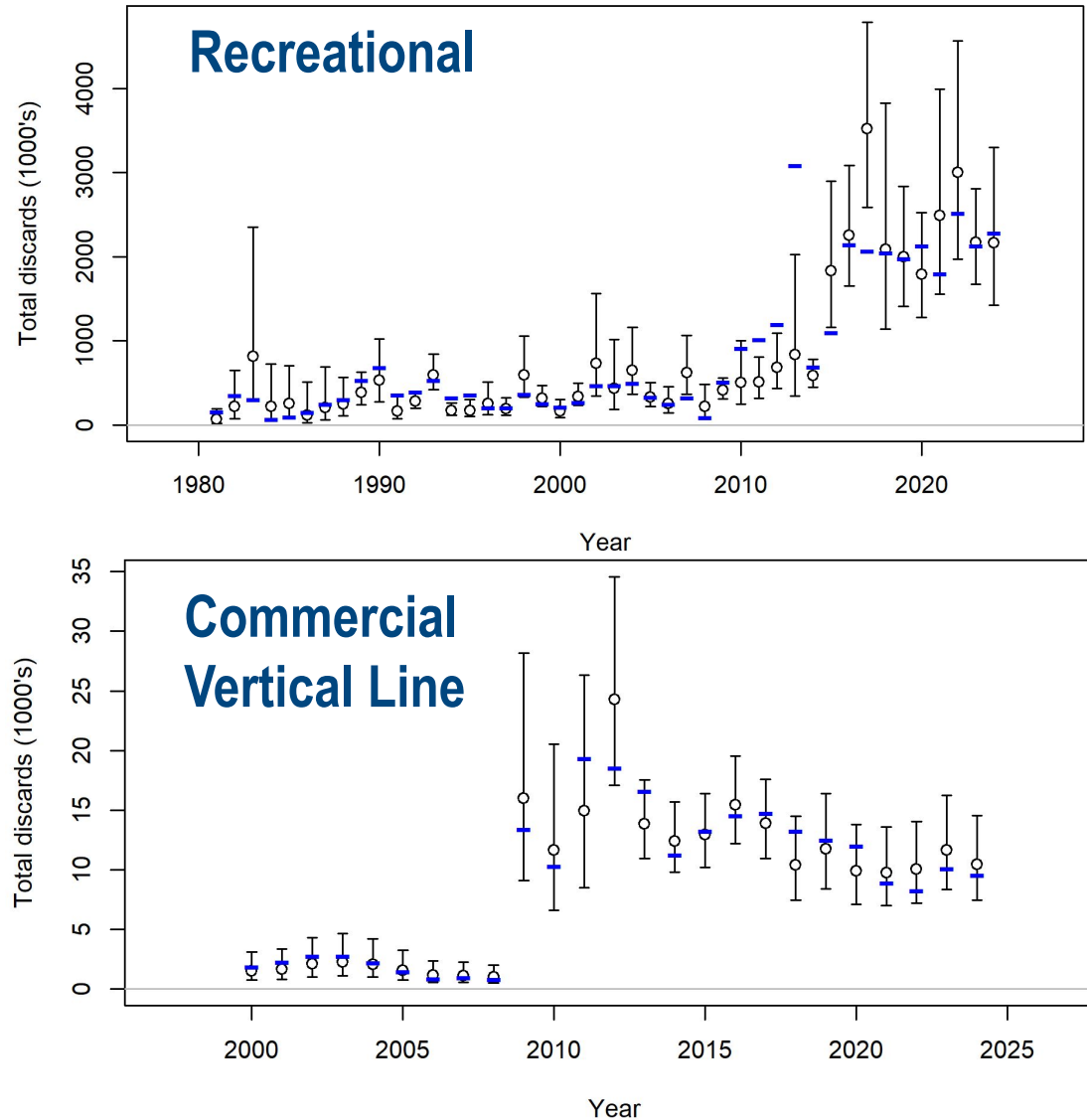
- Model generally expects similar mean weight as observed, as most years remain within the confidence limits of the data



*discards before applying discard mortality

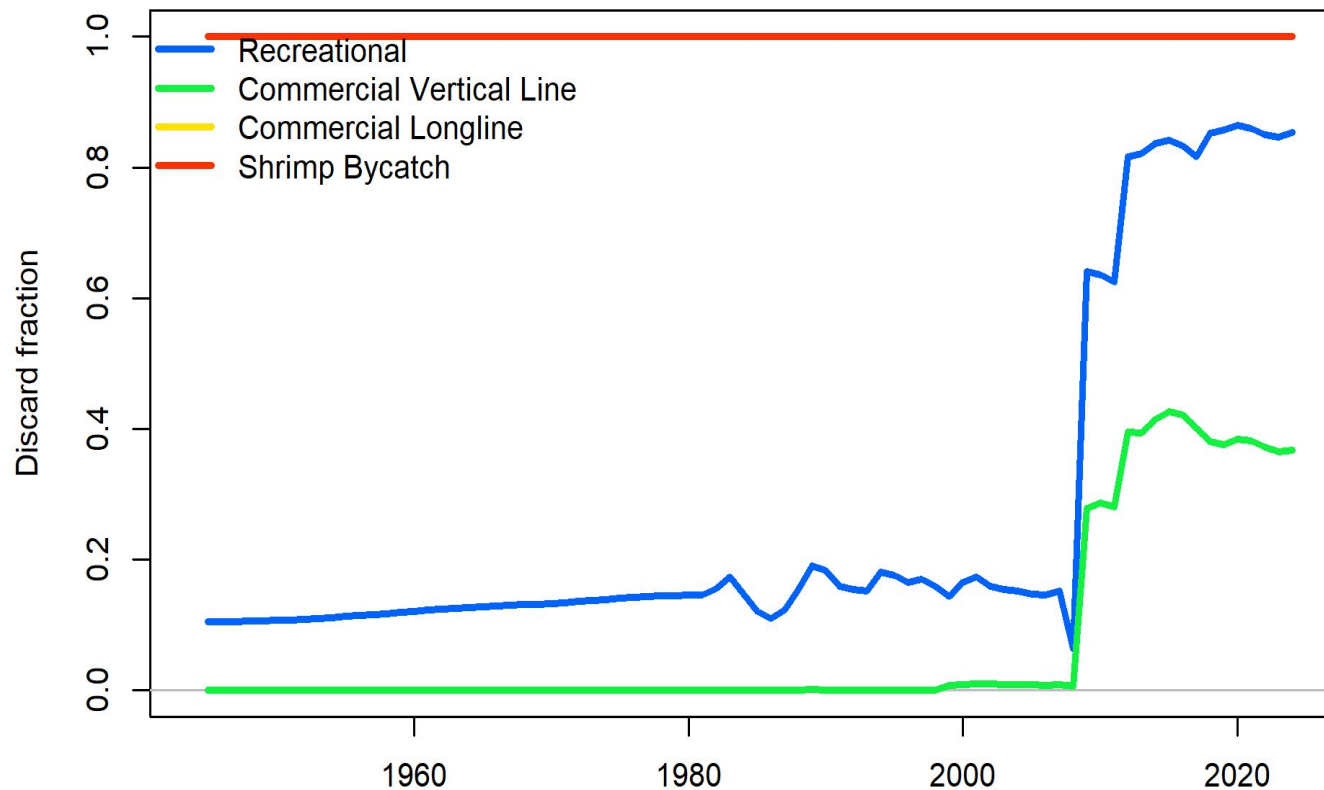
Discards*

- Most years remain within the confidence limits of data for both fleets
- Model predicts much larger discards in 2013 for recreational fleet
 - Bag limit change
 - Reduced open season



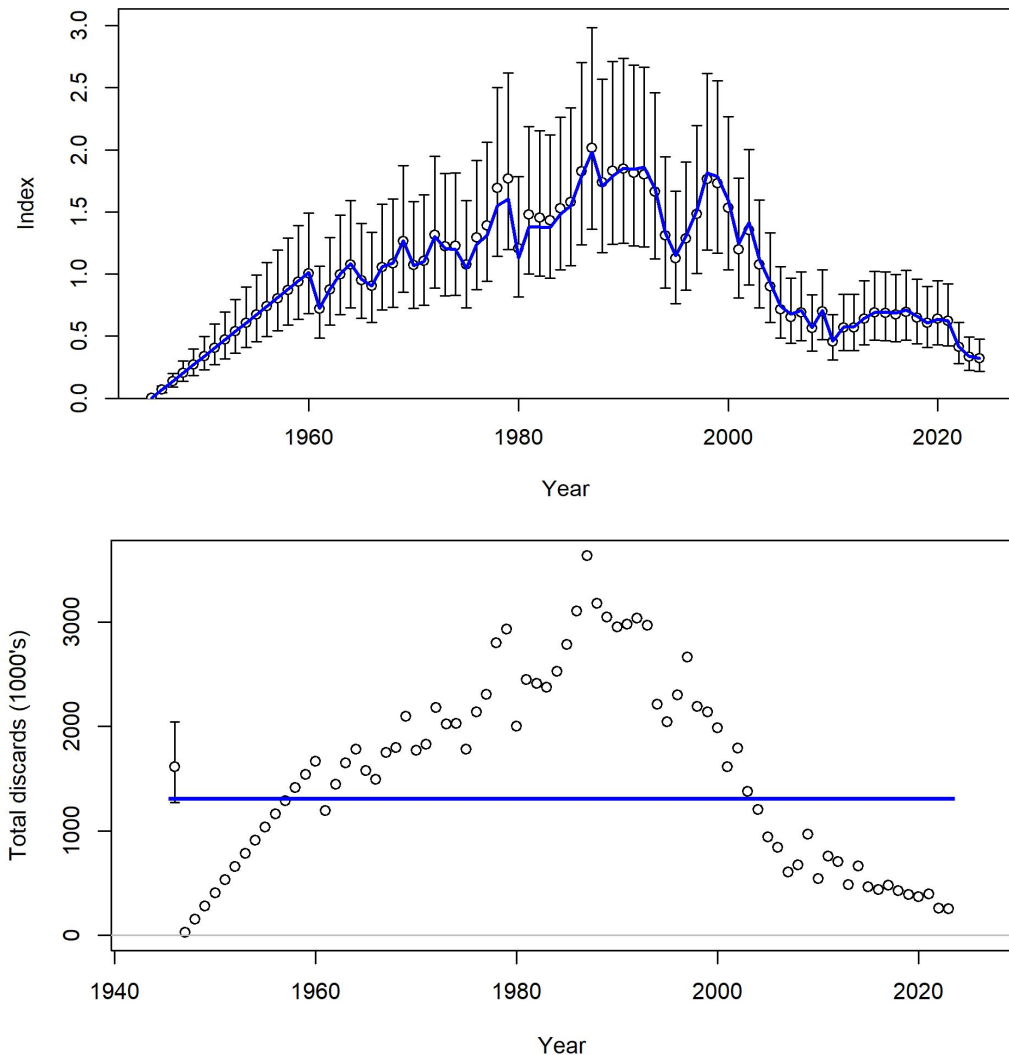
Discard fraction

- Large increase in recent years due to management regulations



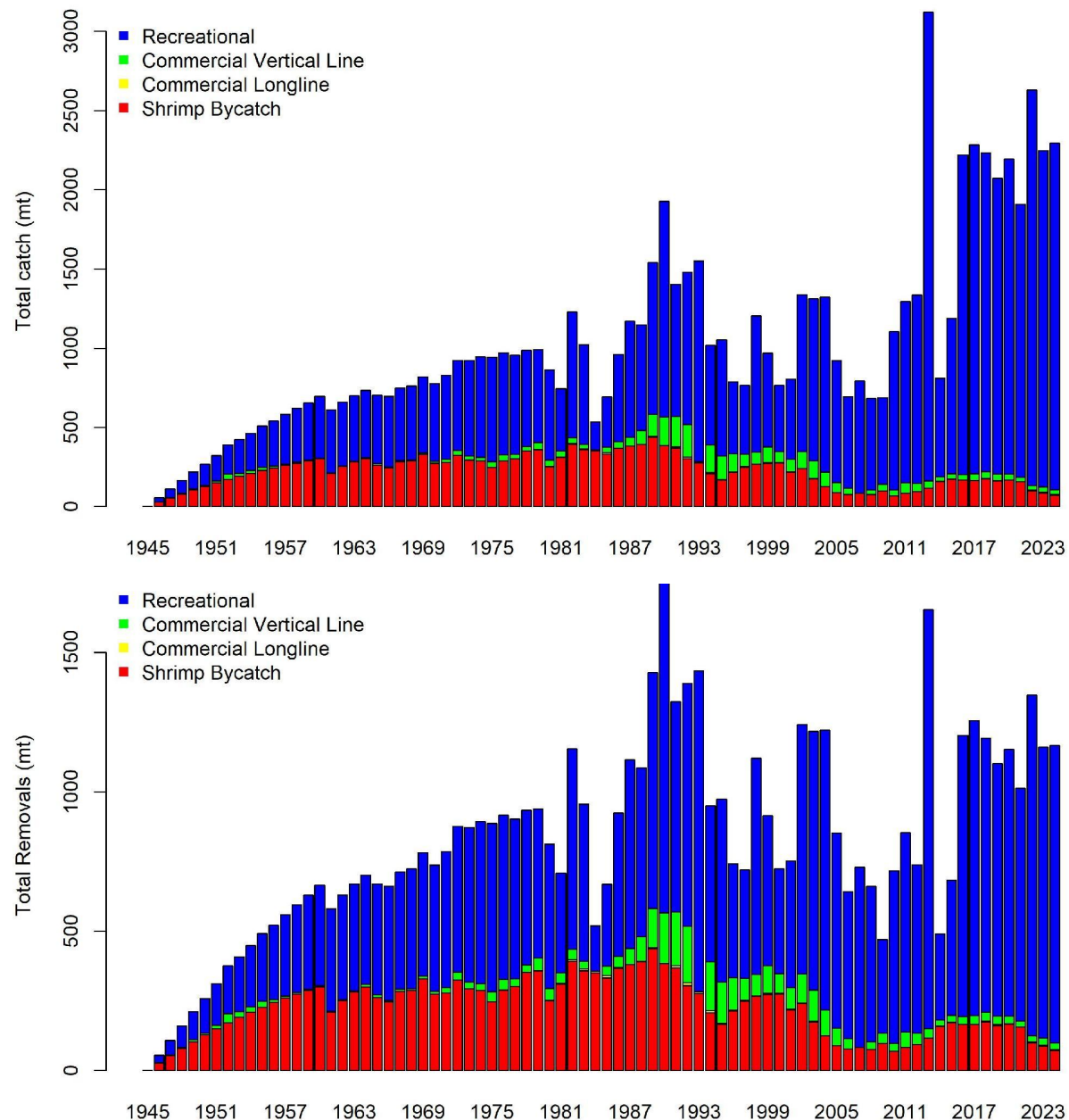
Shrimp bycatch & shrimp effort

- Effort index fits well, except for slight deviation in late 1970s/early 1980s
- Model estimates lower median bycatch estimate than observed
 - Sensitivity runs explored magnitude and uncertainty



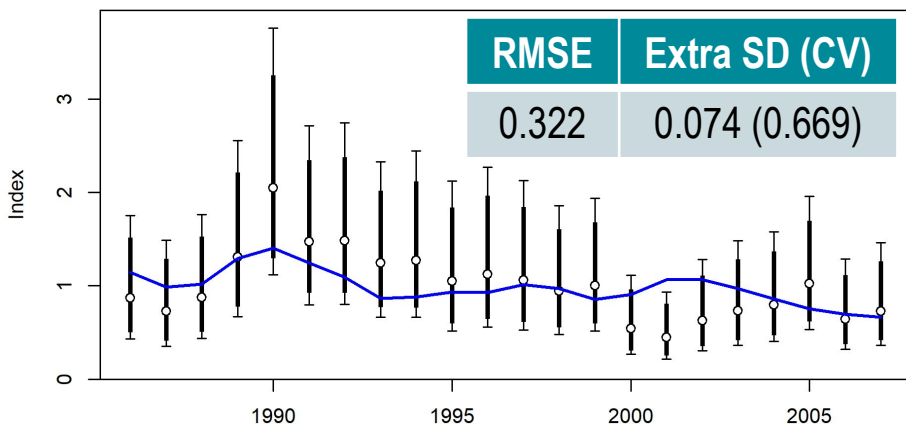
Totals

- Recreational fleet responsible for majority of total catch (landings + discards) and total removals (landings + dead discards)
- Confidential commercial data excluded

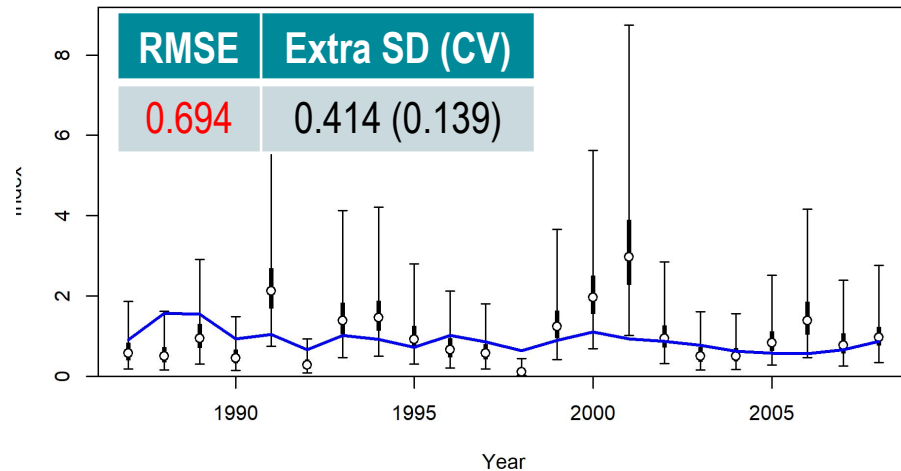


Indices of relative abundance

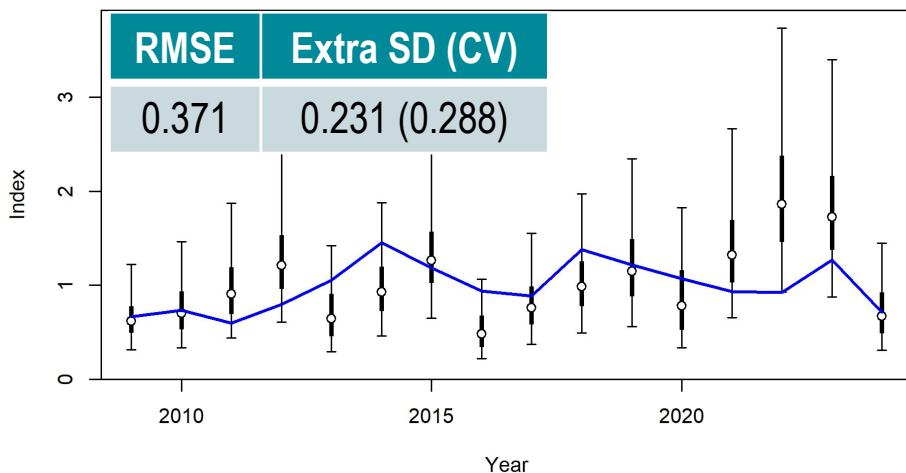
Recreational (SRHS) CPUE



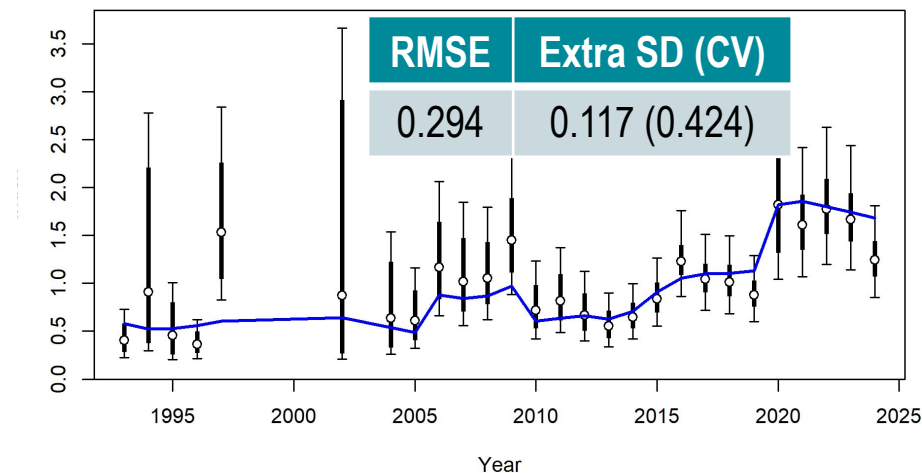
SEAMAP Trawl Early



SEAMAP Trawl Late

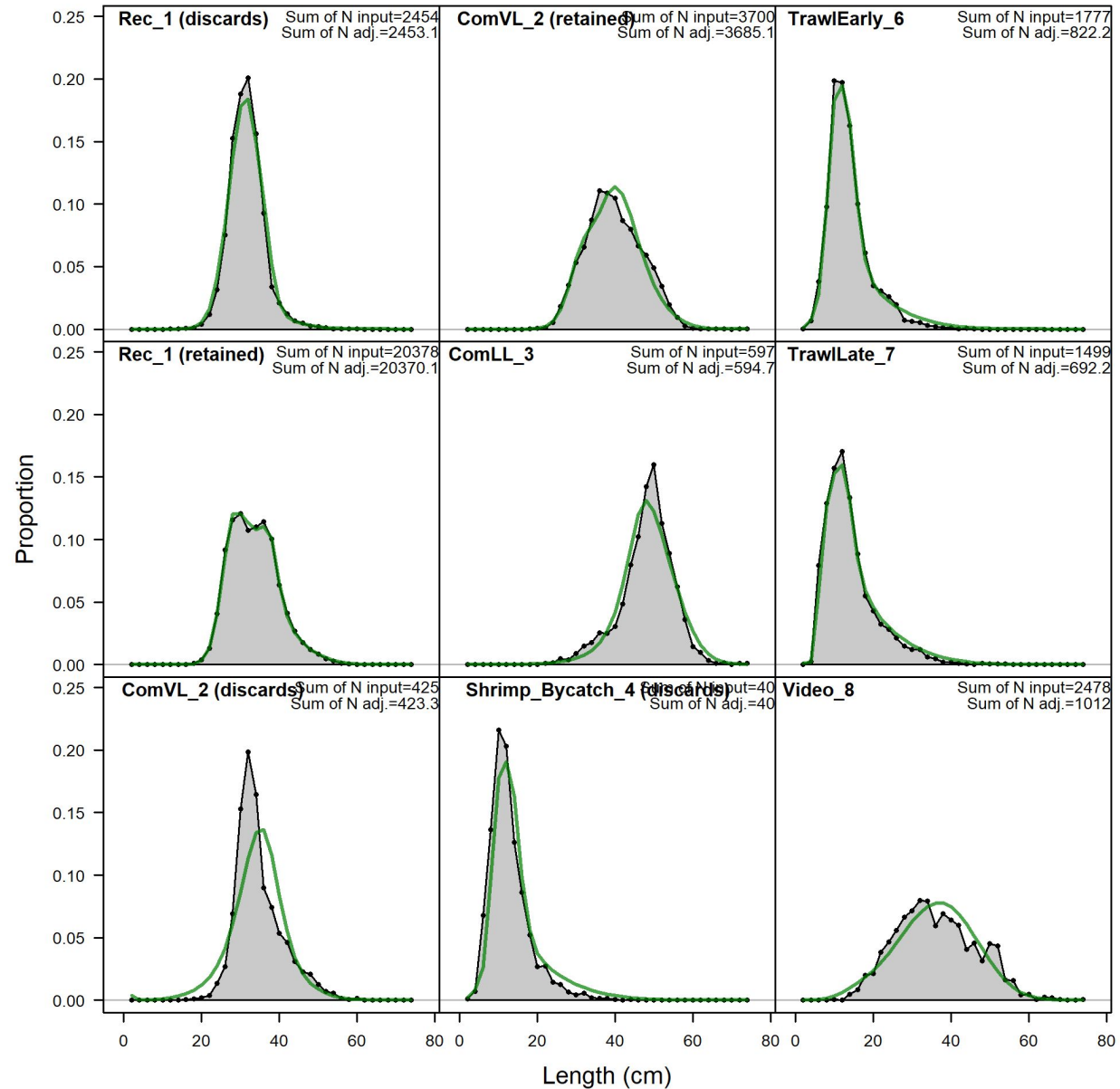


Combined Video



Fits to length comps

- Not fitting to the Shrimp Bycatch (proxy) length compositions



Estimated Dirichlet parameters

- Adjusted sample size converges to the input sample size at values > 5 (fishing fleet lengths)

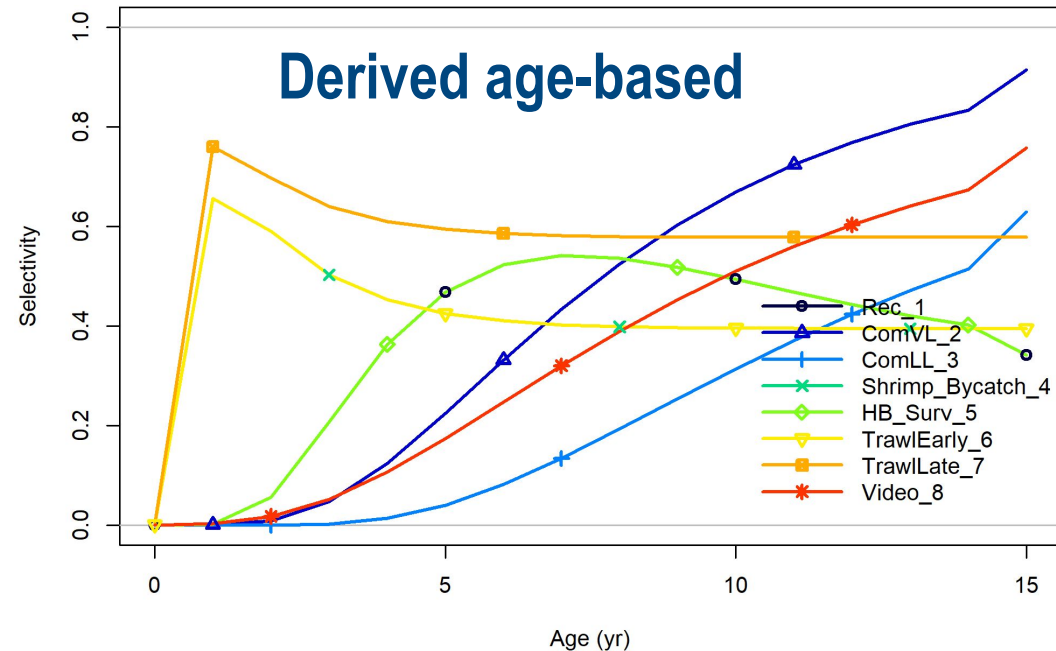
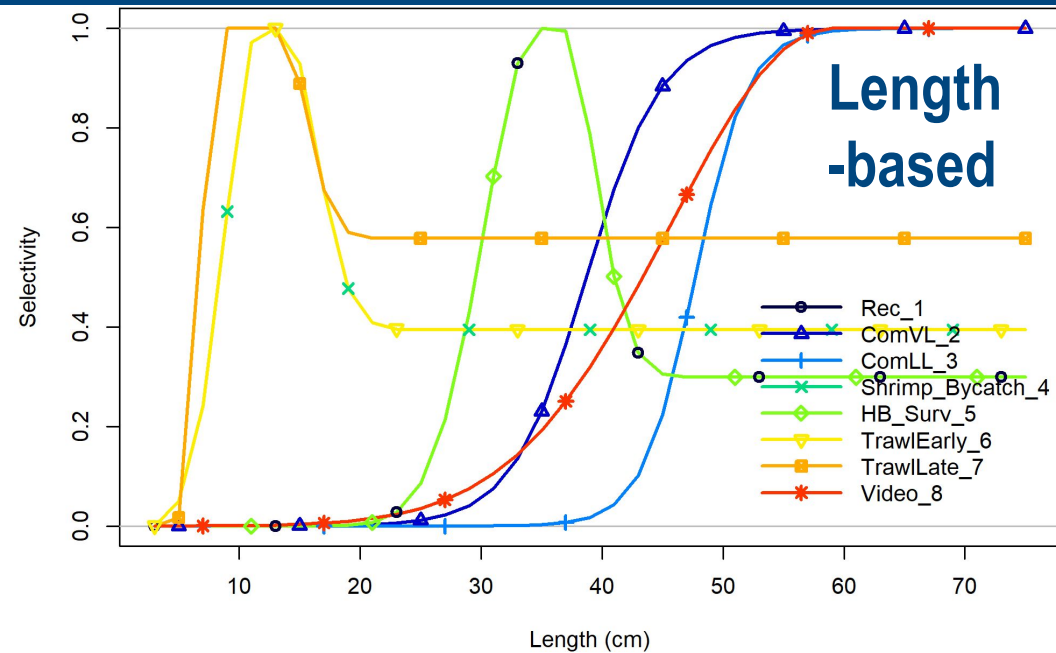
In(DM_theta)	Value (CV)
Recreational (length)	7.858 (0.112)
Commercial Vertical Line & Longline (length)	5.503 (0.137)
SEAMAP Trawl Early and Late (length)	-0.177 (0.606)
Combined Video Survey (length)	-0.394 (0.265)
Recreational (conditional age-at-length)	0.471 (0.221)
Commercial Vertical Line & Longline (conditional age-at-length)	0.503 (0.180)

- Sample sizes adjusted lower for survey length data and conditional age-at-length

Selectivity in 2024

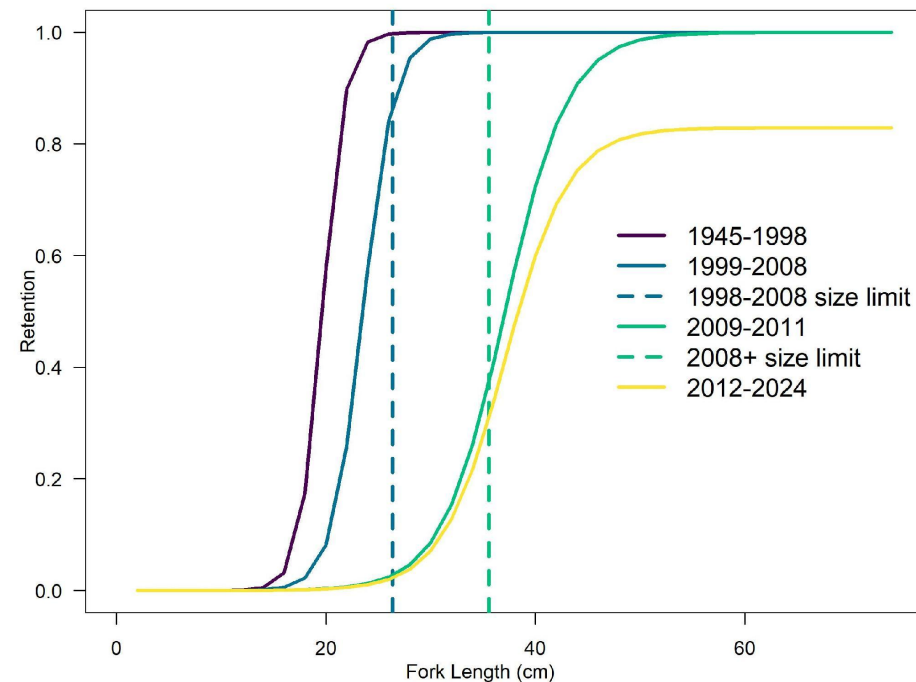
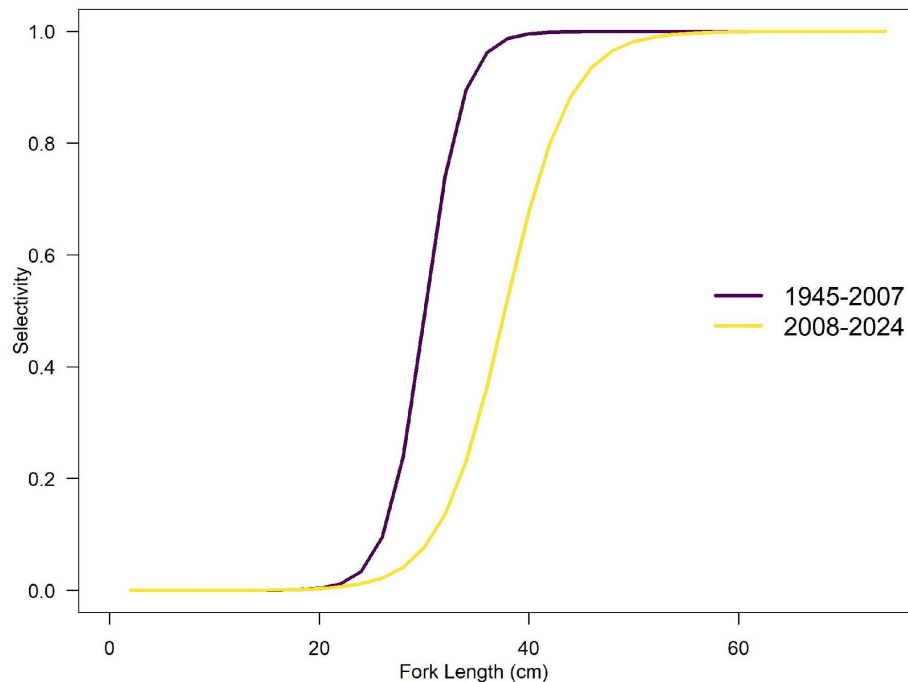
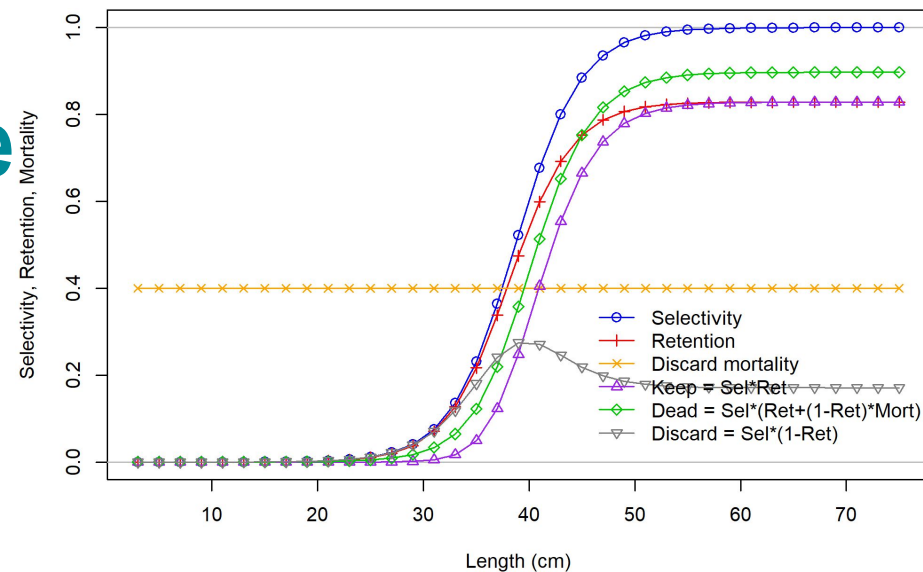
CV>1 in AP Model:

- Recreational
 - Top logit
- SEAMAP Trawl Early/
Shrimp Bycatch
 - Top logit
- Video
 - Top logit
 - Descending width



Commercial Vertical Line

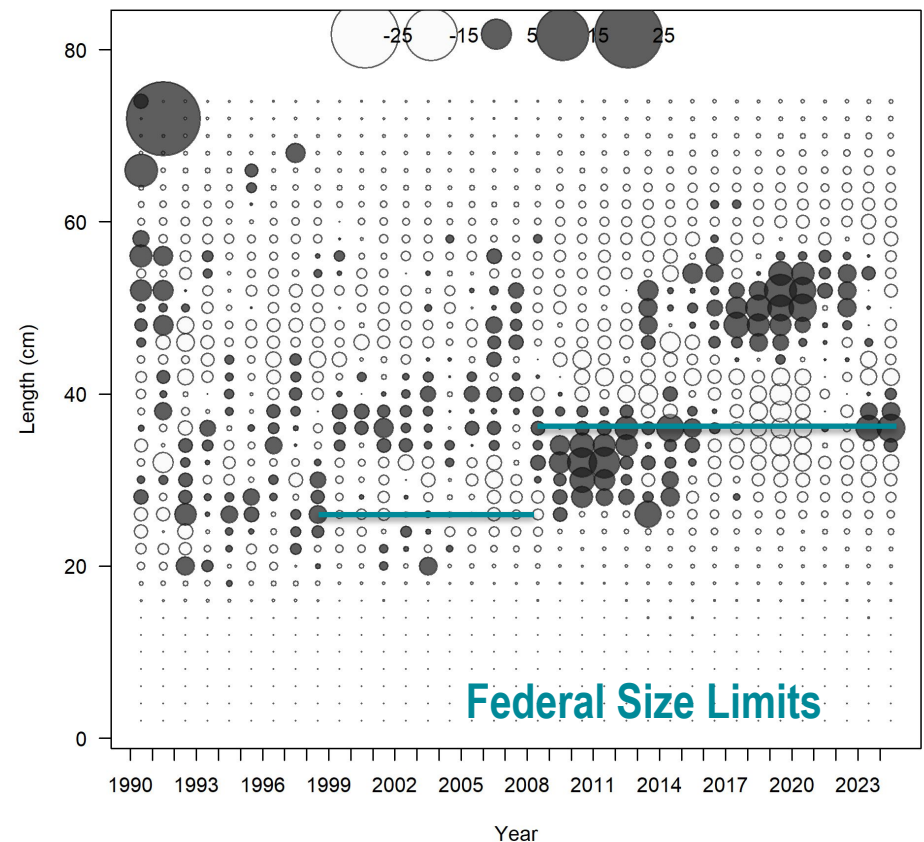
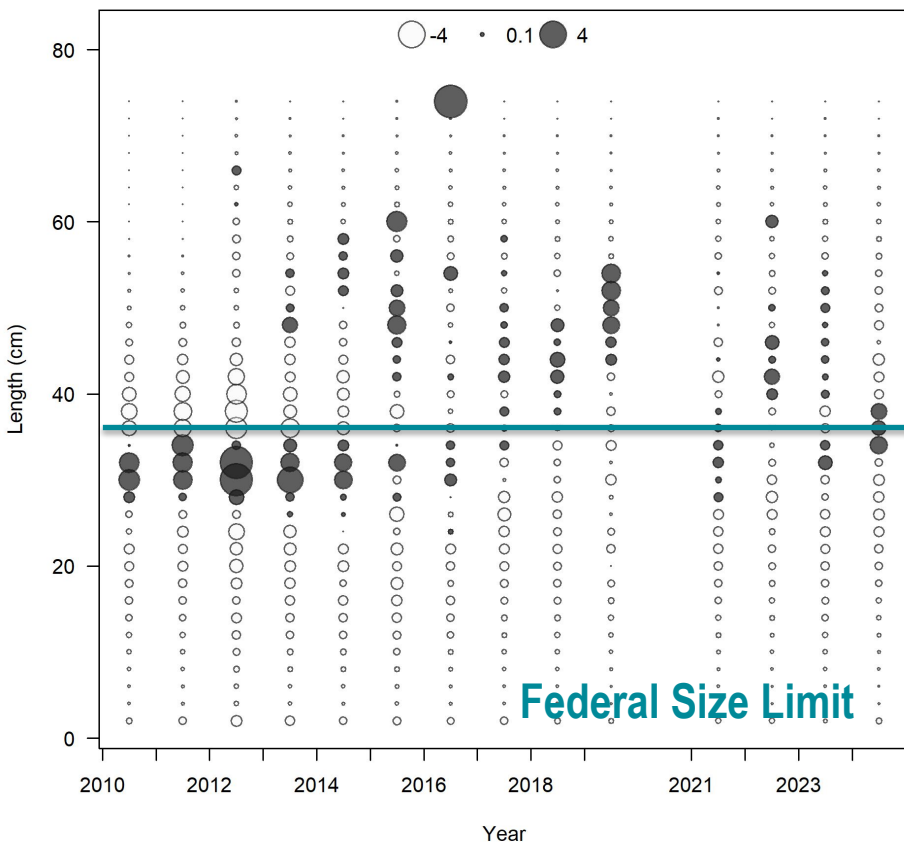
- No selectivity or retention parameters with $CV > 1$



Commercial Vertical Line

Closed = + (observed > expected)
Open = - (observed < expected)

- Larger residuals for retained compositions, patterns evident in residuals for both

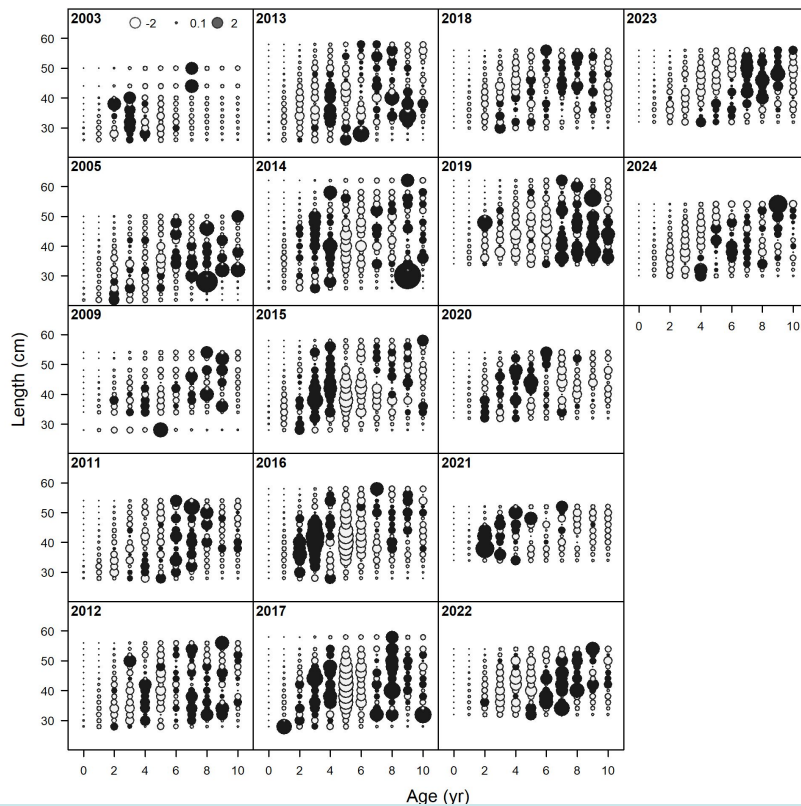


Commercial Vertical line

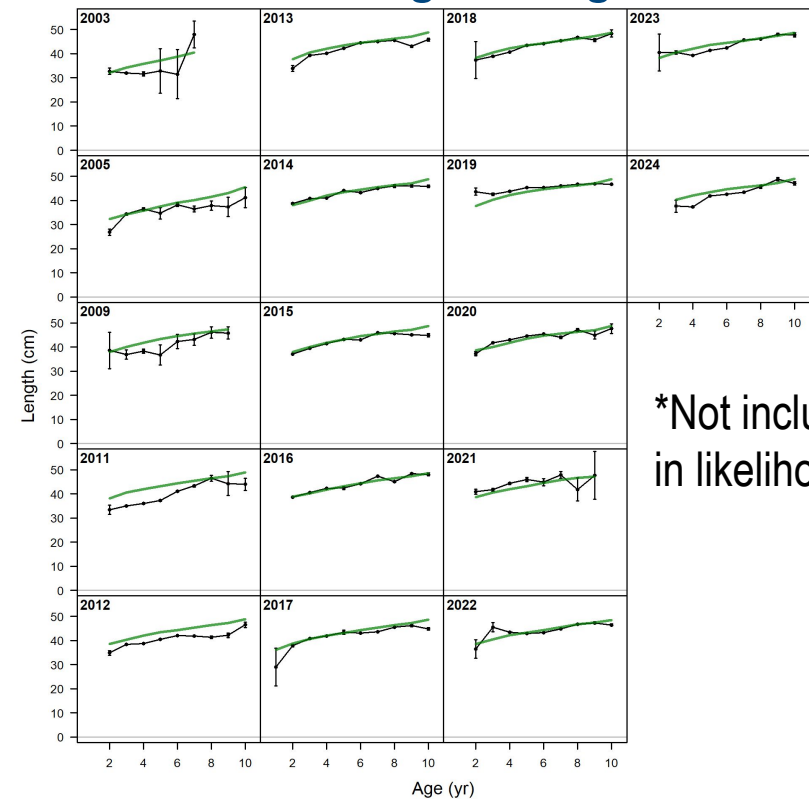
Closed = + (observed > expected)
Open = - (observed < expected)

- Conditional age-at-length residuals up to 11.34
- Expected mean length-at-age similar to observed data

Conditional age-at-length



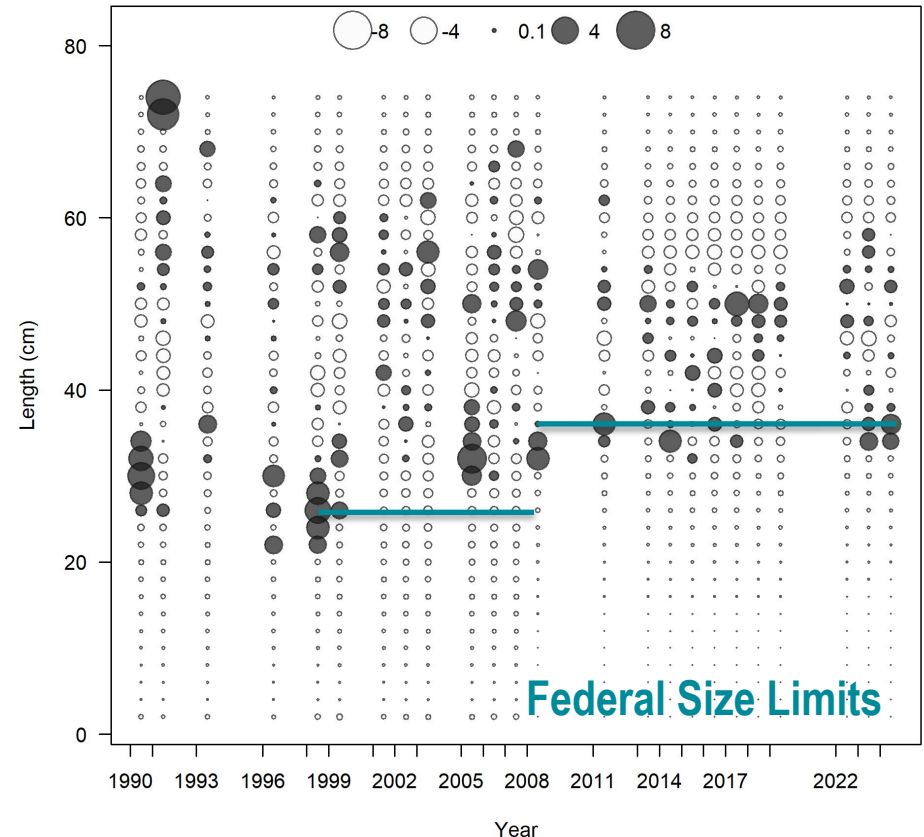
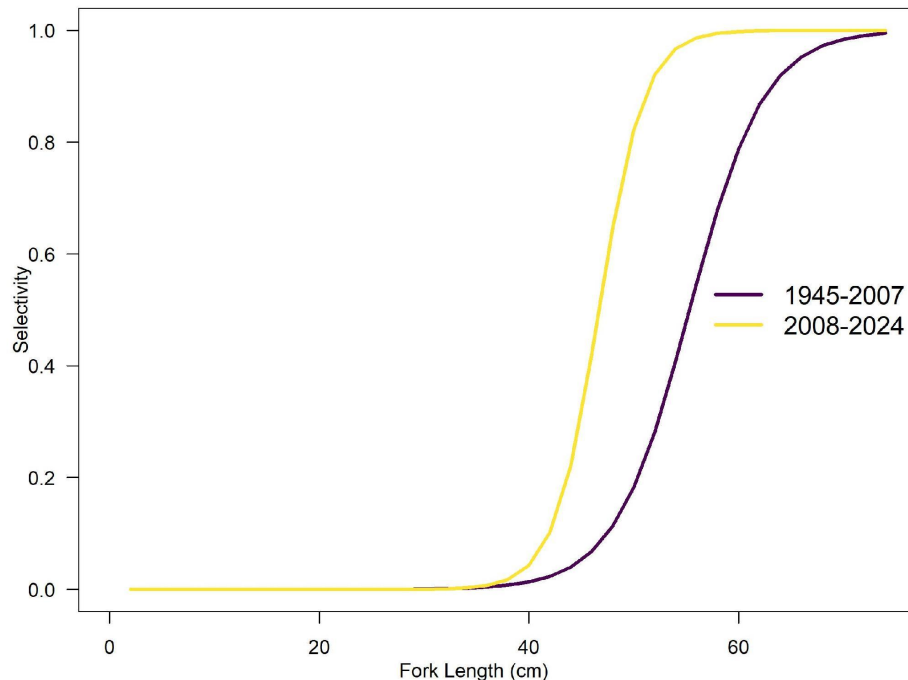
Mean length-at-age*



*Not included in likelihood

Commercial Longline

- No selectivity parameters with $CV > 1$
- No strong patterns in the residuals for retained composition



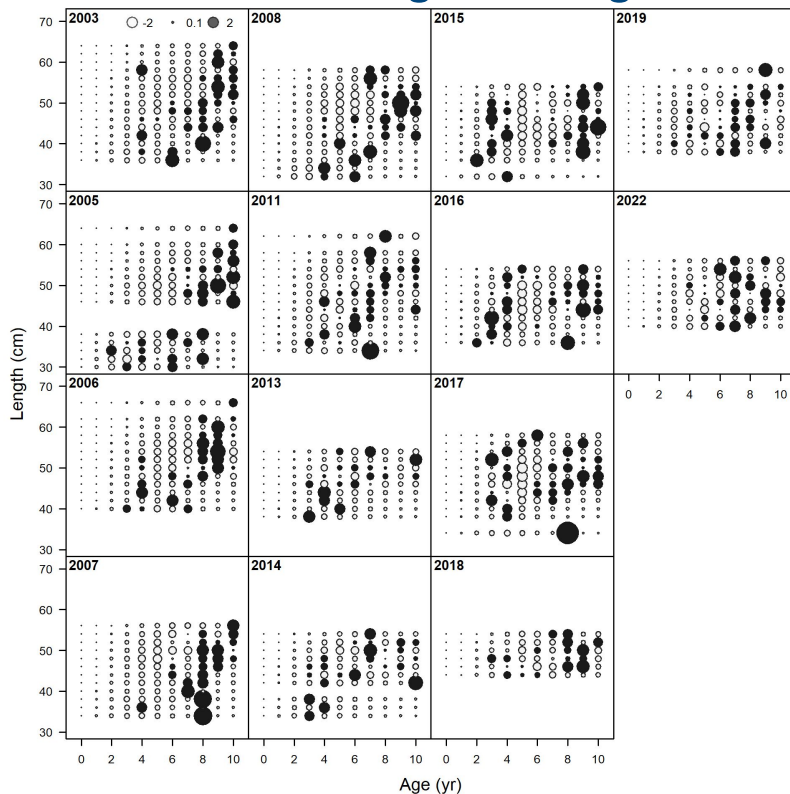
Closed = + (observed > expected)
Open = - (observed < expected)

Closed = + (observed > expected)
Open = - (observed < expected)

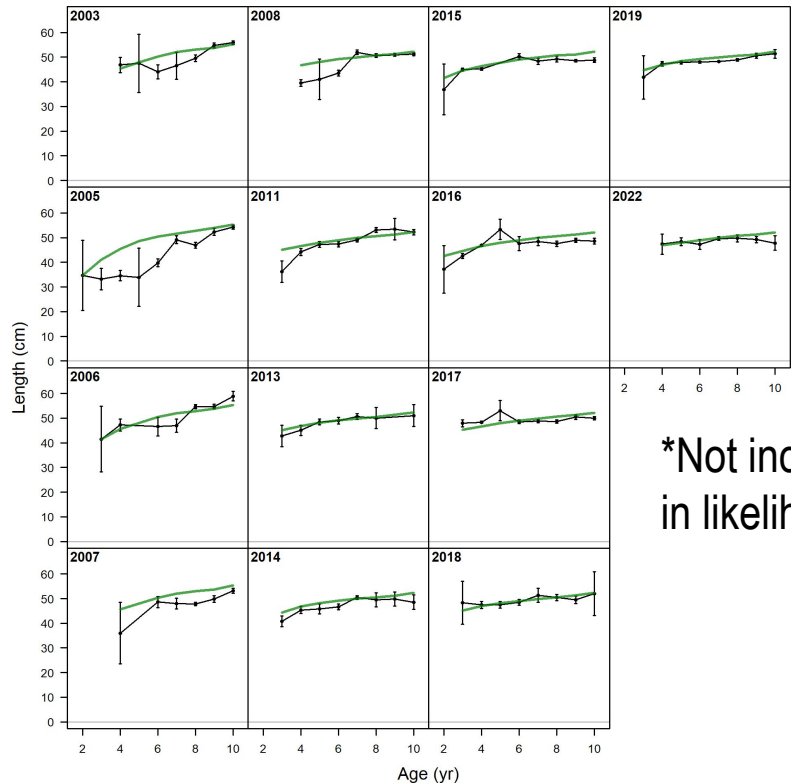
Commercial Longline

- Conditional age-at-length residuals up to 8.01
- Expected mean length-at-age similar to observed data

Conditional age-at-length



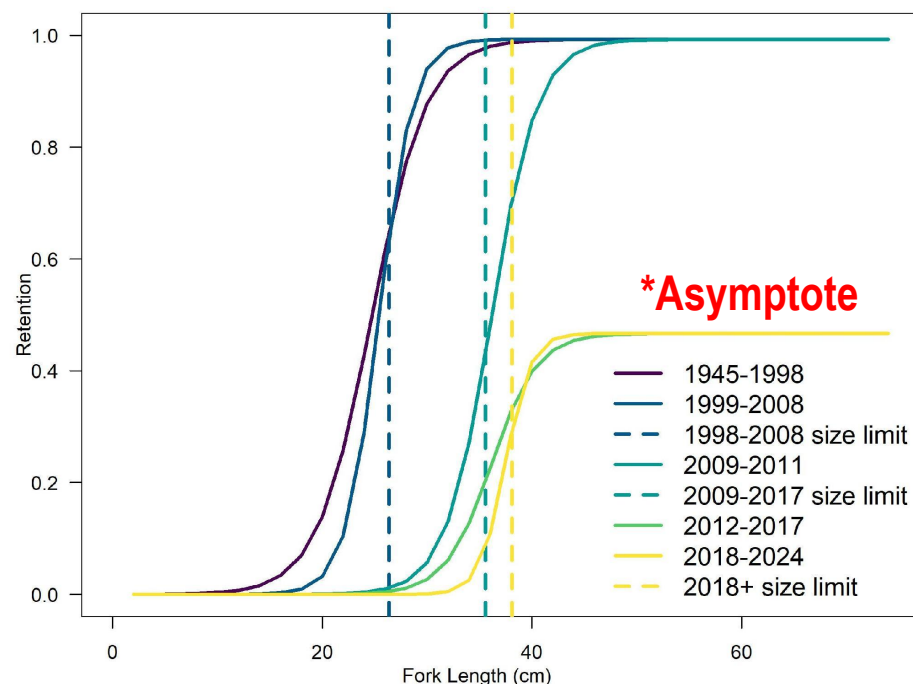
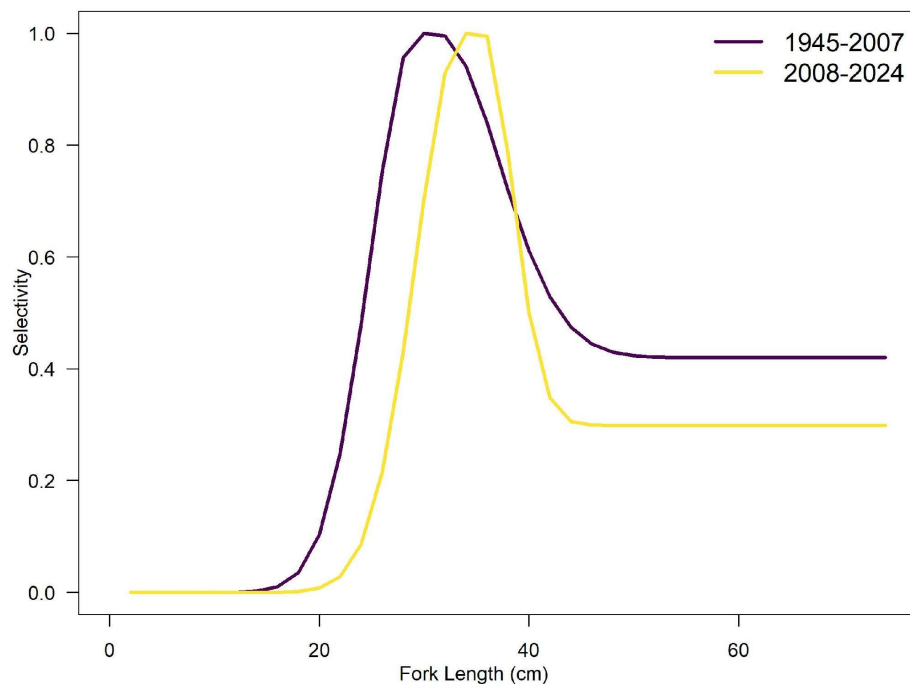
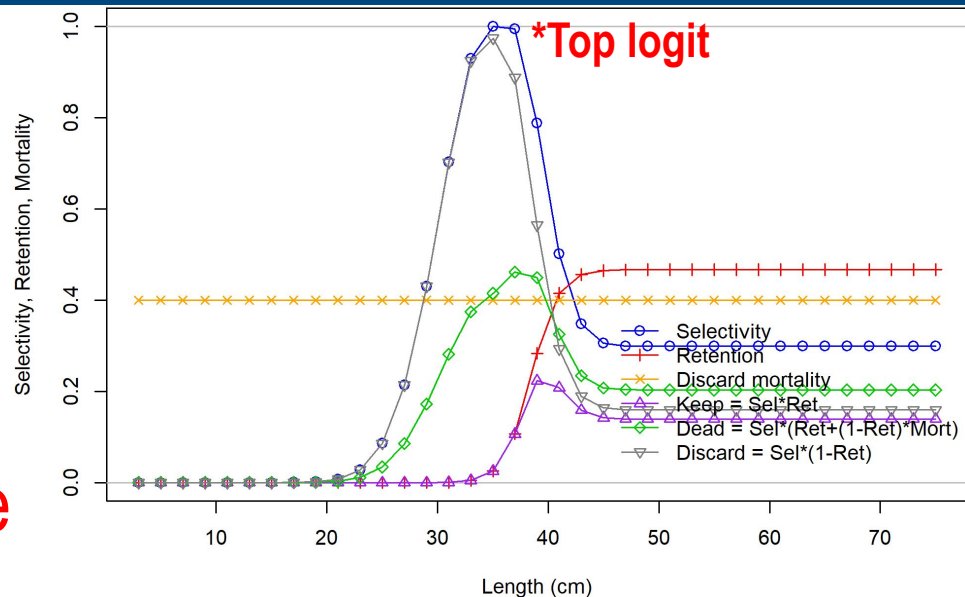
*Mean length-at-age



*Not included
in likelihood

Recreational

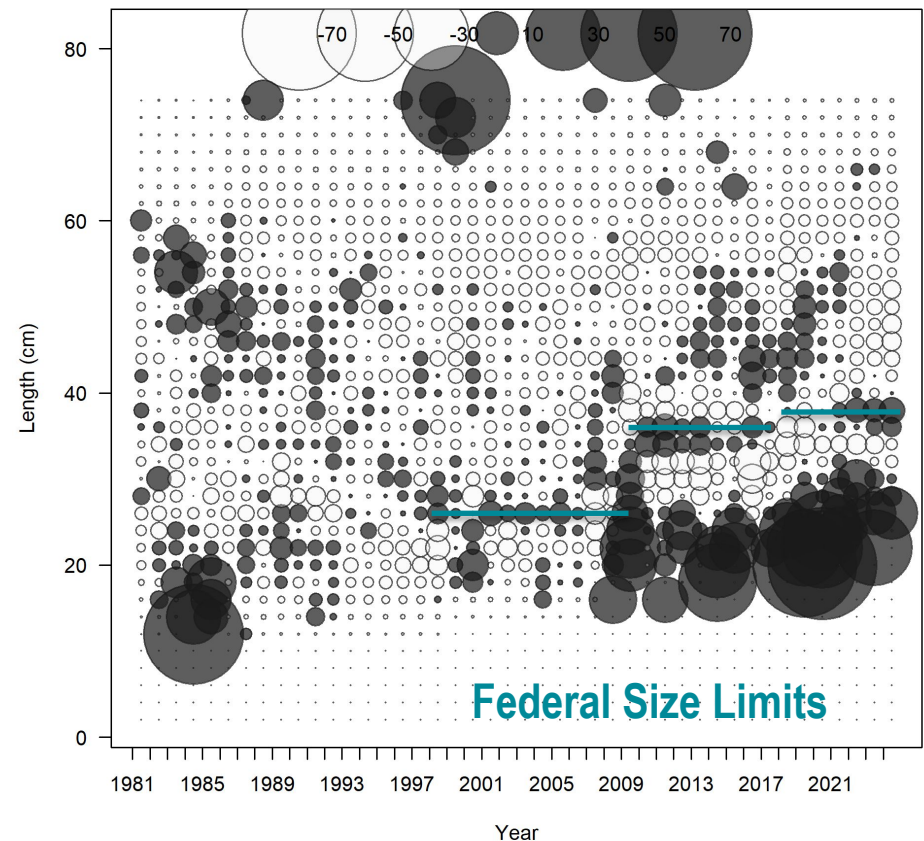
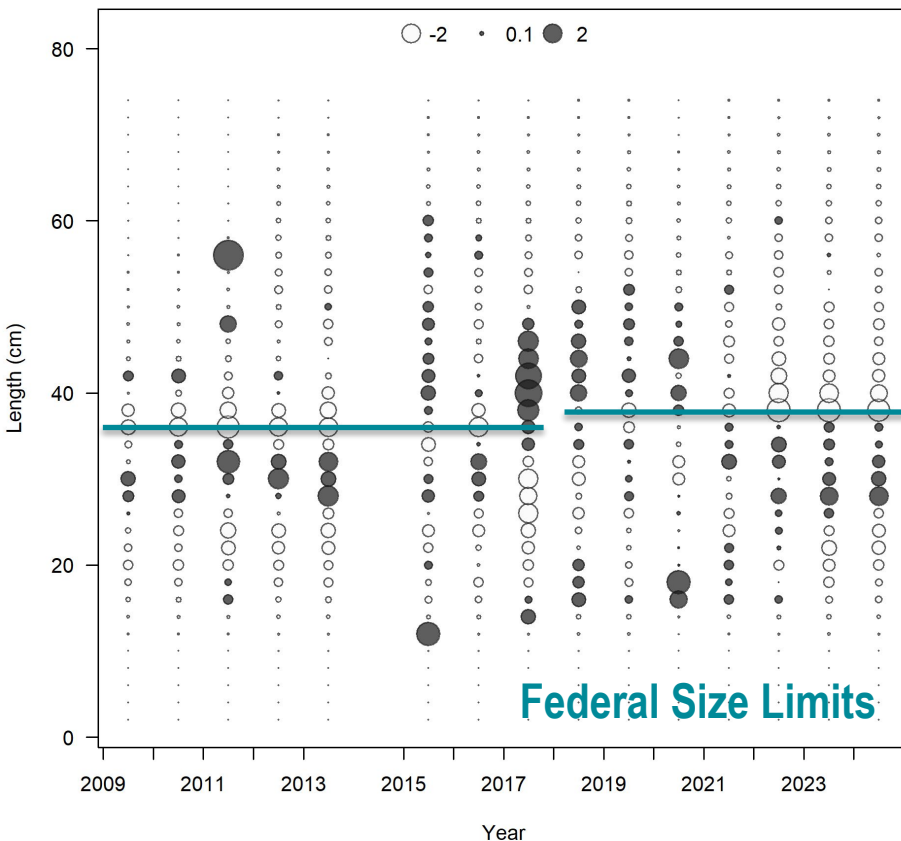
- Selectivity parameters with $CV > 1$: **top logit**
- 2012-2024 block: **asymptote**
 $CV > 1$



Recreational

- Much larger residuals and patterns evident for retained compositions

Closed = + (observed > expected)
Open = - (observed < expected)

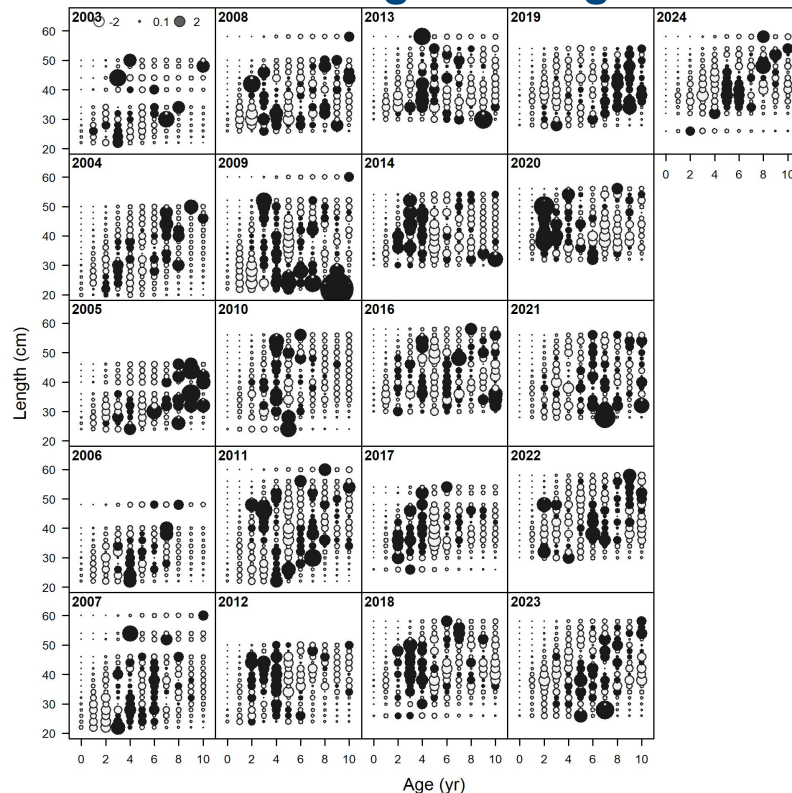


Recreational

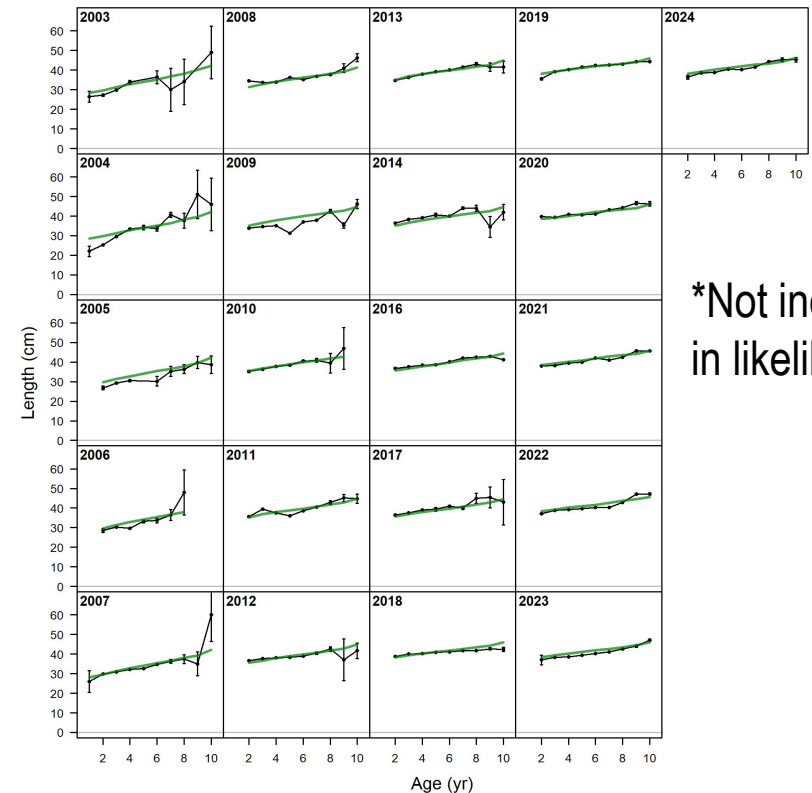
Closed = + (observed > expected)
Open = - (observed < expected)

- Conditional age-at-length residuals up to 18.44
- Expected mean length-at-age similar to observed data

Conditional age-at-length



*Mean length-at-age

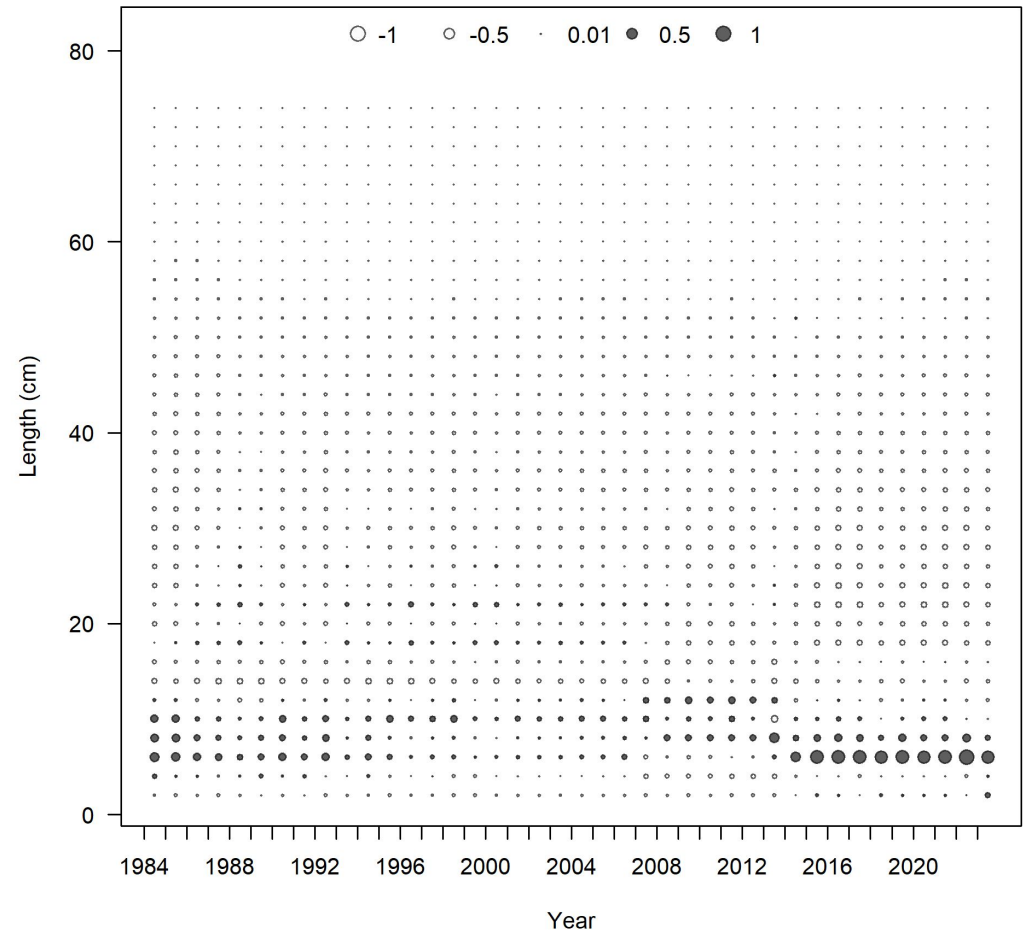


*Not included
in likelihood

Shrimp bycatch

- Not fitting to proxy length compositions for the Shrimp bycatch fleet, but overall residuals remain low
 - Slight pattern since 2015 of observing more 6 cm FL fish

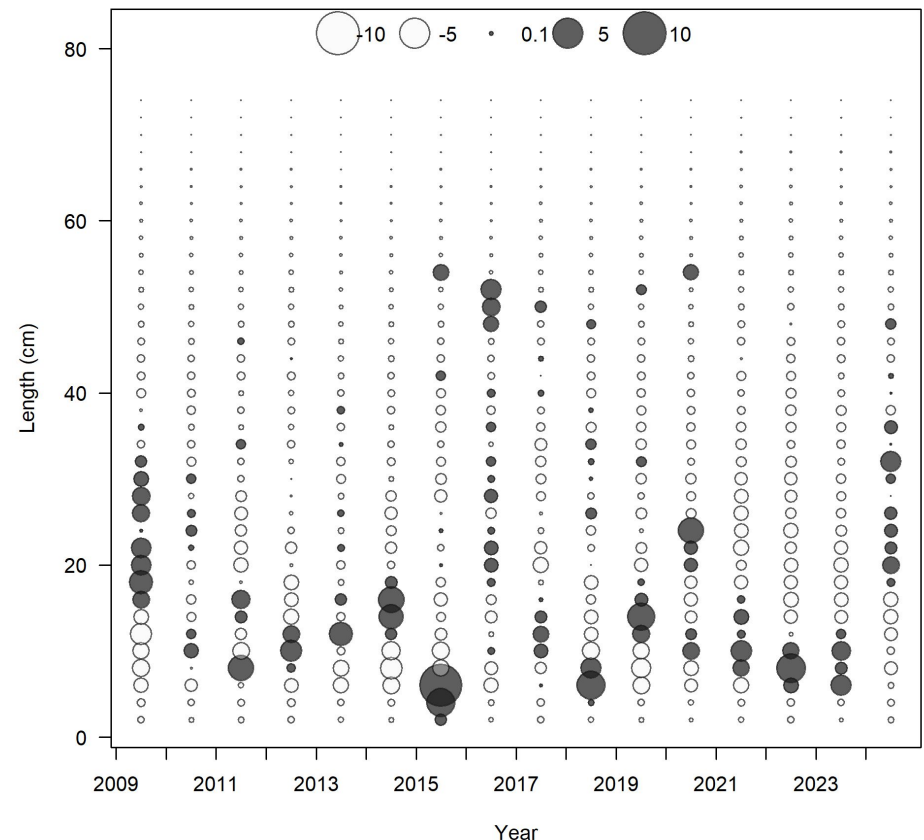
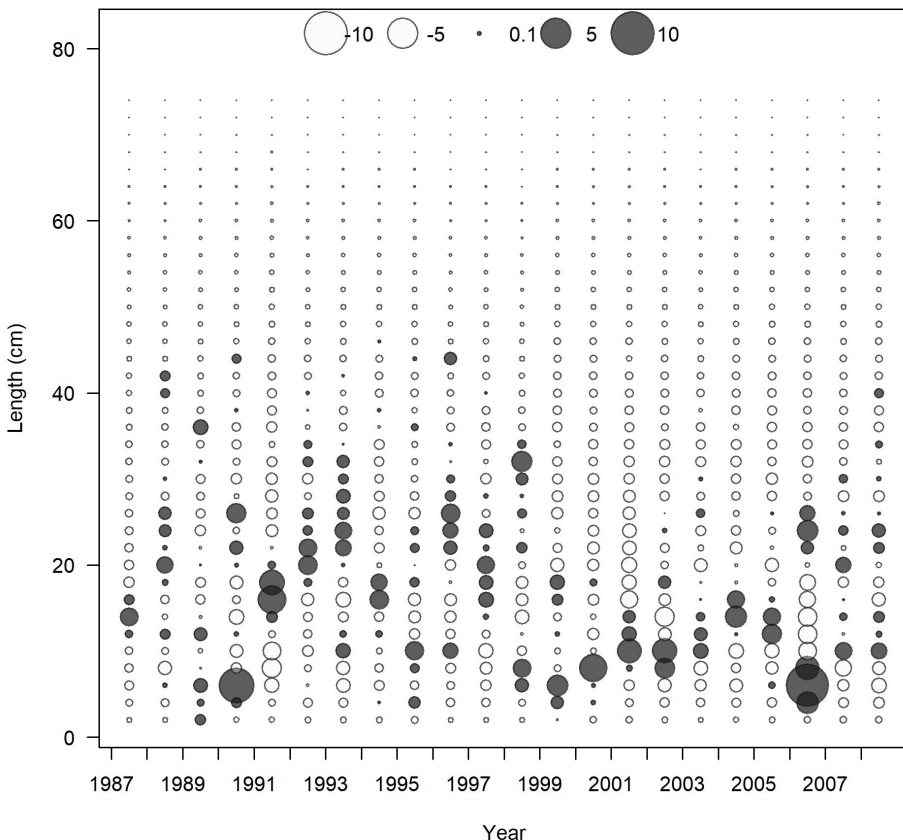
Closed = + (observed > expected)
Open = - (observed < expected)



SEAMAP Trawl Survey

Closed = + (observed > expected)
Open = - (observed < expected)

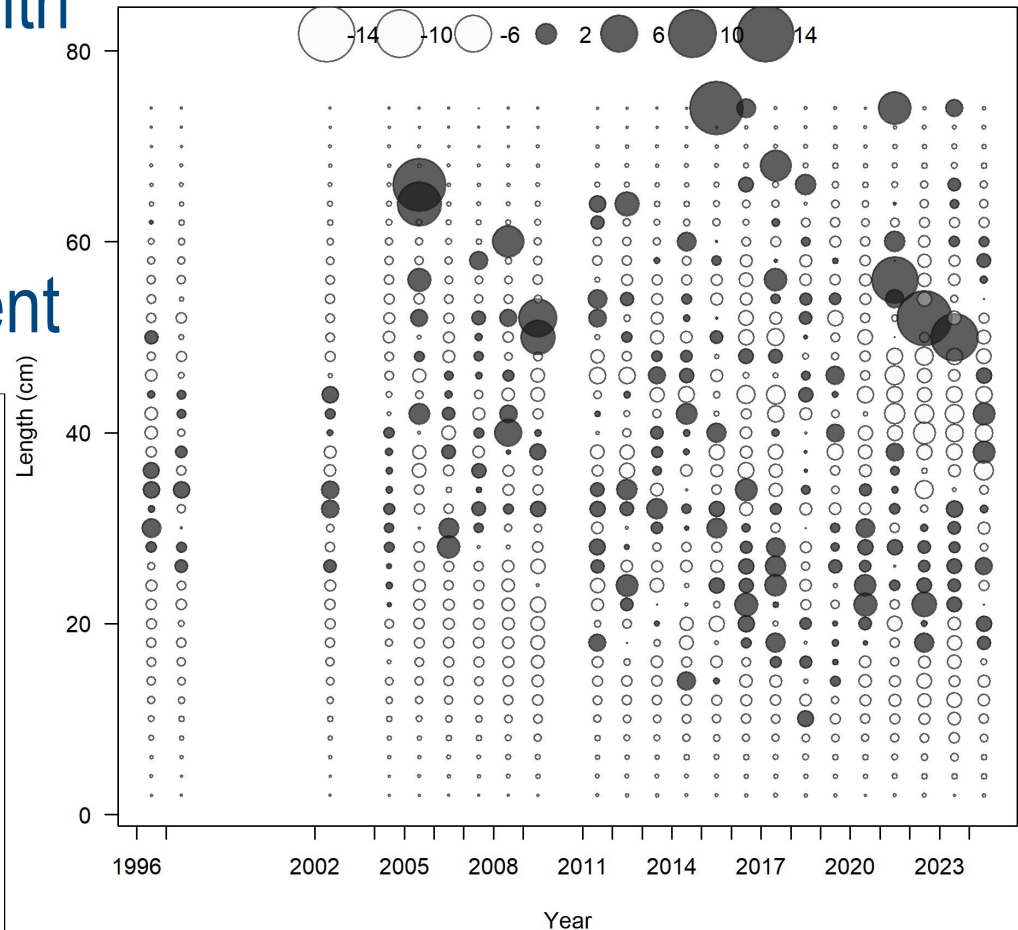
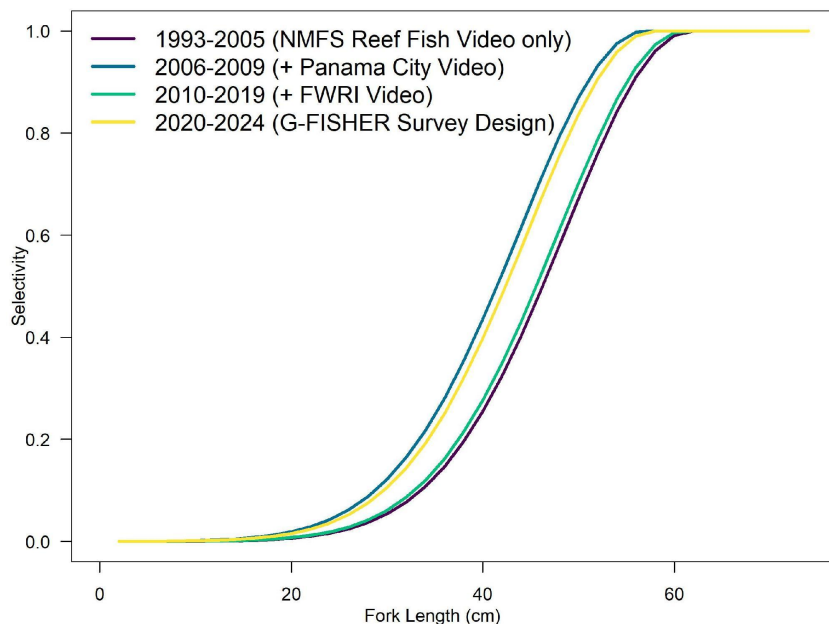
- Selectivity parameters with CV > 1: **top logit**
- No strong patterns evident in residuals



Combined Video Survey

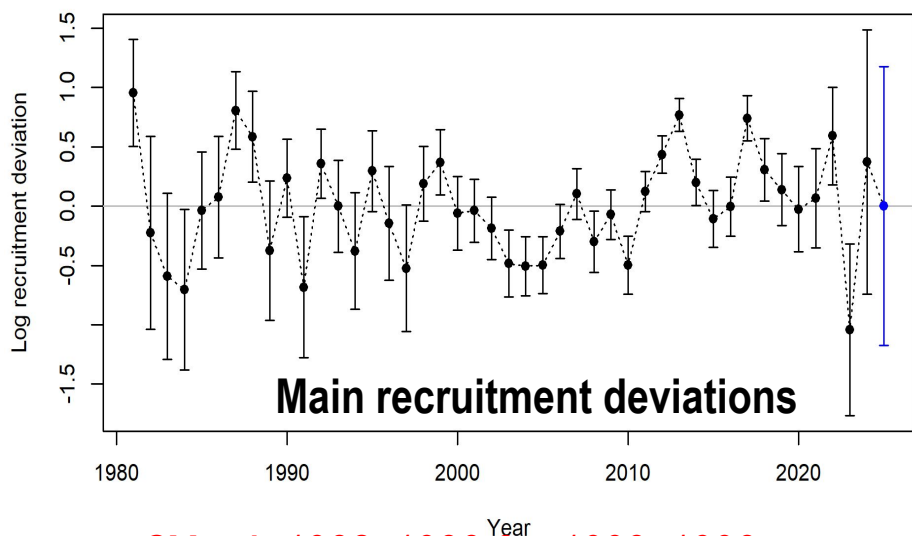
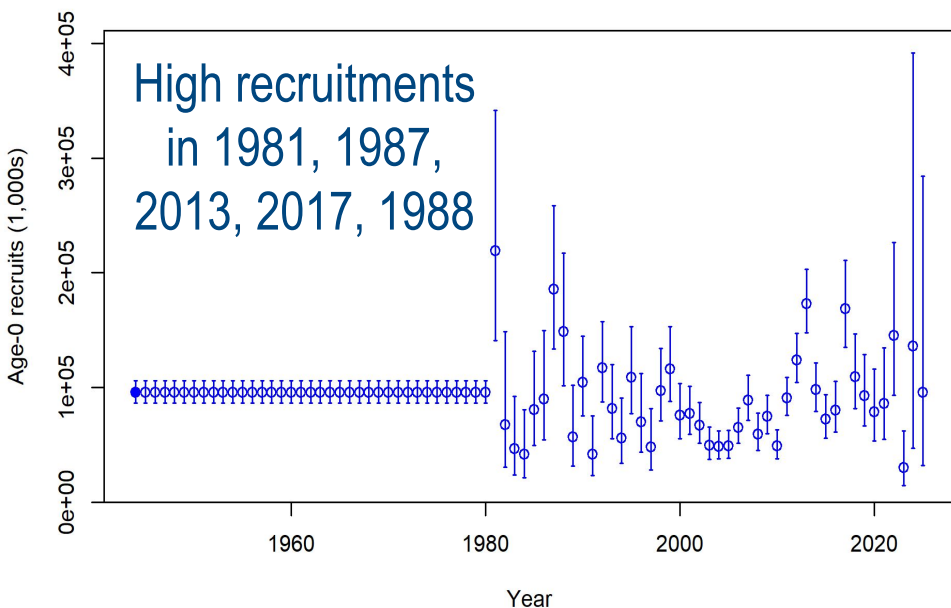
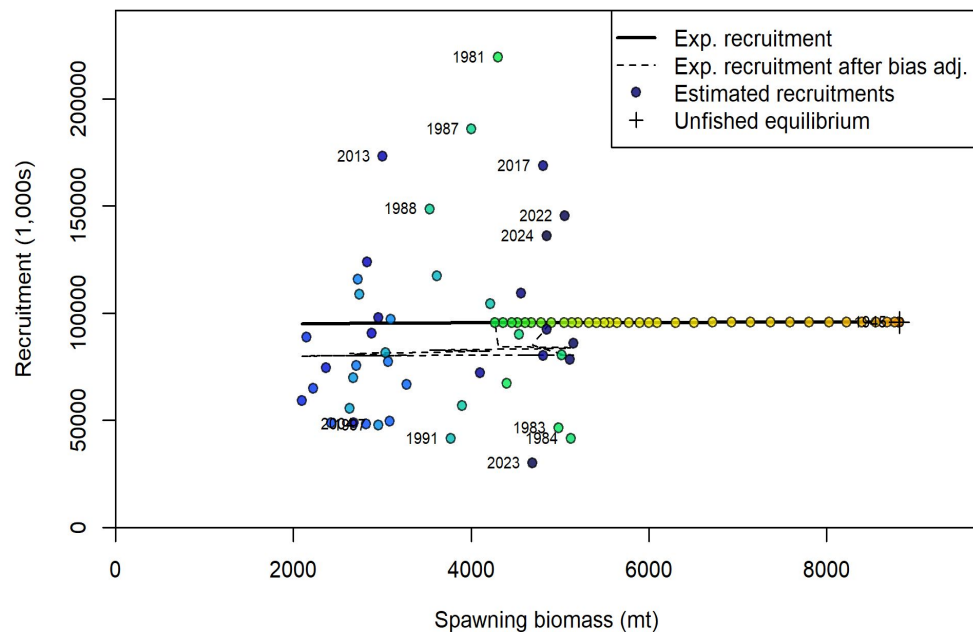
- Selectivity parameters with $CV > 1$: **top logit & descending width**
- No strong patterns evident

Closed = + (observed > expected)
Open = - (observed < expected)



Recruitment

Parameter	Value (CV)
$\ln(R_0)$	11.469 (0.004)
R_0	95,740,000
Steepness	0.99 (NA)
$\text{Sigma}R$	0.6 (NA)

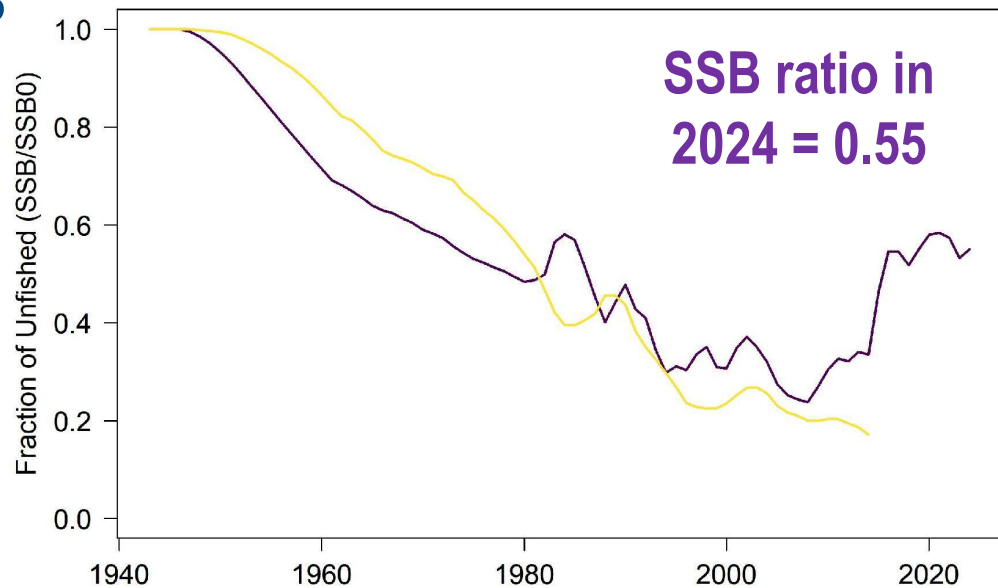
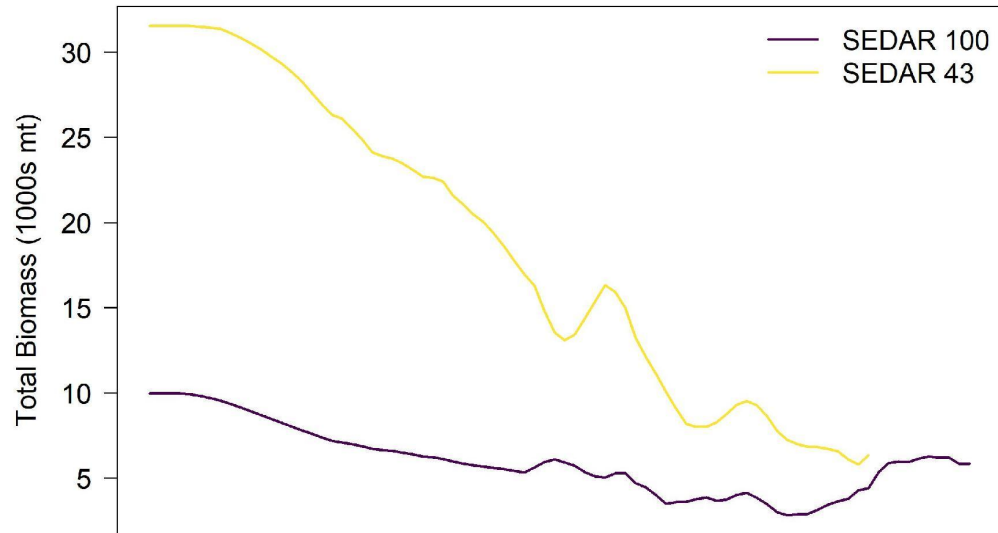
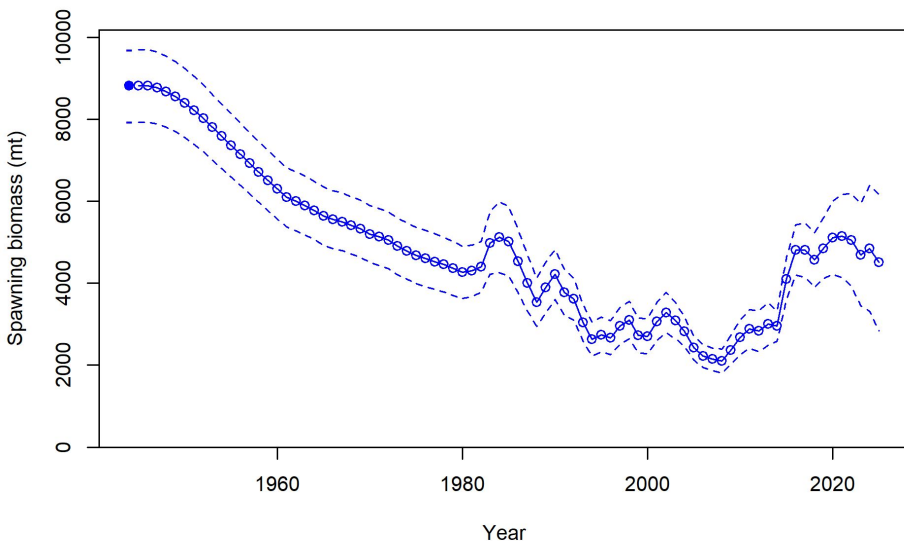


CV > 1: 1982, 1986-85, 1993, 1996, 2000-01, 2007, 2009, 2015-16, 2019-21, 2024



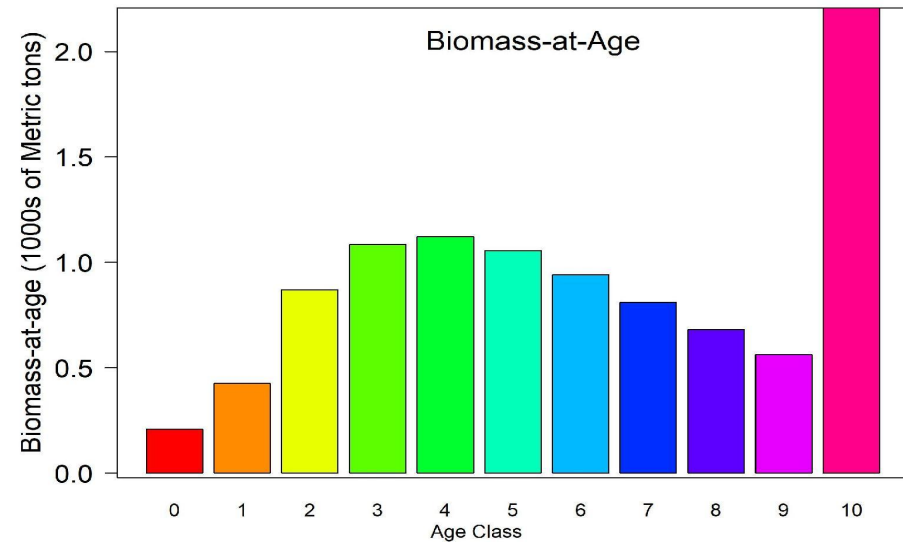
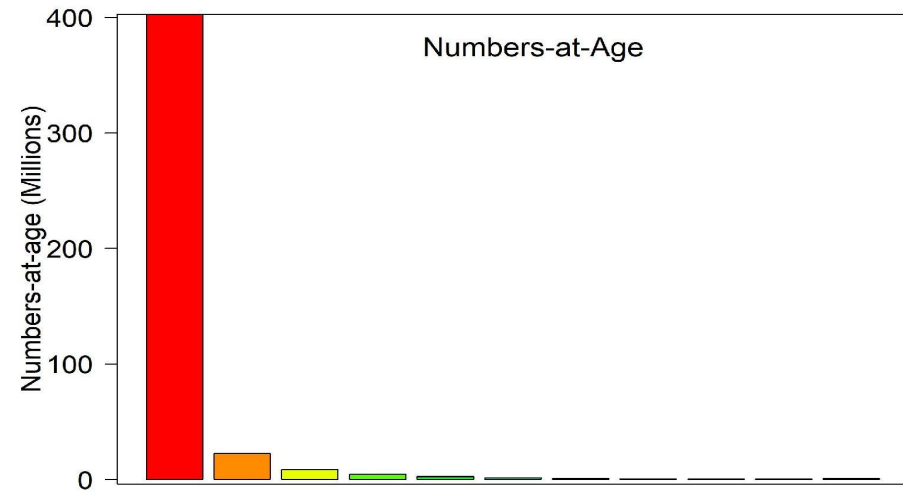
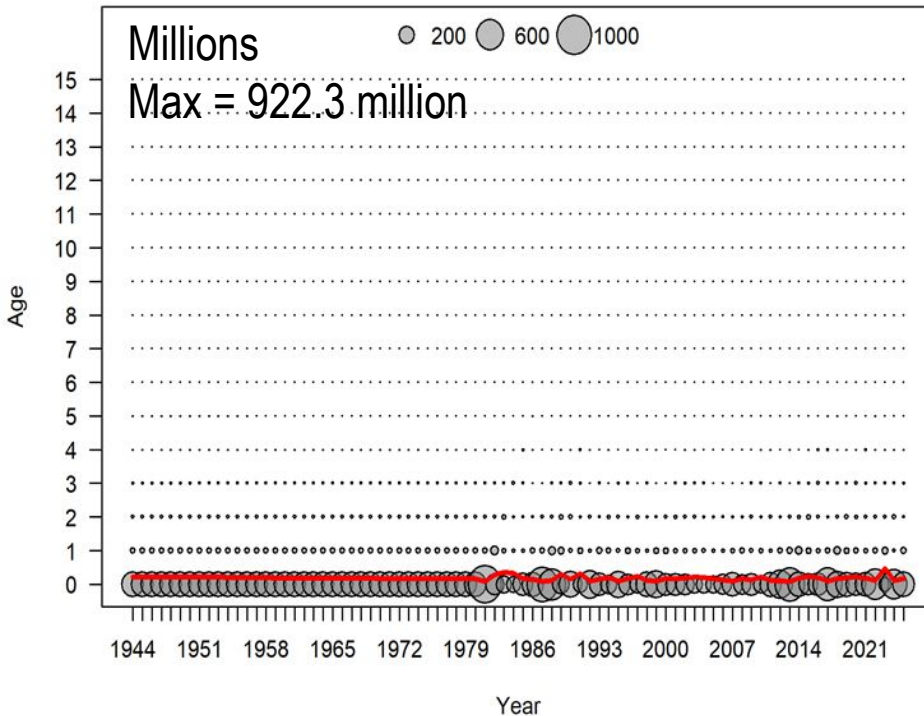
Biomass

- Declined gradually until early 1980s, then declined further throughout the 1990s and 2000s
- Recent levels around 1980s



Numbers-at-age

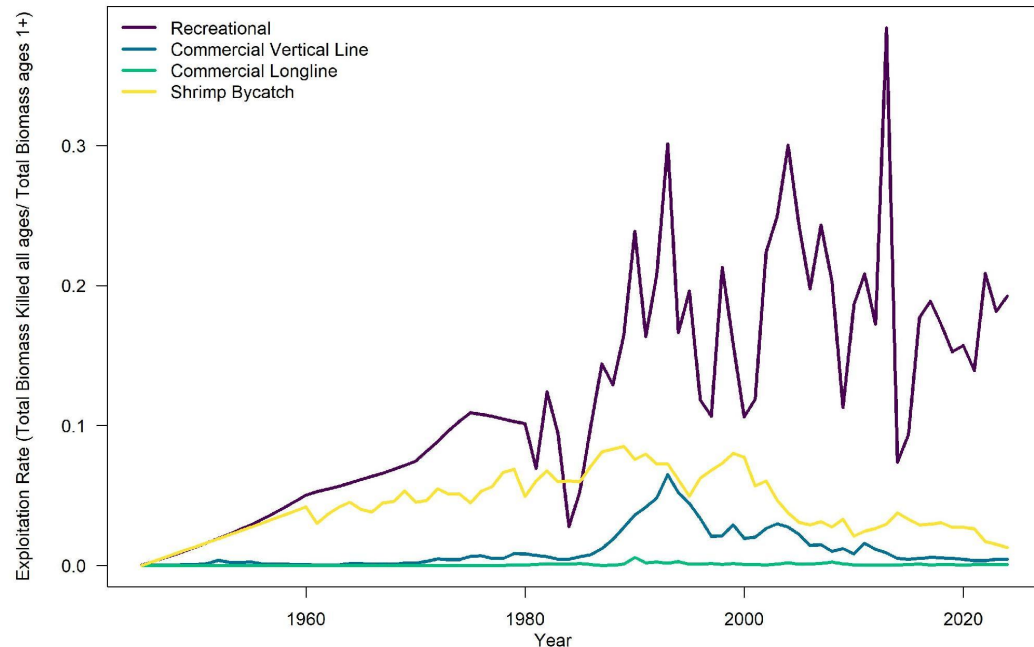
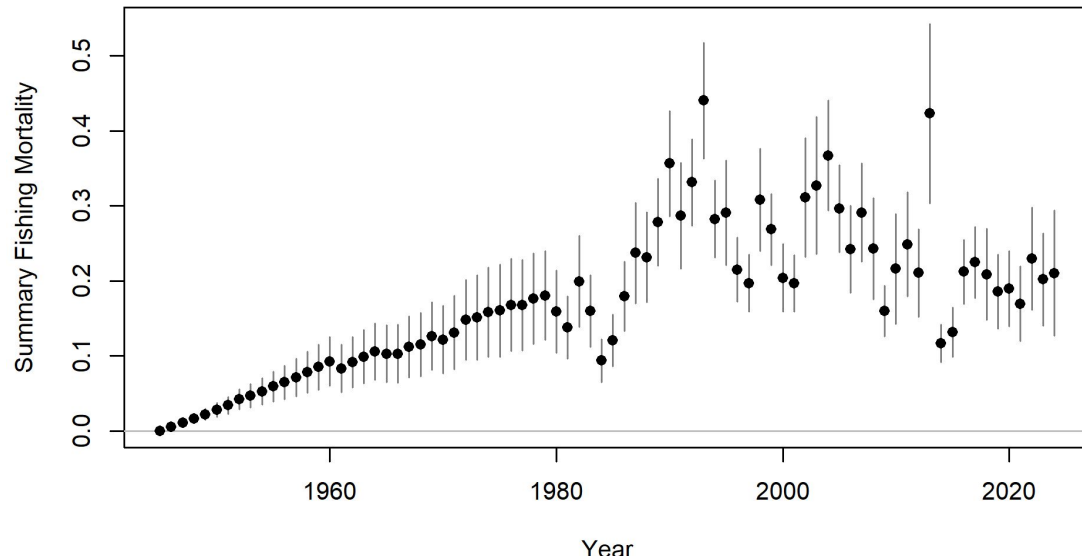
- Average age ~ 0.5 years
- Strong recruitment pulses throughout the time series



Virgin stock condition

Fishing Mortality

- Exploitation highest in 1993 and 2013, largely due to the Recreational fleet
 - Shrimp bycatch has declined considerably in recent years due to economics
 - Commercial exploitation has remained low



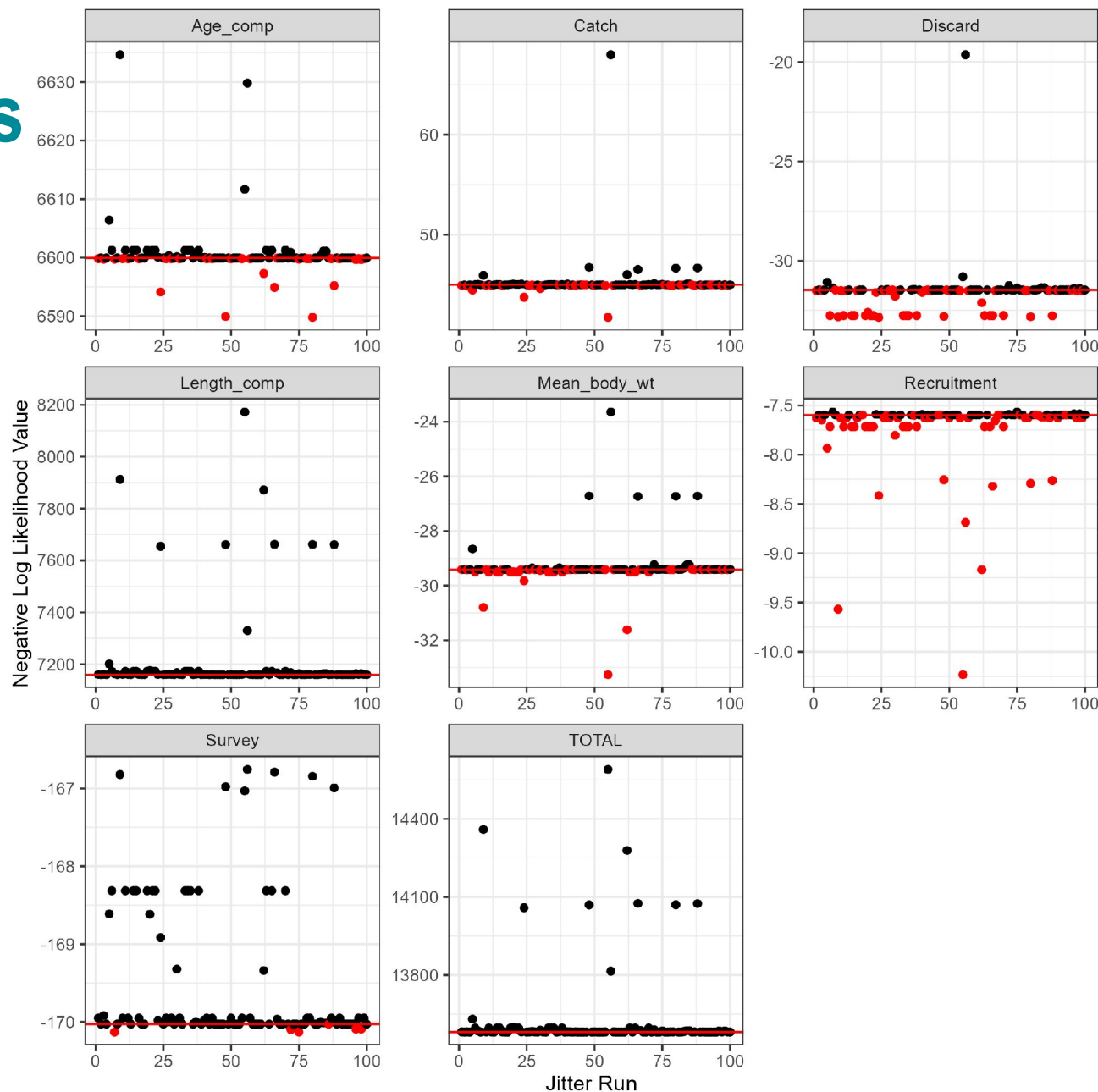
Outline

- Data Review
 - Stock definition
 - Assessment history
 - Regulations
 - Key data decisions
 - Life history
 - Removals
 - Size compositions
 - Age compositions
 - Indices of abundance
 - Survey length composition
- Assessment model
 - Model building
 - AP Model configuration
 - AP Model results
 - **AP Model diagnostics**
 - AP Model sensitivities
 - AP Model projections

Jitter analysis

- No runs revealed a lower NLL than the AP model
- Of 100 runs:

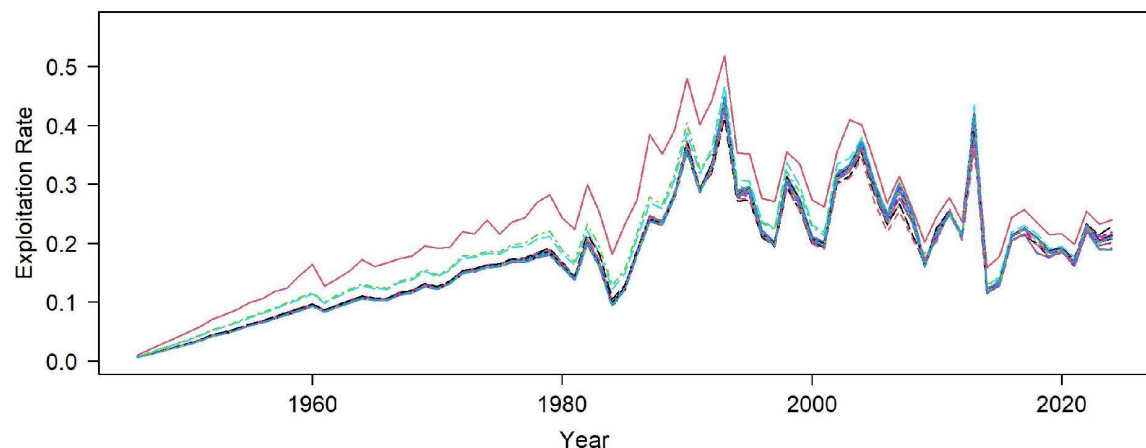
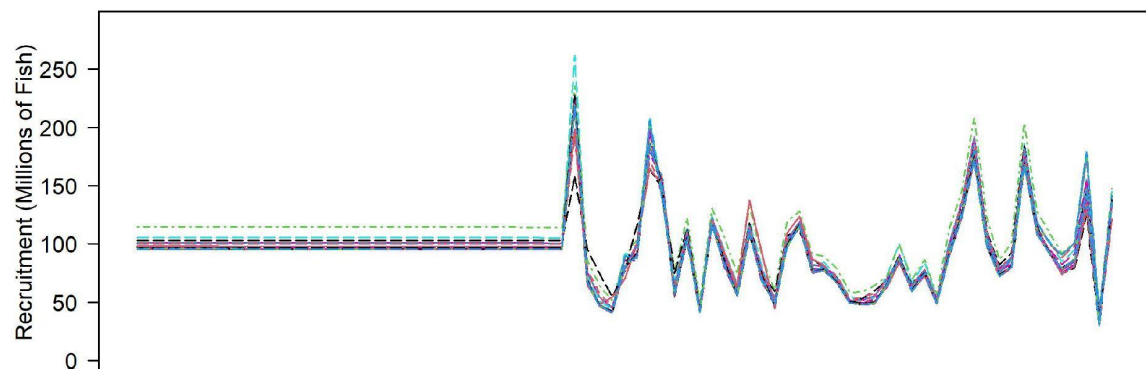
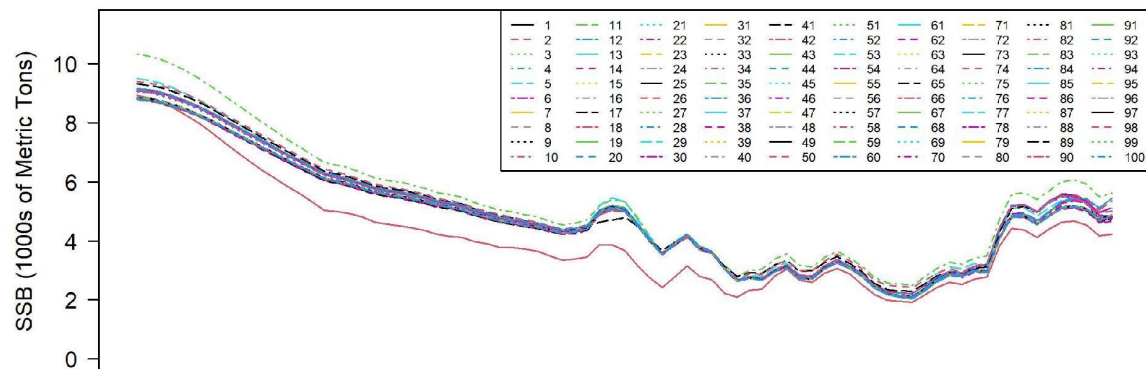
Results	Percent
Same NLL	42
Within 1 NLL	63
Within 5 NLL	70
Within 10 NLL	75
Within 25 NLL	90



Jitter analysis

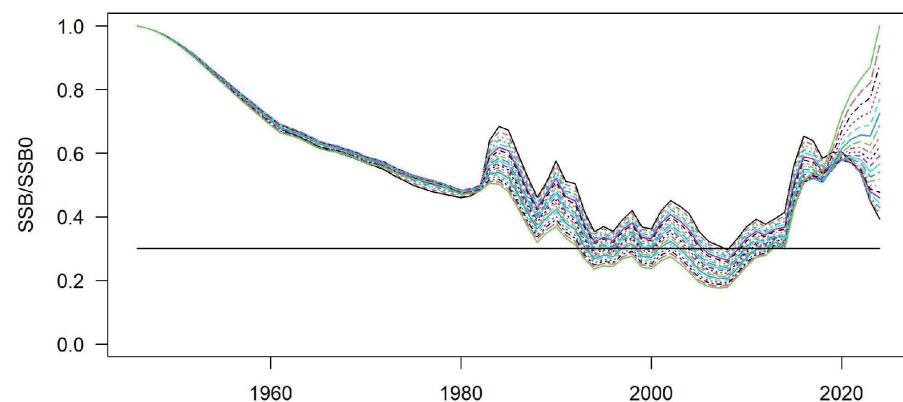
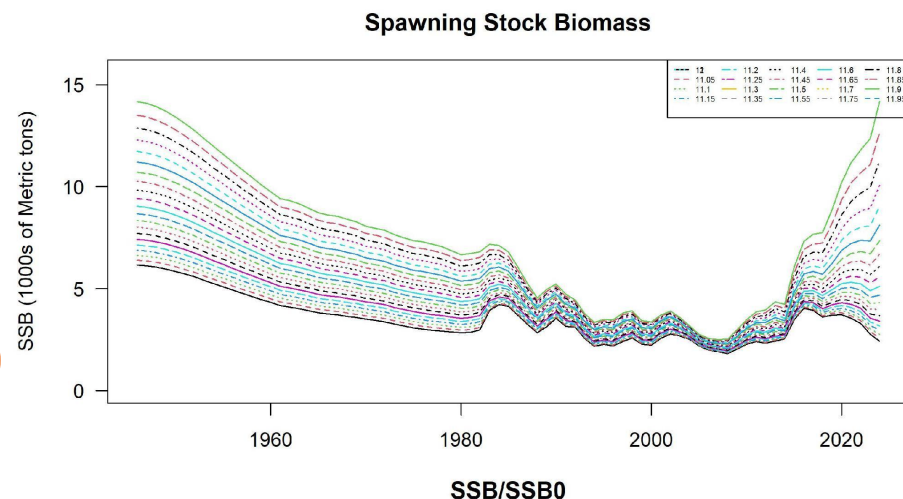
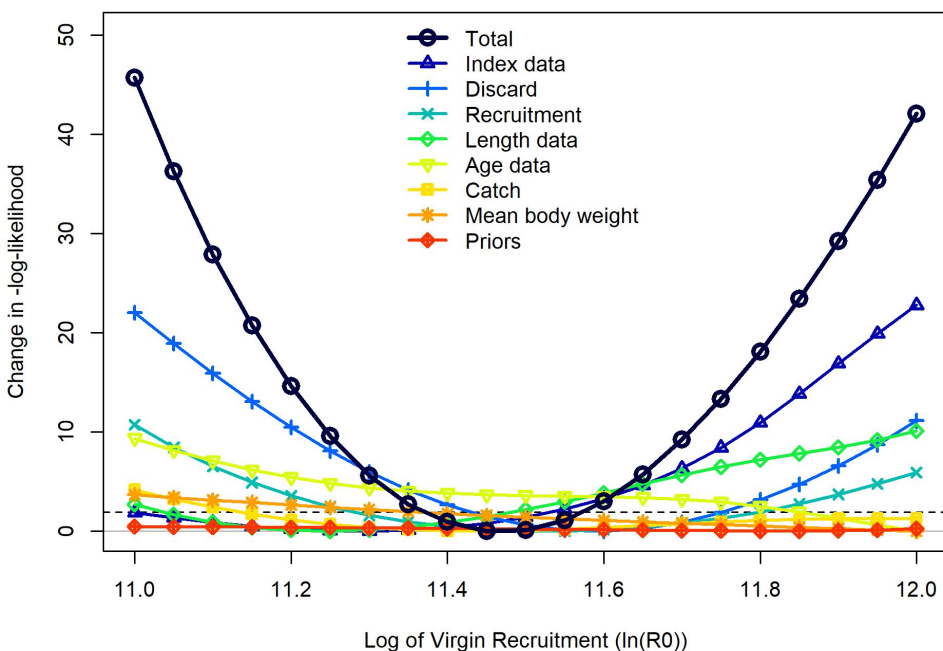
- Majority of runs result in similar trends
- A few runs had very high gradients (i.e., lack of convergence)

Run #	Gradient	NLL
56	4413.36	13814.9
9	397.694	14359.2
3	31.2384	13582.1
30	13.3741	13589.3



Likelihood profile: $\ln(R_0)$

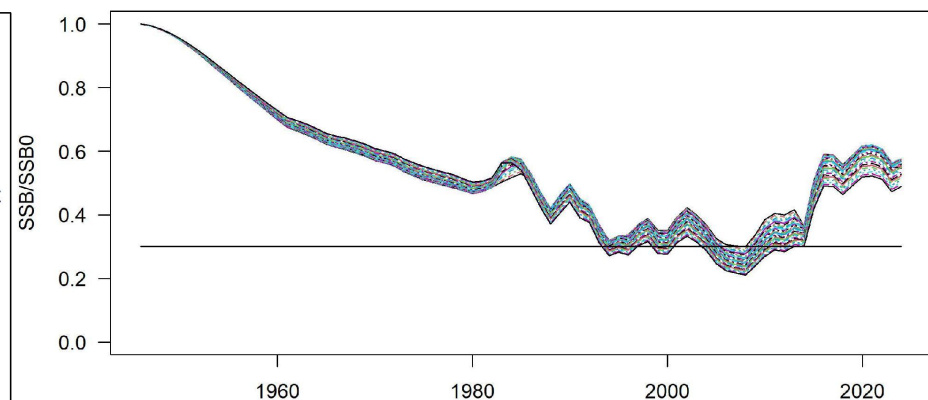
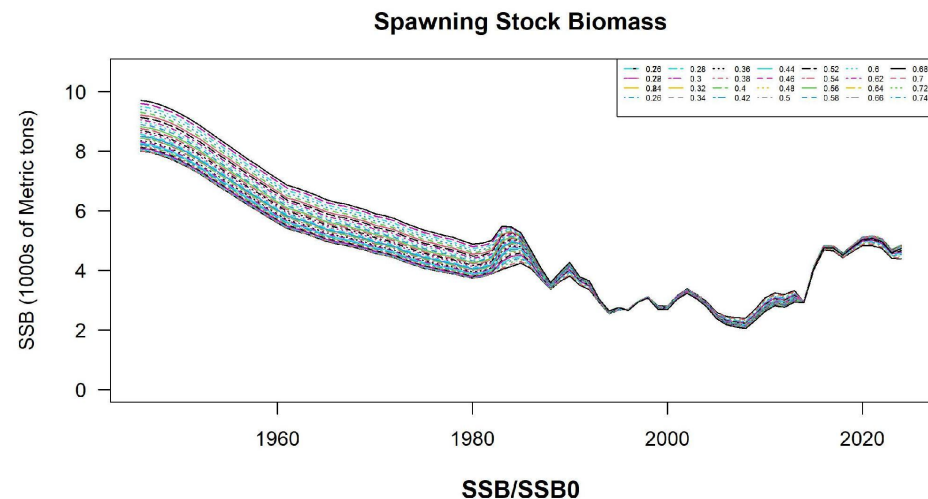
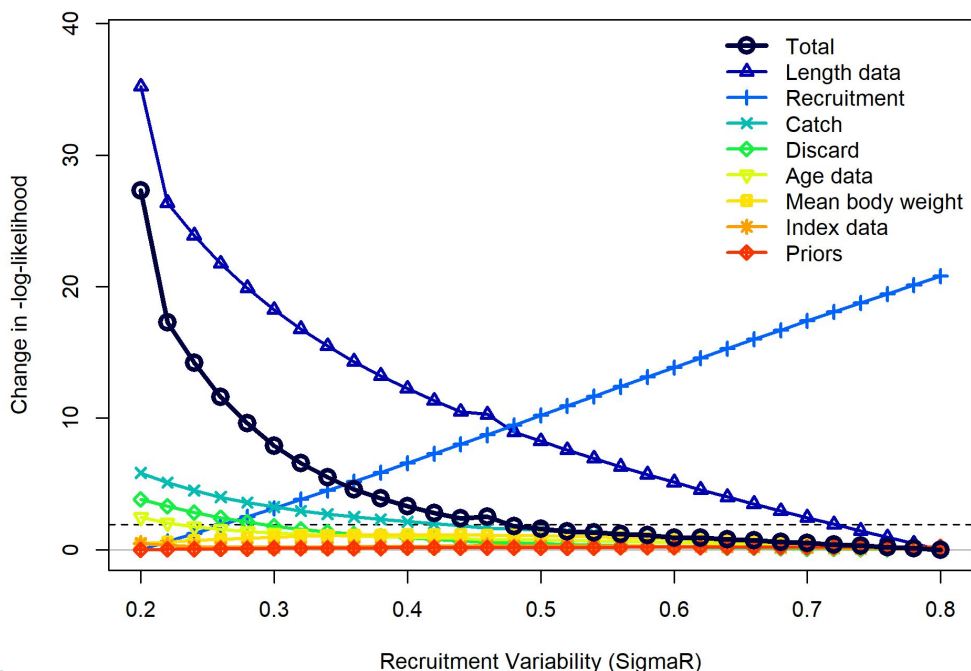
- Total NLL Minimum: 11.45
- 11.4-11.55 within 2 NLL
- **Length data** and **indices** support 11.3, **mean weight (Rec landings)** and **age data** support 12



Label	Value	Parm_StDev	CV
$\ln(R_0)$	11.469	0.051	0.004

Likelihood profile: *SigmaR*

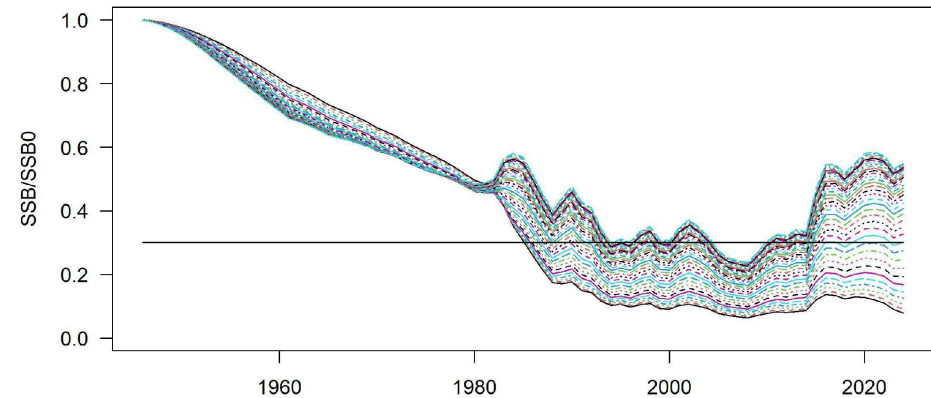
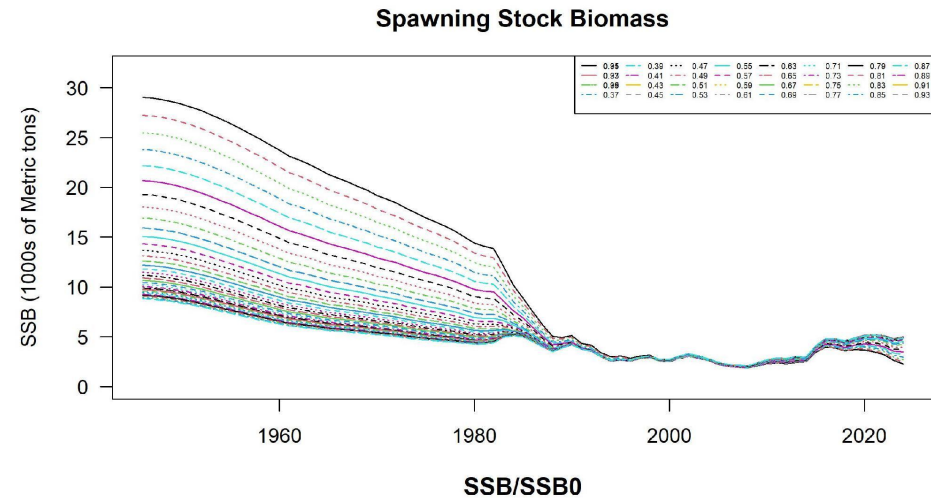
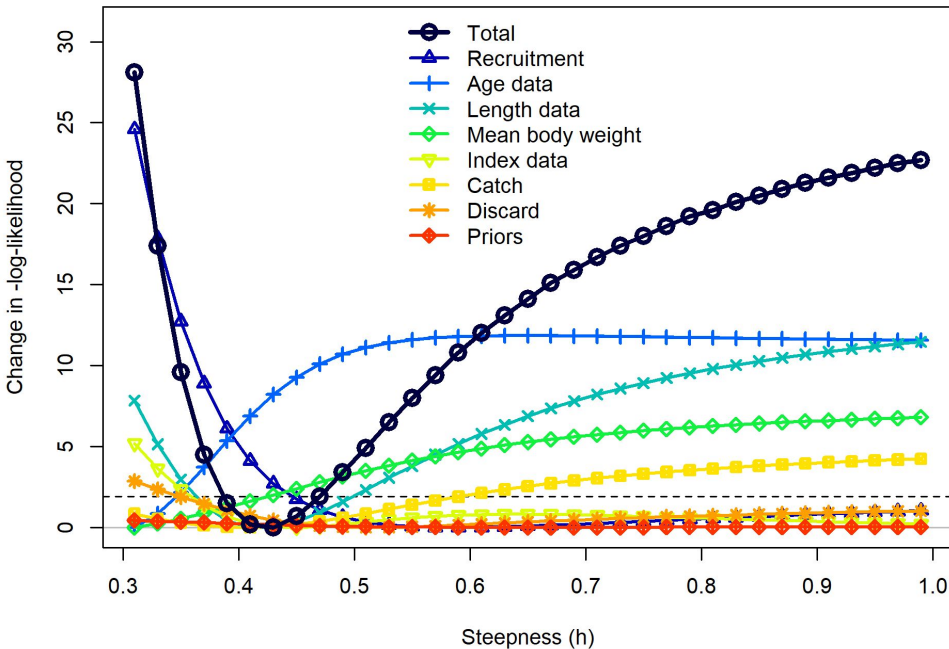
- Total NLL Minimum: 0.8
- 0.48-0.8 within 2 NLL
- **Recruitment** supports 0.2, all data streams support 0.8



Label	Value	Parm_StDev	CV
<i>SigmaR</i>	0.6	-	-

Likelihood profile: steepness

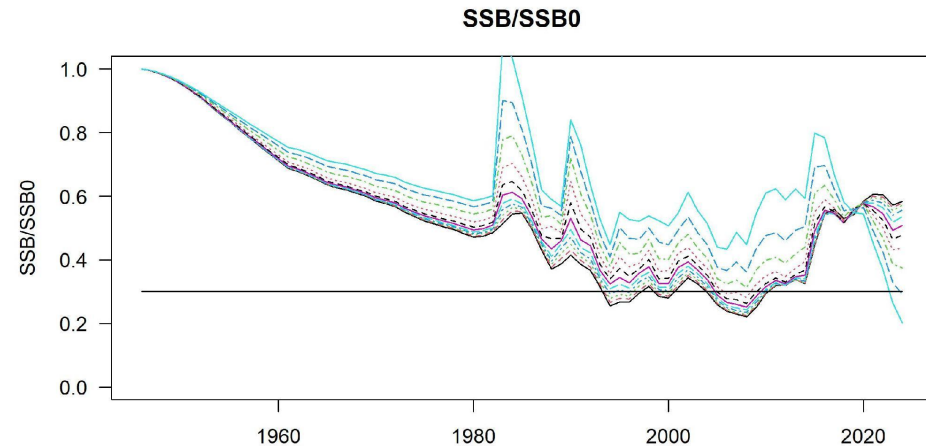
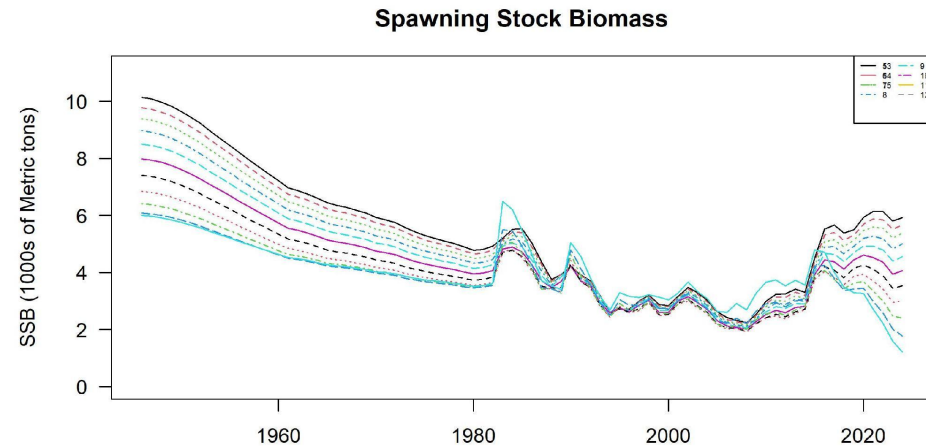
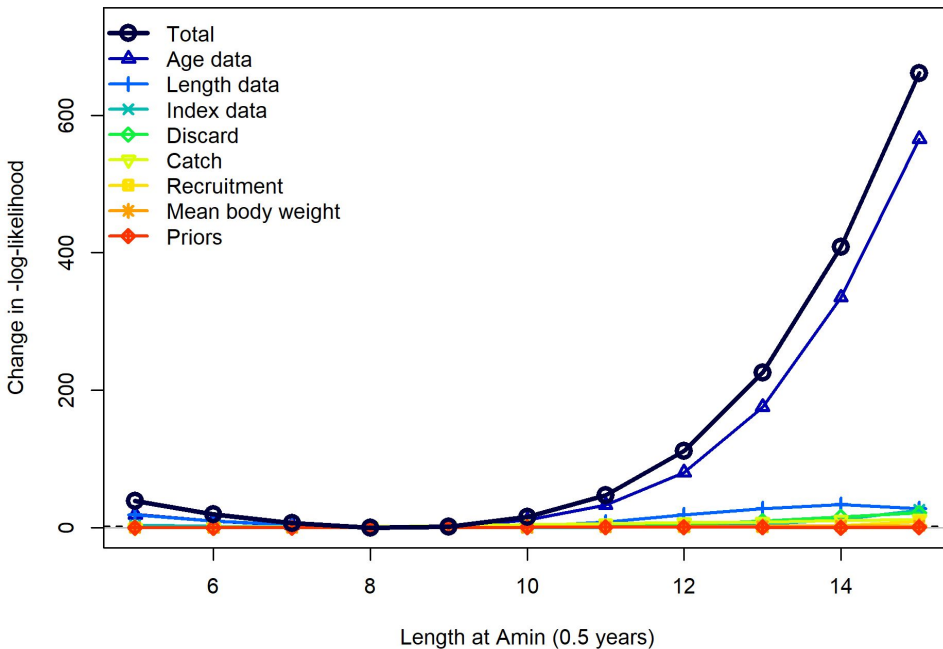
- Total NLL Minimum: 0.43
- 0.39-0.47 within 2 NLL
- **Mean weight (Rec landings)** and **age data** support 0.31, high supported by **discards (0.51)** and **recruitment (0.59)**



Label	Value	Parm_StDev	CV
Steepness	0.99	-	-

Likelihood profile: L_{Amin}

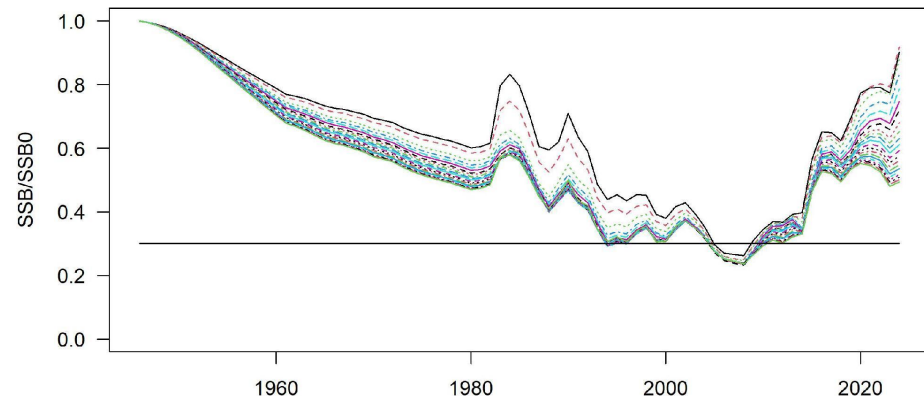
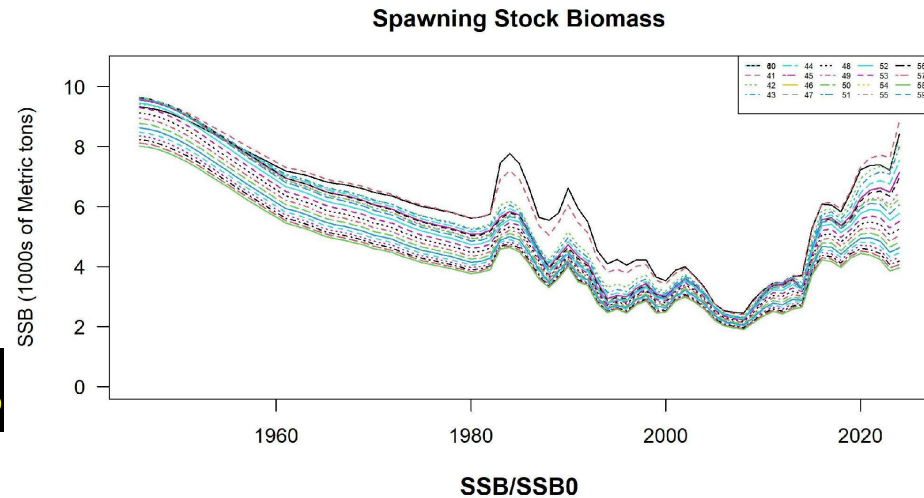
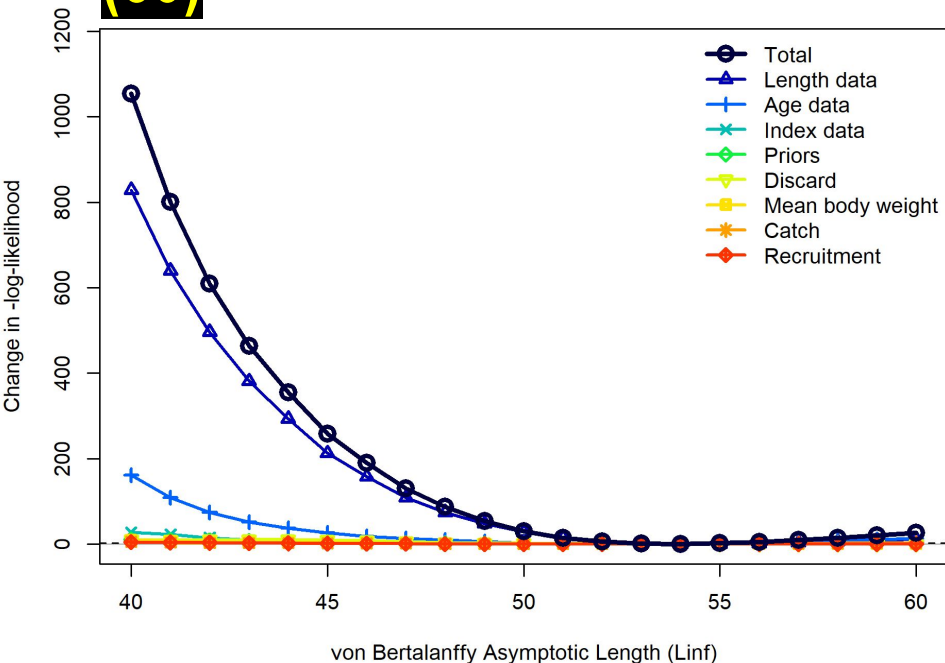
- Total NLL Minimum: 8
- 8-9 within 2 NLL
- **Recruitment** and **catch** supports 5, **indices** support 10



Label	Value	Parm_StDev	CV
L_{Amin}	8.353	0.325	0.039

Likelihood profile: $L_{Amax} (L^\infty)$

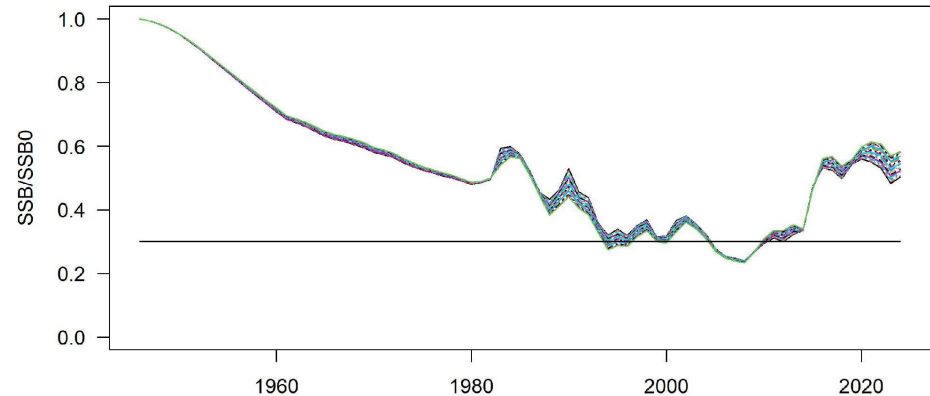
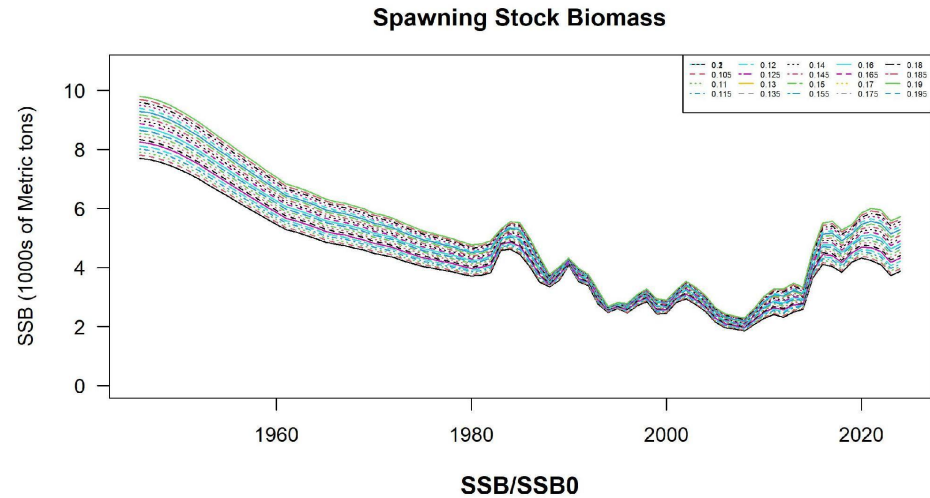
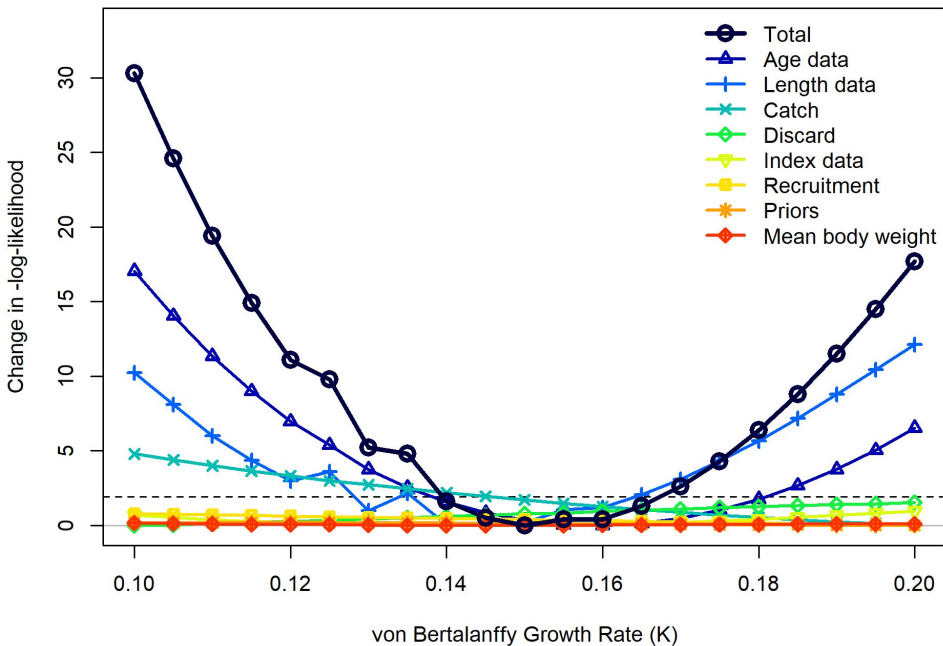
- Total NLL Minimum: 54
- 53-55 within 2 NLL
- **Catch** and **indices** support 50, high supported by **mean weight (Rec landings) (57)** and **discards (60)**



Label	Value	Parm_StDev	CV
L_{Amax}	53.804	0.617	0.011

Likelihood profile: K

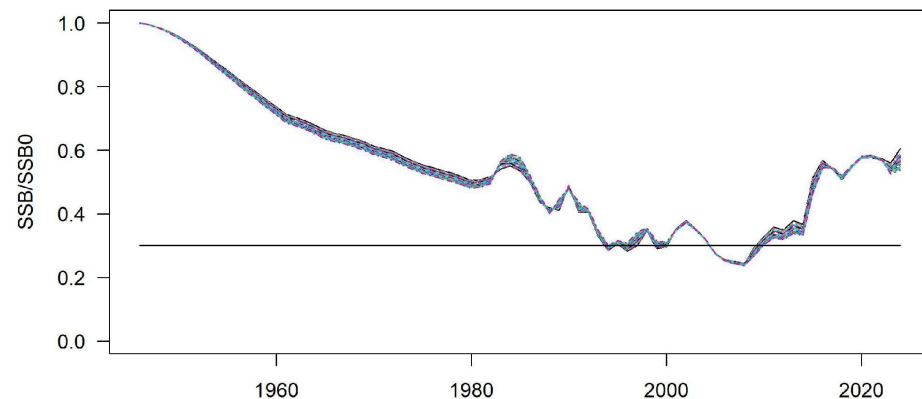
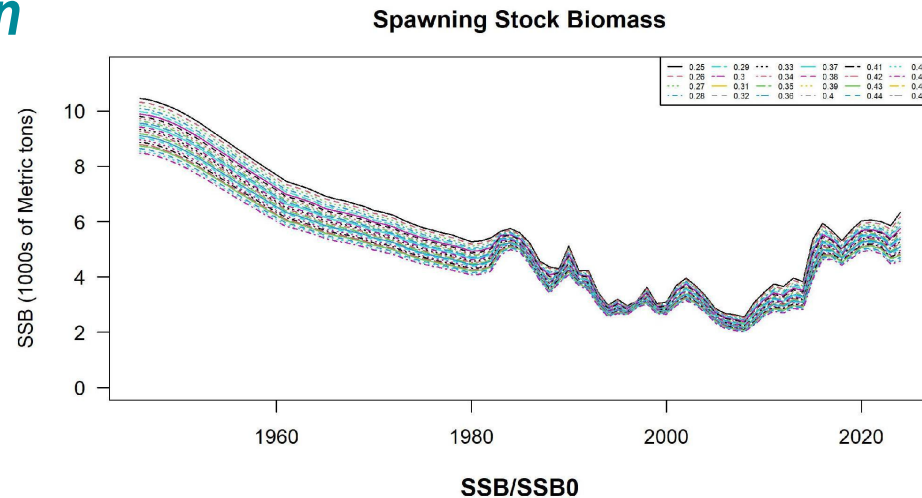
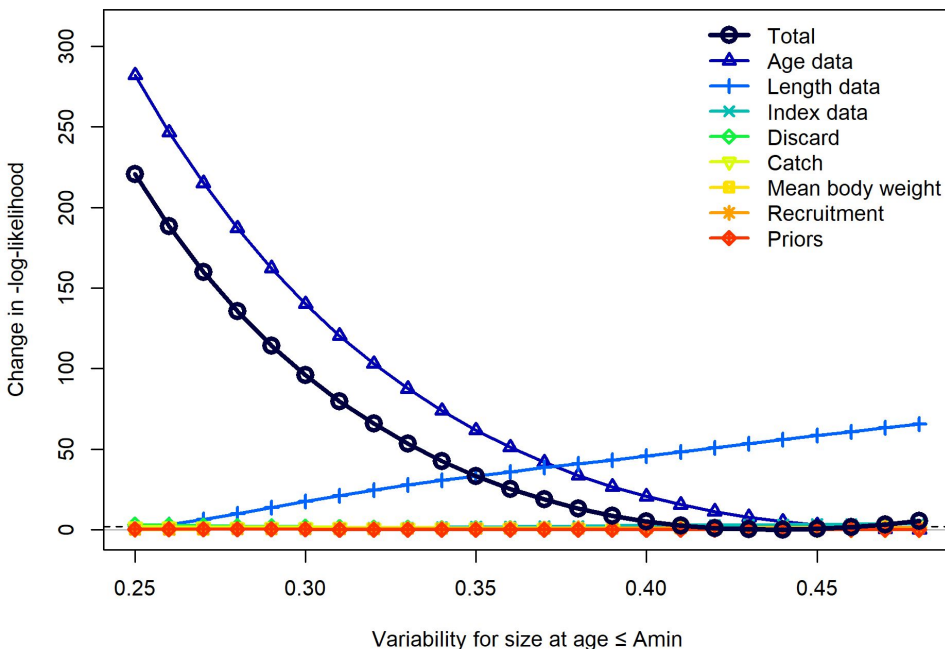
- Total NLL Minimum: 0.15
- 0.14-0.165 within 2 NLL
- **Discards** supports 0.1, **catch** and **recruitment** support 0.2



Label	Value	Parm_StDev	CV
K	0.153	0.007	0.048

Likelihood profile: CV_{Amin}

- Total NLL Minimum: 0.44
- 0.42-0.46 within 2 NLL
- **Indices**, **mean weight (Rec landings)**, **length data**, and **recruitment** support 0.25

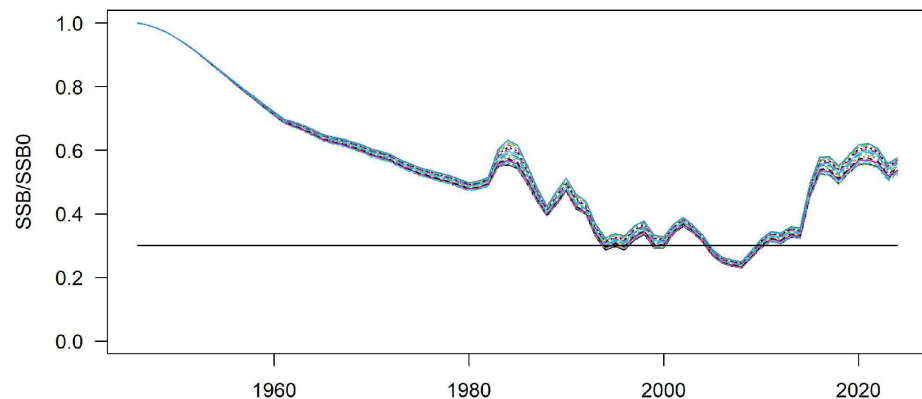
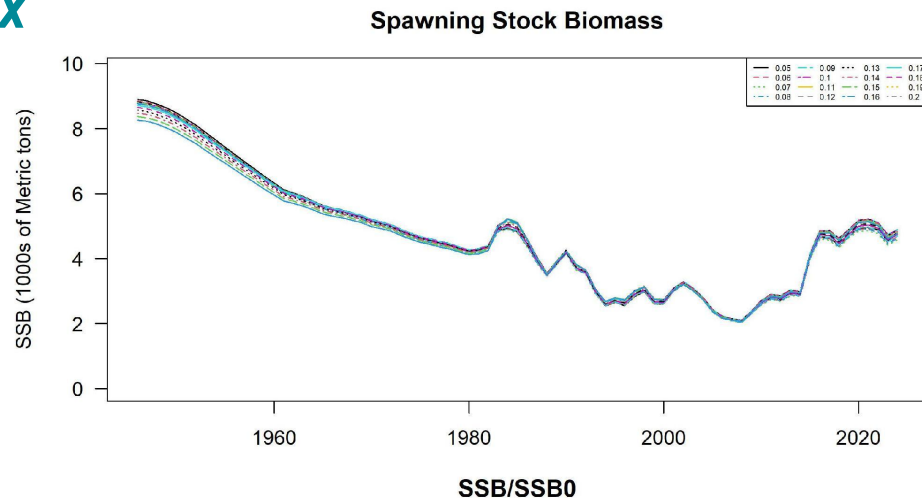
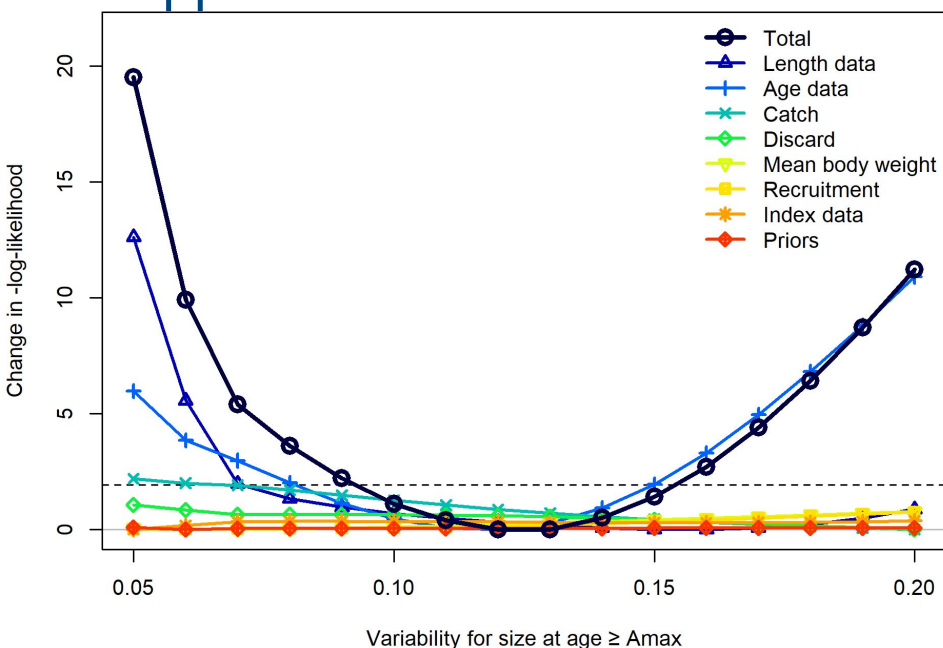


Label	Value	Parm_StDev	CV
CV_{Amin}	0.437*	-	-

*When estimated: 0.437 (0.059)

Likelihood profile: CV_{Amax}

- Total NLL Minimum: 0.12-0.13
- 0.1-0.15 within 2 NLL
- **Indices, recruitment, and mean weight (Rec landings)** support 0.05-0.07, **catch** and **discards** support 0.2

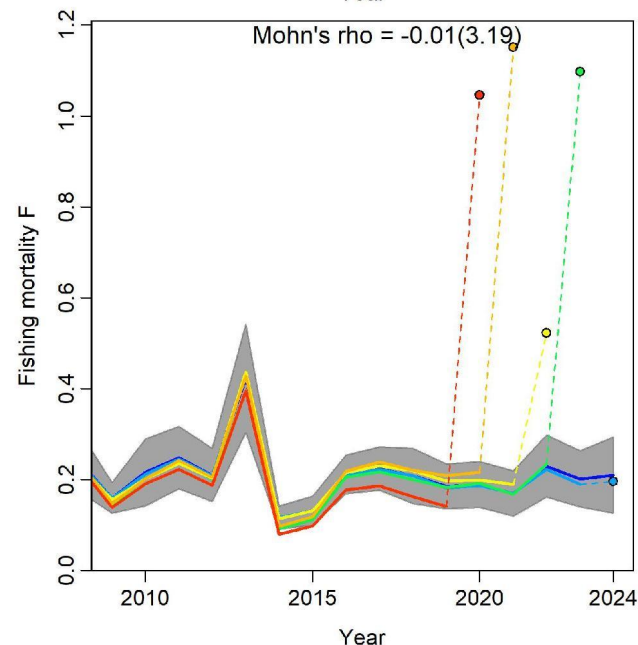
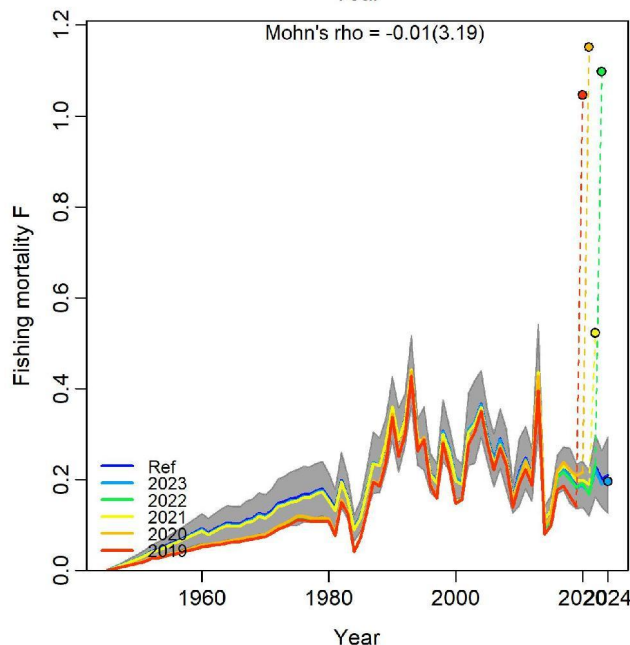
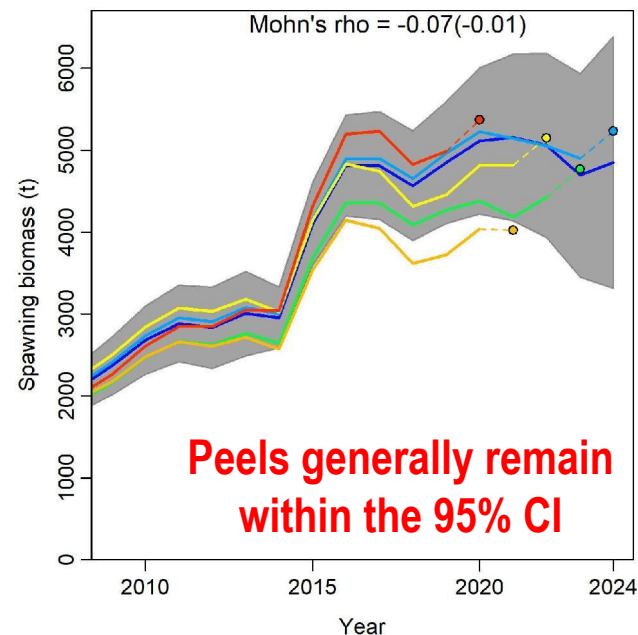
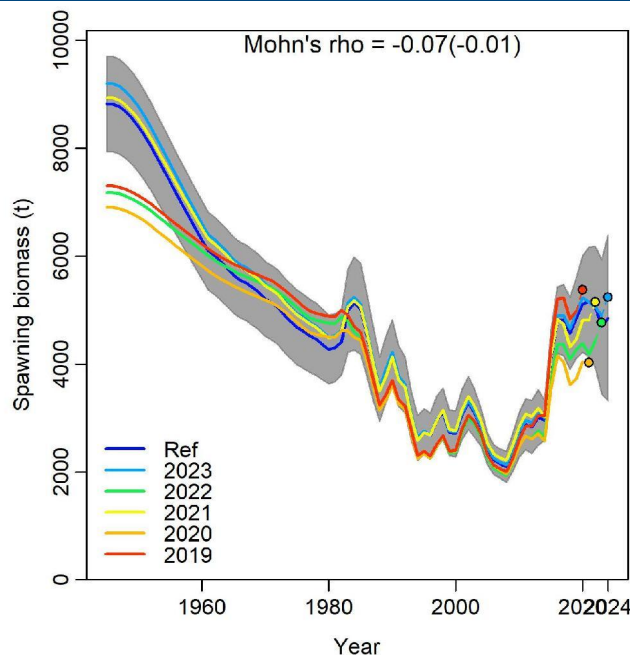


Label	Value	Parm_StDev	CV
CV_{Amax}	0.124*	-	-

*When estimated: 0.124 (0.259)

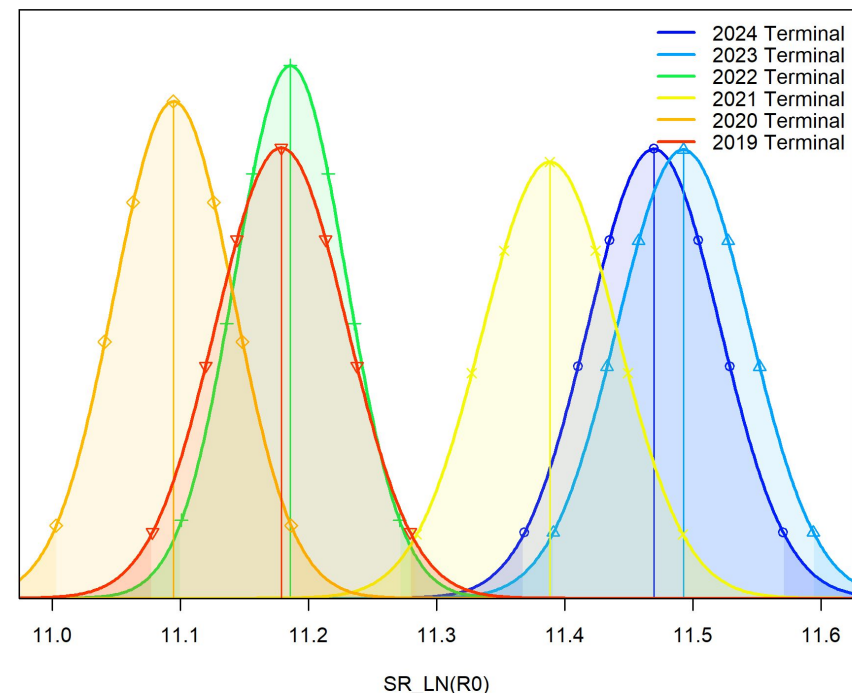
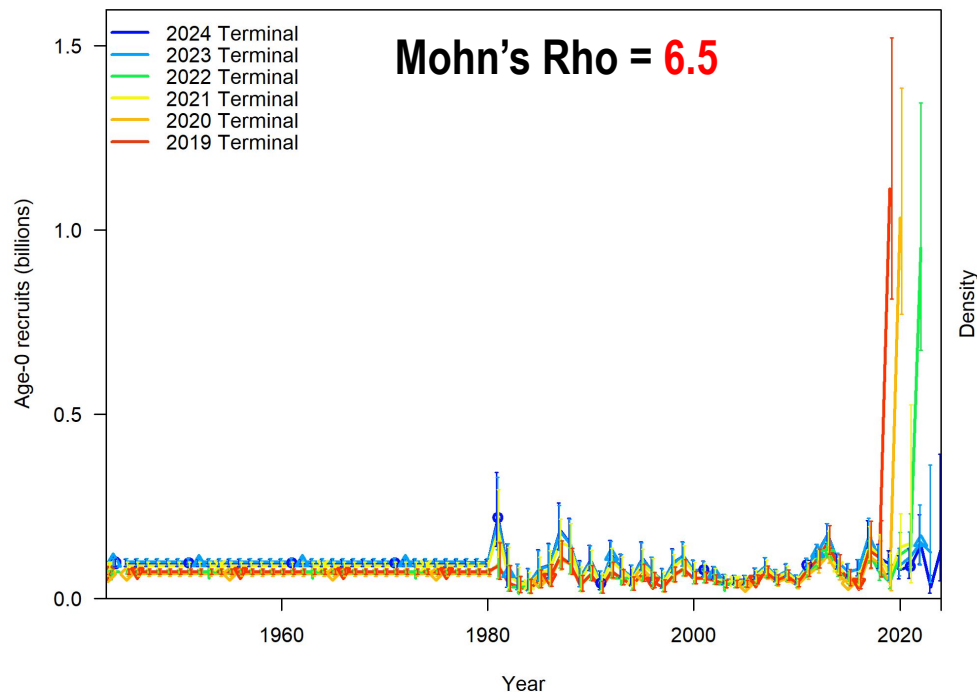
Retrospective bias

- Falls within the acceptable thresholds for long-lived species (-0.15 to 0.2; Hurtado et al. 2015)
- Forecast bias much higher for F



Retrospective runs

- Huge uncertainty in terminal year recruitment as years are peeled off, which also affects $\ln(R_0)$ estimates
 - Similar behavior noted in the SEDAR 43 model



Additional diagnostics (ss3diags) [Carvahlo et al. \(2021\)](#) [*Winker et al. \(2025\)](#)

- Non-random patterns in residuals evident

Data Source	Rec	ComVL	ComLL	SEAMAP Trawl Early	SEAMAP Trawl Late	Video
Index	X	-	-	X	X	X
CAAL*	X	X	X	-	-	-
Length	X	X	X	X	X	X

- Poor predictive skill remains for some data streams

Data Source	Rec	ComVL	ComLL	SEAMAP Trawl Early	SEAMAP Trawl Late	Video
Index	-	-	-	-	X	X
CAAL*	X	X	X	-	-	-
Length	X	X	X	-	X	X

Outline

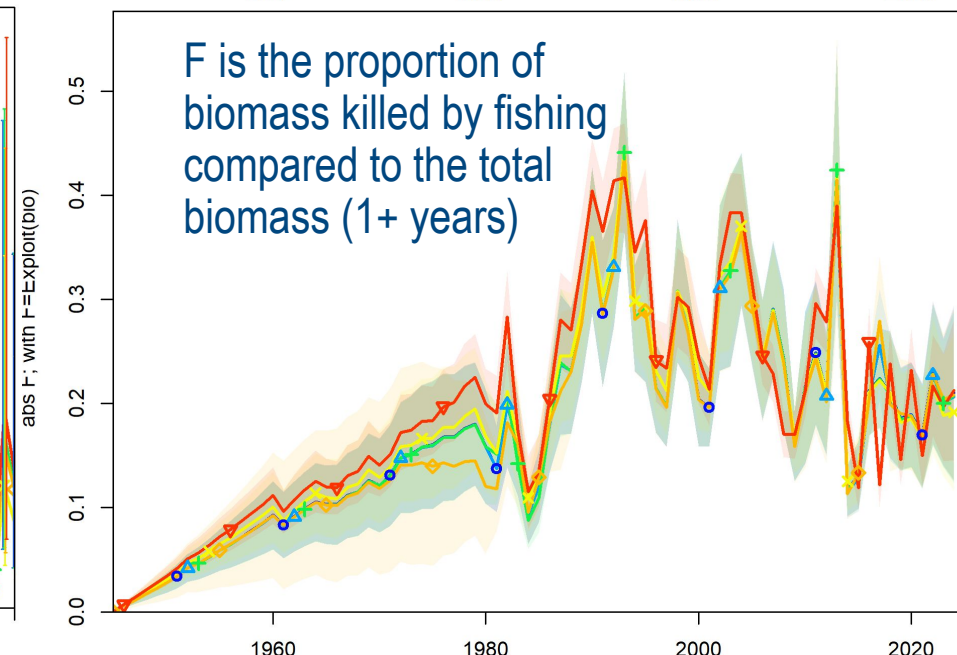
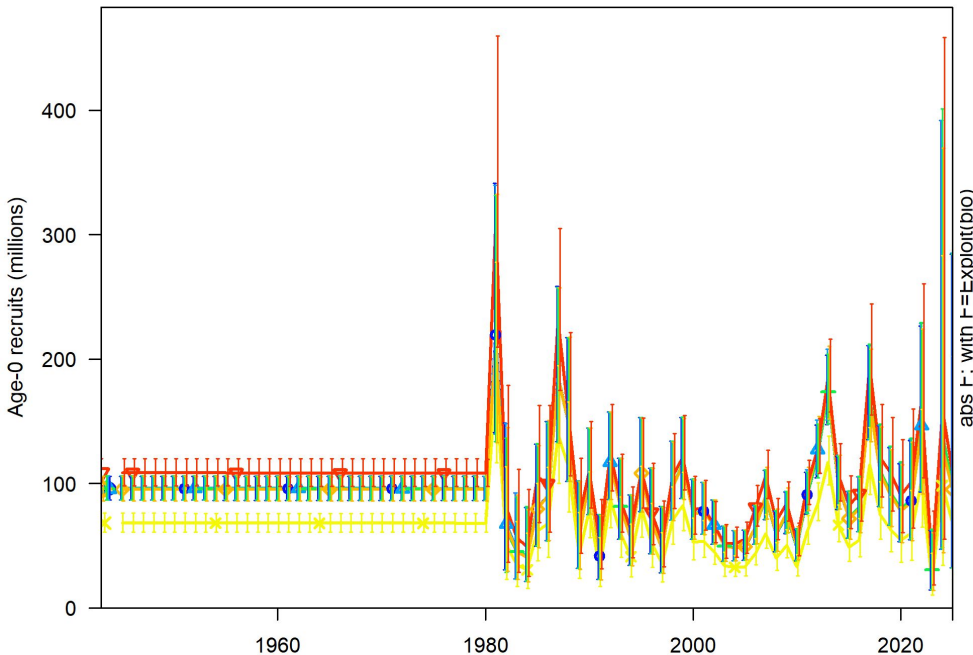
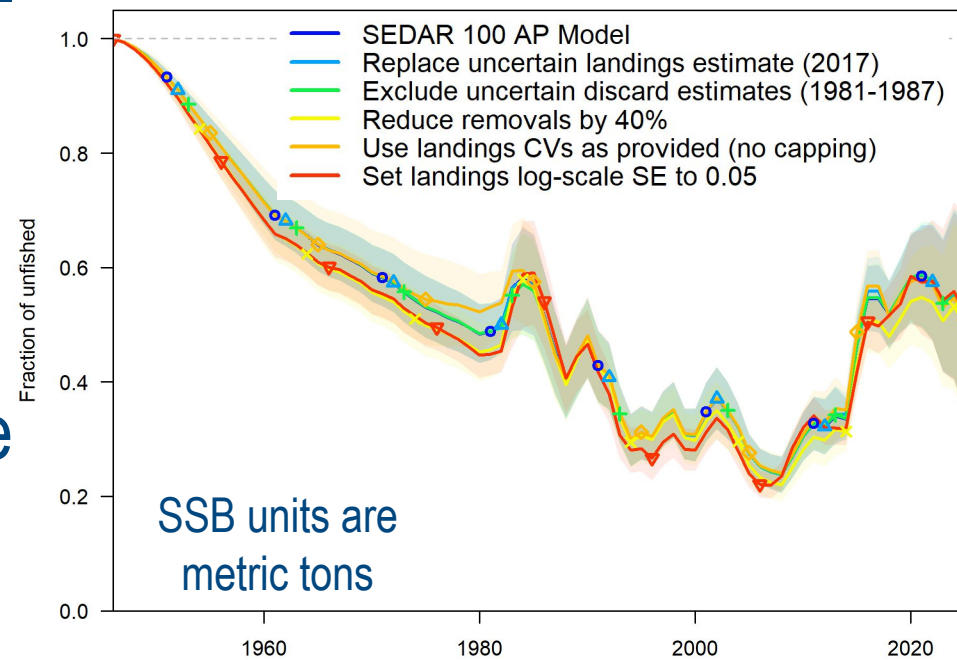
- Data Review
 - Stock definition
 - Assessment history
 - Regulations
 - Key data decisions
 - Life history
 - Removals
 - Size compositions
 - Age compositions
 - Indices of abundance
 - Survey length composition
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 - **AP Model sensitivities**
 - AP Model projections

Sensitivity to assumptions

- Recreational removals
- Discard mortality
- Shrimp bycatch
- Jackknife indices
- Allow platoons for growth
- Estimate steepness
- Fishing mortality
- Age-structured production model
- Combining landings and dead discards
- Start year

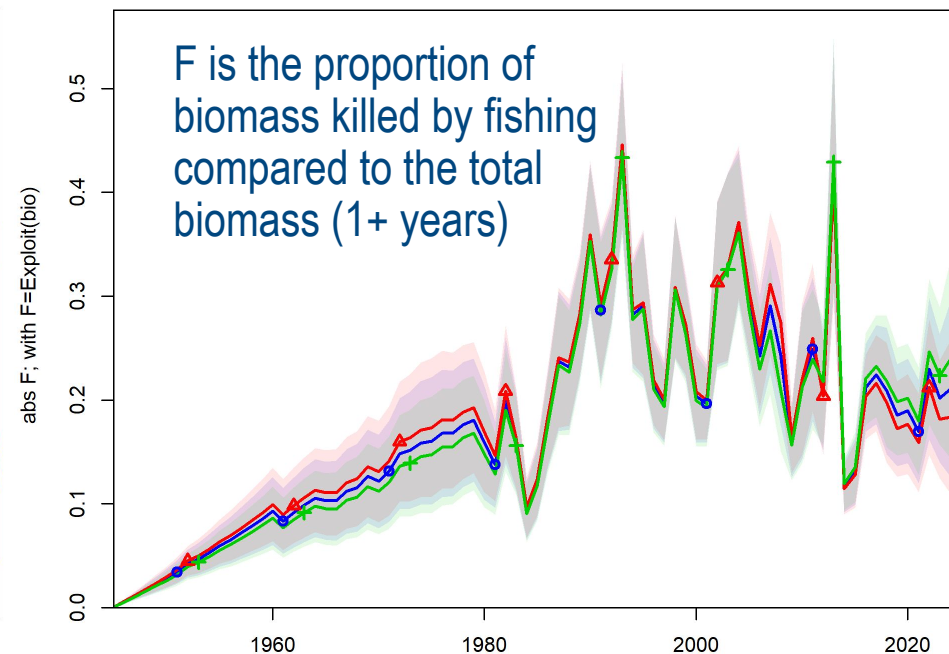
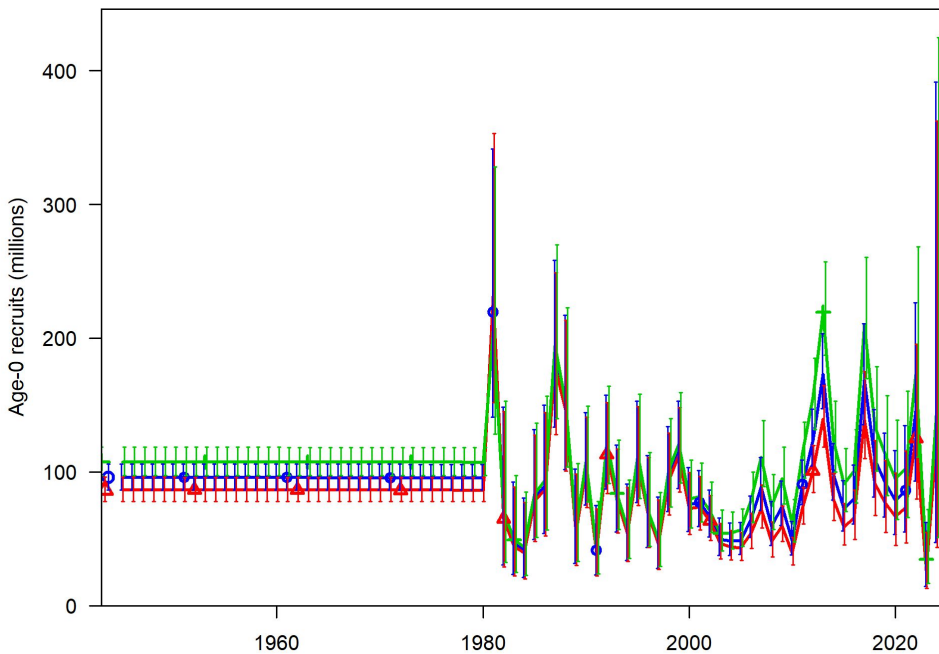
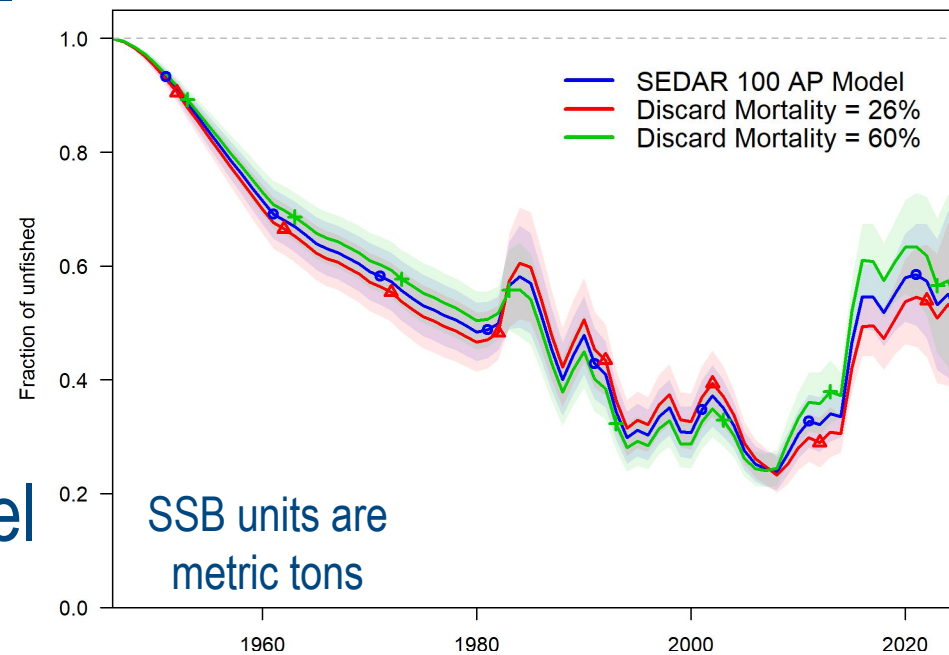
Recreational removals

- Minimal impact on model results, as most trajectories remain within the confidence limits of the AP model



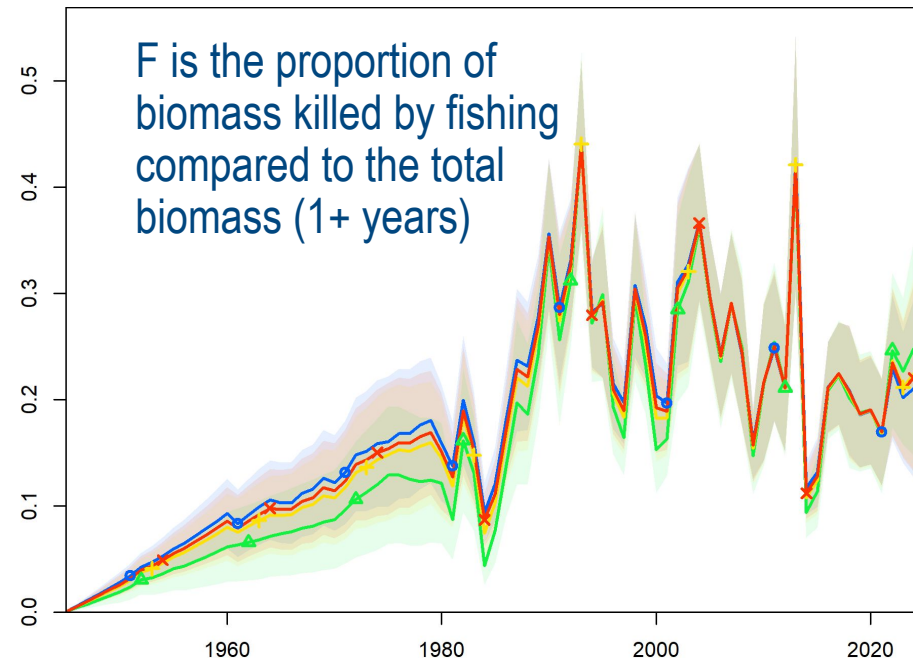
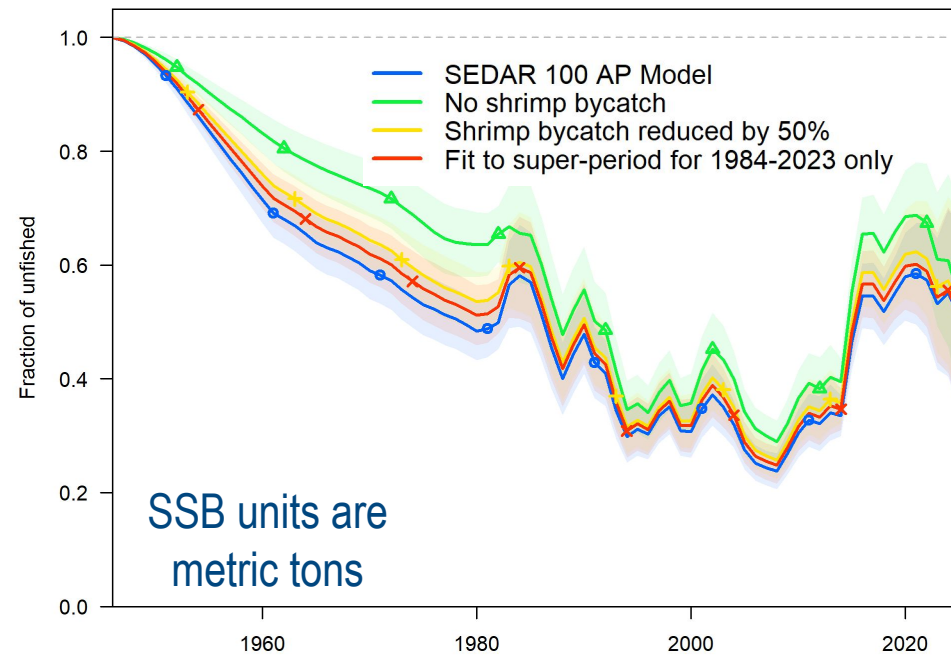
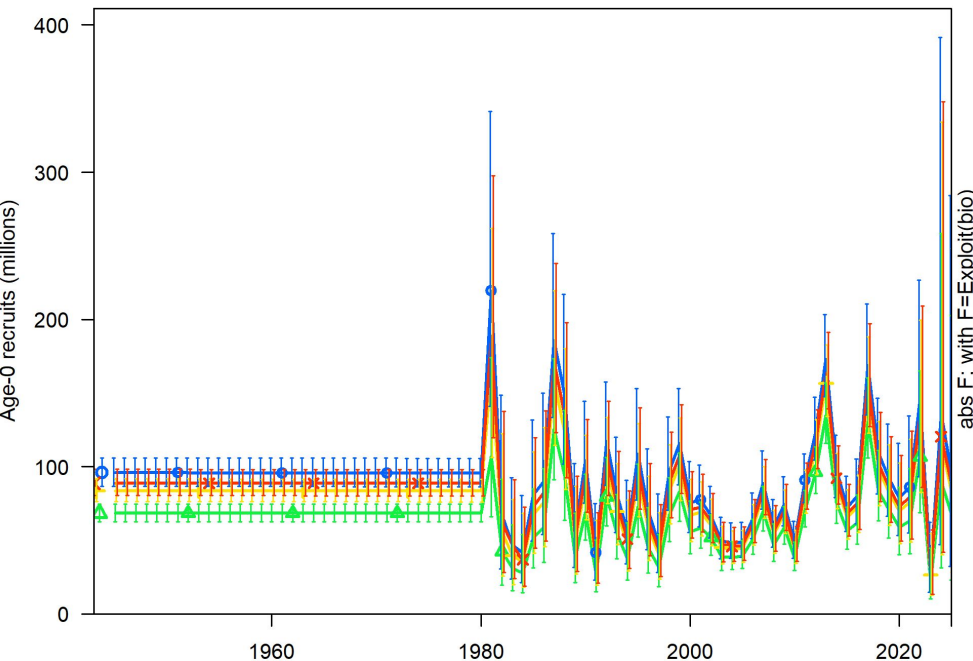
Discard mortality

- Alternative values scaled trends up or down, but generally remain within confidence limits of AP model



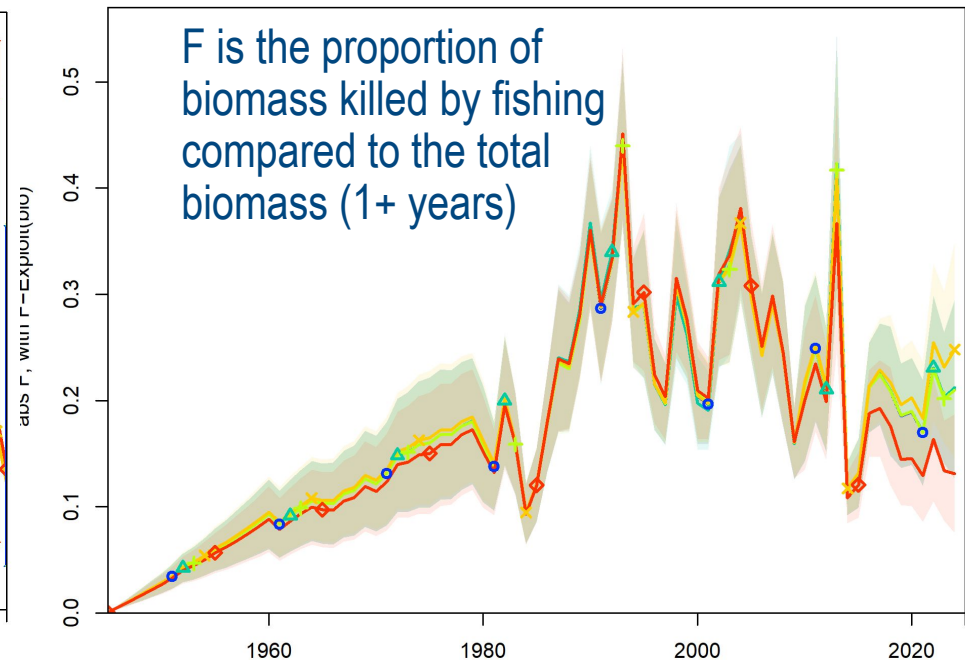
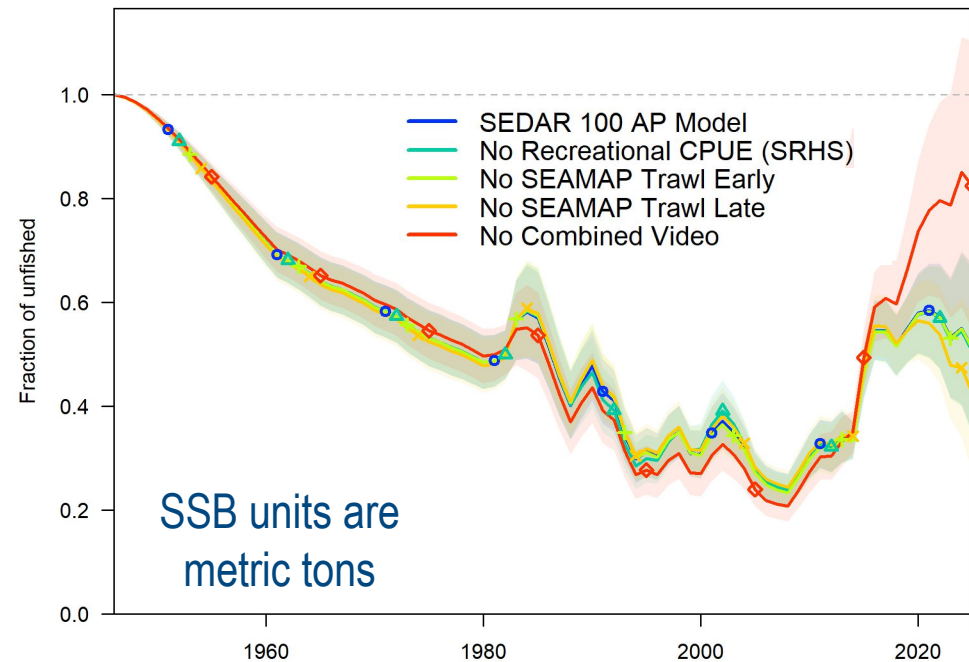
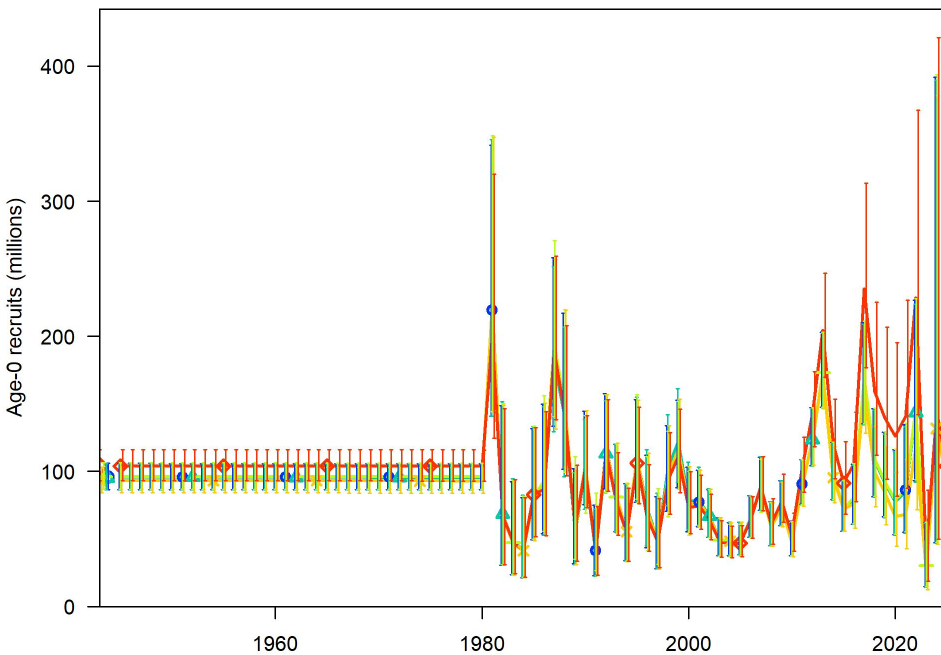
Shrimp bycatch

- Excluding bycatch leads to the largest differences, but trends remain similar
- Minimal impact on results for 1984+ bycatch estimates



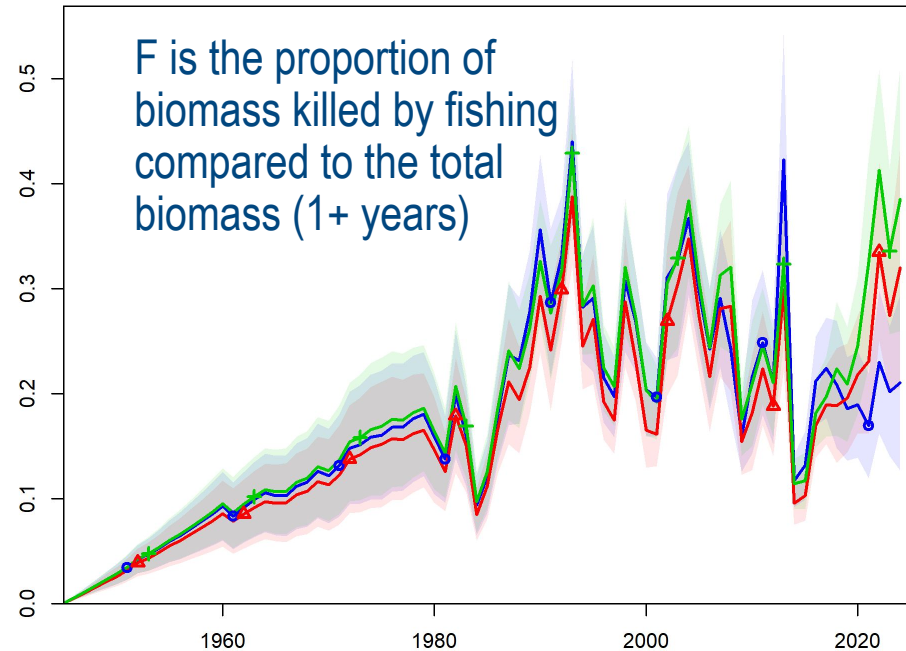
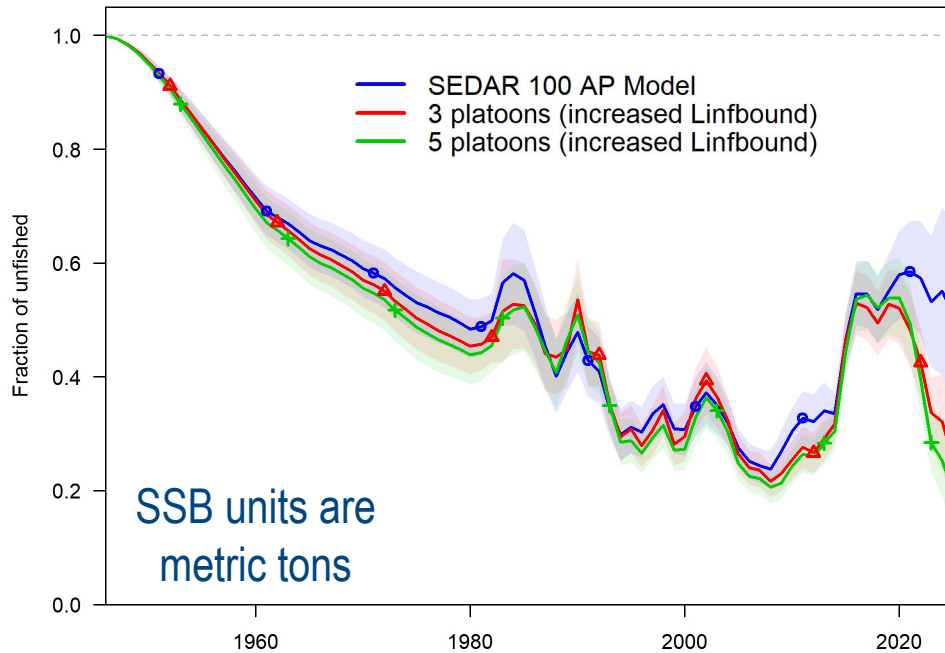
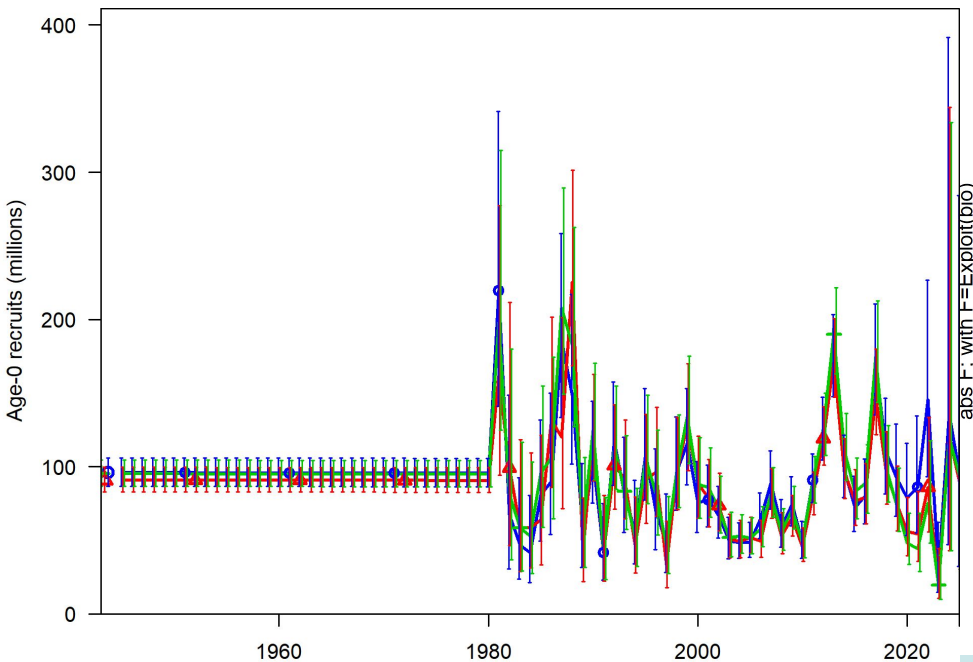
Jackknife indices

- **No video survey** leads to large difference in recent years because model better fits to the SEAMAP Trawl Late index



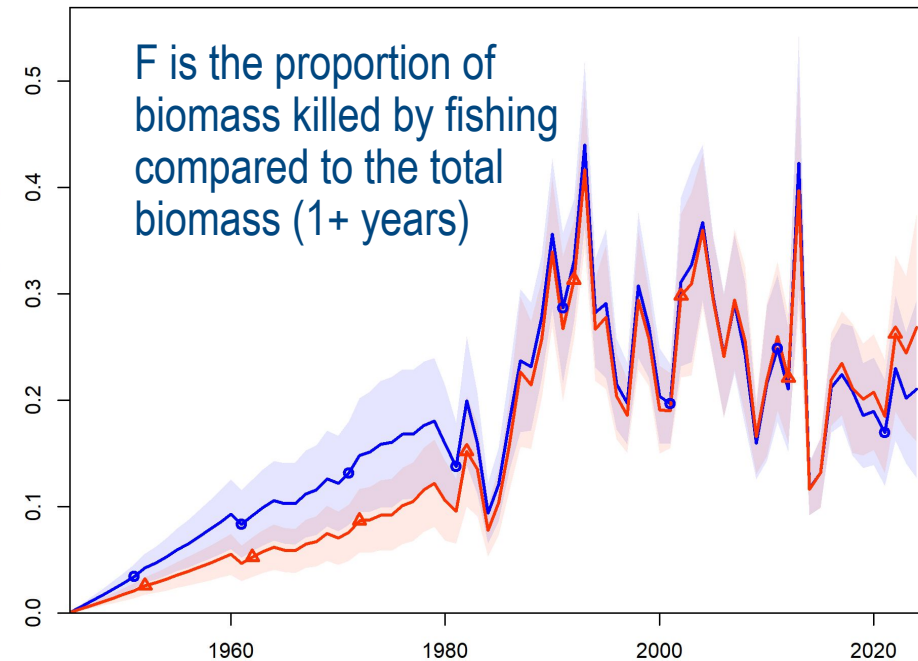
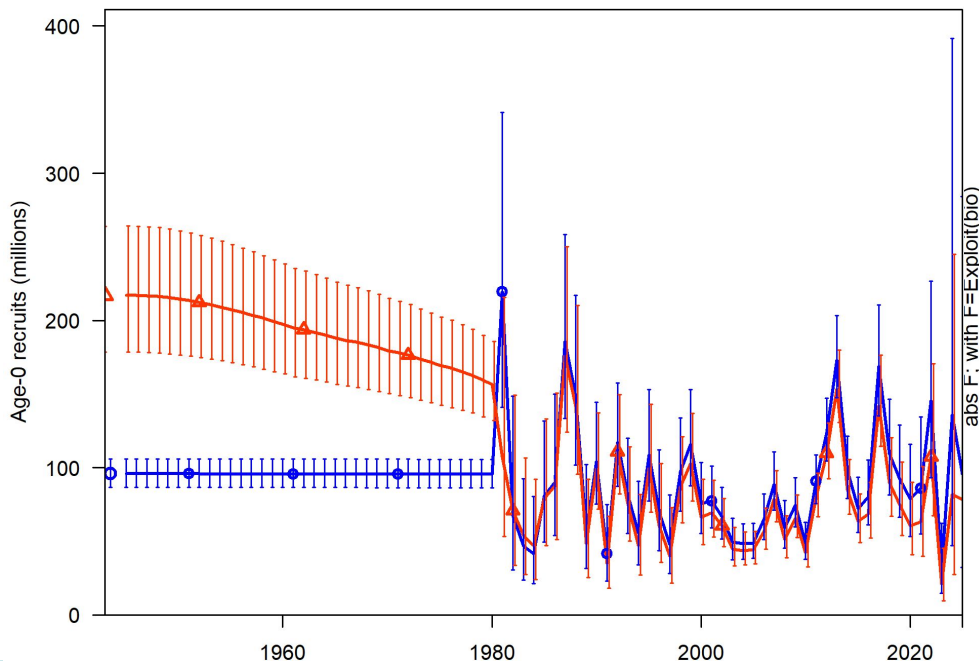
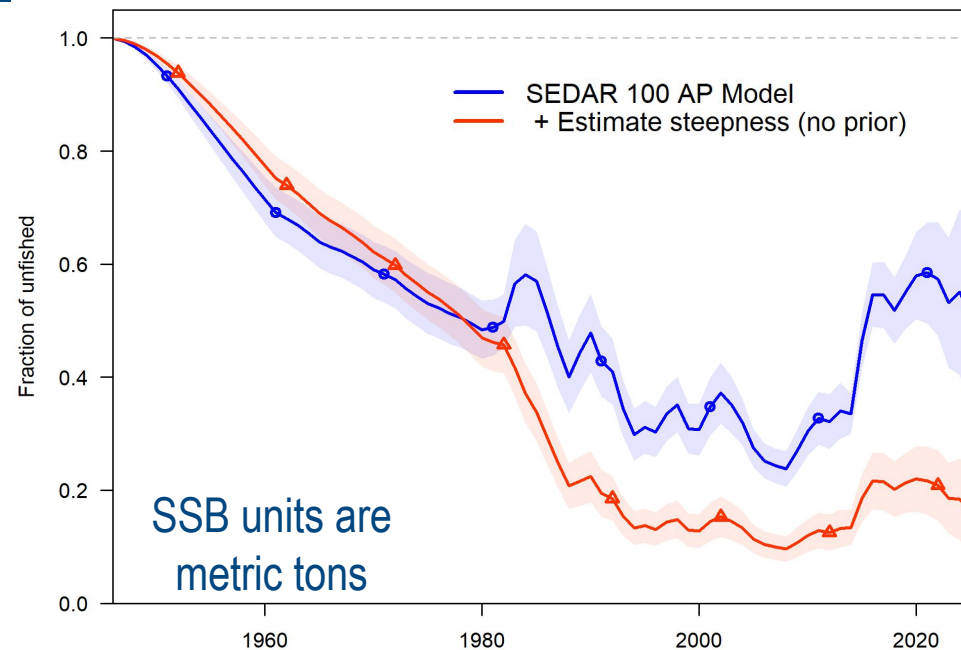
Platoons

- Leads to very different trends in recent years, with higher F and lower SSB
- Growth parameter estimates questionable



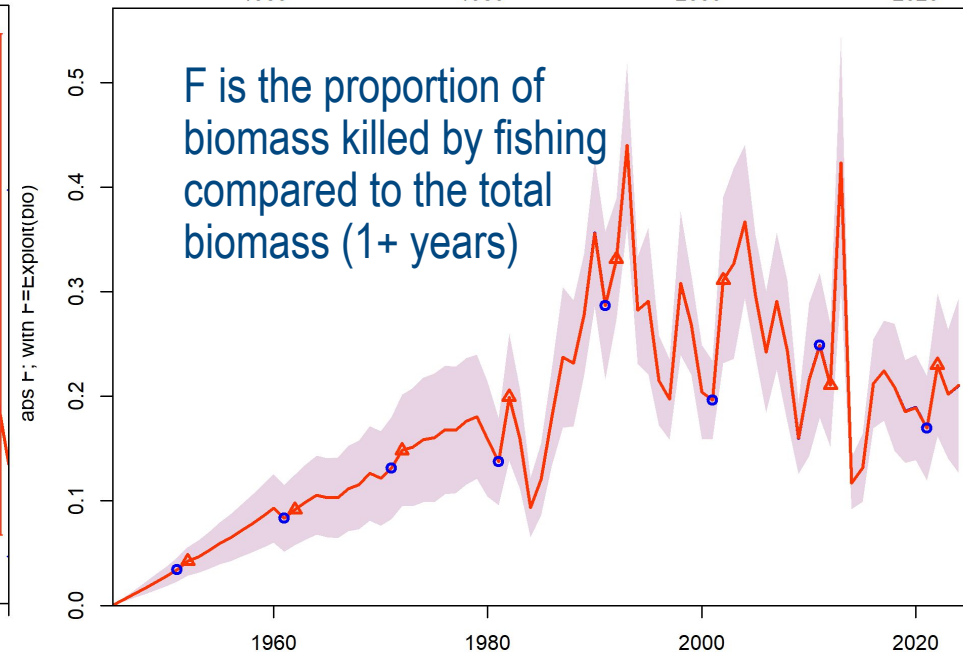
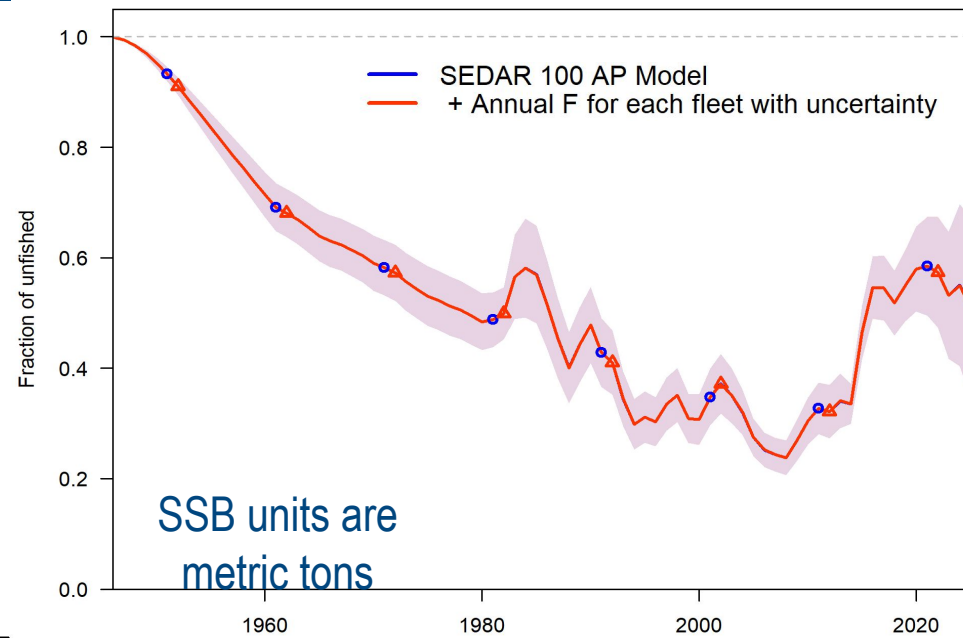
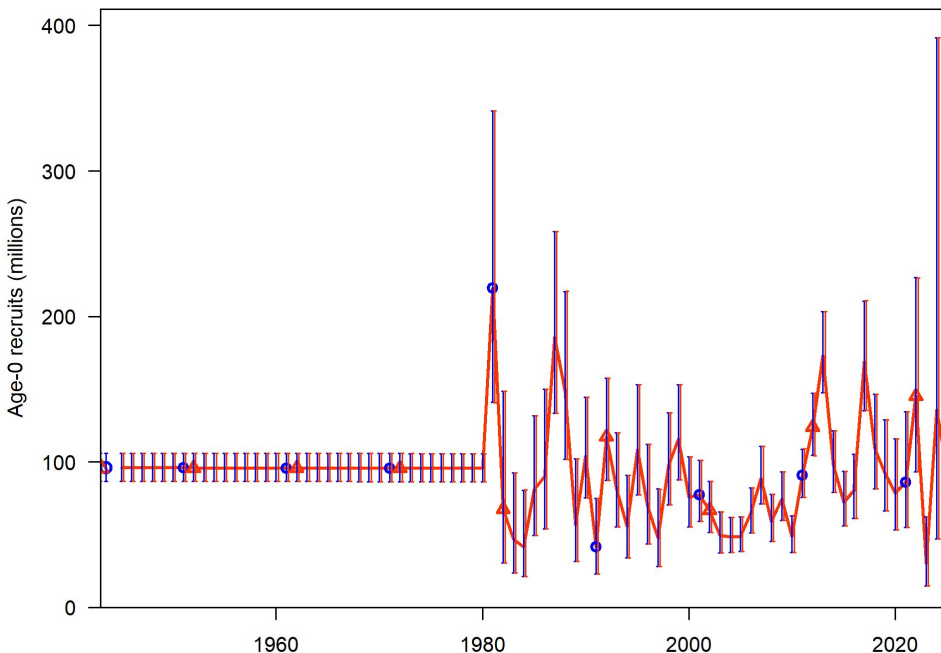
Steepness

- Estimating steepness leads to much lower stock biomass, but lacking support that it is estimable



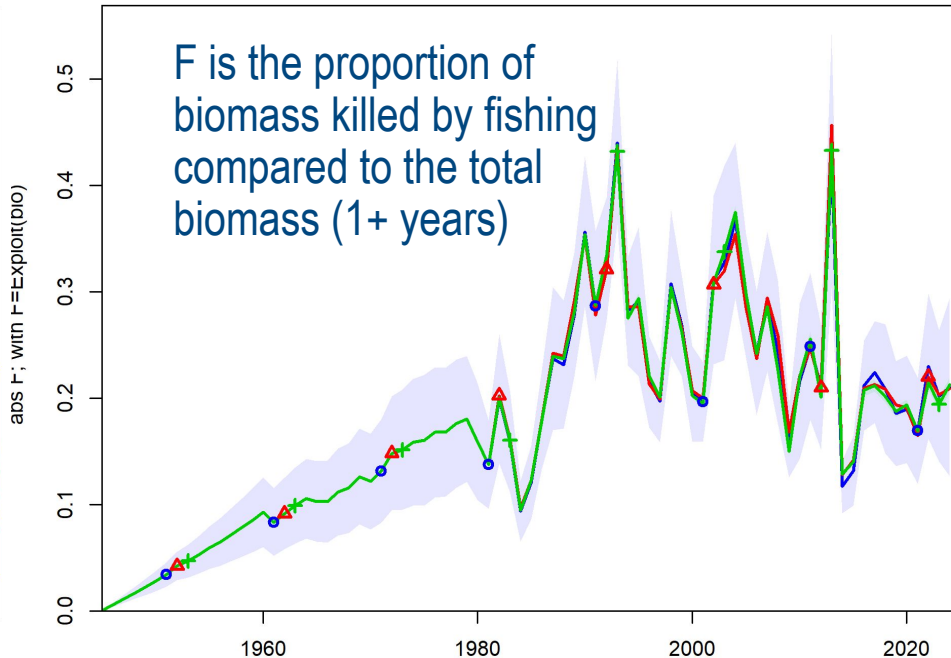
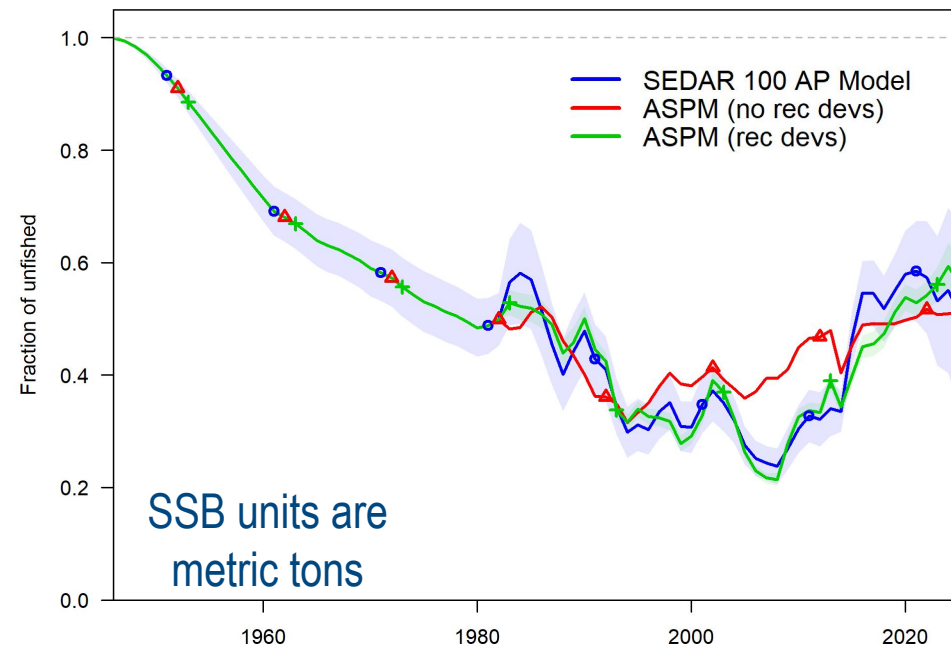
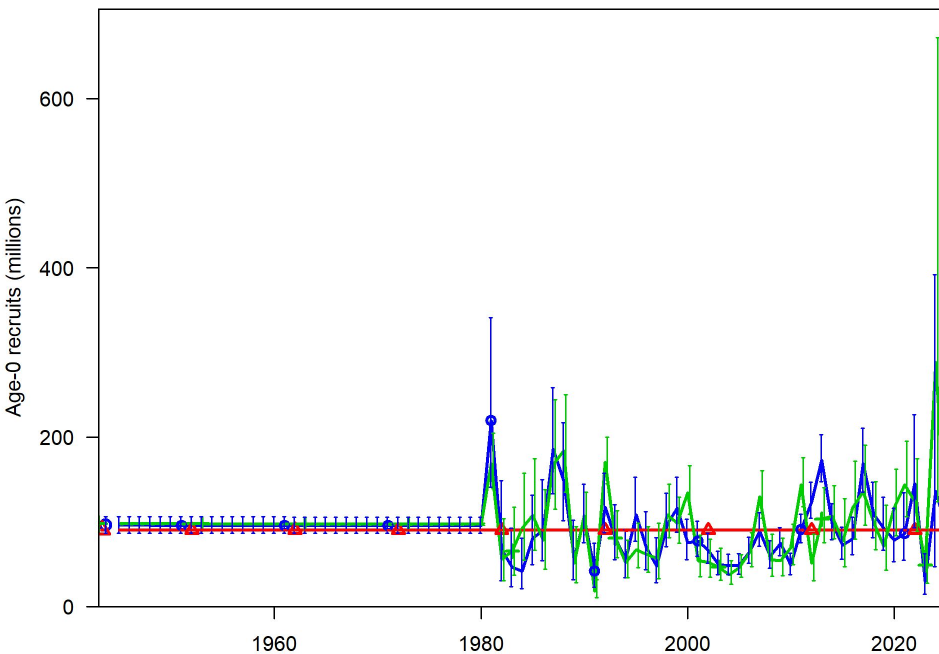
Fishing mortality

- Estimating annual F s for all fleets (including commercial) leads to identical results



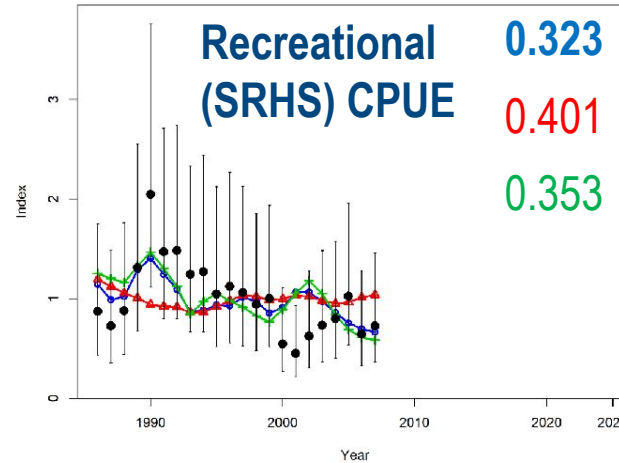
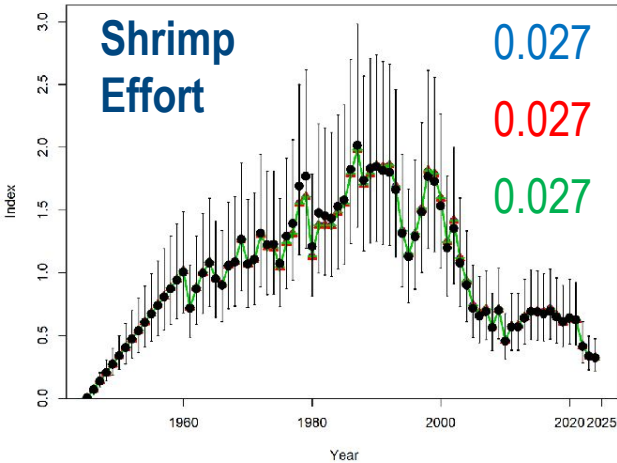
Age-structured production model

- Results more similar for ASPM estimating recruitment deviations, but some deviations evident



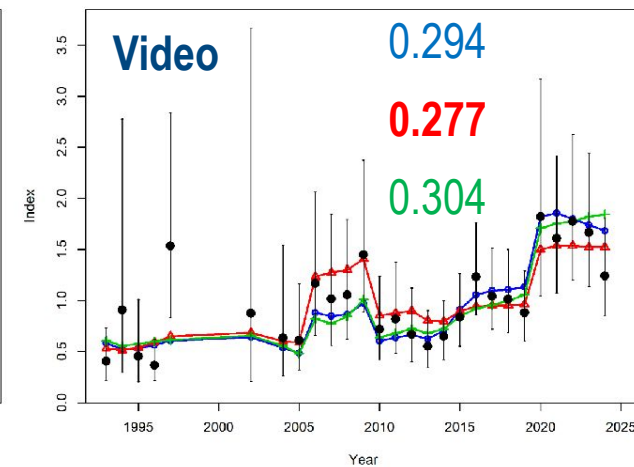
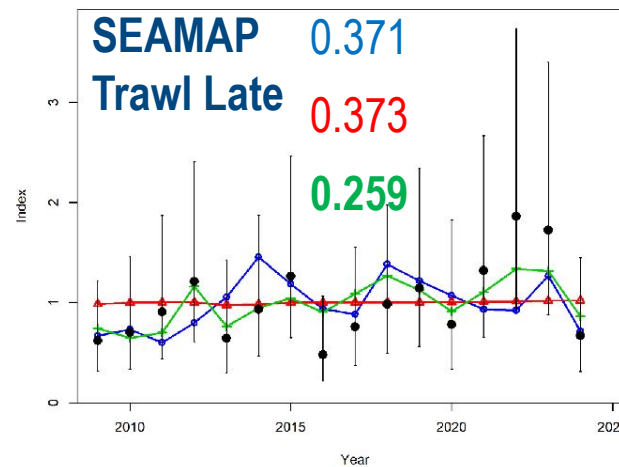
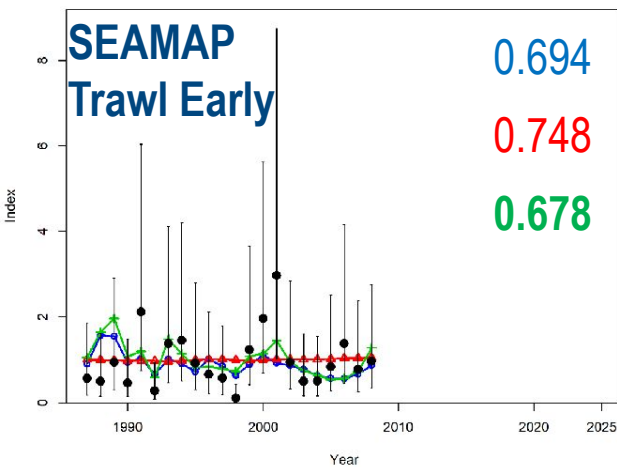
Indices fit comparison (with RMSE)

— SEDAR 100 AP Model
 — ASPM (no rec devs)
 — ASPM (rec devs)



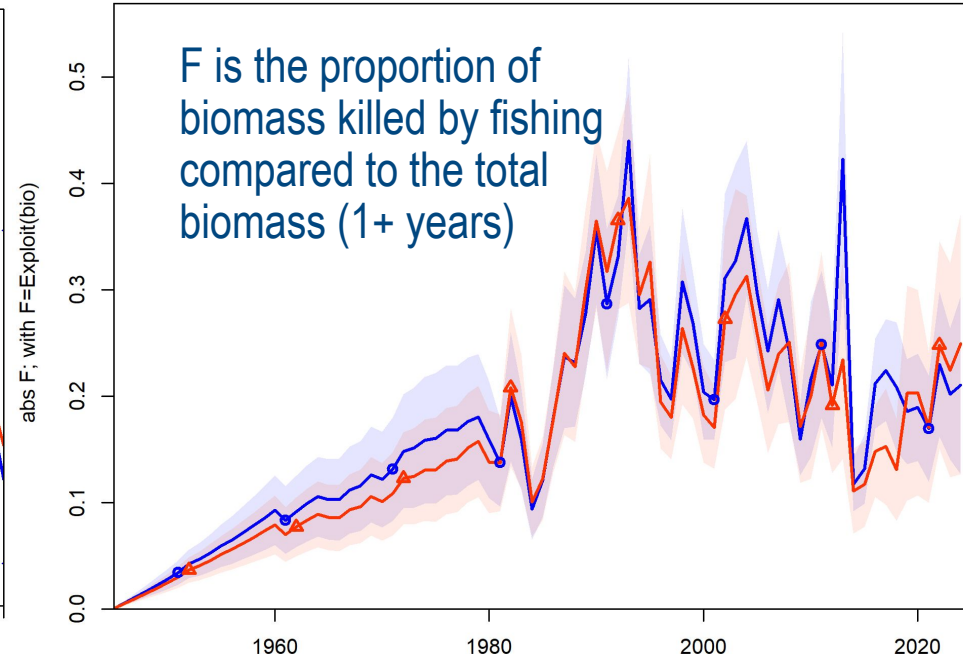
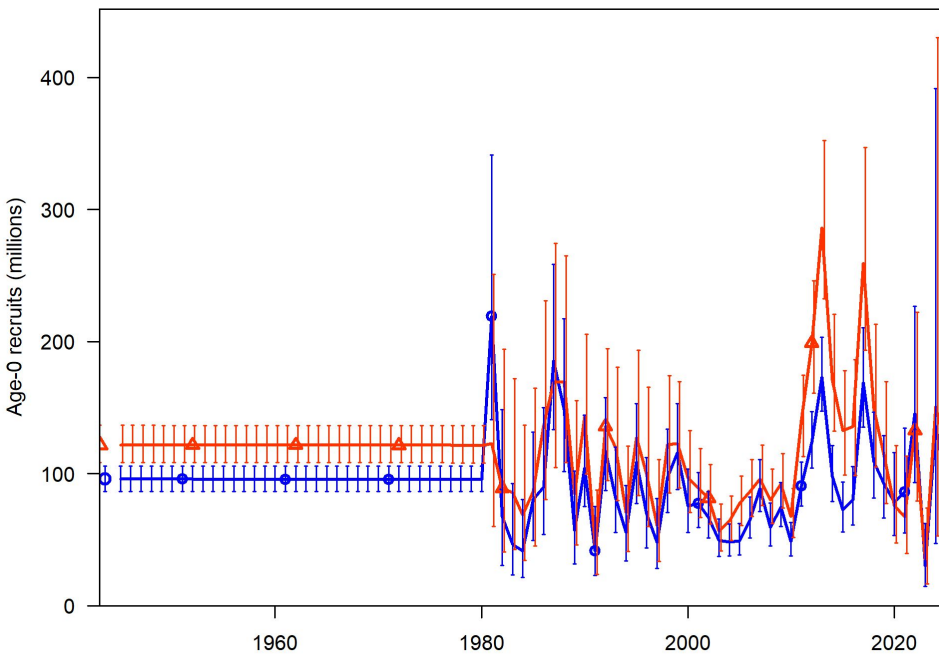
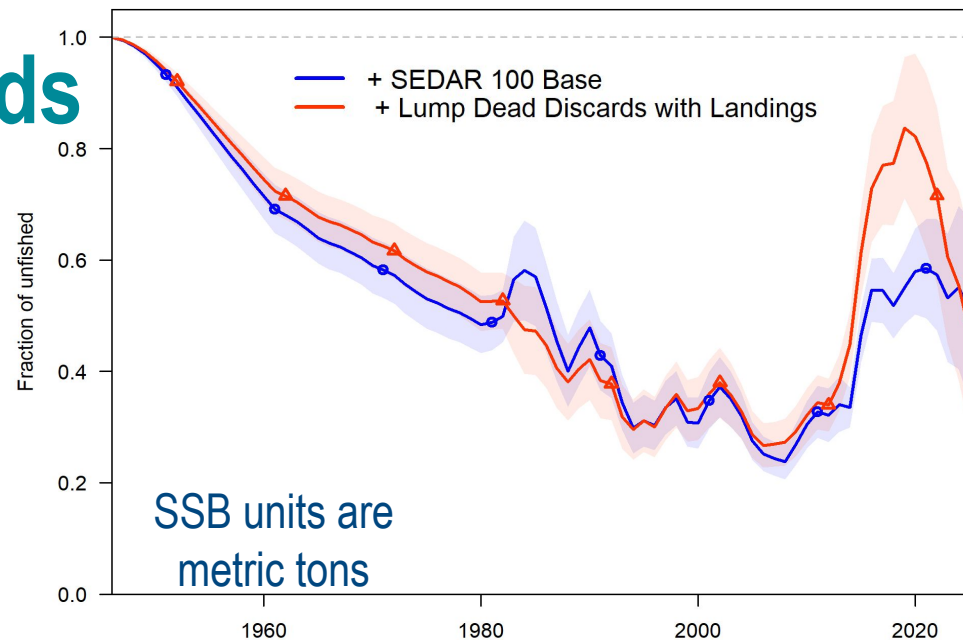
Trends very flat except for video survey when not estimating rec devs

Estimating rec devs improves fits for other surveys



Landings + dead discards

- Large deviation in results in the late 2010s, likely due to increased discarding and rigid selectivity assumption



Start year exploration

Year	Pro	Cons
1945	- Consistent with previous assessment - Starts at virgin conditions	- High uncertainty in historical estimates (recreational 1955-1980, commercial 1949-1986) and no shrimp information before 1960 - Need to back-calculate landings and shrimp bycatch using interpolation back to start
1963	- No landings interpolation needed - Shrimp effort started in 1960	- Still high uncertainty in historical landings (recreational 1963-1980 and commercial 1963-1986) - Need to scale back shrimp bycatch estimates for 1963-1983 (using trend in effort) - Starts in fished conditions, need to approximate initial conditions
1981	- No landings interpolation needed - More confidence in available data	- Still high uncertainty in recreational removals (1981-1985) and commercial landings (1981-1985) - Need to scale back shrimp bycatch estimates for 1981-1983 (using trend in effort) - Starts in fished conditions, need to approximate initial conditions



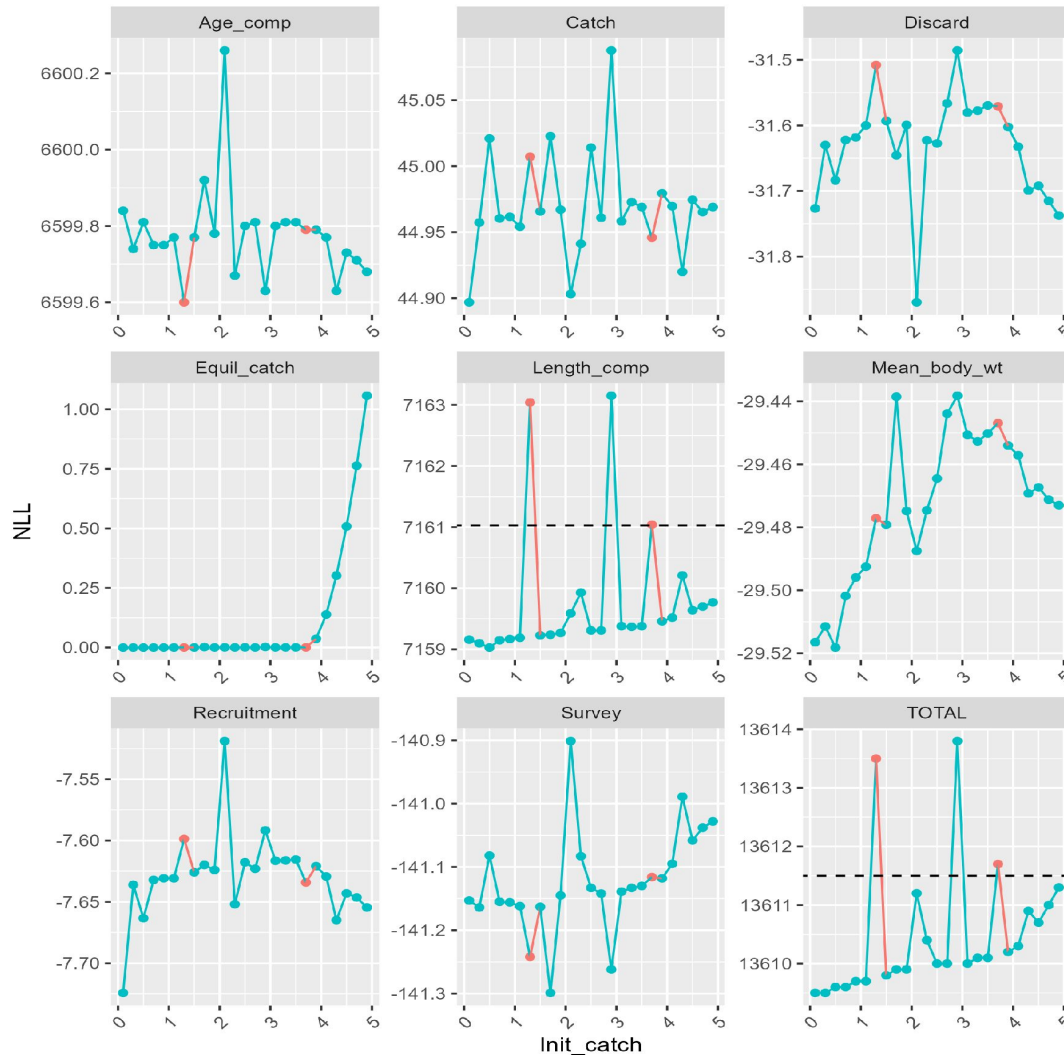
Start year – approach for initial conditions

A search for optimal initial equilibrium catches was done by taking the following steps:

- Each fleet's initial equilibrium catches were set to the mean landings (2020-2024) and initial equilibrium F for the Shrimp Bycatch fleet was set to the average estimate from the AP model
 - 1963 start = 0.084 (1958-1962 average)
 - 1981 start = 0.129 (1977-1981 average)
- Each initial catch (+ the Shrimp Bycatch initial F) was multiplied by a series of scalars ranging from 0.1 to 4.9 in 0.2 increments and the model was re-run
- A likelihood profile of each model run was plotted to determine the most likely scalar (i.e. lowest negative log likelihood) given the information present in the model

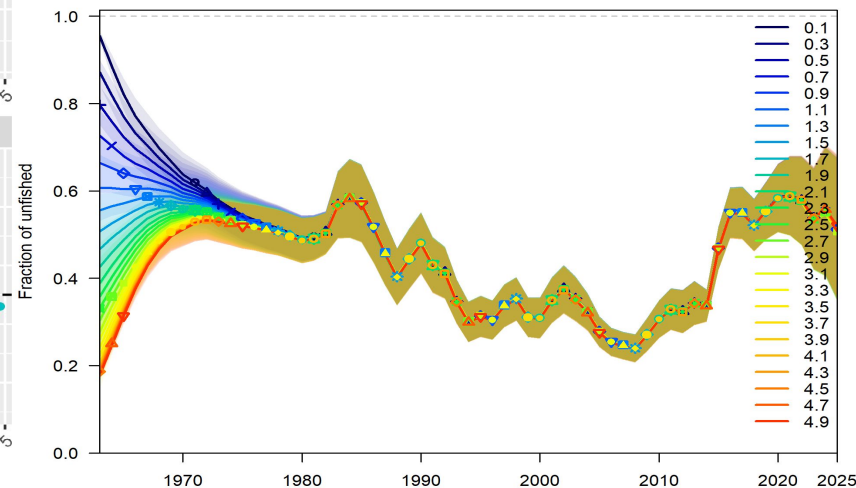
1963 start

- No support for a specific scalar value
- Initial conditions very uncertain but ultimately little difference in most recent years



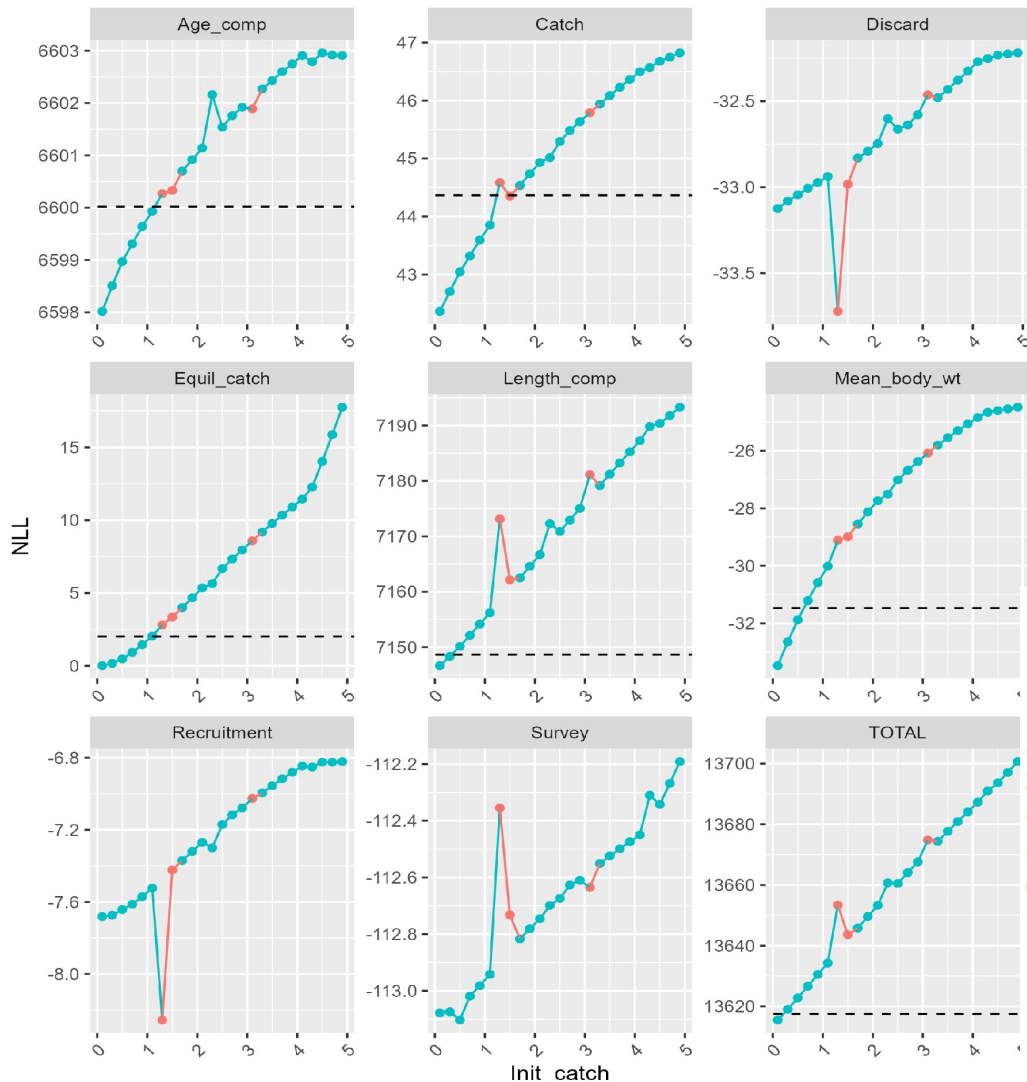
Converged

— No
— Yes



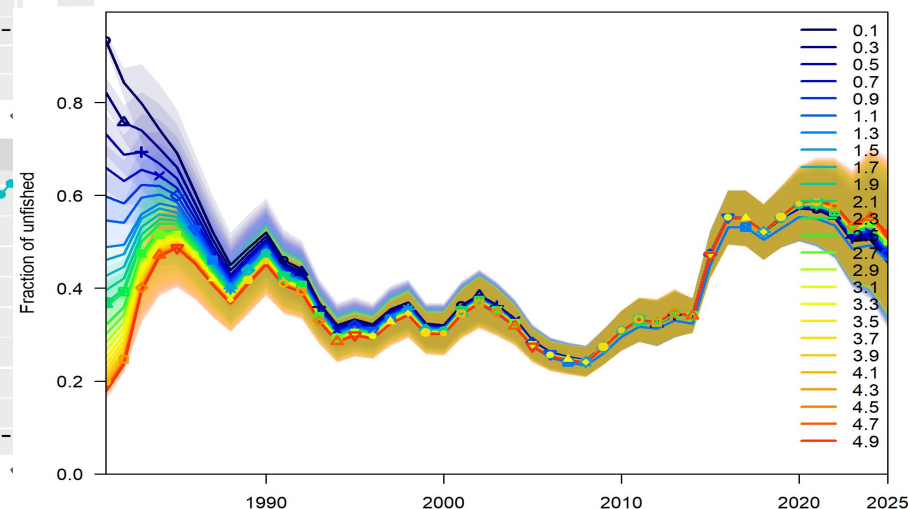
1981 start

- Support for lowest scalar value
- Initial conditions still uncertain, but ultimately little difference in most recent years



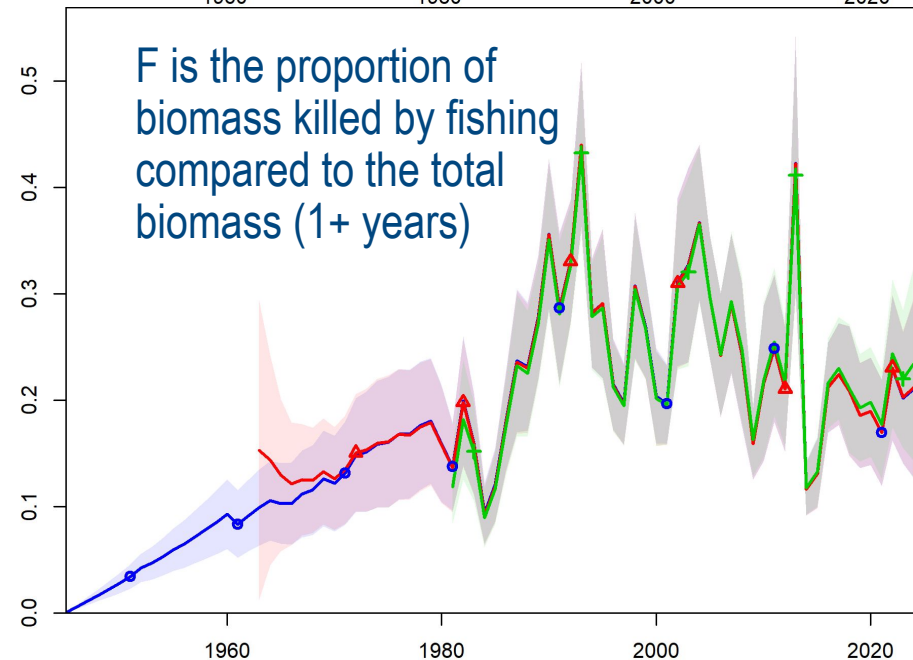
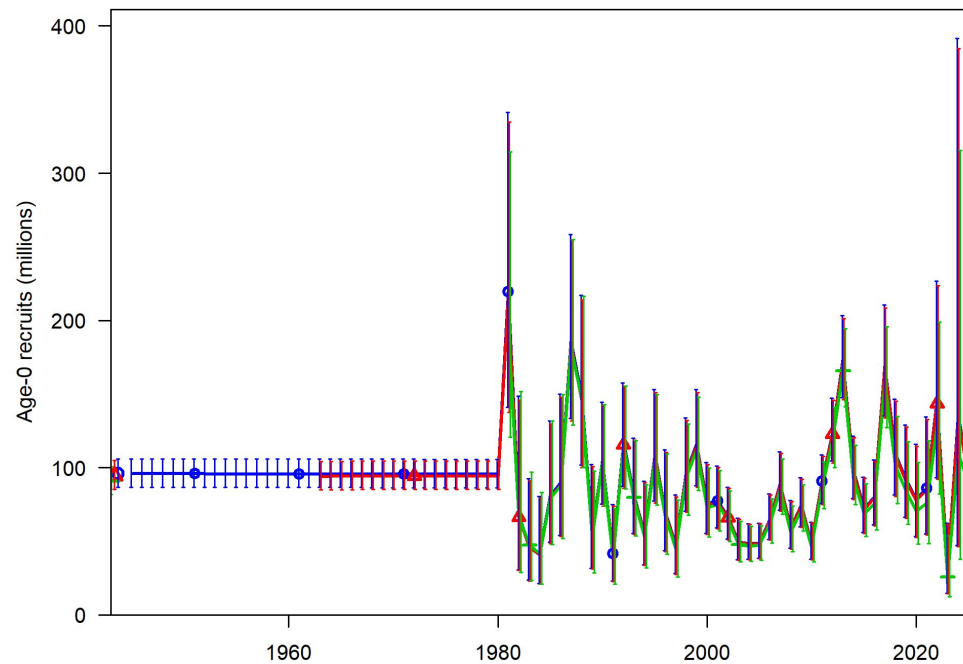
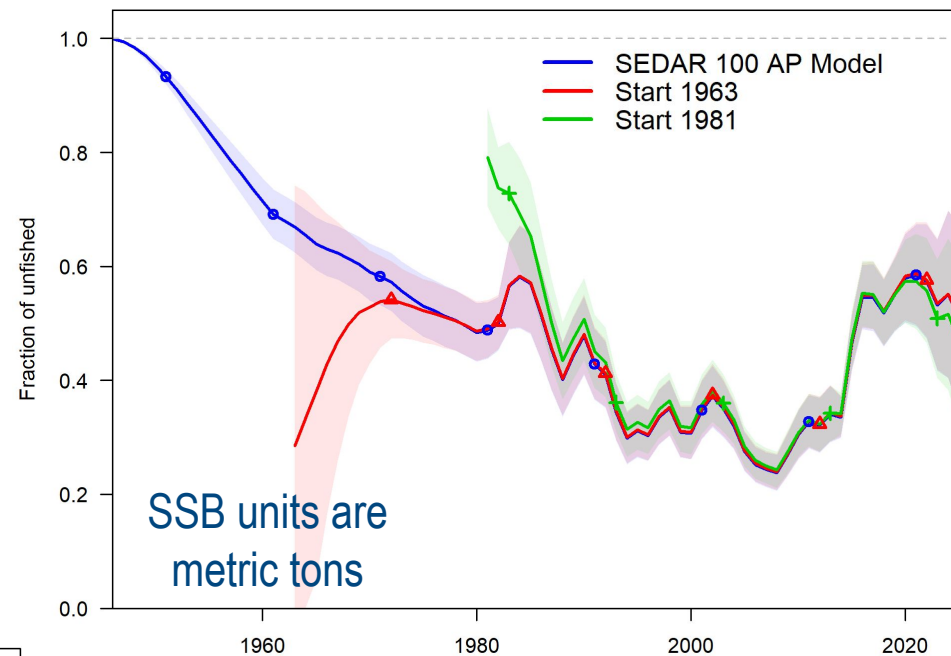
Converged

- No
- Yes



Start year

- Initial conditions for the models very uncertain in 1963, less so in 1981
- Trends remain very similar in recent years



AP Model Conclusions

- SEDAR 100 AP Model incorporates the best available data, addressed the TORs and fixed modeling issues evident in the SEDAR 43 Standard Model
- Diagnostics show an improved model with better fits and help identify key areas of uncertainty
- Sensitivity analyses highlighted how key uncertainties affected the assessment outcome
 - Most showed minimal impact on assessment outcome

Outline

- Data Review
 - Stock definition
 - Assessment history
 - Regulations
 - Key data decisions
 - Life history
 - Removals
 - Size compositions
 - Age compositions
 - Indices of abundance
 - Survey length composition
- Assessment model
 - Model building
 - AP Model configuration
 - AP Model results
 - AP Model diagnostics
 - AP Model sensitivities
 - **AP Model projections**

TORs - projections

- Use the following status determination criteria (SDC):
 - MSY proxy = yield at F_{MSY} or proxy ($F_{30\%SPR}$, Amendment 48)
 - Provide model outputs using alternative MSY proxies as justified by the life history and data available for the stock.
 - If overfished, MSY proxy = $F_{Rebuild}$
 - $MSST = 0.5 * SSB_{MSY}$ (Amendment 44)
 - $MFMT = F_{MSY}$ and $F_{Rebuild}$ (if overfished)
 - $OY = 90\%$ of MSY or proxy (Amendment 48)
 - 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 and spawning stock biomass 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

Projection settings

Parameter	Value	Comment
Relative F		Not used due to allocations below
Selectivity	Average from 2022-2024	Fleet specific selectivity estimated over terminal three years of model
Retention	Average from 2022-2024	Fleet specific retention estimated over terminal three years of model
Recruitment	Average recruitment	Derived from the Beverton-Holt stock-recruit relationship with steepness fixed at 0.99
Interim Landings (2025-2027)	201.64 numbers (Recreational) 19.33 metric tons (Com Vertical Line) 3.62 metric tons (Com Longline)	Used 3-year average of landings (2022-2024)
Shrimp bycatch F	0.034	Average F over 2022-2024
Allocation Ratio	21:79*	Commercial:Recreational

*Allocation ratio based on MRFSS data, not updated to MRIP-FES units yet



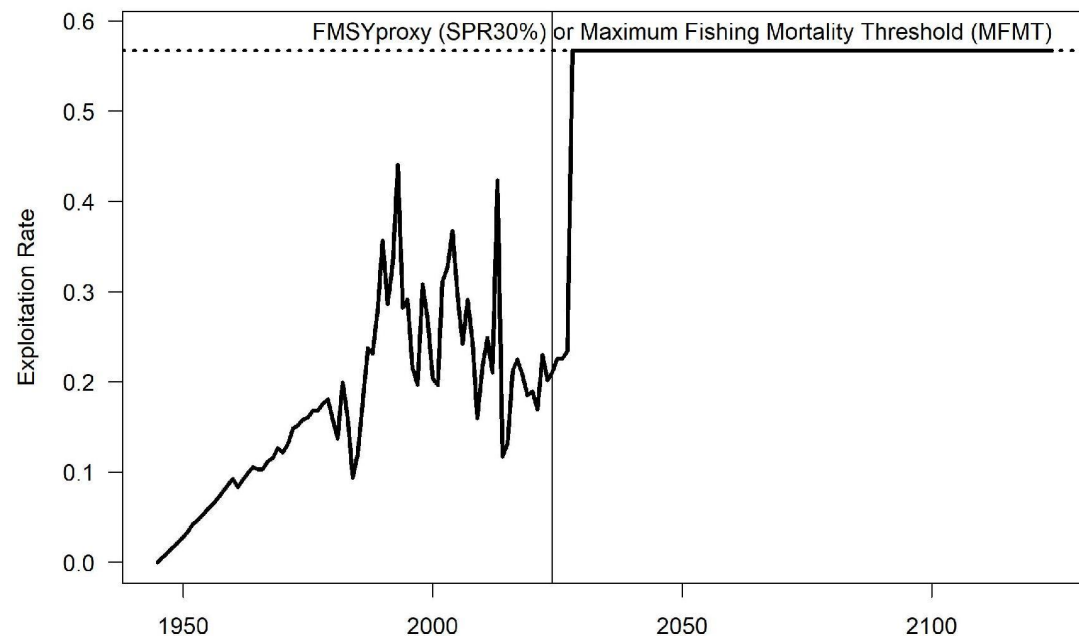
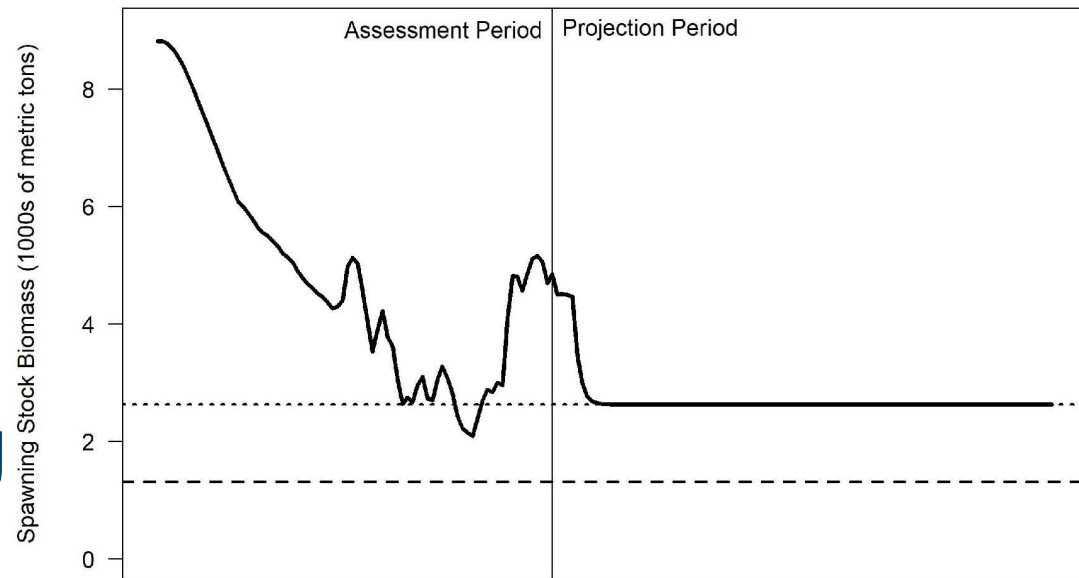
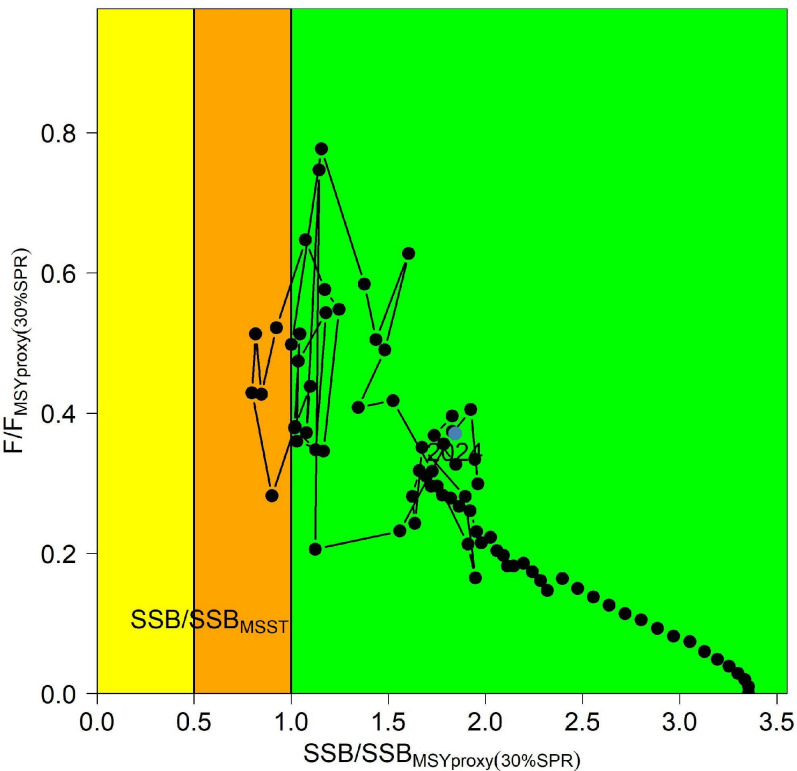
MSRA Benchmarks & Reference Points: 30%SPR

Criteria	Definition	Value
Steepness	Steepness of the Beverton-Holt stock-recruit relationship (fixed)	0.99
R_0	Unfished recruitment (1,000s)	95,750
Generation Time	Fecundity-weighted mean age	7.12
SSB_0	Unfished spawning stock biomass (mt)	8,816
Mortality Rate Criteria		
$F_{MSYproxy}$	Equilibrium F that achieves 30%SPR	0.567
MFMT	$F_{MSYproxy}$	0.567
$F_{Current}$	Geometric mean of the last 3 years of the assessment ($F_{2022-2024}$), including shrimp bycatch fleet	0.214
$F_{Current}/MFMT$	Current stock status based on MFMT NOT OVERFISHING	0.377
Biomass Criteria		
$SSB_{MSYproxy}$	Equilibrium SSB at $F_{30\%SPR}$	2,629
MSST	$0.5 * SSB_{30\%SPR}$	1,315
$SSB_{Current}$	SSB in 2024	4,849
$SSB_{Current}/SSB_{MSYproxy}$	Current stock status based on $SSB_{30\%SPR}$ (Equilibrium)	1.84
$SSB_{Current}/MSST$	Current stock status based on MSST NOT OVERFISHED	3.69
$SSB_{Current}/SSB_0$	SSB ratio in 2024	0.55



Stock Status

- Gulf Gray Triggerfish is **not overfished nor undergoing overfishing**



Comparison of equilibrium yields

*mp wwt = million
pounds whole weight

Assessment	Model	mp wwt*
SEDAR 9 (SEDAR 2006)	State Space Age-Structured Production Model (SS-ASPM)	1.638
SEDAR 9 Update (SEDAR 2011)	State Space Age-Structured Production Model (SS-ASPM)	0.984
SEDAR 43 (SEDAR 2015)	Stock Synthesis	2.230
SEDAR 100 AP Model	Stock Synthesis	1.014
<u>SEDAR 100 Sensitivity Runs</u>		
Reduced Recreational Removals by 40%	Stock Synthesis	0.718
No Shrimp Bycatch	Stock Synthesis	0.785

- Lower equilibrium yields if recreational removals are lower in magnitude or if shrimp bycatch is excluded

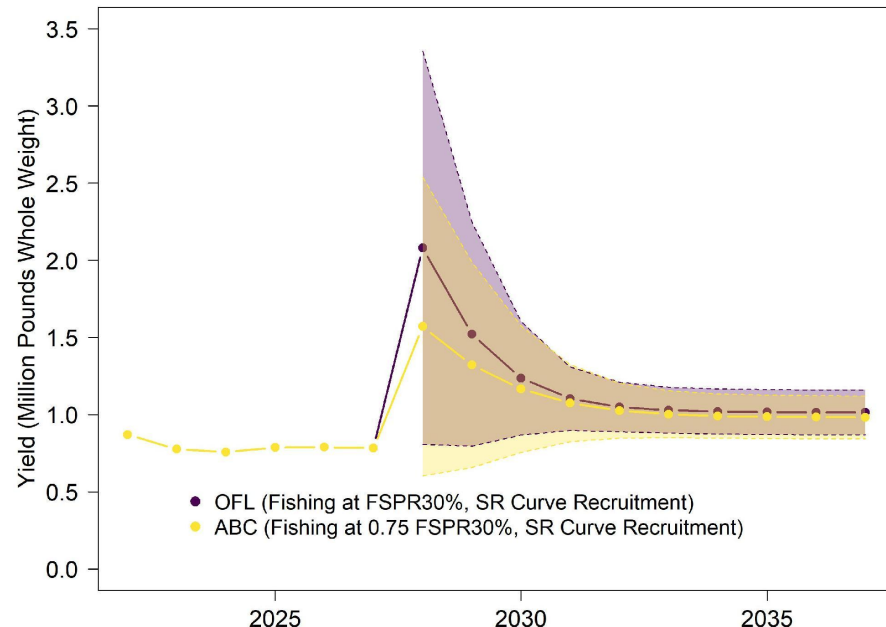
OFL projection: $F=F_{30\%SPR}$

OY = 90% of MSY or proxy (Amendment 48)

Year	Recr (1000s)	F	F/F _{SPR30}	SSB (mt)	SSB/SSB _{SPR30}	SSB/MSST	SSB ratio	OFL (mp wwt)	OY (mp wwt)
2028	95,512	0.567	1	4,463	1.697	3.394	0.506	2.081	1.872
2029	95,373	0.567	1	3,456	1.314	2.629	0.392	1.522	1.369
2030	95,275	0.567	1	2,978	1.133	2.265	0.338	1.236	1.113
2031	95,222	0.567	1	2,770	1.053	2.107	0.314	1.104	0.994
2032	95,198	0.567	1	2,686	1.021	2.043	0.305	1.05	0.945

- Assuming mean recruitment (steepness = 0.99)

Years	Constant Catch
Three (2028-2030)	1.613 mp wwt
Five (2028-2032)	1.399 mp wwt

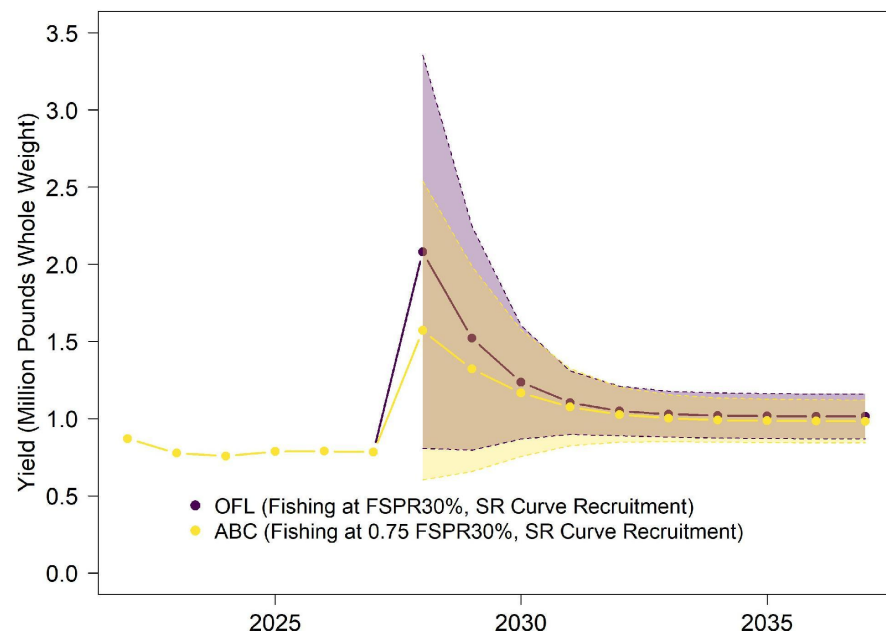


ABC projection: $F=0.75 \cdot F_{30\%SPR}$

Year	Recr (1000s)	F	F/ F_{SPR30}	SSB (mt)	SSB/ SSB_{SPR30}	SSB/MSST	SSB ratio	Yield (mp wwt)
2028	95,512	0.425	0.75	4,463	1.697	3.394	0.506	1.571
2029	95,438	0.425	0.75	3,861	1.468	2.937	0.438	1.322
2030	95,383	0.425	0.75	3,511	1.335	2.671	0.398	1.166
2031	95,349	0.425	0.75	3,321	1.263	2.526	0.377	1.075
2032	95,330	0.425	0.75	3,226	1.227	2.454	0.366	1.026

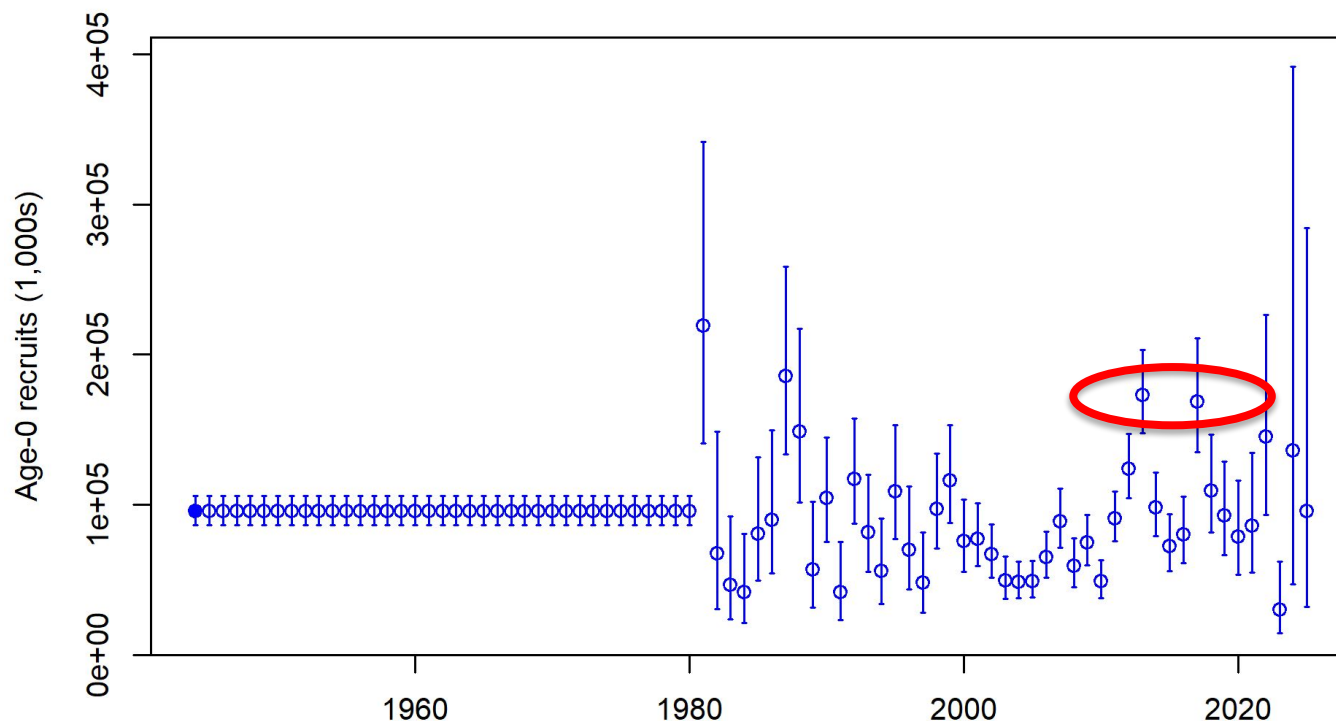
- Assuming mean recruitment (steepness = 0.99)

Years	Constant Catch
Three (2028-2030)	1.353 mp wwt
Five (2028-2032)	1.232 mp wwt



Considerations for projection settings

- Any reason to deviate from using average recruitment in projections?
 - Recent recruitment leads to an above average mean



Research Recommendations



Research Recommendations

Age and Growth

- Investigate methods to better collect age structure samples randomly and systematically from all fishing sectors including surveys
- Continue collaboration with ageing facilities throughout the Gulf and South Atlantic. These efforts will include the annual reading of references sets for Gray Triggerfish and other reef fish, and annual meetings to review the interpretation of ageing structures and the timing of annual band deposition
- Explore epigenetic ageing to potentially improve age estimates

Natural Mortality

- Explore more direct approaches to estimating natural mortality (e.g., Mark-recapture approaches (conventional, telemetry, or close-kin))
- Explore ways to better reflect uncertainty around the mortality at age vector

Reproduction

- Continue data collection for maturity and fecundity
- Update maturity-at-age estimates to see whether the age data updates have changed our understanding of maturity

Discard Mortality

- Continue data collection from observer programs or electronic monitoring programs (e.g., Roberts and Neidig 2019 [SEDAR62-WP10]), particularly to get a better handle on discard mortality for the commercial fleets

Shrimp Bycatch

- Estimates of shrimp bycatch are highly uncertain and considered best available in the interim; further investigation is needed once observer data allow more advanced approaches for estimation

Selectivity and Catchability

- Further investigate and quantify changes in selectivity/catchability through time to improve fit to the length and age composition

Surveys

- Increase collection of length and age information for compositions
- Continue to improve upon standardized indices from the video survey to account for survey design changes through time and space to ensure trends are representative of relative abundance

Sargassum

- Improve our understanding of how sargassum affects Gray Triggerfish recruitment and which life stages are most affected
- Develop indices (with uncertainty estimates) to enable hypothesis testing of environmental linkages within the assessment model

Thank you for your attention!

Questions?

The SEDAR 100 Assessment would not have been possible without the efforts of the numerous SEFSC, Southeast Regional Office (SERO), and Gulf Council staff along with the many state, academic, and research partners involved throughout the Gulf listed as data providers in Section 2 of the SAR. 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) and Sustainable Fisheries Division (SFD), NOAA SEFSC Panama City Laboratory, NOAA SEFSC Mississippi Laboratories, NOAA SEFSC Beaufort Laboratory, FWRI, and the Gulf States Marine Fisheries Commission. We are especially grateful to the Panama City Life History team and other ageing partners for their diligent efforts improving the age data for this assessment, and to the shrimp bycatch team for their thorough analyses and assistance throughout the assessment.

