SEDAR 94: Florida Hogfish

West Florida Shelf

Gulf Council SSC Meeting

Christopher E. Swanson,

Heather Christiansen, and Dustin Addis

USF | FWC-FWRI Marine Fisheries Research

Tampa, Florida 9/29/2026

Outline

- Management History
- Data Input
- Model Configuration
- Model Results
- Model Diagnostics
- Model Uncertainty
- Stock Status Overview
- Bridge Building

Fishery Management Units

SAFMC S37 Snapper Grouper Amendment 37

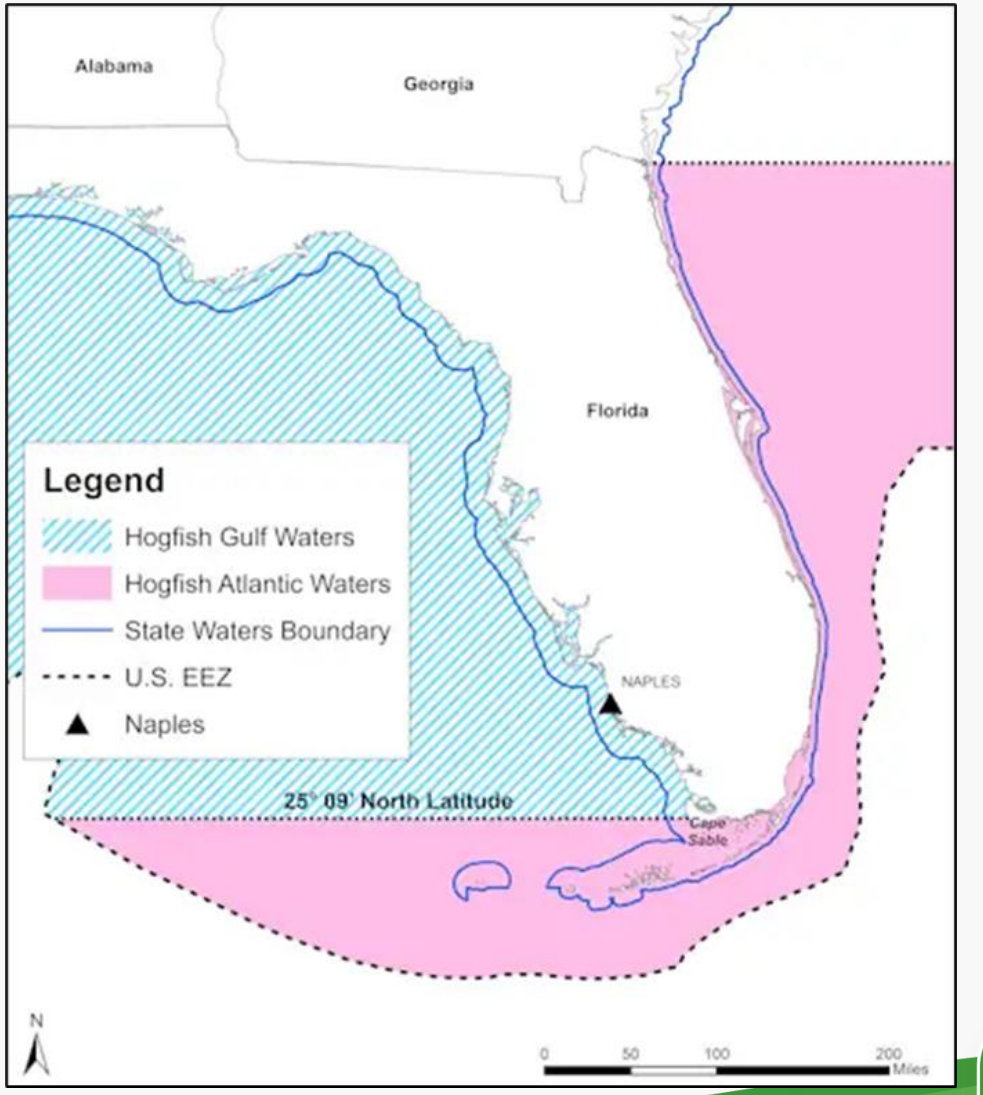
- Stock boundary between Gulf/Atlantic
  - 25 degrees 9 min N Lat (Cape Sable).

Gulf Council Reef Fish Amendment 43

- Revised FMU to be West Florida Shelf stock

FL FWC

- Participates in management within its state waters (0 – 10 miles)



Gulf Management

Size Limits

Federal (10 – 200 Miles)

- 12” (305 mm) FL
  - (11/1999 – 08/2017)
- 14” (356 mm) FL
  - Gulf Reef Fish Amendment 43
  - (08/2017 – present)

FL State Waters (0 – 10 Miles)

- 12” (305mm) FL
  - (07/1994 – 08/2017)
- 14” FL in Gulf
  - (08/2017 – present)

Trip Limits

Commercial

- None

Recreational

- 5 fish per person per day
  - (11/1999 – present)

Current ACL

Combined

- 150,400 lbs. whole weight
  - MRIP-CHTS units

Assessment History

SEDAR 37 (2014) and S37 Update (2017)

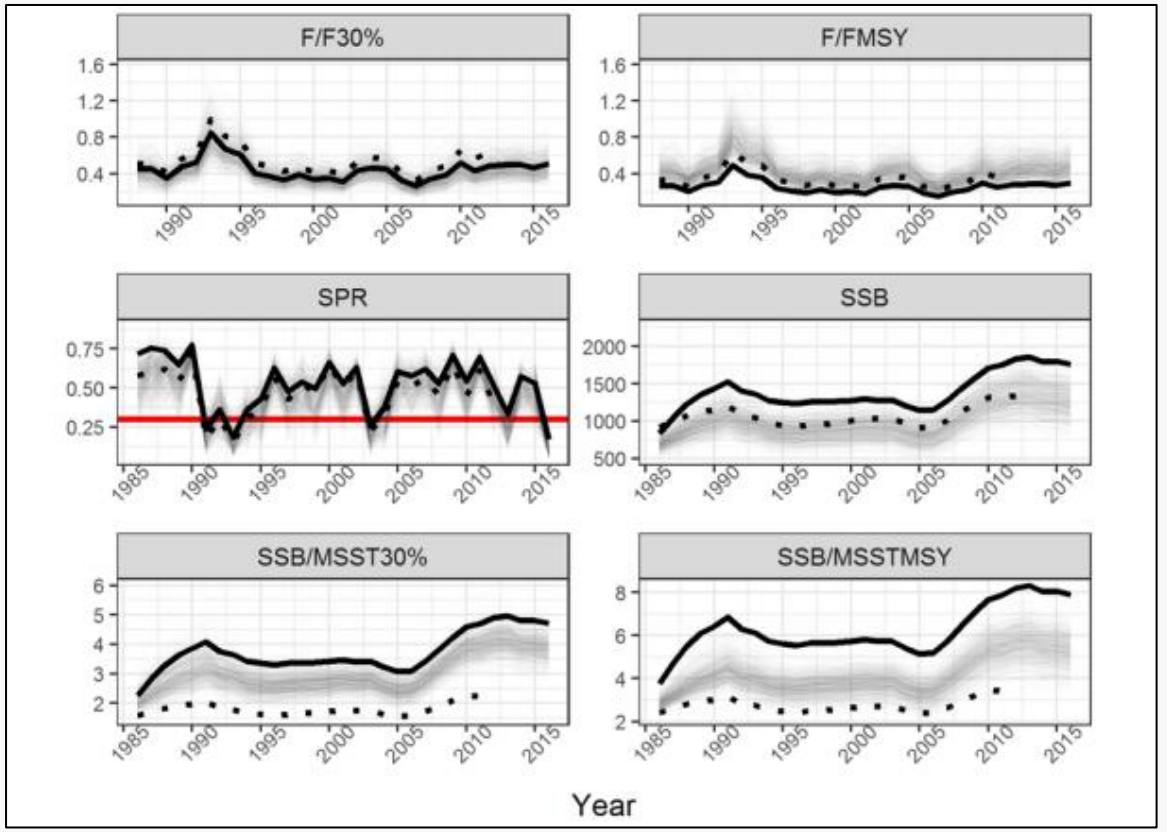
- Conducted in Stock Synthesis v3.24

WFS (Update): 1986 – 2016
5 fleets: • Commercial spear (dome) • Commercial hook-and-line (flat-top) • Commercial trap (dome) • Recreational spear (dome) • Recreational hook-and-line (dome)
8 IOAs • 4 FD – Selectivity linked to fleets • 4 FI – Dome shaped selectivity
Notes: • ***Evidence of misspecification via strong retrospective pattern***

Stock Status

Not overfished

Not undergoing overfishing



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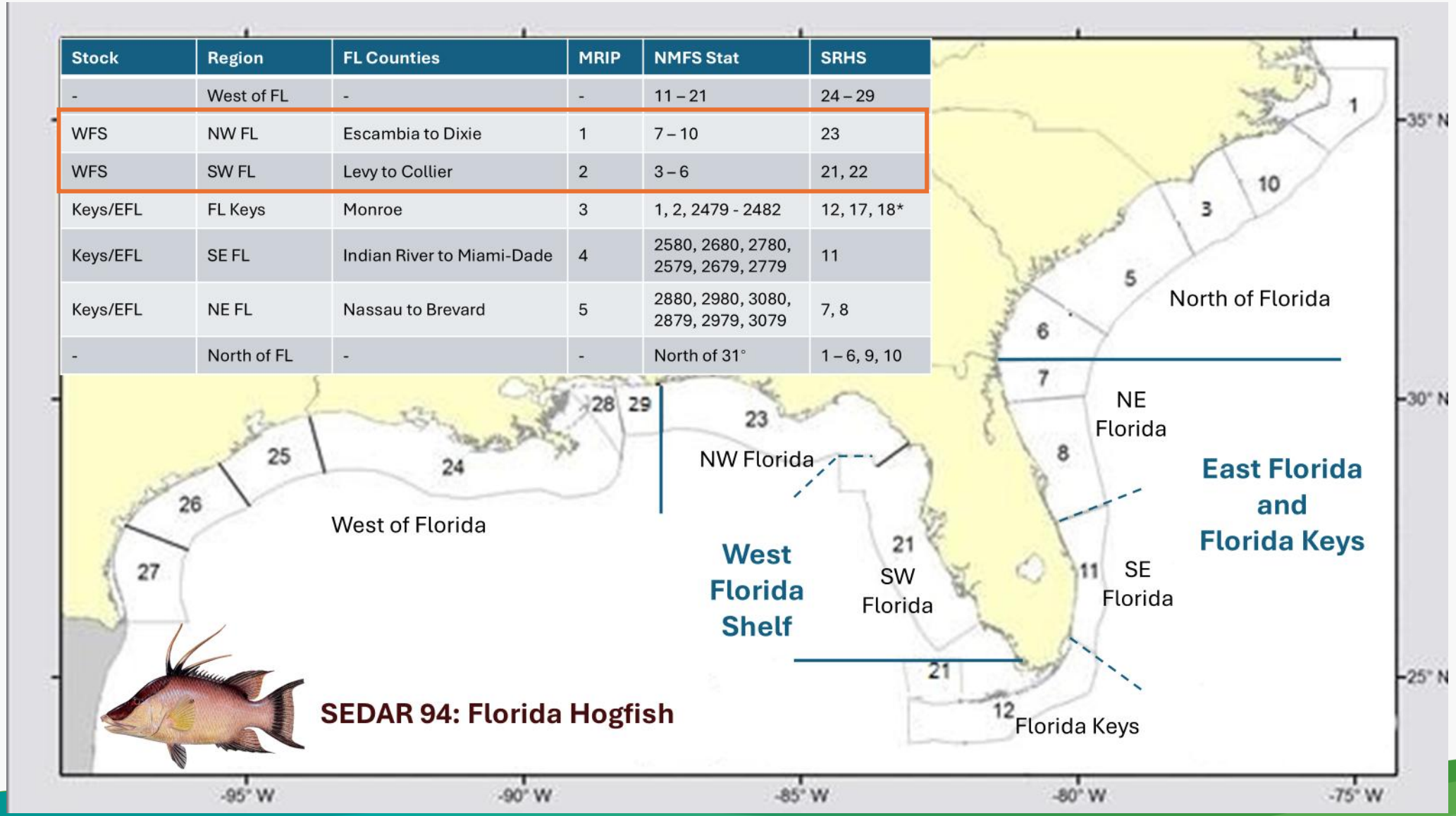
Data: Life History

Regions of Florida

Stock	Region	FL Counties	MRIP	NMFS Stat	SRHS
-	West of FL	-	-	11 – 21	24 – 29
WFS	NW FL	Escambia to Dixie	1	7 – 10	23
WFS	SW FL	Levy to Collier	2	3 – 6	21, 22
Keys/EFL	FL Keys	Monroe	3	1, 2, 2479 - 2482	12, 17, 18*
Keys/EFL	SE FL	Indian River to Miami-Dade	4	2580, 2680, 2780, 2579, 2679, 2779	11
Keys/EFL	NE FL	Nassau to Brevard	5	2880, 2980, 3080, 2879, 2979, 3079	7, 8
-	North of FL	-	-	North of 31°	1 – 6, 9, 10

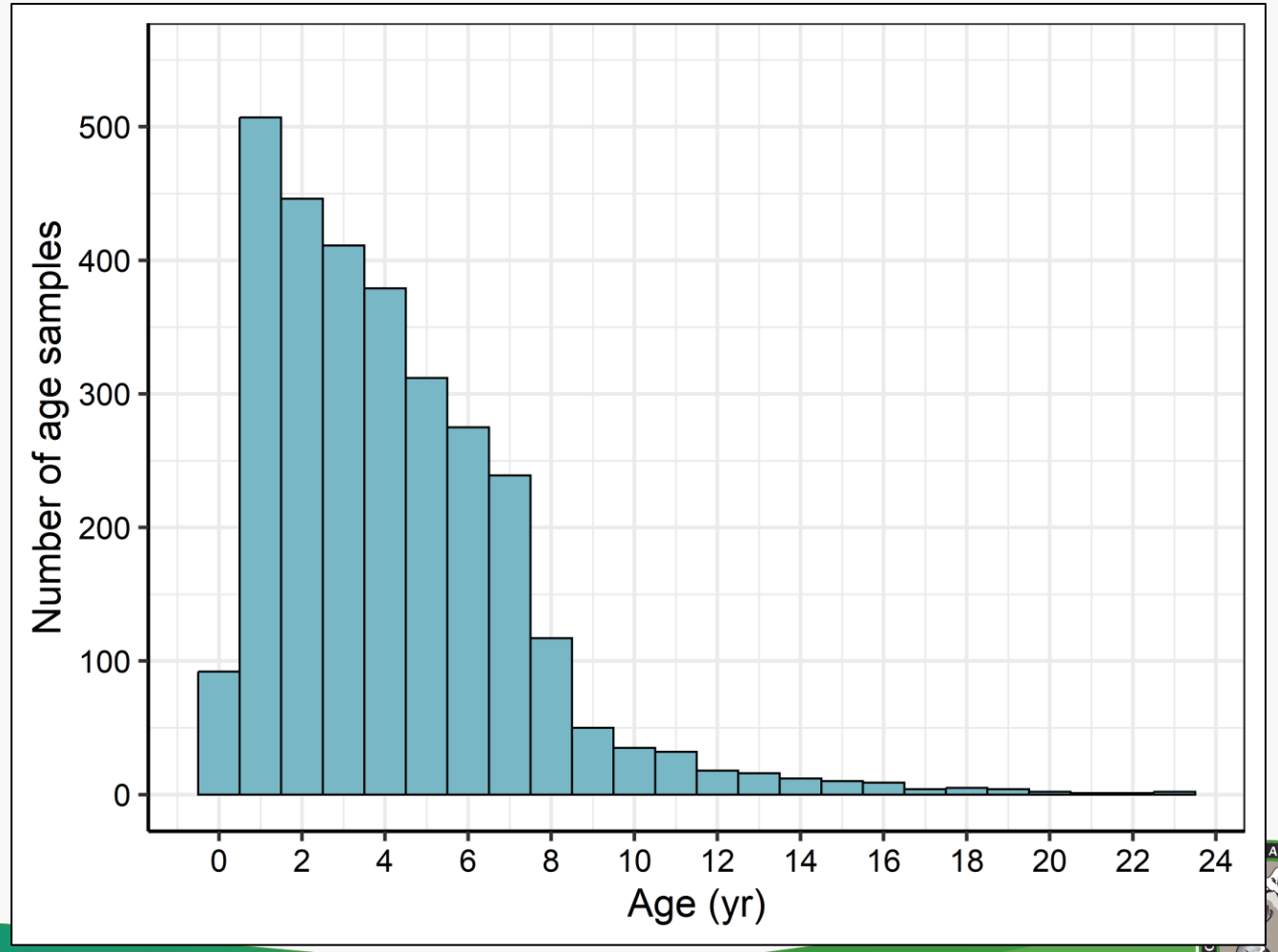


SEDAR 94: Florida Hogfish

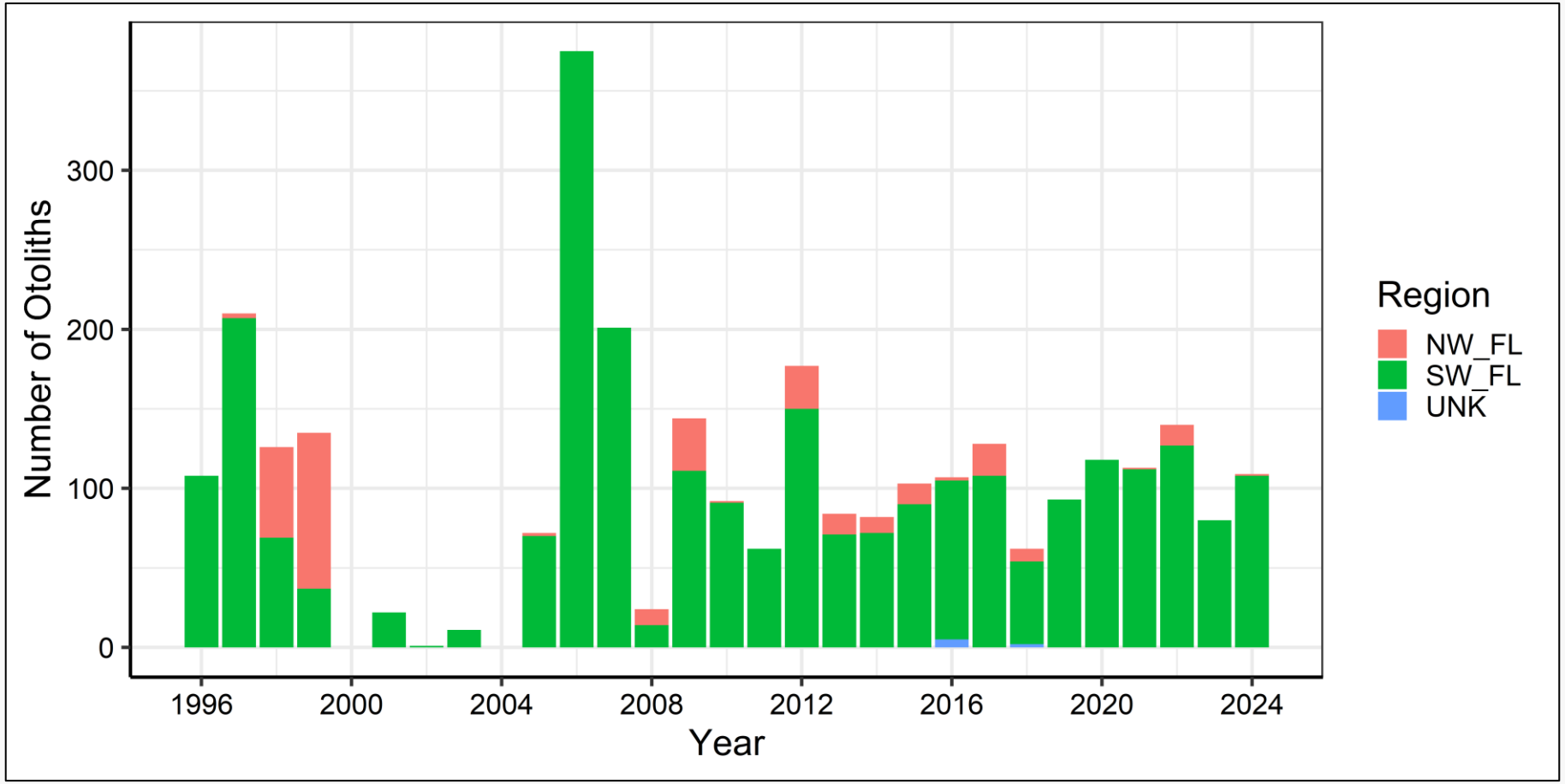
Otolith Samples: Overview

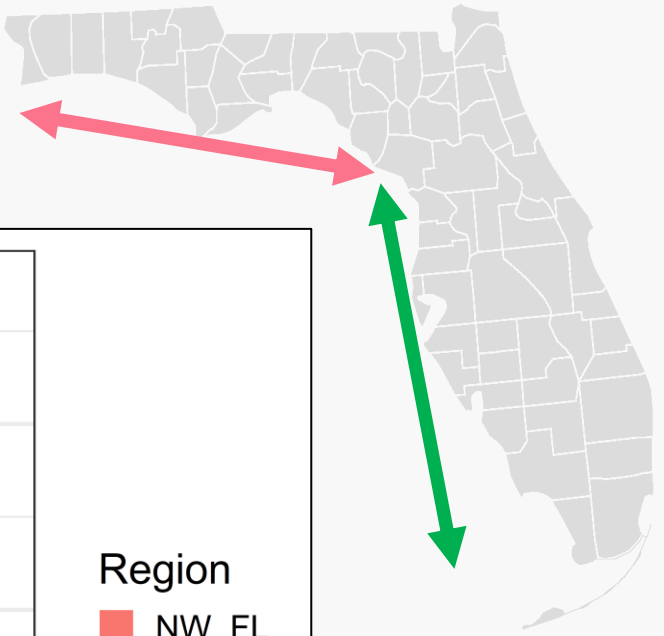
Quantile	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Age	0	1	1	1	1	2	2	2	3	3	4	4	4	5	5	6	6	7	8	10	23

- 27 years of data: **1996 – 2024**
- **2,979 otoliths**
- Maximum age **23 years**
  - No change from SEDAR 37
- 95% fish are <=10 years old
  - 29% of observed max age on WFS (23 yrs.)



Otolith Samples: Region

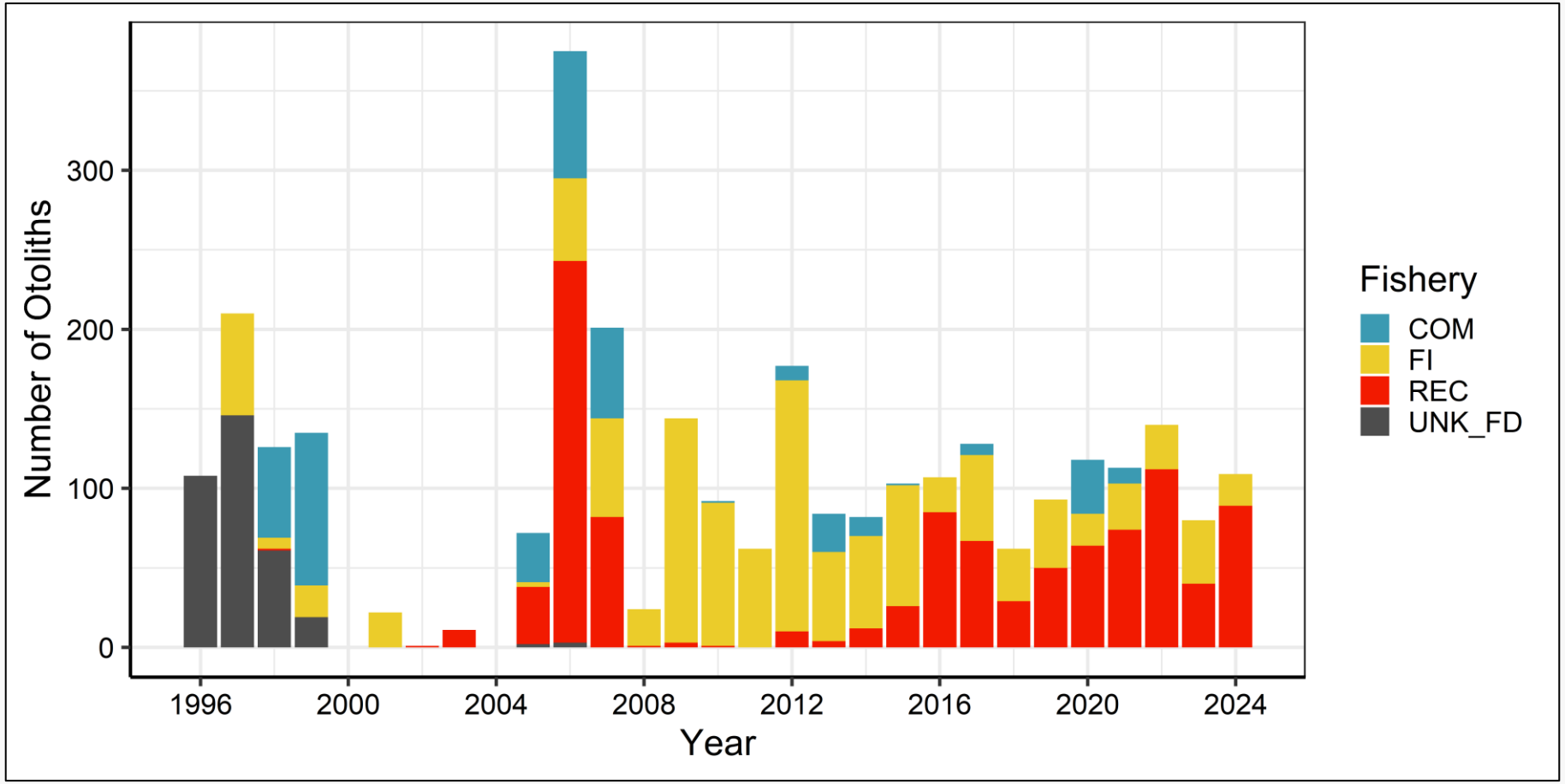




DW Report
Figure 2.13.3b

Region	N	%
NW FL	312	10.5%
SW FL	2660	89.5%

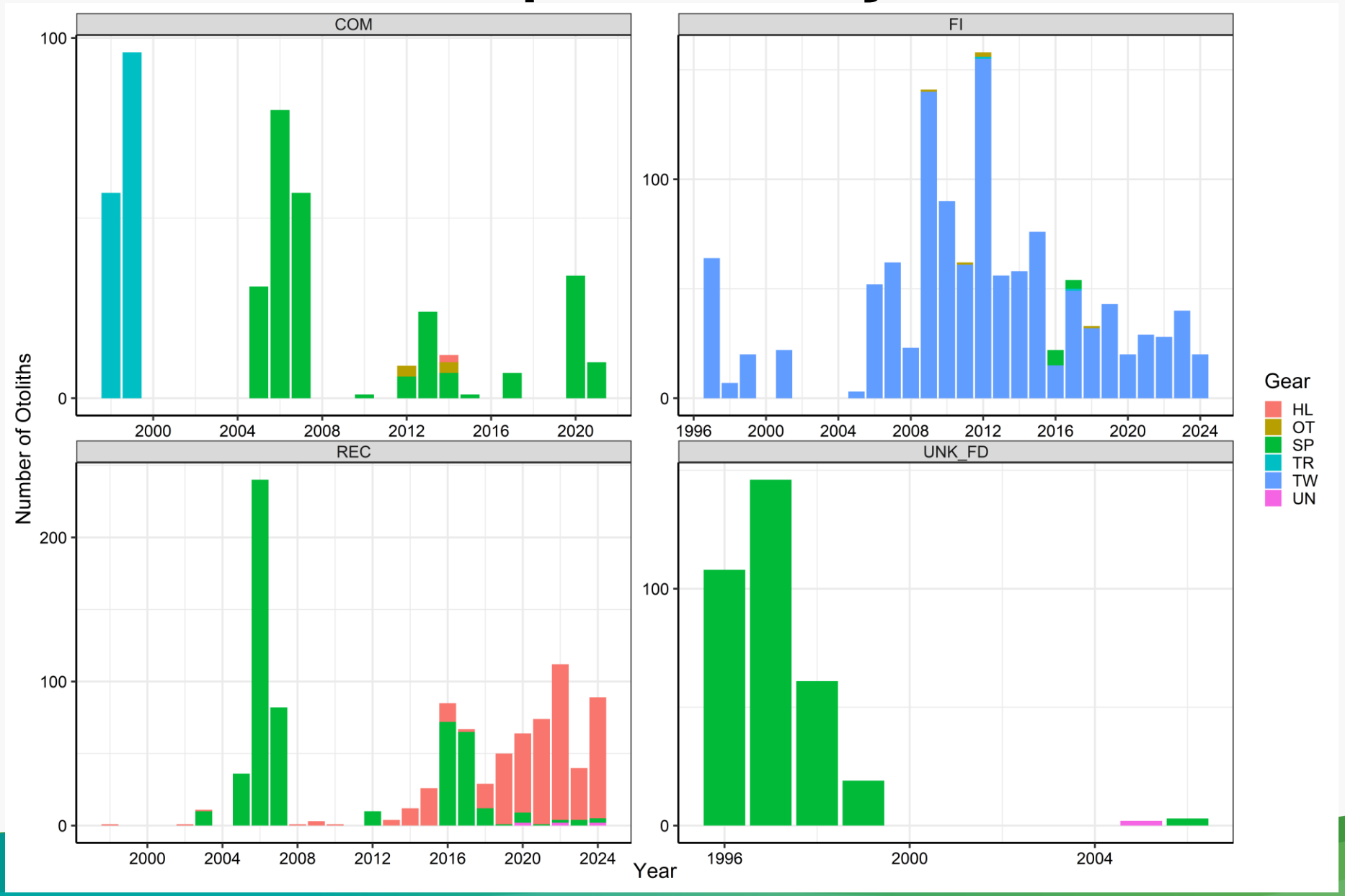
Otolith Samples: Fishery



DW Report
Figure 2.13.15a

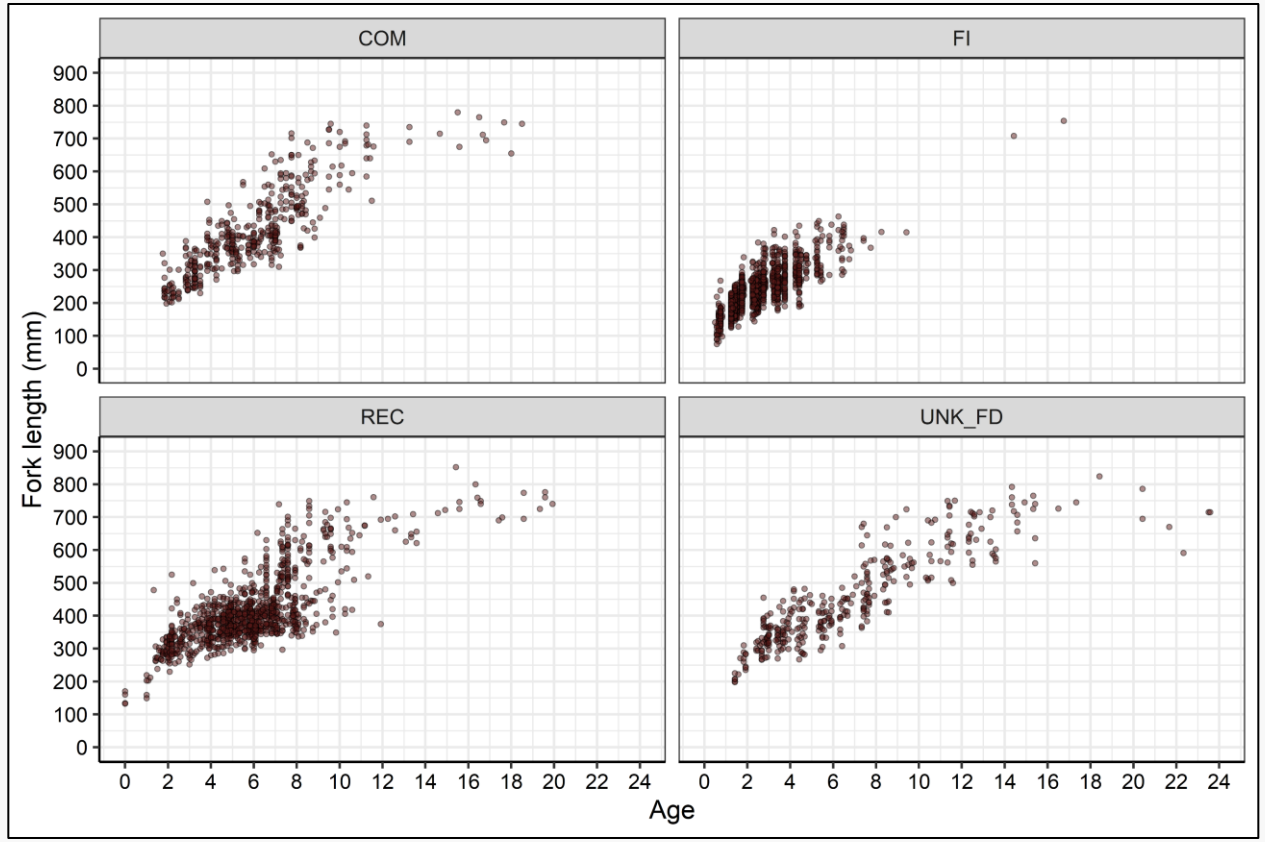
Fishery	n	%
Commercial	419	14.1
Recreational	1038	34.8
Fishery-Independent	1183	39.7
Unknown FD	339	11.4

Otolith Samples: Fishery and Gear

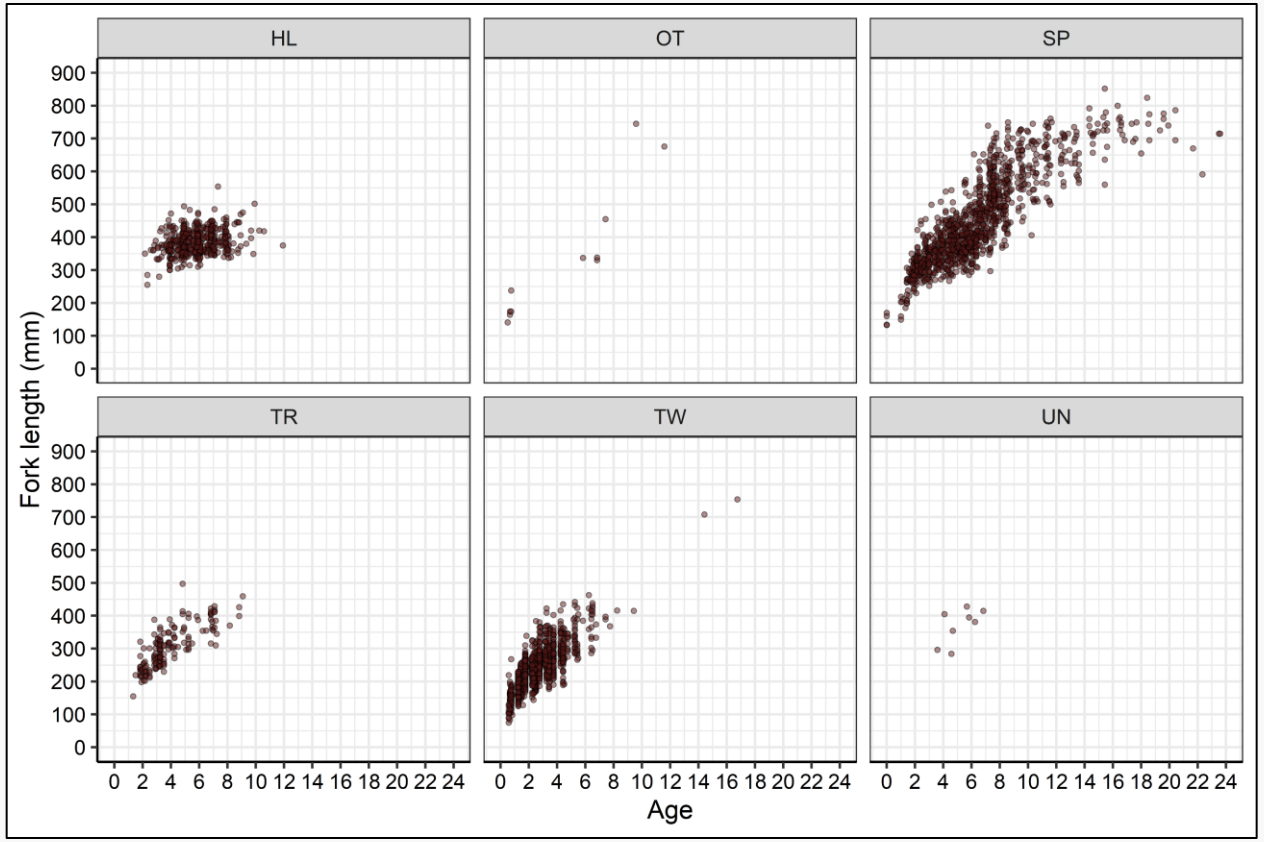


Length-at-age: Fishery and Gear

DW Report
Figure 2.13.34

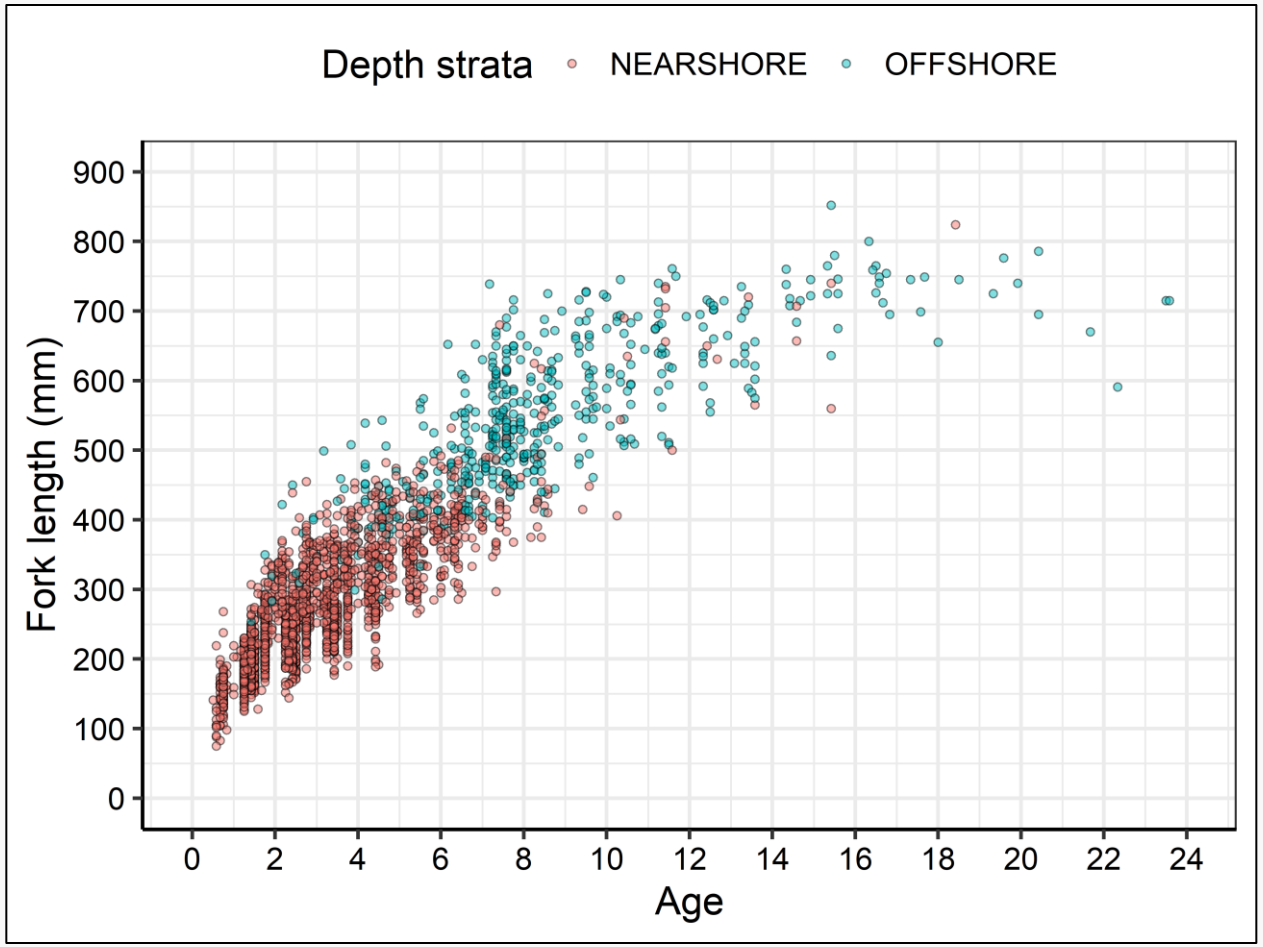


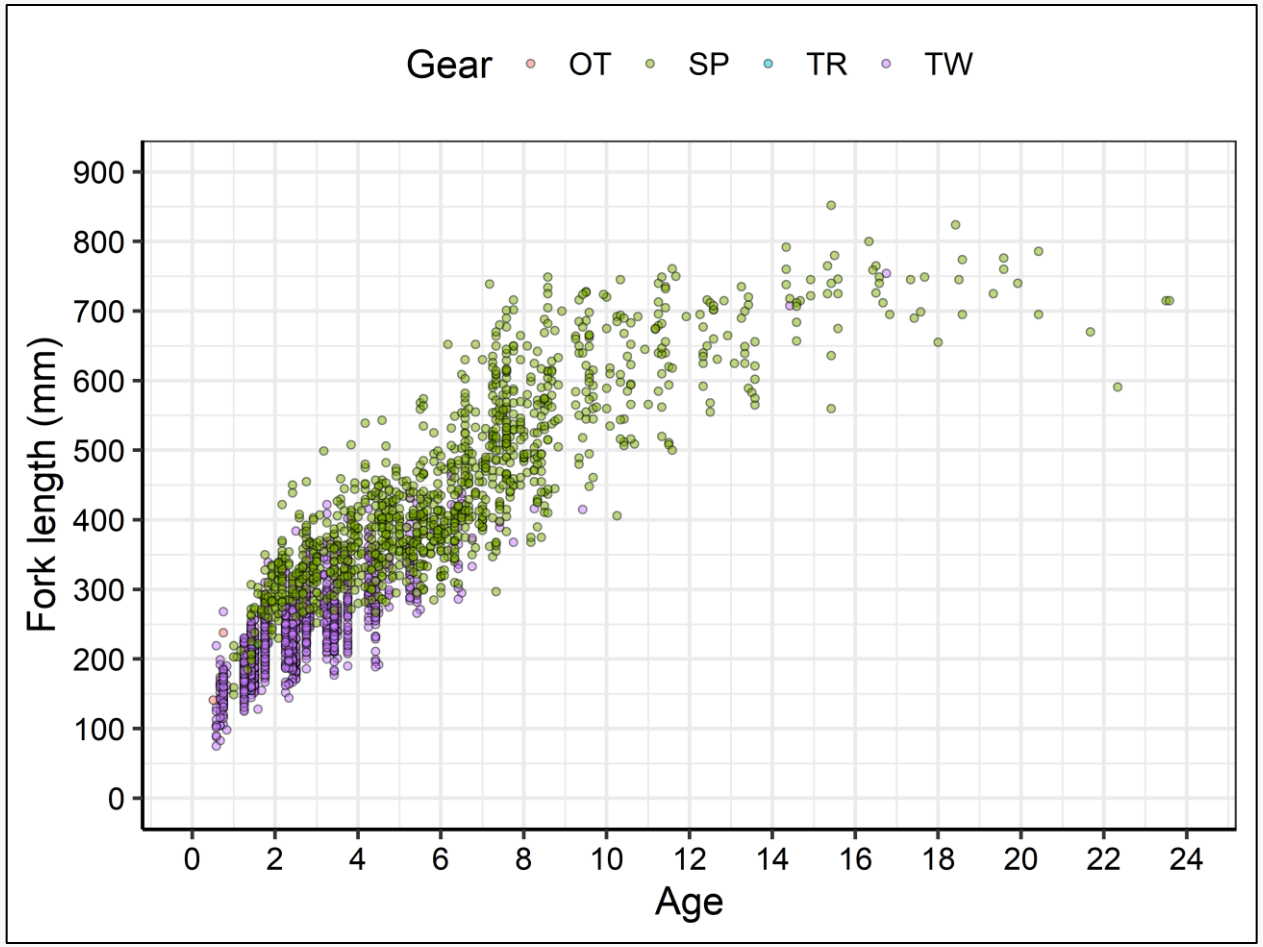
DW Report
Figure 2.13.35



Length-at-age: External Growth Model

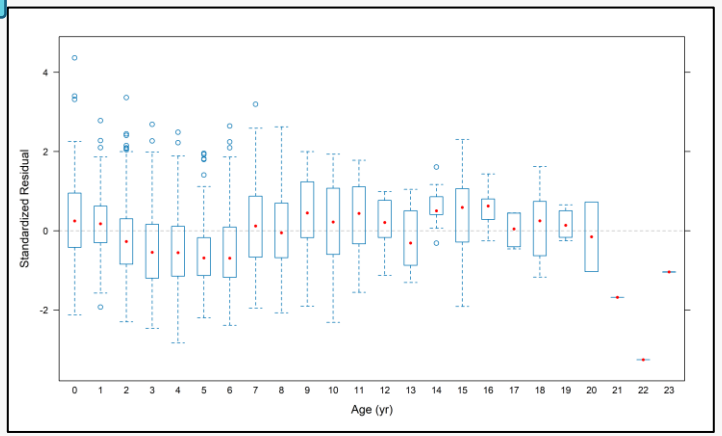
DW Report
Figure 2.13.36a-b





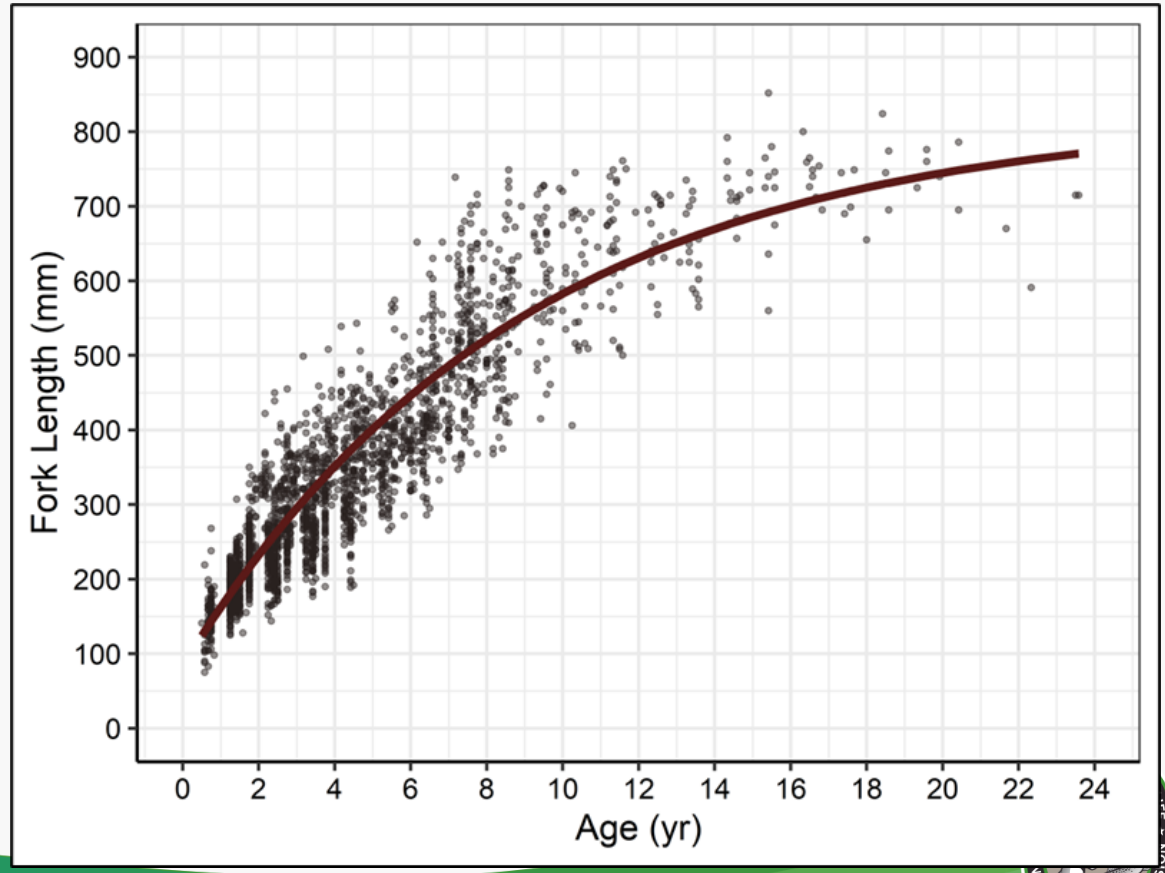
- Data isolated by spear gear plus any fishery-independent sources (predominantly spear and trawl gears)
  - n = 2,317 otoliths available
- Nearshore (<30 m) and offshore (>=30 m) depths (Collins and McBride 2011)

External Growth Model

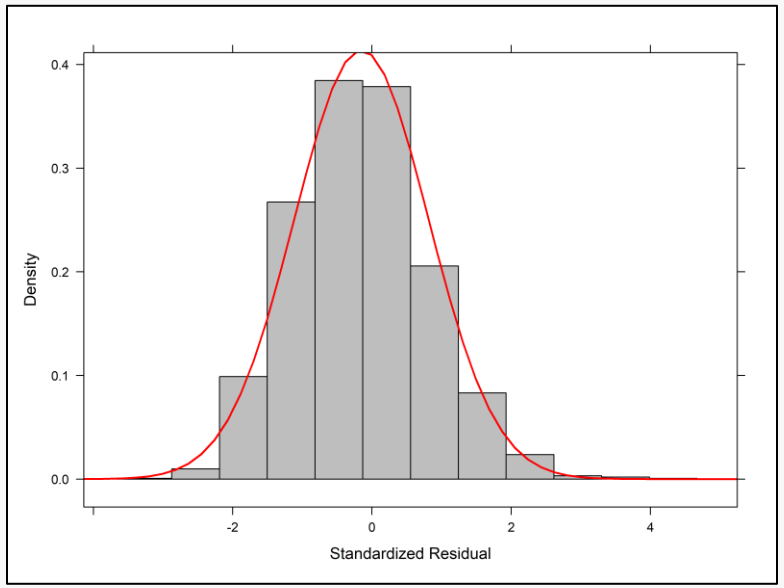


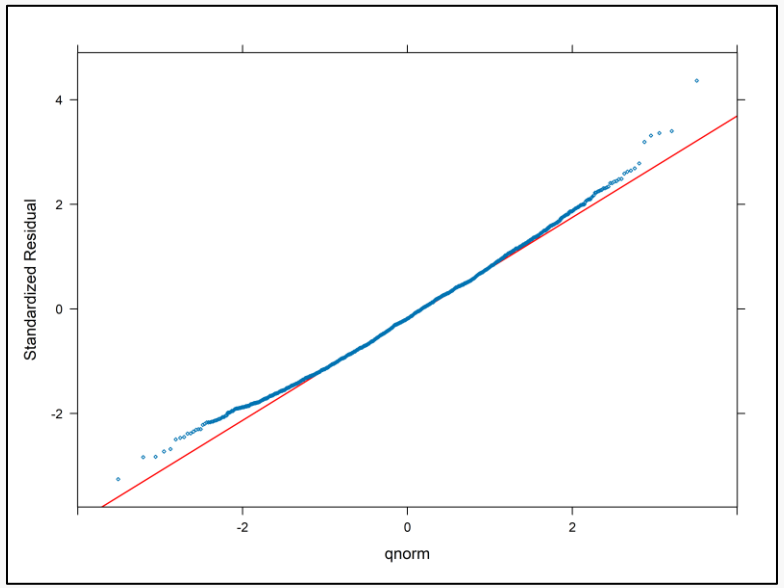
Growth model (n = 2,226)

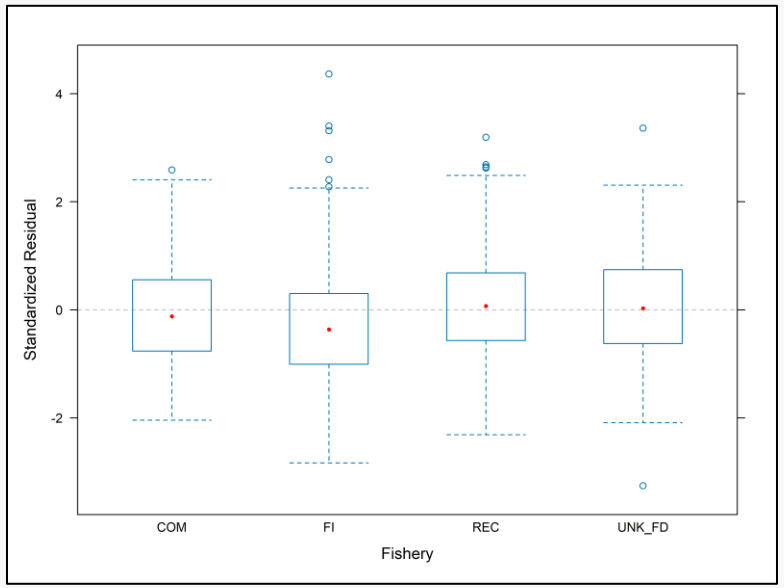
- Size truncated von Bertalanffy growth model (Diaz et al. 2004)
  - Gulf minimum size limits
  - L_∞ = 823 mm FL
  - k = 0.112
  - t_0 = -0.954
  - CV changes linearly with age
    - 0.20 – 0.07
  - Parameters used as initial values in assessment model
  - Fish are born female first, grow, transition to become male, and follow same growth function

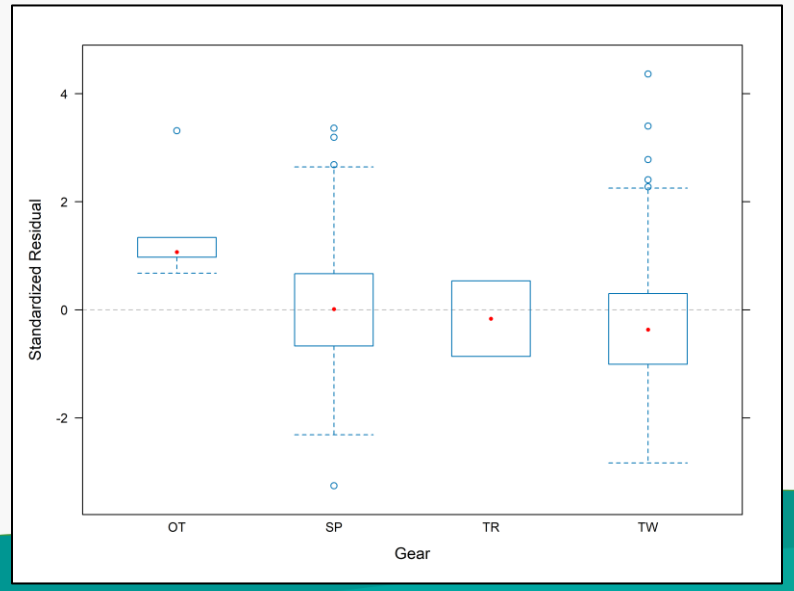


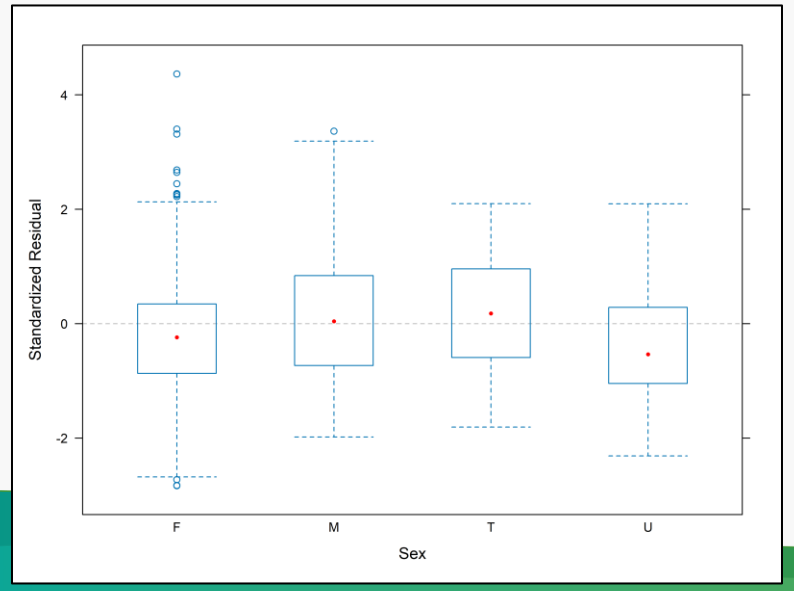
External Growth Model

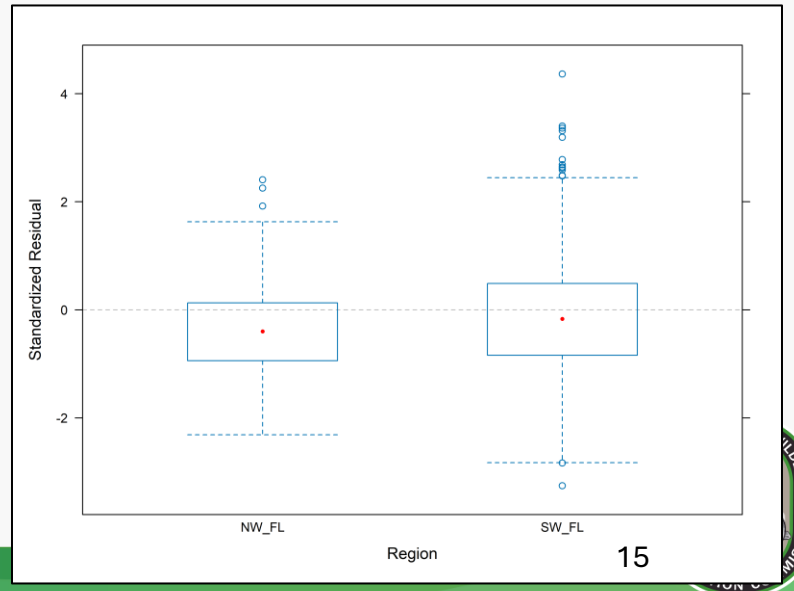










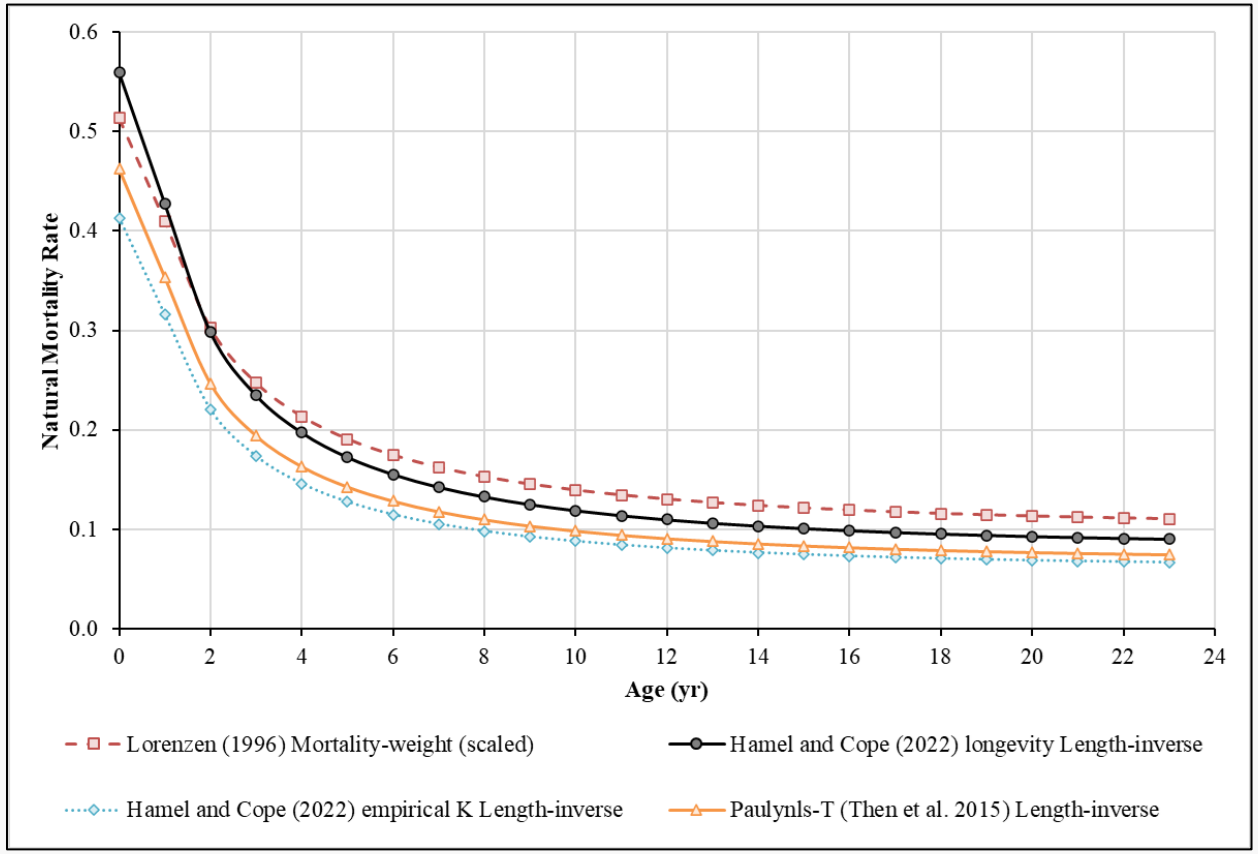


Natural Mortality

- Natural mortality inversely related to fish length

- **Lorenzen (2022)**
  - Longevity (max. age 23 yrs)
    - Hamel and Cope (2022) = 0.235 yr^{-1}
      - Reference age is 3 yrs (black circles)
      - Scaled between ages 3 – 23 yrs (*not pictured*)
- Lorenzen (1996)
  - Length-weight relationship
    - red squares
  - Explored as sensitivity run within assessment model
    - Converted to mortality-at-age via external growth model and treated as fixed vector

DW Report
Figure 2.13.39

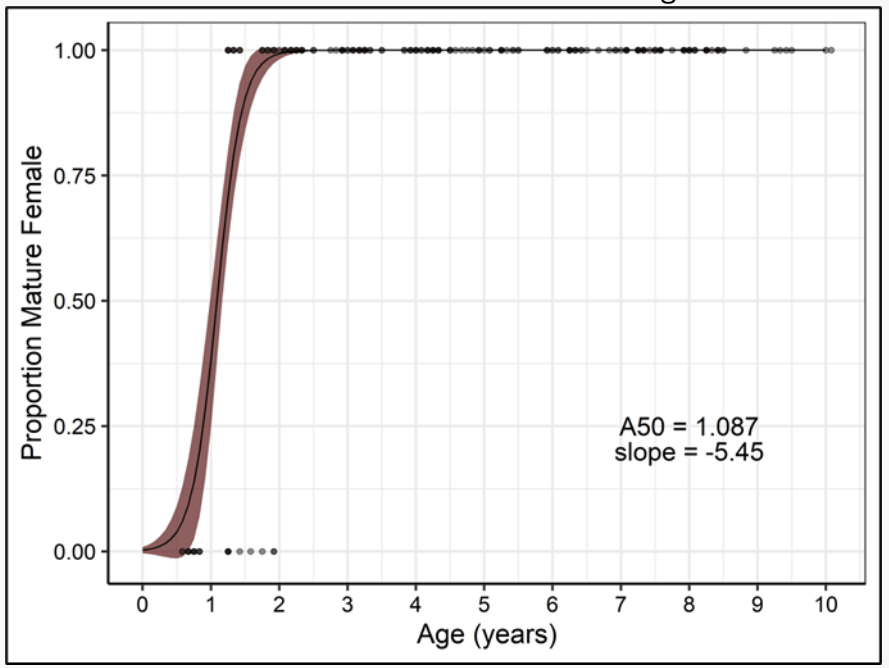


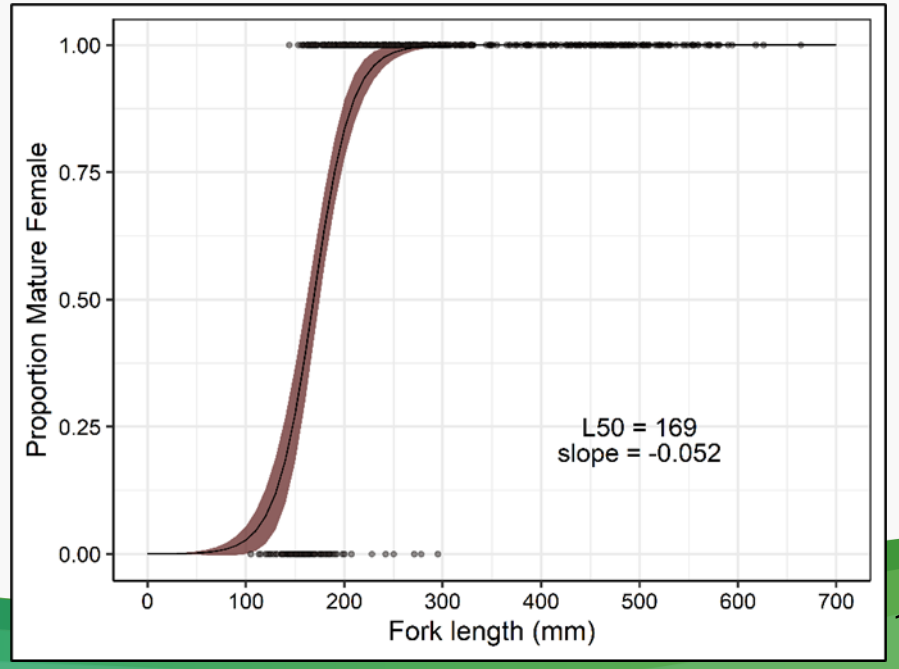
DW Report
Figure 2.13.43a-b

Female Maturity

- No new data since last assessment
  - Re-analyzed according to updated approach
    - Lowerre-Barbieri et al. (2022), Lowerre-Barbieri and Friess (2023)
  - All months given protracted spawning seasonality
    - Spawning occurs in the afternoon as often as daily for as long as 11 months of the year
  - Reproductive phases follow McBride and Johnson (2007)
- Histologically confirmed phases
  - Immature females (class 1) = 0
  - Mature active spawning females (class 3) = 1

- Logistic regression (binomial glm with logit link function)
  - **A50 = 1.09 years (n = 385)**
  - L50 = 169 mm FL (n = 533)

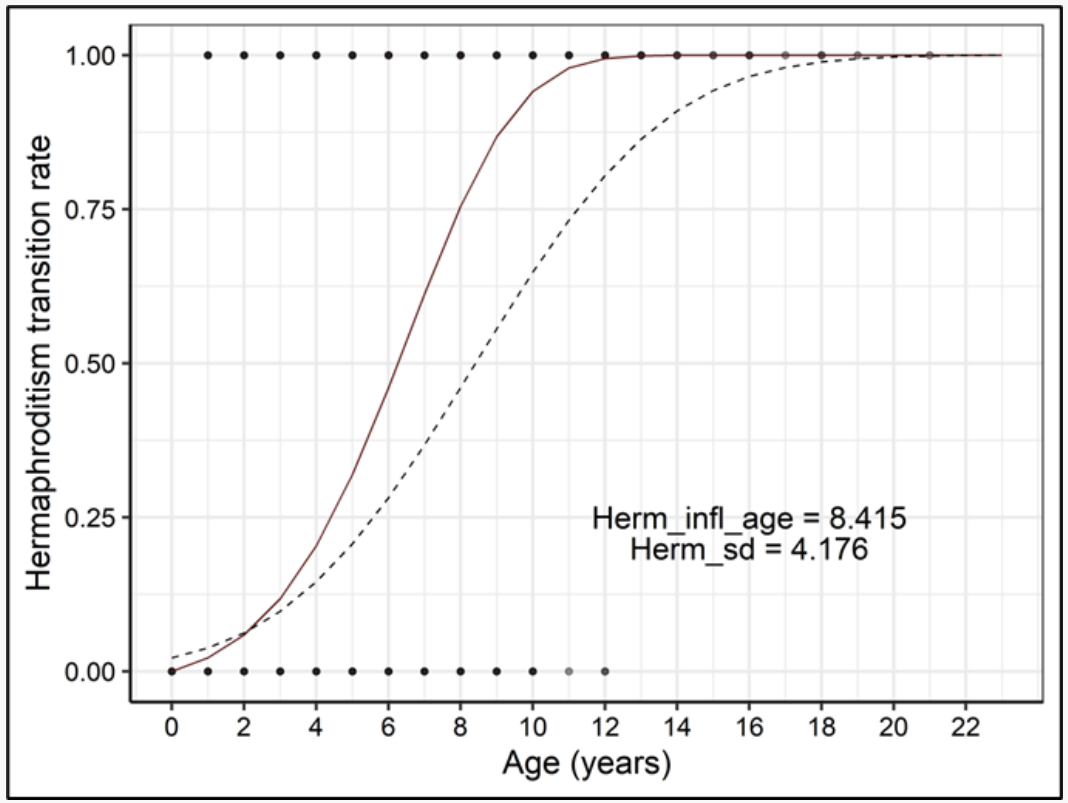




Male Transition

- Hermaphroditism
  - Monandric, protogynous (female to male)
  - Territorial males and female-biased harems
    - Single male maintains 5 – 15 females
  - Sexual transition socially and environmentally mediated
    - Transition takes several months where male removal has potential to significantly disrupt harem stability
  - WFS spatial demographics (Collins and McBride 2011)
    - 2.8 yrs (nearshore), 7.8 years (offshore)
- Repro classes (n = 942)
  - 1 – 4 (imm./mature females)
  - 5 – 10 (transitionals, imm./mature males)
- Transition probabilities
  - Cumulative normal distribution (dotted line)
    - Defines proportion that *change* sex in a time step, not proportion that *are* each sex
  - First fully male age was 13 years.
  - **Herm. infl. age = 8.42 years**

DW Report
Figure 2.13.44a

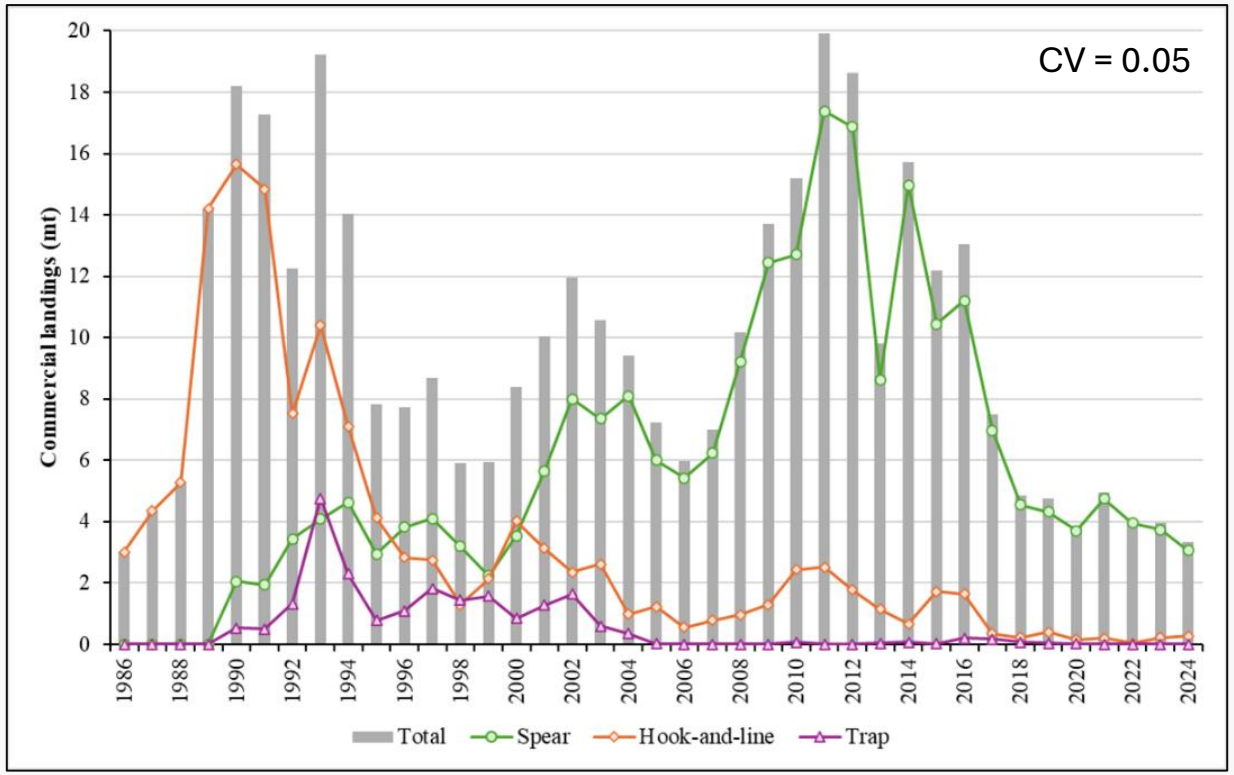


SEDAR 94: Florida Hogfish

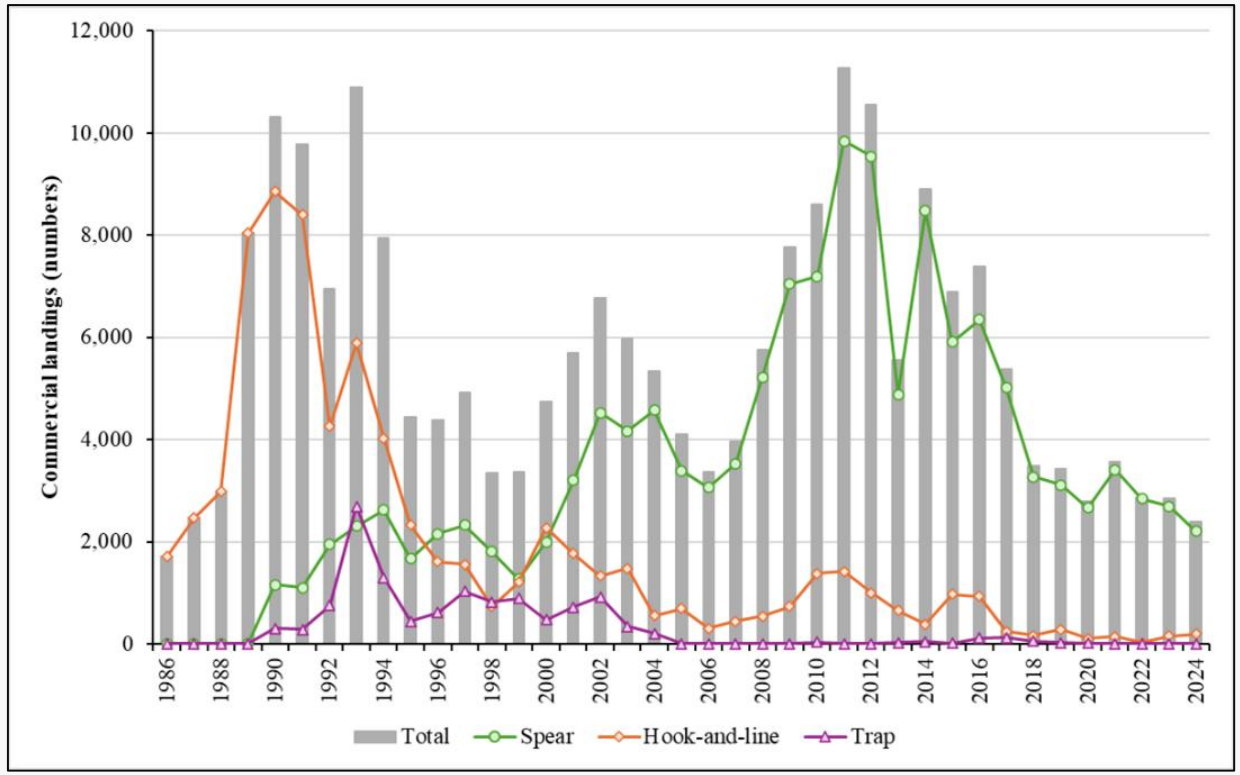
Data: Landings and Releases

Commercial Landings

Florida's Marine Fisheries Trip Ticket Program



AW Report Figure 4.2



AW Report Figure 4.3

AW panel decision points:

- Combine the commercial gears due to paucity of length composition data and model parsimony

Recreational Landings

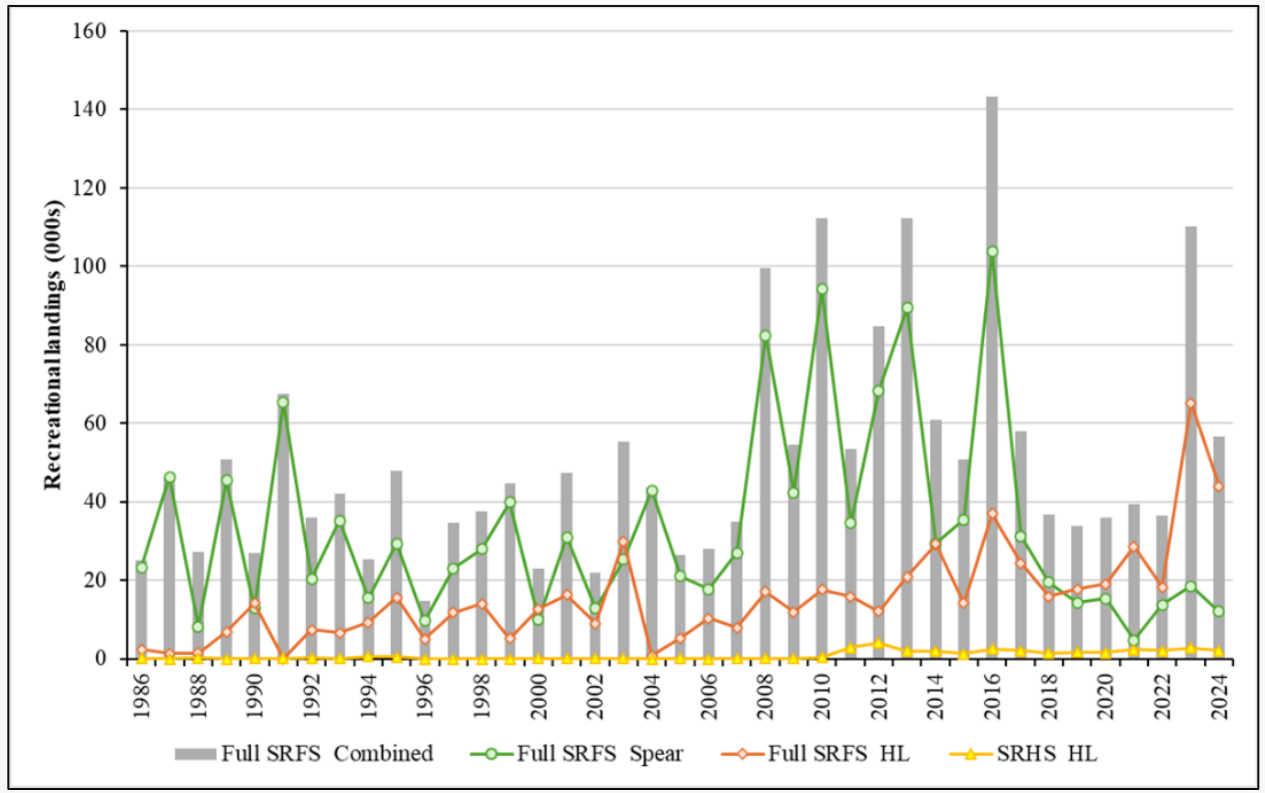
Full SRFS Combined: 1986 – 2024

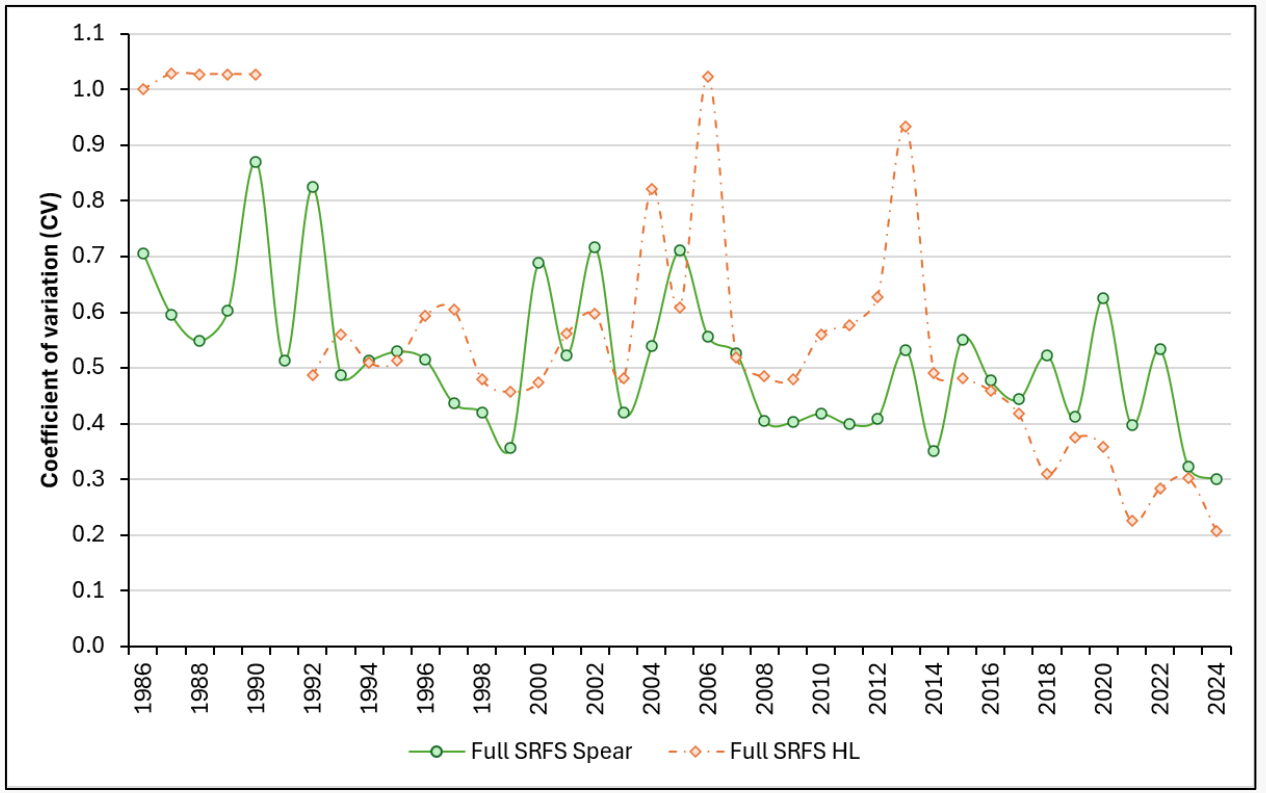
- Florida's State Reef Fish Survey (SRFS)
  - Private mode from 2021 – 2024
  - SRFS ratio-calibrated private mode from 1986 – 2020
  - SRFS (numbers) ratio = 0.455
- Marine Recreational Information Program (MRIP) from 1986 – 2024
  - Charter and shore modes
- Southeast Region Headboat Survey (SRHS)
  - Headboat mode from 1986 – 2024
- Predominant gears
  - Spear and hook-and-line
- CVs often above 30 – 50%

- Flagged years by the Data Workshop
  - 1981 through 1985 due to largely unavailable data

Recreational Landings

AW Report Figure 4.4



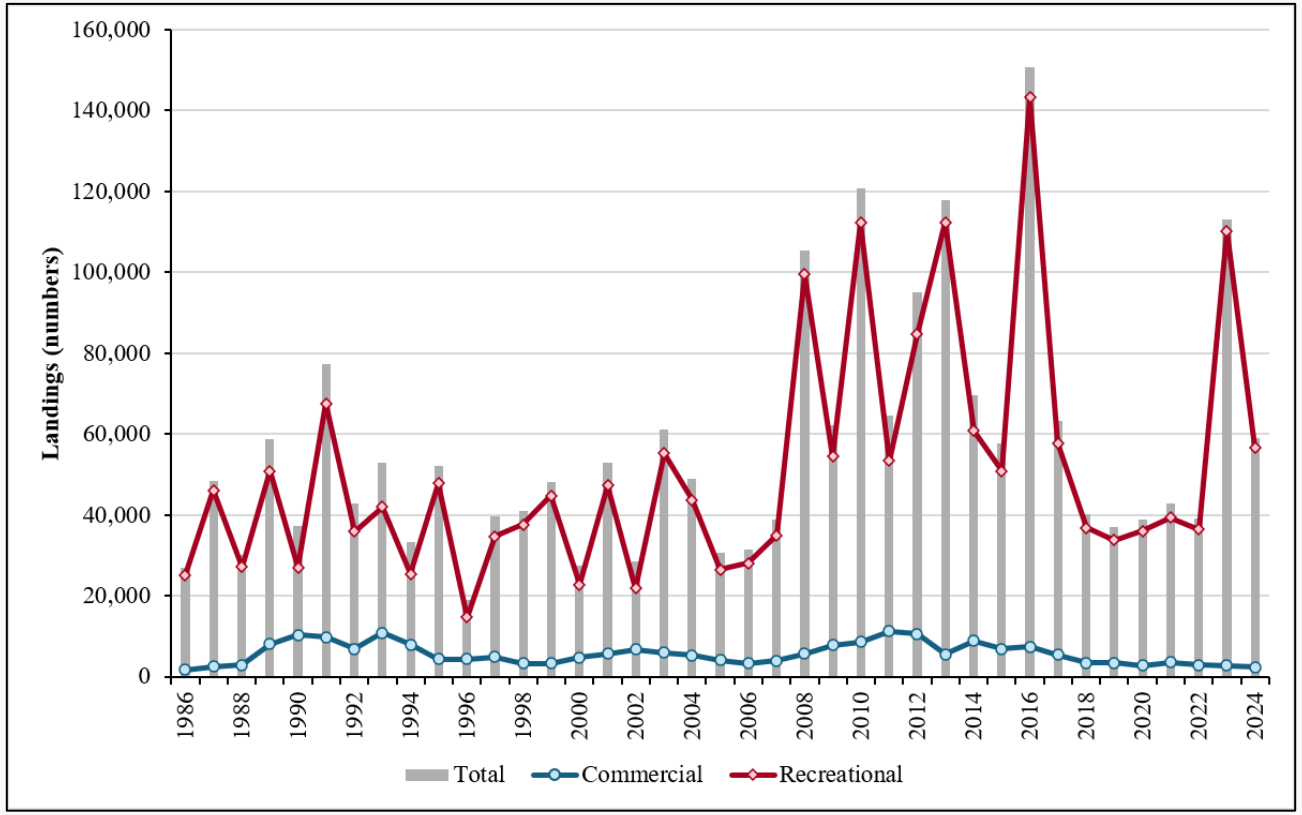


AW panel decision points:

- Combine the SRHS landings with Full SRFS hook-and-line as was done in SEDAR 37

Landings Comparison

AW Report Figure 4.6



- Removals dominated by recreational landings
  - Commercial landings averaged 11.4%

Recreational Discards

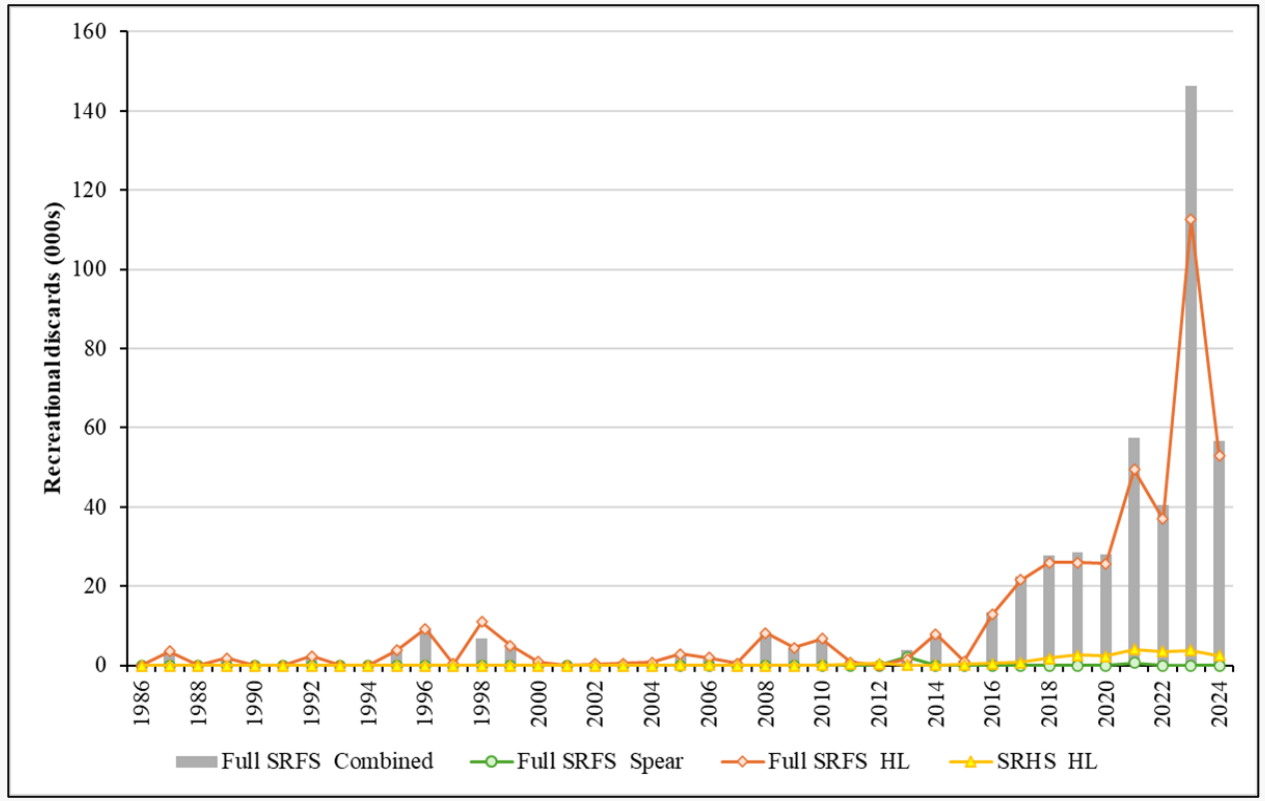
<u>Full SRFS Combined: 1986 – 2024</u>

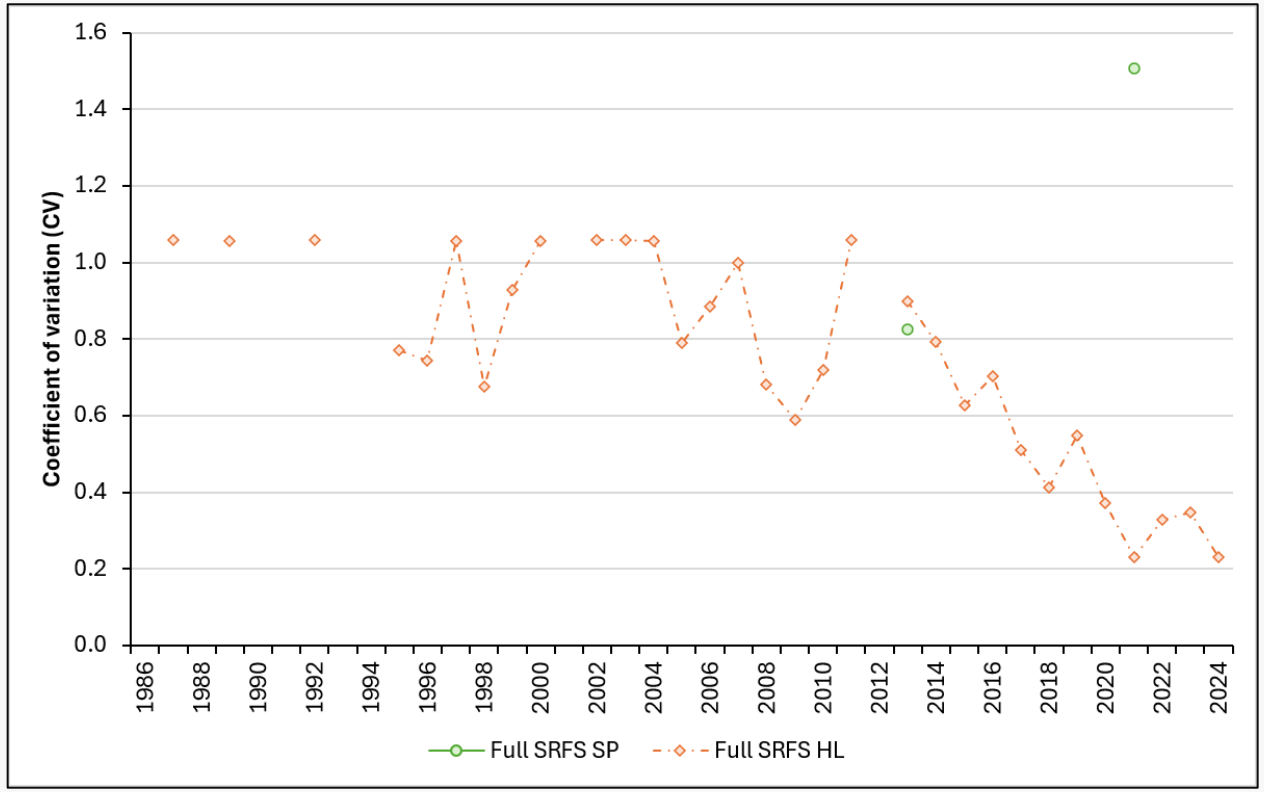
- Florida's State Reef Fish Survey (SRFS)
  - Private mode from 2021 – 2024
  - SRFS ratio-calibrated private mode from 1987 – 2020
  - SRFS (numbers) ratio = 0.5167
- Marine Recreational Information Program (MRIP) from 1987 – 2024
  - Charter and shore modes
- Southeast Region Headboat Survey (SRHS)
  - Headboat mode from 1986 – 2024
- Predominant gears
  - Almost exclusively hook-and-line with some (2 years) spear
- CVs often above 50% but improve at latter part of timeseries

- *No commercial discards available*

Recreational Discards

AW Report Figure 4.5





AW panel decision point:

- Combine the SRHS releases with Full SRFS hook-and-line as was done in SEDAR 37

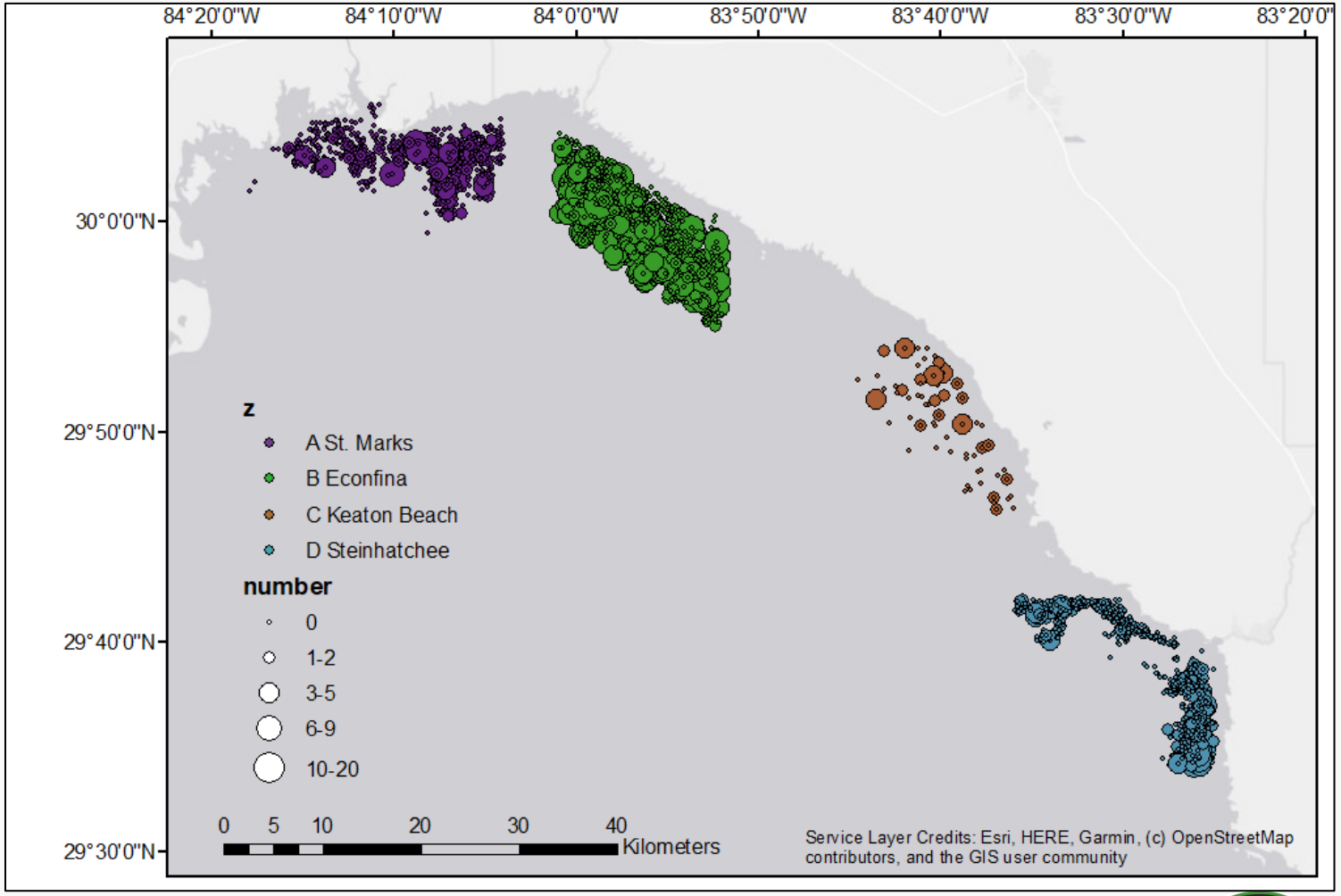
SEDAR 94: Florida Hogfish

Data: Indices of Abundance

Seagrass Trawl

SEDAR 94 DW-14: Young of Year Hogfish Index of Abundance from Seagrass Trawl Surveys of the Florida Big Bend

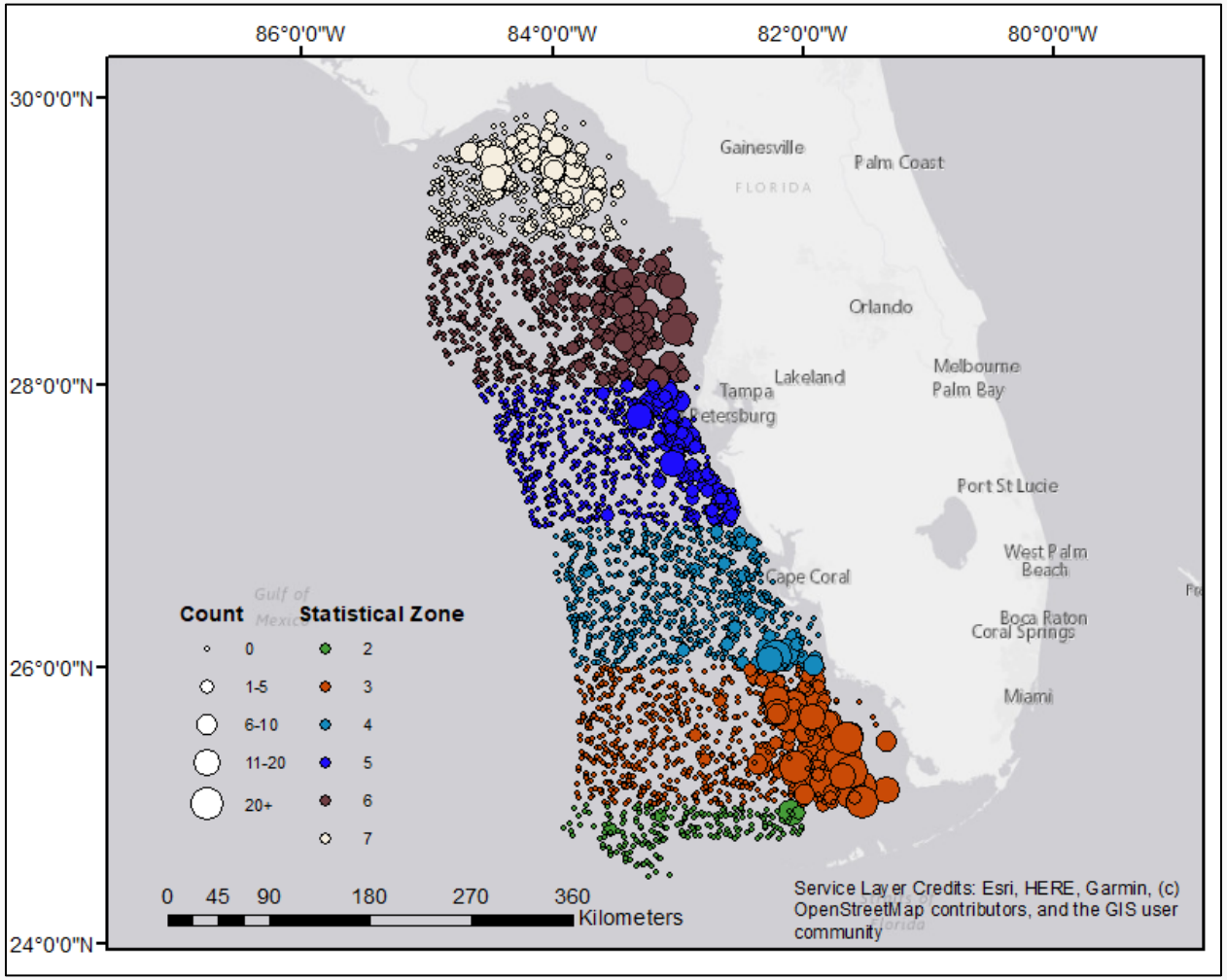
- Sampling Design: Fishery independent stratified random sampling
- Gear: 6.1 m otter trawl
- Spatial Coverage: Big Bend, Florida
- Years: 2008 – 2024
- Months: June – October
- Lengths: < 165 mm SL
  - median: 77 mm SL; stage: Age 0



SEAMAP Trawl

SEDAR 94 DW-13: Hogfish Index of Abundance form the Annual FWRI-SEAMAP Trawl Survey along the West Florida Shelf

- Sampling Design: Fishery independent stratified random sampling
- Gear: 12.8m shrimp trawl
- Spatial Coverage: Statistical zones 3 - 7
- Years: 2010 - 2024
- Months: June, July, October, November
- Lengths: 25- 800 mm FL
  - mode 150 mm

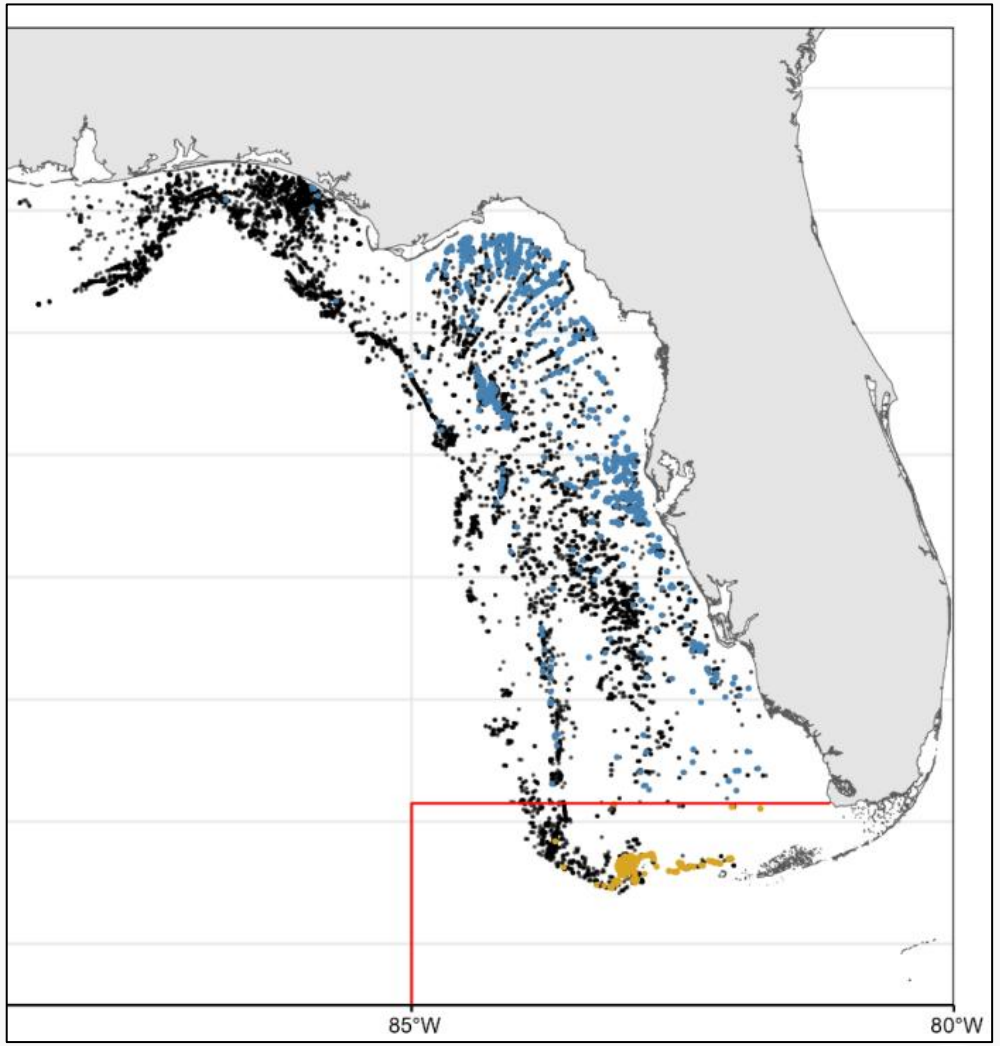


Combined Video Survey

SEDAR 94 DW-19: Indices of abundance for Gulf and Atlantic Hogfish (Lachnolaimus maximus) using data from multiple video surveys

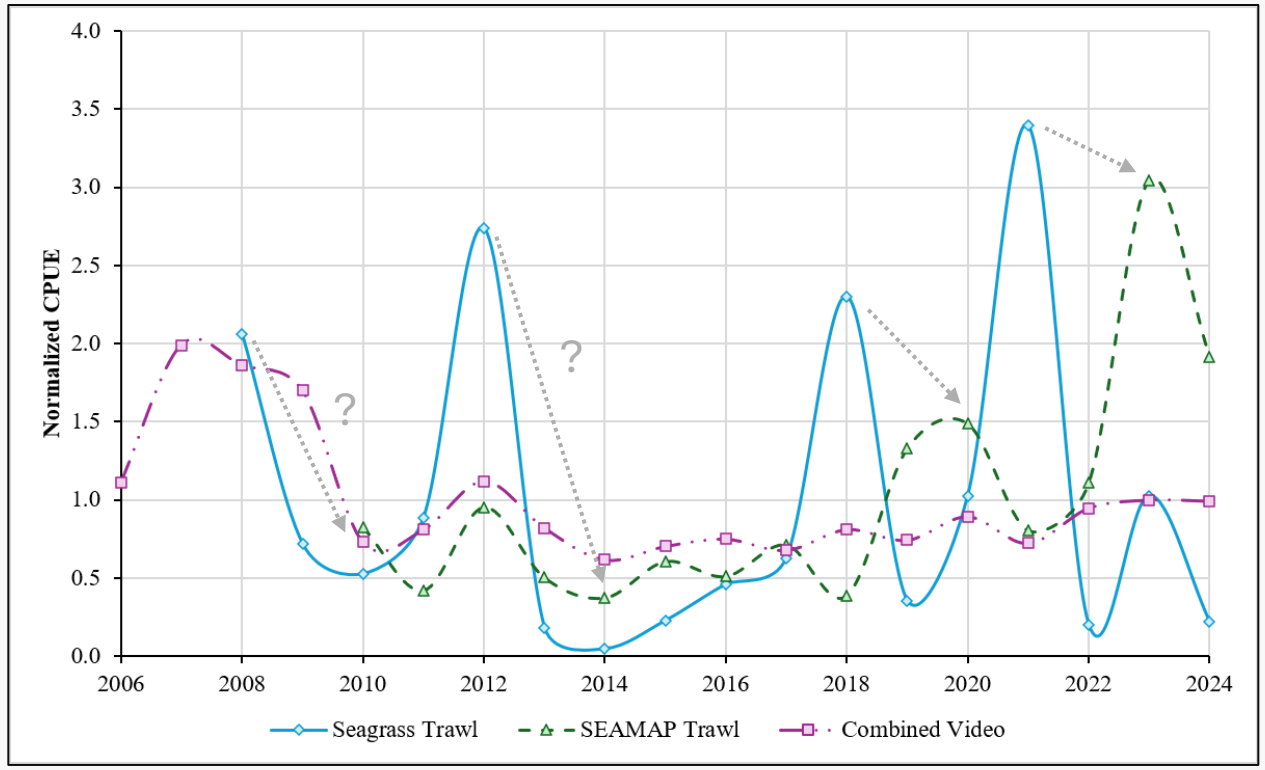
- Stationary video surveys with SRS design
  - NMFS SEAMAP reef fish video survey (SRFV)
  - NMFS Panama City Lab
  - Florida Fish and Wildlife Research Institute survey (FWRI, starting year 2008)
  - After 2020, unified survey design under G-FISHER
- Gear
  - Paired stereo-imaging cameras
    - Sites selected at random from known reef areas identified through habitat mapping (multi-beam and side-scan sonar) and were deployed.
- Spatial Coverage
  - Stat Zones 3-7
  - Depths from 10 – 180m
- Years
  - SRFV: 2006– 2019
  - PC: 2006 – 2019
  - FWRI: 2008 – 2019
  - G-FISHER: 2020-2024
- Months
  - Daylight hours between April through September

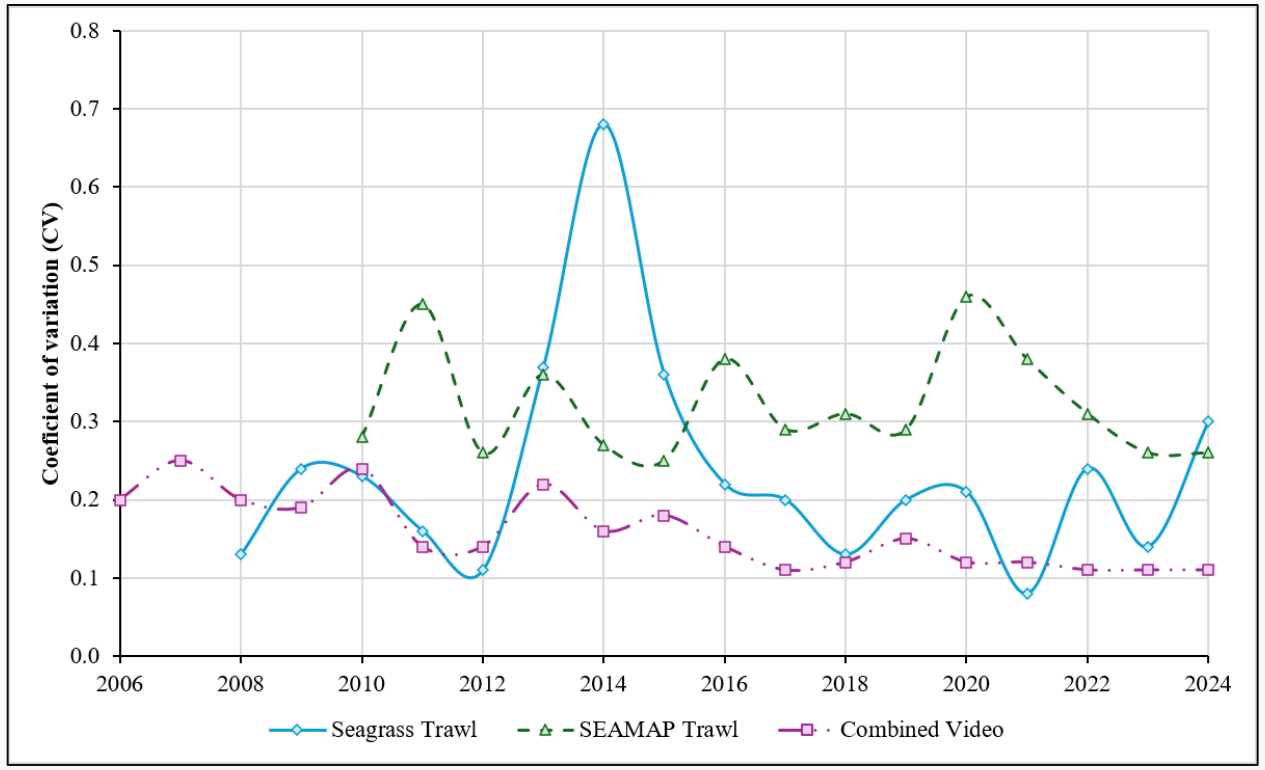
- Length composition data only (subadult, adult)



Indices of Abundance

AW Report Figure 4.7

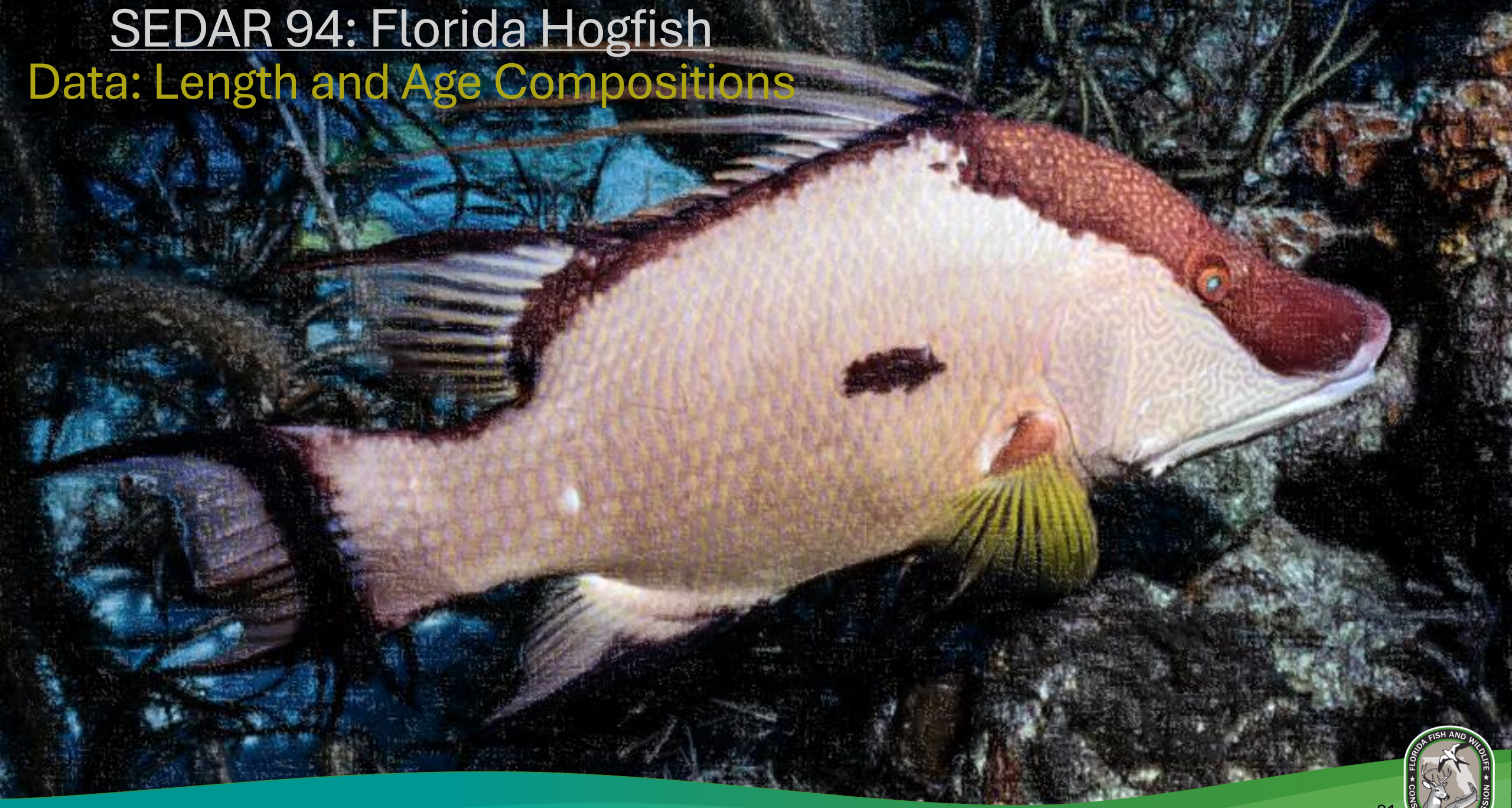




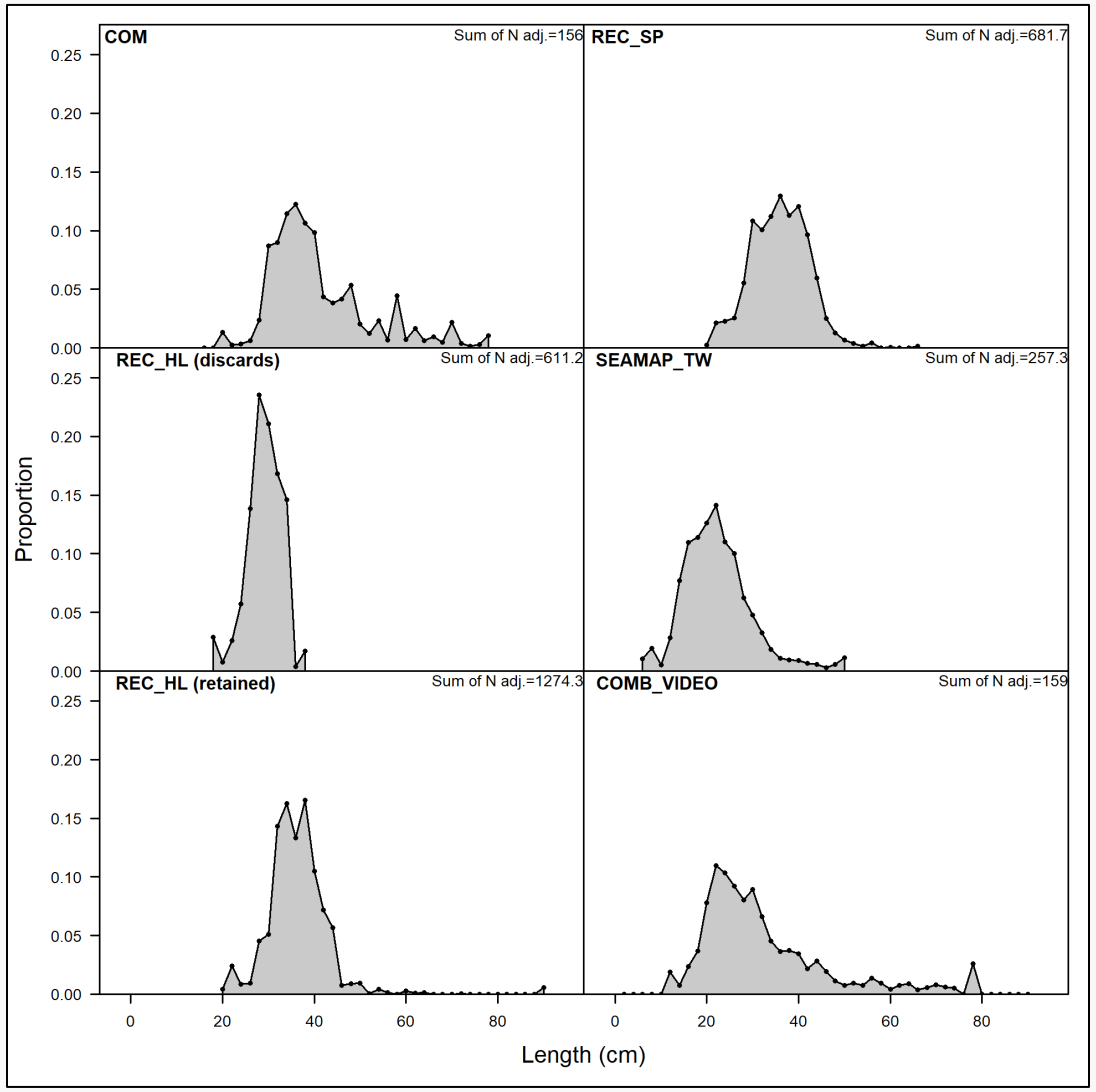
- Index trends mostly stable but variable with limited signal
- Recruitment appears cyclical with possible environmental disruptions (e.g., 2010 [BP Oil], 2014 [Red Tide])
  - See Chagaris et al. WFS-FEM, SEDAR 105, Red Tide Mortality TWG
- SEAMAP trawl picks up recruitment signal ~2 years later
  - May also be susceptible to environmental disruptions?
  - Gives appearance of increasing trend towards end but may have missed the earlier signals?

SEDAR 94: Florida Hogfish

Data: Length and Age Compositions

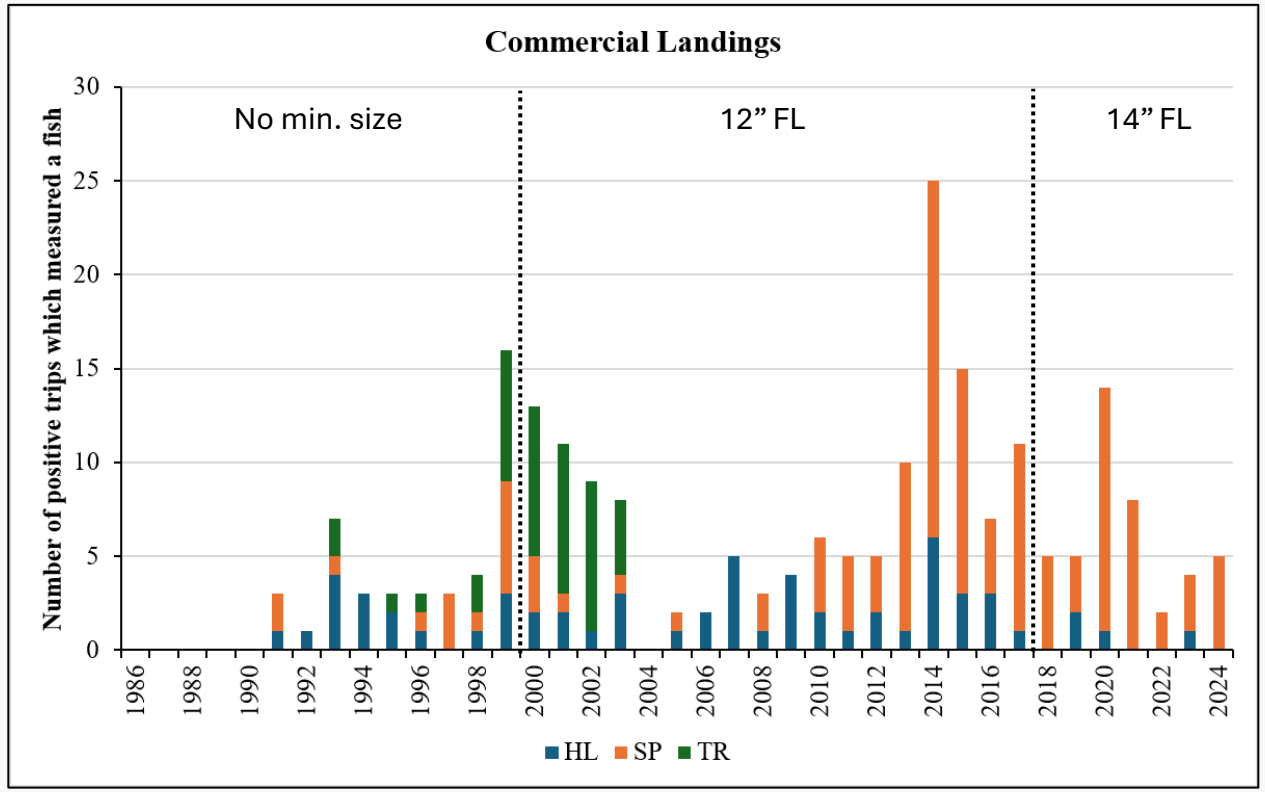


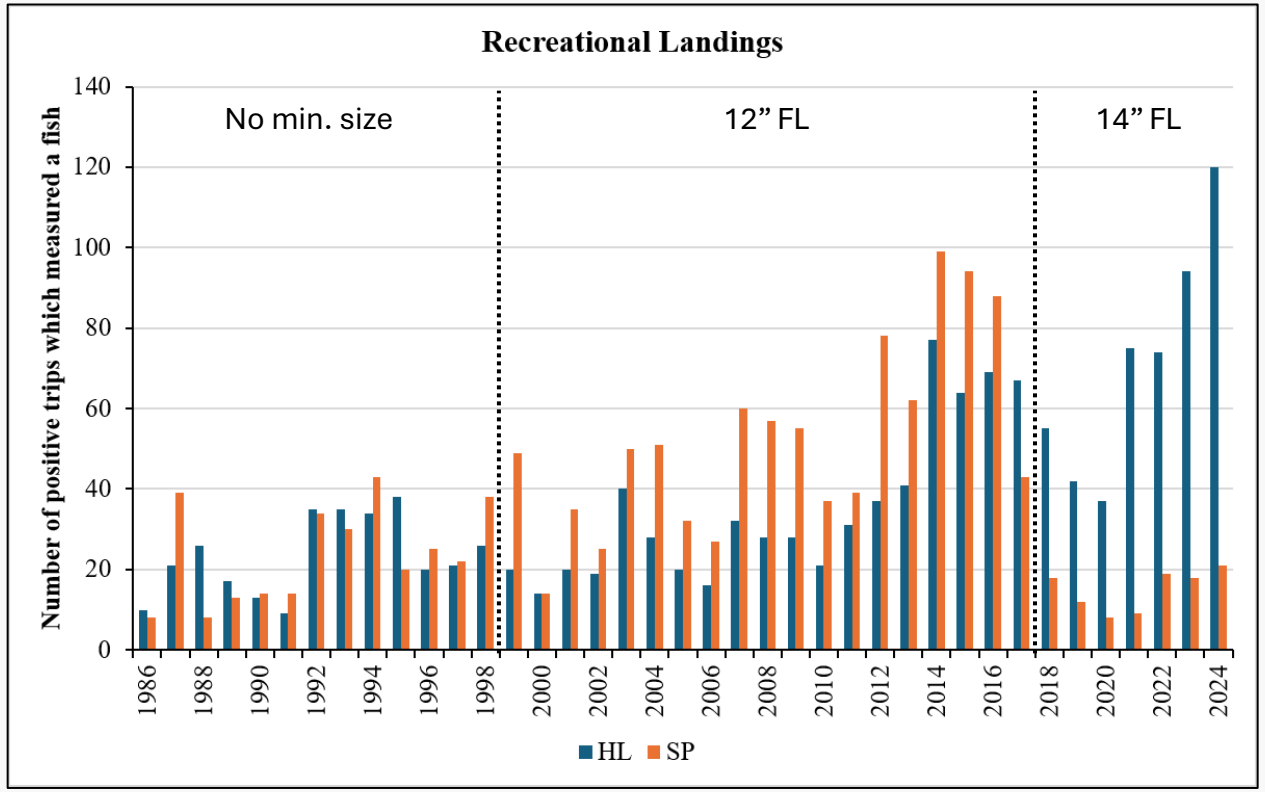
Length Composition Data



- Fork length (2 cm bins)
  - 2 – 90 cm
  - Largely unimodal distributions
- Fishery length comps weighted by landings or live releases
  - Distributions heavily dome-shaped with more larger individuals captured by the commercial fishery
  - Retained lengths generally followed changes to minimum size limits
  - Discards were largely below minimum size limits
- Index length comps weighted by index values

Fishery Length Compositions





- Data characterized by low annual sample sizes with ‘noisy’ lengths

<u>AW Panel decision point:</u>

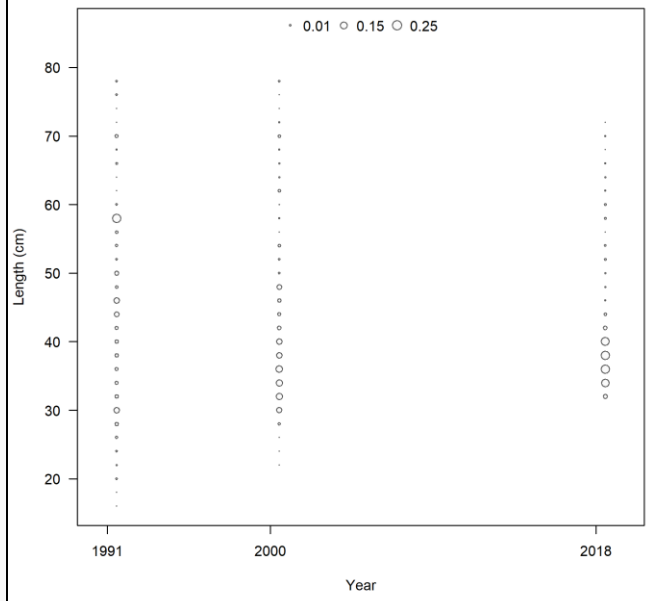
- Utilize “super-period” approach in Stock Synthesis
  - Aggregate composition data and input sample sizes by *regulatory time blocks*
  - Model expected values based on combined distribution with annual weight relative to input sample size

Fishery Length Compositions

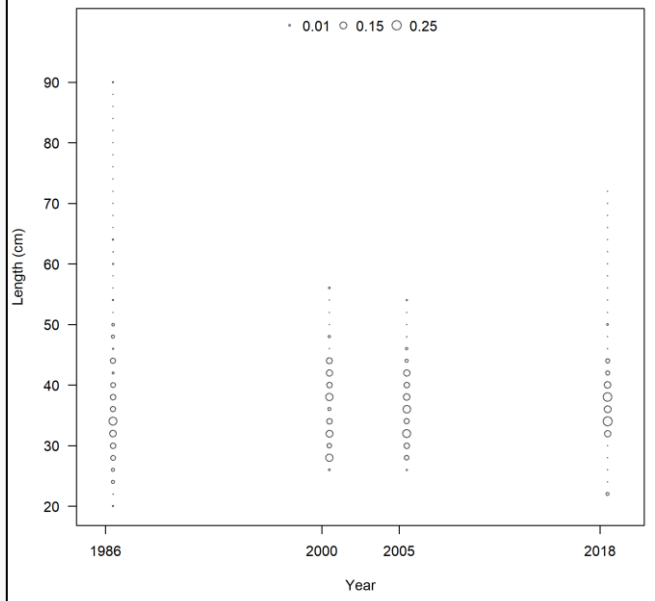
Fleet	Partition	Years	Number of Positive Annual Trips	Super-periods (pos. trips)
Commercial	Landings	1991– 2024	avg. = 7 (q1 = 3, median = 5, q3 = 9)	1991 – 1999 (43), 2000 – 2017 (141), 2018 – 2024 (43)
Recreational	Landings (HL)	1986 – 2024	avg. = 13 (q1 = 6, median = 9, q3 = 20)	1986 – 1999 (85), 2000 – 2004 (42), 2005 – 2017 (171), 2018 – 2024 (217)
Recreational	Landings (SP)	1986 – 2024	avg. = 13 (q1 = 7, median = 11, q3 = 20)	1986 – 1999 (151), 2000 – 2017 (331), 2018 – 2024 (52)
Recreational	Live Releases	2005, 2009, 2013, 2015 – 2024	avg. = 19 (q1 = 4, median = 15, q3 = 28)	2005 – 2017 (35), 2018 – 2024 (212)

** No super-periods applied to index length comps **

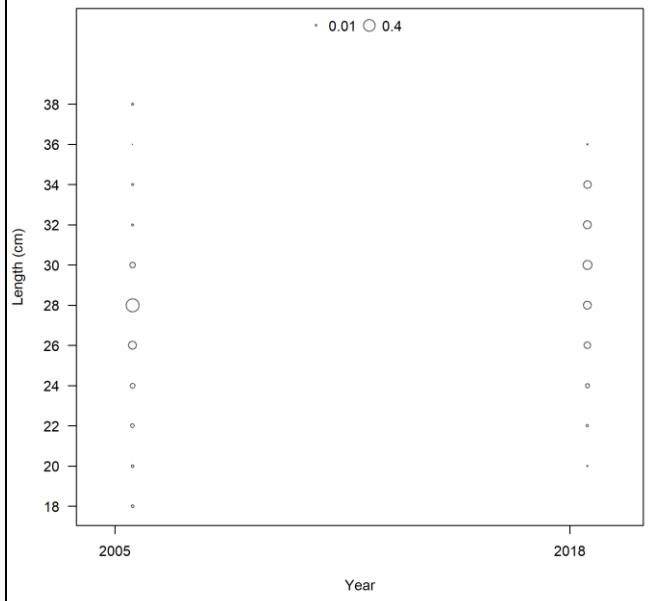
COM



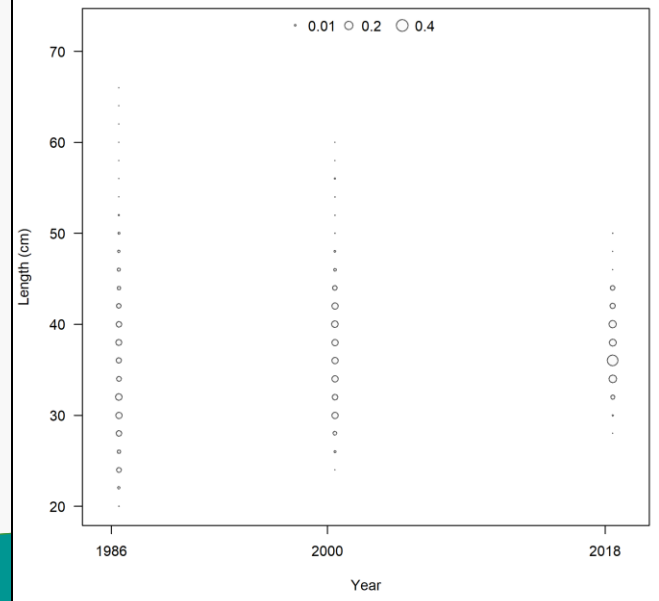
REC HL (retained)



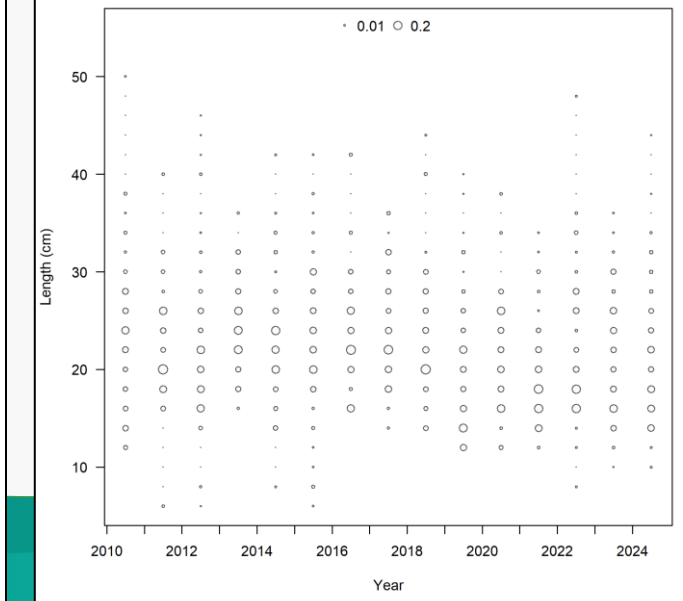
REC HL (discards)



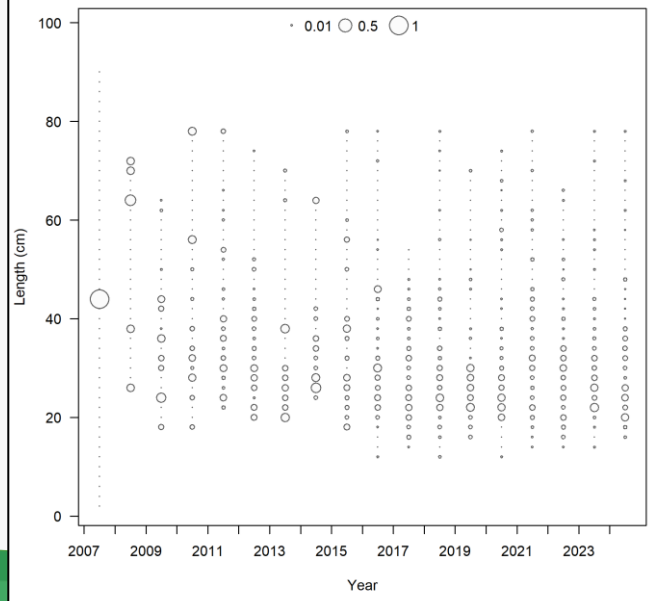
REC SP



SEAMAP

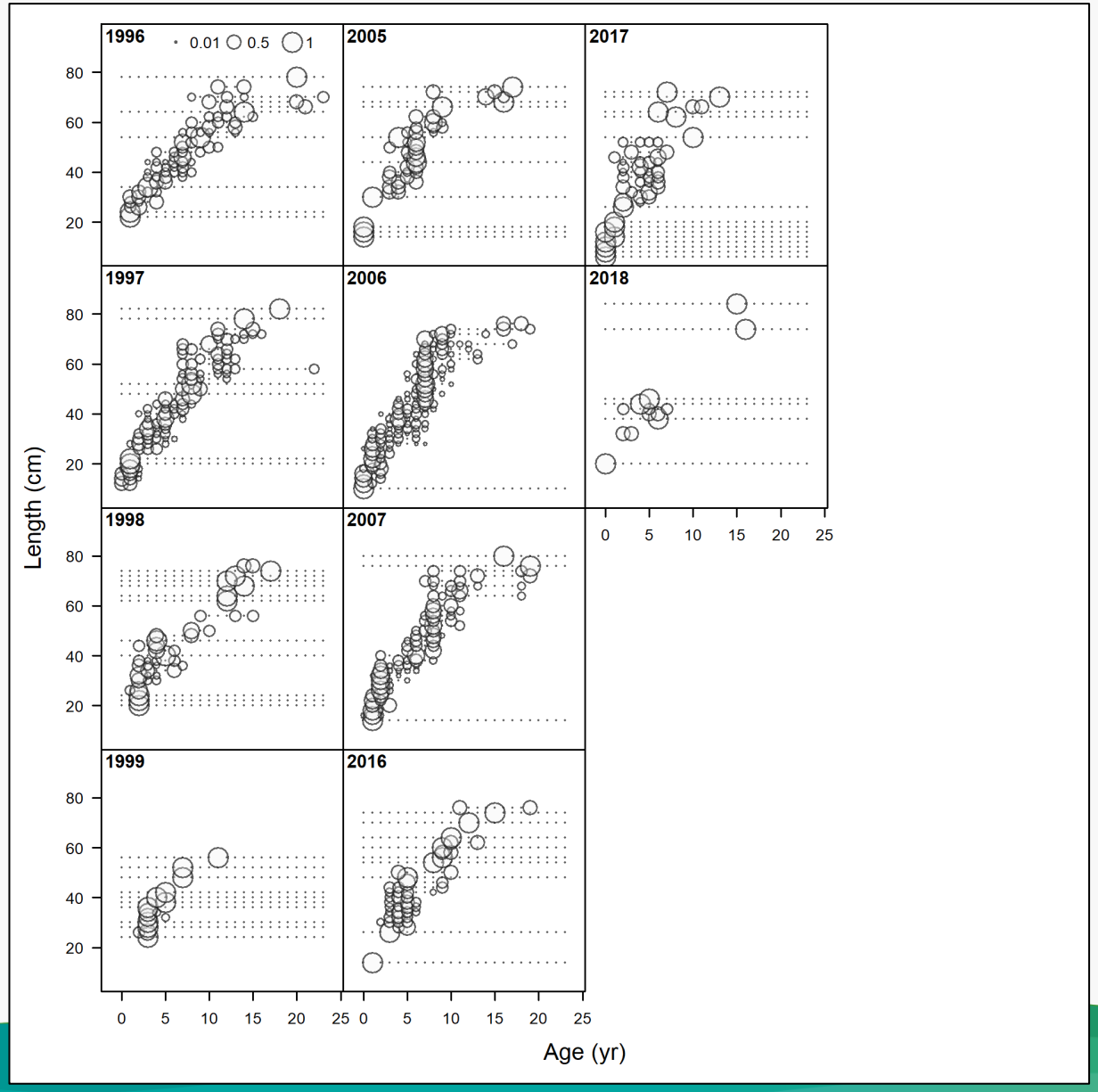


COMB VIDEO



Conditional Age-at-Length

AW Report Figure 4.10



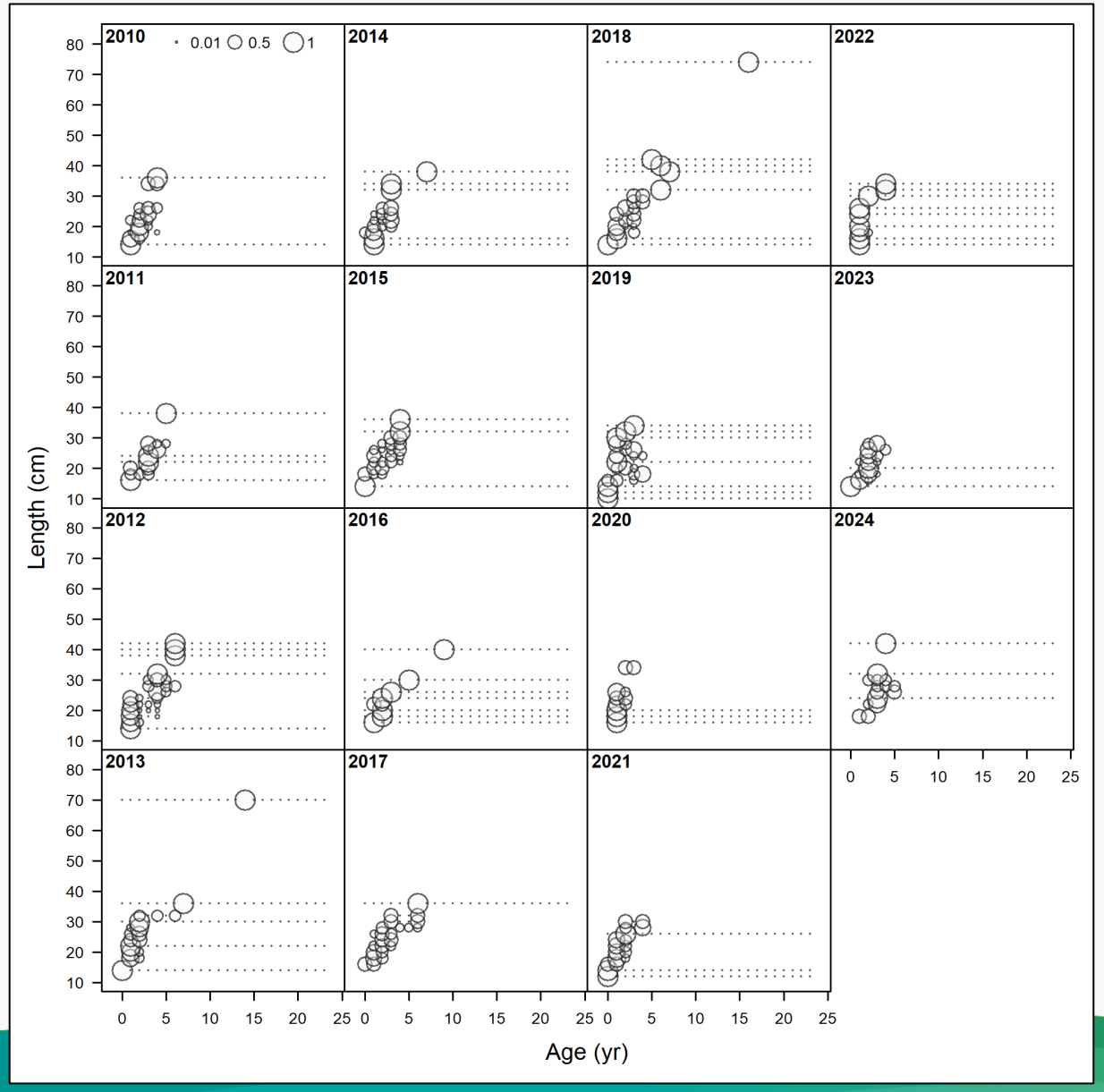
Goal: reliably inform internal estimation of growth

- Fishery-independent research
  - McBride and Richardson (1996-1999)
  - Collins and McBride (2005-2007)
  - Faletti and Stallings (2016-2018)

  - Data isolated to spear gear
    - 2 cm FL bins
    - Not linked to any fleet
    - Provides fullest range of lengths-at-age
    - Best informer for *Linf* parameter

Conditional Age-at-Length

AW Report Figure 4.9



- SEAMAP Trawl Survey
  - 2 cm FL bins
  - Predominantly ages 1 – 5 years
    - Informs lower portion of growth curve
  - Comparatively more consistent sampling across timeseries

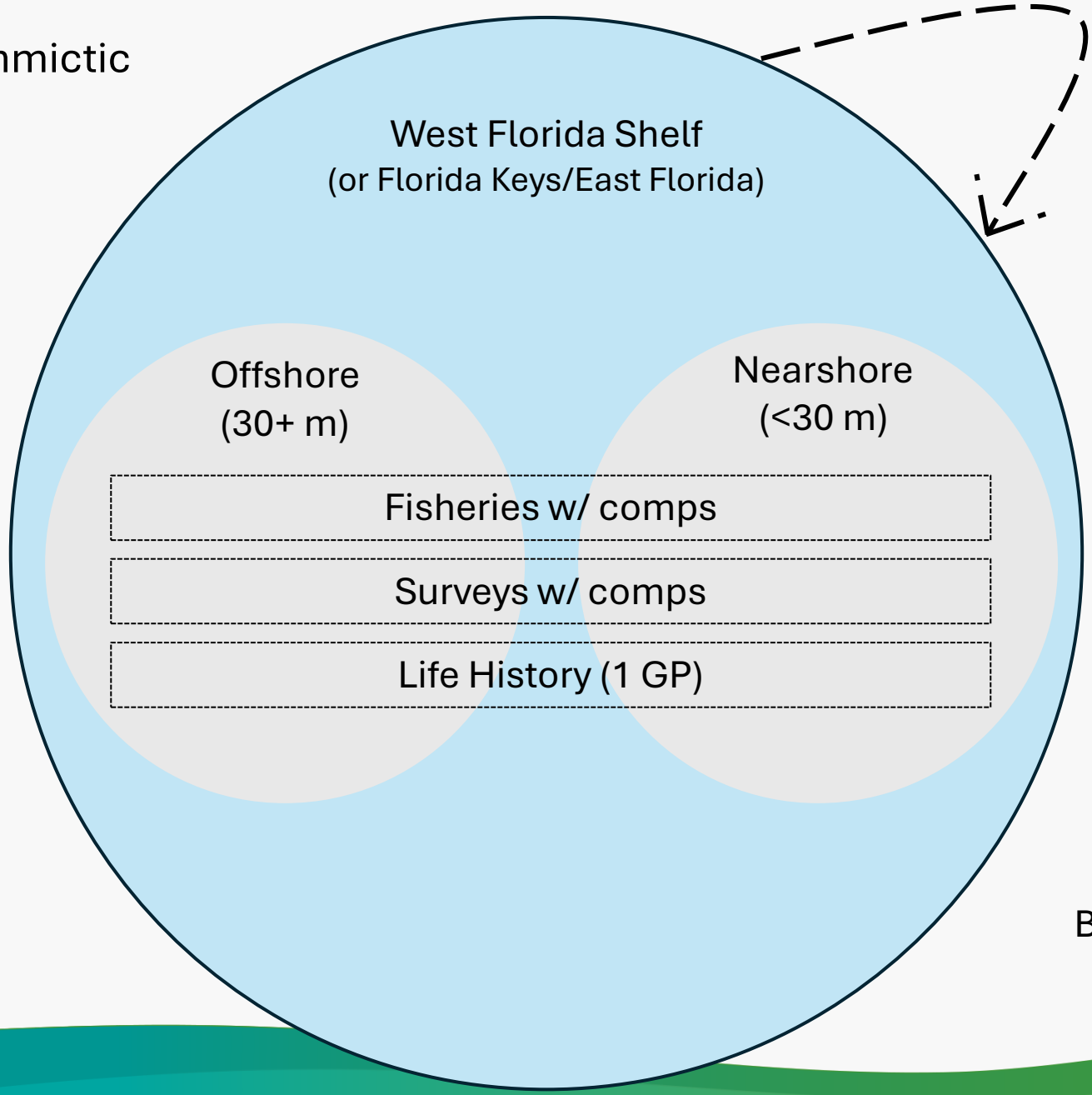
- AW Panel decision points:
  - Remove sparse COM and RECsp as well as REChl age data
    - Not informative for reliably estimating growth
    - Conflict particularly with REChl data
      - CAAL data concentrated in mid-range
      - *Linf* chased upper bound of 130 cm FL
  - Remove FI Baitfish Survey ages
    - Limited years and largely duplicative of SEAMAP trawl ages

SEDAR 94: Florida Hogfish

WFS Base Model Configuration

Population Structure:

Spatially aggregated panmictic



Based on Goethel et al. (2023)

WFS Base Model Configuration

Assessment Model

- Stock Synthesis v.3.30.24.1
  - SCA in the integrated analysis class
- Fair to moderate complexity

Spatio-temporal

- Years: 1986 – 2024
- 1 season (annual), 1 area (stock)
- Spawning: January 1
  - Core season: Dec - Apr
- Settlement: one event on Feb 1 at age-0
  - Pelagic larval period ca. 34 days
- Time-blocks: follow min size/bag limits
  - 1986-1999, 2000-2017, 2018-2024

Life History

- VB growth estimated internally
  - Initial values from Data Workshop
    - *Linf*: 82.3 cm FL; *k* = 0.112
  - Platoons: 3
    - Distribution: 0.15, 0.70, 0.15
- Ages: 0 – 23
- Natural mortality defined by Lorenzen
  - *M* = 0.235 for ages 3-23
- Length-weight: fixed params
- Female maturity: fixed age-logistic
- Fecundity: spawning biomass at length
- Two-sex model:
  - Female to male hermaphroditism based on stock-specific functions
  - Management quantities based on combined SSB (Brooks et al. 2008)

WFS Base Model Configuration

Fishing Fleets

- Commercial (COM)
  - Combined gear: SP, HL, TR
  - Landings (mt)
    - Fit exactly
  - No discards
- Recreational hook-and-line (REChl)
  - Landings and discards (000s)
    - Landings fit exactly
  - Discard mortality: 41.4%
- Recreational spear (RECsp)
  - Landings (000s)
    - Fit exactly
  - No discards

Surveys

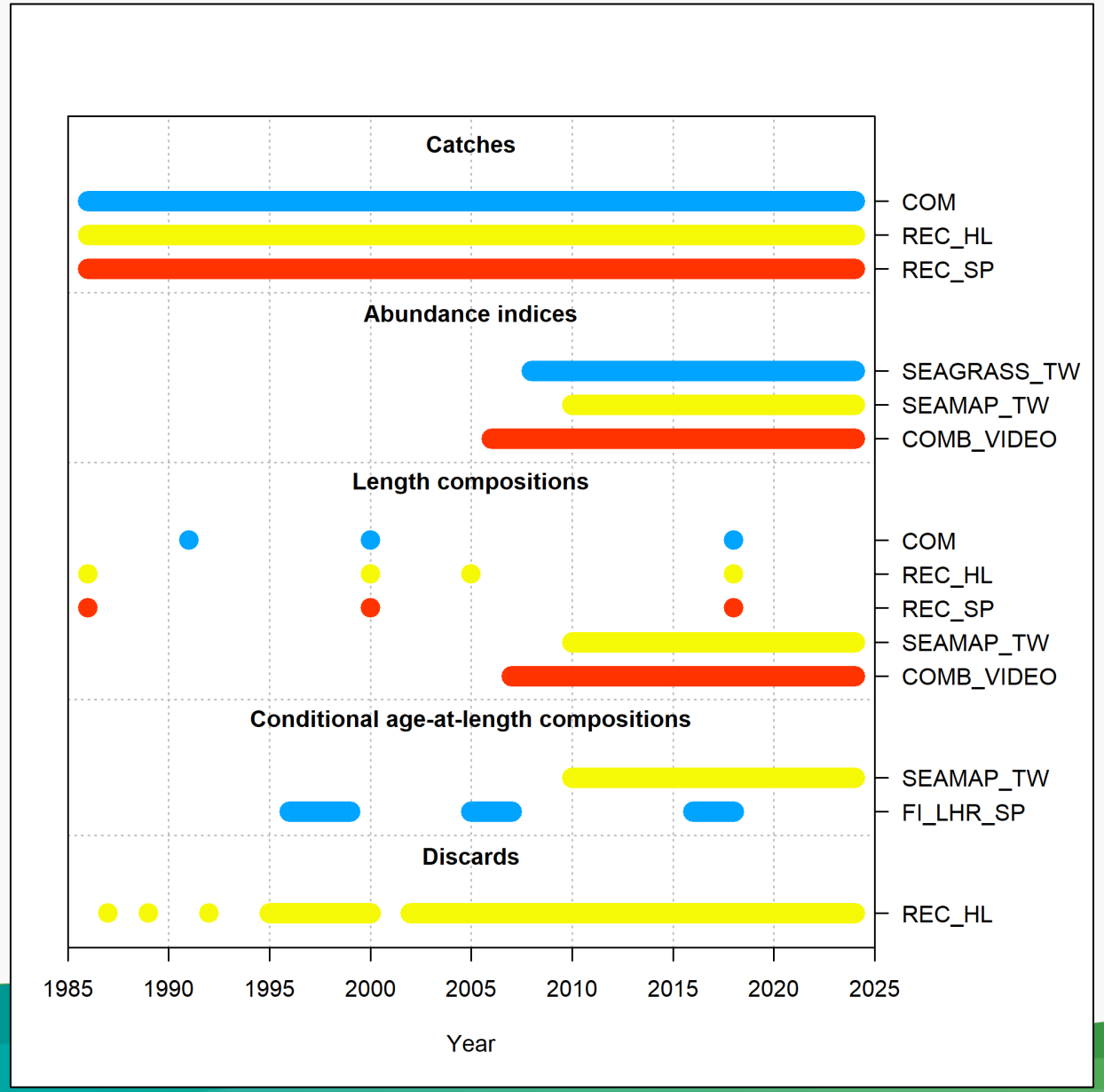
- FWRI Seagrass Trawl
  - Number of fish/trawl
- SEAMAP Trawl
  - Number of fish/trawl
- Combined Video Survey
  - Weighted mean of Max N (numbers)

WFS Base Model Configuration

- Length Composition Data (2 cm bins)
  - Commercial (COM)
    - Landings only
      - Super-periods applied following time blocks
  - Recreational hook-and-line (REChl)
    - Landings and discards
      - super-periods applied following time blocks
  - Recreational spear (RECsp)
    - Landings only
      - Super-periods applied following time blocks
  - SEAMAP Trawl and Combined Video Surveys
    - Annual compositions retained

- Conditional Age-at-Length (CAAL)
  - SEAMAP Trawl Index
  - Fishery-independent spear
    - Life history research

WFS Base Model Configuration



AW Report Figure 4.1

WFS Base Model Configuration

Fleet Selectivity (length-based)

- Commercial (COM)
  - Double normal (domed w/ flexibility)
  - No discards available
    - Selectivity functions as retention
- Recreational hook-and-line (REChl)
  - Double normal (domed w/ flexibility)
  - Estimated retention (flat-topped)
    - Time-varying: 1986-1999, 2000-2017, 2018-2024
  - Discard mortality = 41.4%
- Recreational spear (RECsp)
  - Double normal (domed w/ flexibility)
  - No discards

Index Selectivity (length-based)

- FWRI Seagrass Trawl
  - Linked as age-0 recruitment (constant)
- SEAMAP Trawl
  - Double normal (domed w/ flexibility)
  - Constant catchability
- Combined Video
  - Single logistic (flat-topped)

WFS Base Model Configuration

Recruitment Dynamics

- Beverton-Holt stock-recruitment model
  - Virgin recruitment in log-space (*ln(R0)*) and standard deviation of log of recruitment (*sigmaR*) estimated within model
  - *Steepness (h)*
    - Assumed age-0 recruitment was variable across a long-term average (h = 0.99)
    - Lack of contrast in catch timeseries prevent *steepness* from being estimated
  - *SR_regime* offset applied to 1985 (before start year)
    - Assumes population is not in equilibrium at model start year
- Simple recruitment deviations
  - Sum-to-zero constraint
- Main recruitment deviations
  - 1986 – 2024 (period of higher data-richness)
  - No early recruitment deviations
- Bias adjustments (following Methot and Taylor 2011)

WFS Base Model Configuration

Parameters

- 87 out of 124 parameters estimated
  - *Life history: 26*
  - *Stock-recruitment: 6*
  - *Annual recruitment deviations: 39*
  - *Catchability: 3*
  - *Selectivity: 50*

Reported Fishing Mortality Rates

- Exploitation rate
  - Dead biomass/total age_1+ biomass
    - Accounts for females and males
    - Consistent with tracking female and male SSB
  - Utilized in SEDAR 37 and cited for multiple fleet selectivities

WFS Base Model Configuration

Model Convergence Criteria

- Total likelihood
  - Sum of individual data source component's likelihoods
- Invertible Hessian matrix
  - Obtain uncertainty estimates
- Maximum gradient <0.0001

Error Structure

- Assumes log-normal for all landings, indices, and discard data

Multinomial Distribution

- Length composition data of landings, discards, and indices
- CAAL of fishery-independent data

Weighting

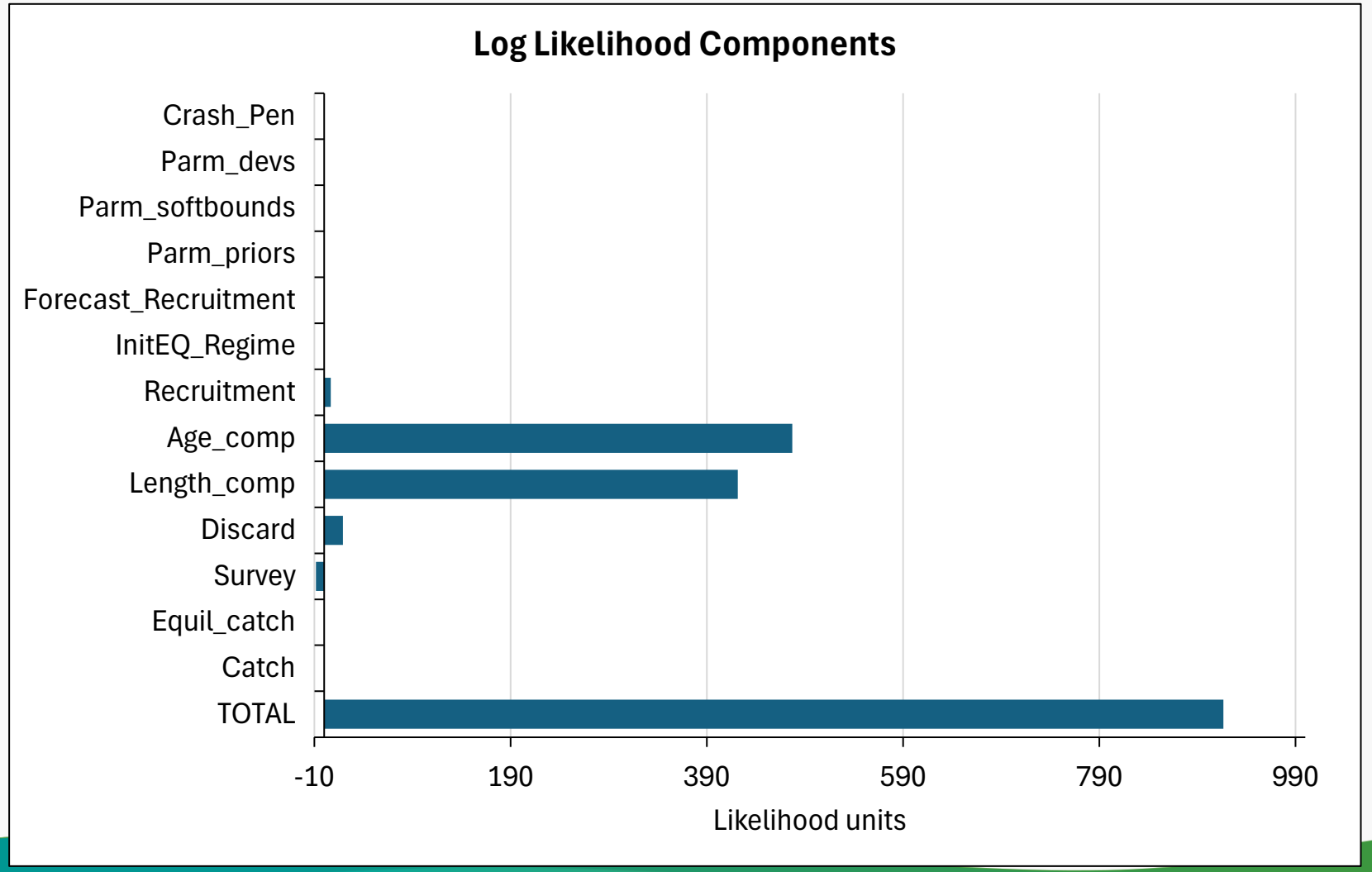
- Length composition
  - Number of positive trips which measured a fish as input sample size
- CAAL
  - Number of fish per 2 cm length-at-age bin
- Francis (2011) re-weighting
  - Improved fits to all indices and length/age data via LL
  - Most components down-weighted
    - Upweighted REChl lengths (2.5) and RECsp lengths (1.3)

SEDAR 94: Florida Hogfish

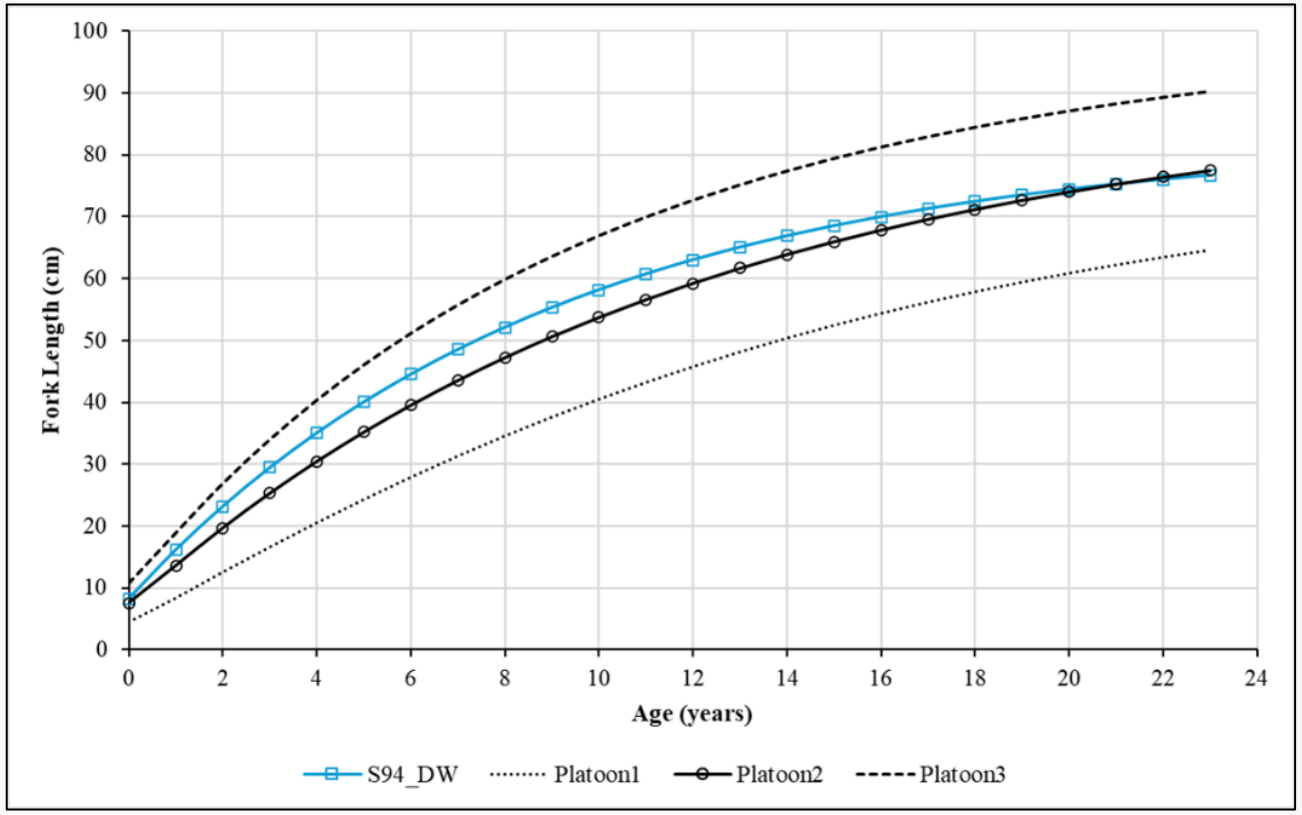
WFS Base Model Fits

Model Likelihood Components

Total negative log-likelihood = 916.605



Internal Estimation of Growth

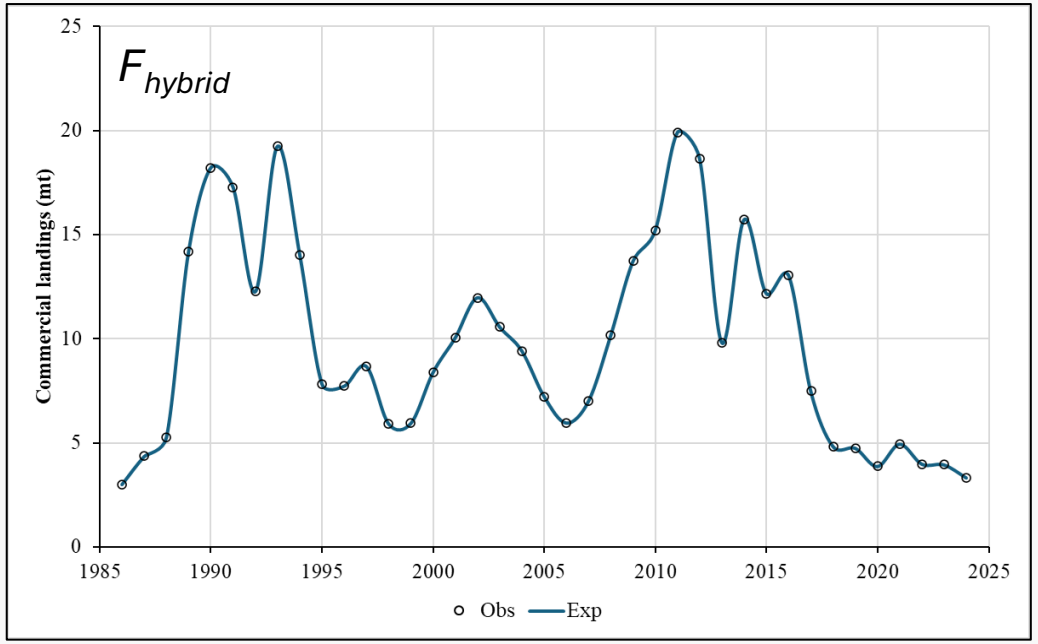


AW Report Figure 4.11

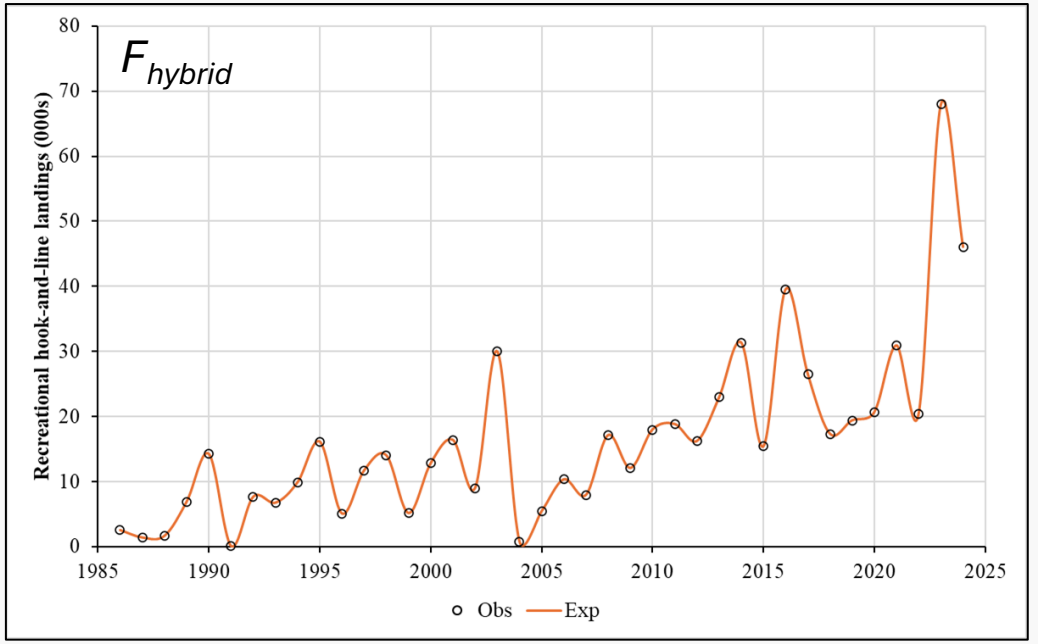
- Von Bertalanffy
  - L_{inf} = 89.6 cm FL
  - k = 0.083
  - Platoon 2 follows VB parameters
- Platoons
  - Number of age-0 recruits partitioned annually according to a normal distribution
    - 0.15, 0.70, 0.15
  - *Platoon_sd_ratio* = 0.85
    - Values > 2 indicate no meaningful shift in mean size-at-age
    - Values < 0.5 considered unrealistic

Landings

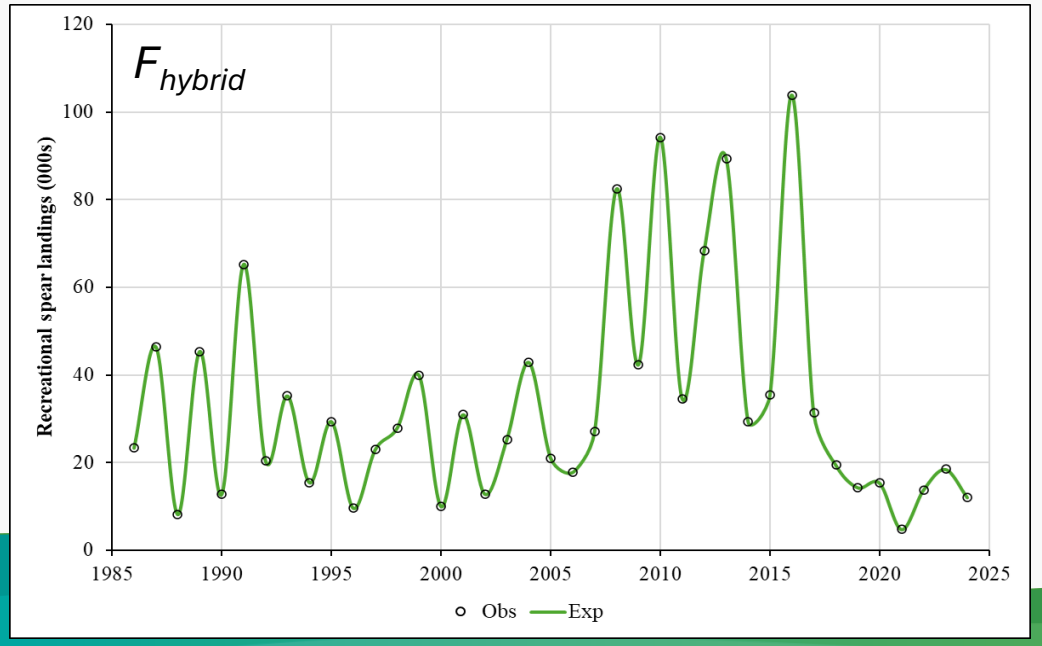
AW Report Figure 4.12



AW Report Figure 4.13

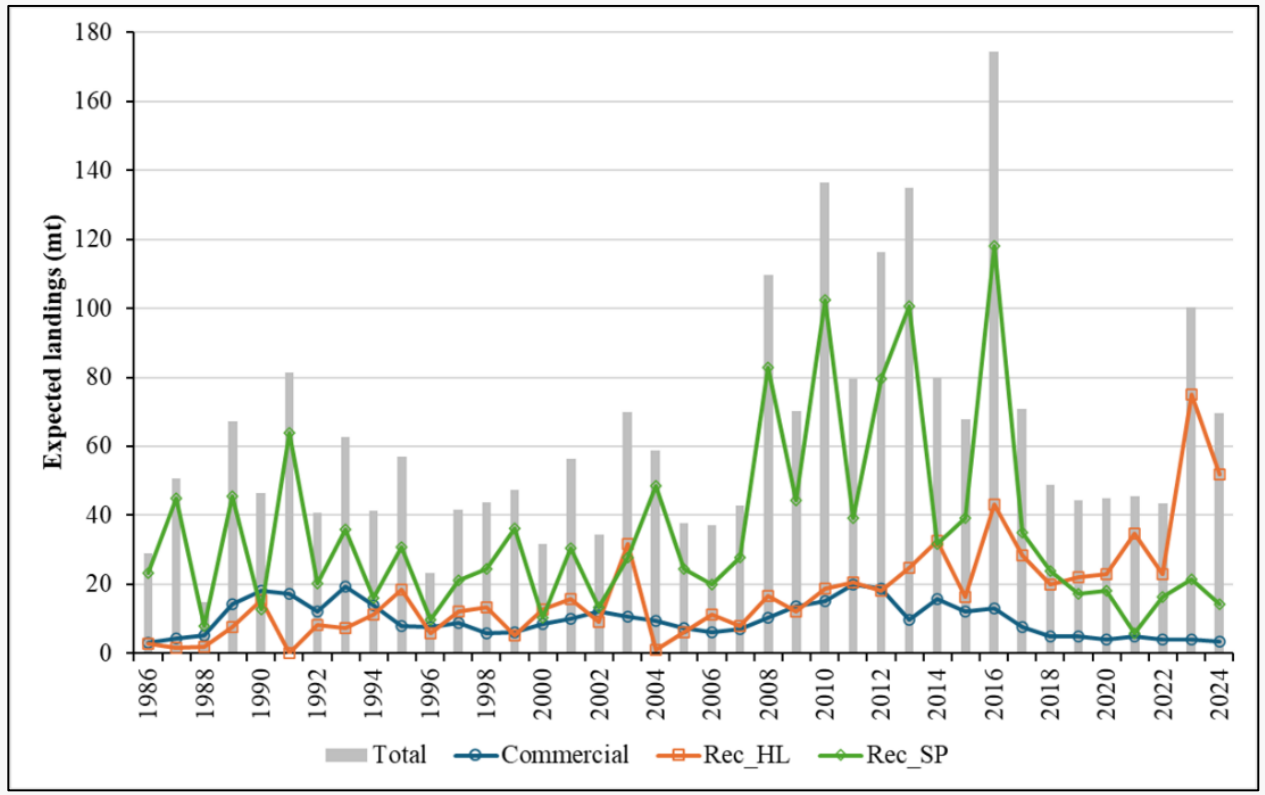


AW Report Figure 4.14

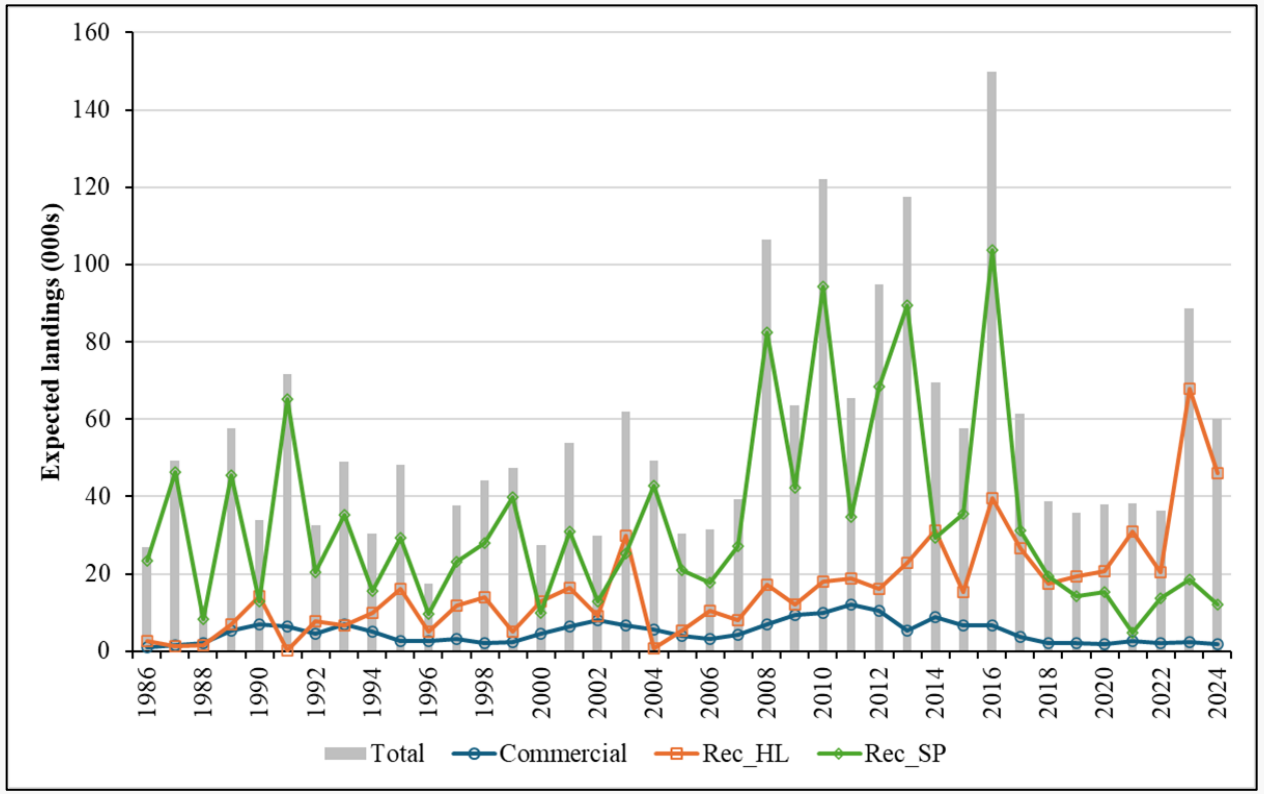


Landings

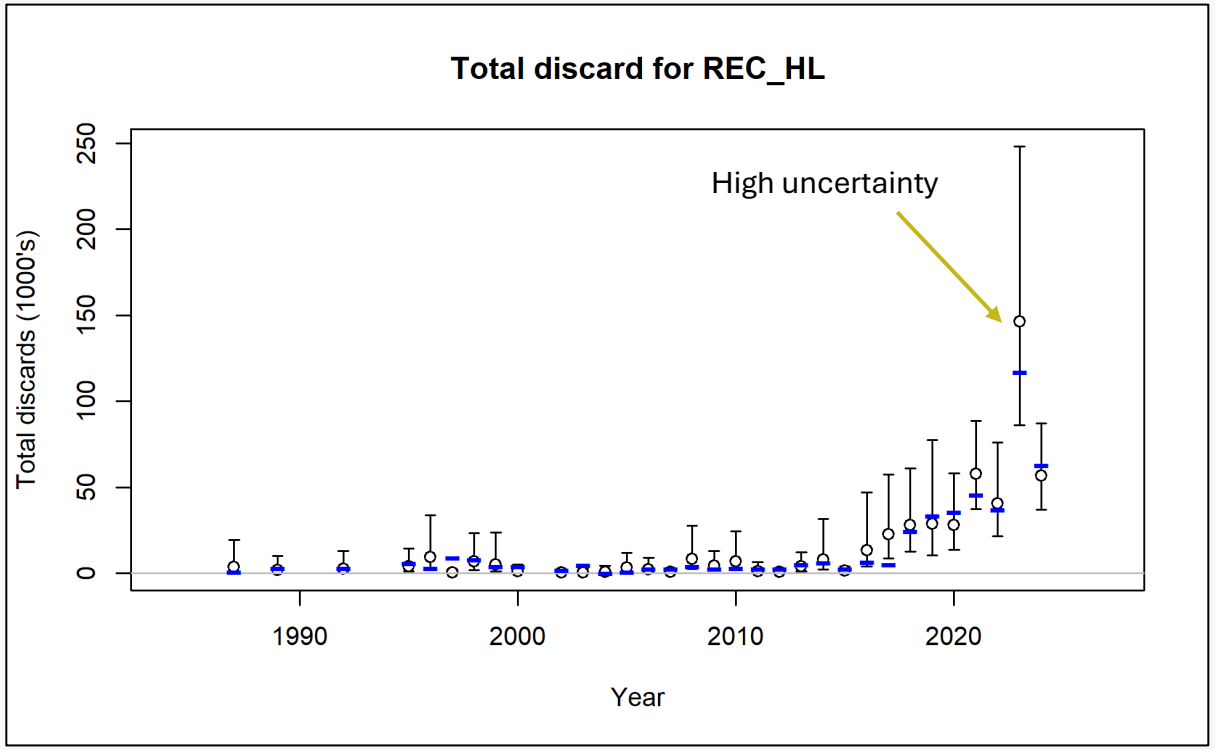
AW Report Figure 4.15



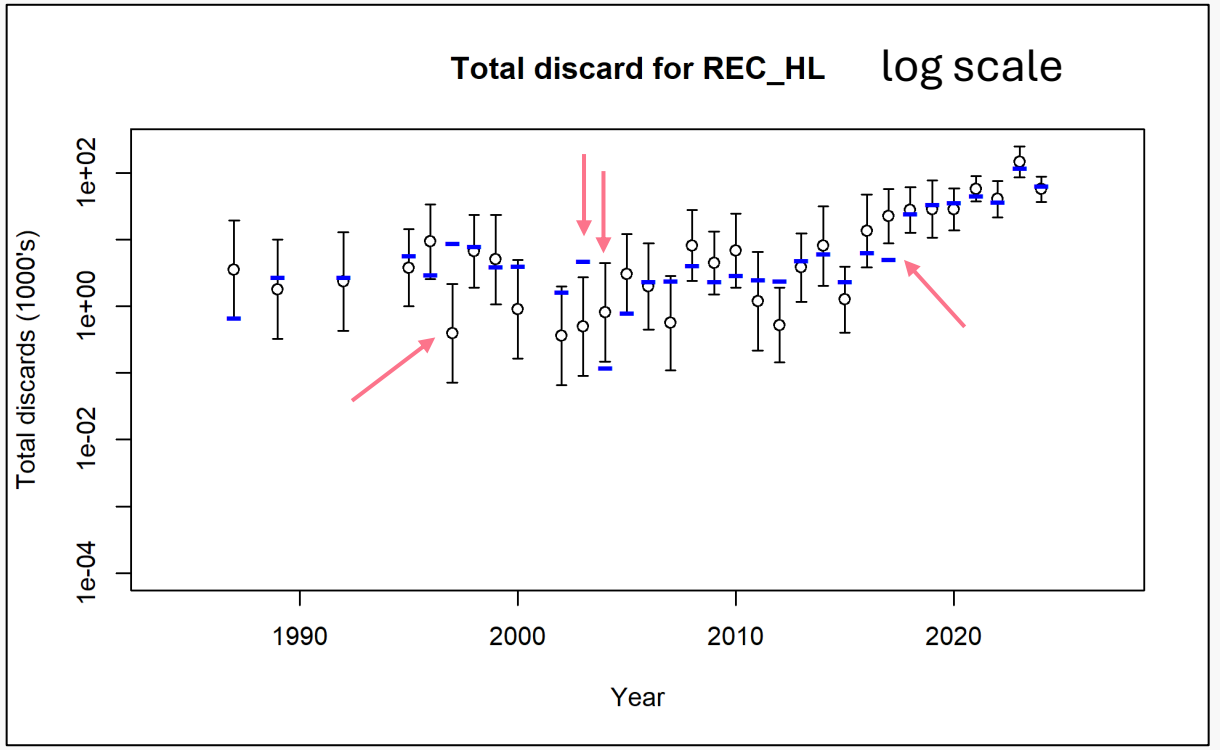
AW Report Figure 4.16



Discards

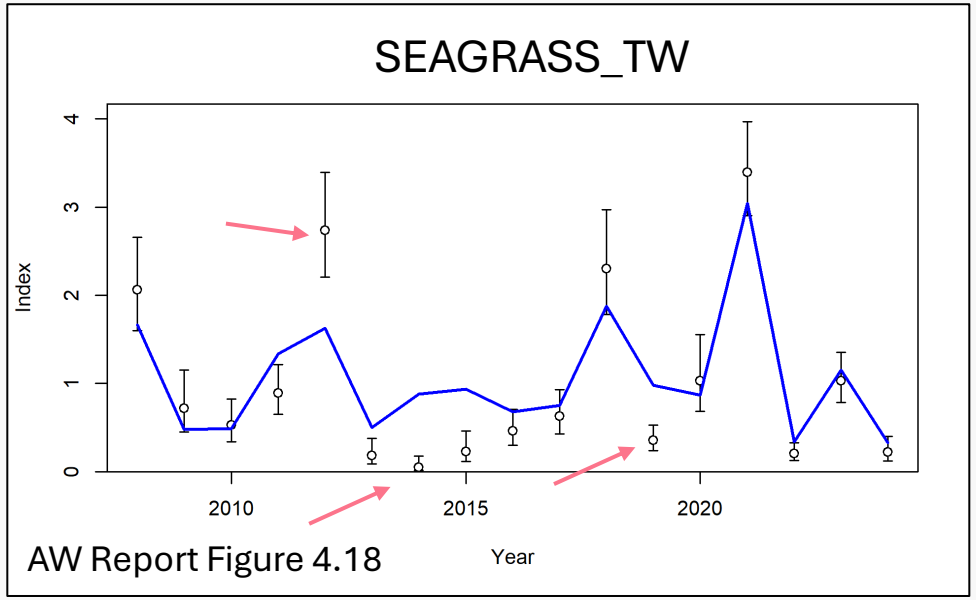


AW Report Figure 4.17

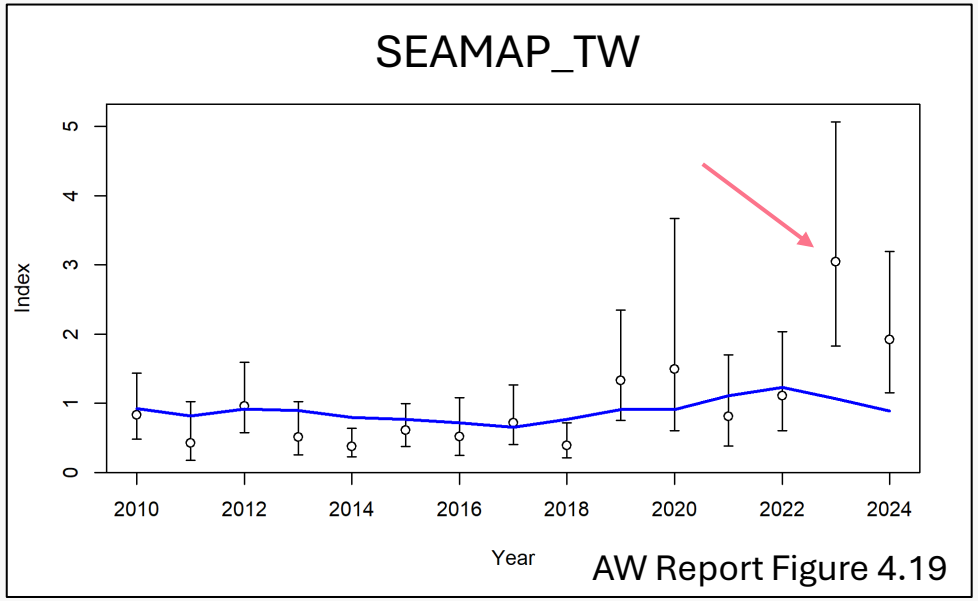


- Poor fit in some years
  - Product of F_{hybrid} configuration which fits landings near exact but can result in poorer fits to discards

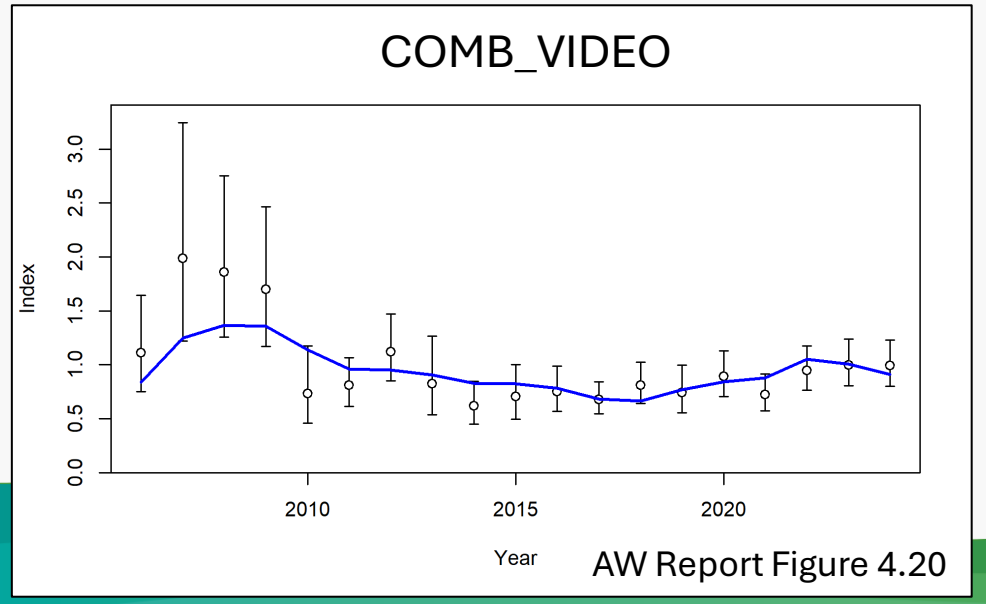
Indices of Abundance



AW Report Figure 4.18



AW Report Figure 4.19

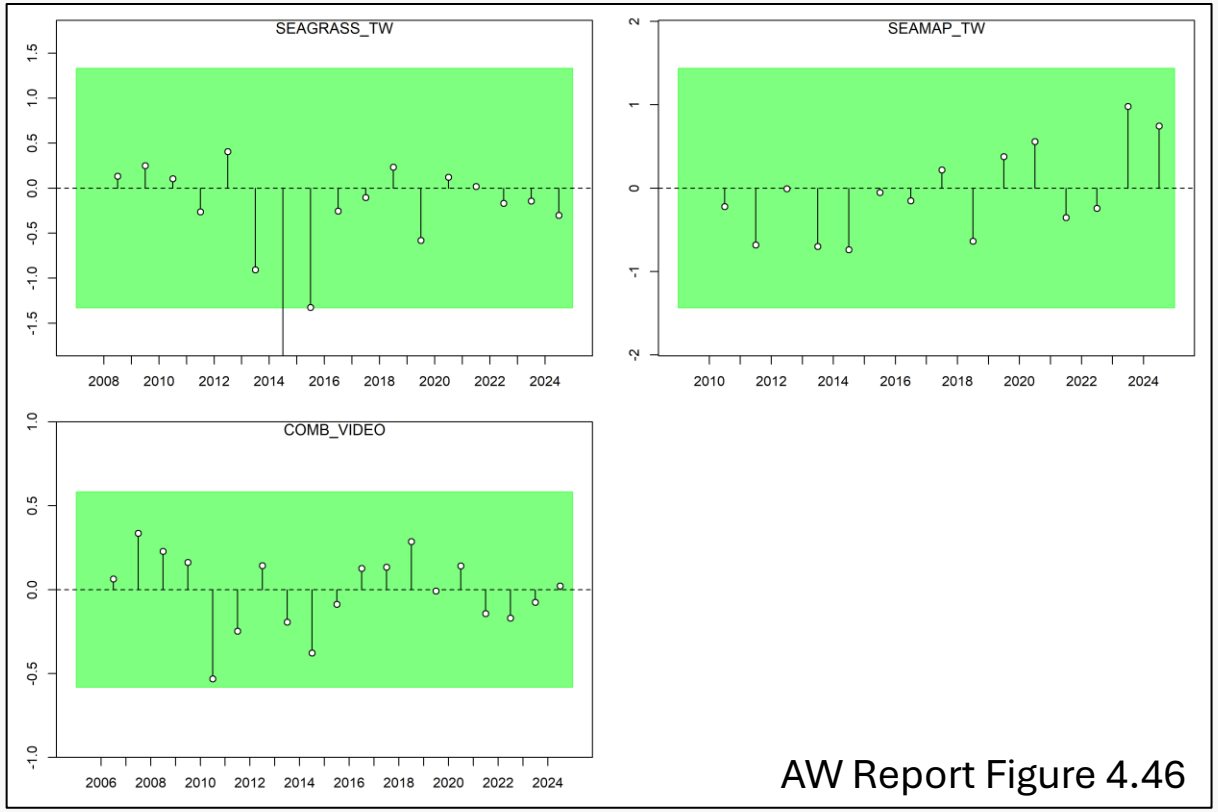


AW Report Figure 4.20

Index residuals

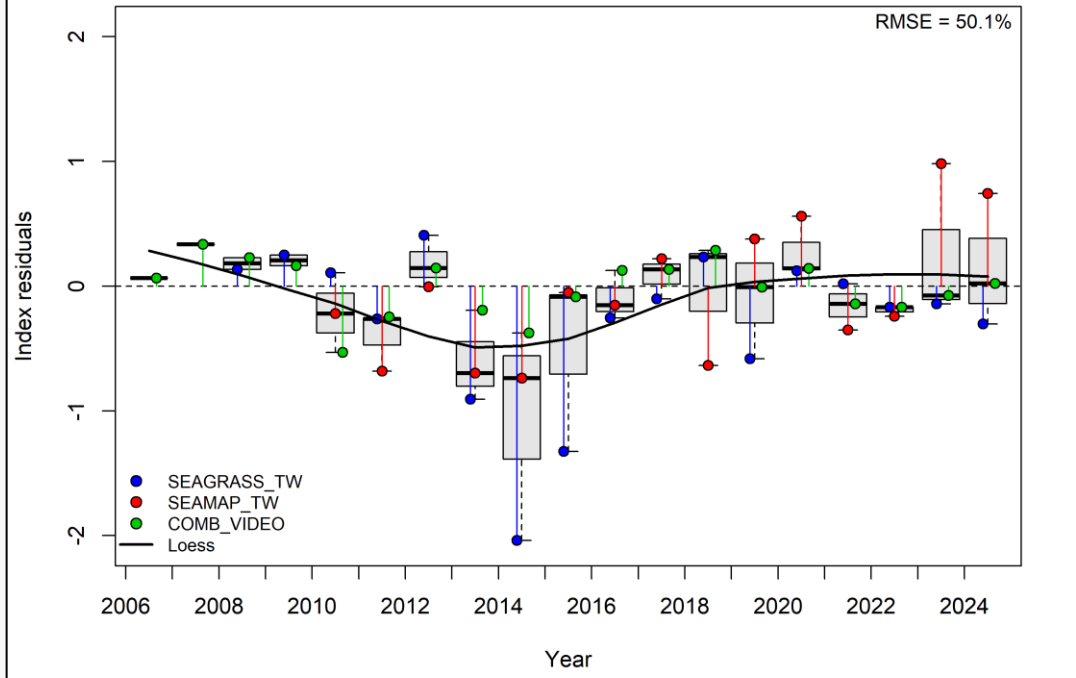
INDEX	RUNS.P	TEST	SIGMA3.LO	SIGMA3.HI	TYPE
SEAGRASS_TW	0.261	Passed	-1.33151	1.331509	CPUE
SEAMAP_TW	0.155	Passed	-1.43683	1.43683	CPUE
COMB_VIDEO	0.243	Passed	-0.58245	0.582452	CPUE

INDICES	RMSE %	nobs
SEAGRASS_TW	67.2	17
SEAMAP_TW	52.8	15
COMB_VIDEO	22.2	19
Combined	50.1	51

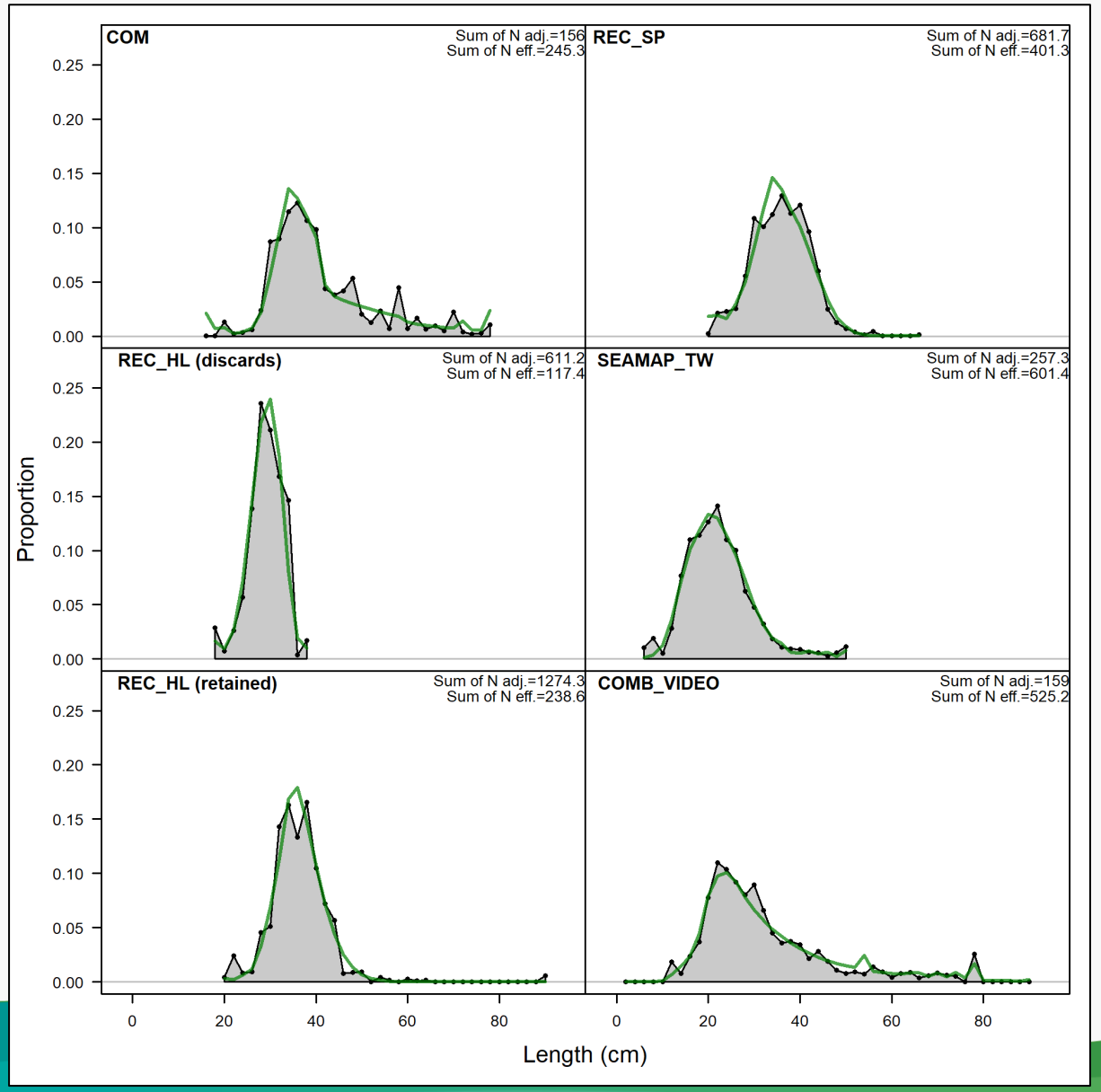


AW Report Figure 4.46

AW Report Figure 4.45a



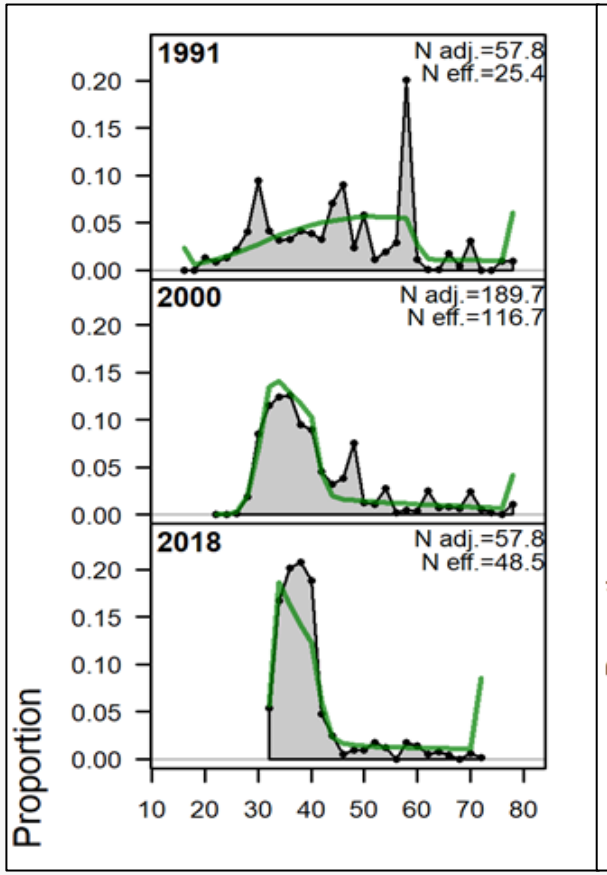
Length Composition



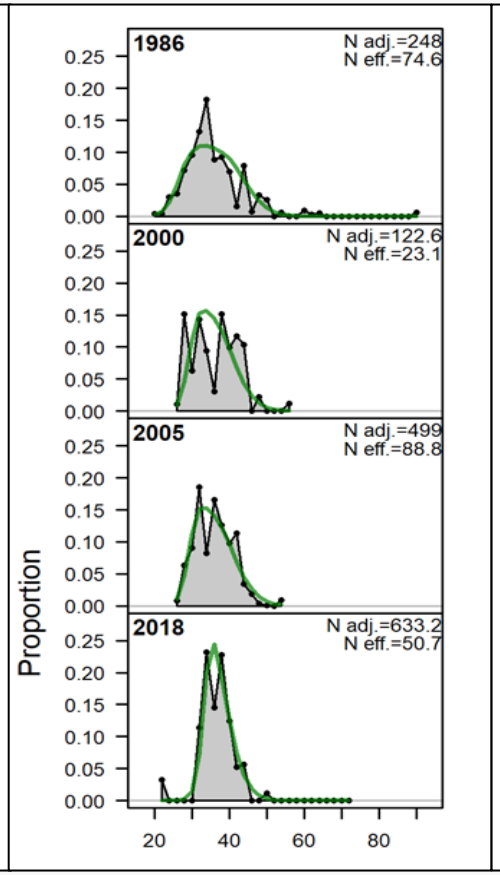
AW Report Figure 4.21

Length Composition

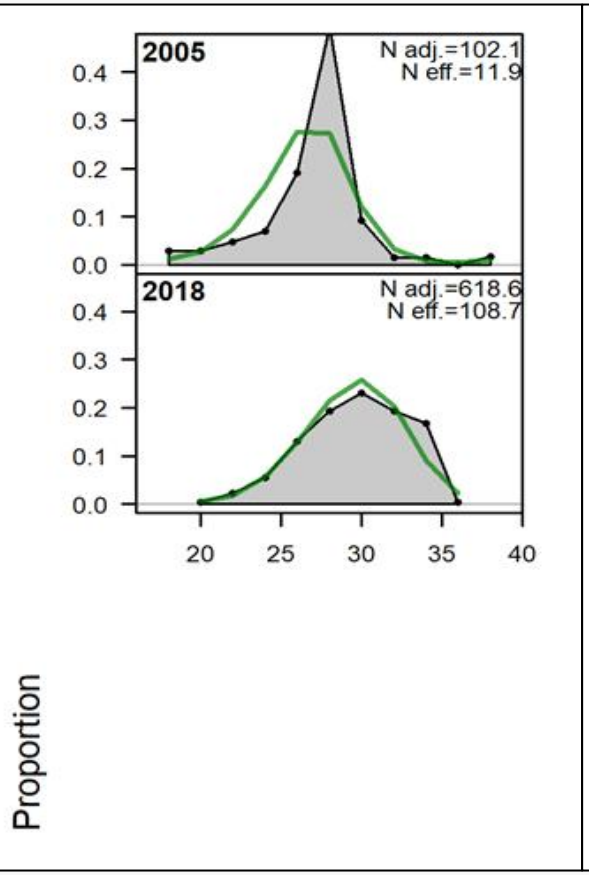
COM



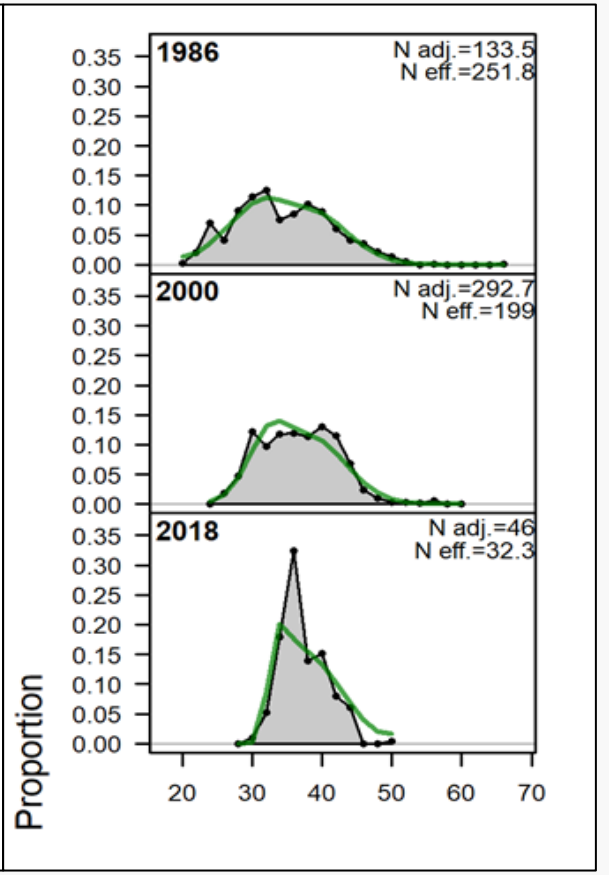
REChl retained



REChl discards



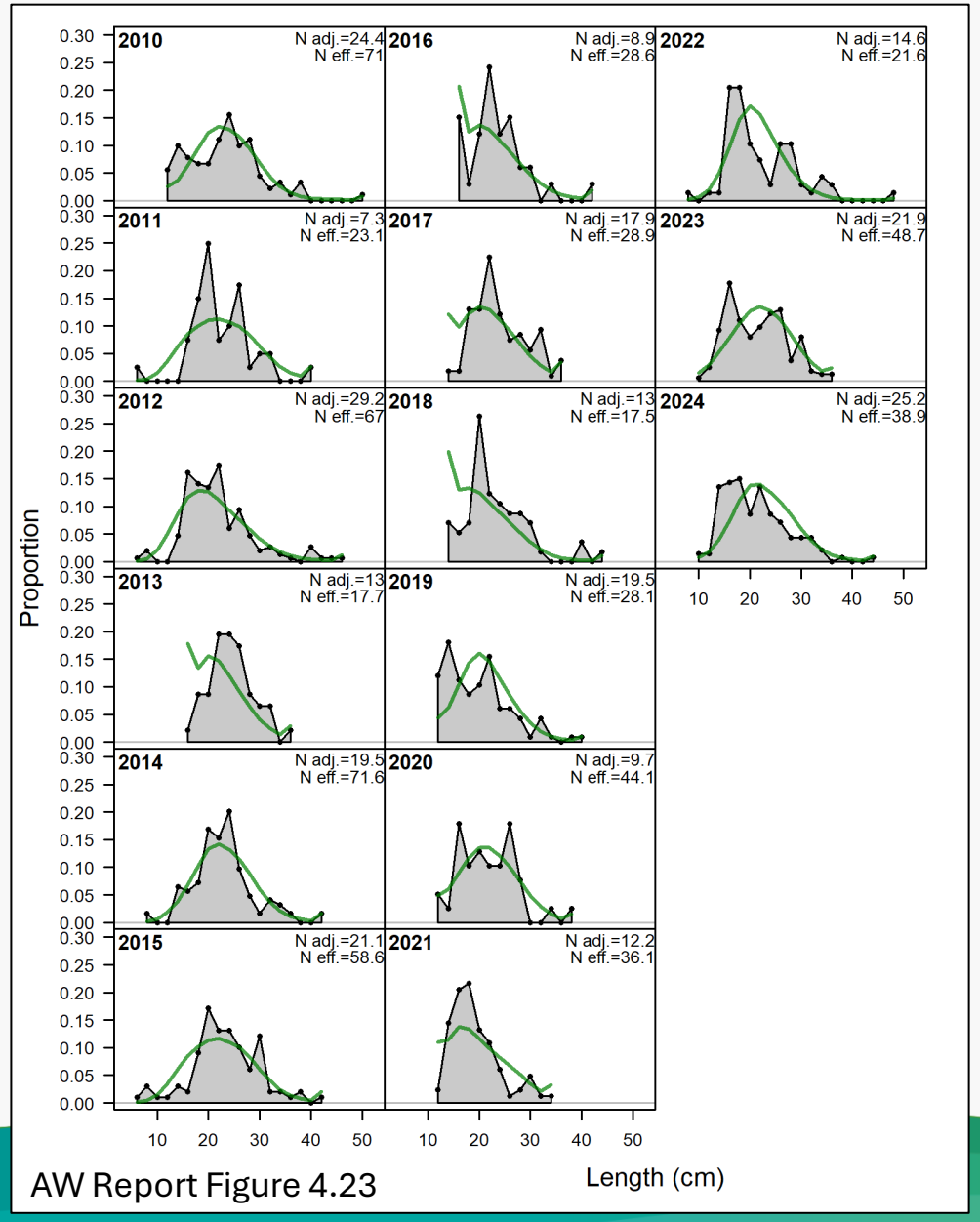
RECsp



AW Report Figure 4.22

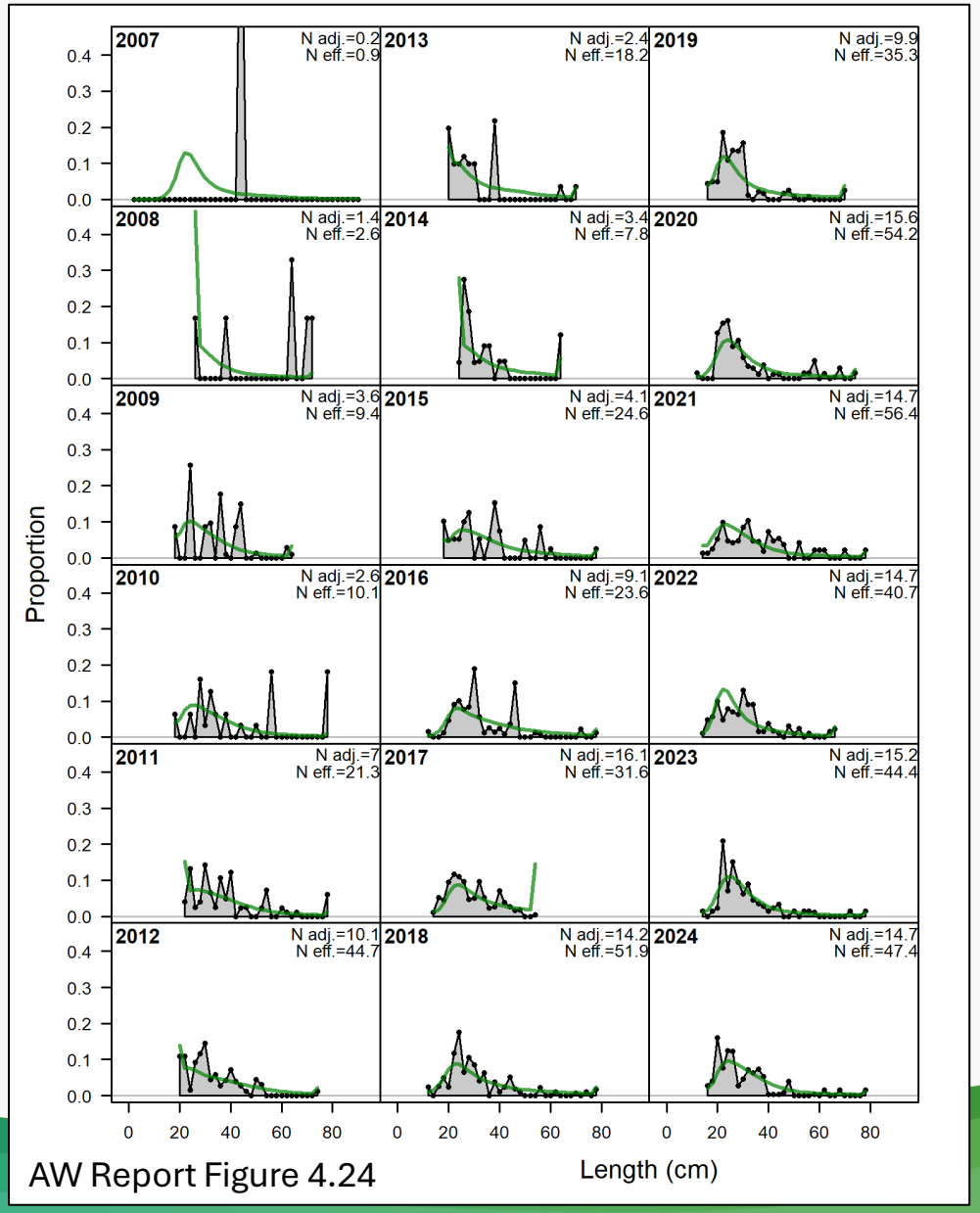
Length Composition

SEAMAP Trawl



AW Report Figure 4.23

Combined Video

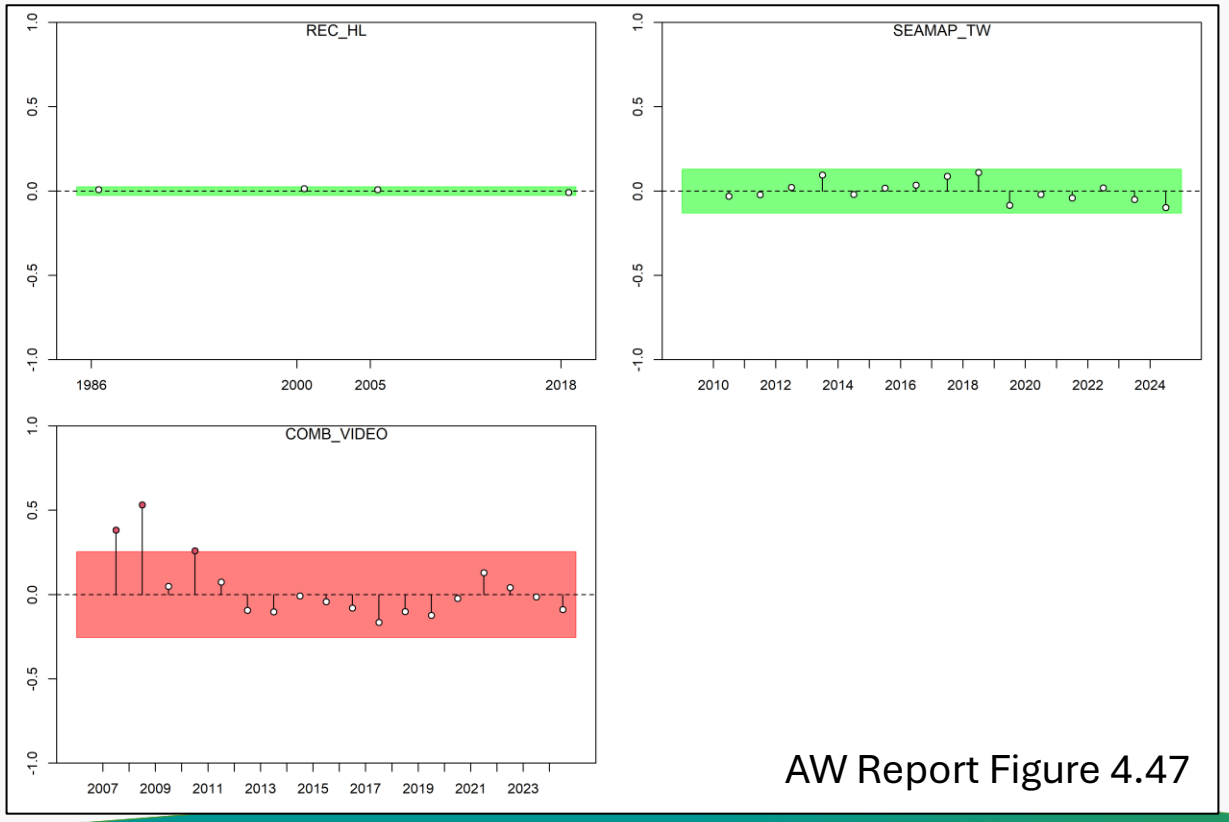


AW Report Figure 4.24

Length Composition Residuals

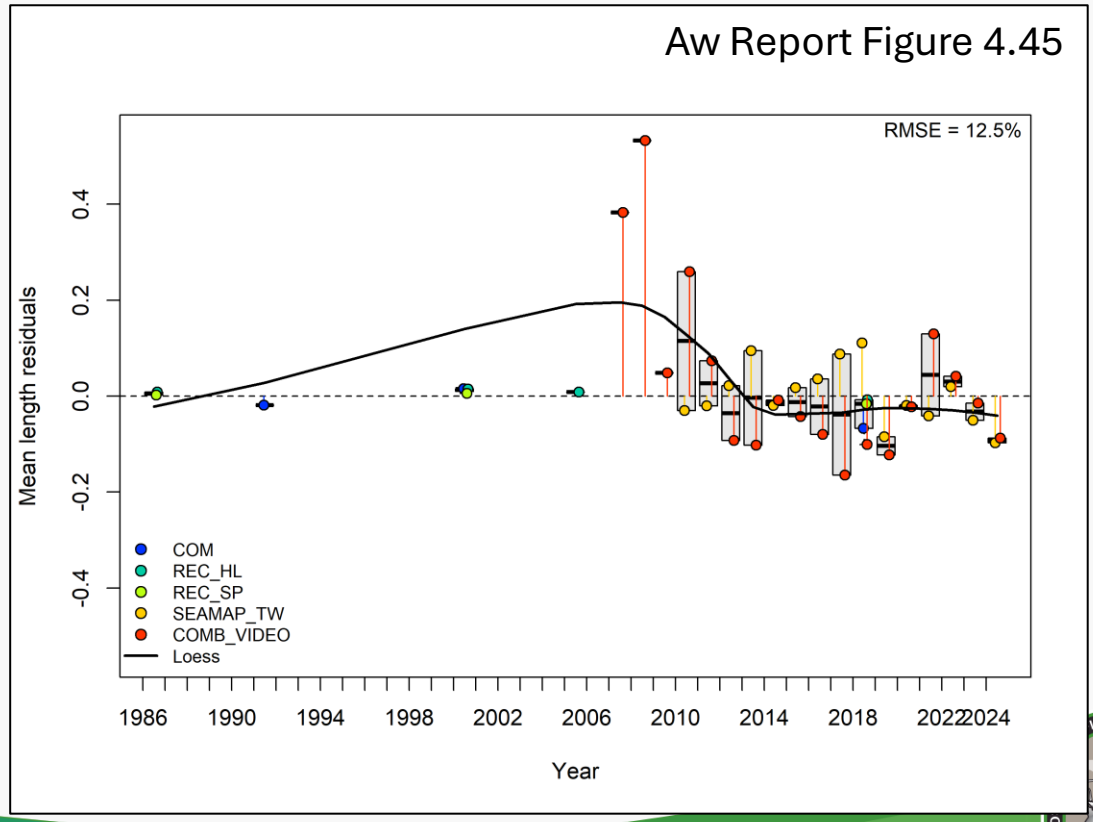
INDEX	RUNS.P	TEST	SIGMA3.LO	SIGMA3.HI	TYPE
REC_HL	0.159	Passed	-0.02522	0.025217	length
SEAMAP_TW	0.215	Passed	-0.12992	0.12992	length
COMB_VIDEO	0.002	Failed	-0.25396	0.253958	length

INDICES	RMSE %	nobs
COM	4.2	3
SEAMAP_TW	6	15
COMB_VIDEO	18.4	18
REC_HL	1	4
REC_SP	1	3
Combined	12.5	43

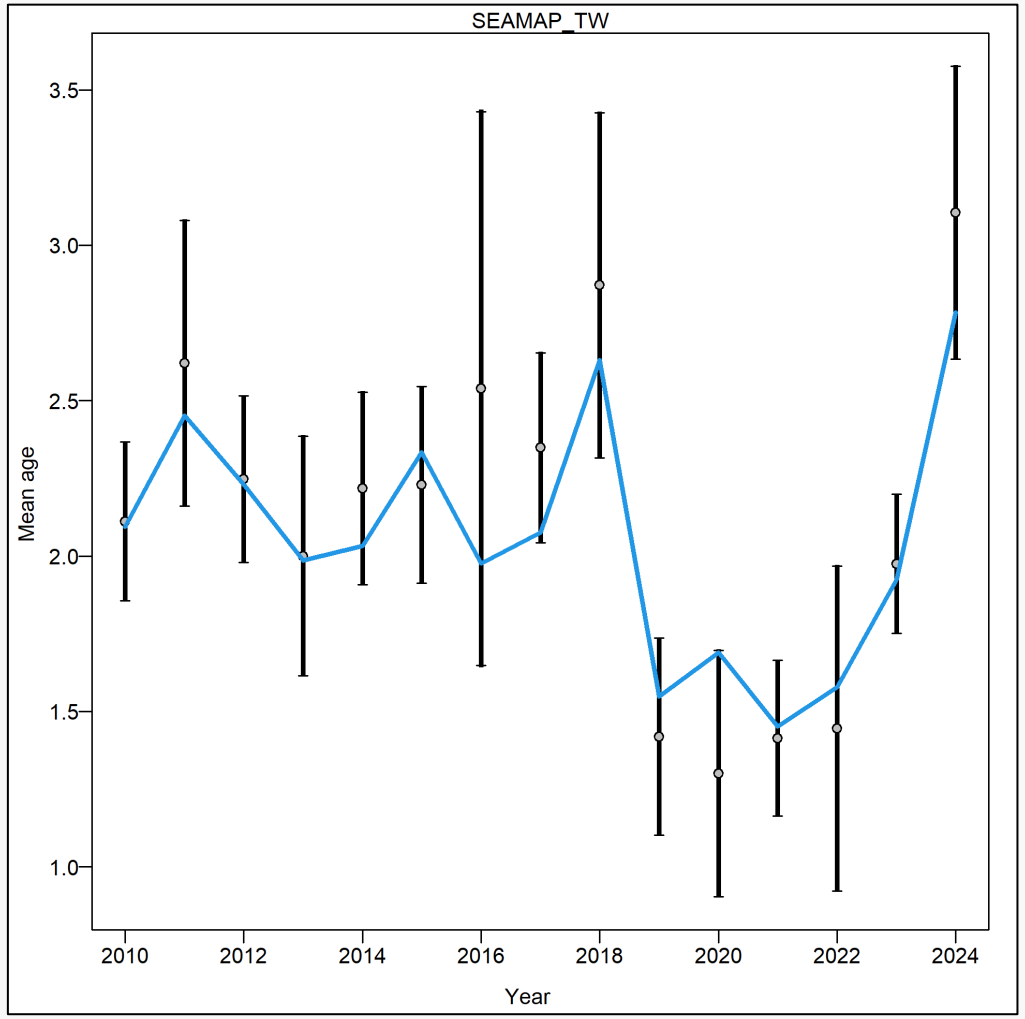


AW Report Figure 4.47

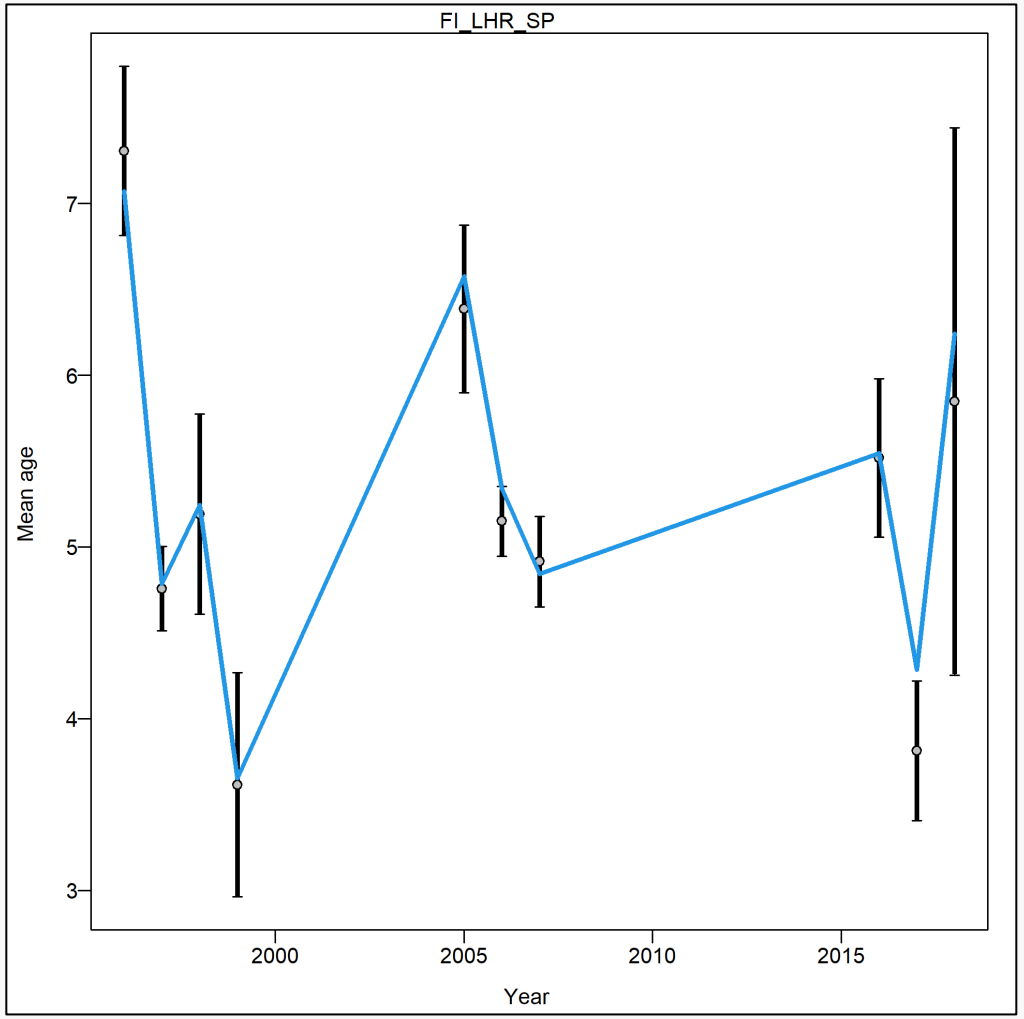
Aw Report Figure 4.45



Conditional Age-at-Length



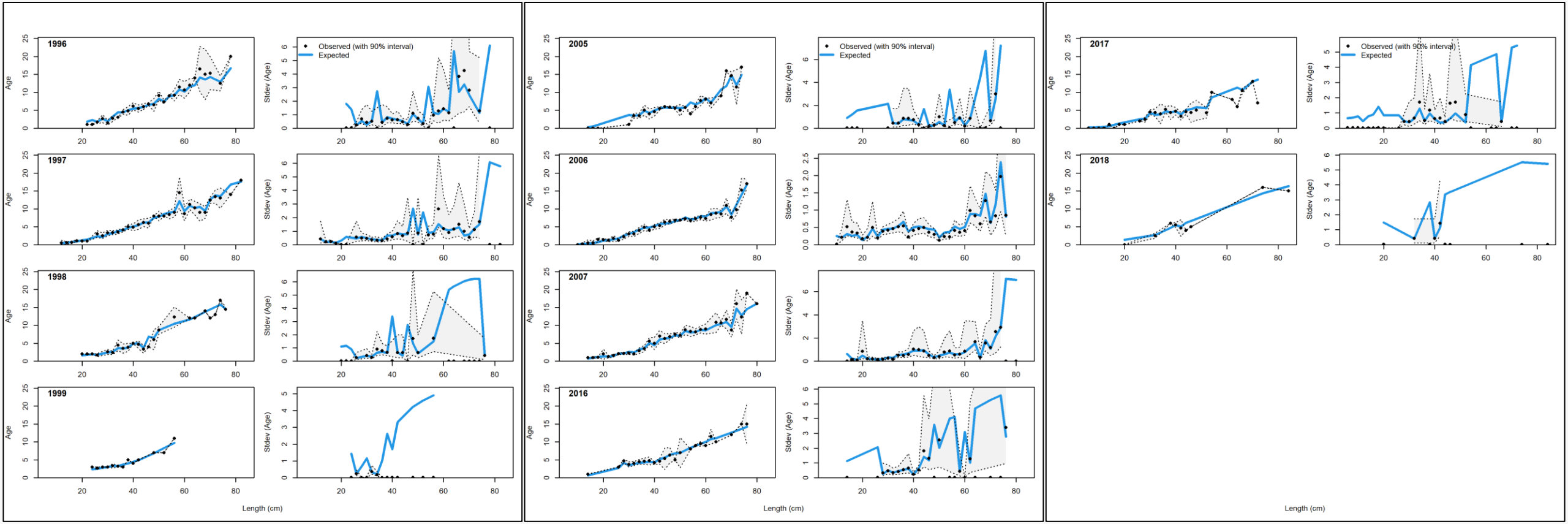
AW Report Figure 4.26a



AW Report Figure 4.26b

Conditional Age-at-Length

Fishery-independent Spear data

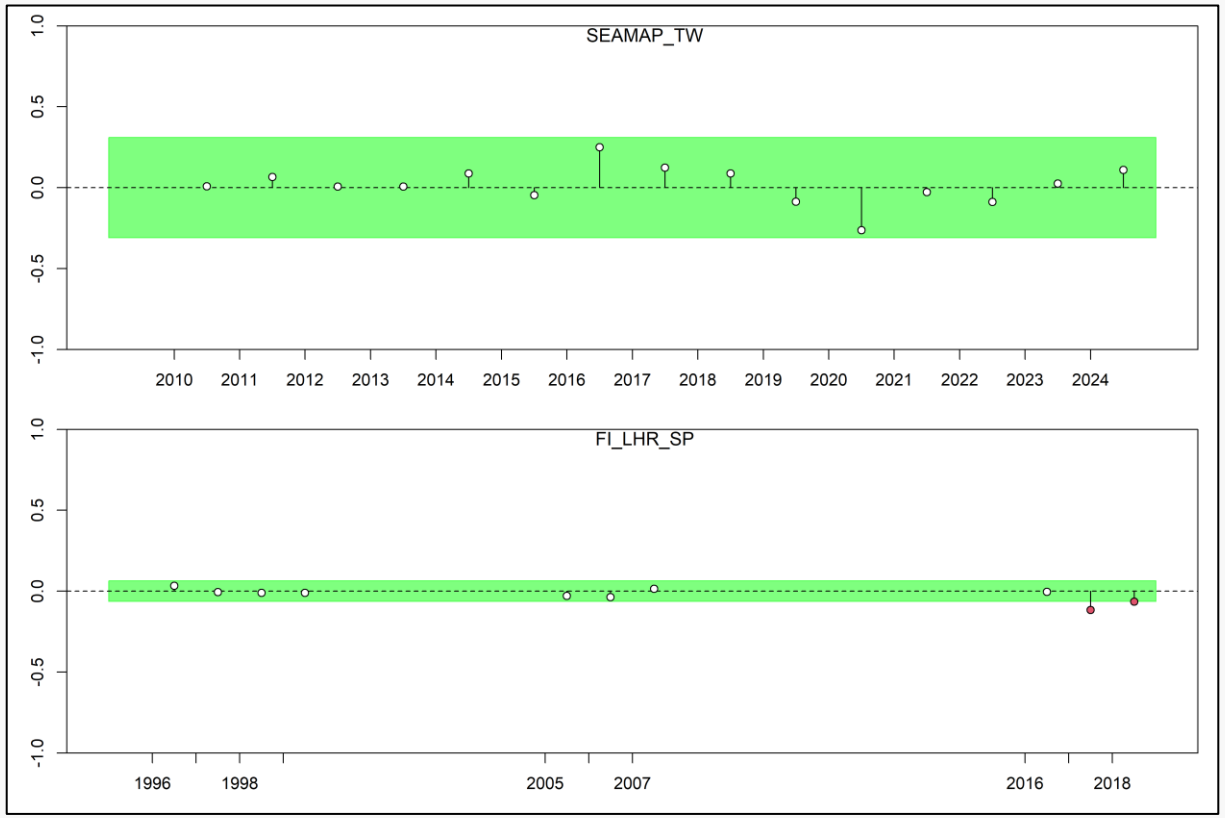


Adapted from AW Report Figure 4.28

Conditional Age-at-Length

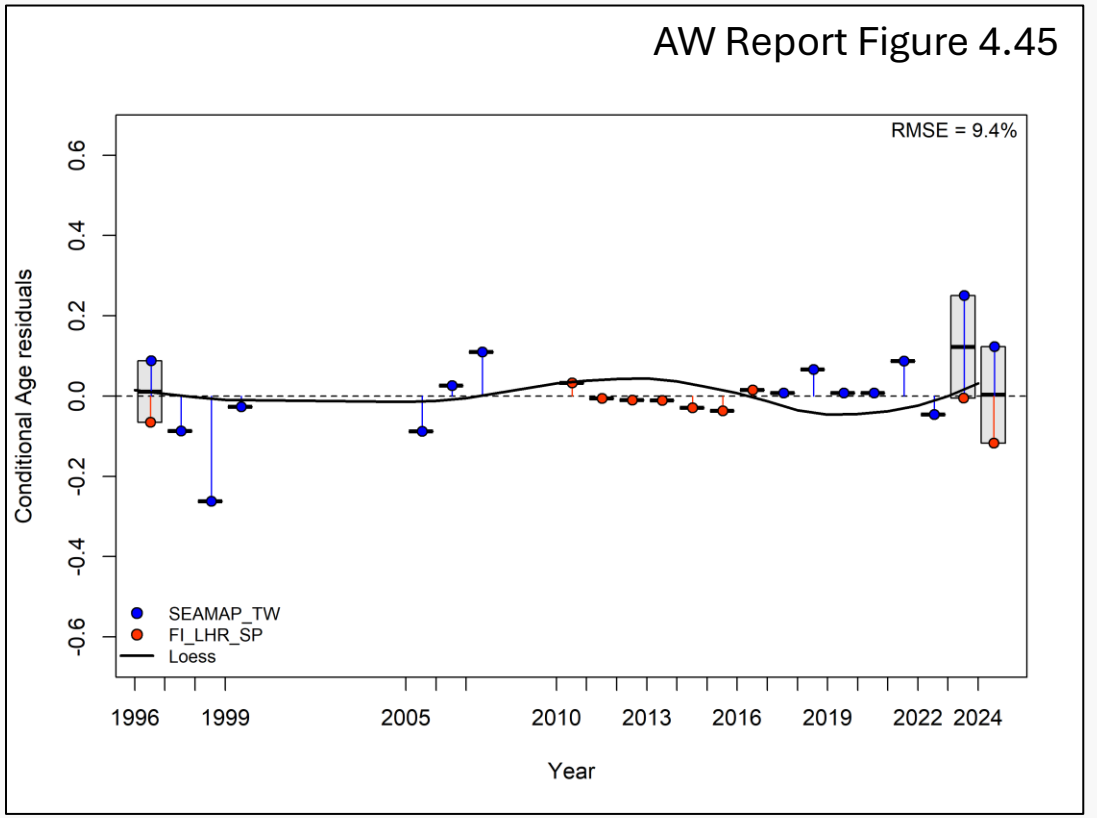
INDEX	RUNS.P	TEST	SIGMA3.LO	SIGMA3.HI	TYPE
SEAMAP_TW	0.052	Passed	-0.31034	0.31034	Con
FI_LHR_SP	0.411	Passed	-0.06378	0.063777	Con

INDICES	RMSE %	nobs
FI_LHR_SP	4.7	10
SEAMAP_TW	11.5	15
Combined	9.4	25

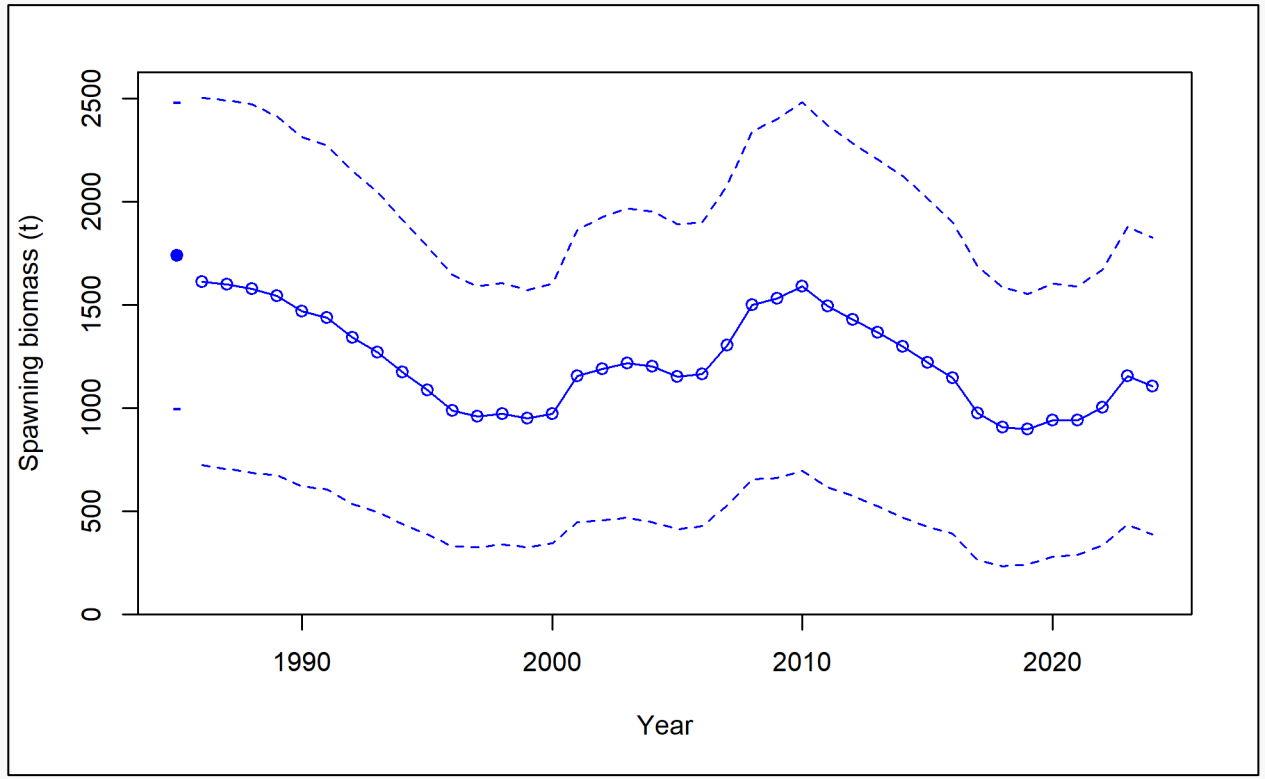


AW Report Figure 4.47

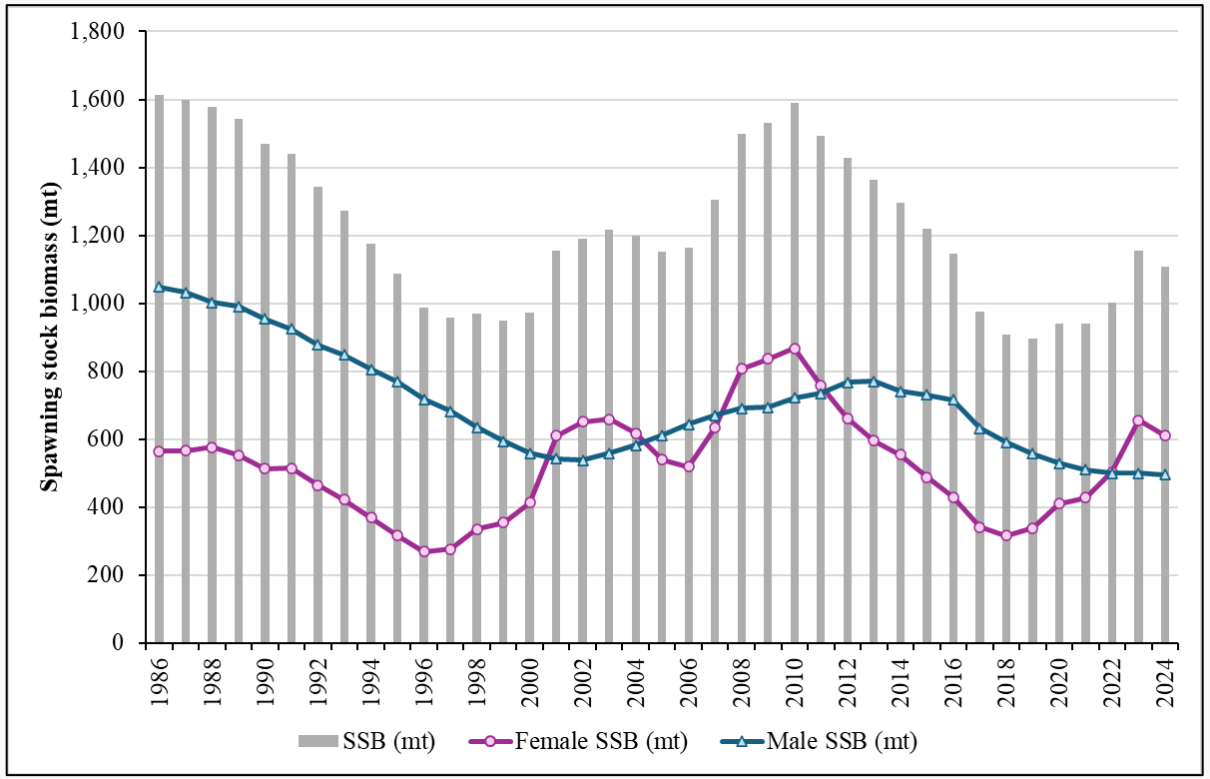
AW Report Figure 4.45



Spawning Stock Biomass (male and female)

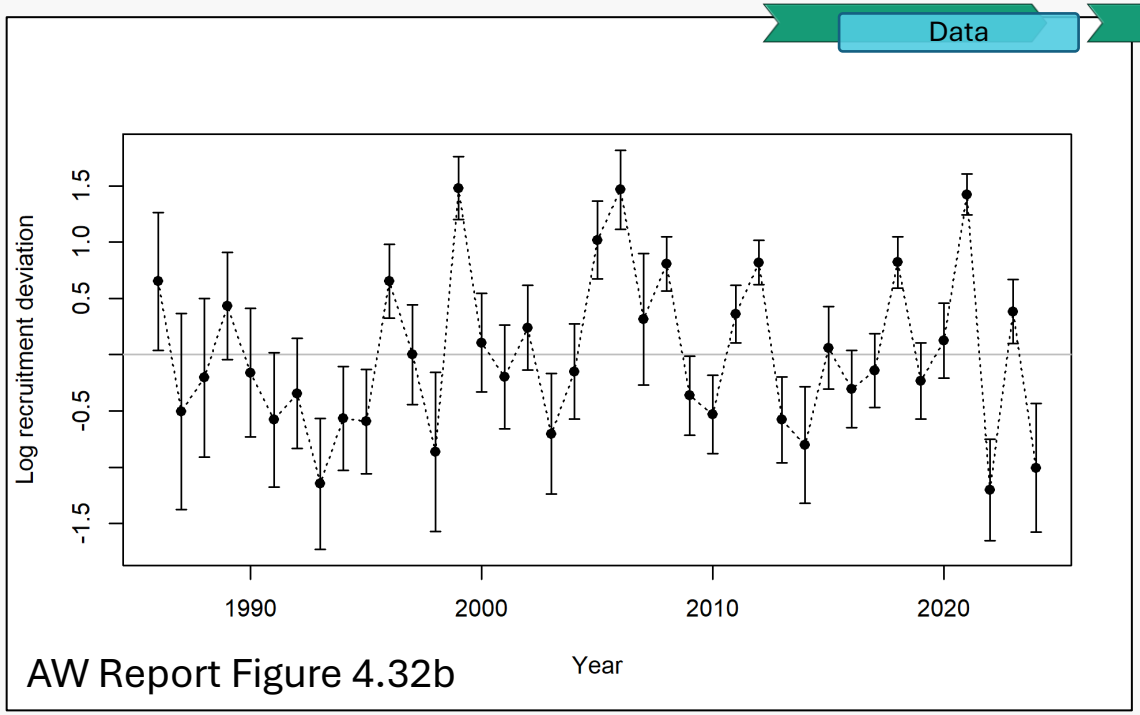


AW Report Figure 4.30a

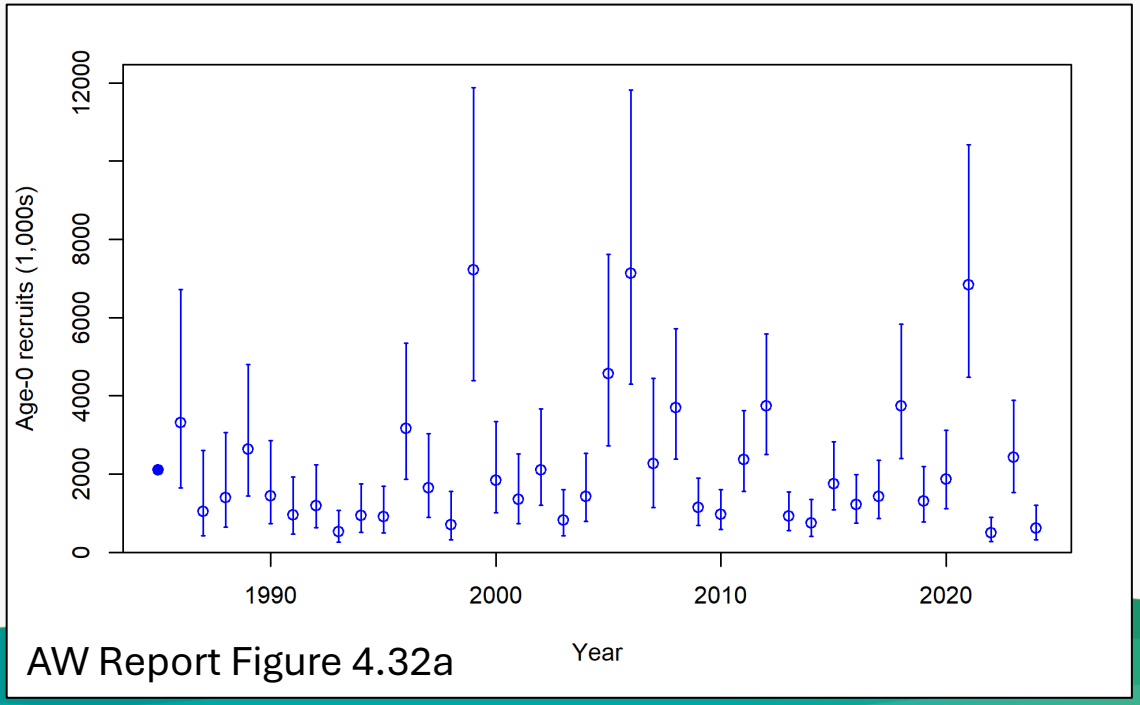


AW Report Figure 4.30b

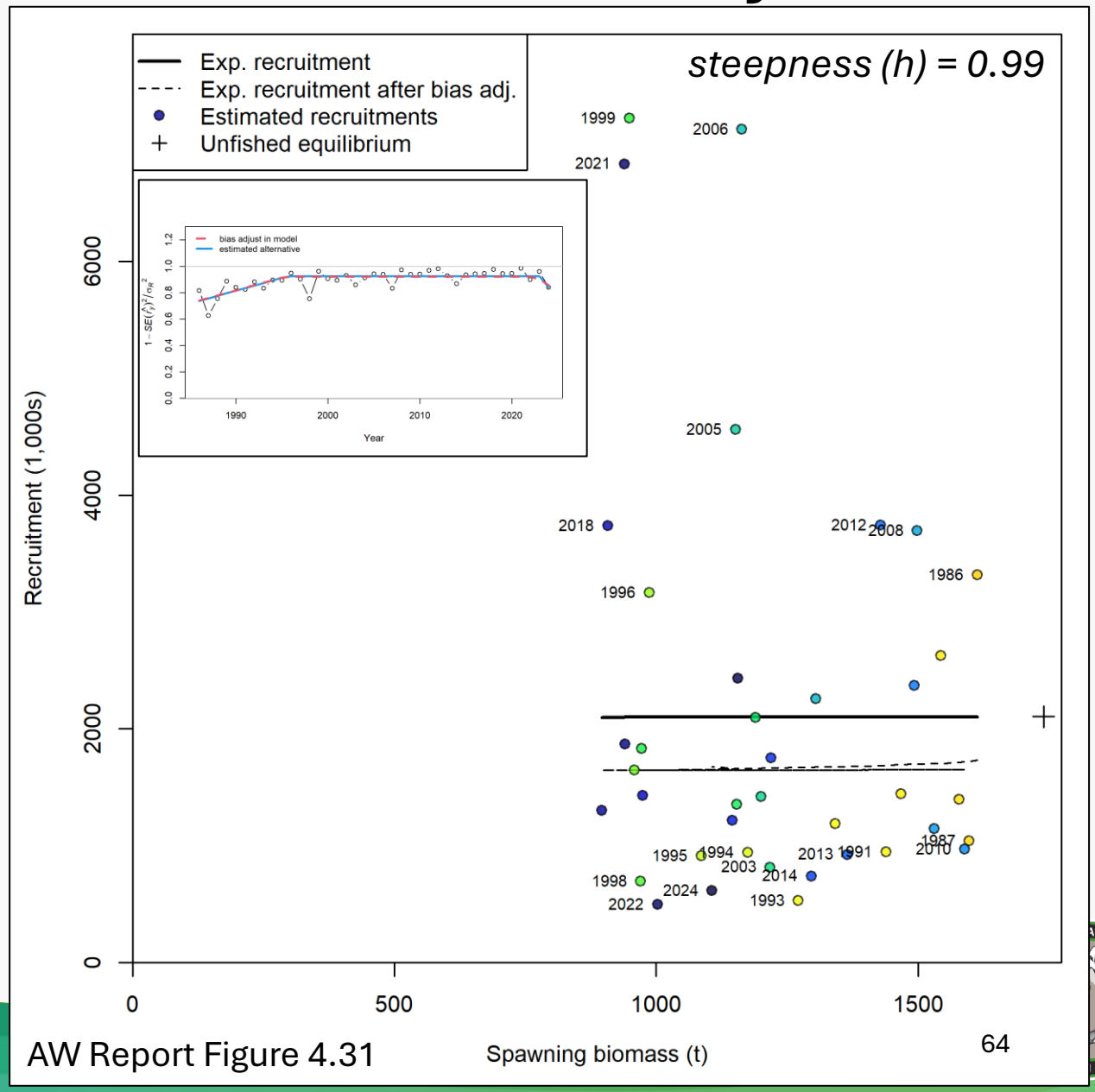
Stock-Recruitment Dynamics



AW Report Figure 4.32b



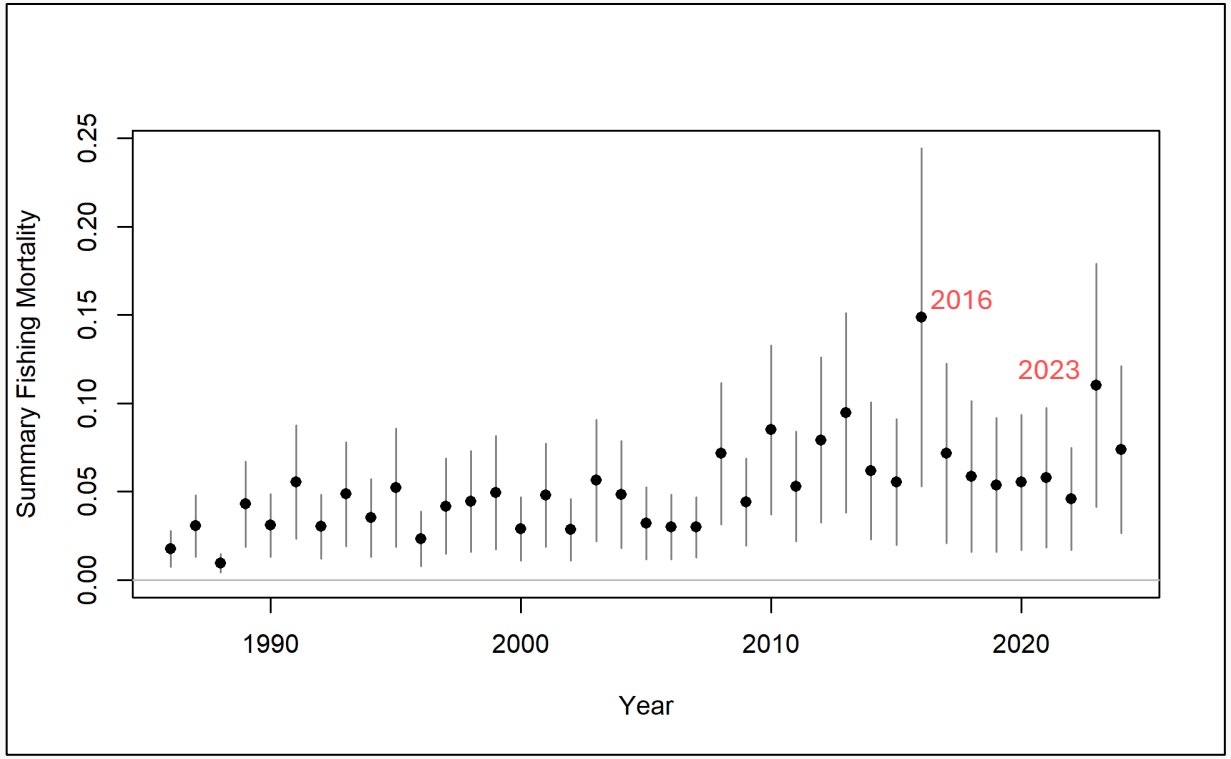
AW Report Figure 4.32a



AW Report Figure 4.31

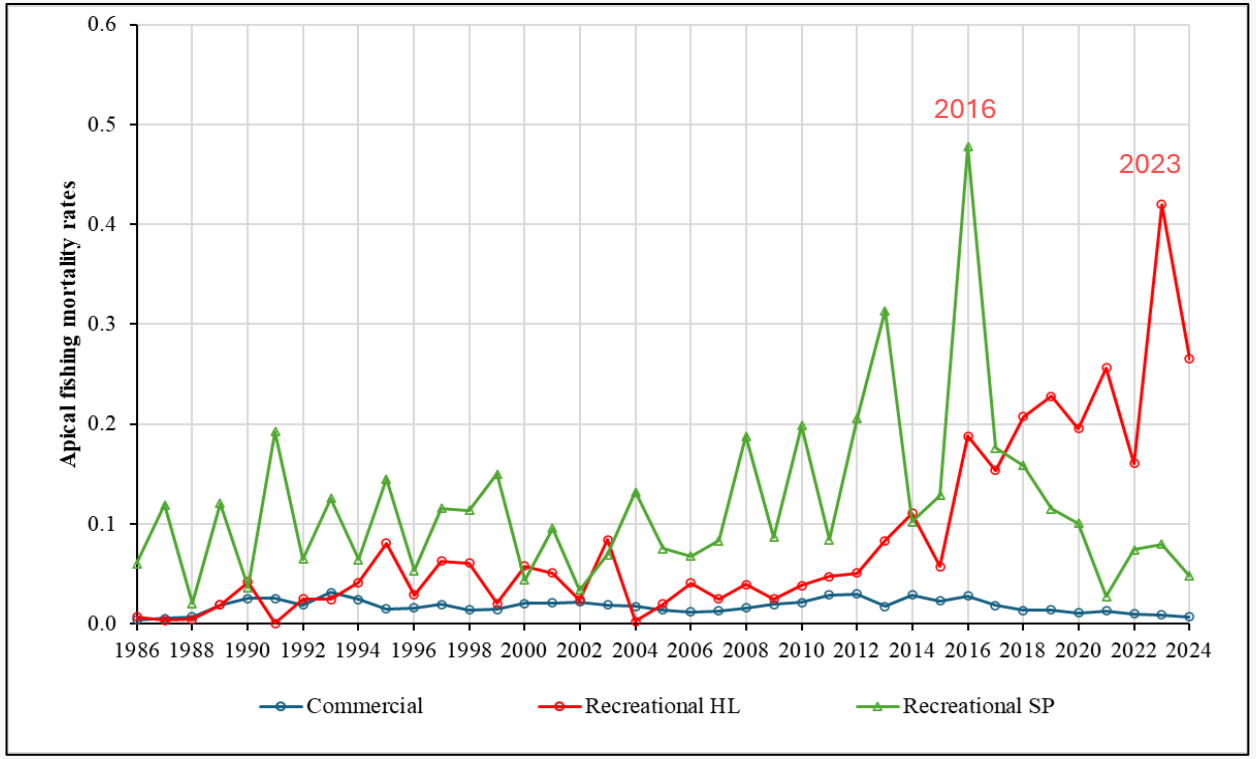
Fishing Mortality Rates

Exploitation rates



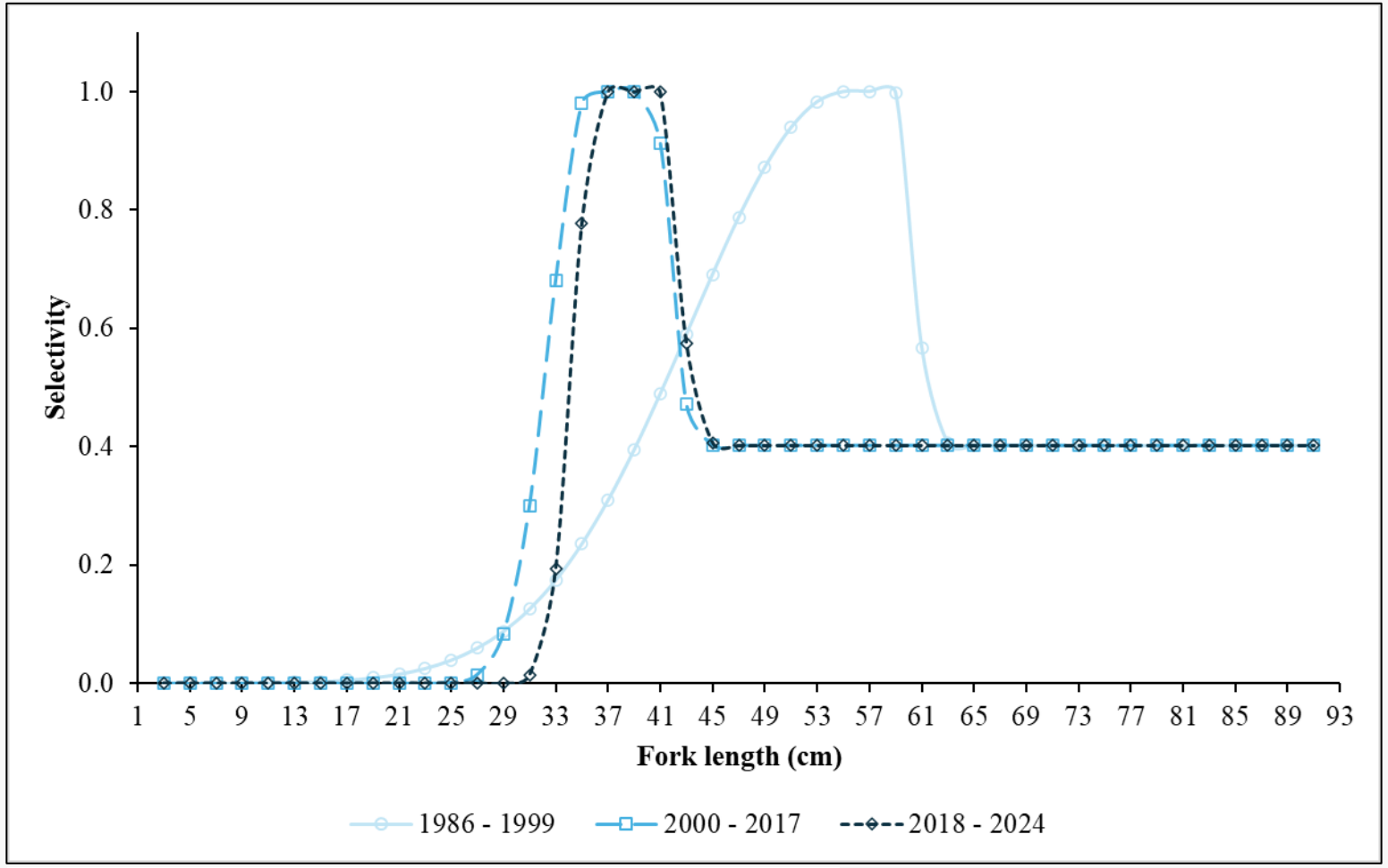
AW Report Figure 4.34

Apical fishing mortality rates



AW Report Figure 4.35

Selectivity: Commercial



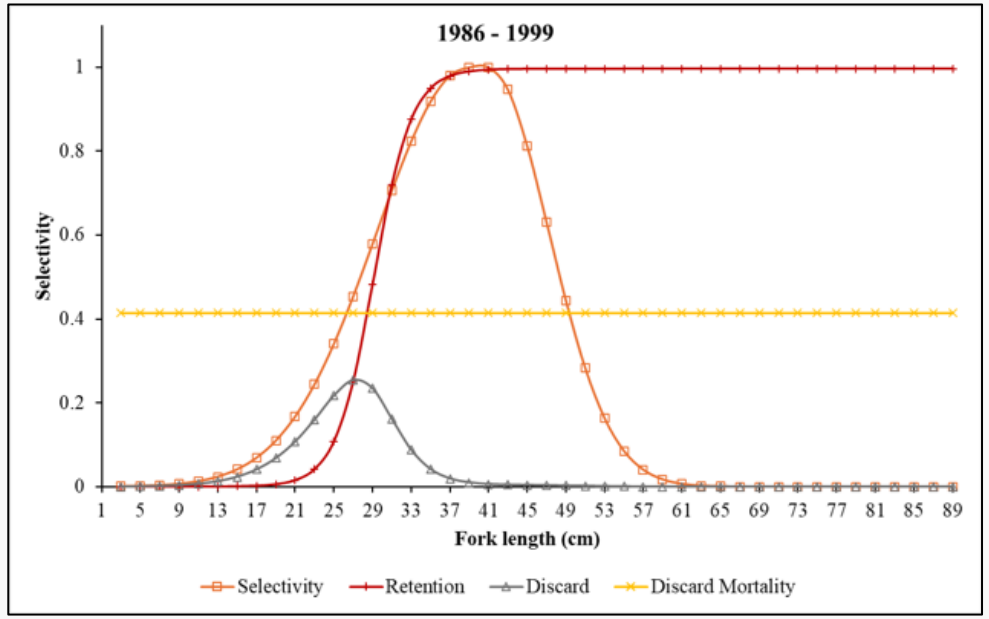
AW Report Figure 4.36

Time Blocks:

- 1986 – 1998: No minimum size limits
- 1999 – 2017: 12” (305 mm) FL minimum size
- 2018 – 2024: 14” (356 mm) FL minimum size

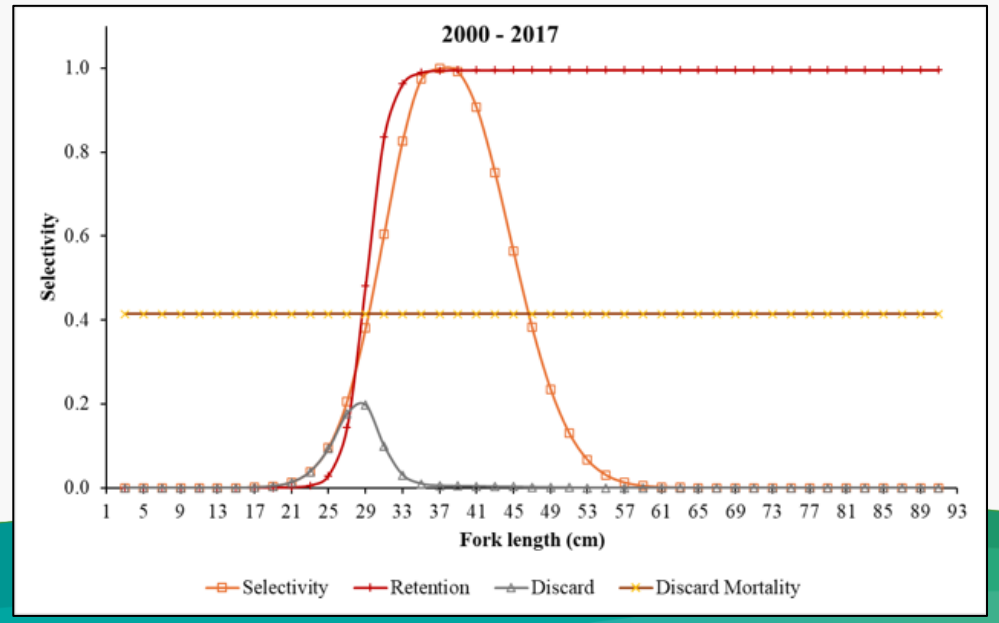
Selectivity: Recreational HL

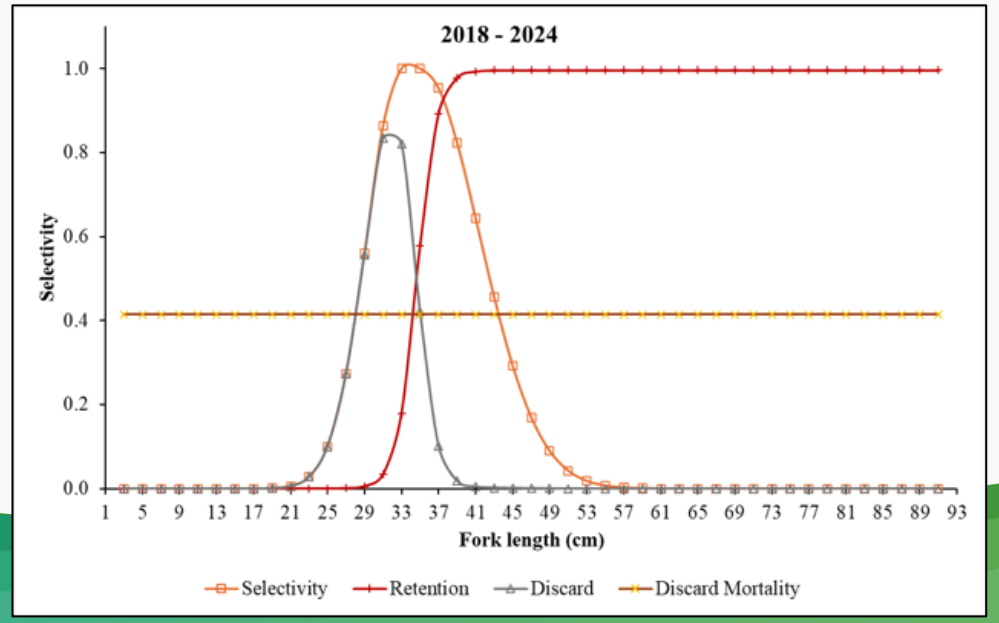
Adapted from AW Report Figure 4.37



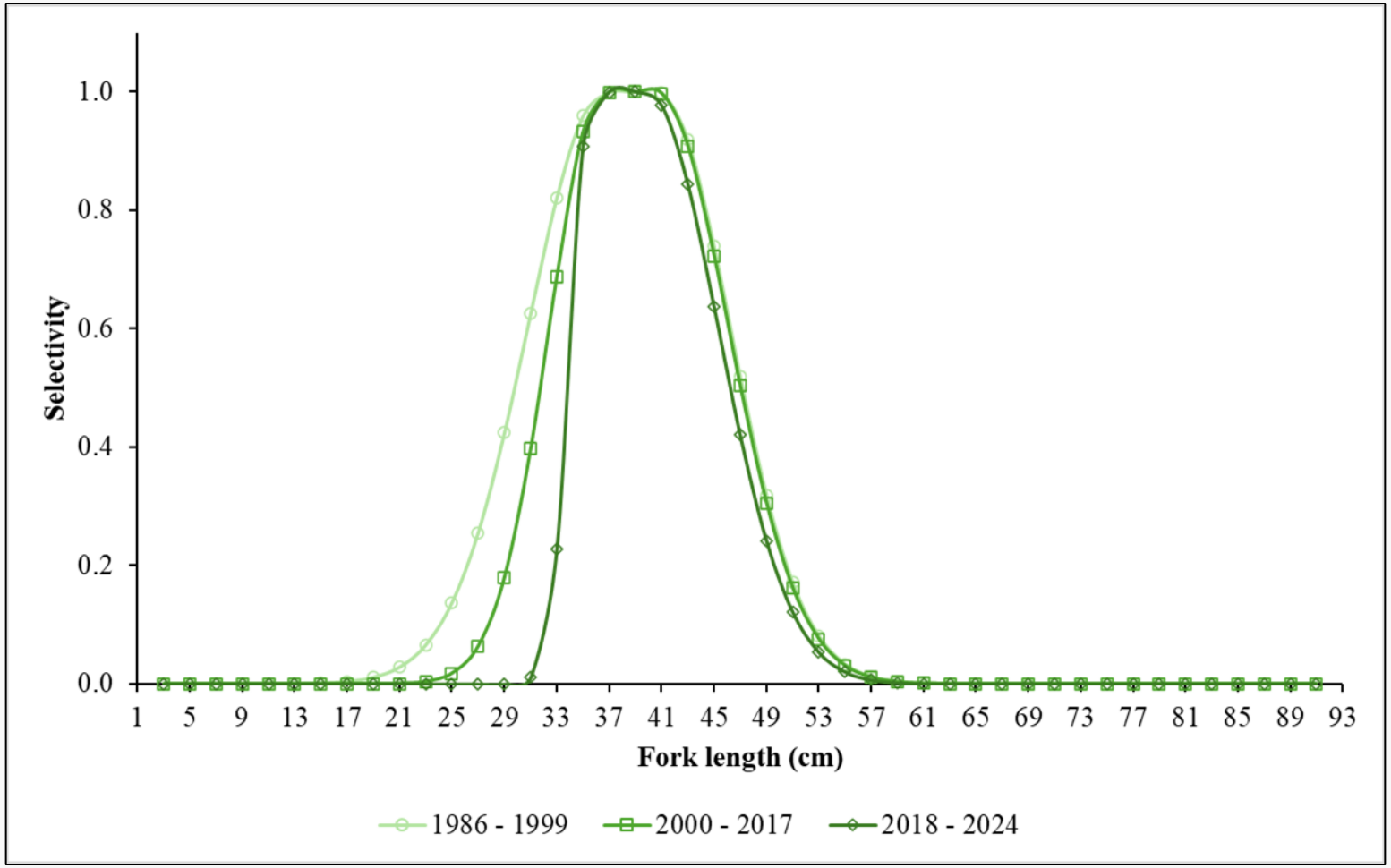
Time Blocks:

- 1986 – 1998: No minimum size limits
- 1999 – 2017: 12” (305 mm) FL minimum size
- 2018 – 2024: 14” (356 mm) FL minimum size





Selectivity: Recreational SP

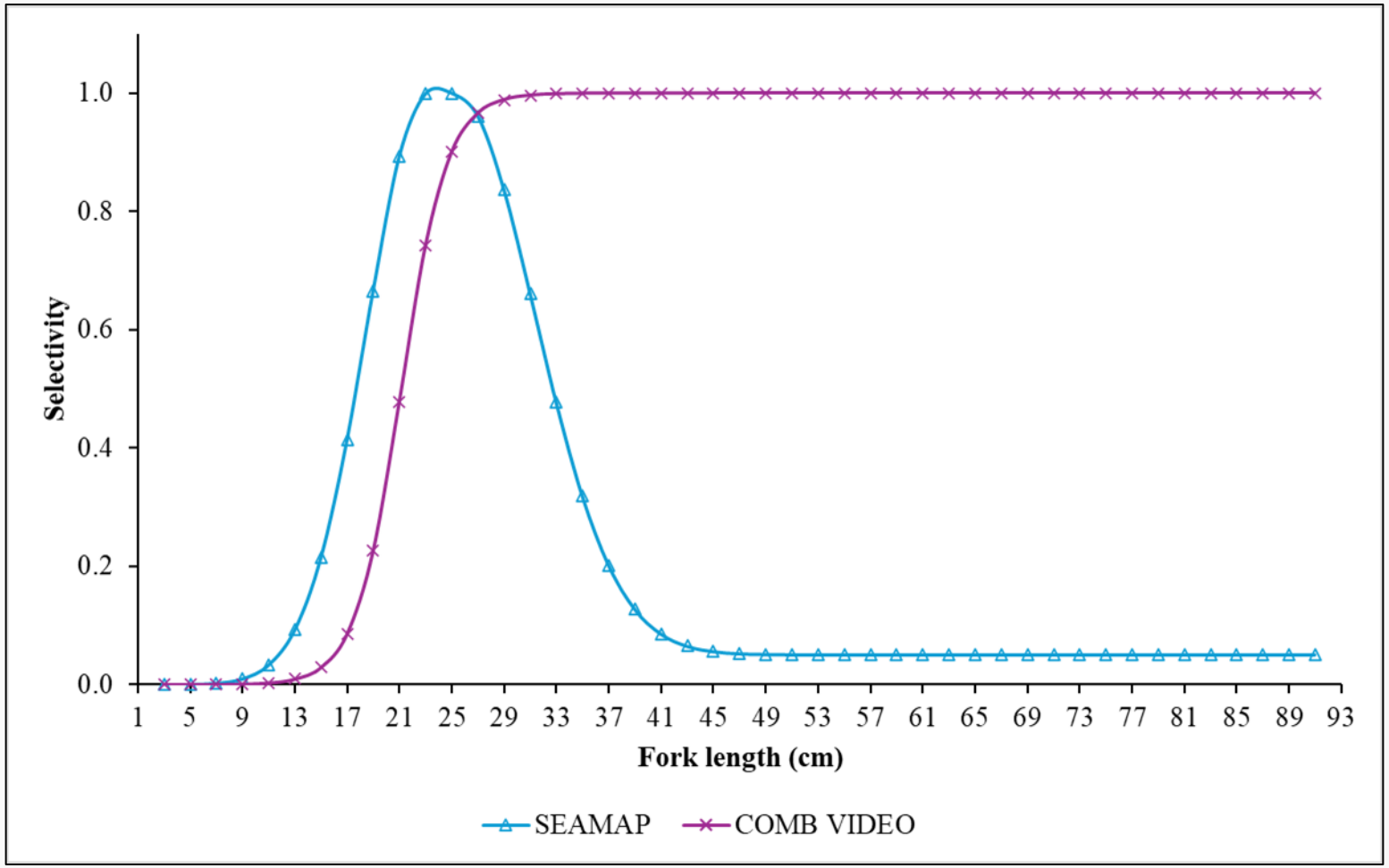


AW Report Figure 4.38

Time Blocks:

- 1986 – 1998: No minimum size limits
- 1999 – 2017: 12” (305 mm) FL minimum size
- 2018 – 2024: 14” (356 mm) FL minimum size

Selectivity: Indices



AW Report Figure 4.39

SEDAR 94: Florida Hogfish

WFS Base Model Diagnostics

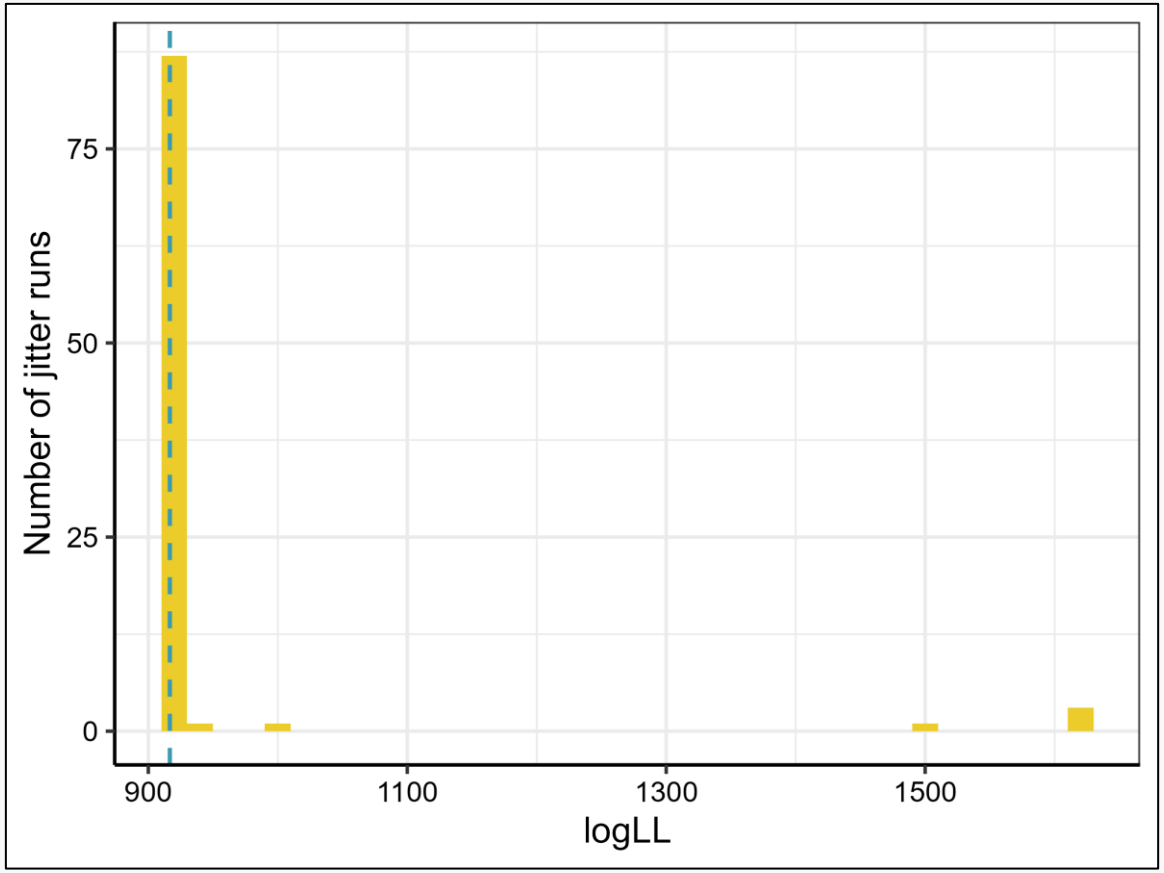
Model Convergence

- No estimated parameters on the bounds
- Final gradient <0.0001
- Positive definite Hessian

Jitter Analysis

- 100 jittered runs
  - Parameter initial values jittered by 20%
  - 59% had a low gradient (<0.0001)
  - 77% runs within 2 LL units from min

- No jittered runs contained a total likelihood lower than the WFS base model.
- Results suggested that the WFS base model had converged on a global solution.



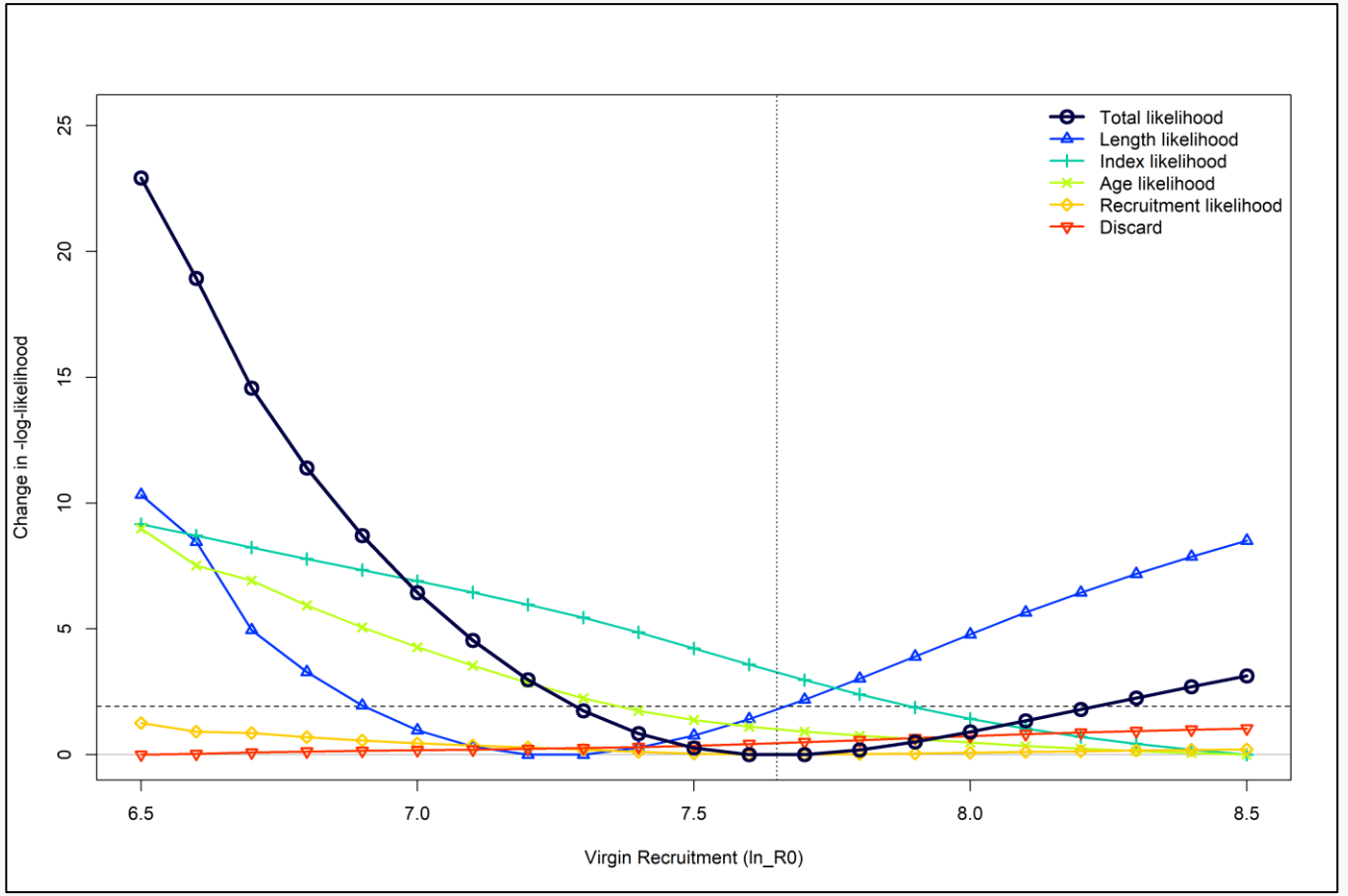
AW Report Figure 4.44

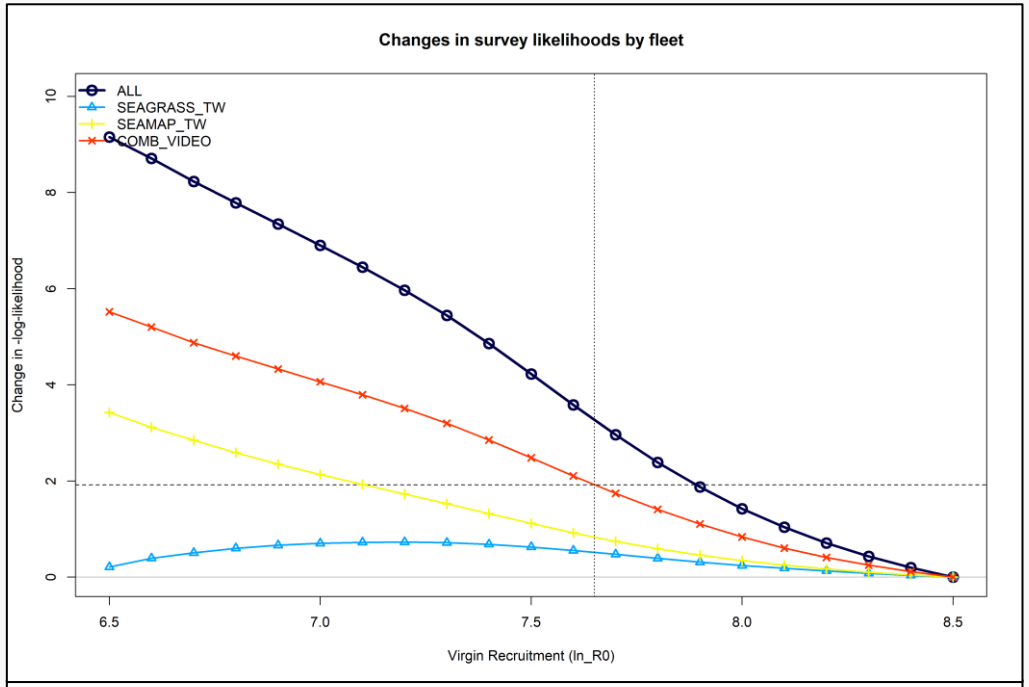
Model Consistency

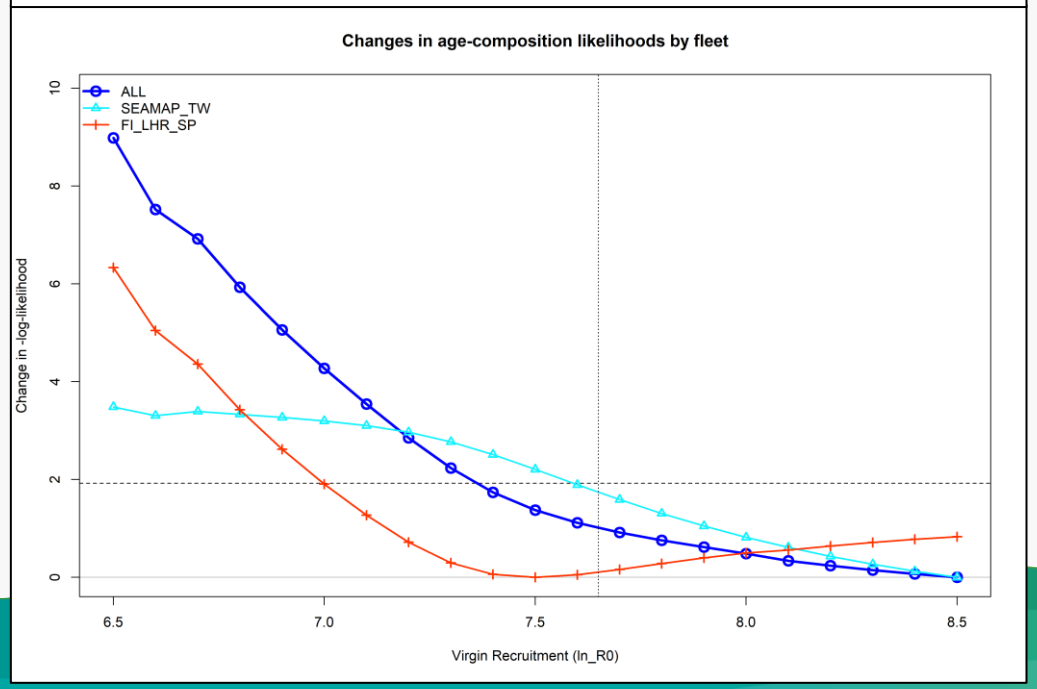
AW Report Figure 4.49

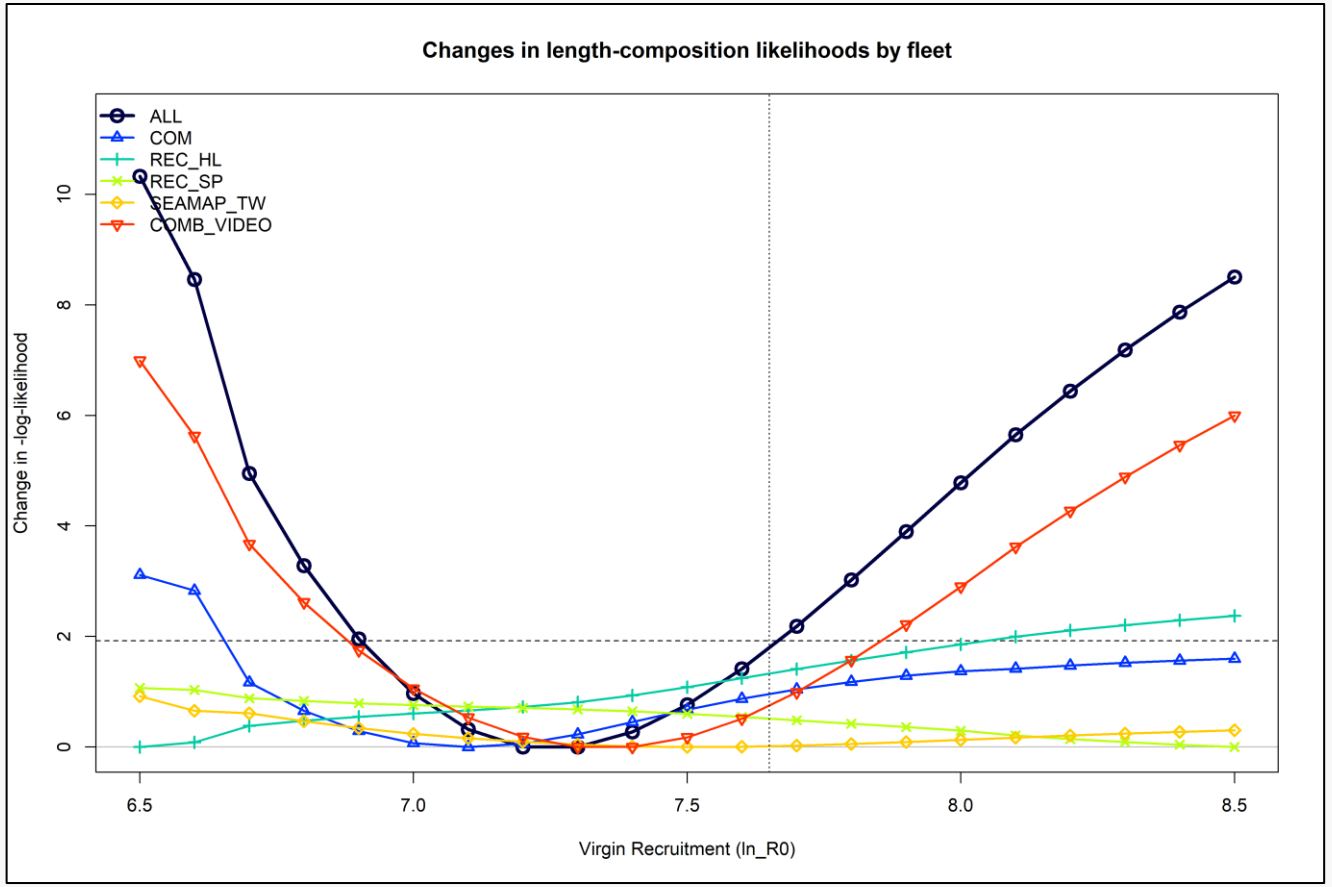
Profiling of ln(R_0) parameter

- Identify how sources of information influence various model estimates
- R_0 ≈ global scaling parameter
- Mostly informed by length (blue), index (teal) and age (lime) data
  - Minimum ~ln(7.6)
- Not informed by recruitment variability (golden)
  - Supports recruitment being primarily informed by composition data and indices




Changes in survey likelihoods by fleet
ALL
SEAGRASS_TW
SEAMAP_TW
COMB_VIDEO
Change in -log-likelihood
Virgin Recruitment (ln_R0)


Changes in age-composition likelihoods by fleet
ALL
SEAMAP_TW
FI_LHR_SP
Change in -log-likelihood
Virgin Recruitment (ln_R0)

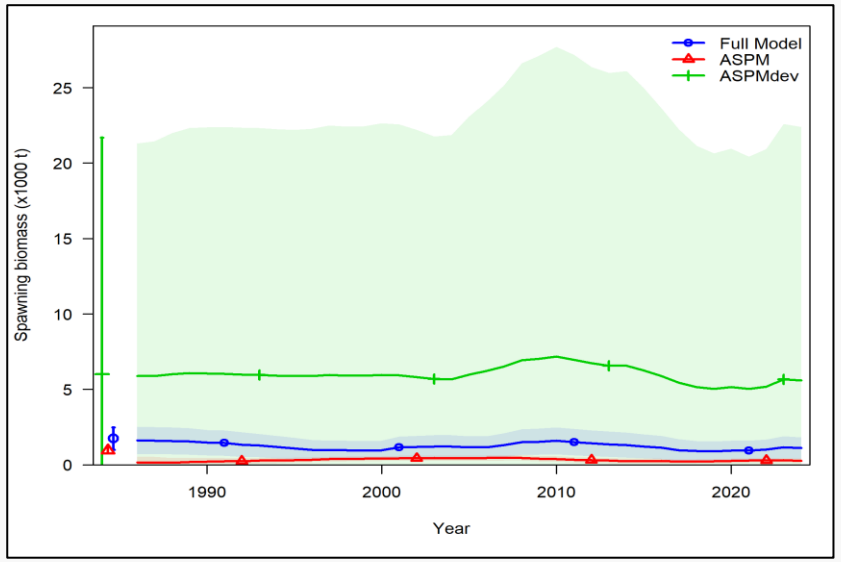

Changes in length-composition likelihoods by fleet
ALL
COM
REC_HL
REC_SP
SEAMAP_TW
COMB_VIDEO
Change in -log-likelihood
Virgin Recruitment (ln_R0)

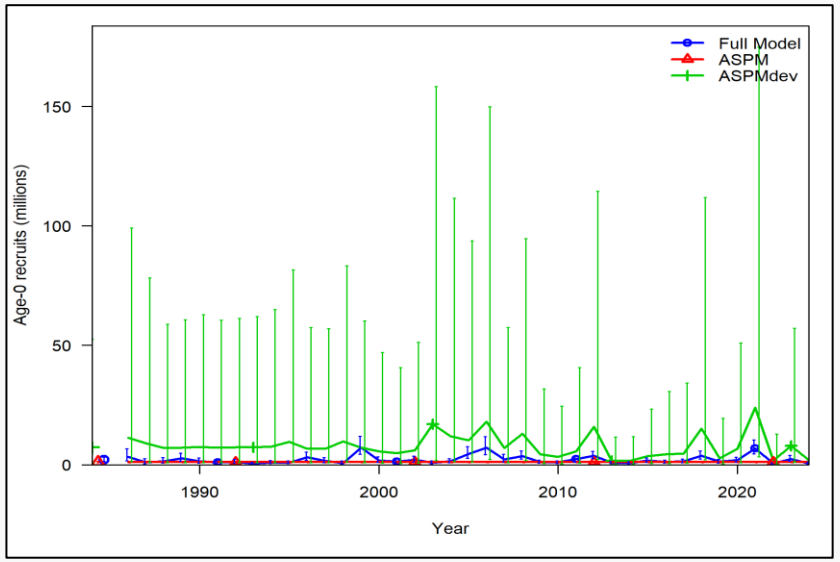
Model Consistency

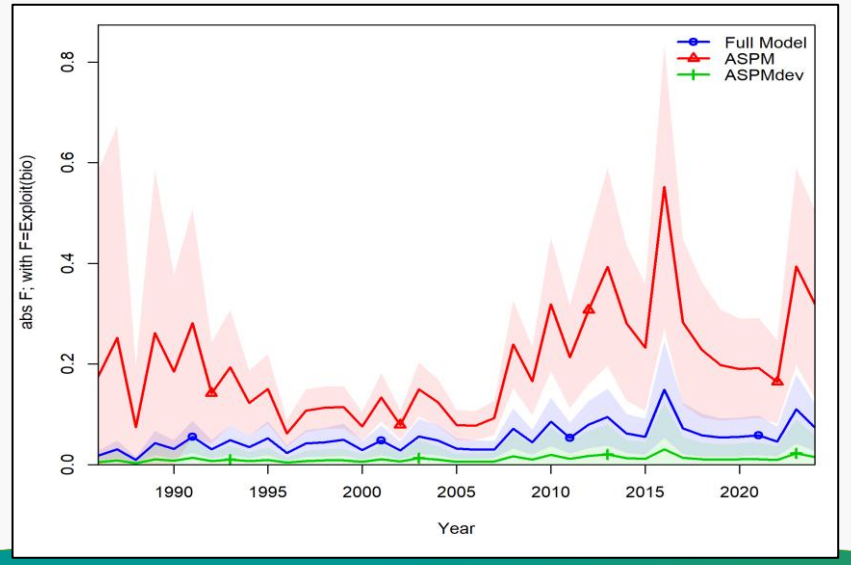
Age Structured Production Models (ASPM)

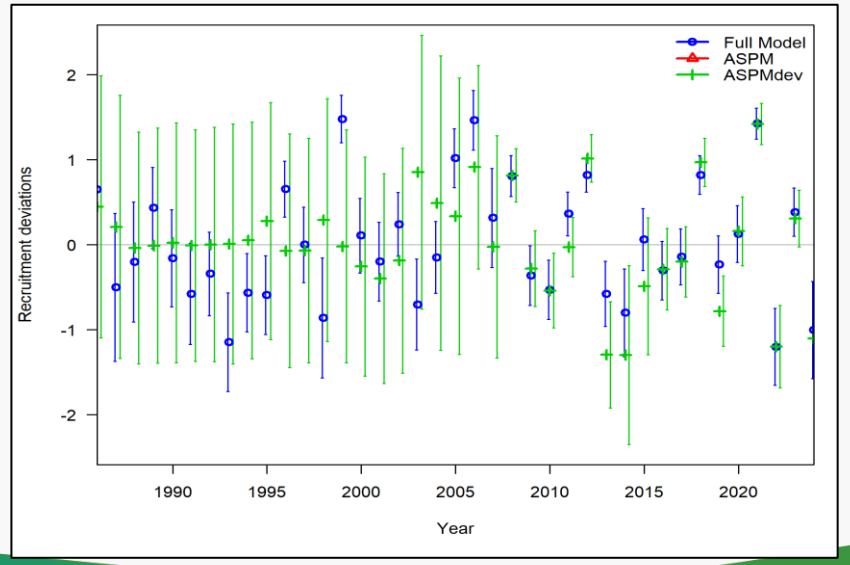
- Model results indicate the production function was unable to drive stock dynamics
  - Catch and index data not informing one another
    - Indices lacking contrast, catches and SEAMAP index increasing towards end of timeseries
  - Greater reliance on length and age composition data to inform population scale and recruitment variability
- ASPM - population and recruitment magnitudes significantly lower with higher exploitation values
- ASPM_dev - recruitment deviations (process error) useful for further improving fit to indices
  - Estimates contain significant uncertainty without composition data

Age Structured Production Models (ASPM)

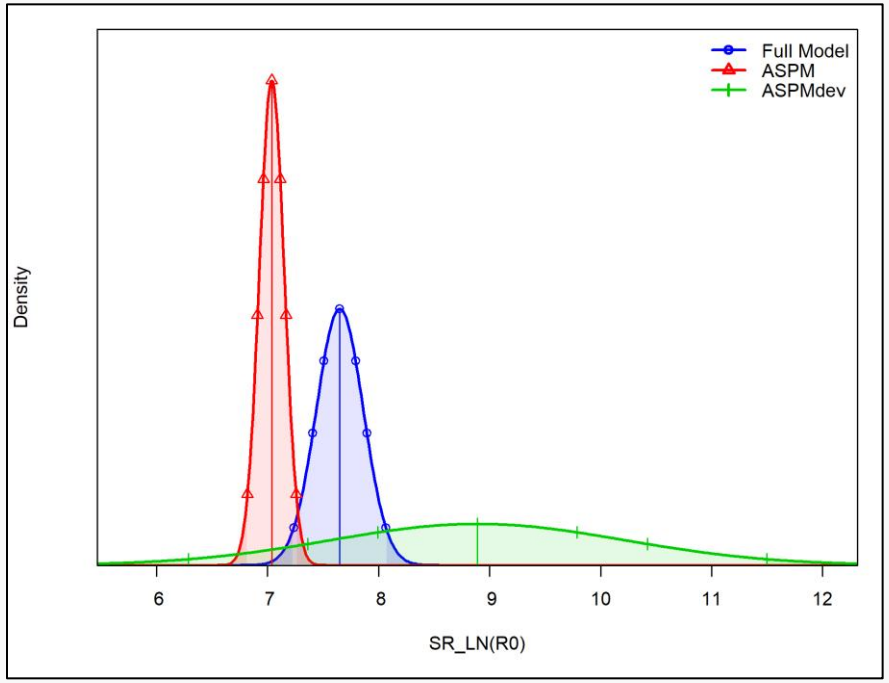


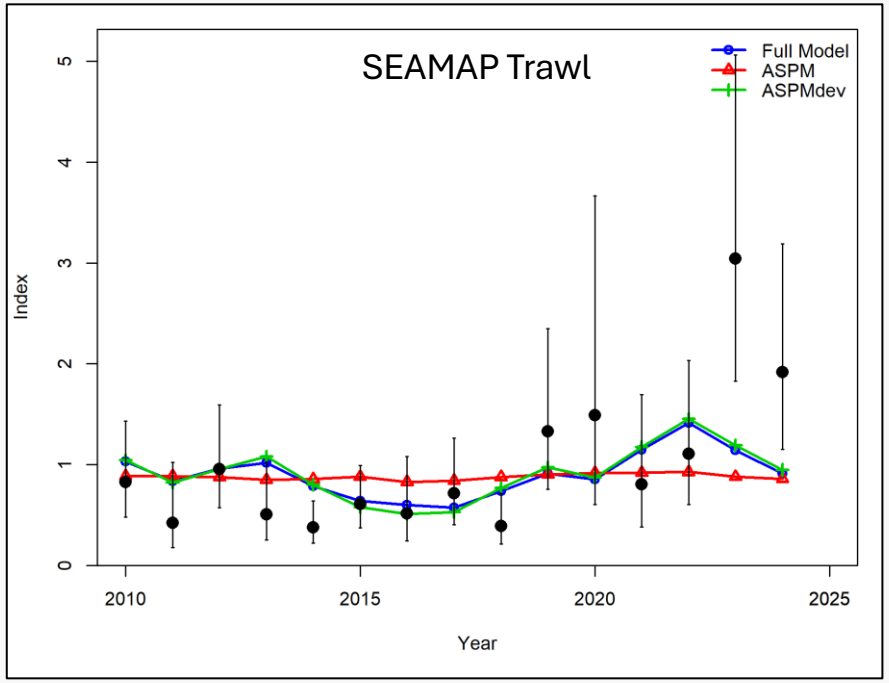


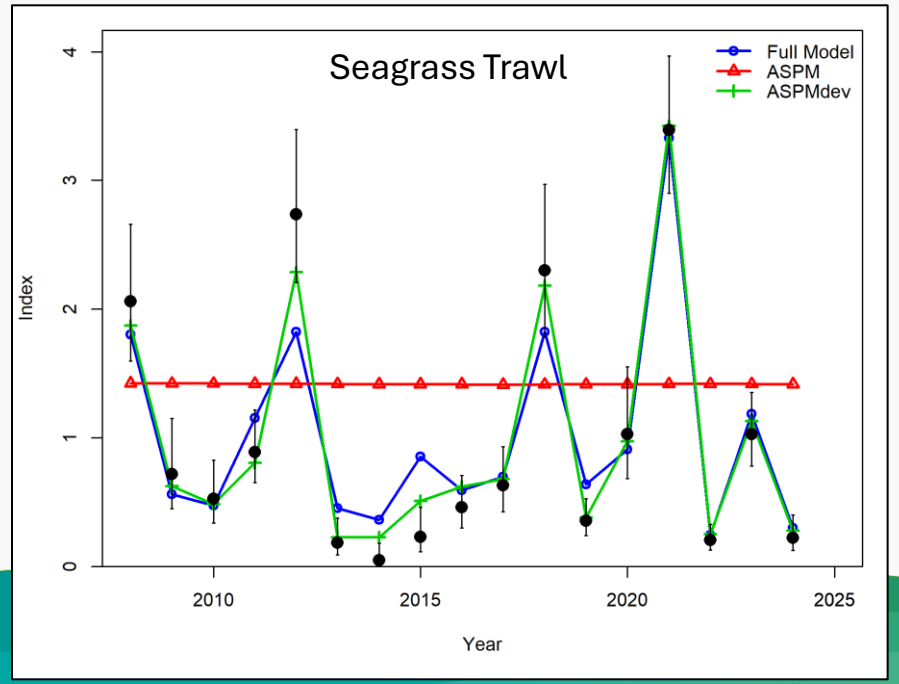


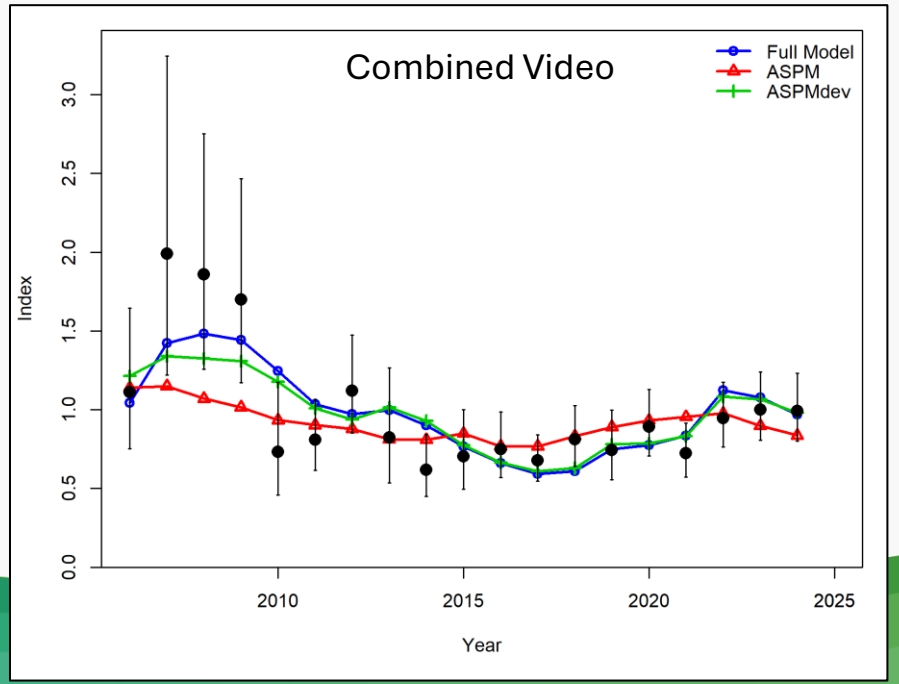


AW Report
Figure 4.50









AW Report
Figure 4.51

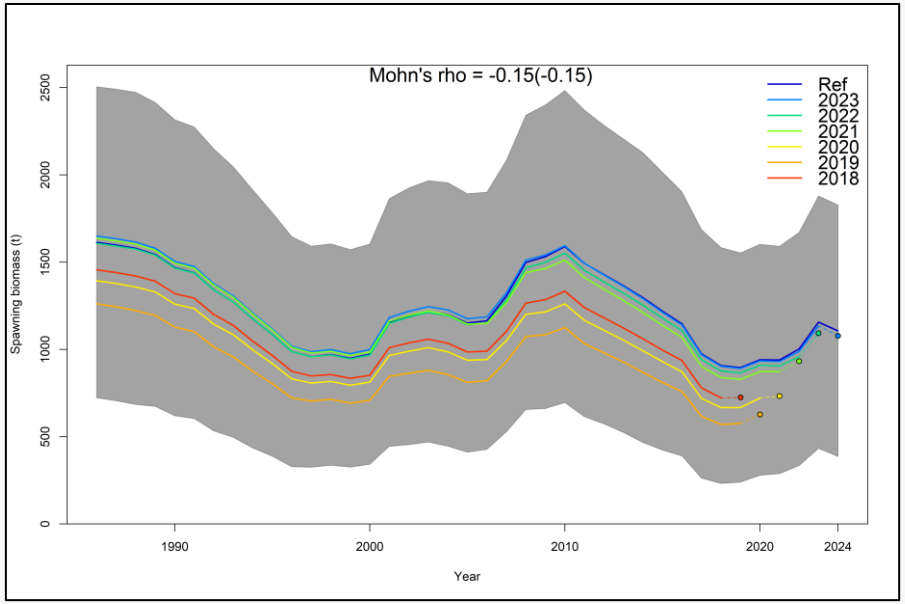
Model Consistency and Predictive Skill

Retrospective Analysis

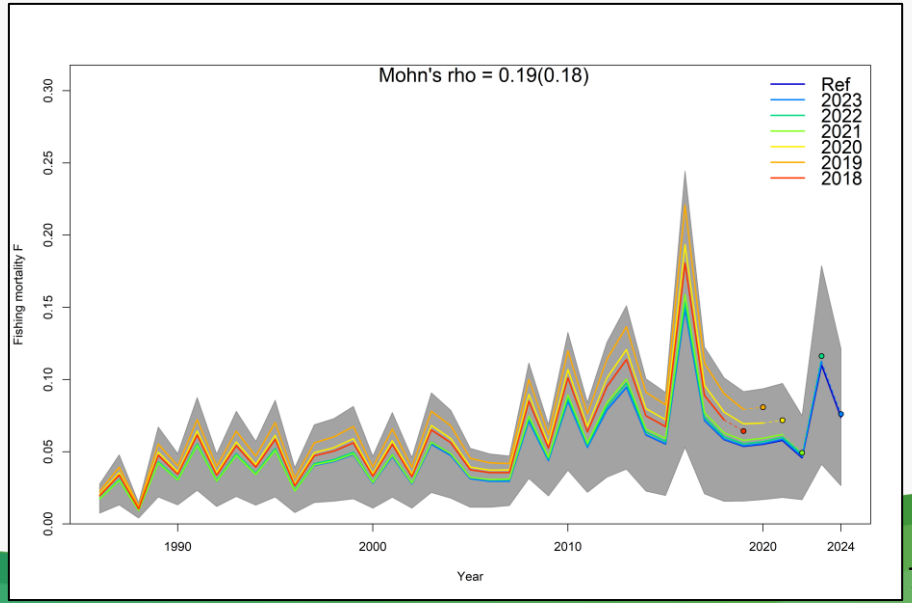
- Helps evaluate the effect of the final years on model results where patterns can indicate model misspecification or temporal dynamics
- Evaluated visually and quantitatively
  - Mohn's Rho
  - Hurtado –Ferro et al (2015) "Rule of thumb"
    - - 0.15 to 0.20 for longer-lived species
- Six-year peel (2018 – 2023)
  - Terminal time block
  - Values within Rho bounds and model uncertainty
    - Pattern detected when main recruitment deviations extended to 2024

Retrospective Forecasting

- Model-based hindcasts to six-year peels
- Evaluated visually and quantitatively
  - Forecast bias corresponding to Mohn's Rho
  - All retrospective forecasts fell within 95% CI of base model



AW Report Figure 4.52a



AW Report Figure 4.52b

Predictive Skill

AW Report Table 4.15

Model Component	Data Source	MASE	Model MAE	Naïve MAE	N
Index of Abundance	Seagrass Trawl	0.561	0.943	1.682	6
	SEAMAP Trawl	0.942	0.588	0.624	6
	Combined Video	0.853	0.116	0.136	6
	Combined	0.674	0.549	0.814	18
Conditional Age-at-length	SEAMAP Trawl	0.344	0.095	0.277	6
	Combined	0.344	0.095	0.277	6
Length Composition	SEAMAP Trawl	0.791	0.075	0.095	6
	Combined Video	0.713	0.063	0.089	6
	Combined	0.753	0.069	0.092	12

*** MASE (Mean Absolute Scaled Error) = Average of mean absolute error of prediction residuals (Model MAE)/Naïve Predictions (Naïve MAE)

Sensitivity Runs

Natural Mortality

Base: Longevity-based estimator (max. age 23) for reference ages 3 – 23

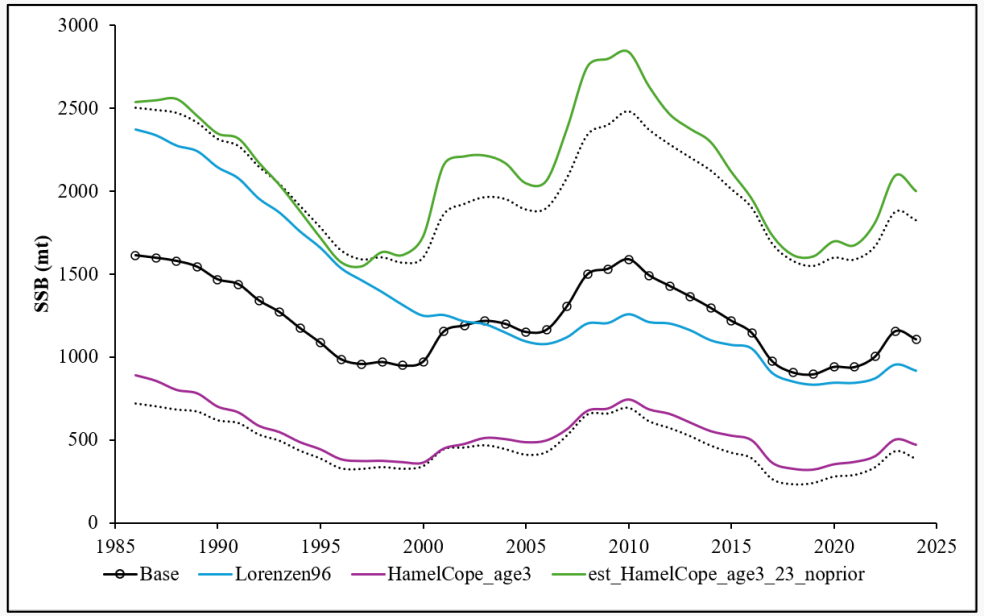
- *M* = 0.235; *M(a)* = 0.988 – 0.168

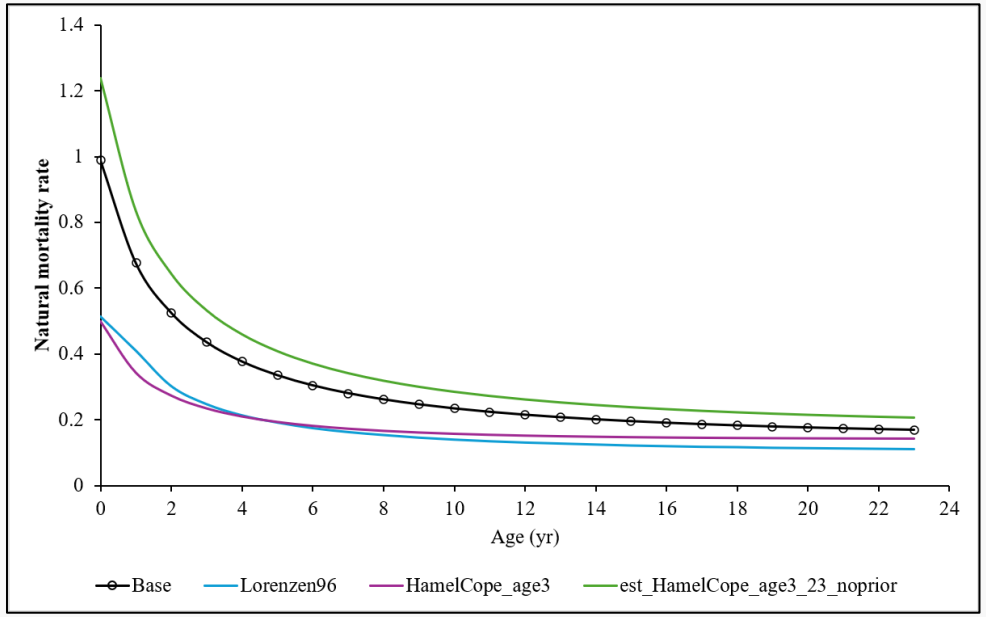
1) Mortality-at-weight model based on Lorenzen (1996)
   - *M(a)* = 0.514 – 0.110
     - "Lorenzen96" scenario
   - Higher *Linf* (114.7 cm) to help compensate but worsened total LL
   - Method used in SEDAR 94 KEYS/EFL model

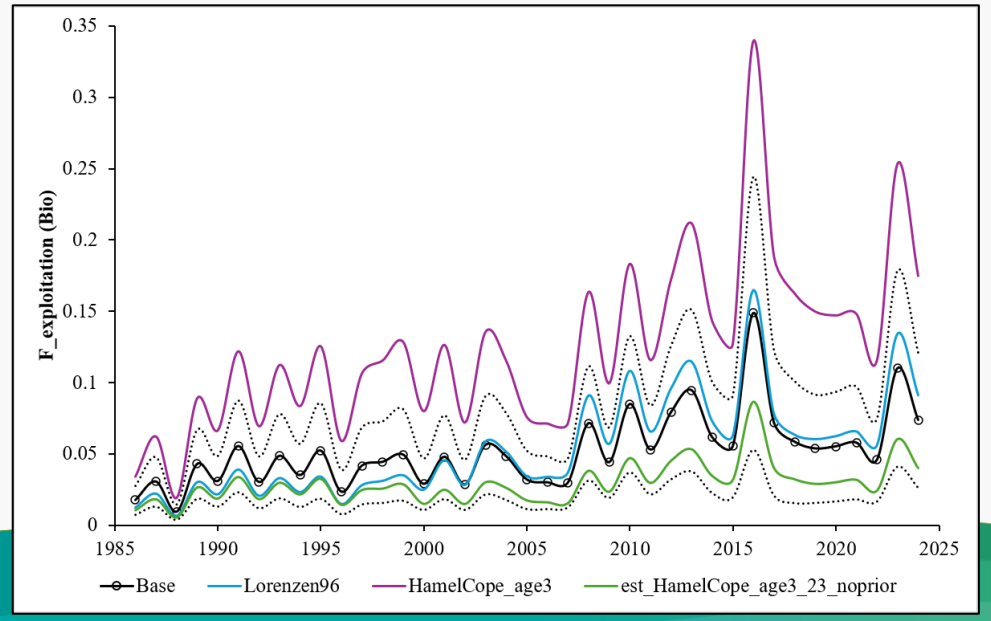
2) Longevity-based estimator for reference age-3
   - *M* = 0.235; *M(a)* = 0.498 – 0.144
     - "HamelCope_age3" scenario
     - Utilized in earlier iteration of WFS model development
   - Lower *Linf* (54.2 cm) and worsened total LL

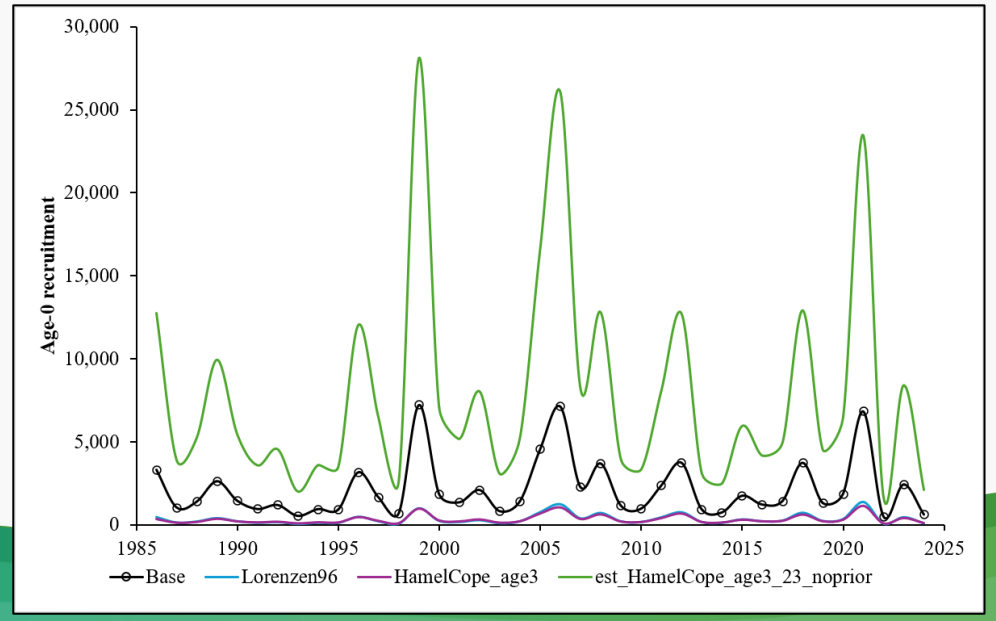
3) Longevity-based estimator freely estimated within model
   - *M* = 0.286 averaged across ages 3 – 23; *M(a)* = 1.239 – 0.205
     - "est_HamelCope_age3_23_noprior" scenario
     - Not a significantly different total LL; adds uncertainty to population estimates
   - Similar *Linf* (86.5 cm) but much higher recruitment

Natural Mortality









AW Report
Figure 4.55

Sensitivity Runs

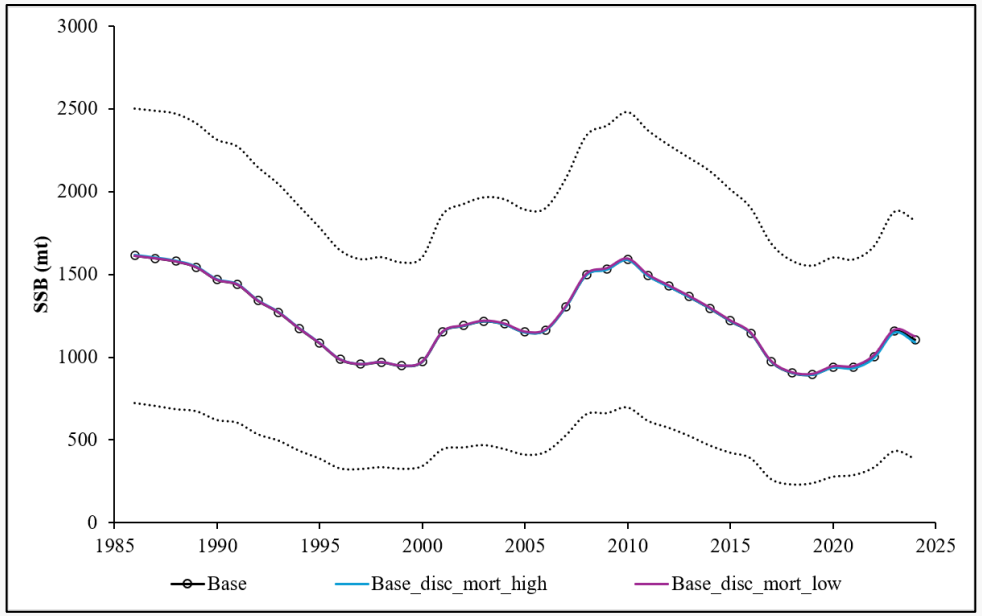
RECh1 Discard Mortality Rates

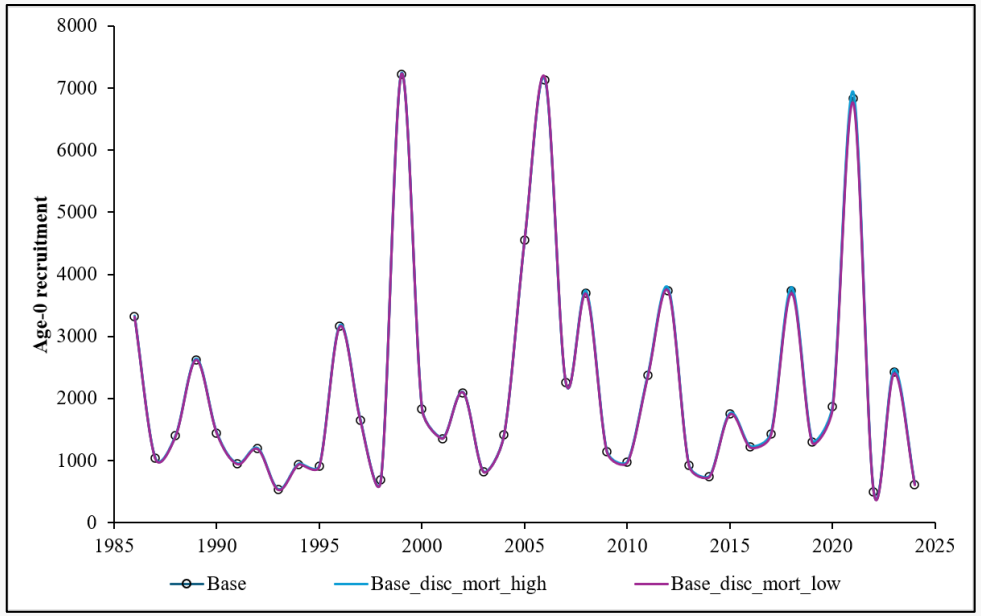
- Low = 23.8% (S94-DW-12)
- High = 59% (S94-DW-16)

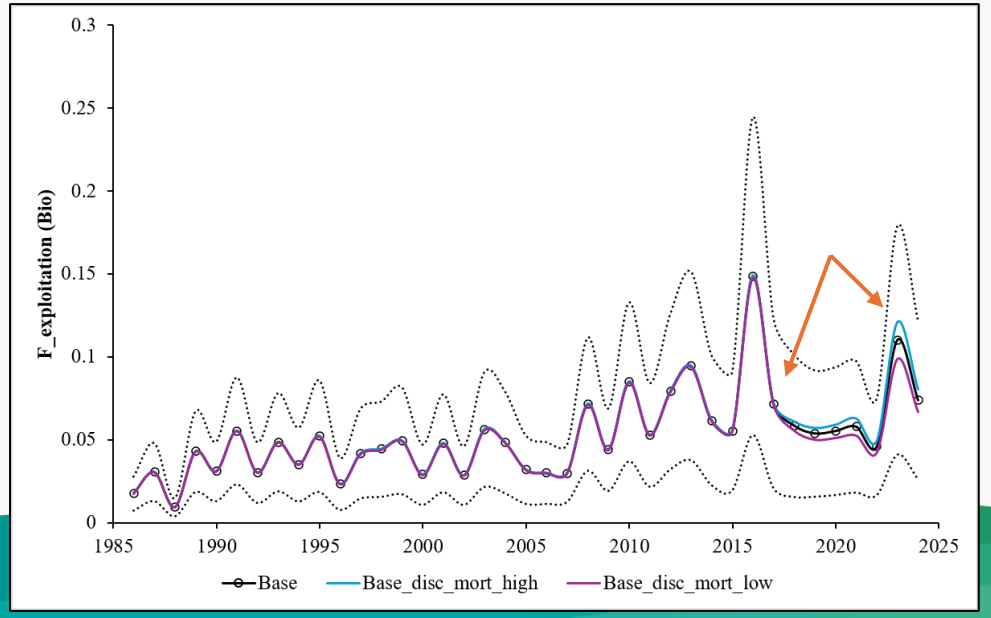
- Model rather insensitive to changes in recreational discard mortality.
- Higher rates corresponded to higher exploitation rates, and vice-versa.
  - Predominantly observed in years 2018 – 2024
- Age-0 recruitment was nearly unchanged with <1% average difference.

- Obs RECh1 discards comprised on average 33% of obs RECh1 total catch
  - Predominantly observed in years 2018 – 2024

Discard Mortality







AW Report Figure 4.56

SEDAR 94: Florida Hogfish

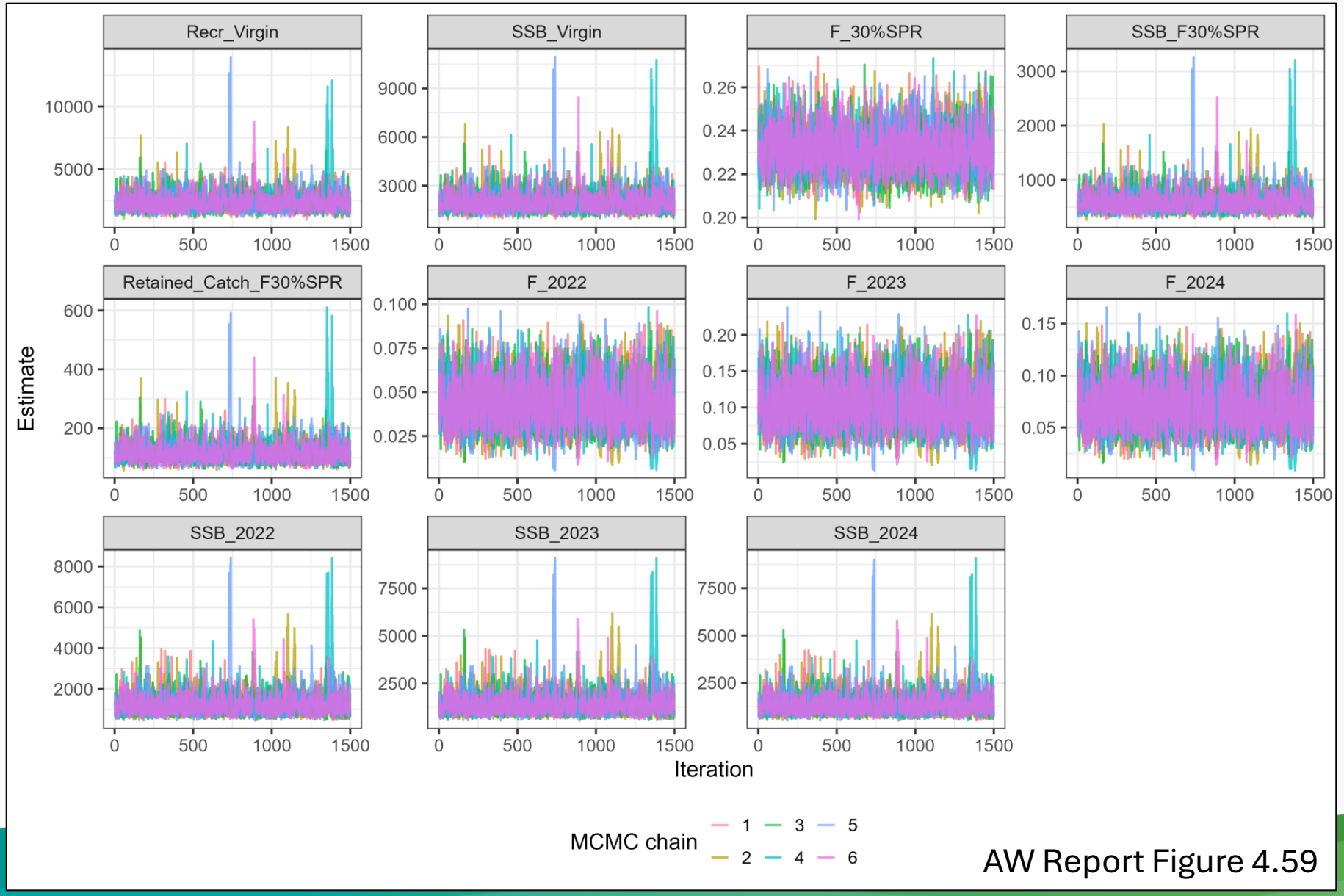
WFS Base Model Uncertainty

Model Uncertainty

Markov chain Monte-Carlo (MCMC)

- Re-configure recruitment deviations in WFS base model
  - Remove zero-sum constraint
- Generate posterior distributions of model parameters and derived quantities
  - R_0, SSB_0, SSB_{2024}, F_{2024},
  - $F_{30\%SPR}$, $SSB_{F30\%SPR}$, Retained yield at $F_{30\%SPR}$
- Convergence
  - Visual inspection of trace plots
  - Geweke's diagnostic for single chains
  - Gelman and Rubin's (1992) potential scale reduction factor (PSRF) for combined chain
- Six chains
  - 2,000 iterations saved from the 1,000,000 performed (thinned every 500th)
    - Burn-in set at 500
  - 1,500 iterations remained for each chain
    - Combined total = 9,000 iterations

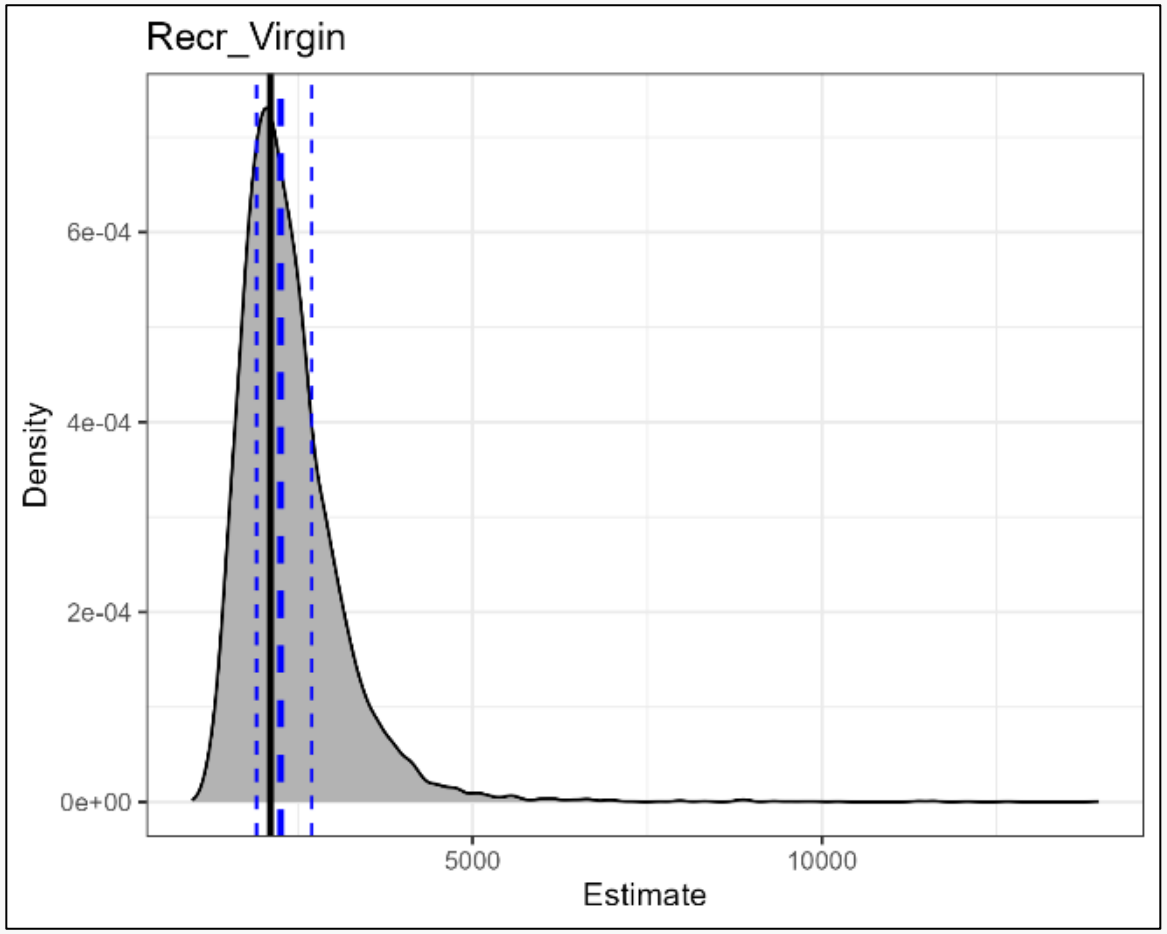
MCMC Analysis

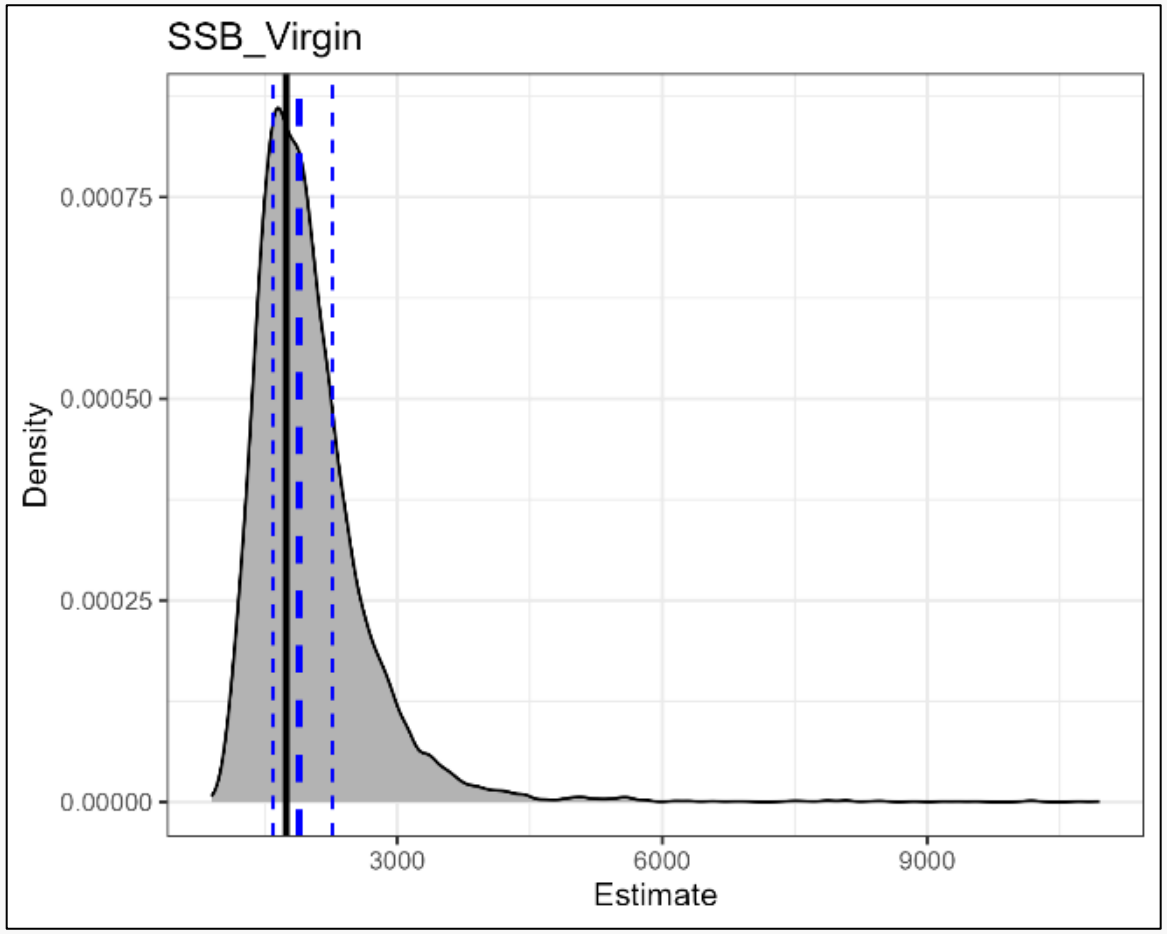


AW Report Figure 4.59

MCMC Analysis

AW Report Figure 4.60

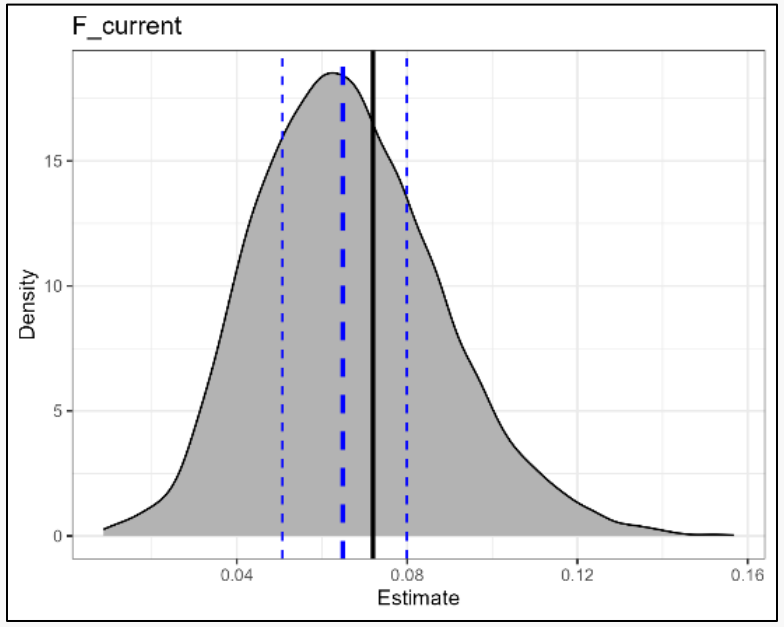


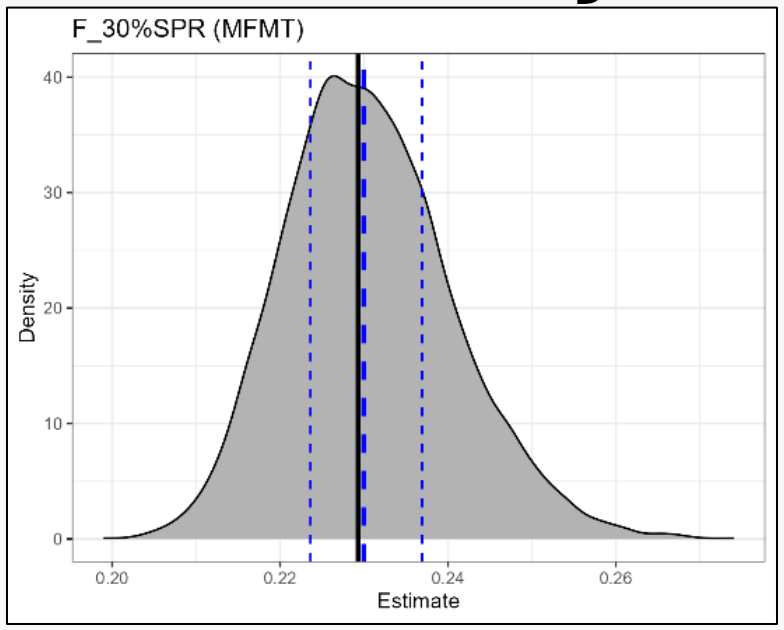


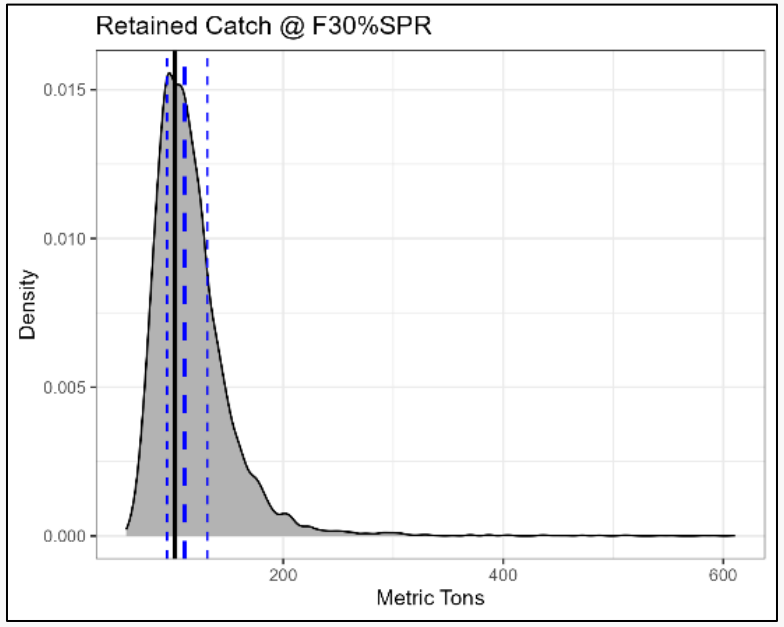
The blue dashed lines indicate the median and interquartile range and the solid black line is the MLE from the WFS base model.

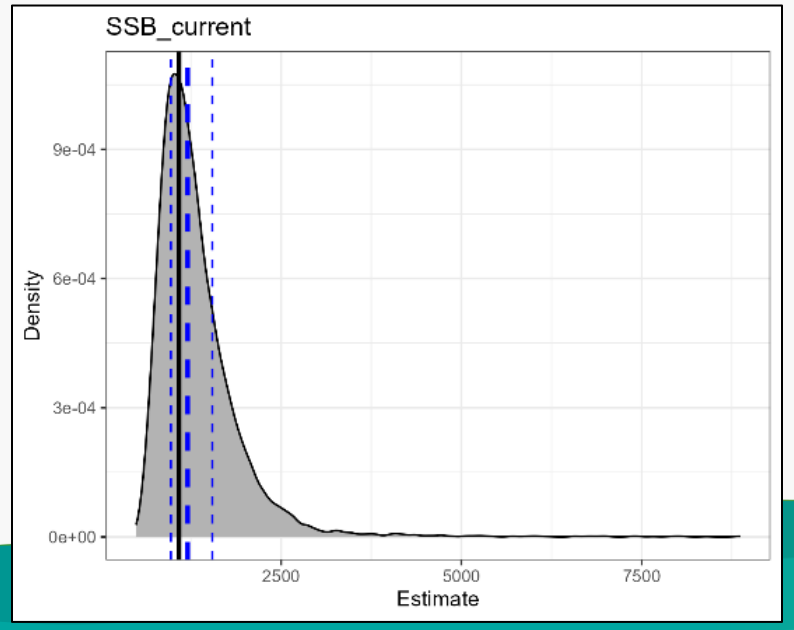
MCMC Analysis

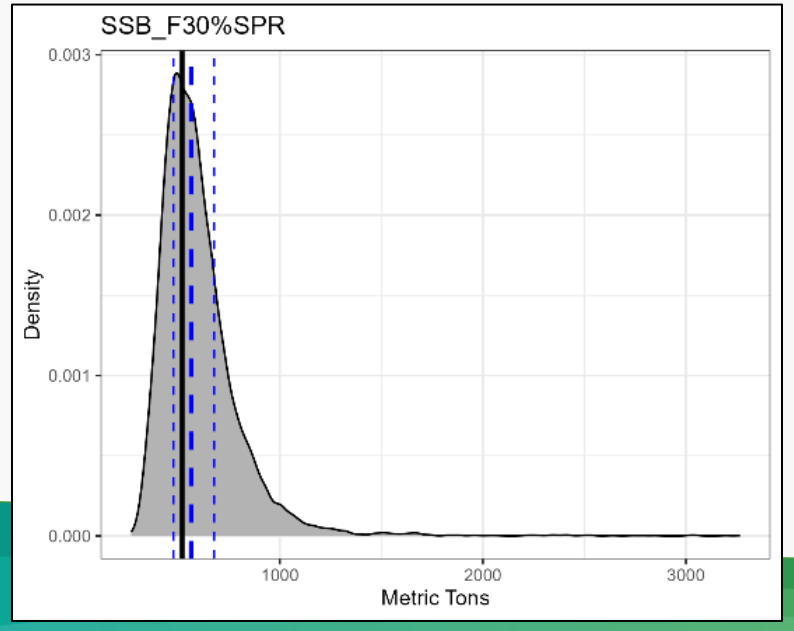
AW Report Figure 4.61

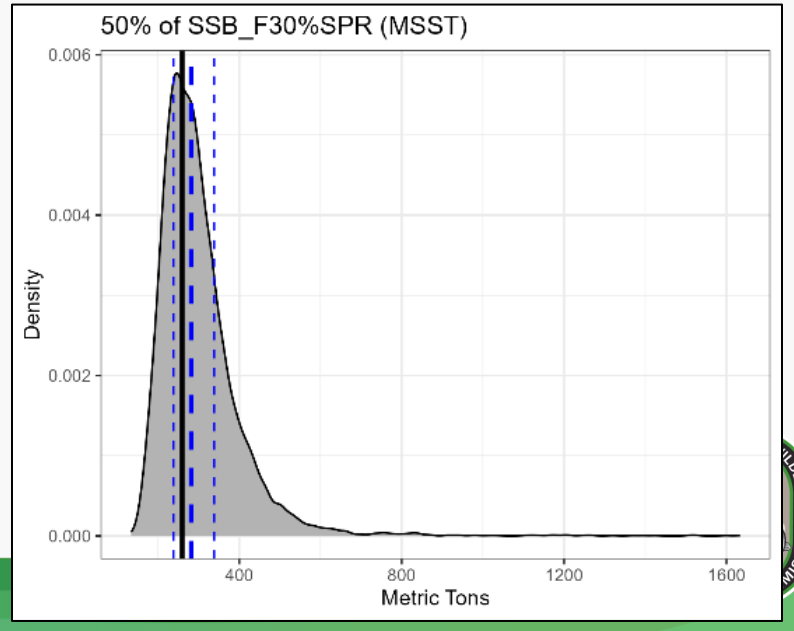










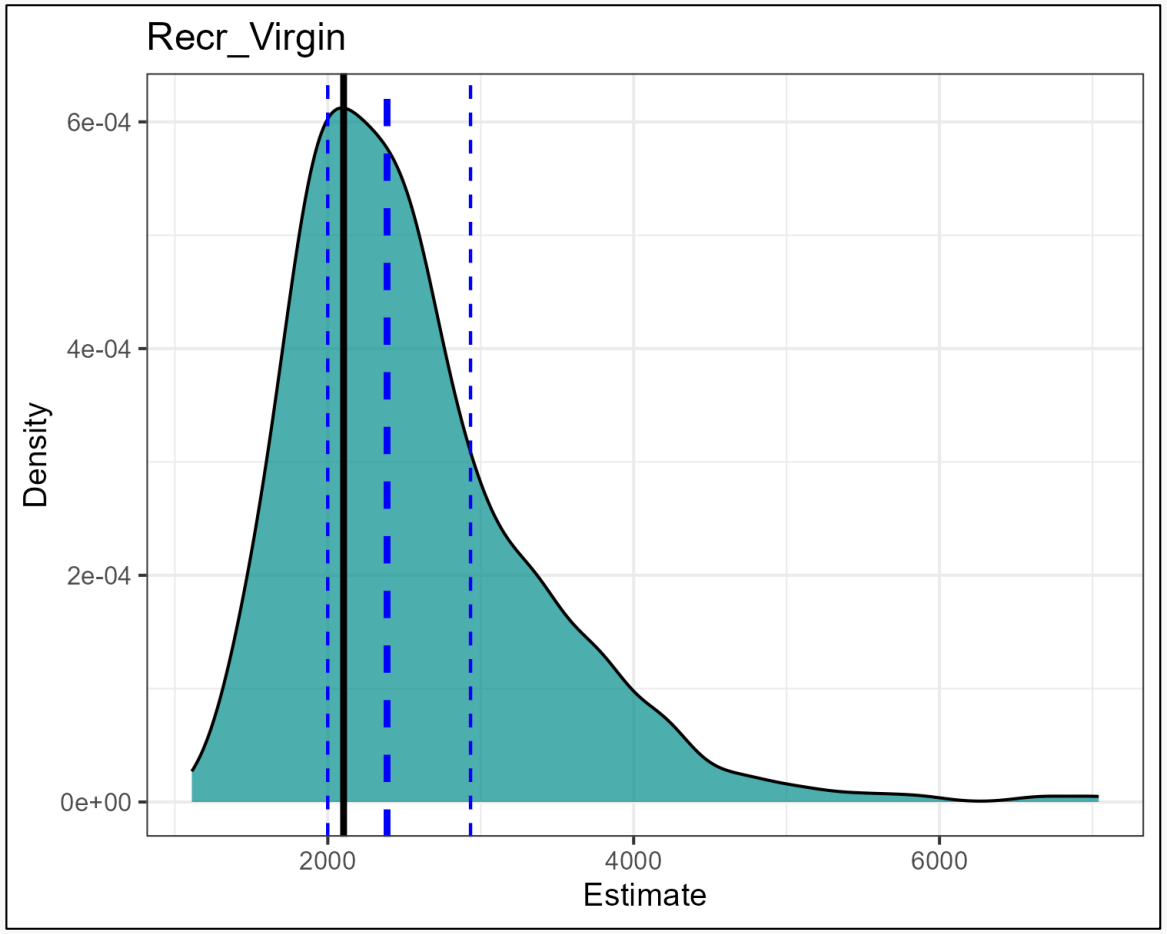


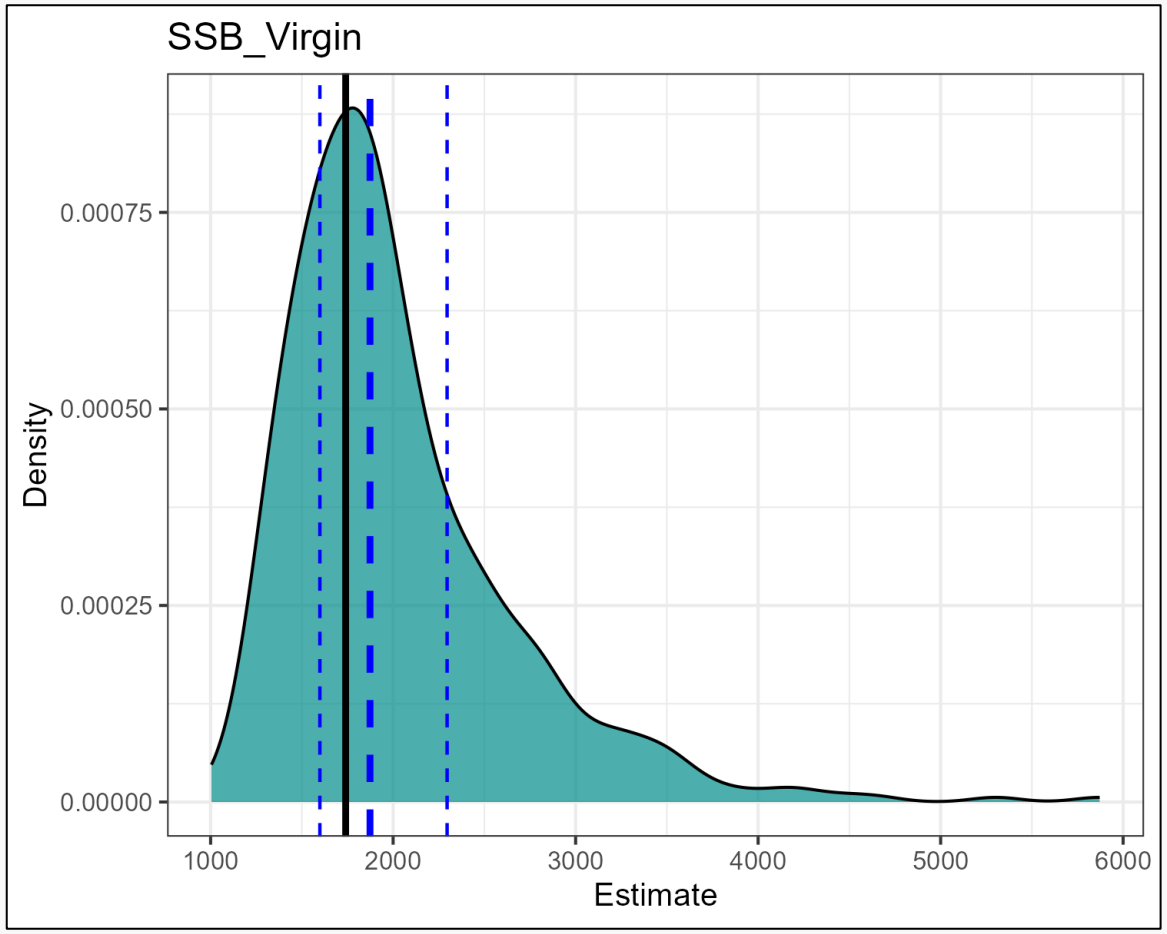
Parametric Bootstrap

- Bootstrapping in SS
  - *"An internal parametric bootstrap function generates a simulated data set by parametric bootstrap sampling the* ***expected values given the input observation error.****"* (Section 12.8 SS Manual)
    - Causes some mismatch between *observed* values and distribution medians when model doesn't fit observed data well.
- WFS
  - 500 bootstrapped datasets
    - 490 runs with gradient <0.0001
    - 34% of runs had at least one parameter on bounds
  - WFS base model estimates fell within the interquartile ranges of selected parameter estimates and derived quantities distributions
  - Similar to MCMC posterior distributions

Bootstrap Analysis

Adapted from AW Report Figure 4.62

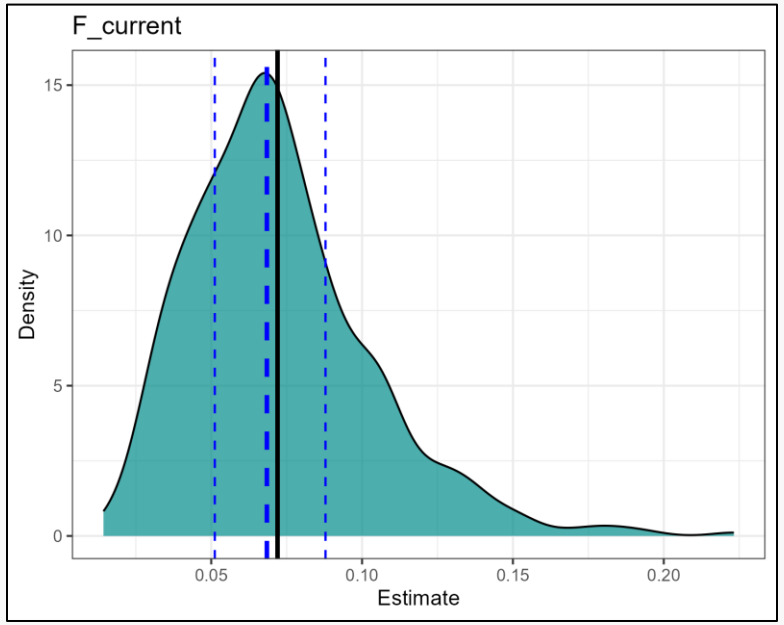


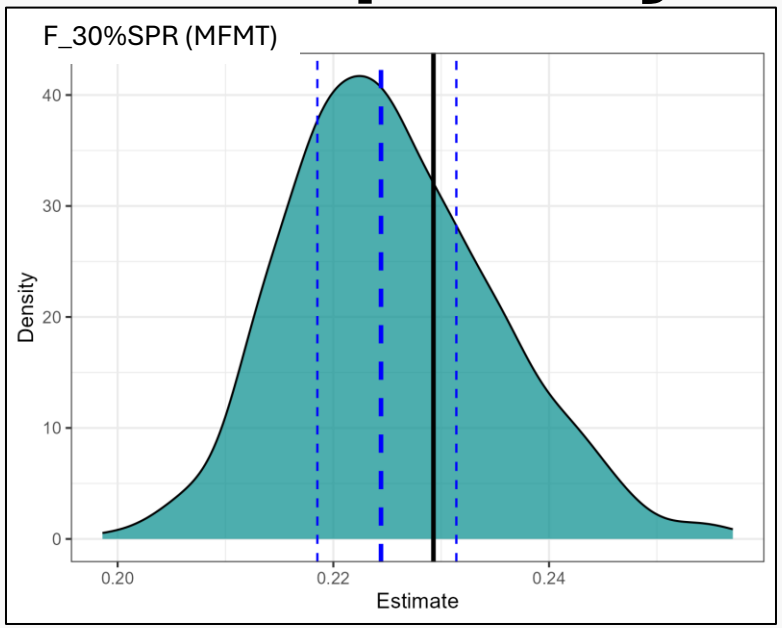


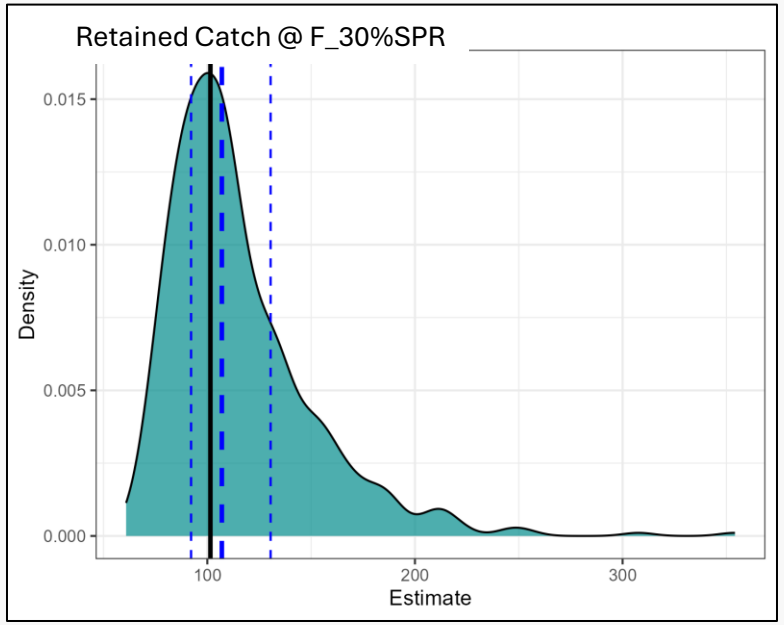
The blue dashed lines indicate the median and interquartile range and the solid black line is the MLE from the WFS base model.

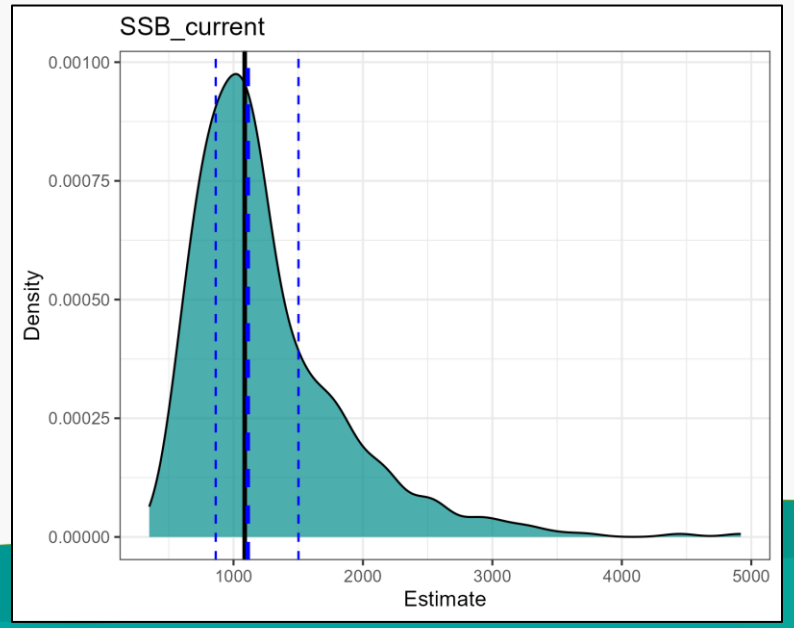
Bootstrap Analysis

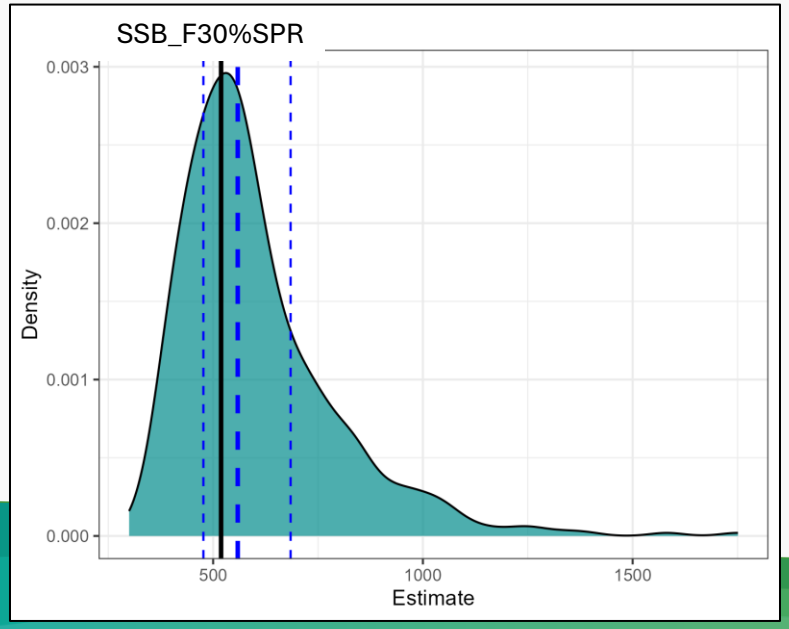
Adapted from AW Report Figure 4.63

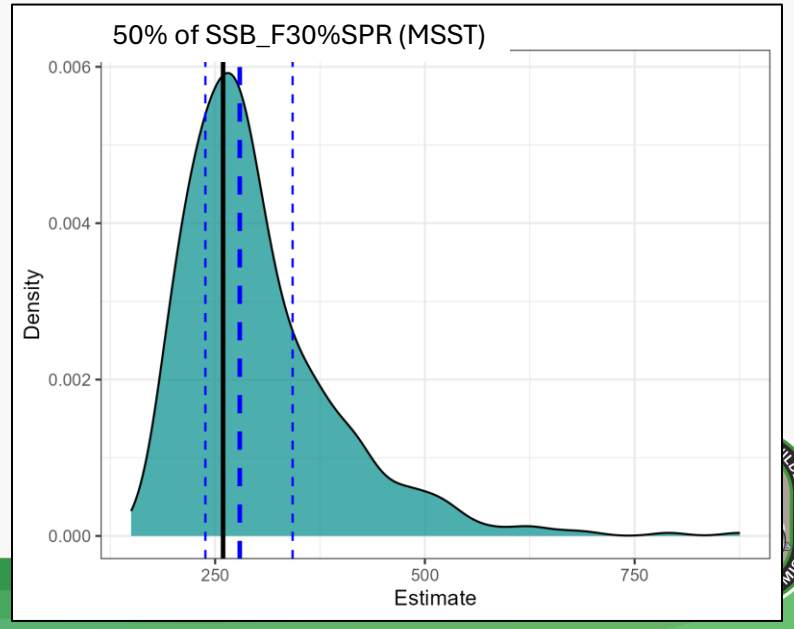








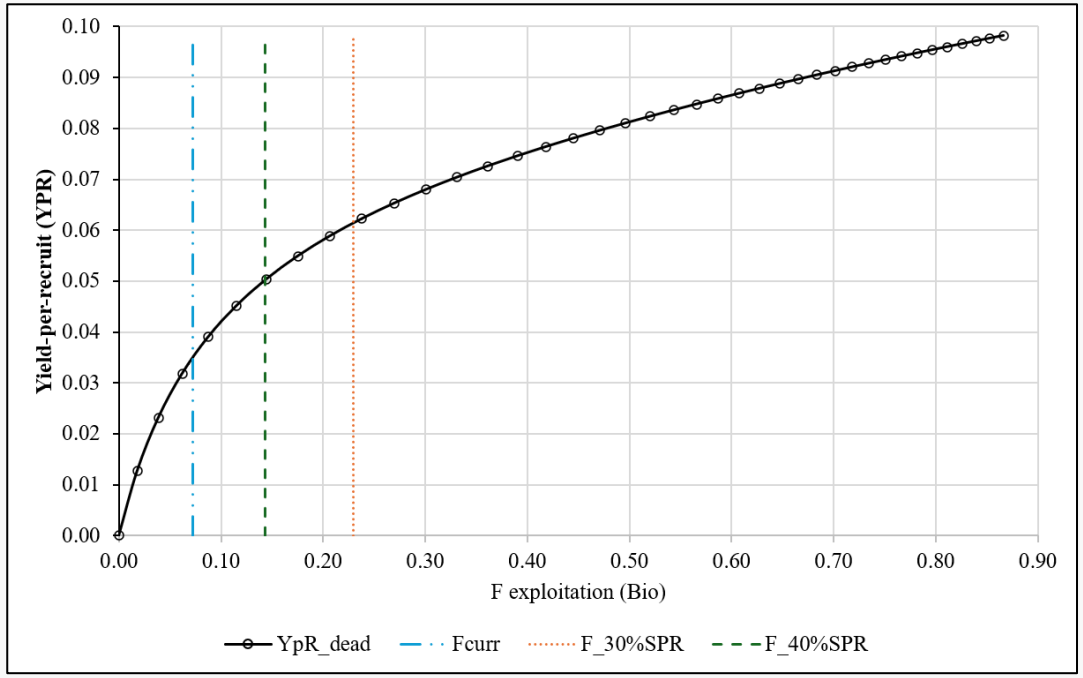


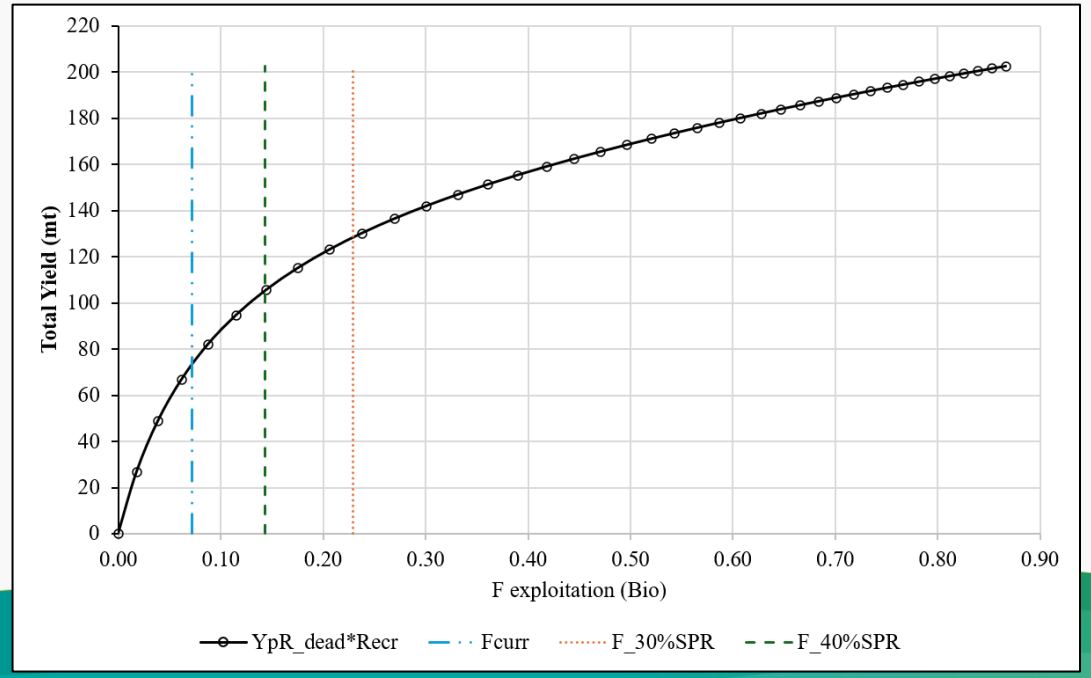


SEDAR 94: Florida Hogfish

Stock Status Overview

AW Report Figure 4.57a,c

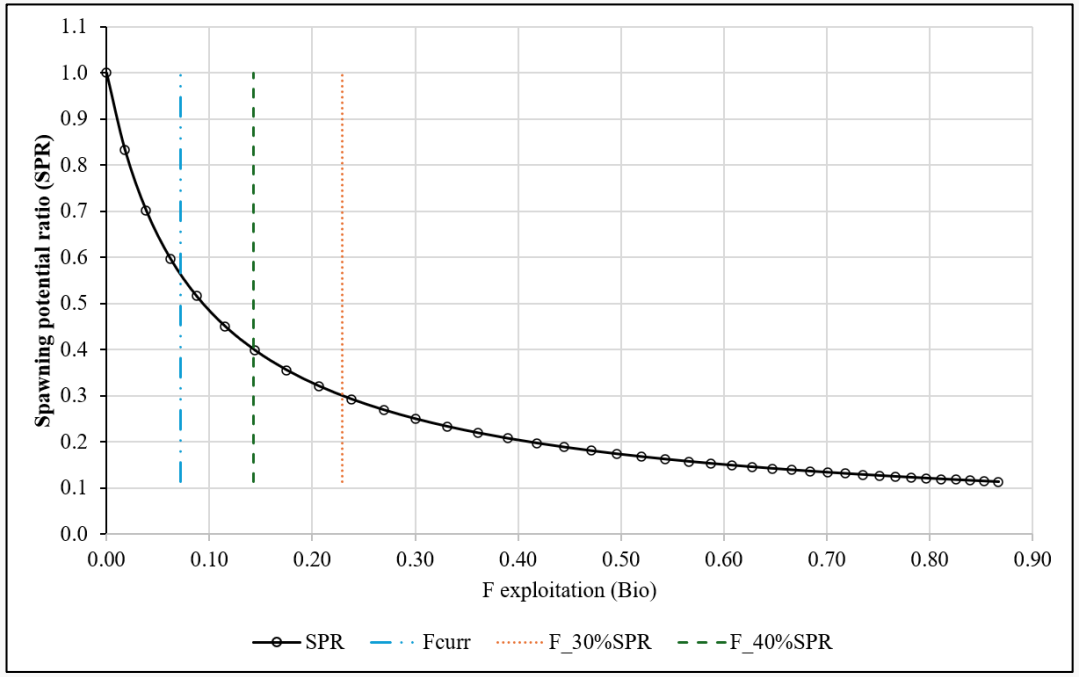


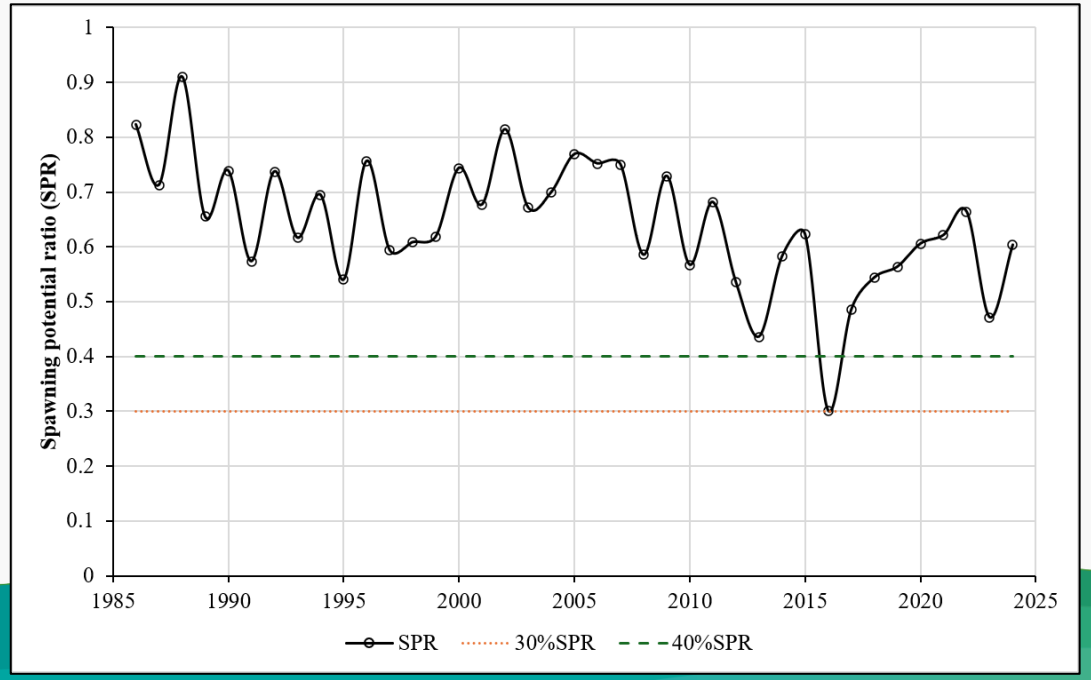


Per-recruit Analysis

- YPR highest at $F_{30\%SPR}$ with equilibrium total yields at 128.282 mt (282,813 lbs.)
  - Retained yield at 101.489 mt (223,745 lbs.)
- YPR at $F_{40\%SPR}$ 18% lower with equilibrium total yield at 105.185 mt (231,893 lbs.)
  - Retained yield at 85.098 mt (187,608 lbs.)

** *steepness (h)* = 0.99 **





Spawing Potential Ratio (SPR)

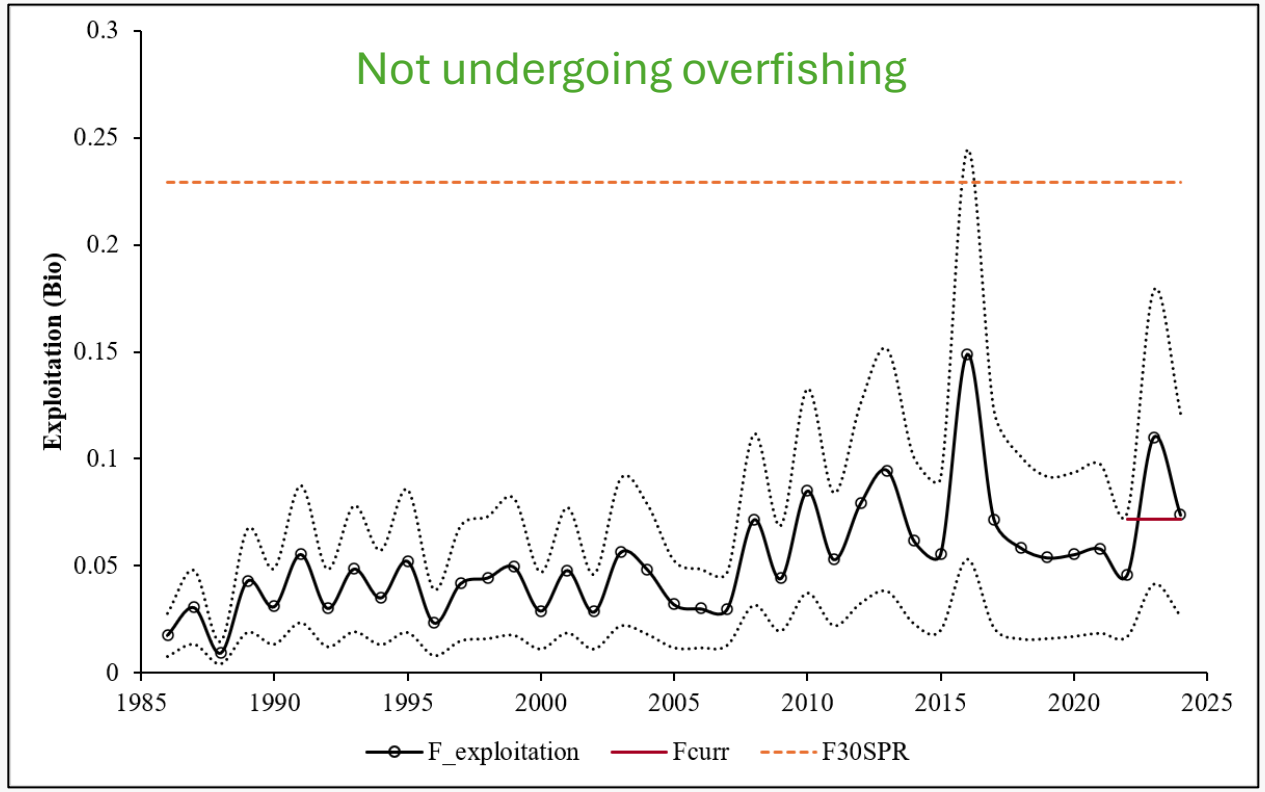
- $F_{current}$ = 0.072 SPR = 0.55
- $F_{40\%SPR}$ = 0.143
- $F_{30\%SPR}$ = 0.229

- Trend: largely stable with variability, recent decreases
  - Above management targets
  - 2000 – 2017: avg. SPR = 0.63
    - 1986 – 1999: avg. SPR = 0.68
  - 2018 – 2024: avg. SPR = 0.58

Stock Status

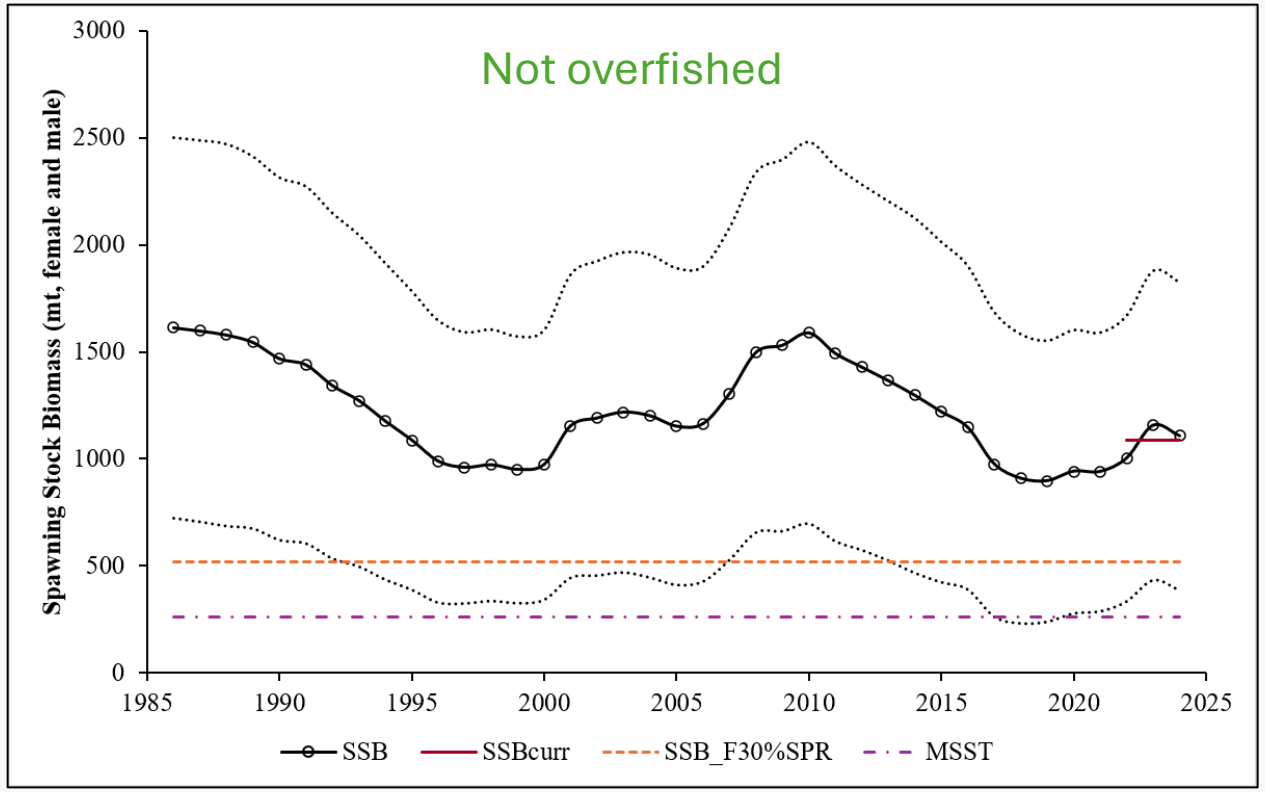
SPR-based reference points

AW Report Figure 4.64



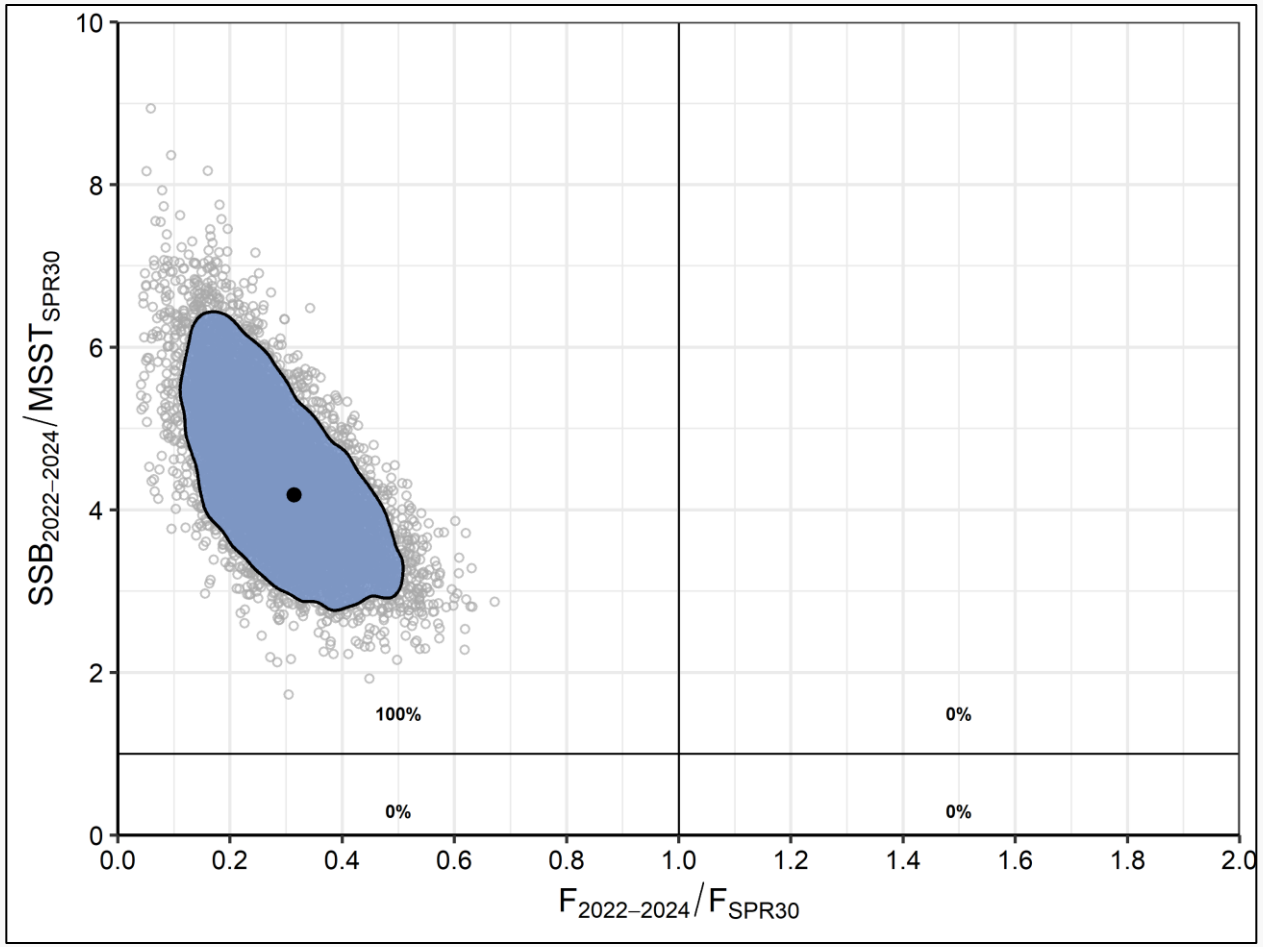
$F_{current}/F_{30\%SPR}$ = 0.229

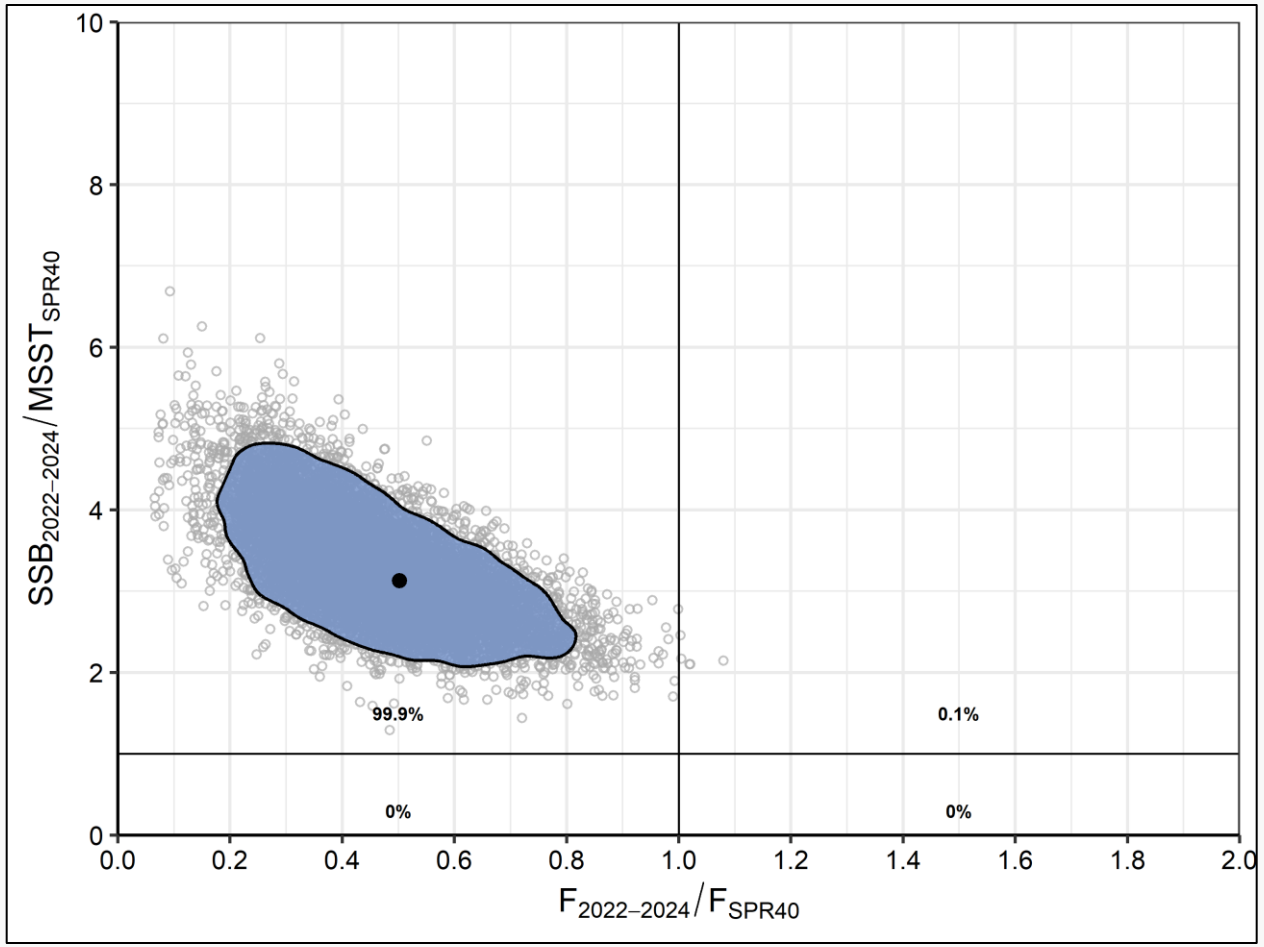
AW Report Figure 4.65



$SSB_{current}/MSST$= 4.188

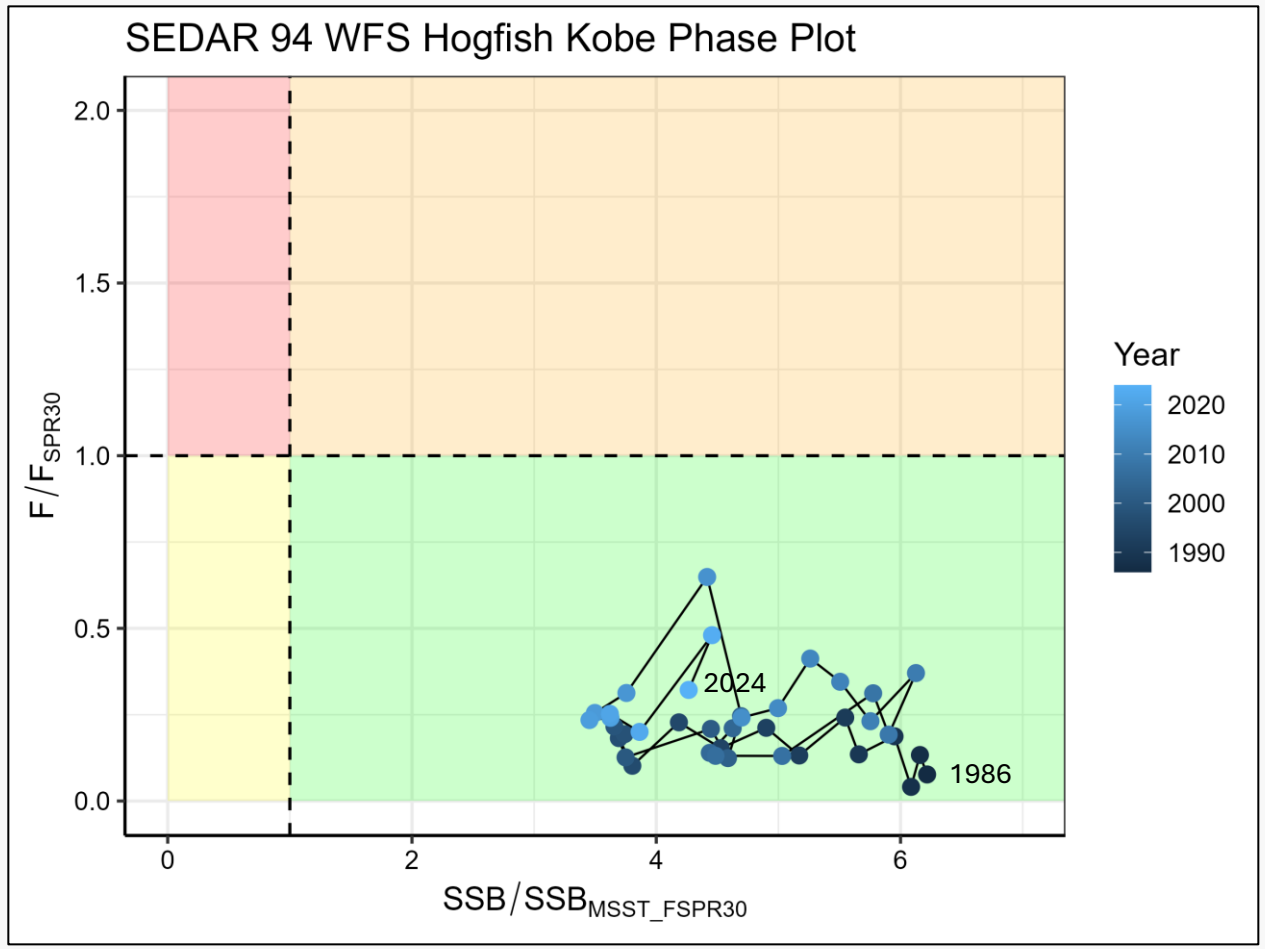
Stock Status

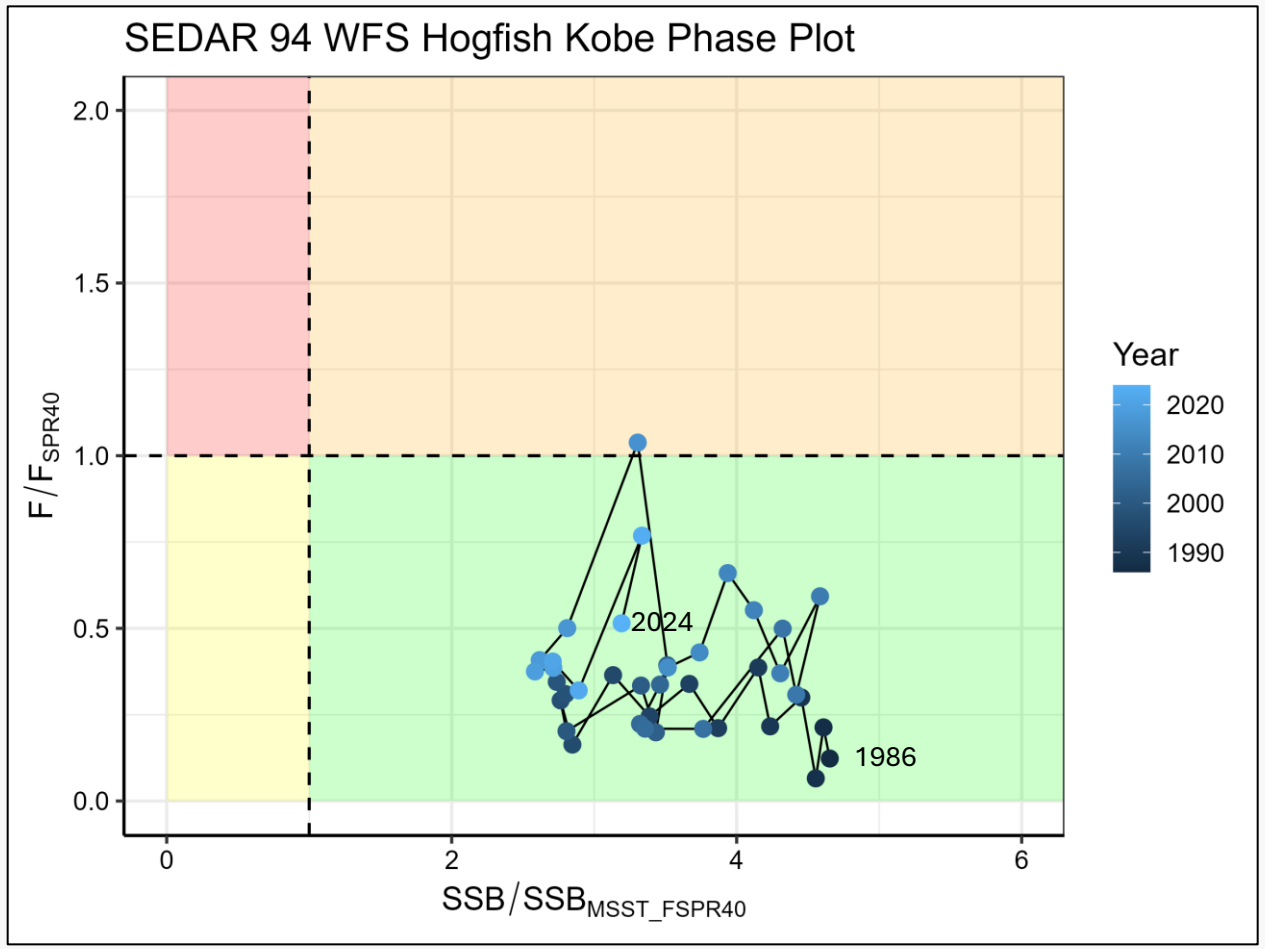




Phase plots of the terminal estimates based on the MCMC from the WFS base model

Stock Status





Stock Status

Criteria	Gulf Council Definition	40% SPR	**30% SPR**
MSY	The retained yield at F_{MSY} or $F_{SPR\ proxy}$	85.098 mt (187,608 lbs.)	101.489 mt (223,745 lbs.)
$F_{MSY\ or\ proxy}$	The fishing mortality rate associated with MSY or SPR proxy	0.143 yr^{-1}	0.229 yr^{-1}
MFMT (Maximum Fishing Mortality Threshold)	$F_{MSY\ or\ SPR\ proxy}$	0.143 yr-1	0.229 yr-1
$SSB_{MSY\ or\ proxy}$	The estimated spawning stock biomass associated with F_{MSY} or $F_{SPR\ proxy}$	693.335 mt (1,528,542 lbs.)	518.900 mt (1,143,979 lbs.)
MSST (Minimum Stock Size Threshold)	**0.50***$SSB_{MSY\ or\ FSPR\ proxy}$	346.668 mt (764,271 lbs.)	259.450 mt (571,989 lbs.)

Criteria	Gulf Council Definition	Value
$F_{current}$ (recent average fishing mortality rate)	The geometric mean of F exploitation for 2022 – 2024	0.072 yr^{-1}
$SSB_{current}$ (recent average SSB)	The geometric mean of SSB for 2022 – 2024	1,086.509 mt

SEDAR 94: Florida Hogfish

WFS Bridge Building

Continuity Models

TOR 2.2

- *"Provide a continuity model consistent with the prior benchmark (SEDAR 37) and update (SEDAR 37U) assessment configurations,* ***if one exists****, updated to include the most recent observations.* ***Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered."***

- *"Provide additional continuity models which update these prior assessment's configurations and terminal years with ~~MRIP-FES~~ (SRFS) landings and discards."*

- **Strict continuity models largely unreproducible due to changes in data streams**
  - 1) Updated the SEDAR 37 WFS base model to the configuration of the SEDAR 94 KEYS base model ("S37data_S94config" scenario)
  - 2) Updated the SEDAR 37 WFS base model by replacing the MRFSS/MRIP ad-hoc recreational landings by gear with the Full SRFS back-calculated landings by gear ("S37_SRFS" scenario)

WFS Continuity Model

Objective: SEDAR 37AU base model data incorporating SEDAR 94 configuration

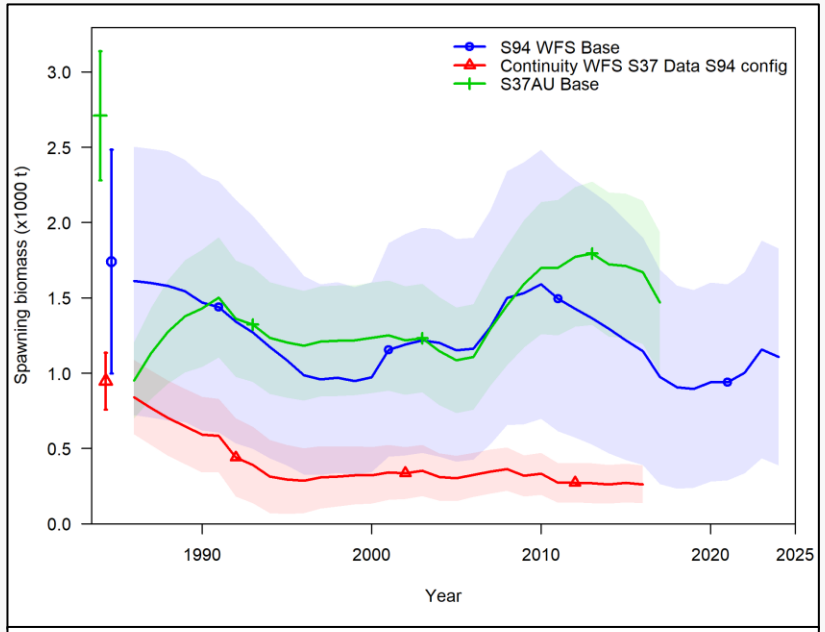
Key Configuration Changes to S37U:

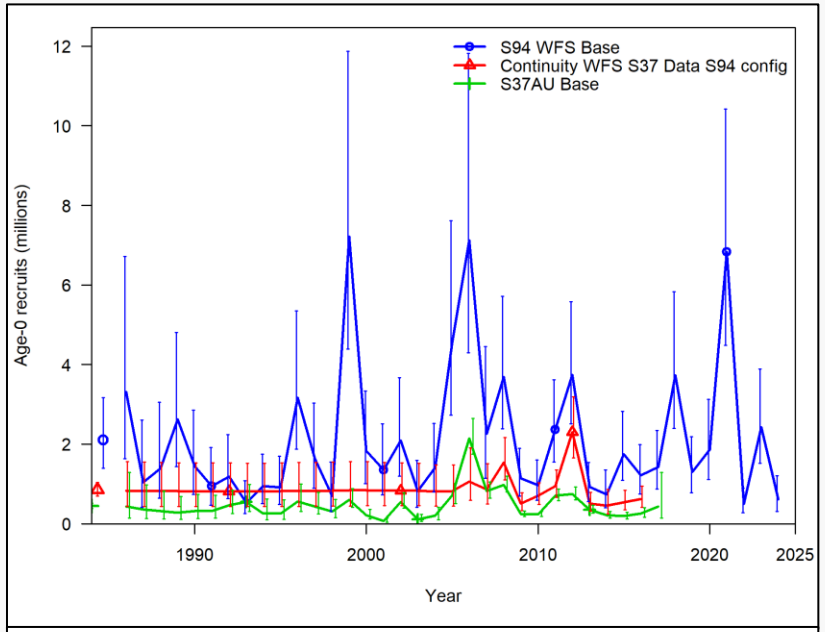
- SS model version 3.24 to 3.30
- Combined commercial fishery fleets
  - 3 Comm fleets into 1
- Added regulatory time block in 2000
- Indices
  - Removed all FD
  - Removed FI Baitfish
- Applied S94 natural mortality, growth, maturity, hermaphroditism configs
  - Fixed growth at S94
  - Utilized 3 platoons with stdev ratio at S94
- Selectivity
  - Time varying with regulatory block
  - All fleets/surveys double normal function except Comb Video (single logistic)
- Fixed *steepness* at 0.99
  - Estimated *sigmaR*
- Removed early recruitment deviations
- Estimated initial F for RECsp only
- Applied super periods to fishery length comps
- Applied Francis weighting on length and age comps

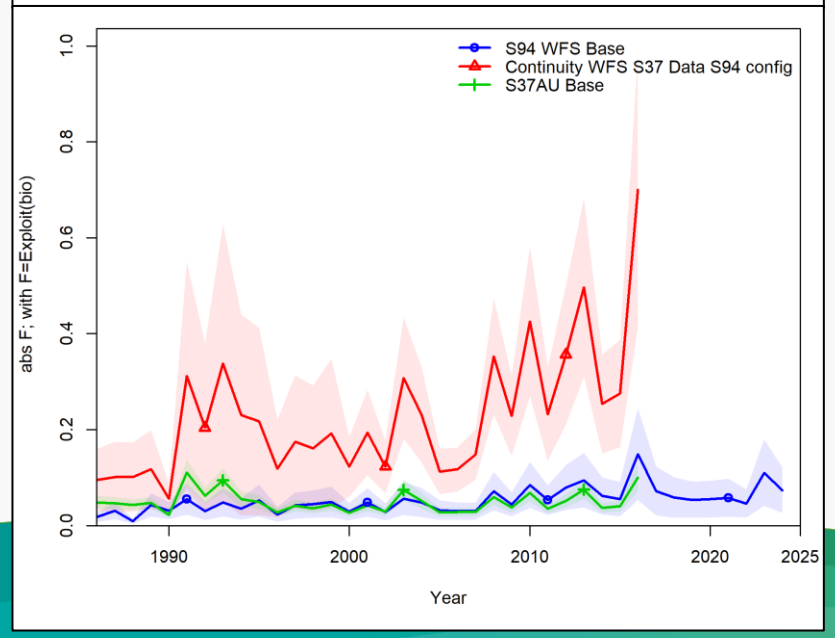
WFS Continuity Model Comparison

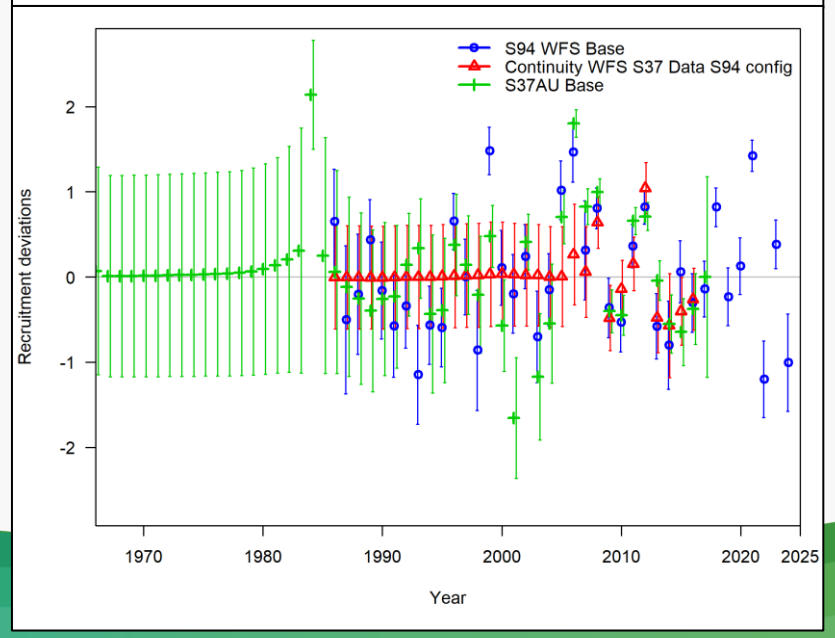
	SEDAR 37AU Base	S37U Data S94 Config	SEDAR 94 Base
Model years	1986-2016	1986-2016	1986-2024
Fleets	Comm HL Comm Spear Comm Trap Rec HL Rec Spear	Gen Comm Rec HL Rec SP	Gen Comm Rec HL Rec SP FI_SP
Indices	Comm HL Comm Spear Rec HL Rec Spear Baitfish SEAMAP Trawl Comb Video Seagrass Trawl	Seagrass Trawl SEAMAP Trawl Comb Video	Seagrass Trawl SEAMAP Trawl Comb Video
steepness	0.86	0.99 (fixed)	0.99 (fixed)
ln(R0)	6.10	6.61	7.65

WFS Continuity Model Comparison



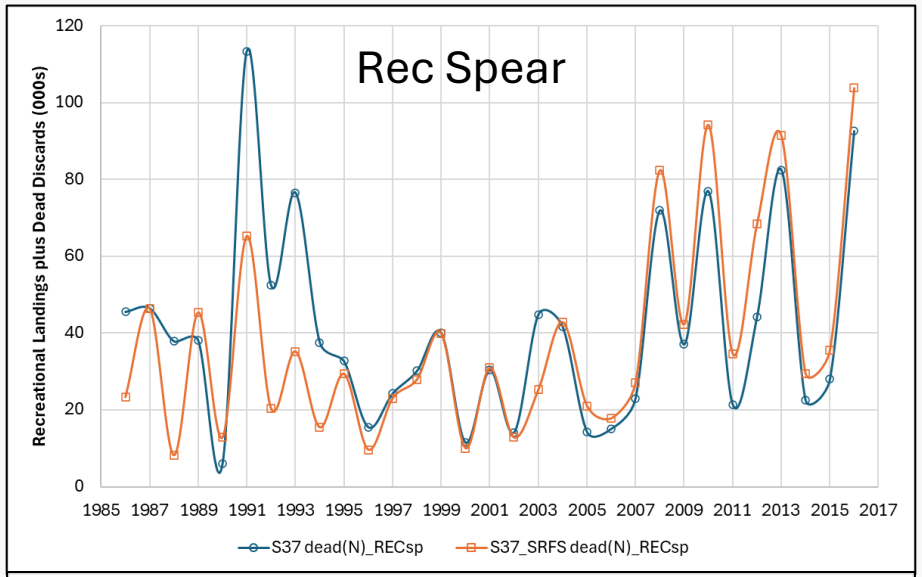


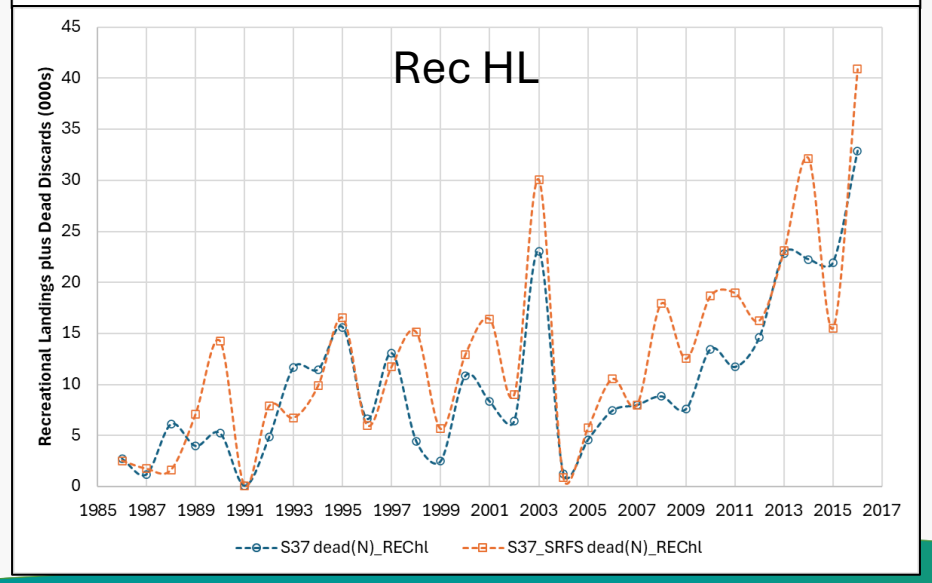


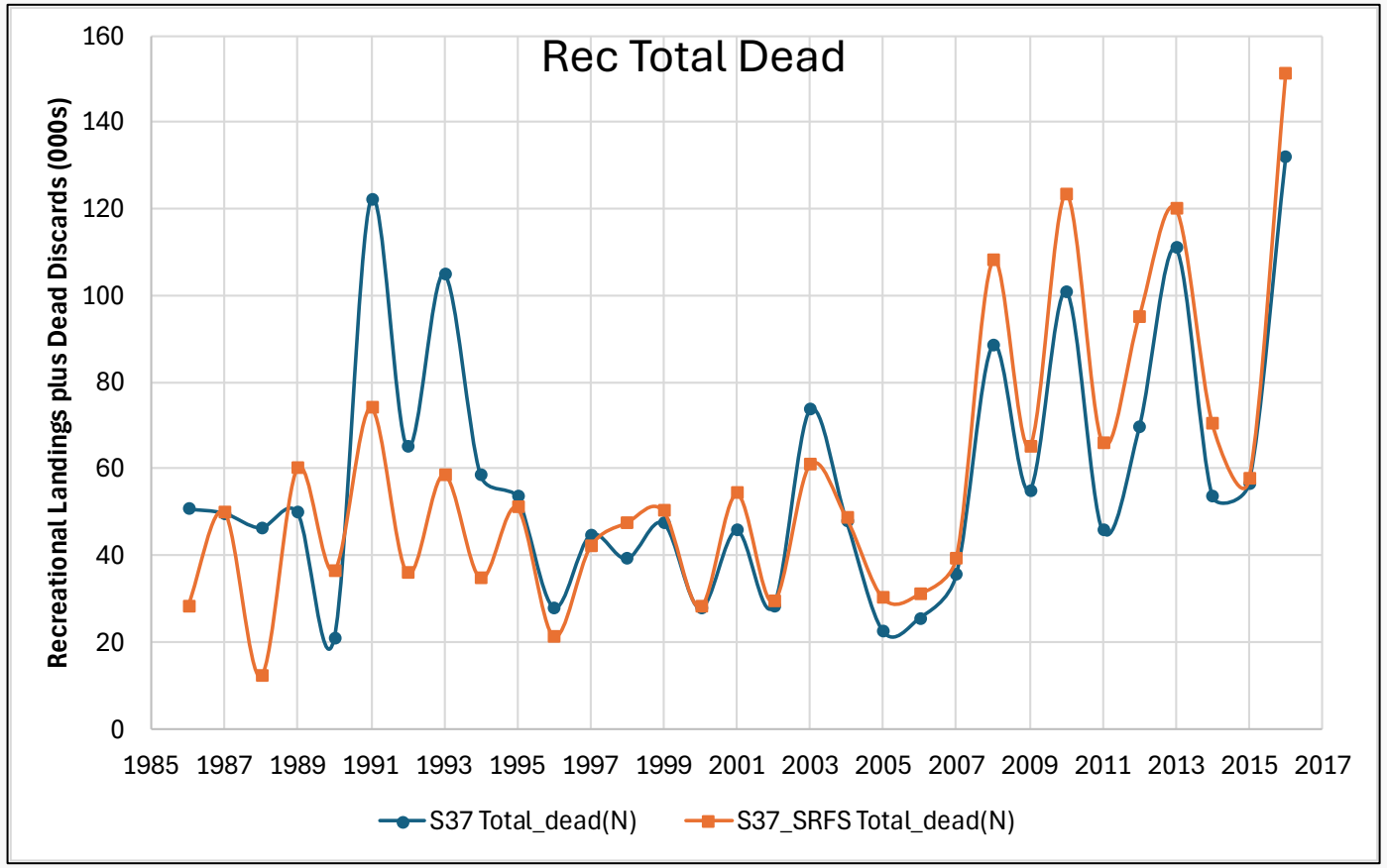


AW Report
Figure 4.67

WFS S37U with SRFS-Calibrated Landings



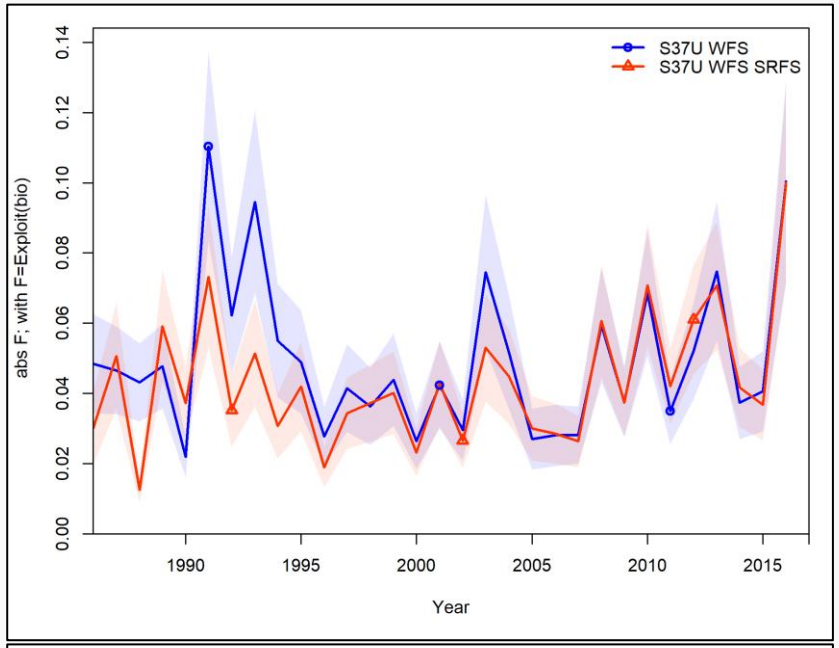


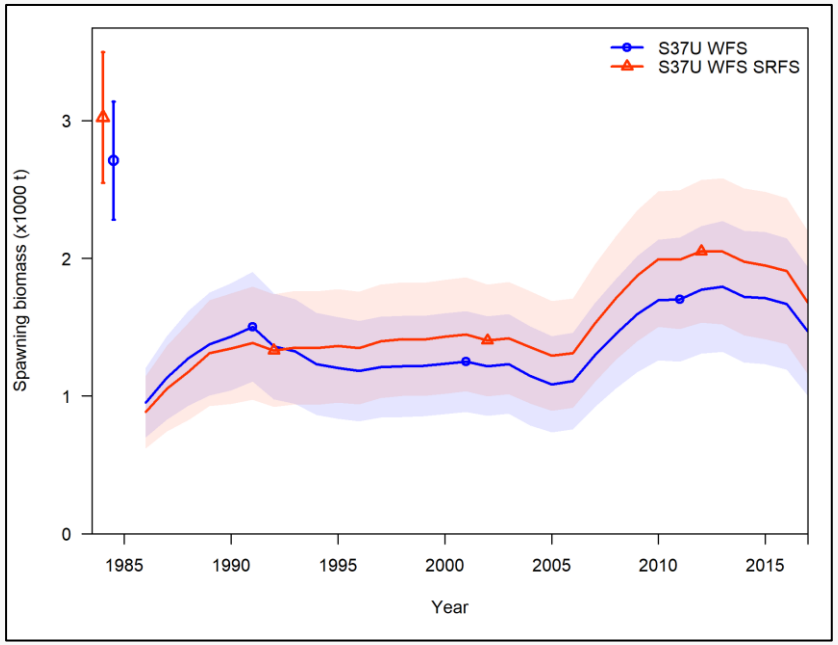


** S37 in CHTS units **

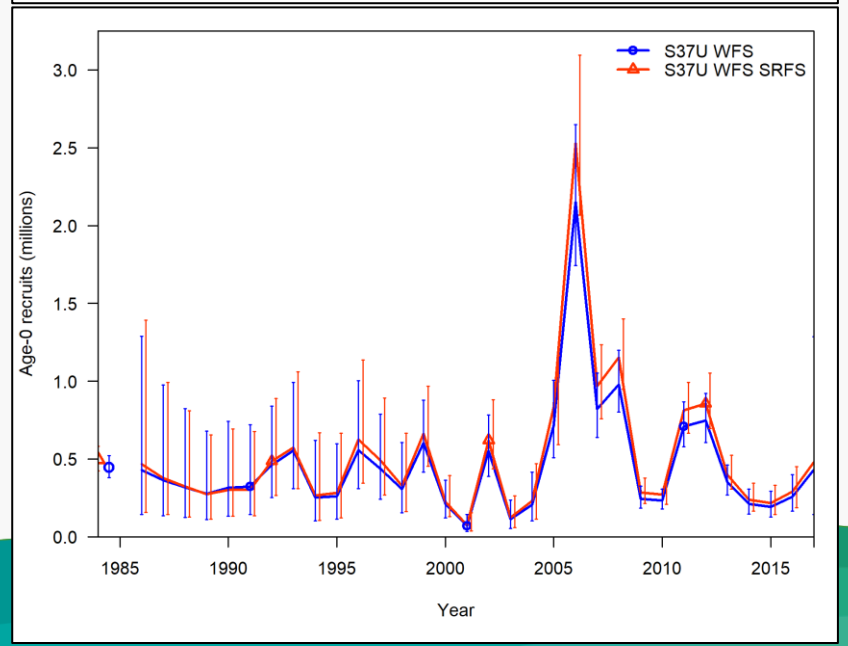
AW Report Figure 4.68

WFS S37U with SRFS-Calibrated Landings





AW Report Figure 4.69



- Populations estimates not meaningfully different
  - Overlap with S37 Base uncertainty bounds
- Exploitation follows the new landings trend
  - Increases to recruitment and SSB scales


Thank You!