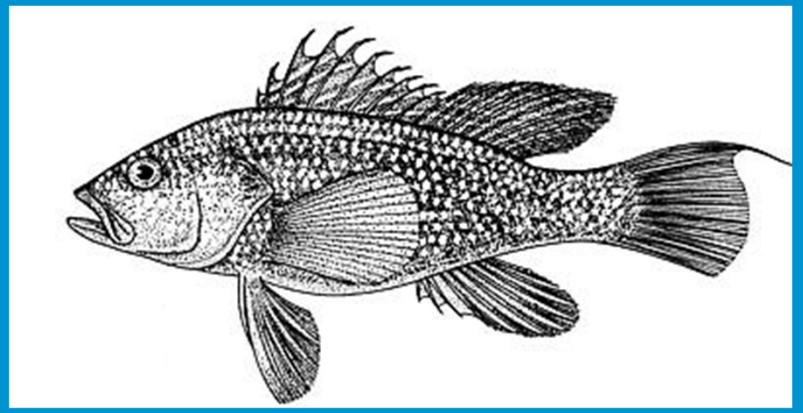
NOAA FISHERIES

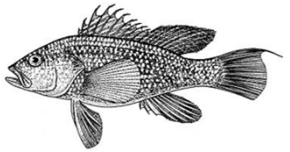
Northeast Fisheries Science Center

Black Sea Bass

Research Track Stock Assessment



Objective and Terms of Reference



Objective: Develop the assessment and projection methodology that will be used in subsequent management track assessments

Terms of Reference (TORs):

1. Identify relevant ecosystem and climate influences on the stock….
2. Estimate catch from all sources including landing and discards…
3. Present the survey data used in the assessment…
4. Estimate annual fishing mortality, recruitment and stock biomass…
5. Define status determination criteria…
6. Develop appropriate methods for producing projection…
7. Report on the status of research recommendations…
8. Develop a backup assessment approach…

Black Sea Bass RT Stock Assessment Working Group

Working Group Members:

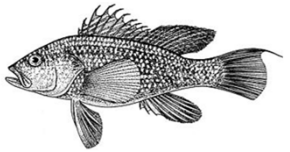
- Anna Mercer (NEFSC) - chair
- Kiersten Curti (NEFSC) - assessment lead
- Julia Beaty (MAFMC)
- Gavin Fay (UMassD - SMAST)
- Marissa McMahan (Manomet)
- Jason McNamee (RIDEM)
- Tim Miller (NEFSC)
- Sam Truesdell (MADMF/NEFSC)
- Ricky Tabendera (NEFSC/HCRI)

Working Group Meetings: 42

Other Contributors: 31 total

- Alex Hansell (NEFSC)
- Andy Jones (NEFSC)
- Jeff Brust (NJDEP)
- Lisa Chong (MSU)
- Scott Large (NEFSC
- Abby Tyrell (NEFSC)
- Andie Painten (UMassD - SMAST)
- Maria Cristina Perez (UMassD - SMAST)
- Hannah Verkamp (CFRF)
- John Wiedenmann (Rutgers)
- Paula Fratantoni (NEFSC)
- Gary Shephard (NEFSC - retired)

2023 Research Track Advances



- Multi-region state-space modeling framework that accounts for spatial dynamics, differences in productivity and movement between regions
- Ecosystem impacts (bottom temperature) on productivity
- Range expansion and varying catchability impacts on indices of abundance (VAST modeling)
- Reevaluation of discard mortality and natural mortality
- Enhanced reproducibility of data inputs and time series development to account for spatial structure

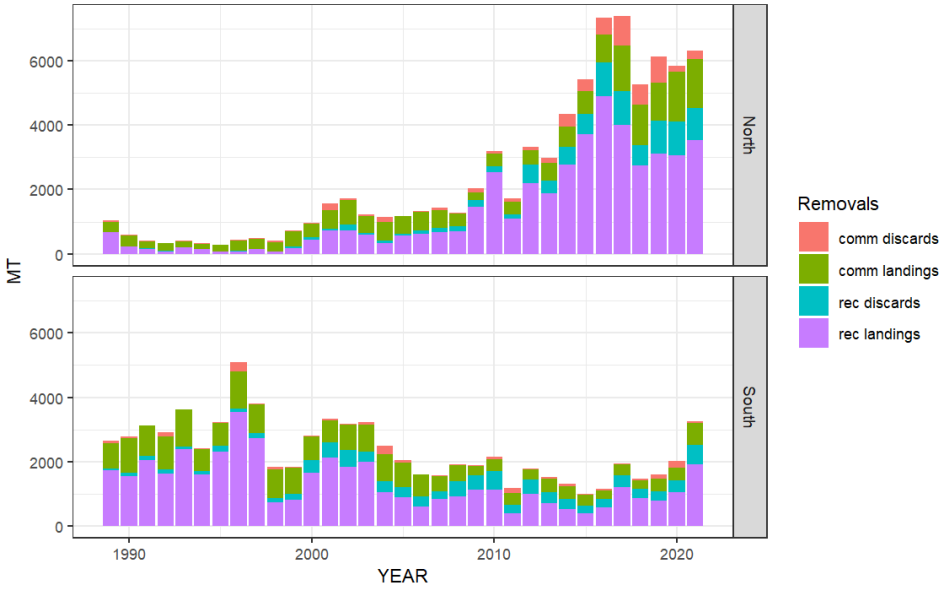
TOR 2: Fishery Data

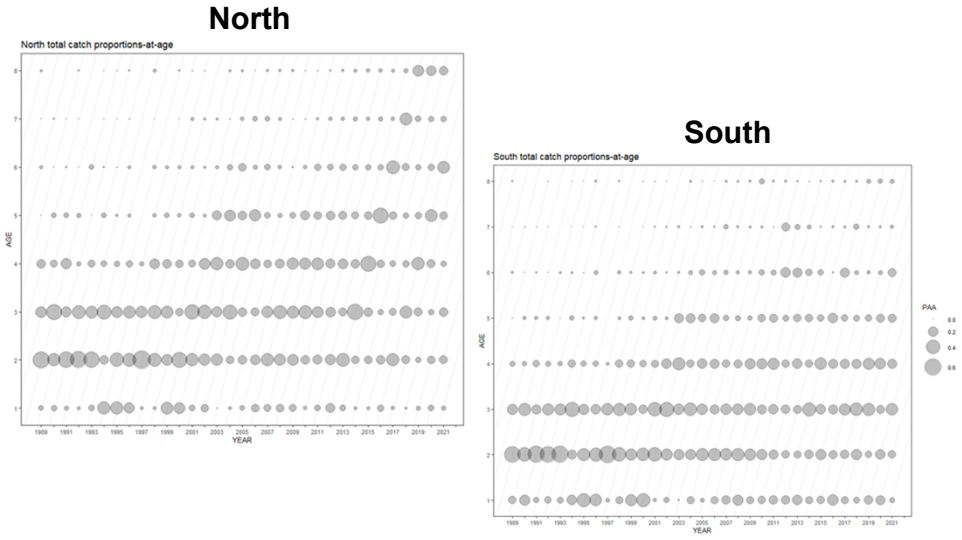
Accomplishments

- Reevaluation of discard mortality
- Spatiotemporal fishery characterization and catch expansions with semi-automation of catch estimation and repeatable rules for borrowing

  → Transitioned from trawl/non-trawl fleets to commercial/recreational fleets
- Addition of scallop fleet to discard estimation
- New data stream (CFRF Black Sea Bass Research Fleet) for discards at length and age-length keys

  → CFRF kept length frequencies could not be incorporated because market category not included

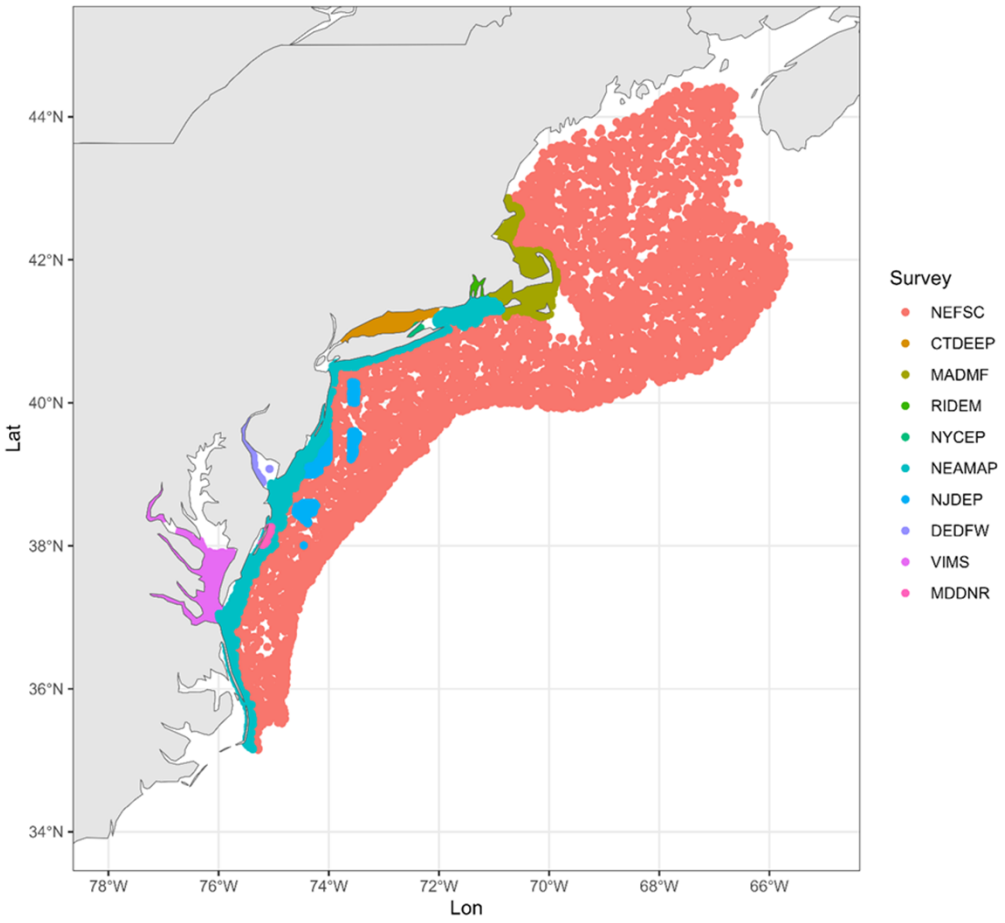




TOR 3: Survey data

Accomplishments

- 26 indices of abundance considered
  - New indices of abundance explored (ventless trap survey, fall trawl surveys, commercial CPUE)
- Included Gulf of Maine strata in NEFSC trawl survey indices
- Standardization of individual surveys
- Spatio-temporal (VAST) modeling to produce aggregate indices of abundance
- Fishery dependent indices of abundance (Recreational CPA and Commercial CPUE)



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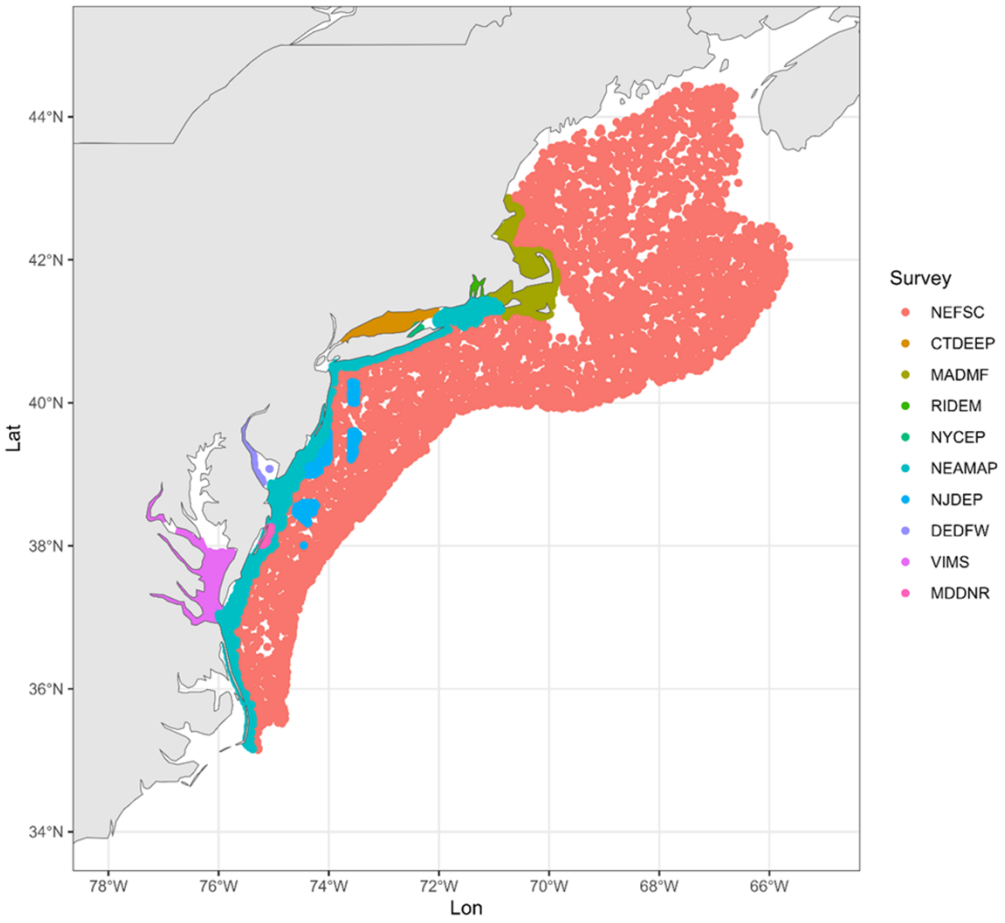


Vector Autoregressive Spatio-Temporal (VAST) Modeling

Background

- Previous assessments fit to 10 individual trawl surveys, many with small spatial footprints
- Some state surveys were standardized to account for changes in catchability, but only in aggregate index values, not age compositions

VAST

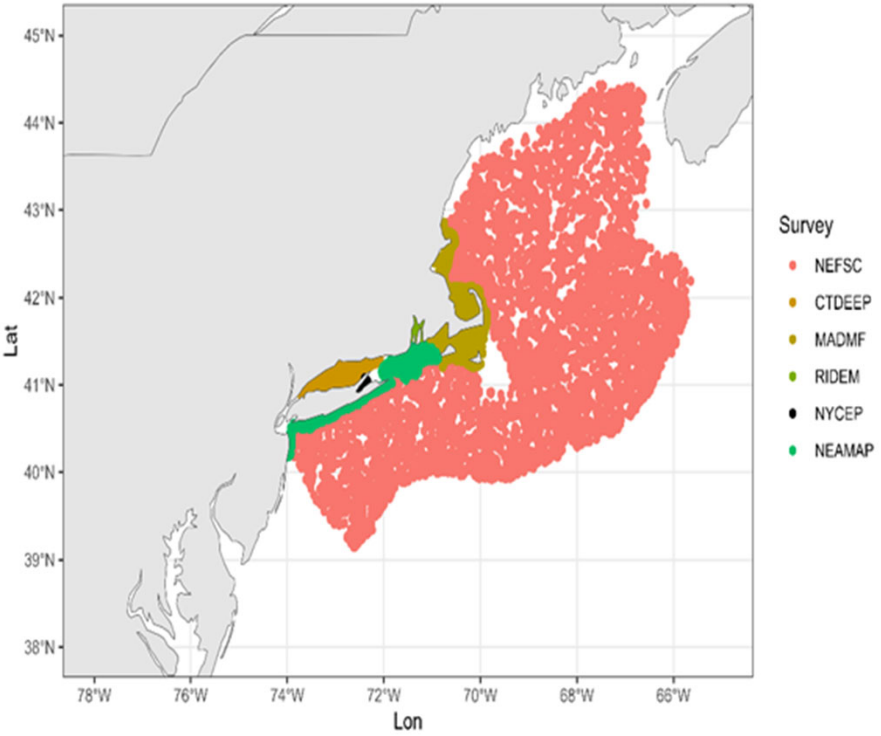
- Spatio-temporal delta GLMM (Thorson et al. 2019)
- Area weighting
- Catchability and habitat covariates
- Condition on missing covariates
- Univariate and multivariate

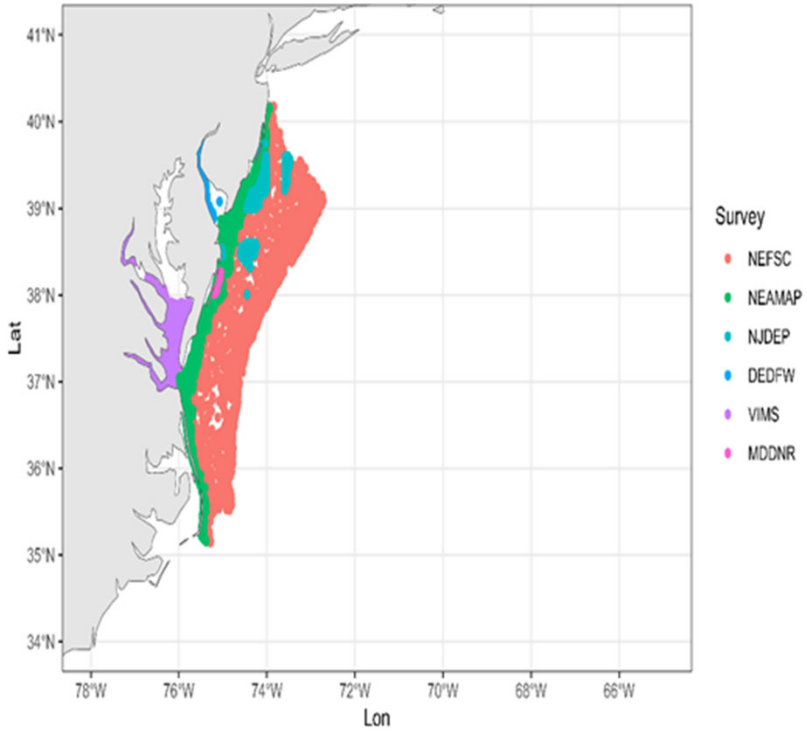
Benefits

- Changes in availability (O'leary et al. 2022)
- Combine multiple surveys (Hansell et al. 2020)
- Standardize index (Thorson et al. 2015)
- Standardize age comps (Shelton et al. 2014)
- Reduce retros (Cao et al. 2017)
- Climate impacts (Perretti and Thorson, 2019)

Vector Autoregressive Spatio-Temporal (VAST) Modeling

Individual state and federal trawl survey data were combined into aggregate time series using VAST models that incorporated environmental covariates to account for time-varying catchability among surveys and spatial changes between survey footprints





VAST modeling

Covariates selected by AIC:

Bottom temp (density)

~~Depth~~

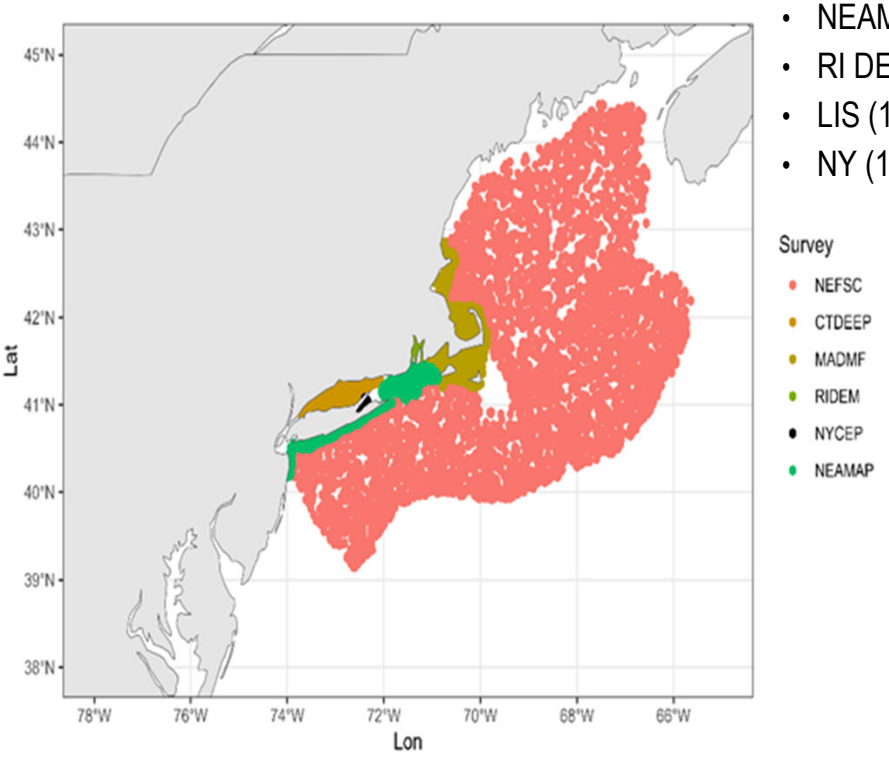
~~Shelf water volume anomaly~~

Survey (catchability)

Survey:age (catchability)

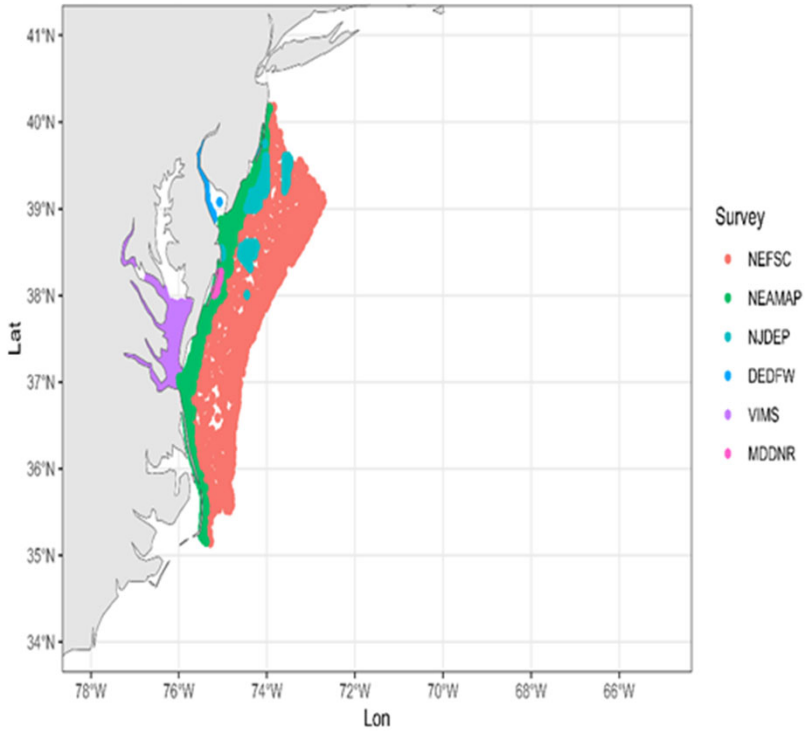
North

- Albatross (1989 – 2008)
- Bigelow (2009 – 2021)
- MADMF (1989 – 2021)
- NEAMAP (2008 – 2021)
- RI DEM (1989 – 2021)
- LIS (1989 – 2021)
- NY (1989 – 2020)

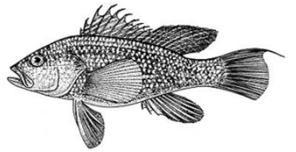


South

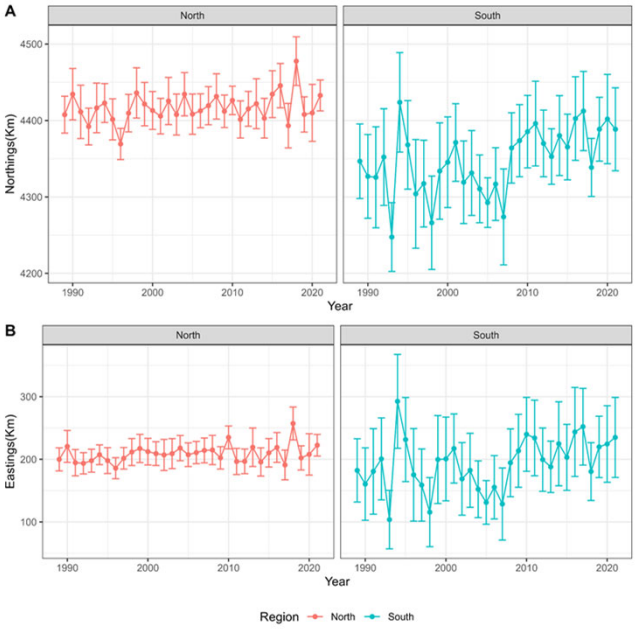
- Albatross (1989 – 2008)
- Bigelow (2009 – 2021)
- NEAMAP (2008 – 2021)
- MD (1989 – 2021)
- DE (1998 – 2021)
- VIMS(1989 – 2021)
- NJ (1989 – 2021)



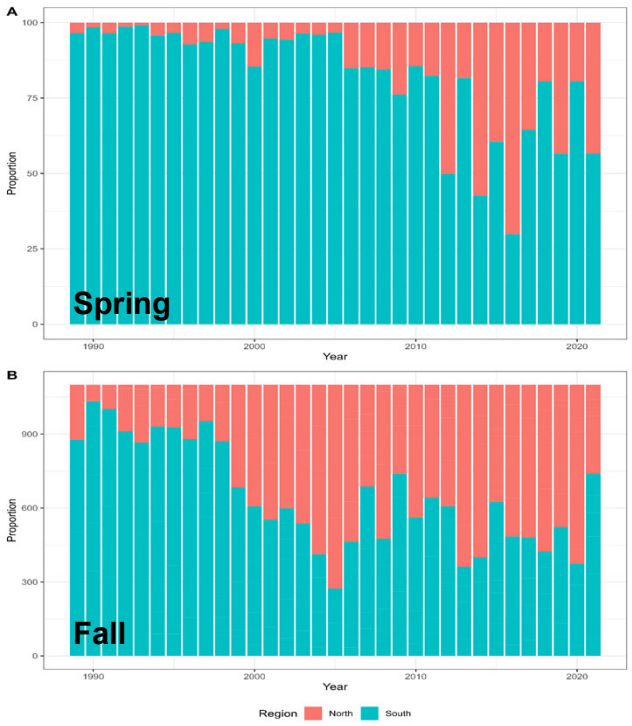
VAST modeling



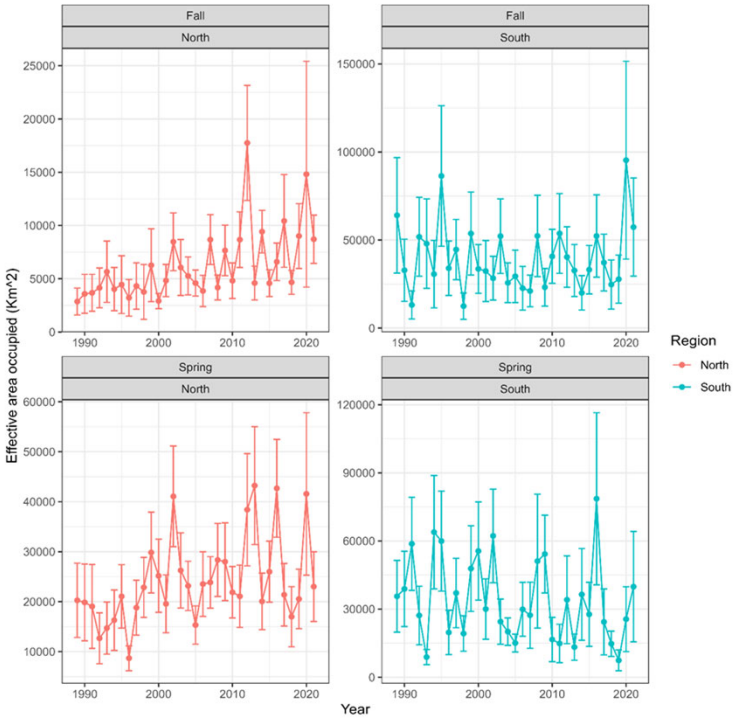
Spring center of gravity



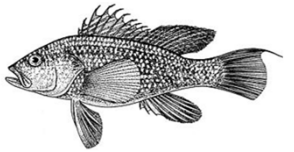
Proportion caught by area



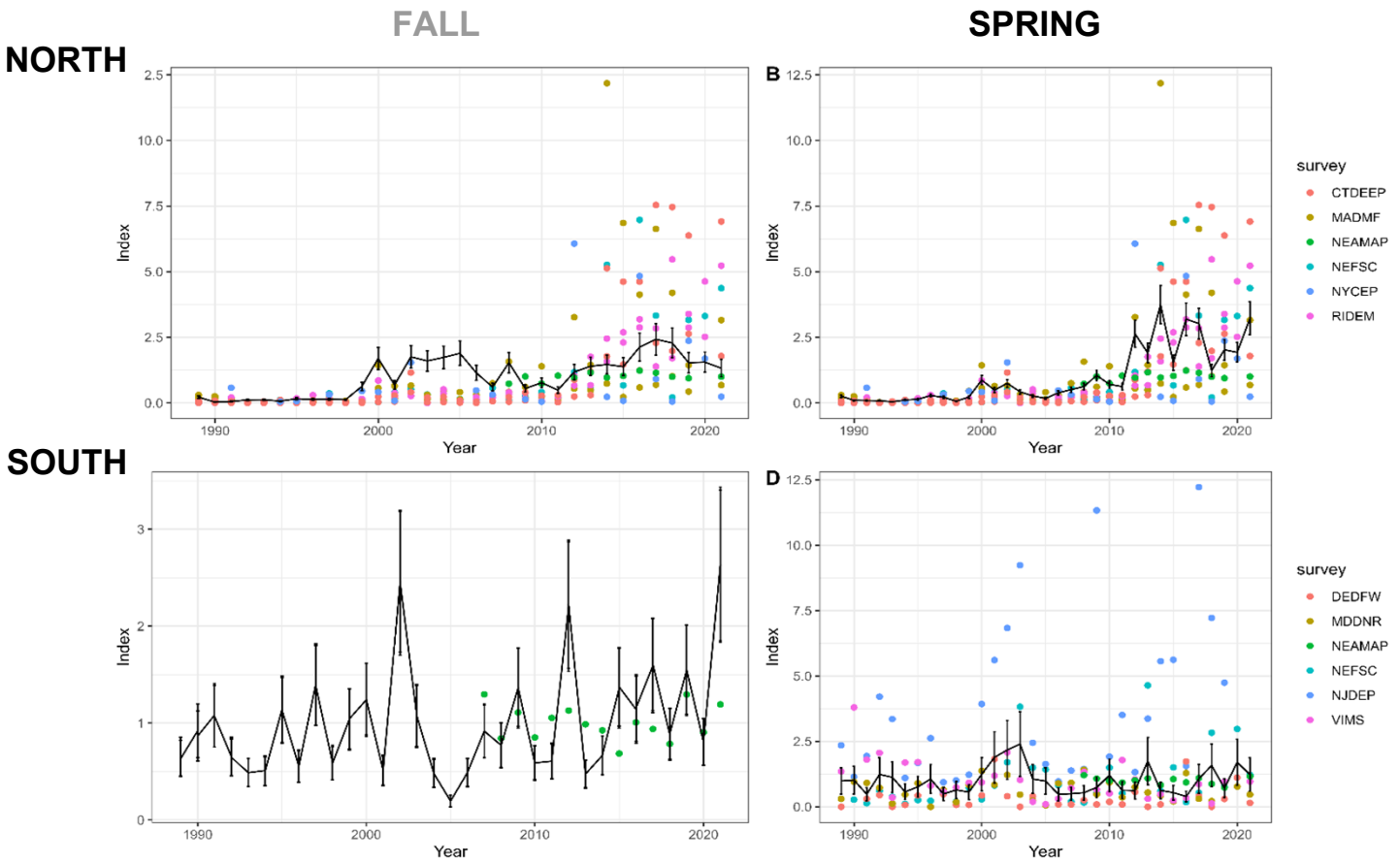
Effective area occupied



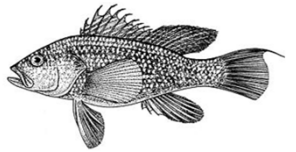
VAST modeling



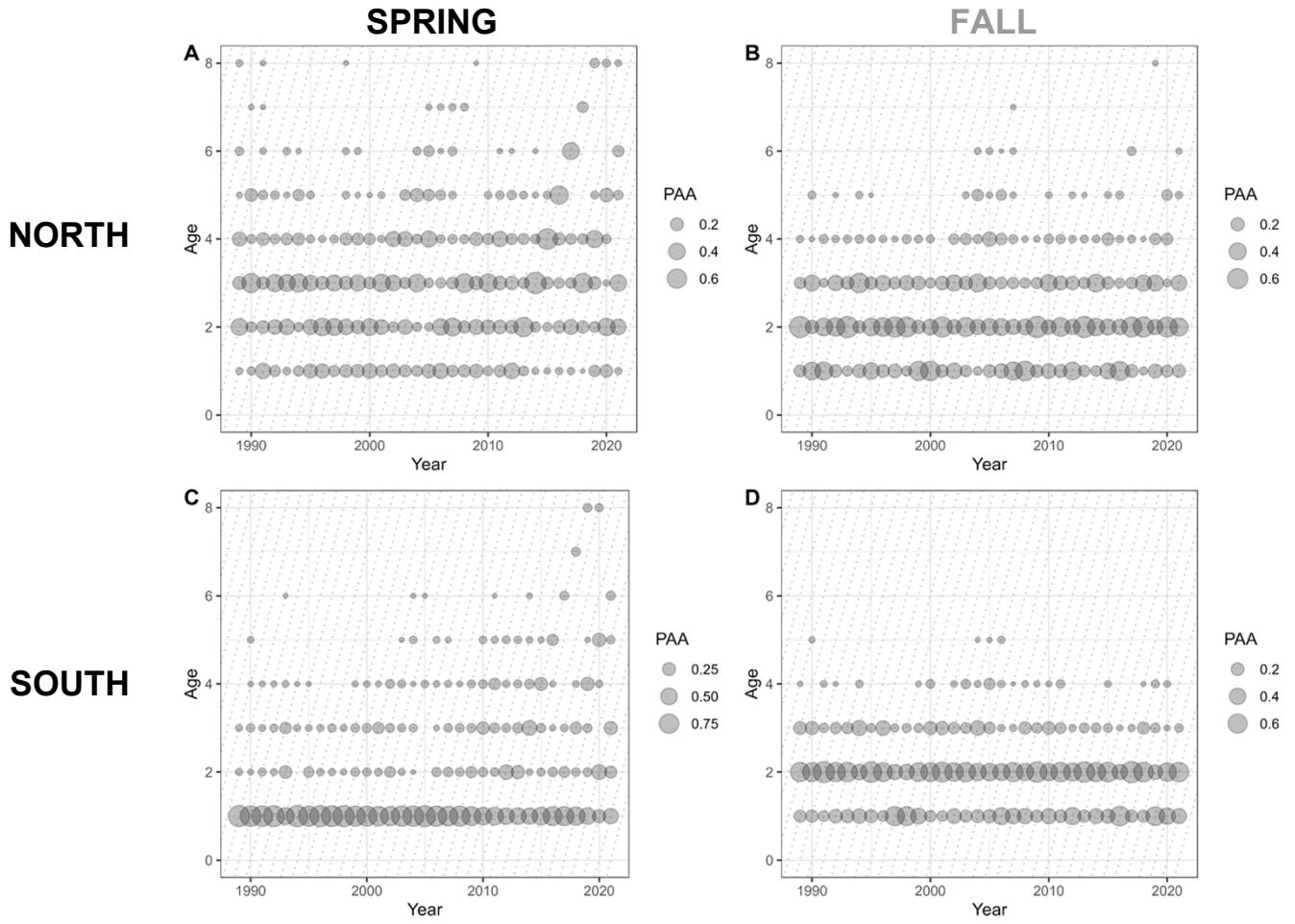
Aggregate time series



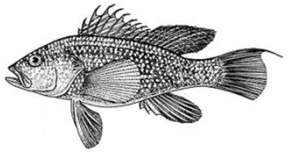
VAST modeling



Age compositions

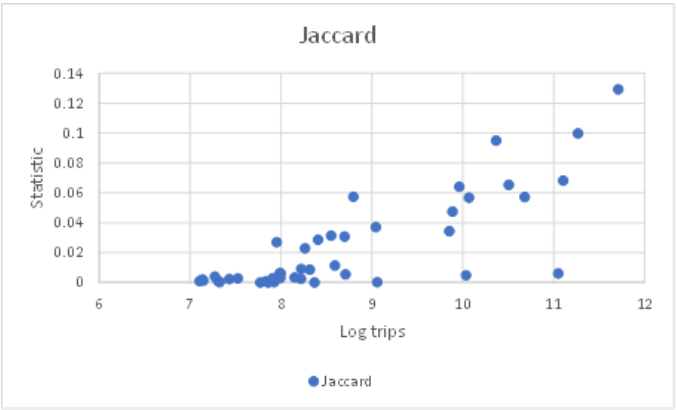


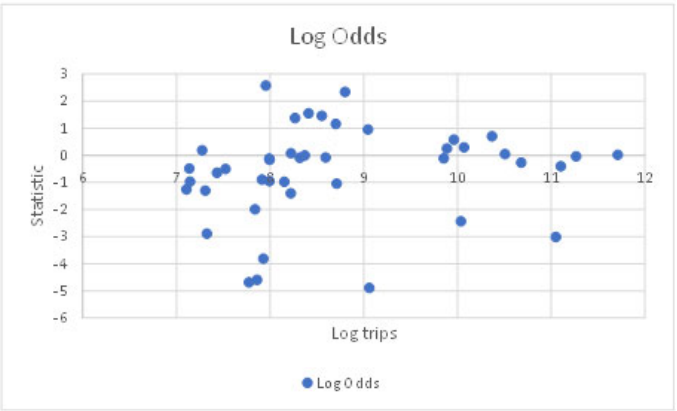
Recreational catch-per-angler



- Guild approach used since 2016
  - Guild = group of species commonly associated with the target species
  - Effort is any trip that captured any of the guild species
- Previous assessments used Jaccard index to define the guild but Jaccard shown to have prevalence bias
- Evaluated several “centralized” methods
- Log odds ratio selected based on diagnostics and documentation

Evaluation of prevalence bias (south)





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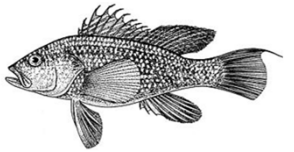
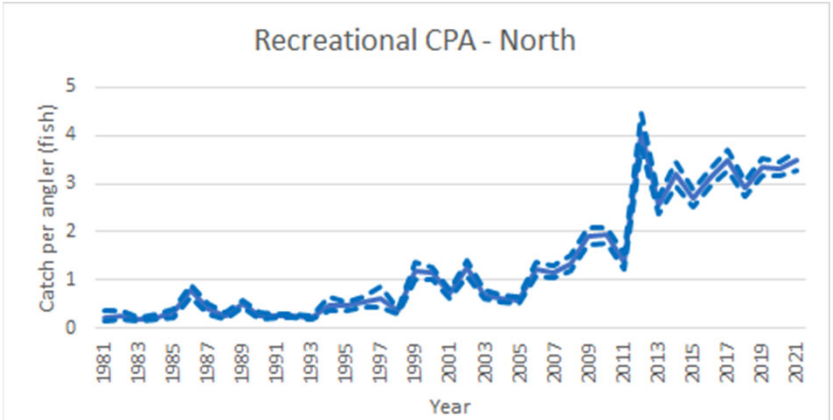
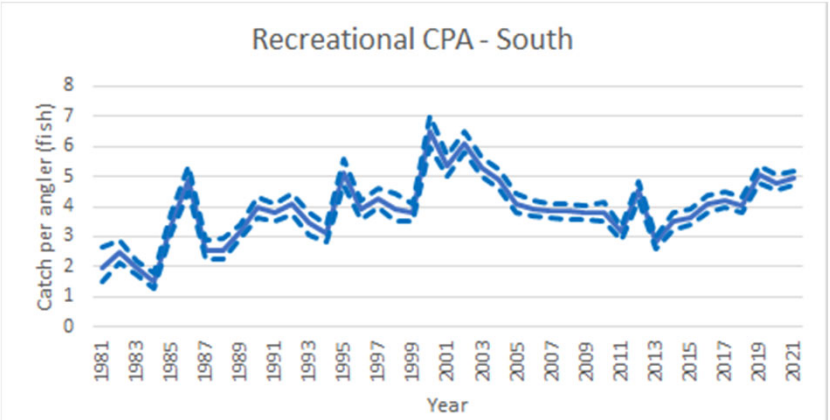
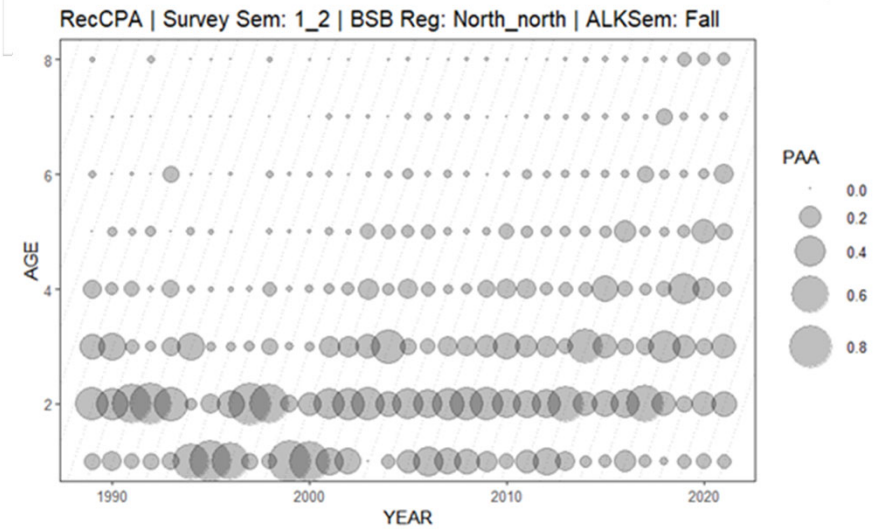
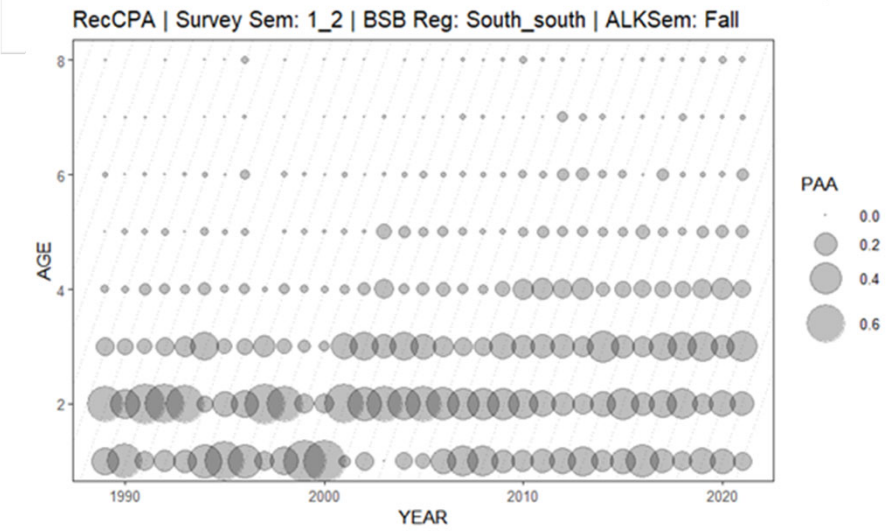


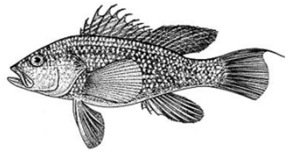








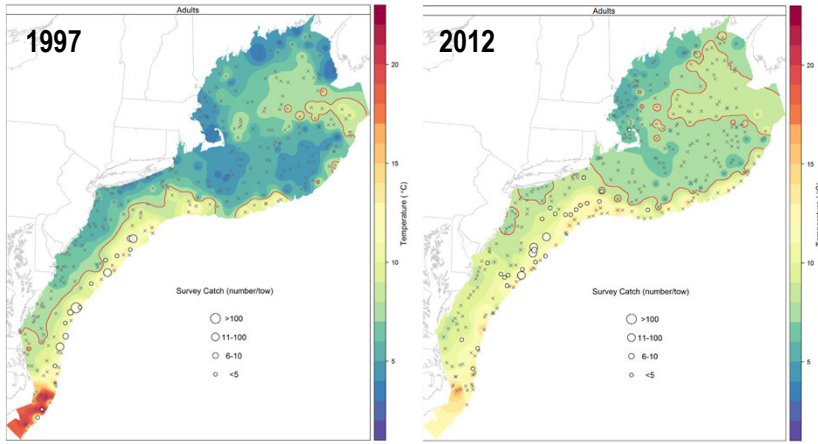
TOR 1: Ecosystem Considerations



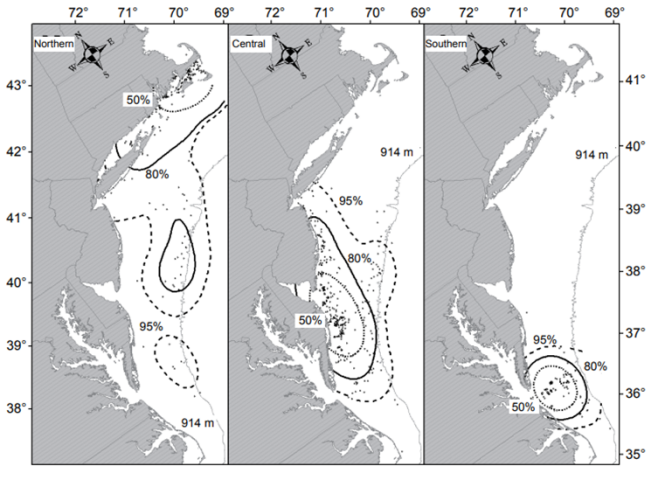
Accomplishments

- Spatiotemporal modeling of abundance indices
- Temporal and spatial patterns in biology
- Food habits
- Reevaluation of natural mortality
- Evaluation of hypotheses regarding ecosystem drivers (building off Miller et al. 2016, Moser and Shepherd 2009)
  - Winter bottom water temperature across shelf drives productivity
  - Shelf water volume during winter drives mixing

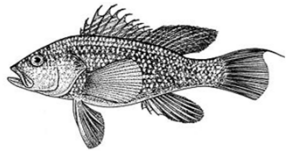
Miller et al. 2016



Moser and Shepherd 2009

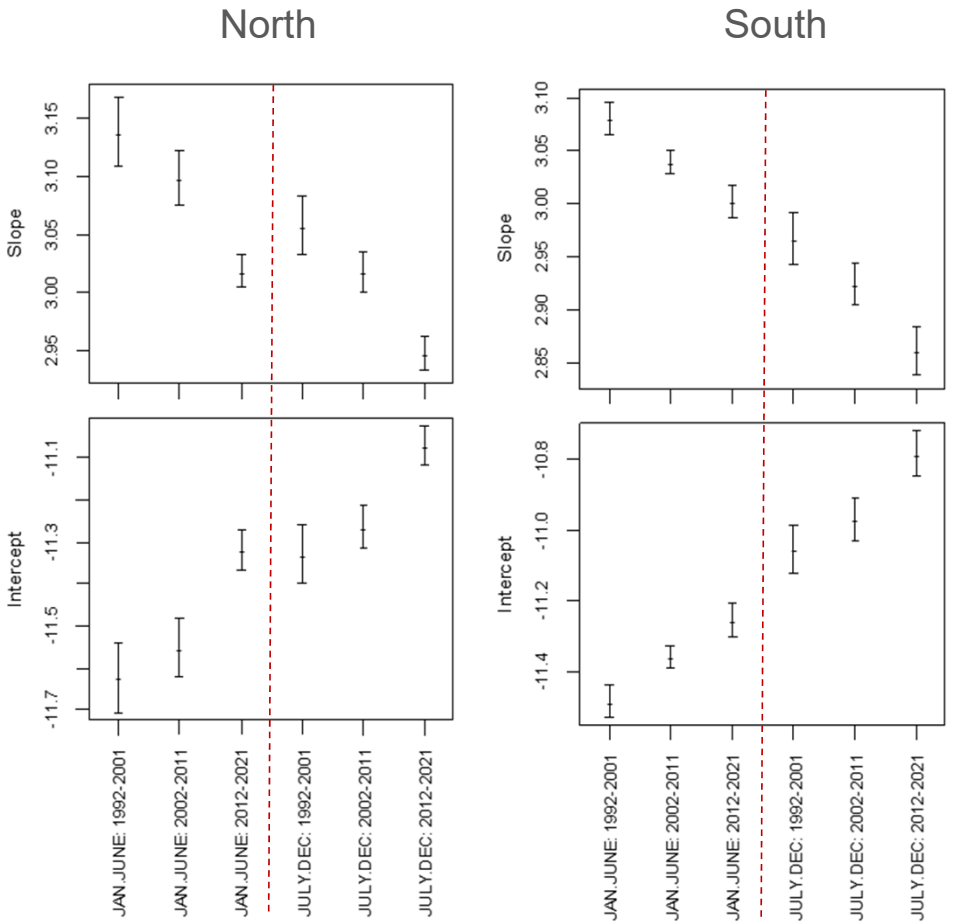


Biology: Length-weight relationship

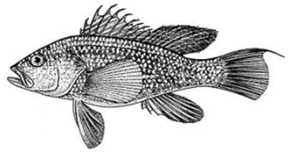


- Significant differences between semesters
- During the fall semester, significant differences between regions
- Over the time series, relationship between length and weight differed post-2011 in the north and between each decade in the south

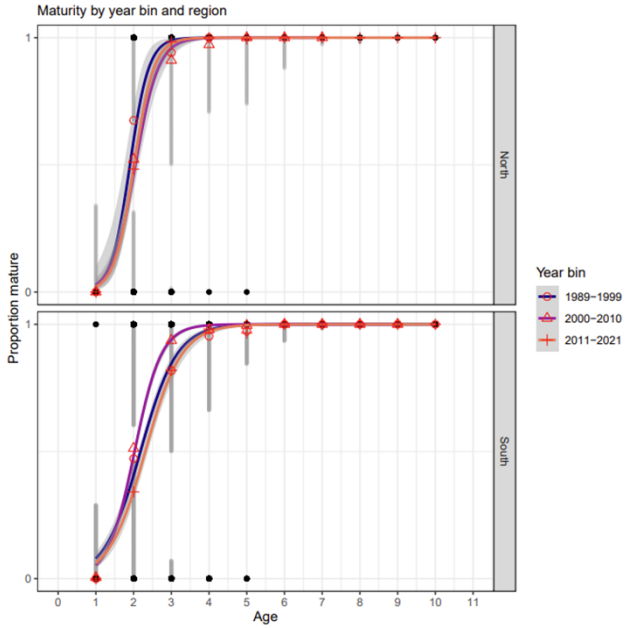
- Semester, region and time-specific relationships used to convert sampled fishery lengths to weight

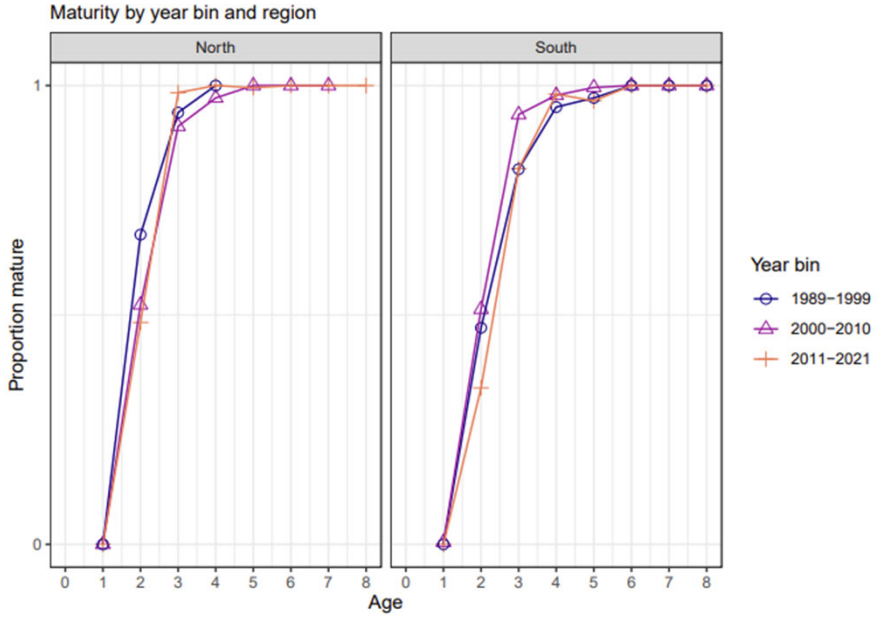


Biology: Maturity



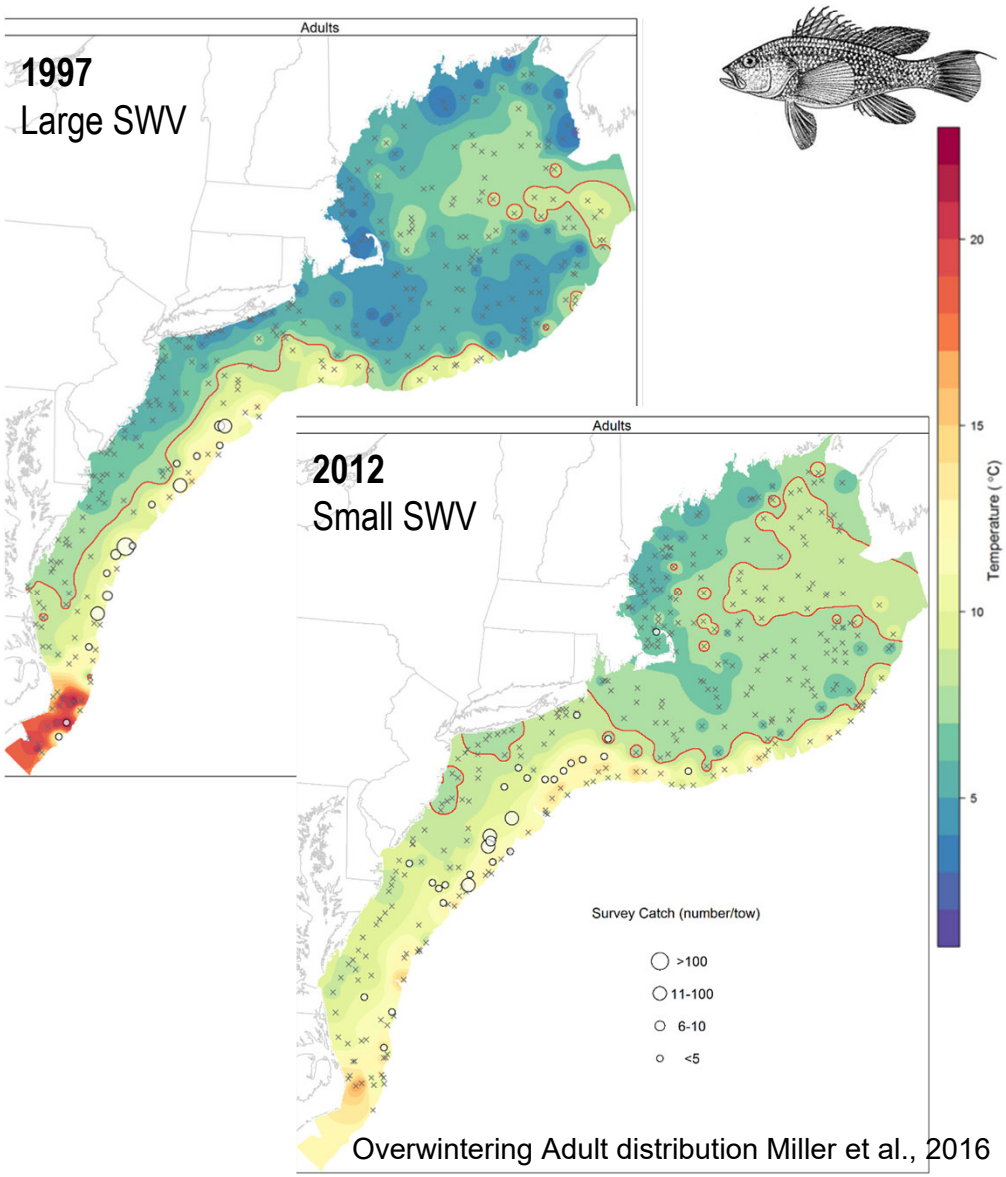
- Did not vary significantly over region, sex or decades (binomial GLMs)
- 50% maturity: ~ 2 years old and ~ 21 cm
- Observed proportions (by region and decade) used for WHAM





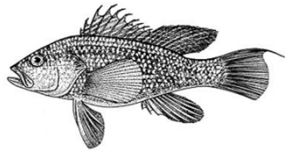
Overwintering habitat preferences (Miller et al. 2016)

- Shelf slope front divides well-mixed shelf water from saltier and relatively warm offshore water
- Winter offshore distribution correlated with location of shelf-slope front
- Years with warmer temperatures (and smaller shelf water volume) → sea bass more widely distributed across shelf
- Lack of correlation between YOY and year class strength → overwintering survival during first year a potential bottleneck



Overwintering Adult distribution Miller et al., 2016

Seasonal migrations (Moser & Shepherd 2009)



- Move offshore to edge of continental shelf in fall, returning to inshore spawning areas in spring with high degree of site fidelity
- Extent of seasonal migrations vary by location
- During winter, individuals from northern and southern regions mix & are captured in offshore winter trawl fishery
  - Location of catch is not necessarily indicative of source region
  - Misattribution of catch could contribute to retrospective pattern

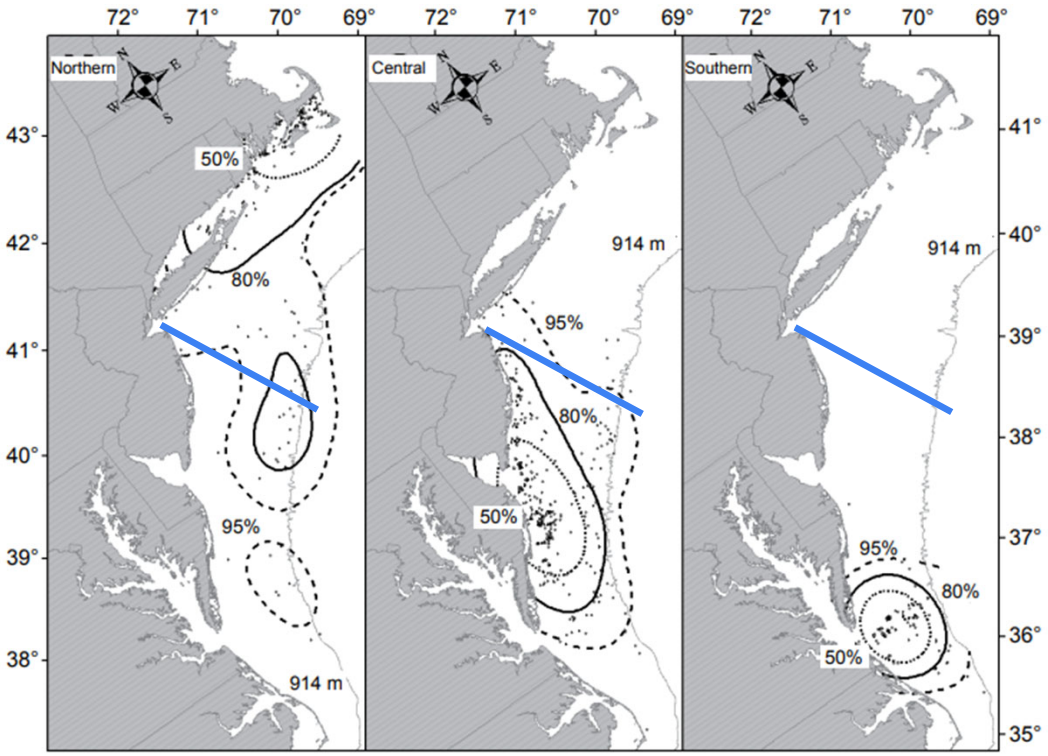
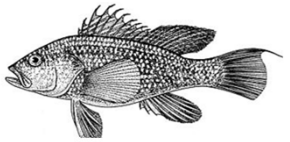


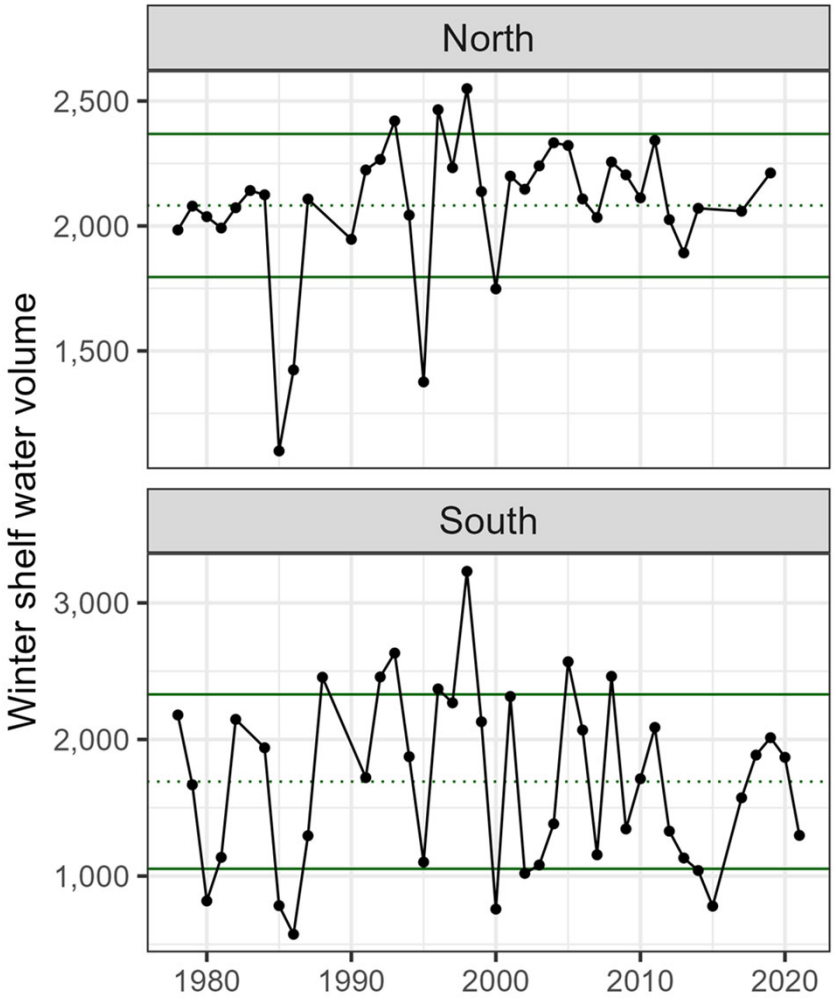
Fig. 6. Percent volume contours of black sea bass tag recaptures released from the Northern, Central and Southern areas. The area within the dashed line contains 95% of tag recaptures, the solid line contains 80% of tag recaptures and the dotted line contains 50% of the recaptured tags from the respective area. Small circles indicate the respective tag recapture locations for tags released in that area.

Shelf water volume



Hypothesis: Higher shelf water volume (lower temp/salinity) → less offshore winter thermal habitat → more movement of BSB from northern region to southern region (possible misattribution of catch)

Test correlation between shelf water volume and distribution metrics from VAST modeling

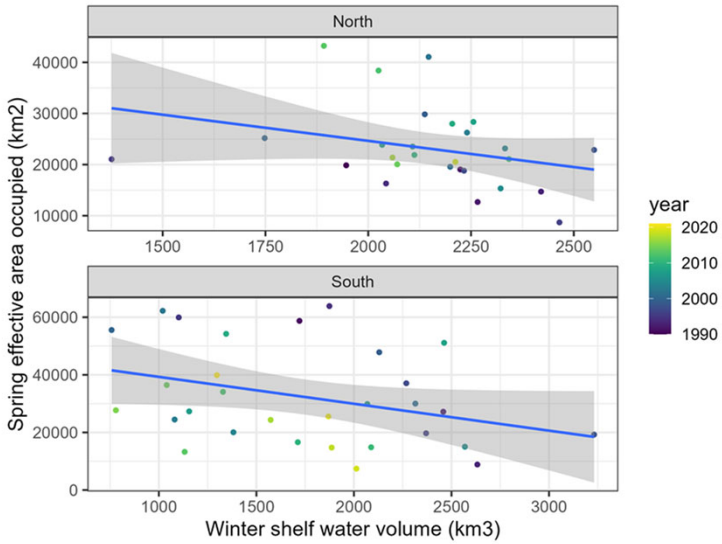


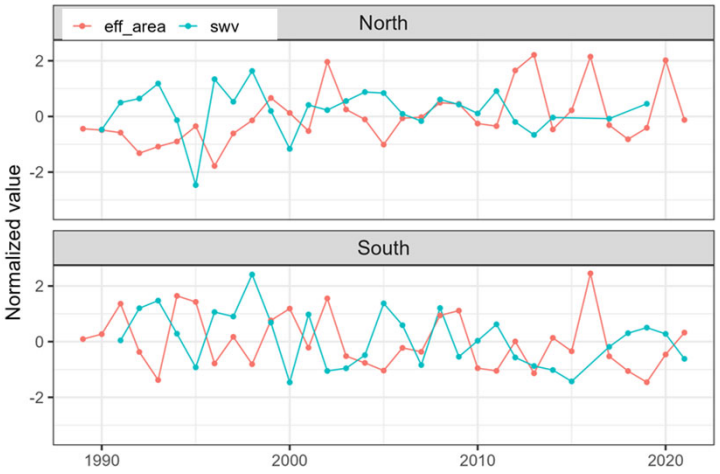
Shelf water volume not significantly correlated with BSB spring effective area occupied or center of gravity

Neither metric were pursued further as a proxy for mixing

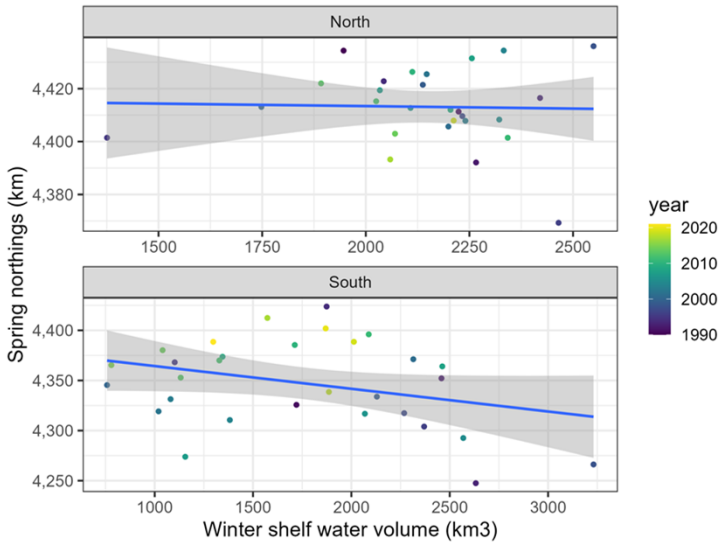
Future work: Define better response variable to measure the extent of winter mixing

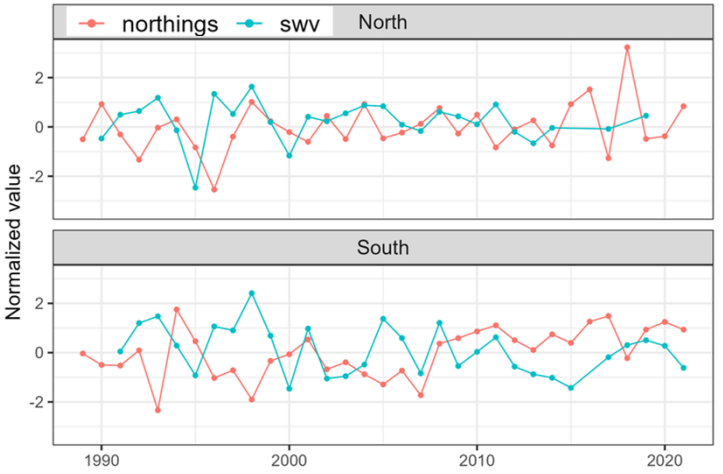
Effective Area Occupied



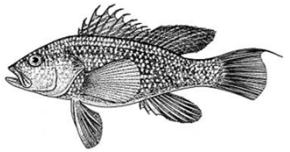


Center of Gravity



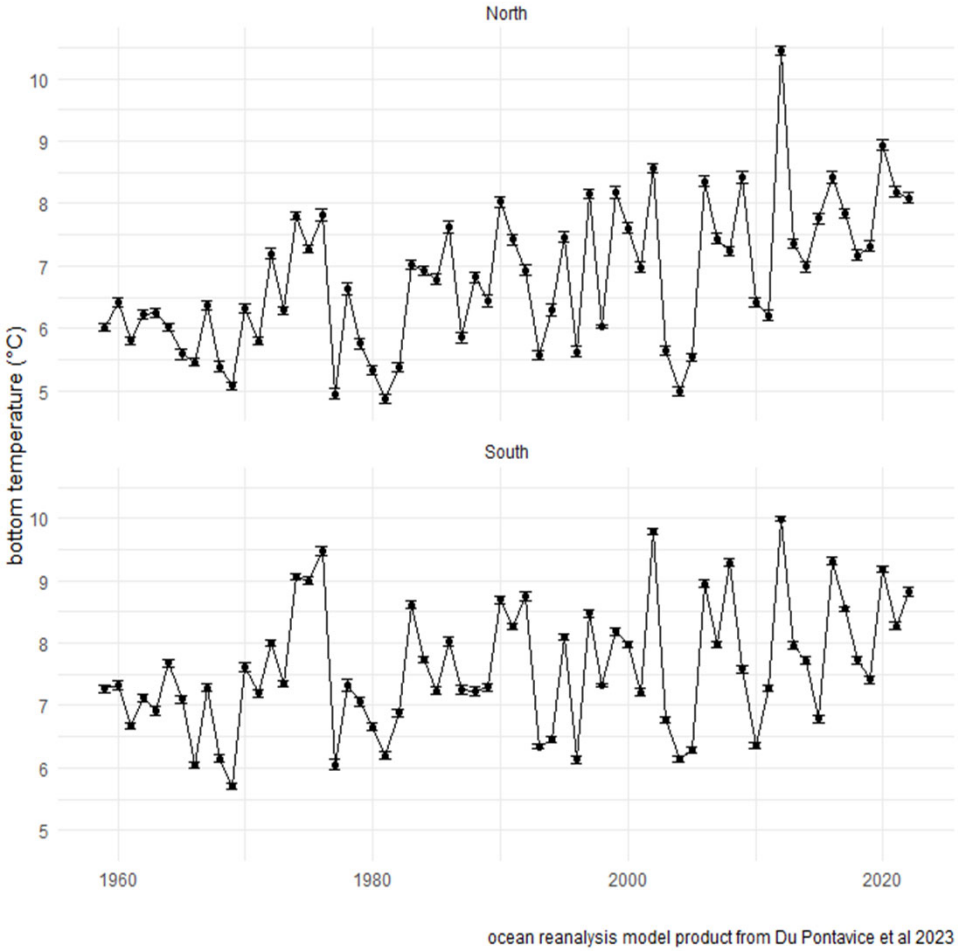


Winter bottom temperature



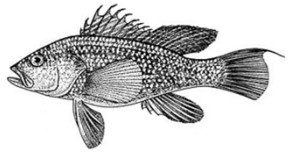
Hypothesis: Higher winter bottom water temperature across shelf → higher overwinter survival → higher recruitment

- BT from combined reanalysis data product
  du Pontavice et al. 2023
  - Mean winter (Feb-March) data aggregated north and south of Hudson Canyon
- Reanalysis product highly correlated with in situ measurements and provides a complete time-series for use in assessment model
- Reanalysis has better temporal resolution because limited in situ measurements from winter months



ocean reanalysis model product from Du Pontavice et al 2023

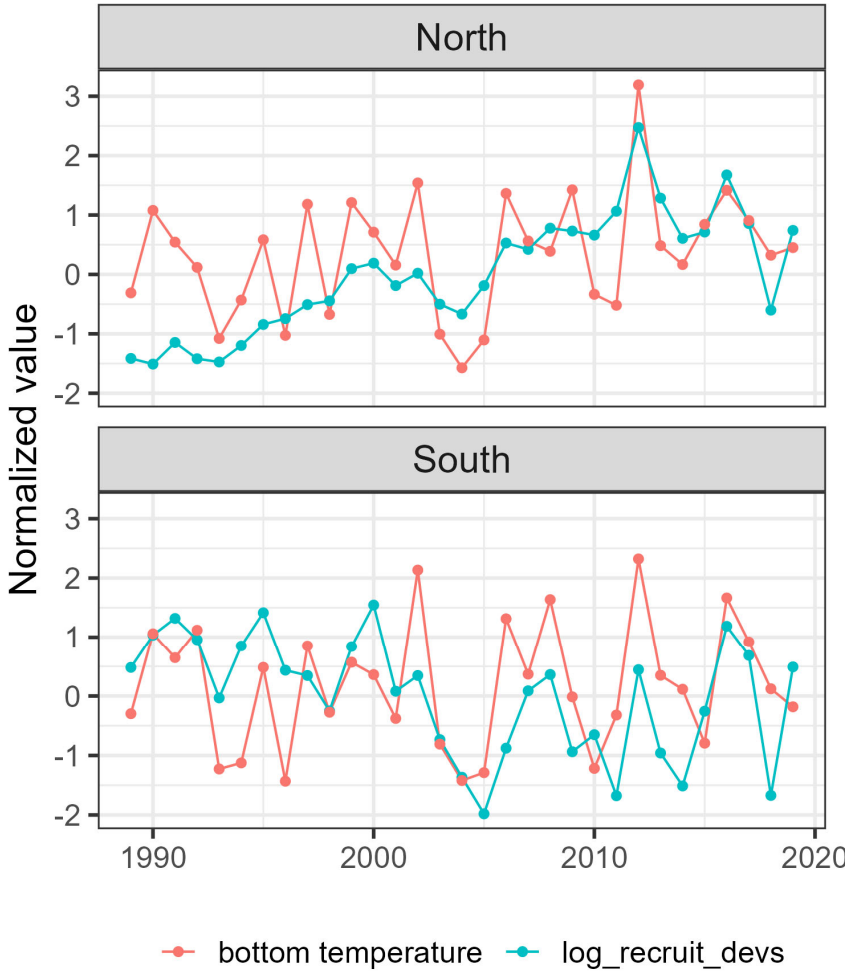
Winter bottom temperature



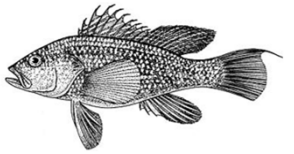
- Compared recruitment deviations from the 2021 region-specific ASAP models with the derived winter bottom temperature time series
- Significant Pearson correlations in both regions
- While array of caveats using recruitment estimates from past assessment models, provides initial support for hypothesis

Winter bottom temperature incorporated as a covariate on recruitment in recommended model

Future work: Consider different ways of representing age-1 recruits (e.g., age-1 from fall VAST model)

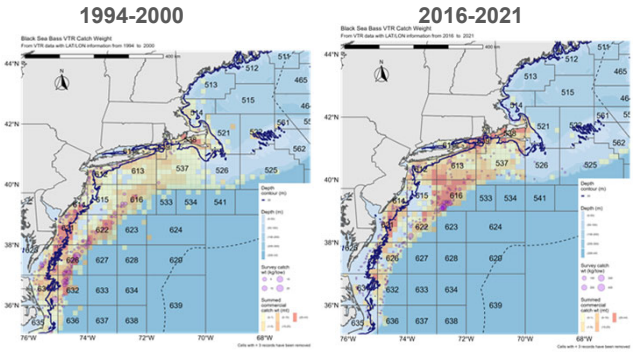


Stakeholder knowledge

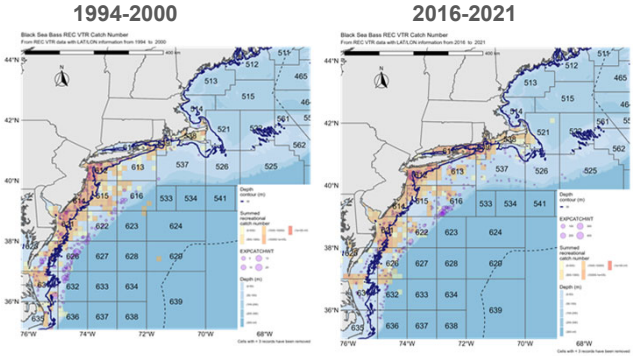


- Worked with industry groups to develop list of black sea bass stakeholders and contact information
- Developed a list of topics to cover with each stakeholder
- 16 conversations (most BSB fishing for over 20 years)
  - 10 commercial / 6 recreational
  - 7 Mid-Atlantic, 9 New England (VA to MA)
  - 4 gear types (trawl, pot gillnet, hook and line)
- Topics discussed included: fishing operations, fishery selectivity, biogeography (distribution, abundance), migration, habitat associations, environmental drivers, behavior, trophic ecology, and CPUE drivers
- Direct applications to the stock assessment
  - Sense check fishery data & discard mortality estimates
  - Inform commercial CPUE index development
  - Interpret trends in fishery data and survey indices
  - Interpret model outputs and results

Commercial



Recreational

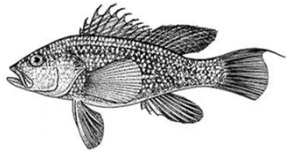


TORs 4-6: Model, reference points and projections

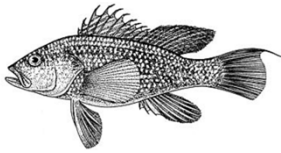
Accomplishments

- Research track so focus is on methodology
- Multi-region state-space model (multi-WHAM)
  - Accounts for spatial dynamics and differences in productivity
  - Mixing between regions
  - Bottom temp covariate on recruitment
  - Projections consider recent recruitment dynamics
- Supporting stock synthesis model
  - Sense checked WHAM outputs
  - Provided movement estimates

The Woods Hole Assessment Model

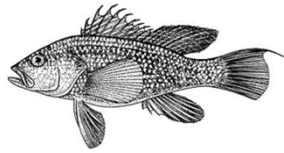


BSB Multi-WHAM formulation



- Two regions (Boundary approximates location of Hudson Canyon) with movement
- Time series: 1989 - 2021; Ages 1-8+
- Fishery catch
  - Commercial and recreational fleets in each region
  - Fleet Selectivity: Time and age varying processes in the north only
- Indices
  - Spring VAST and Recreational CPA (with adjusted CVs)
  - Selectivity: Age and/or year varying processes in the north only
- Environmental processes: bottom temperature covariate on recruitment in both regions
- Maturity: Age and time-varying
- Movement rates (priors from Stock Synthesis)
- Natural mortality = 0.4 (constant across ages, years, regions)

Data component configuration

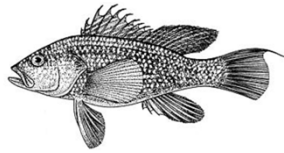


Data component	Mean Selectivity model	Random effects configuration	Age Composition Likelihood
North Commercial	age-specific (flat-topped at ages > 3)	2D-AR1 (age and year)	Dirichlet-Multinomial
North Recreational	age-specific (flat-topped at ages > 6)	2D-AR1 (age and year)	Logistic-normal (0s as missing)
South Commercial	logistic	None	Logistic-normal (AR1, 0s as missing)
South Recreational	logistic	None	Logistic-normal (AR1, 0s as missing)
North Recreational CPA	age-specific (flat-topped at ages > 1)	AR1 (year)	Logistic-normal (0s as missing)
North VAST	age-specific (flat-topped at ages > 4)	2D-AR1 (age and year)	Dirichlet-Multinomial
South Recreational CPA	age-specific (flat-topped at ages > 2)	None	Logistic-normal (AR1, 0s as missing)
South VAST	age-specific (flat-topped at ages > 1)	None	Logistic-normal (AR1, 0s as missing)

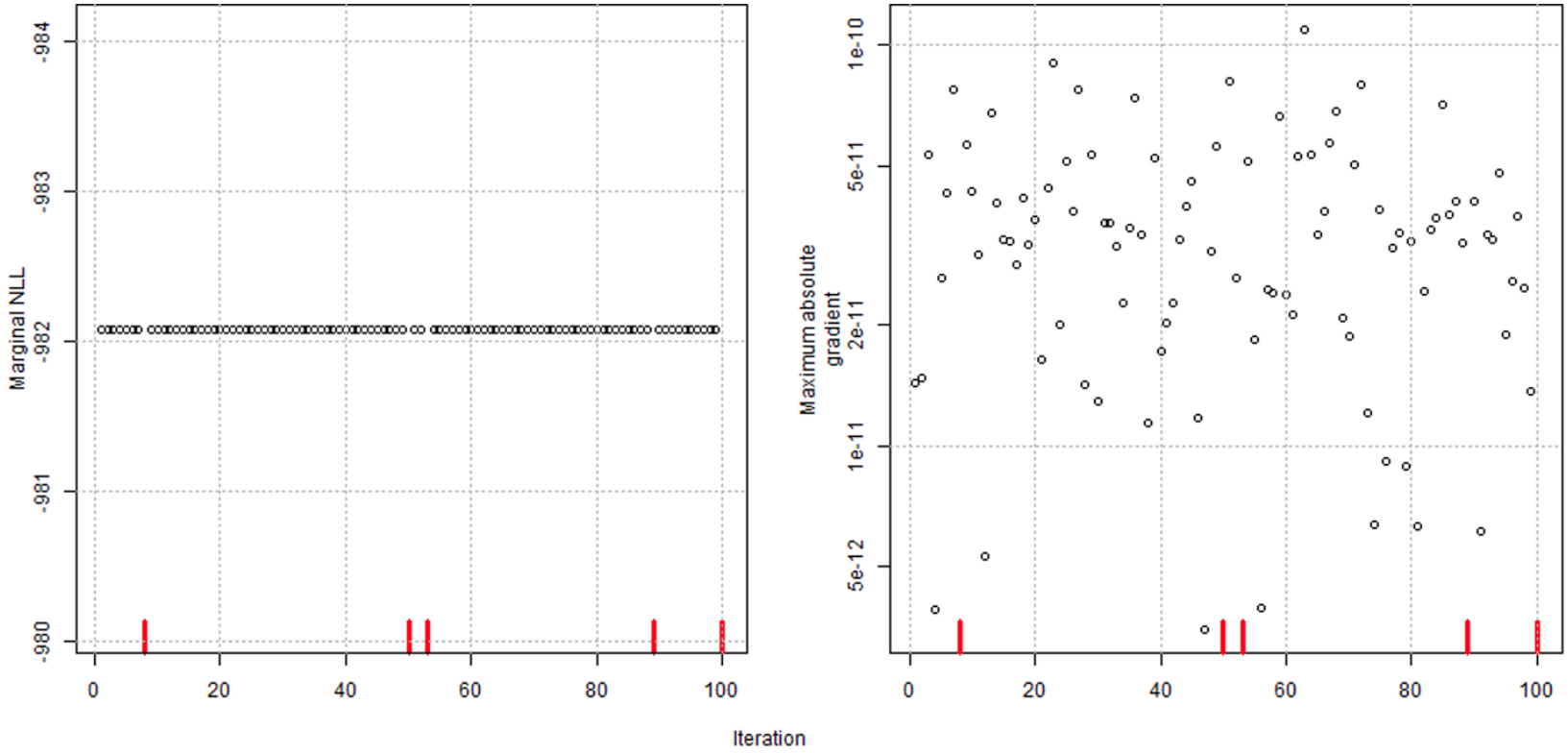
Rec CPA CVs were deemed implausibly small (CVs: 0.02-0.06)

→Estimated a scalar of the SD of the log-aggregate Rec CPA indices

Jitter analysis

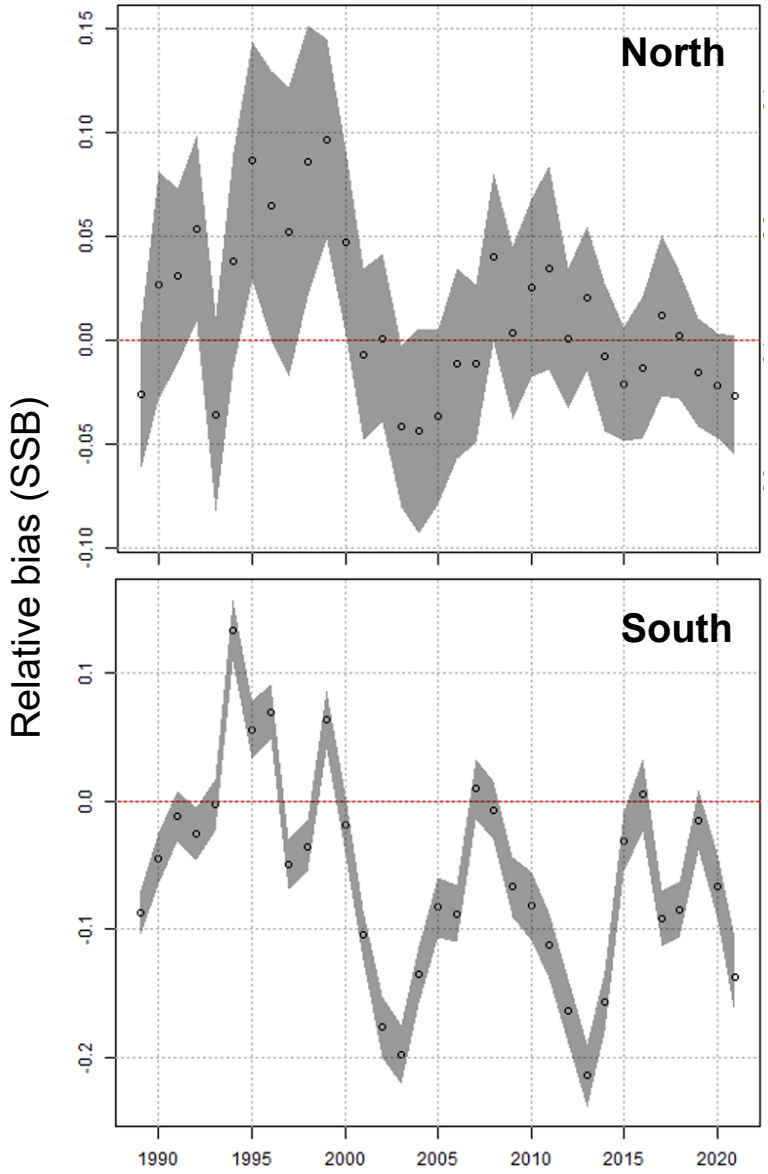


- All converged runs resulted in the same marginal negative log likelihood
- Absolute value of the gradients at the optimized values were all less than 10^{-9}



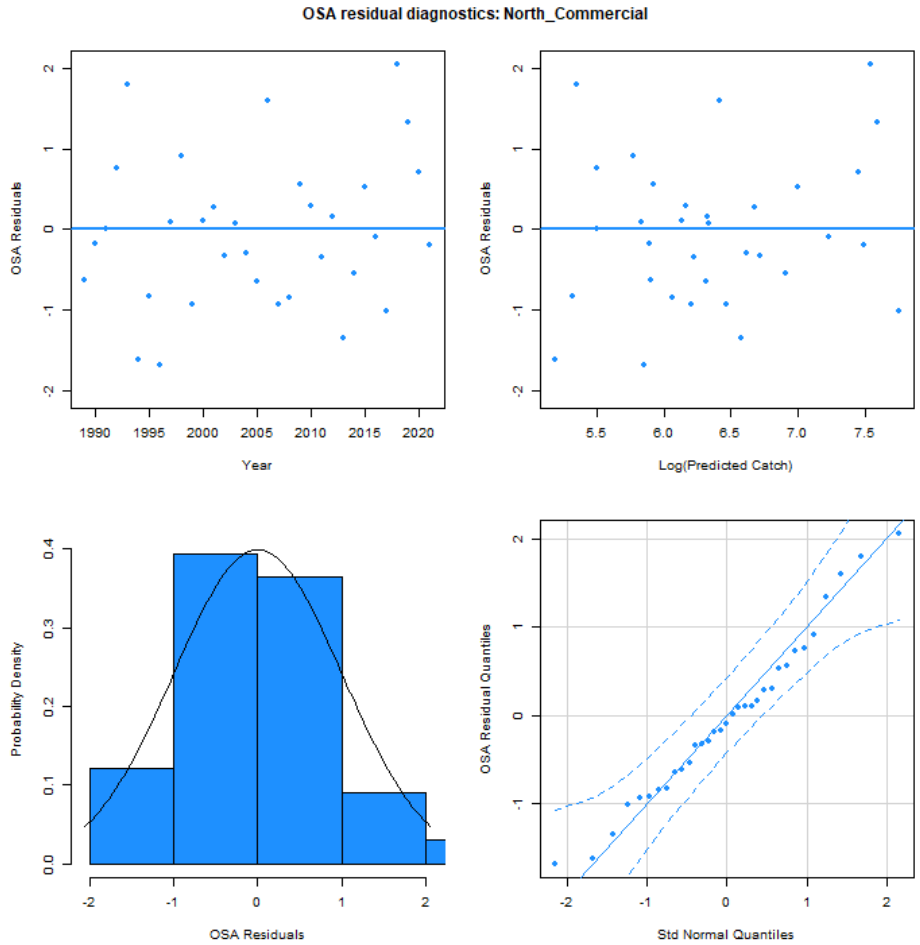
Self test

- Simulated 100 data sets conditional on all estimated random effects & fit the same model configuration
- Model failed to converge for 7 data sets with maximum absolute gradients < 10-6 for only 9 and 10-4 for 52 of the 93 successfully fitted models
- Poor convergence likely due to the estimation of the scalar for SD of northern RecCPA
- Across all fits (including those with poor convergence), SSB estimates appeared to be reliable



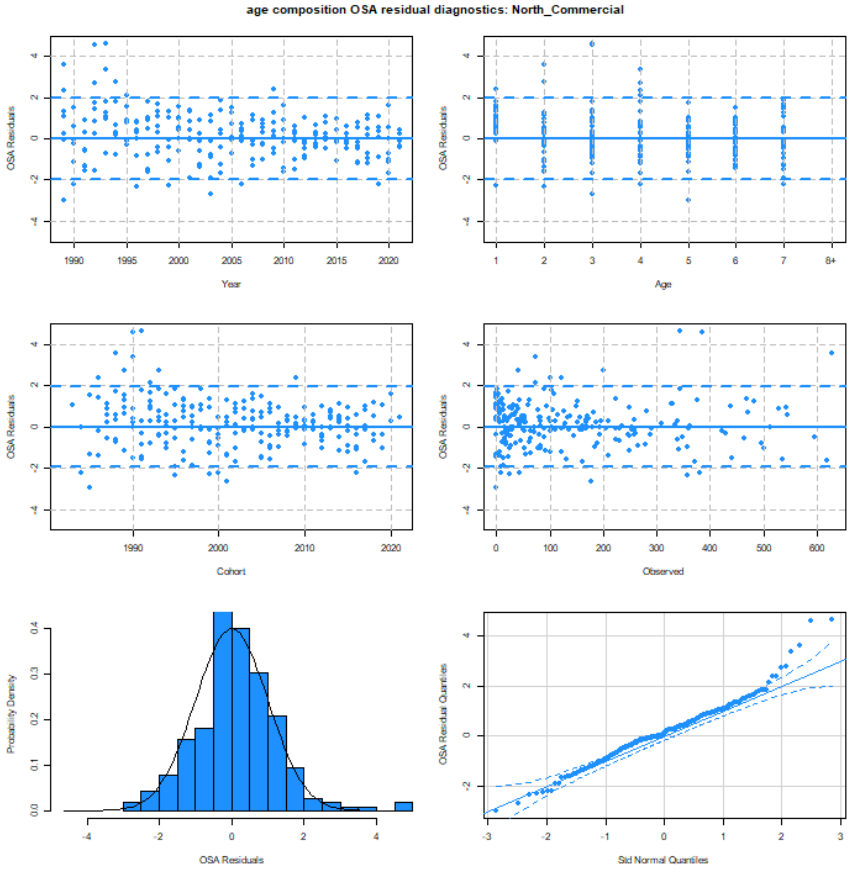
OSA residuals: North commercial fleet

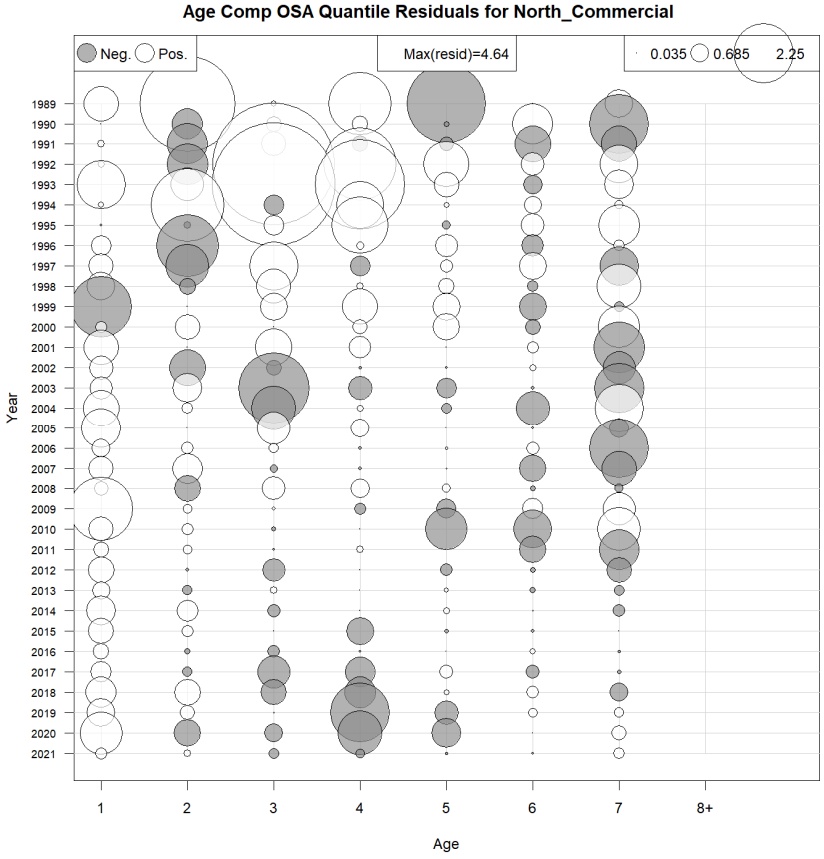
Aggregate catch: no evidence of misspecification



OSA residuals: North commercial fleet

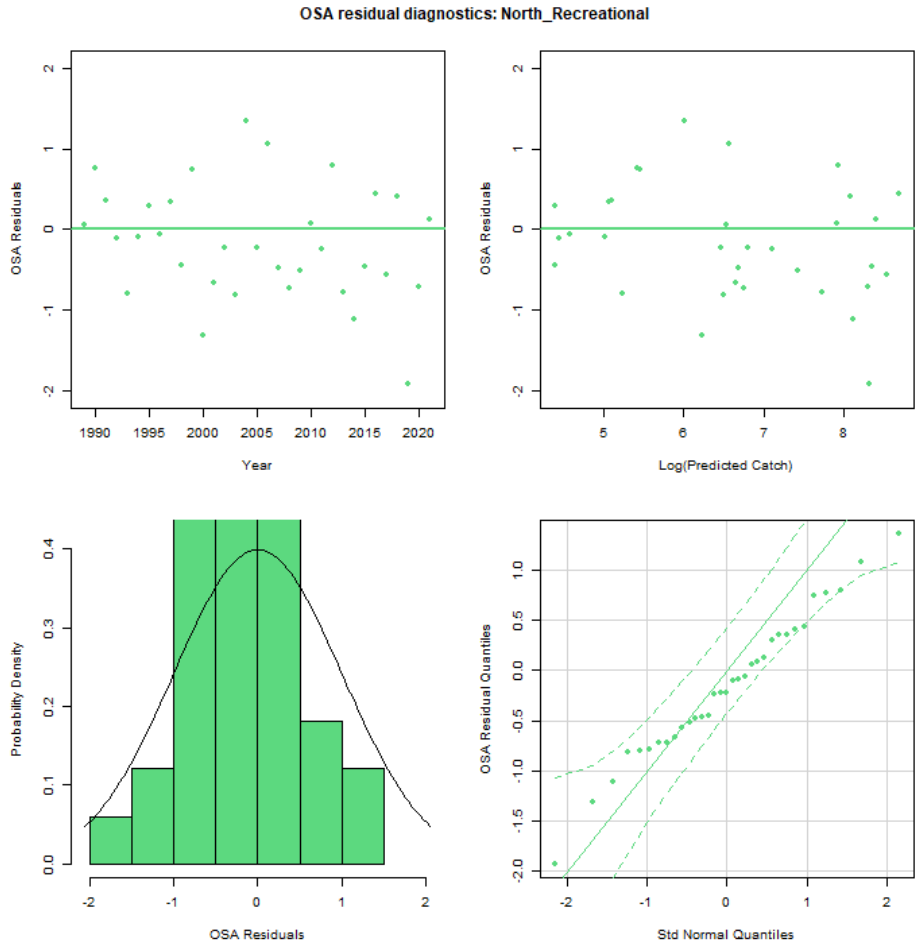
Age compositions: Some indication of residual trends early in the time series and for age-1





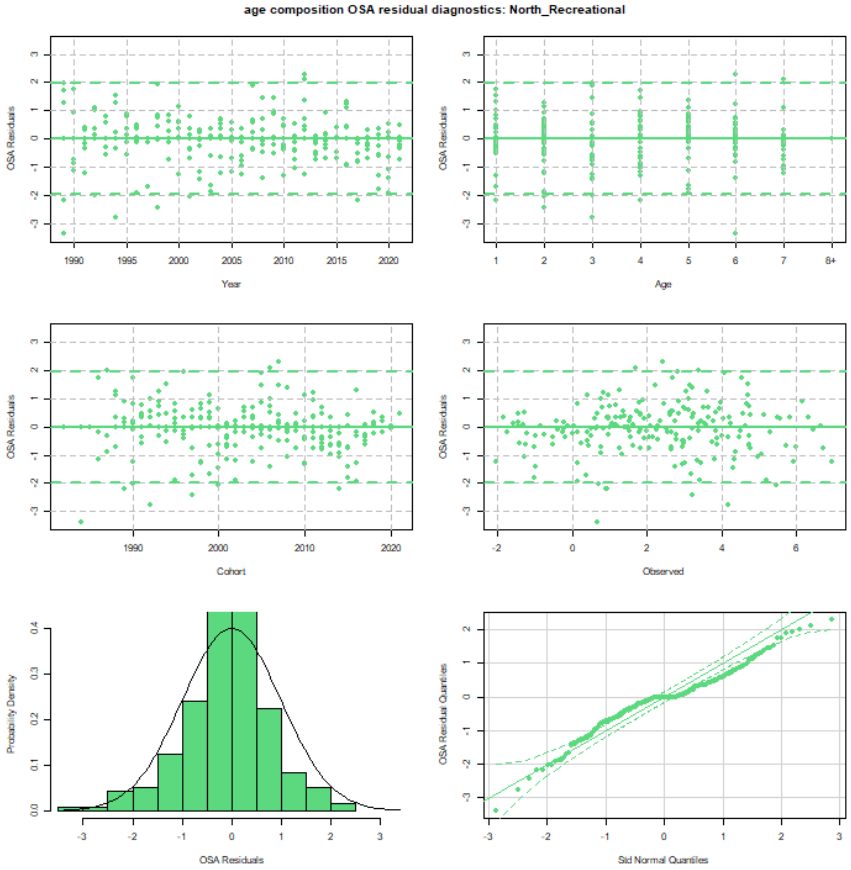
OSA residuals: North recreational fleet

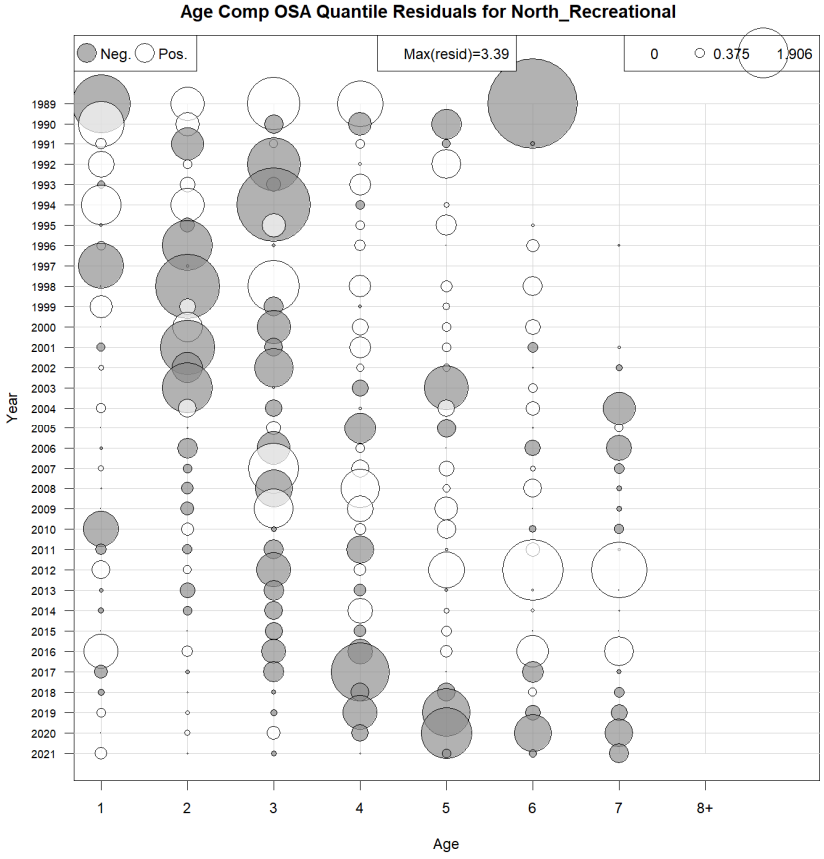
Aggregate catch: no evidence of misspecification



OSA residuals: North recreational fleet

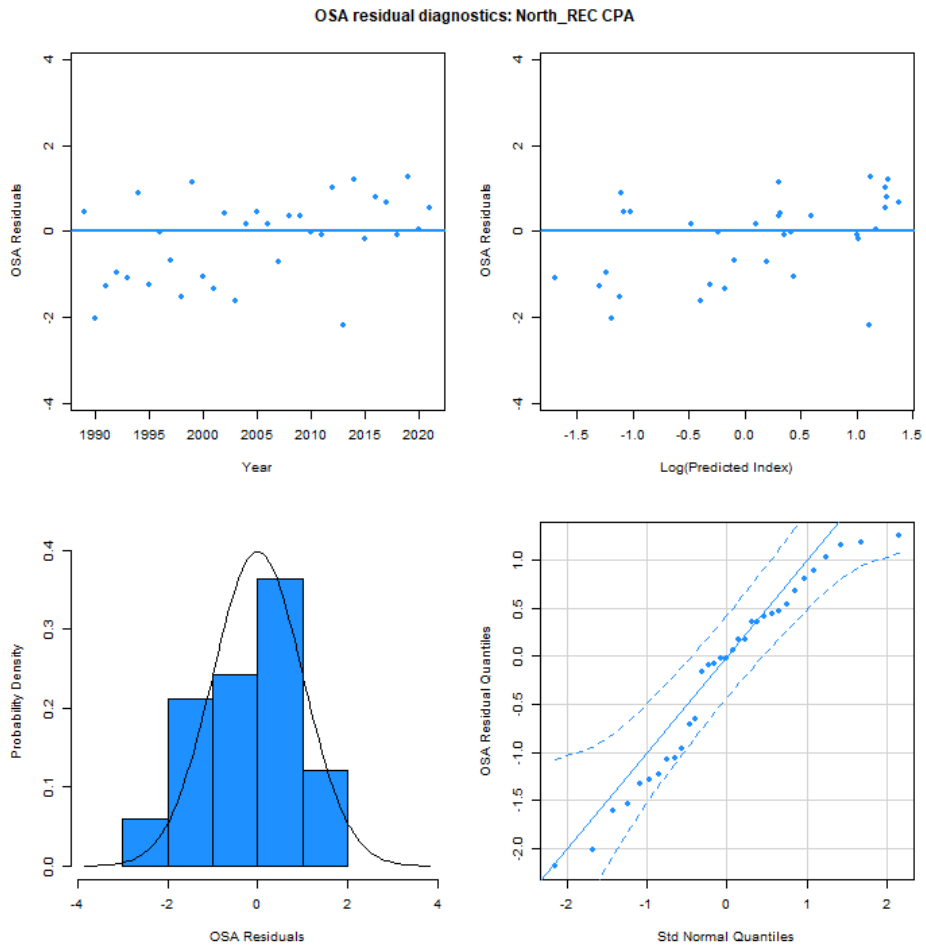
Age compositions: Some tendency of underdispersion





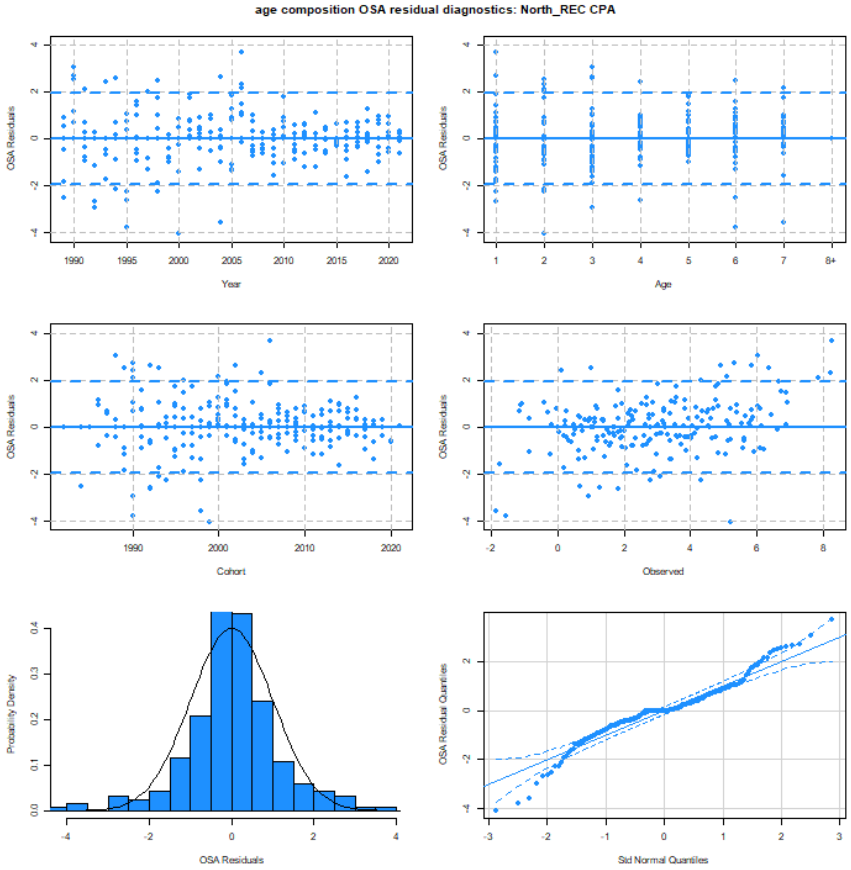
OSA residuals: North Rec CPA index

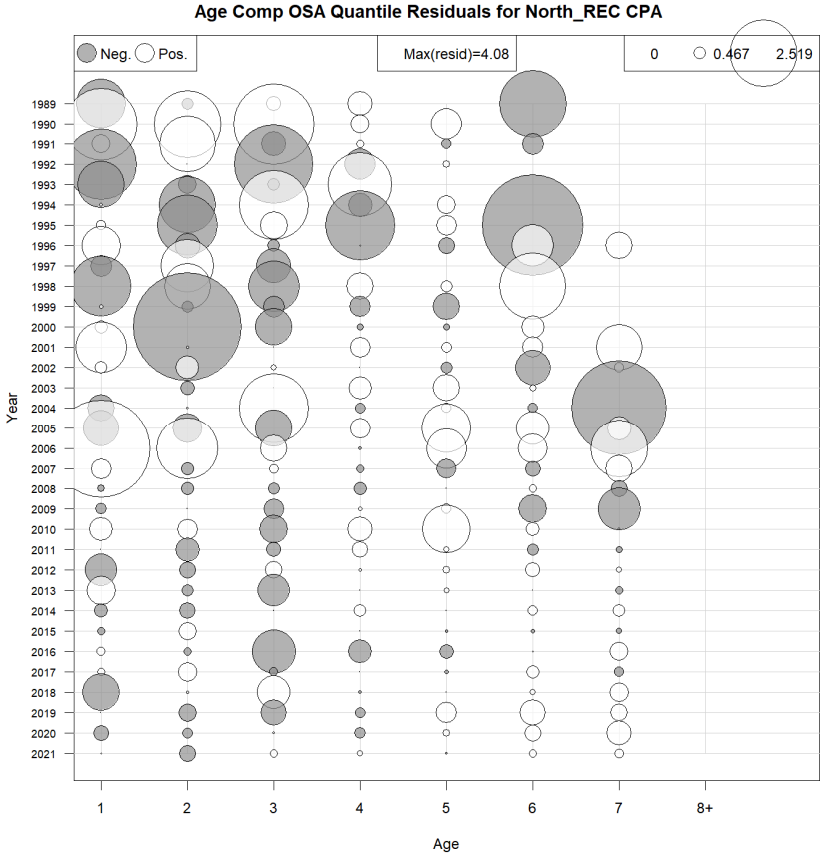
Aggregate index: no signs of misspecification



OSA residuals: North Rec CPA index

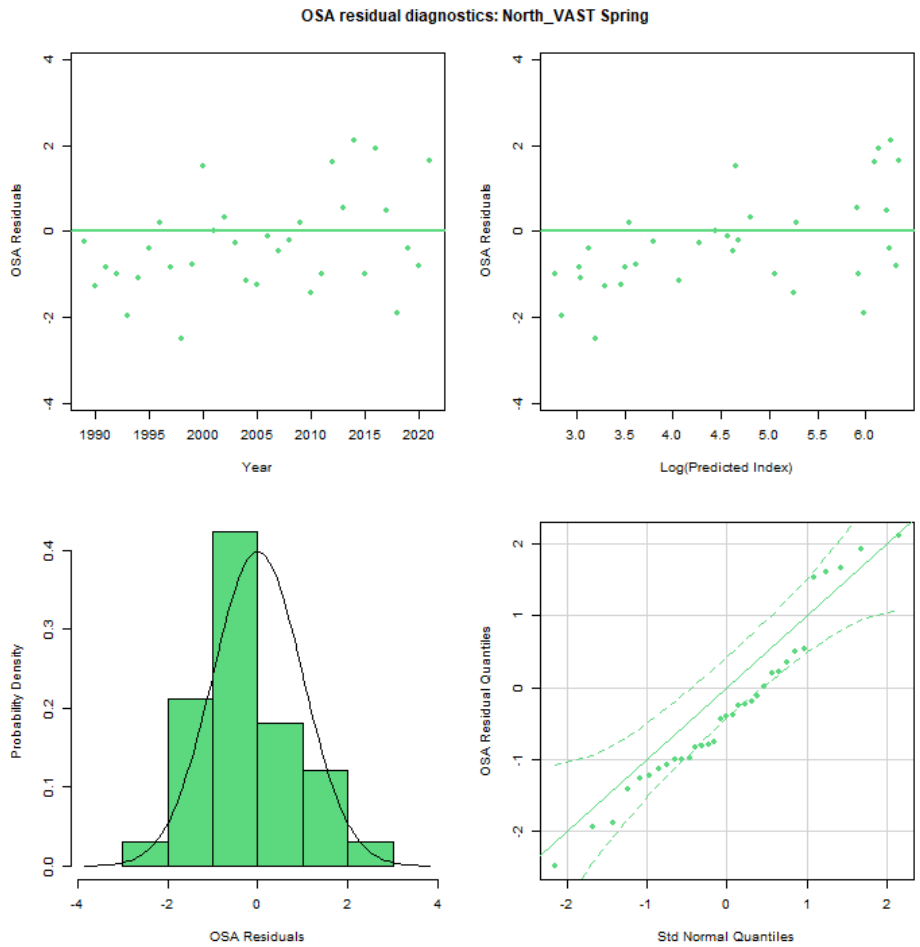
Age compositions: No signs of misspecification





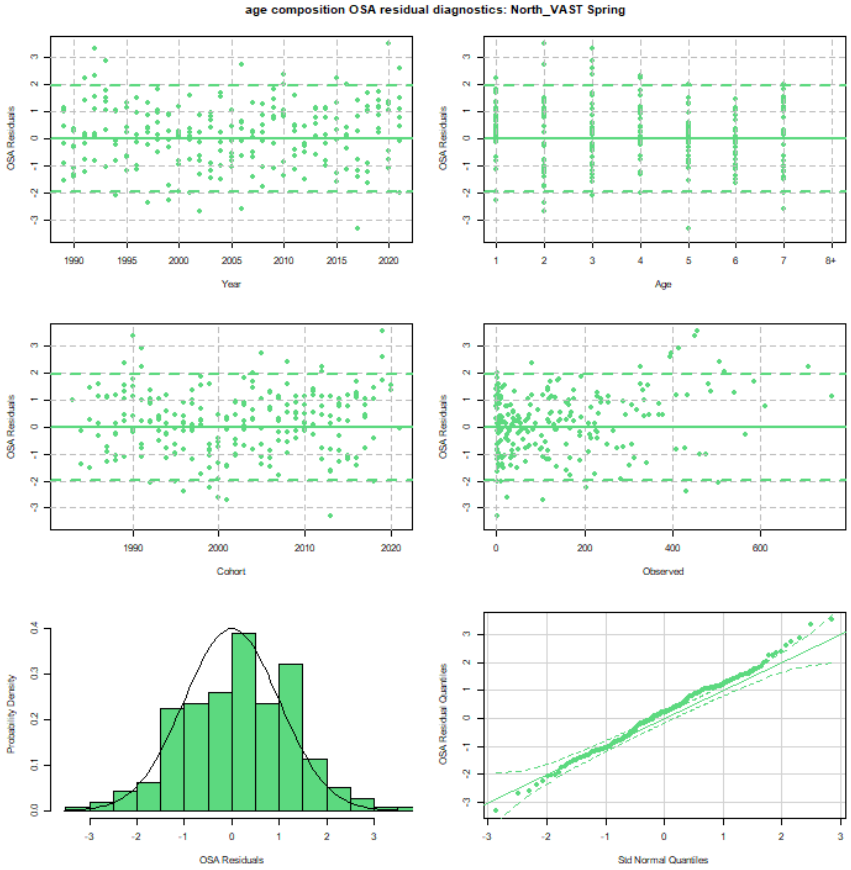
OSA residuals: North spring VAST index

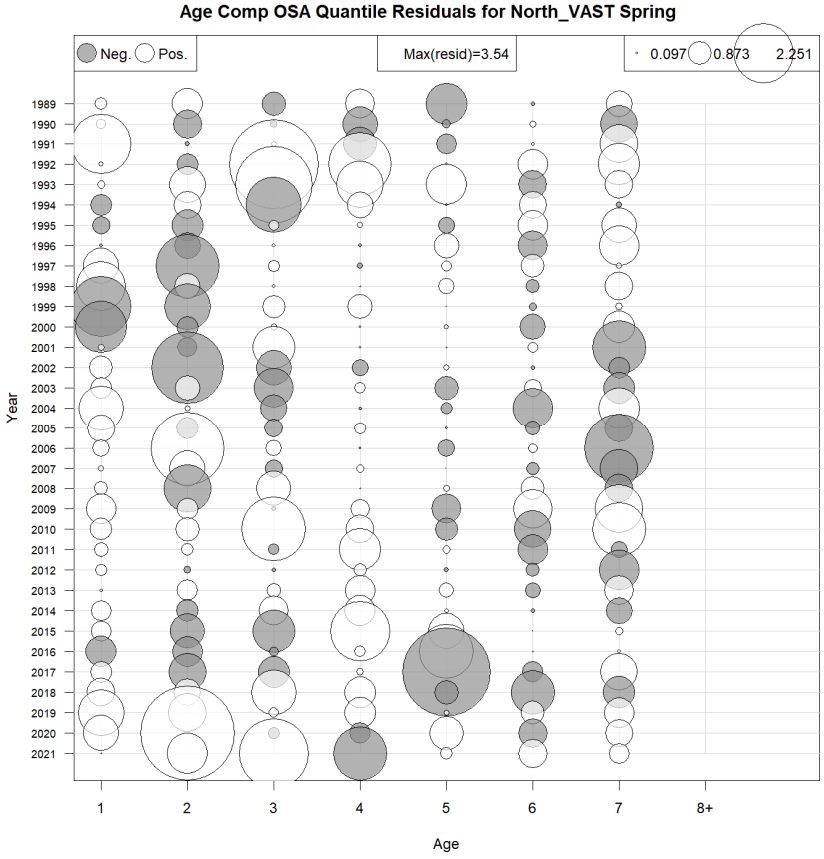
Aggregate index: some tendency toward negative residuals, primarily before 2000



OSA residuals: North spring VAST index

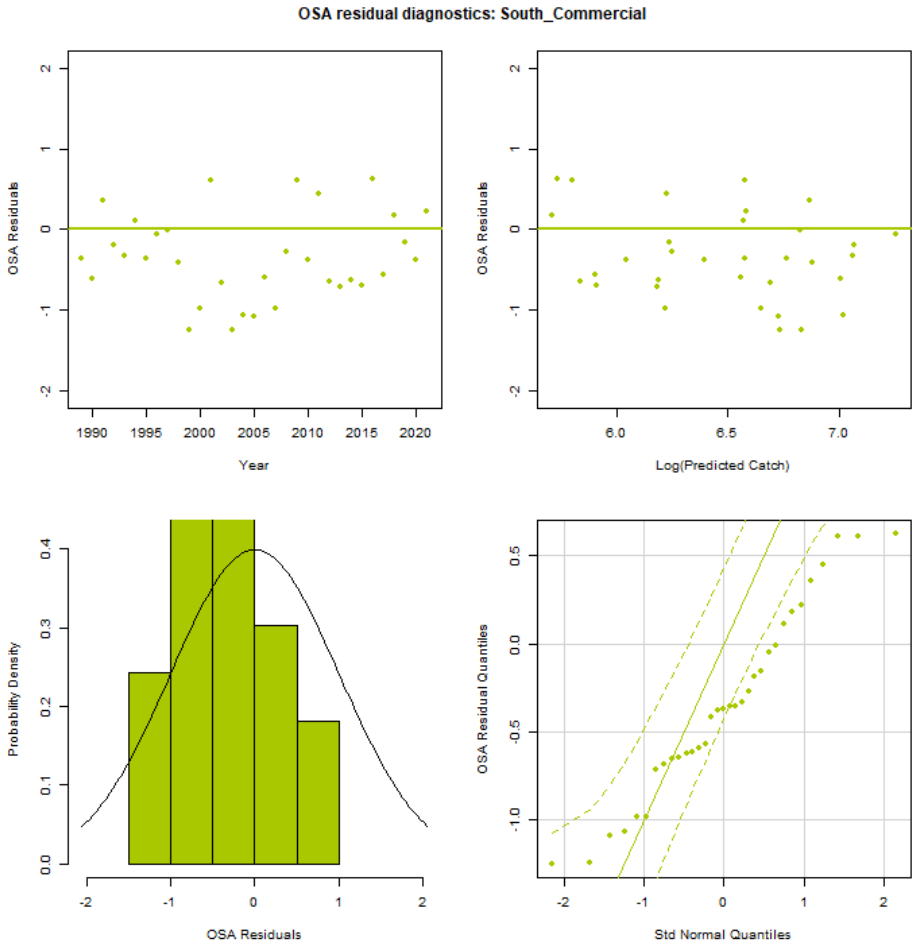
Age compositions: Some indication of positive residuals, particularly at age-1





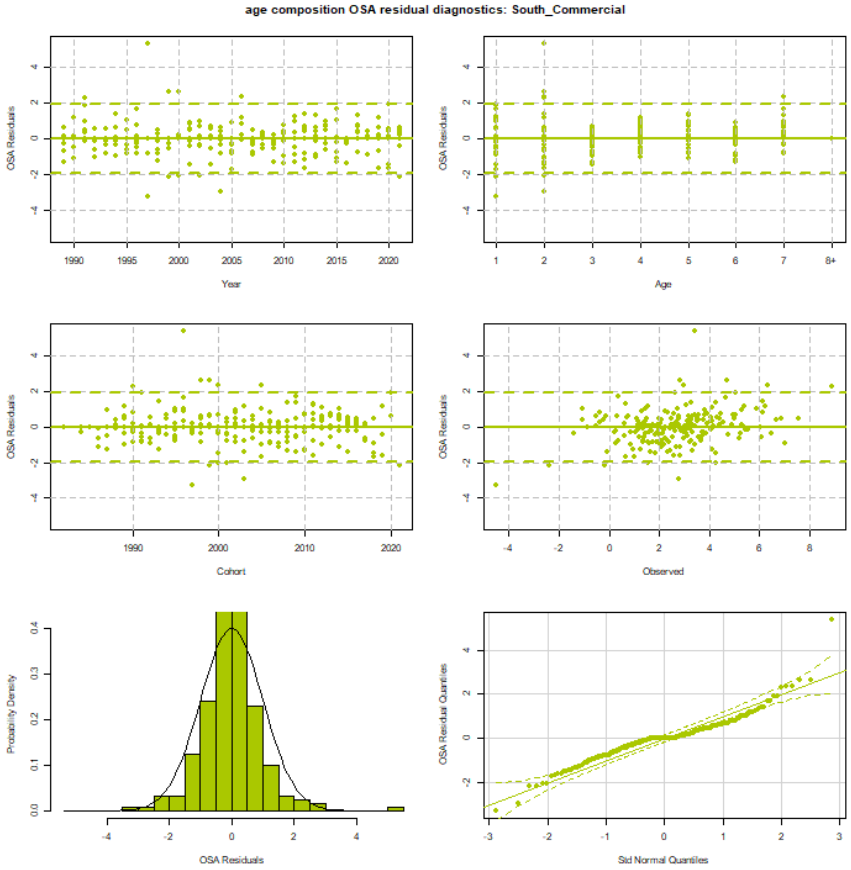
OSA residuals: South commercial fleet

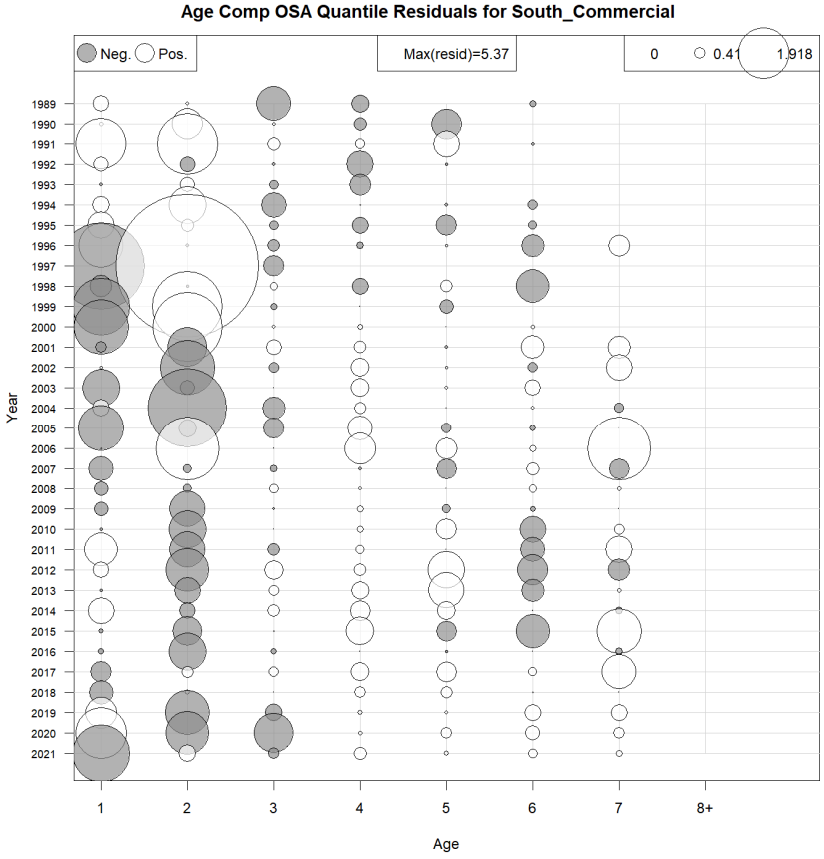
Aggregate catch: tendency for negative residuals



OSA residuals: South commercial fleet

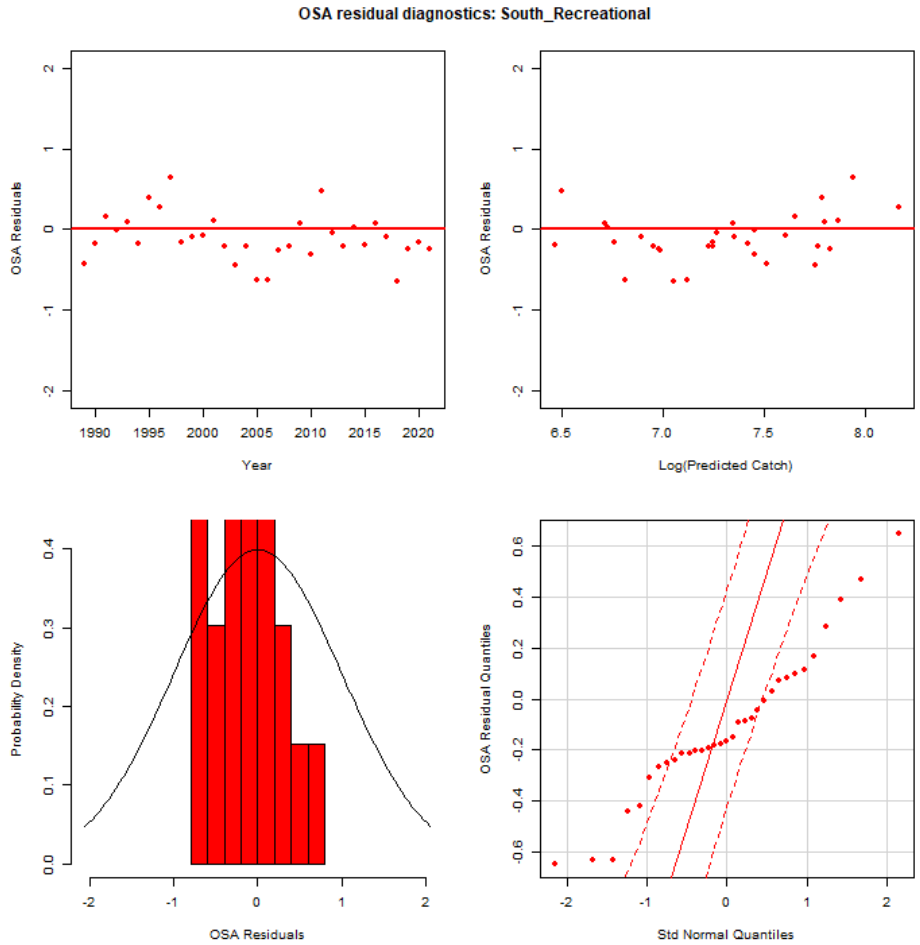
Age compositions: No evidence of misspecification





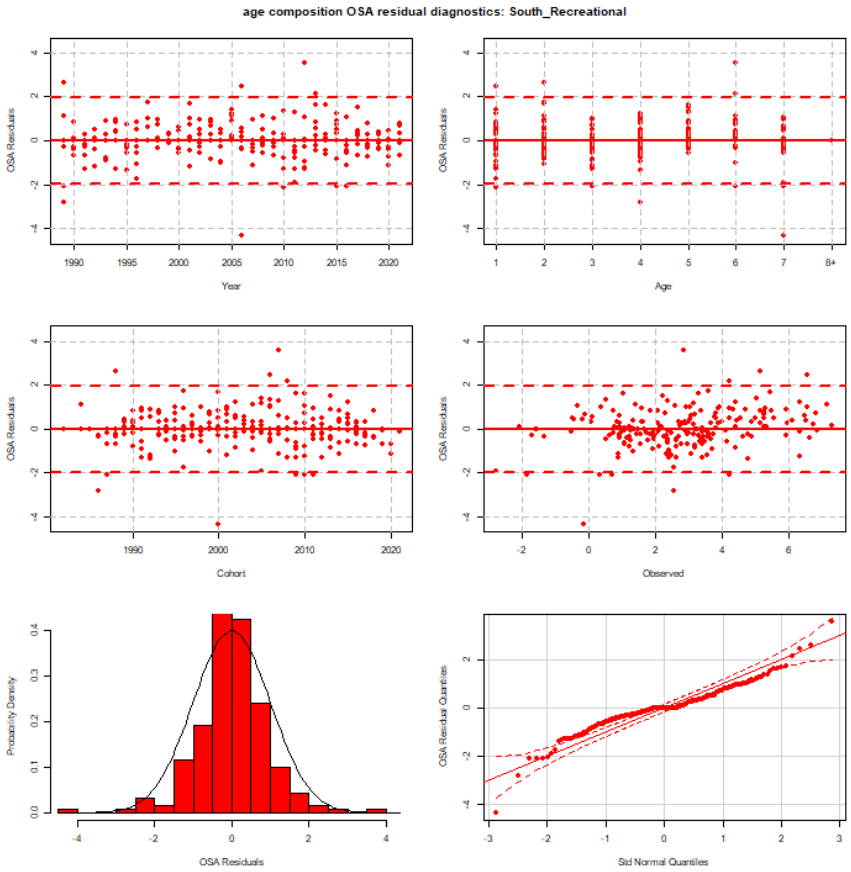
OSA residuals: South recreational fleet

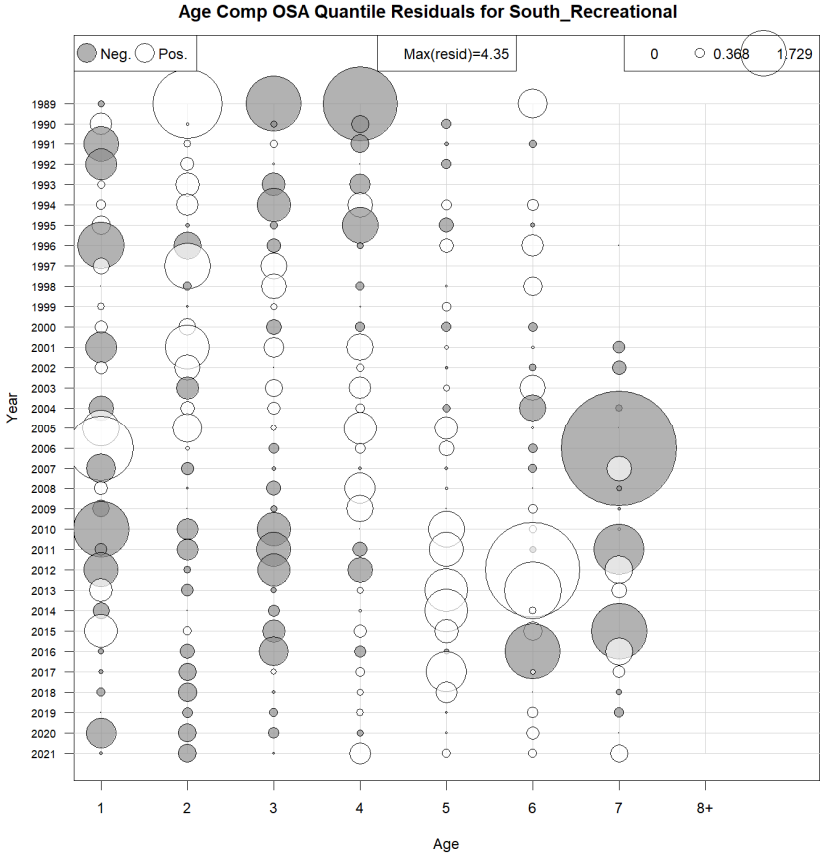
Aggregate catch: Underdispersion but no trends



OSA residuals: South recreational fleet

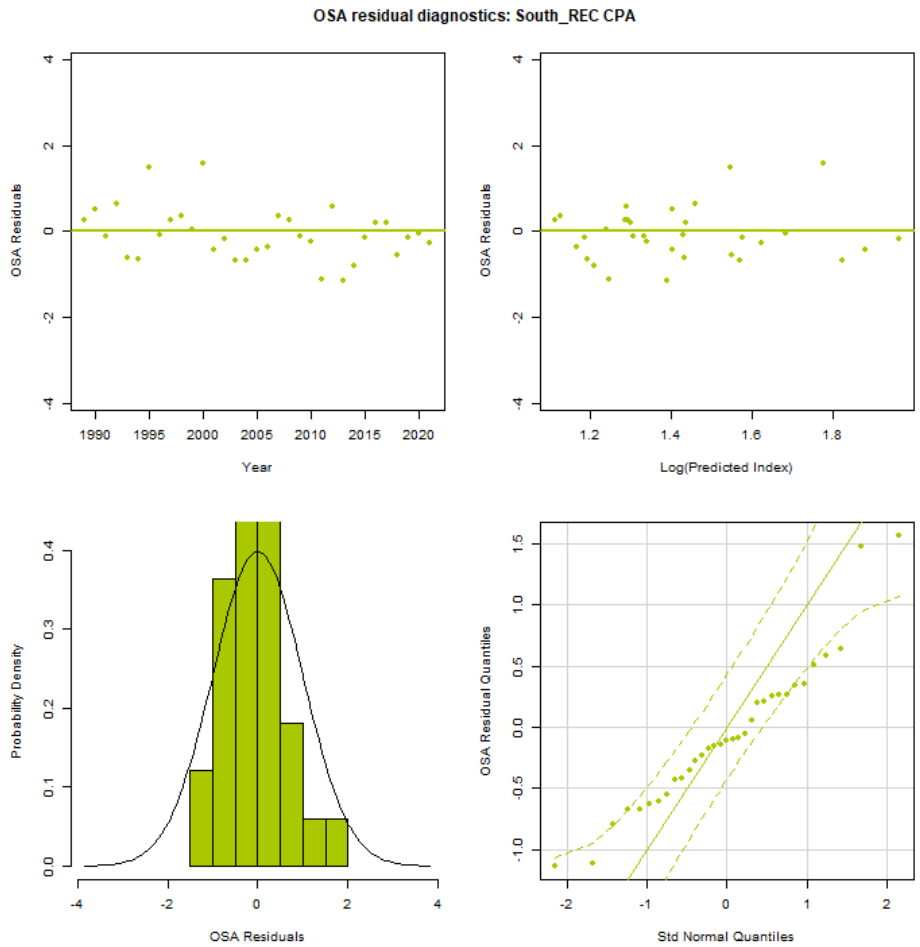
Age compositions: Some tendency of underdispersion





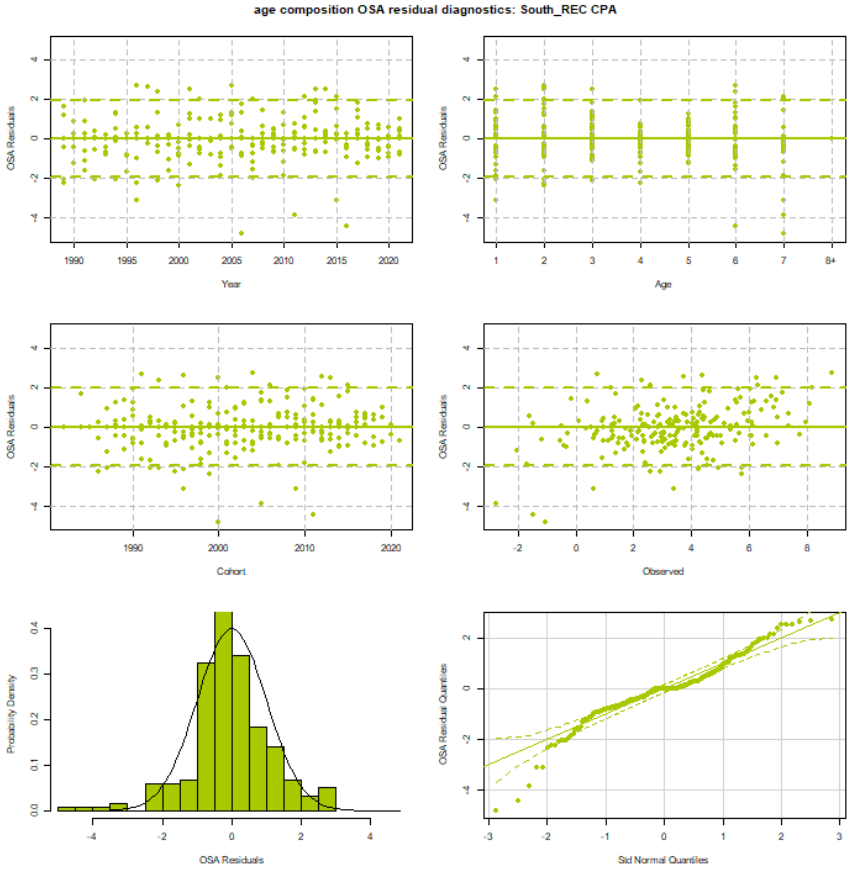
OSA residuals: South Rec CPA index

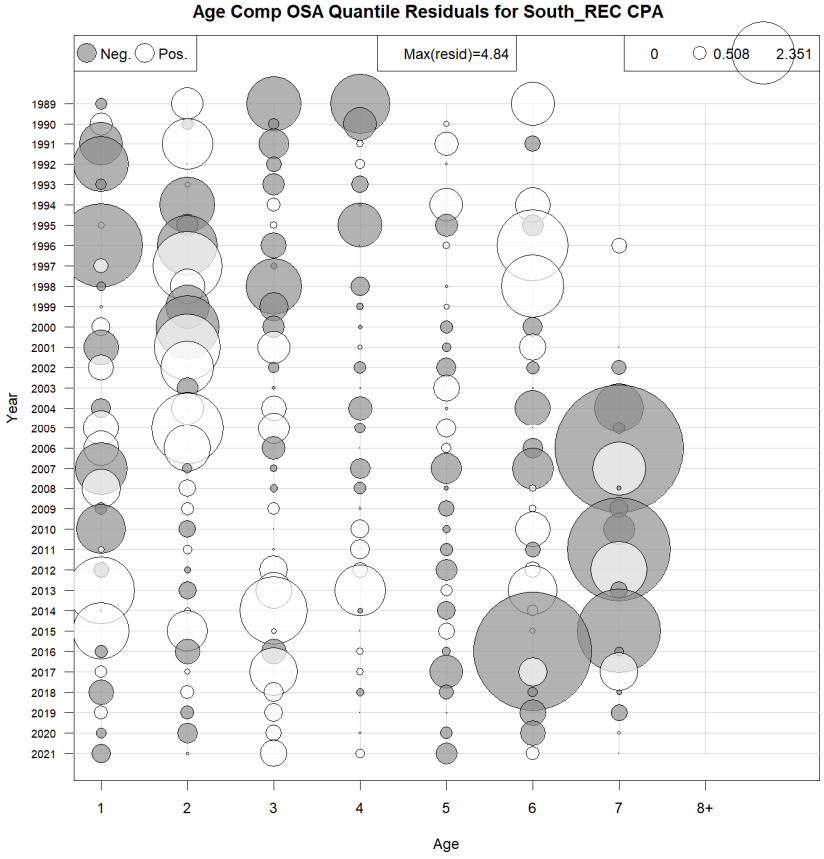
Aggregate index: Slightly under-dispersed



OSA residuals: South Rec CPA index

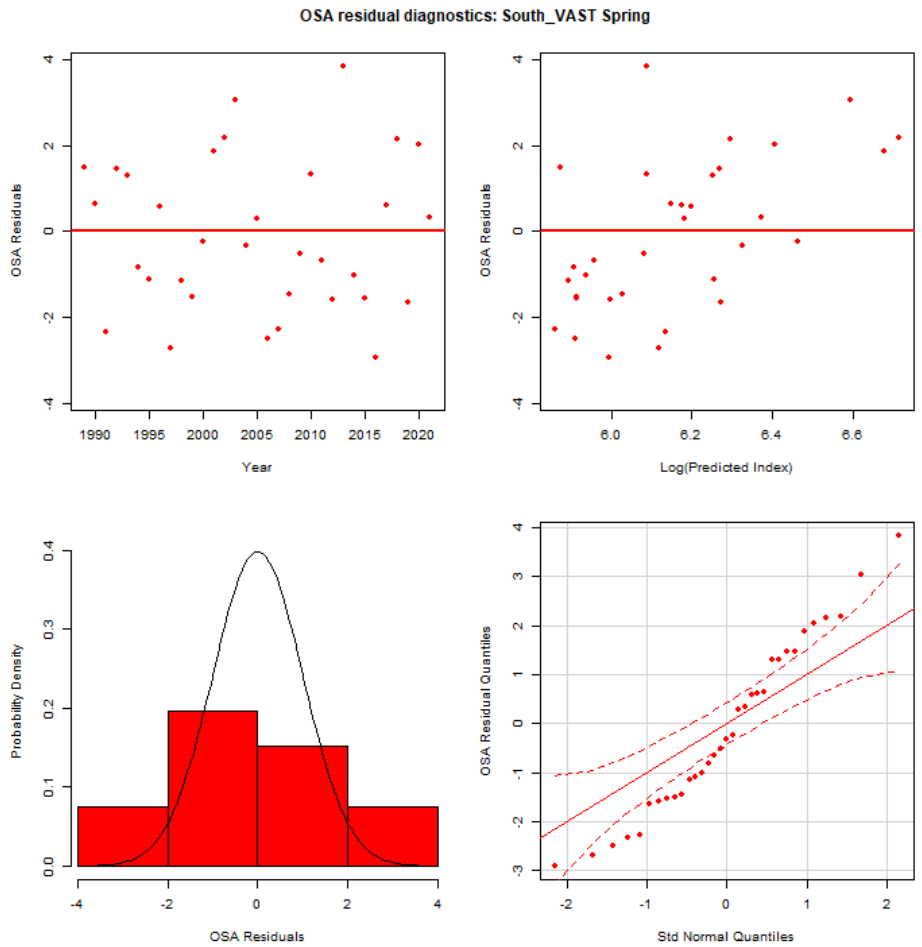
Age compositions: Some large negative residuals at older ages, but otherwise no apparent trends





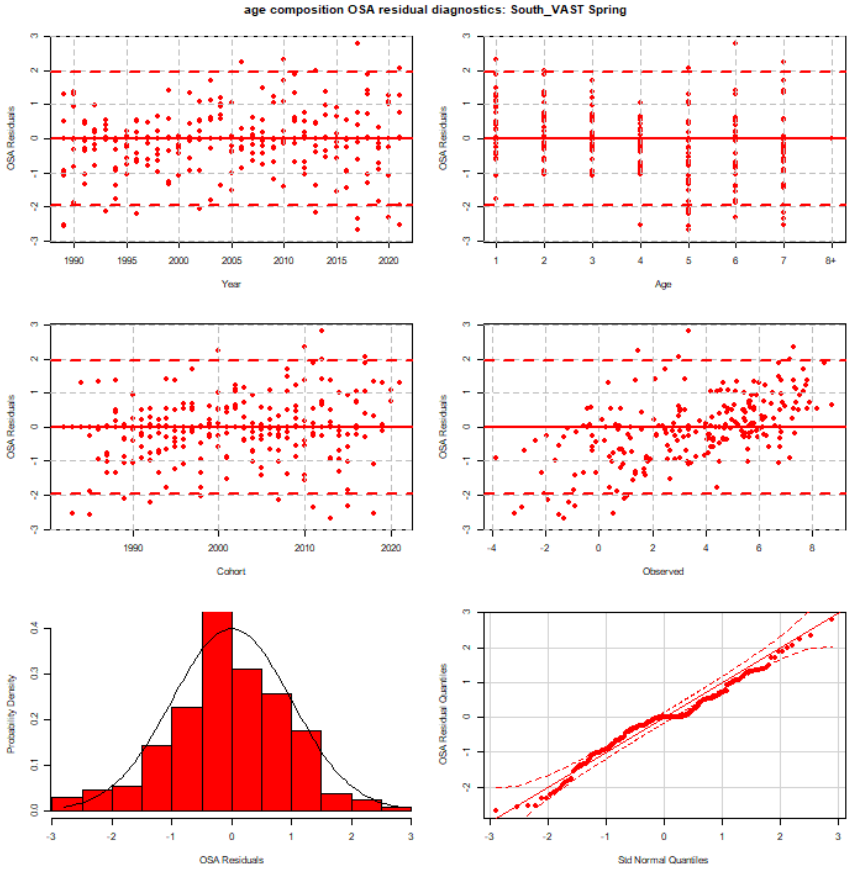
OSA residuals: South spring VAST index

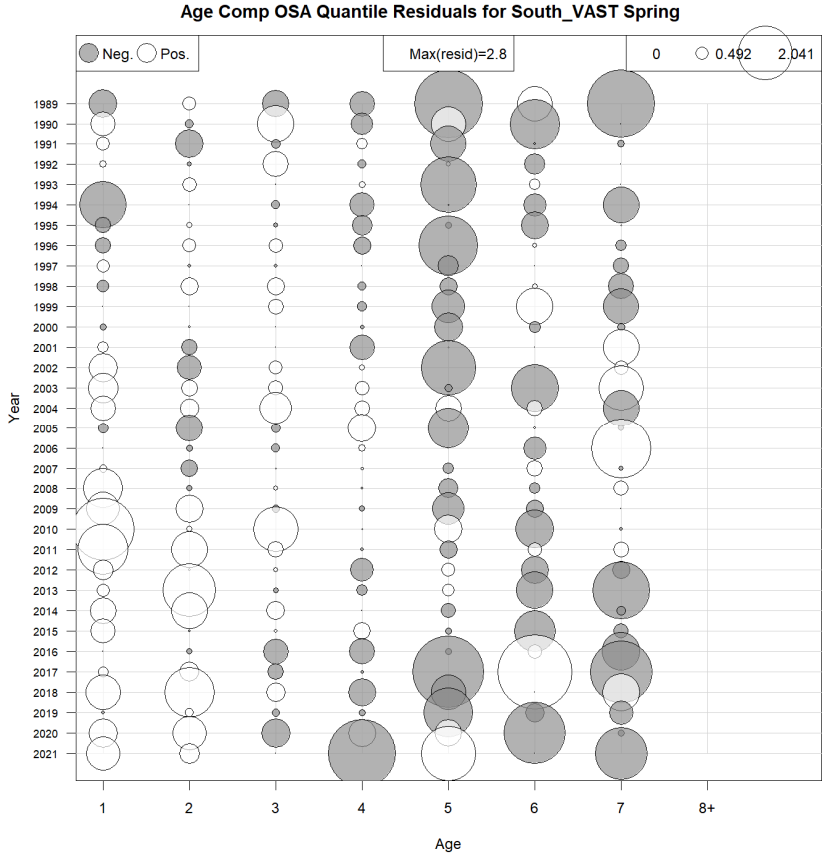
Aggregate index: some tendency of overdispersion



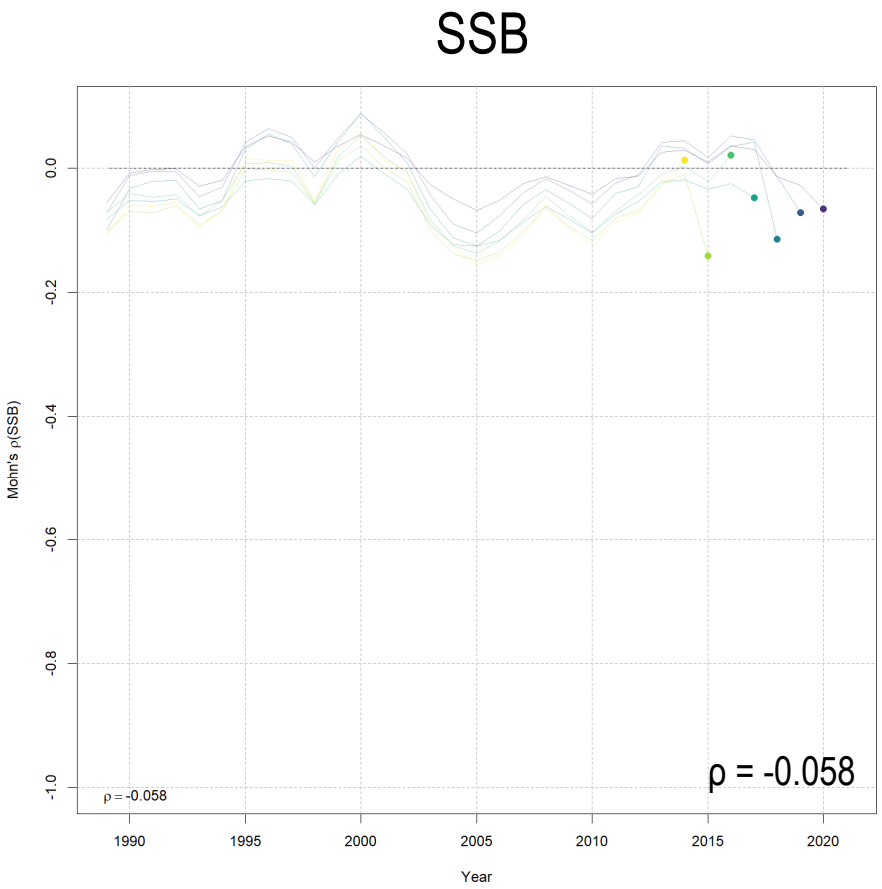
OSA residuals: South spring VAST index

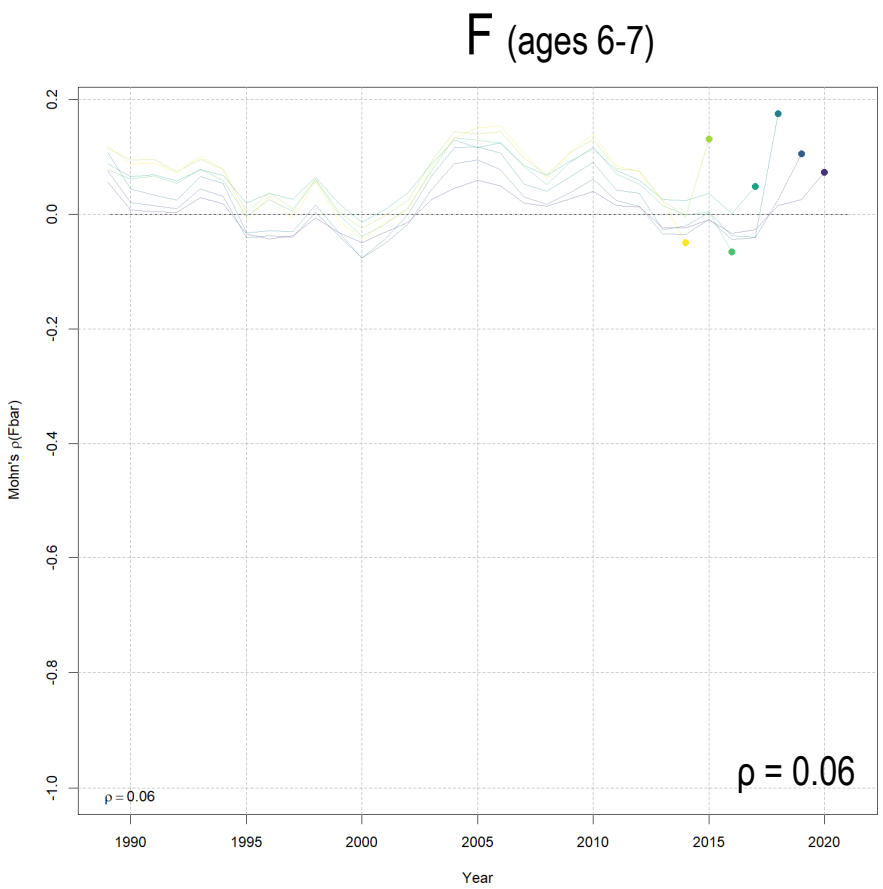
Age compositions: Some trend with observed proportion and age



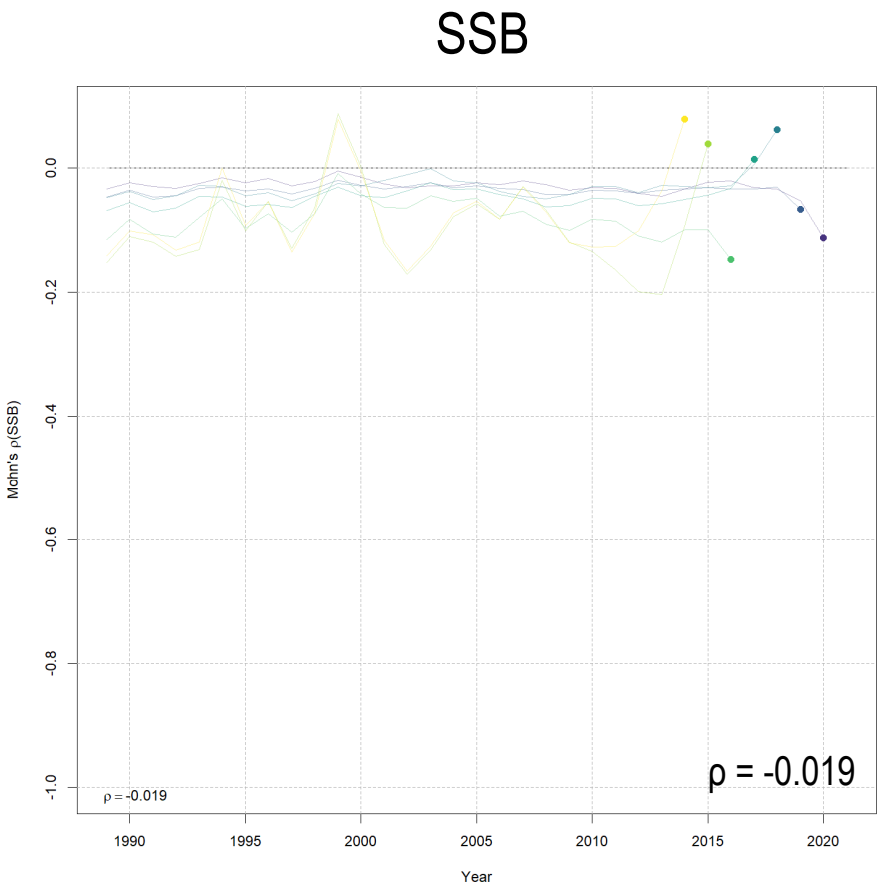


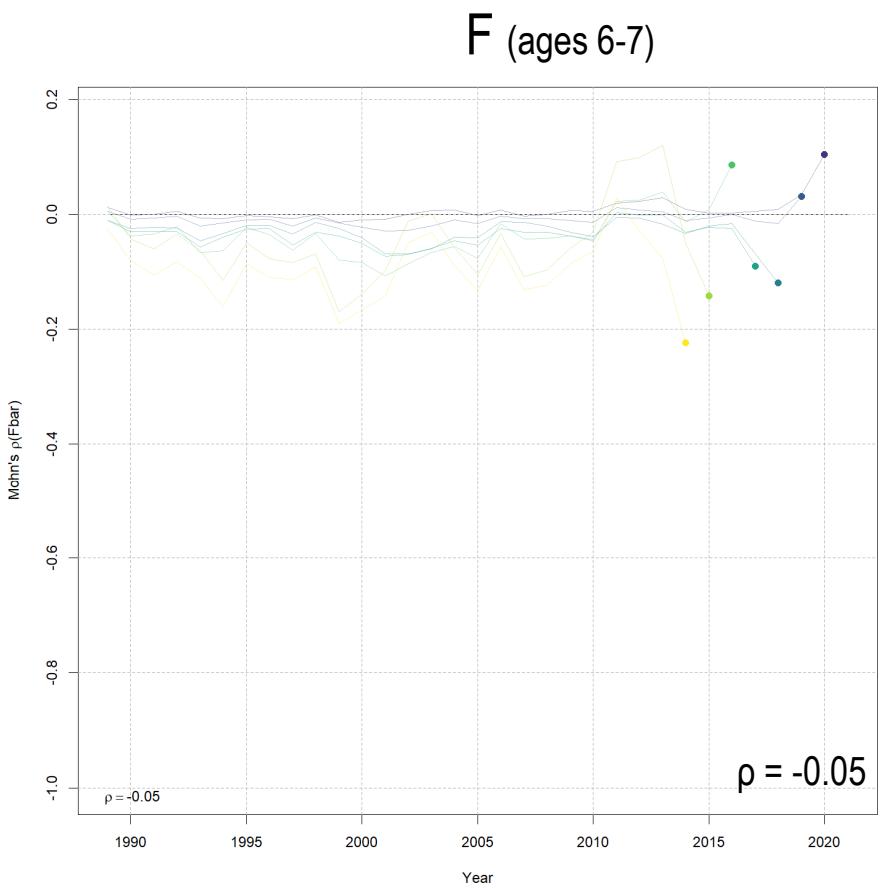
Retrospective analysis: North



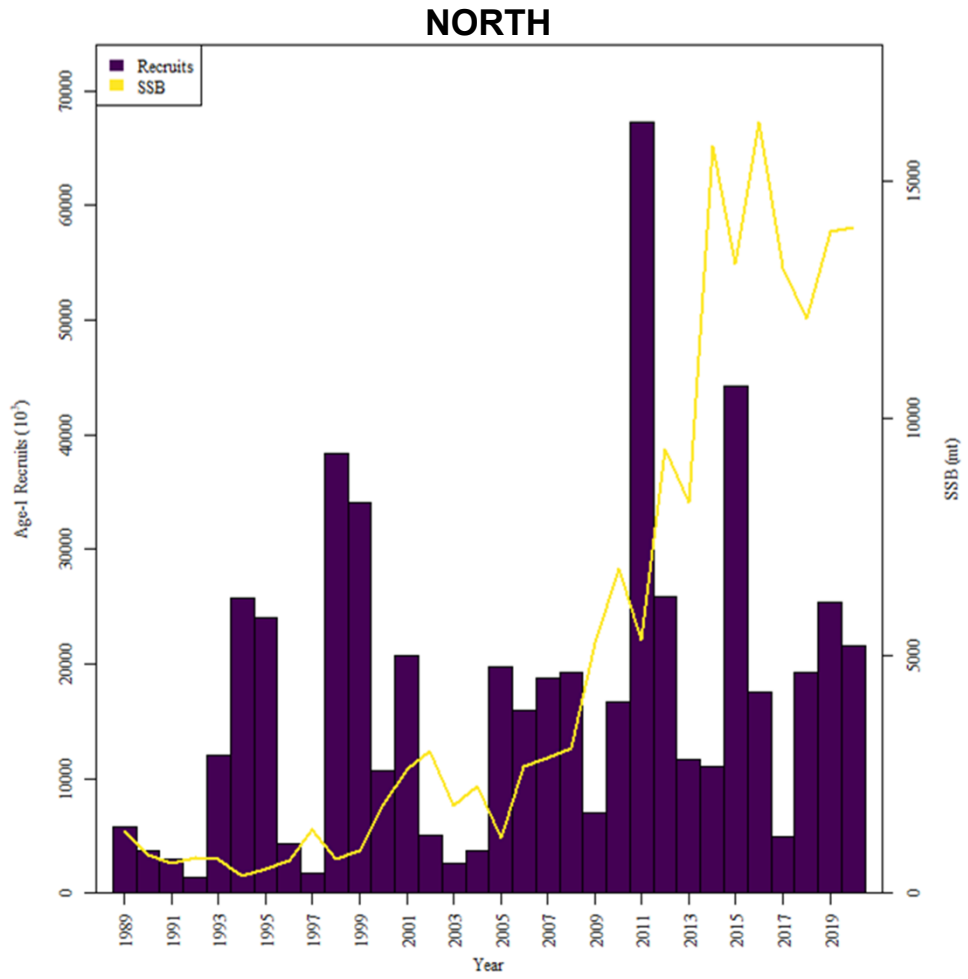


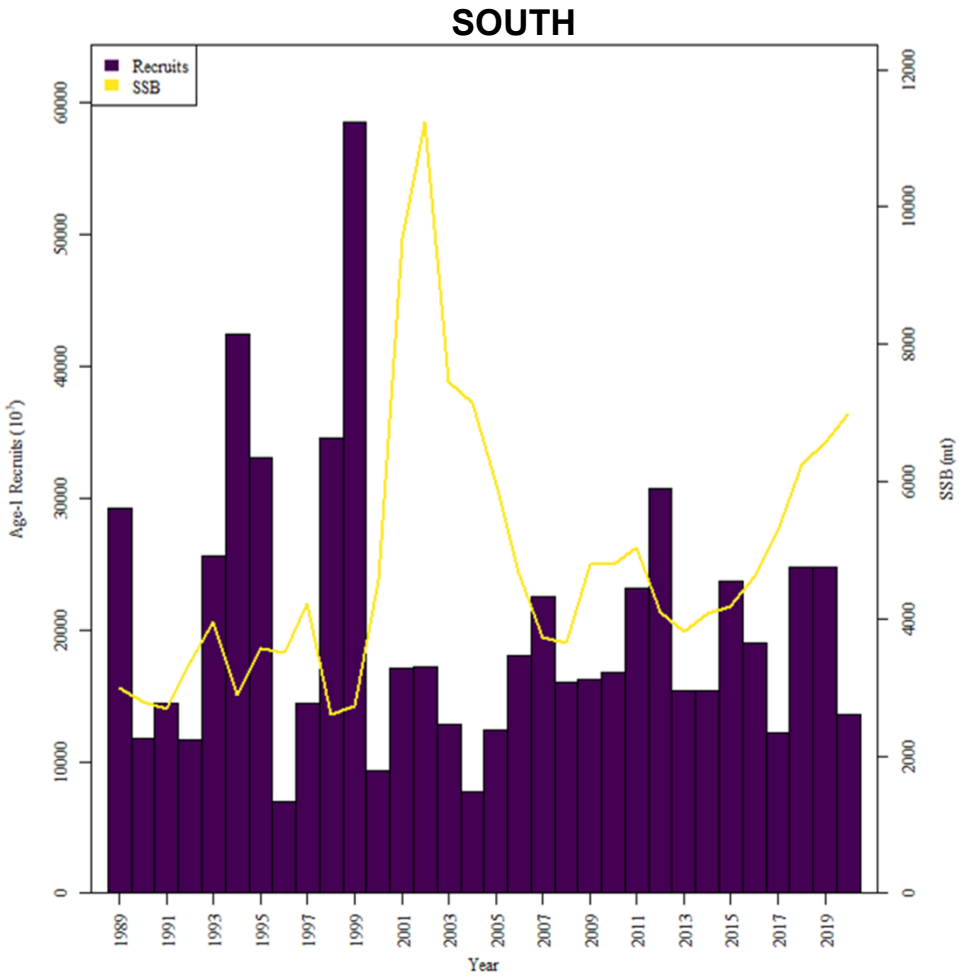
Retrospective analysis: South



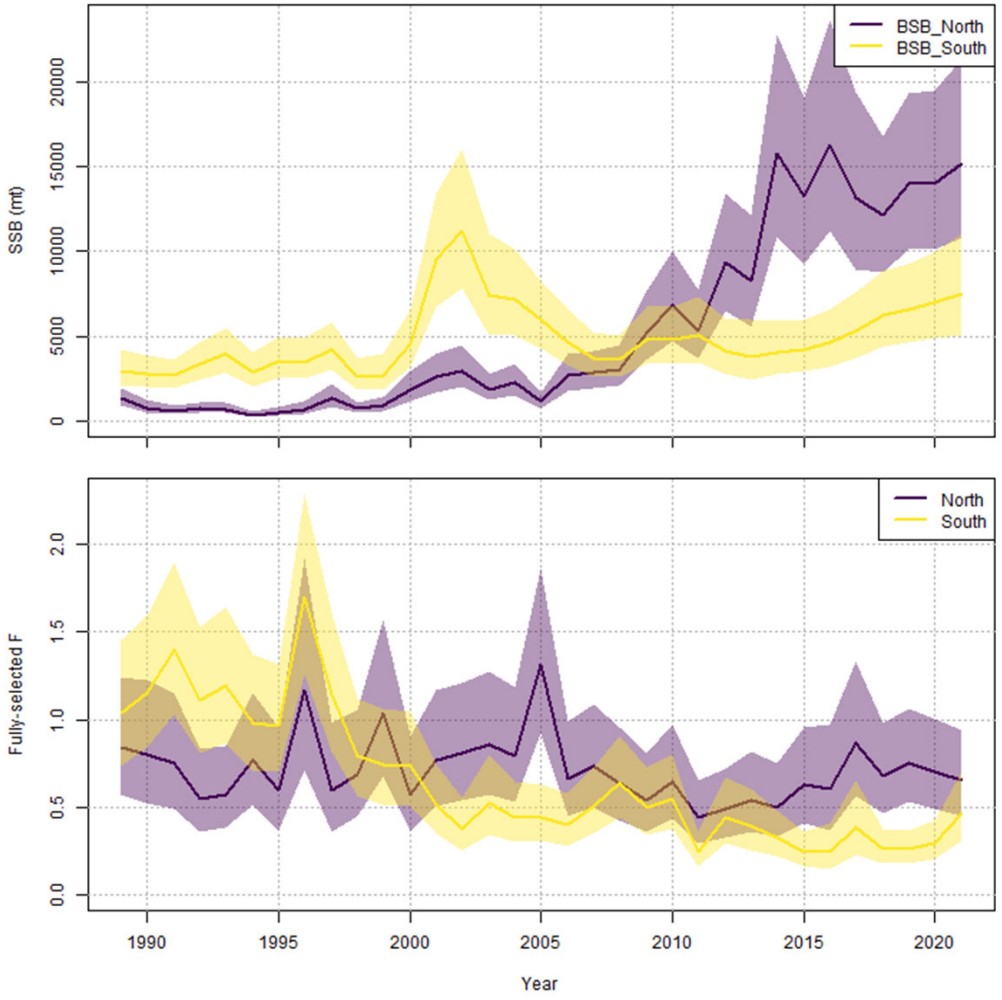


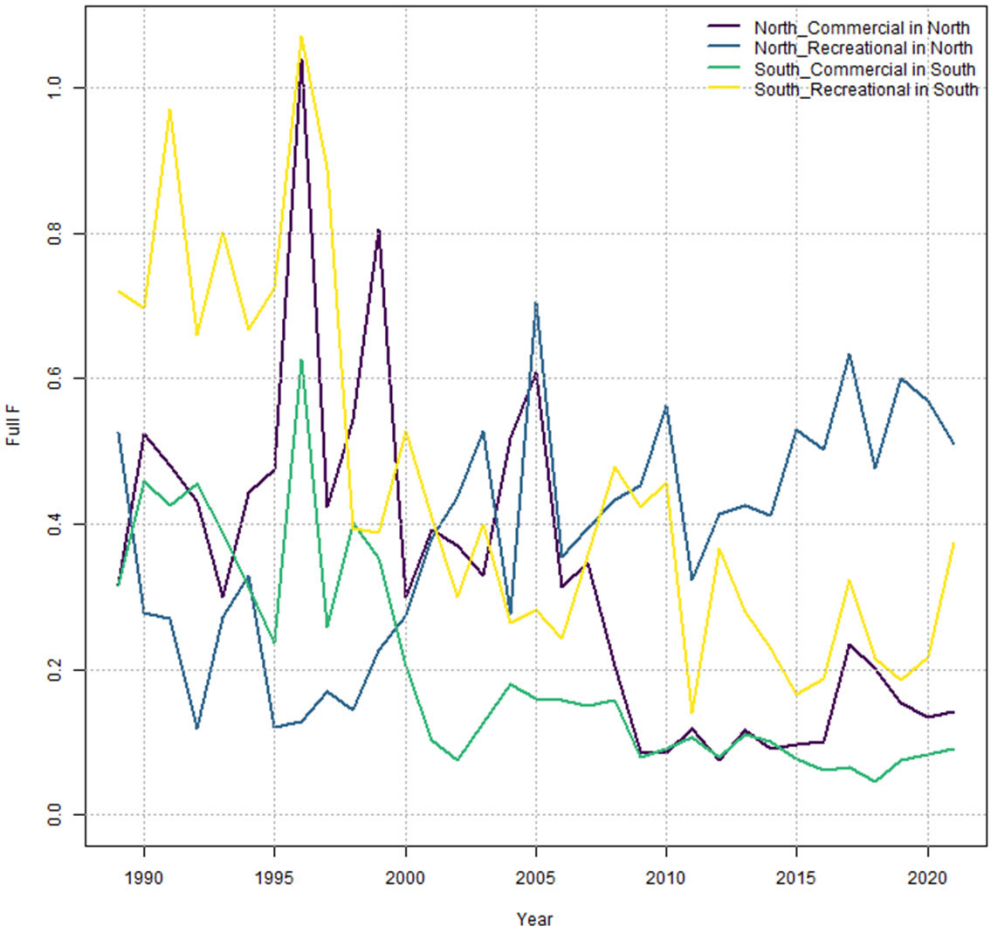
Estimated SSB and recruitment





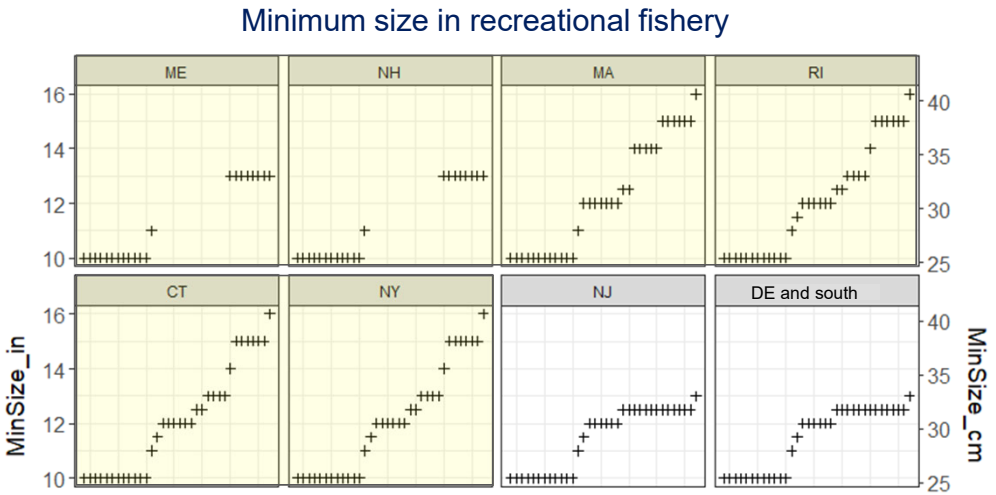
Estimated SSB and fishing mortality

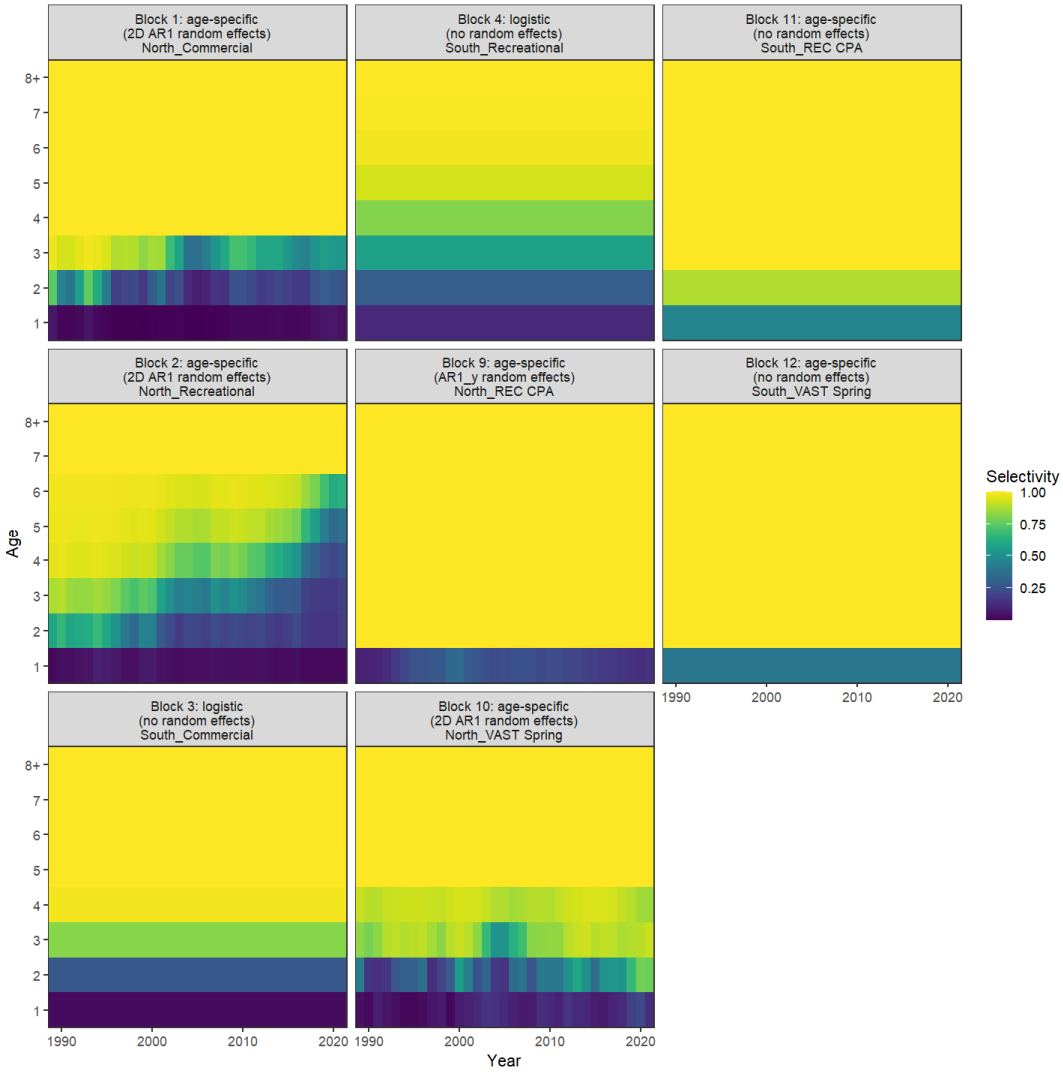




Selectivity

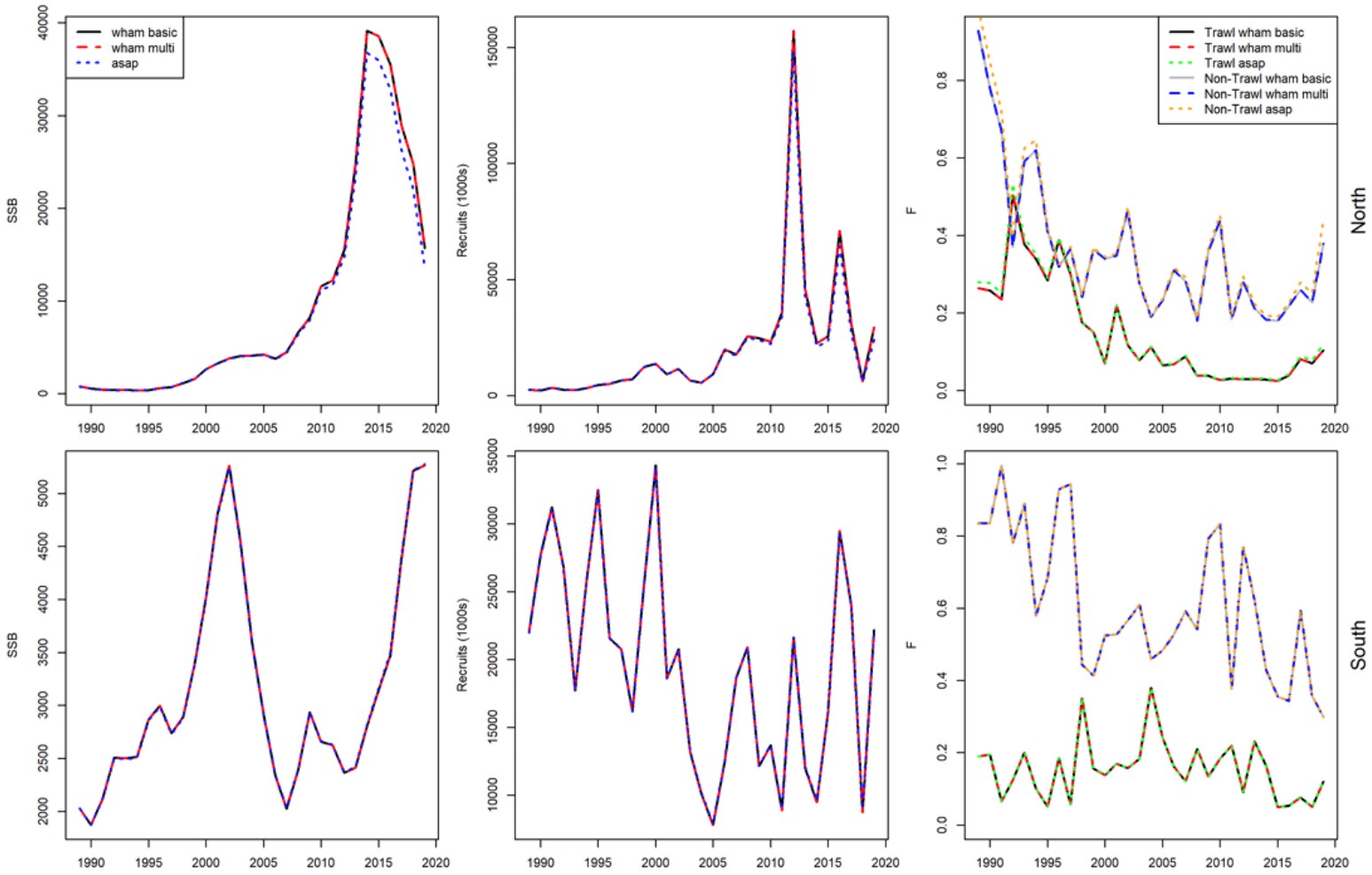
Data component	Mean Selectivity model	Random effects configuration
North Commercial	age-specific (flat-topped at ages > 3)	2D-AR1 (age and year)
North Recreational	age-specific (flat-topped at ages > 6)	2D-AR1 (age and year)
South Commercial	logistic	None
South Recreational	logistic	None
North Recreational CPA	age-specific (flat-topped at ages > 1)	AR1 (year)
North VAST	age-specific (flat-topped at ages > 4)	2D-AR1 (age and year)
South Recreational CPA	age-specific (flat-topped at ages > 2)	None
South VAST	age-specific (flat-topped at ages > 1)	None



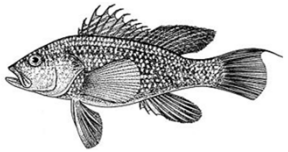


Road to the proposed model

Comparing ASAP with standard WHAM & multi-WHAM



Bridge runs to 2023 RT data



0: 2021 MT configuration

1: NEFSC spring BTS and Rec CPA only

2: Transition to comm/rec fleets (update fishery catches and catch WAA estimates)

3: Update NEFSC spring BTS (include GOM strata) and Rec CPA (new guild method, *original* CVs)

4: Add 2020-2021

5: Update maturity

6: Add NEAMAP

7: Update remaining spring state indices

8: Rec CPA and both spring and fall VAST

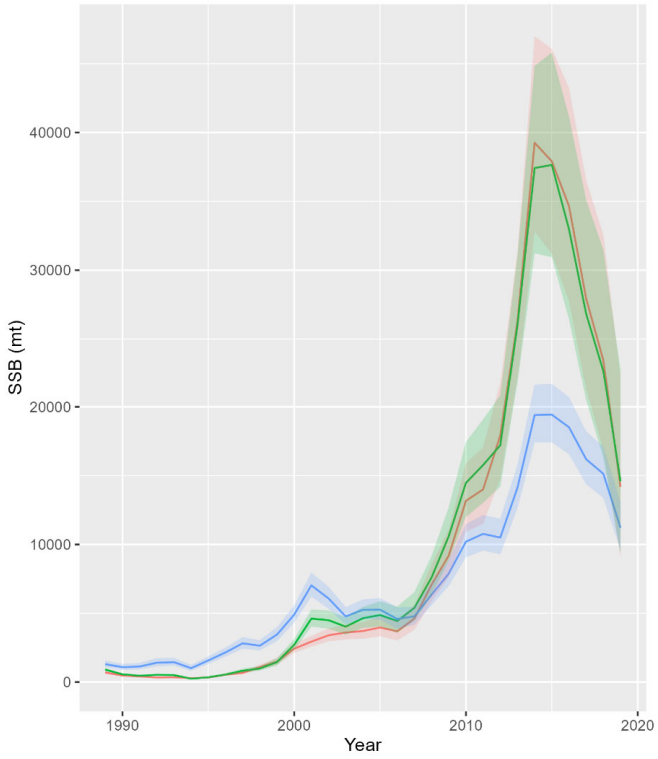
9: Rec CPA and spring VAST only

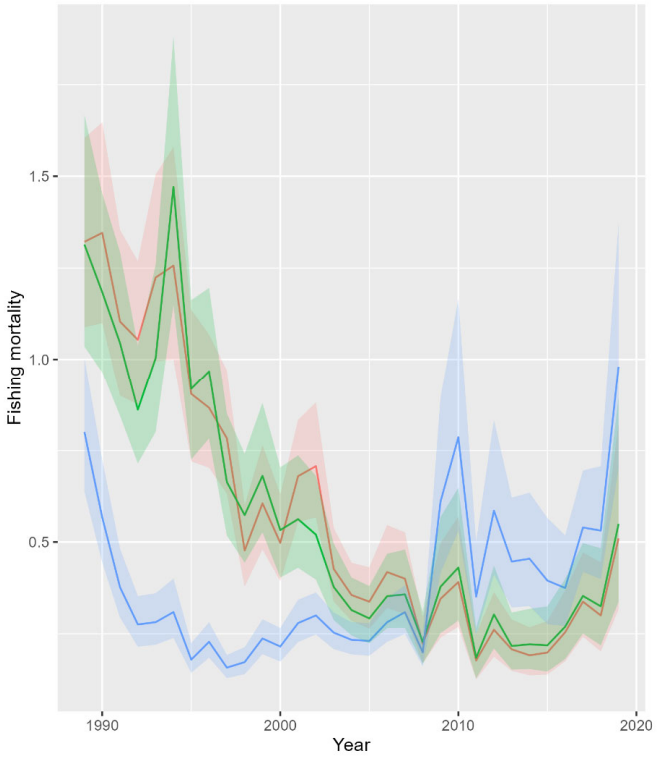
B. Runs 1-3: updating fishing fleets, NEFSC BTS, Rec CPA

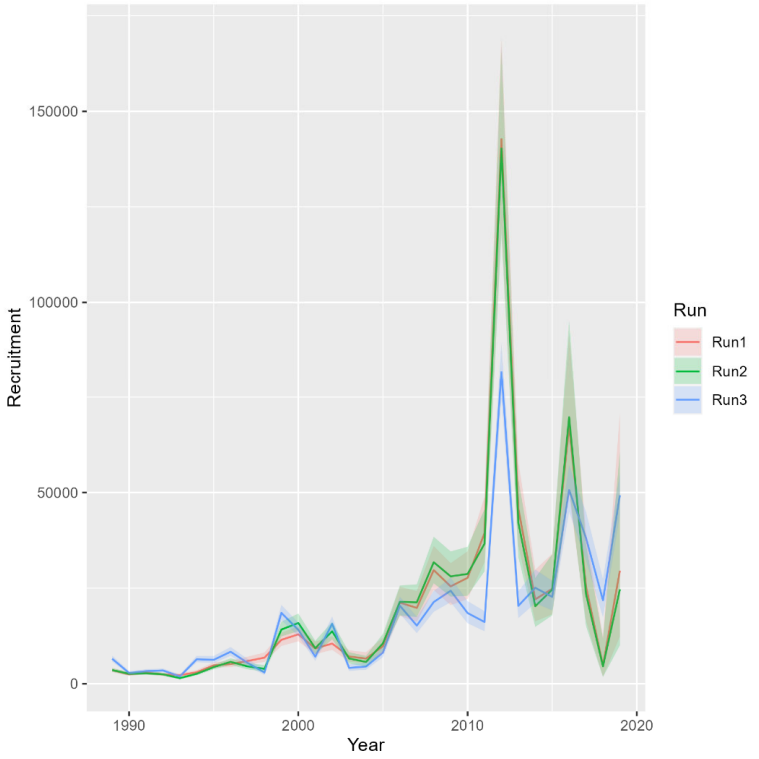
Mohn's rho

Run	F	SSB	Rect
1	1.472	-0.608	-0.628
2	1.371	-0.568	-0.634
3	0.777	-0.351	-0.153

North





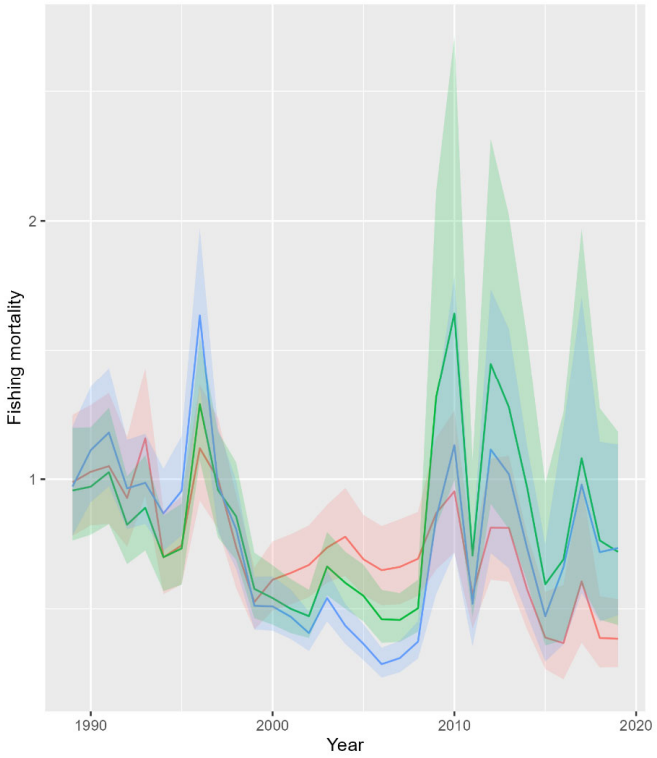


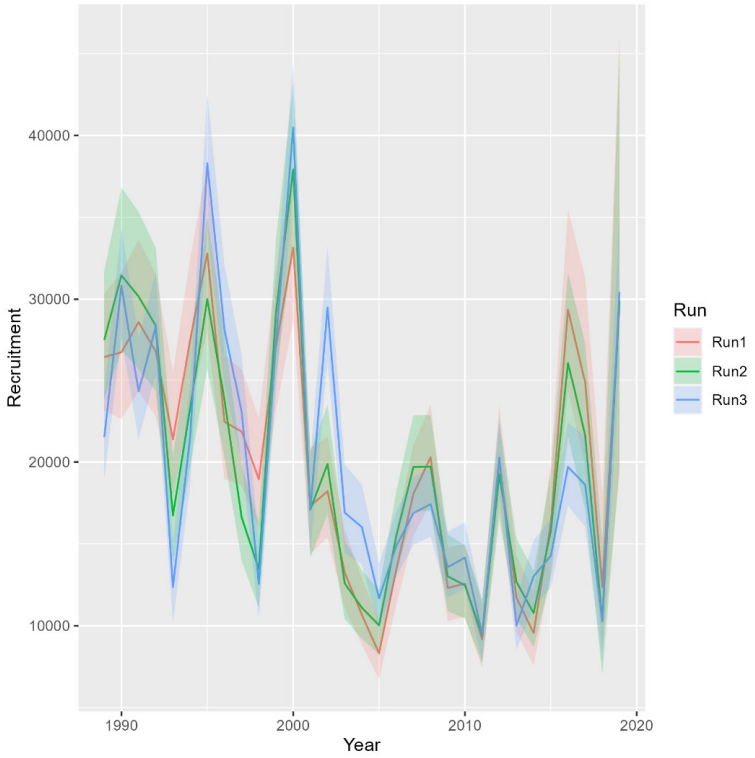
B. Runs 1-3: updating fishing fleets, NEFSC BTS, Rec CPA

Mohn's rho

Run	F	SSB	Rect
1	-0.147	0.166	0.389
2	-0.002	0.057	0.161
3	-0.087	0.074	0.05

South



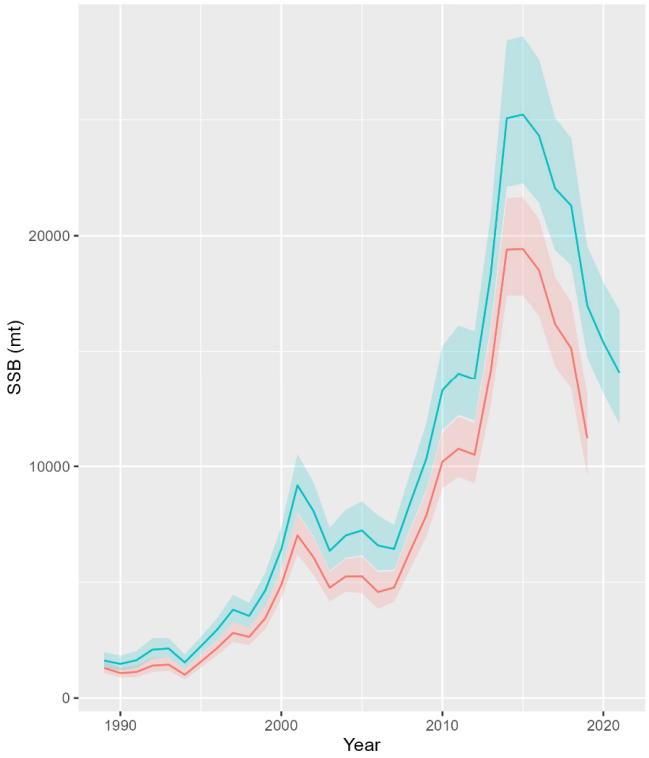


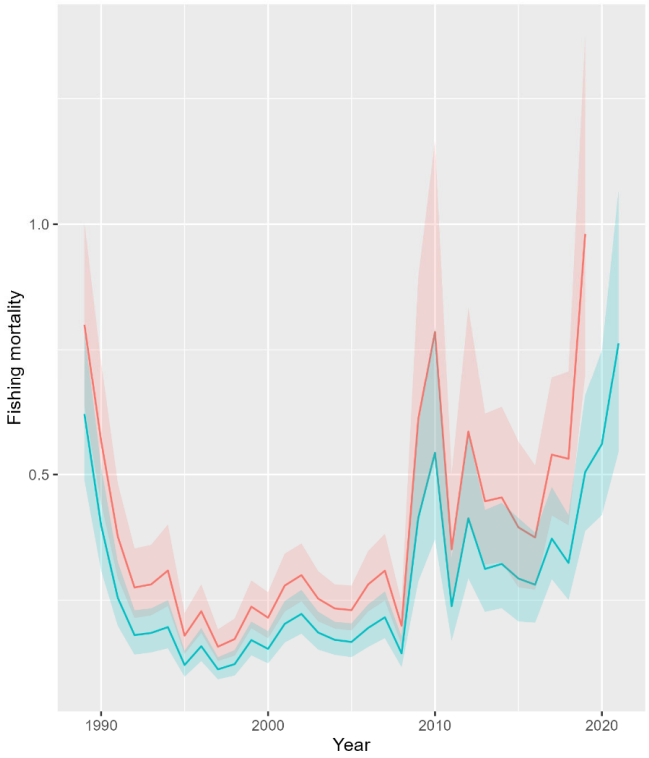
B. Runs 3-4: Adding 2020-2021

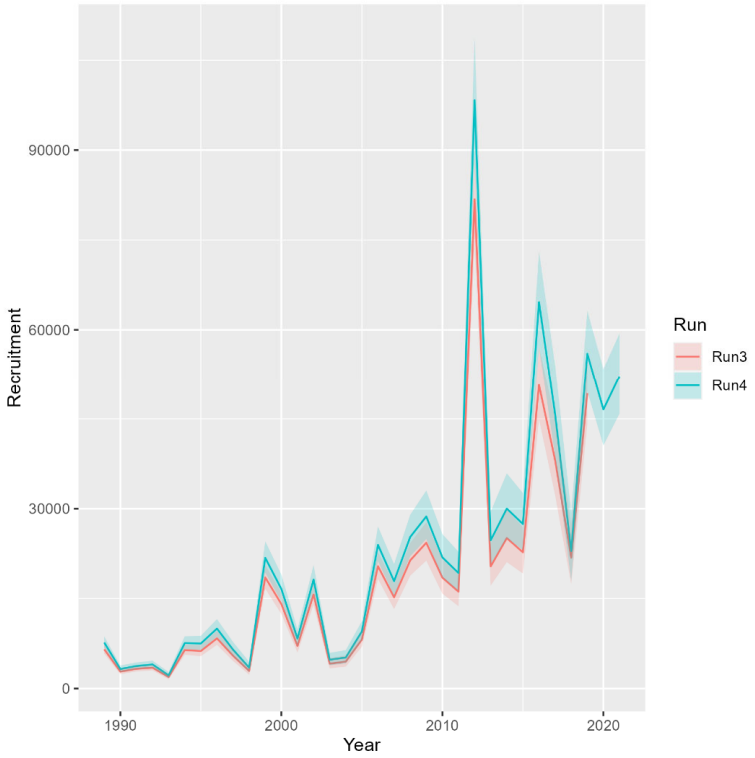
Mohn's rho

Run	F	SSB	Rect
3	0.777	-0.351	-0.153
4	1.294	-0.431	-0.165

North





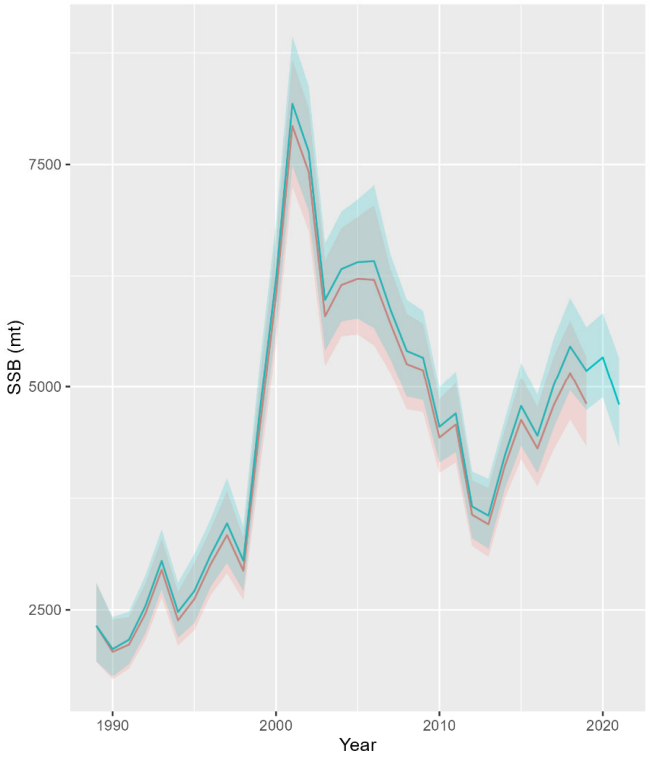


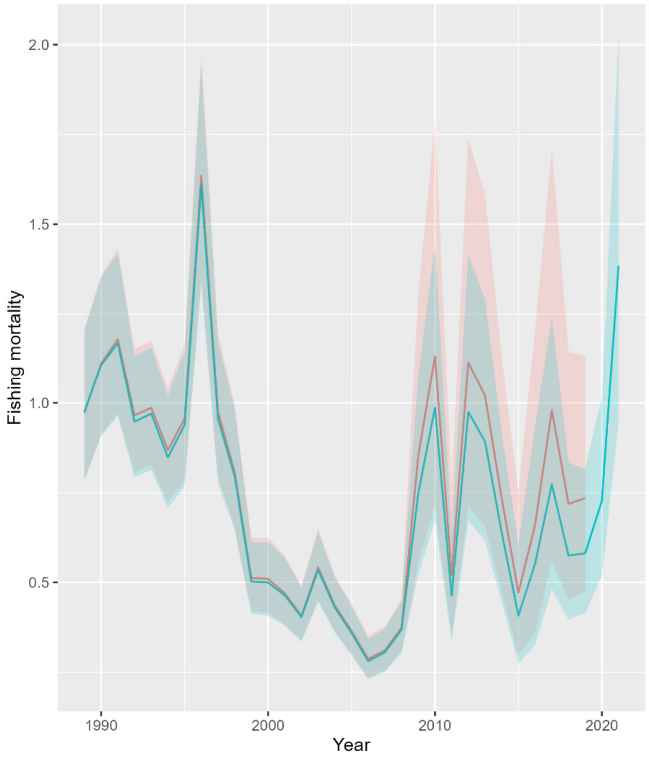
B. Runs 3-4: Adding 2020-2021

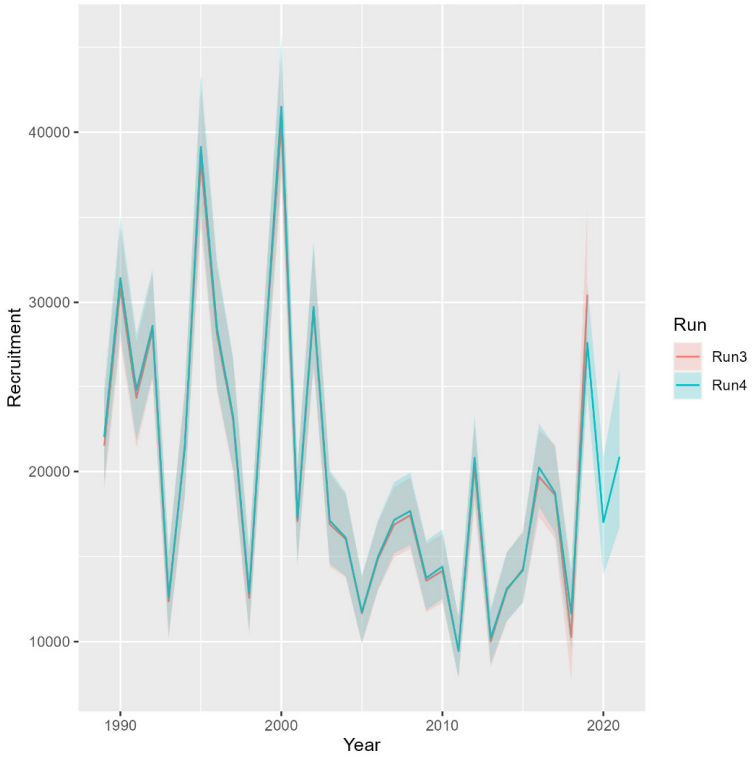
Mohn's rho

Run	F	SSB	Rect
3	-0.087	0.074	0.05
4	0.107	-0.017	0.005

South





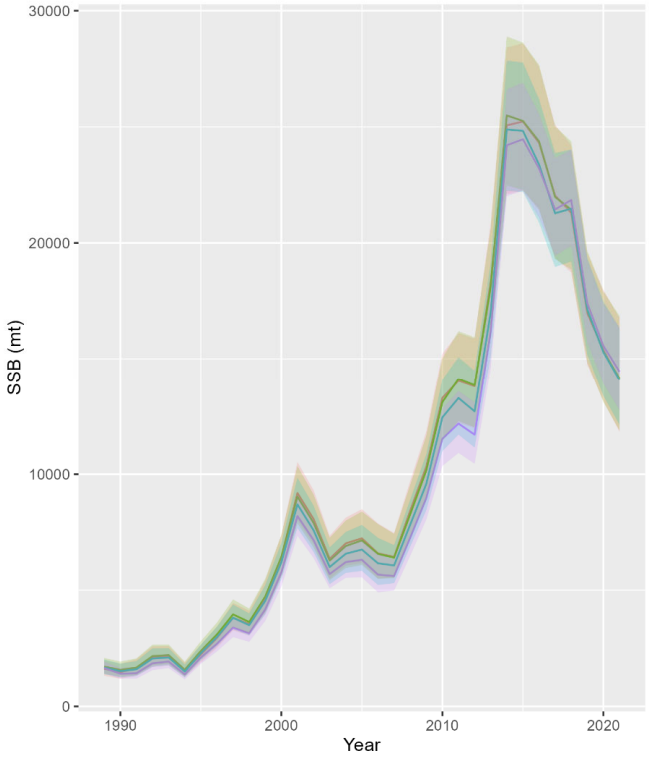


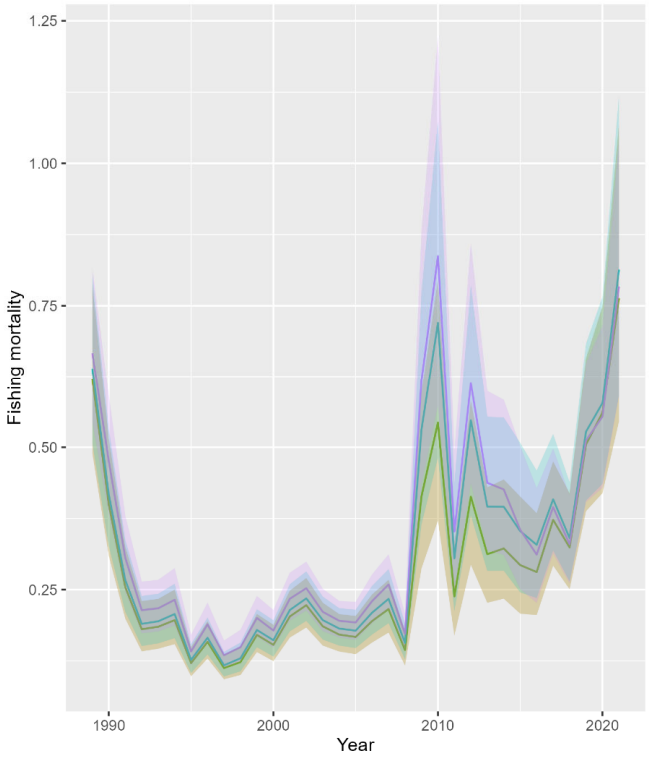
B. Runs 4-7: Add maturity, NEAMAP, remaining state indices

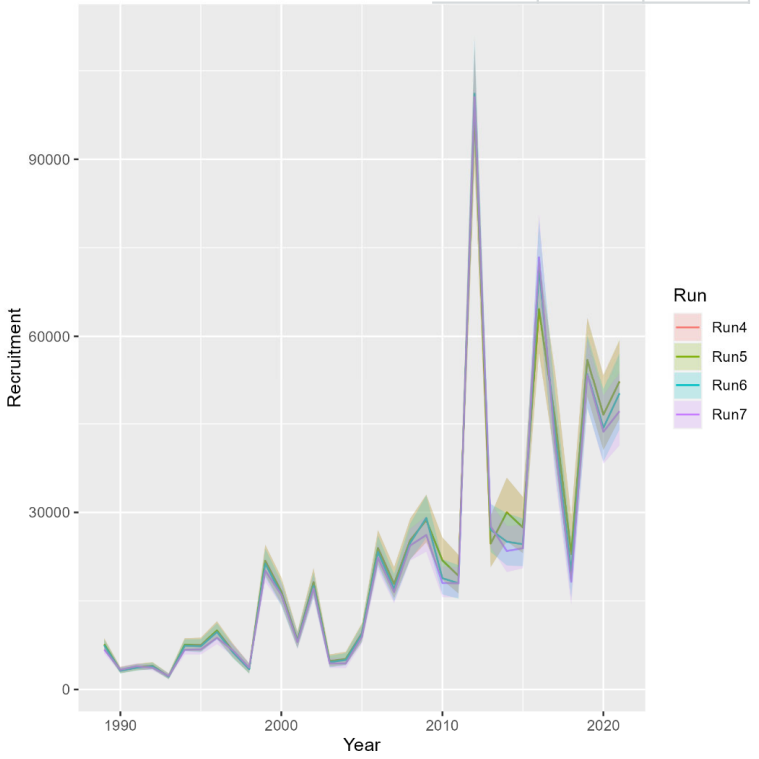
Mohn's rho

Run	F	SSB	Rect
4	1.294	-0.431	-0.165
5	1.294	-0.431	-0.165
6	1.232	-0.444	-0.129
7	0.986	-0.388	-0.125

North





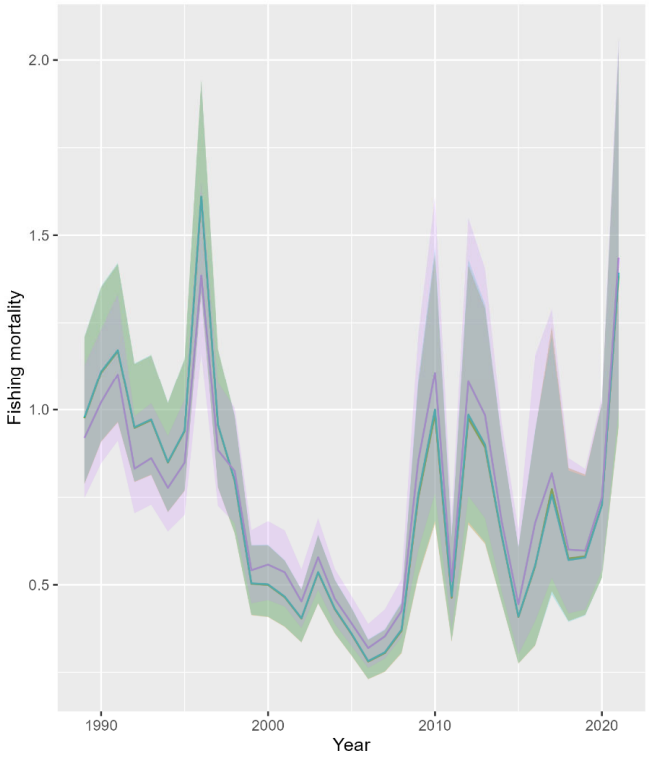


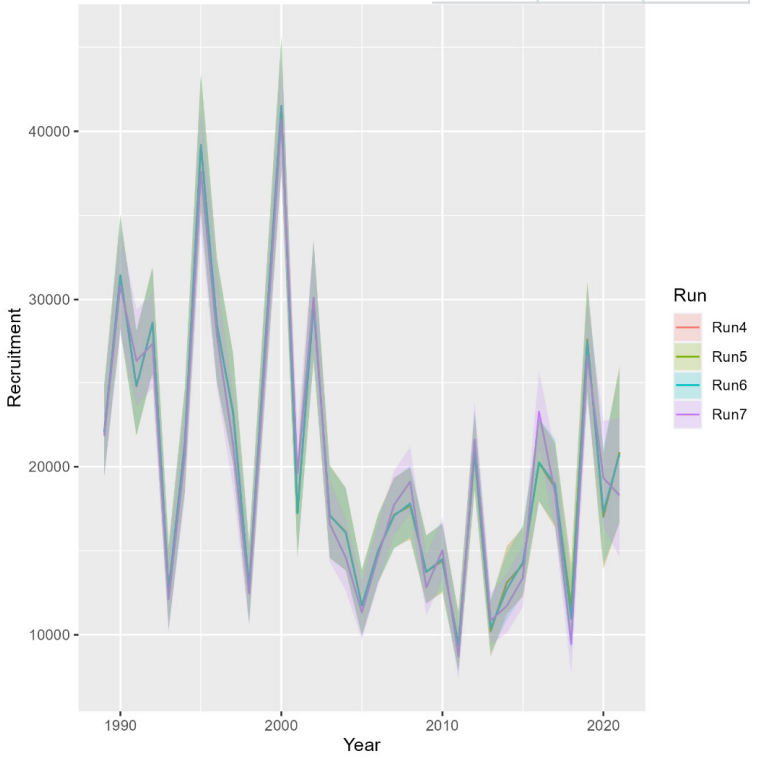
B. Runs 4-7: Add maturity, NEAMAP, remaining state indices

Mohn's rho

Run	F	SSB	Rect
4	0.107	-0.017	0.005
5	0.107	-0.015	0.005
6	0.106	-0.013	-0.029
7	0.121	-0.012	-0.061

South



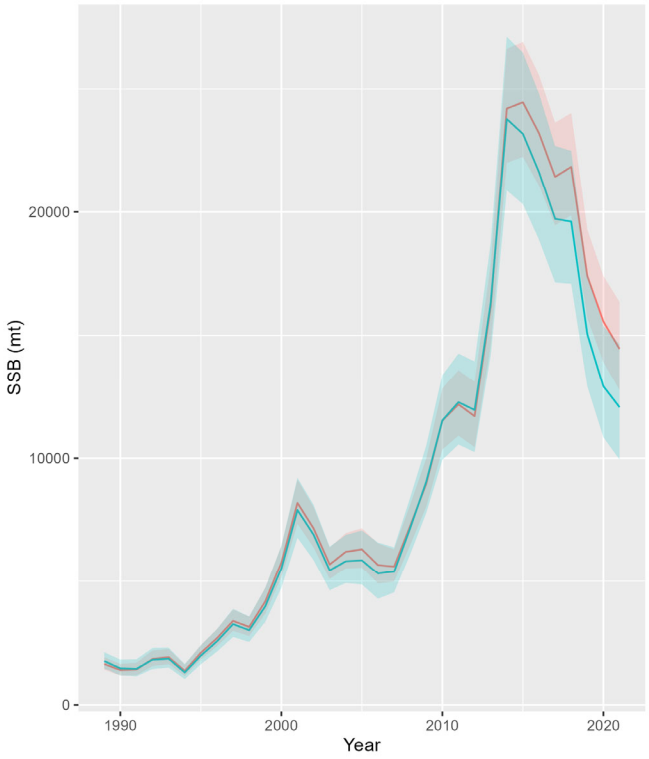


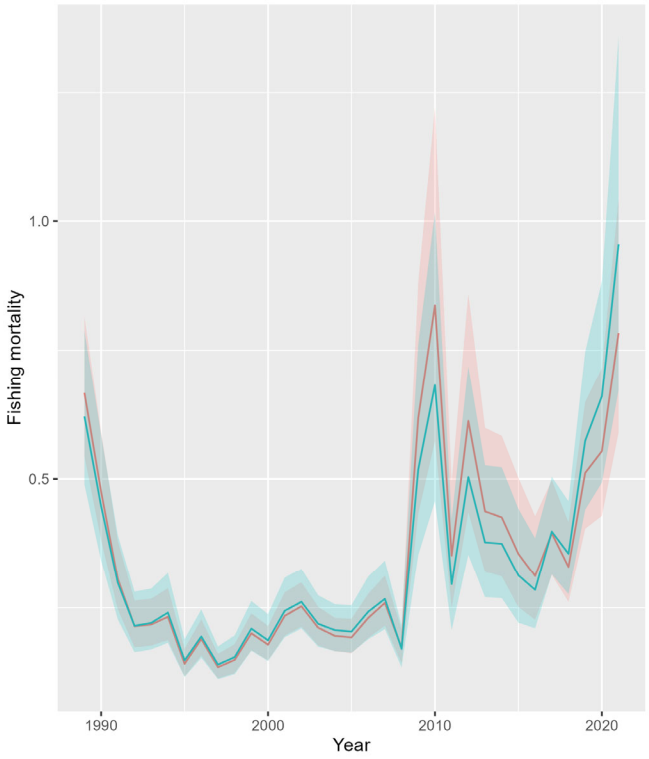
B. Runs 7 & 9: Adding spring VAST index

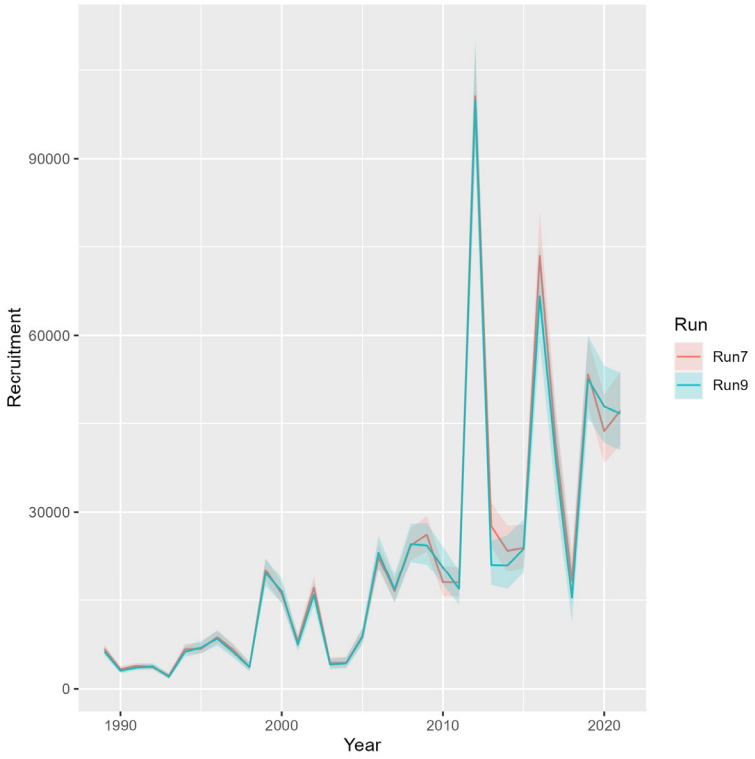
Mohn's rho

Run	F	SSB	Rect
7	0.986	-0.388	-0.125
9	1.446	-0.449	-0.078

North





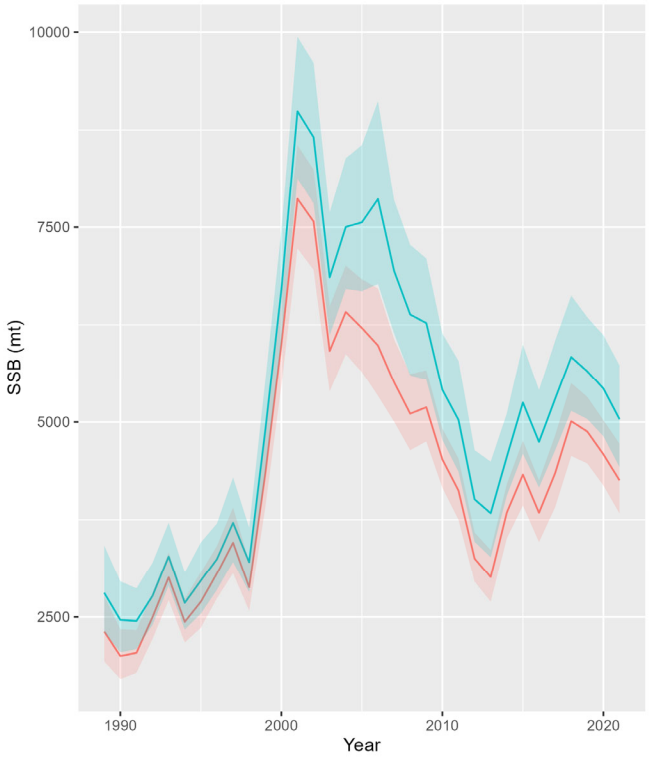


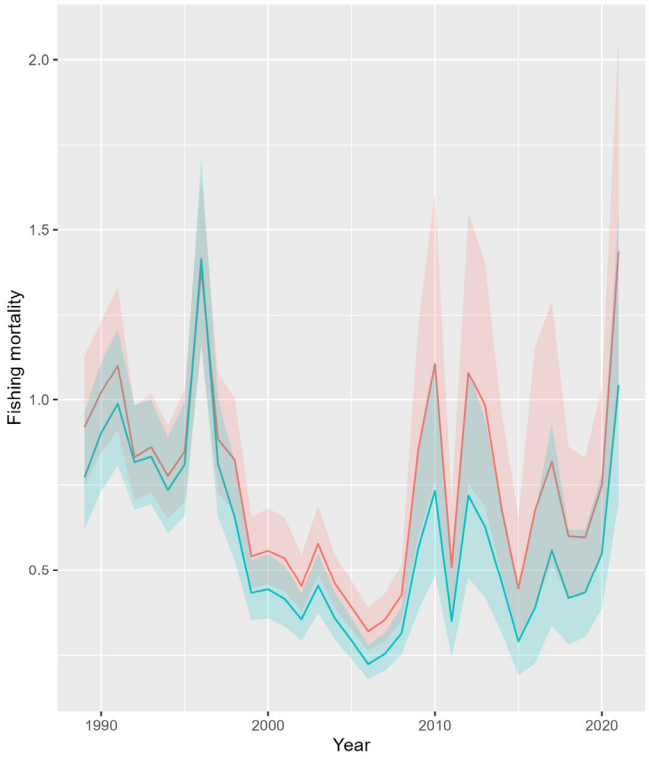
B. Runs 7 & 9: Adding spring VAST index

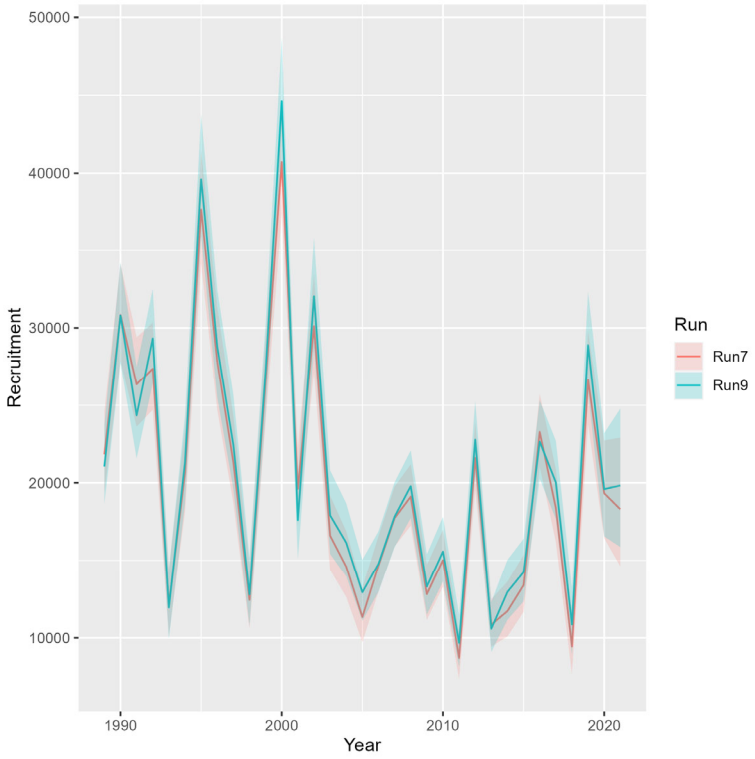
Mohn's rho

Run	F	SSB	Rect
7	0.121	-0.012	-0.061
9	0.088	-0.013	-0.005

South





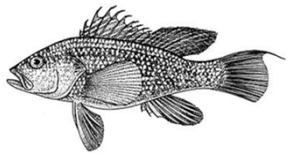


TORs 4-6: Model, reference points and projections

Reference points and projections…

- Stock status recommendations are not part of the RT TORs and the results from this RT will not be used directly in management.
- This RT will inform a MT scheduled for June 2024 that will provide updated estimates of stock status using data through 2023 and will be used to inform management measures for 2025-2026.

- Reference points were based on recent 5-year averages of selectivity, maturity and weight-at-age and incorporated recruitment estimates from 2000 onward
- Short-term projections include forecasted bottom temperature covariate for recruitment



TORs 4-6: Model, reference points and projections

Reference points

$F_{MSY\ PROXY} = F_{40\%} = 1.03$ (cannot be compared to previous ASAP values)

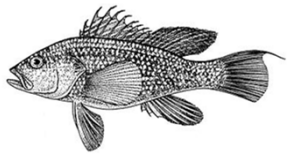
$SSB_{MSY\ PROXY} = 12{,}491$ mt (14,441 mt in 2021 MT)

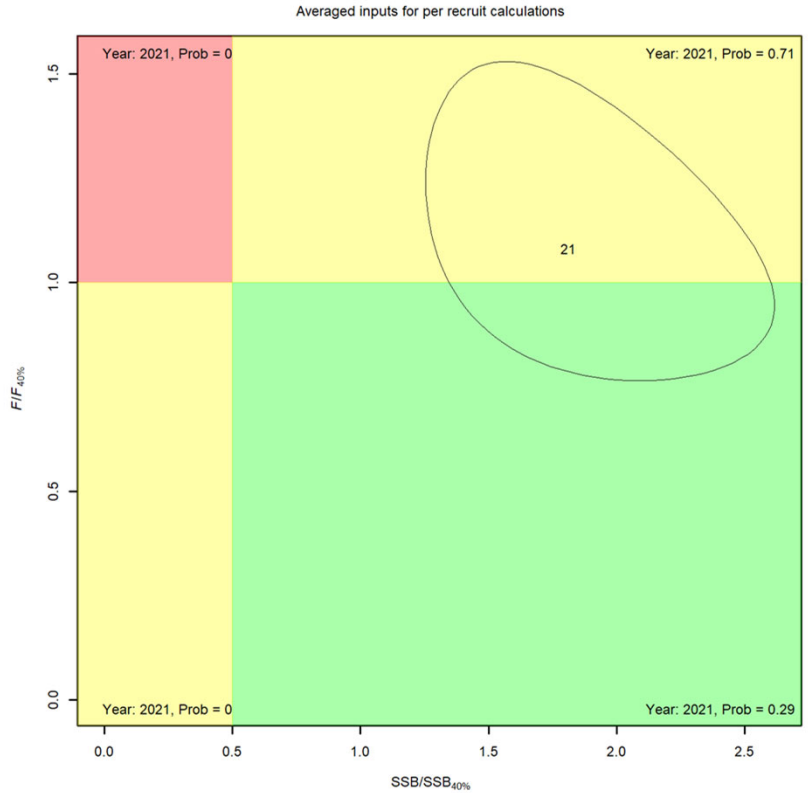
$MSY_{PROXY} = 3{,}975$ mt (5,334 mt in 2021 MT)

Terminal year (2021) estimates

$F_{2021} = 1.12 = 108\%$ of $F_{40\%}$

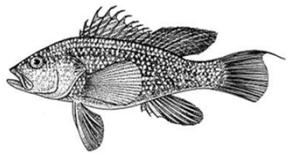
$SSB_{2021} = 22{,}630$ mt $= 181\%$ of $SSB_{MSY\ PROXY}$

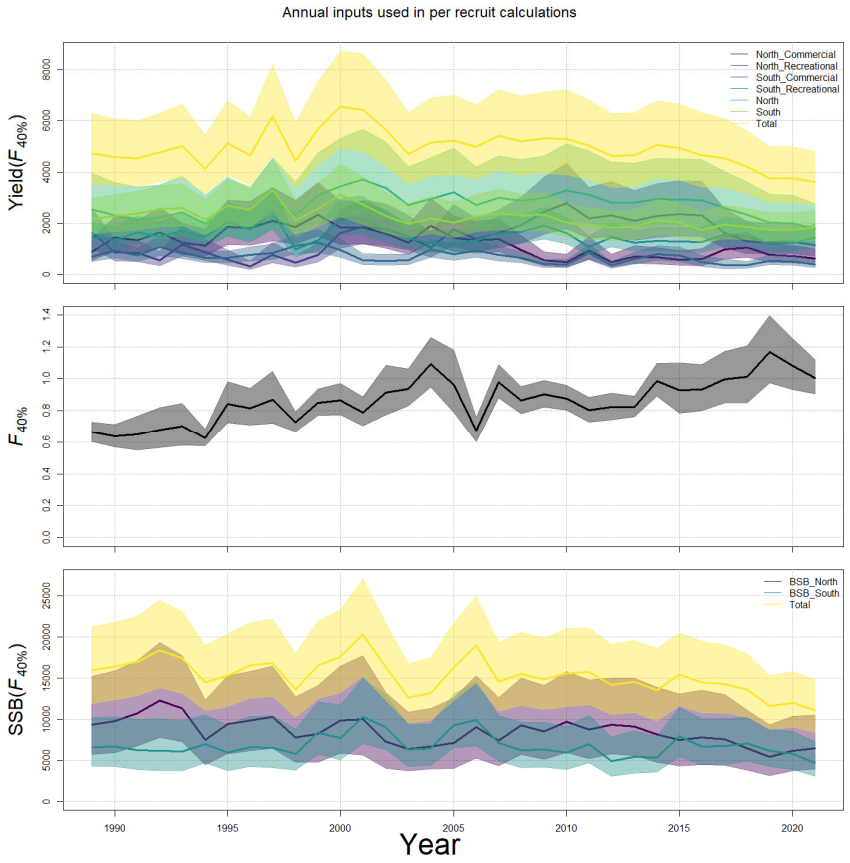


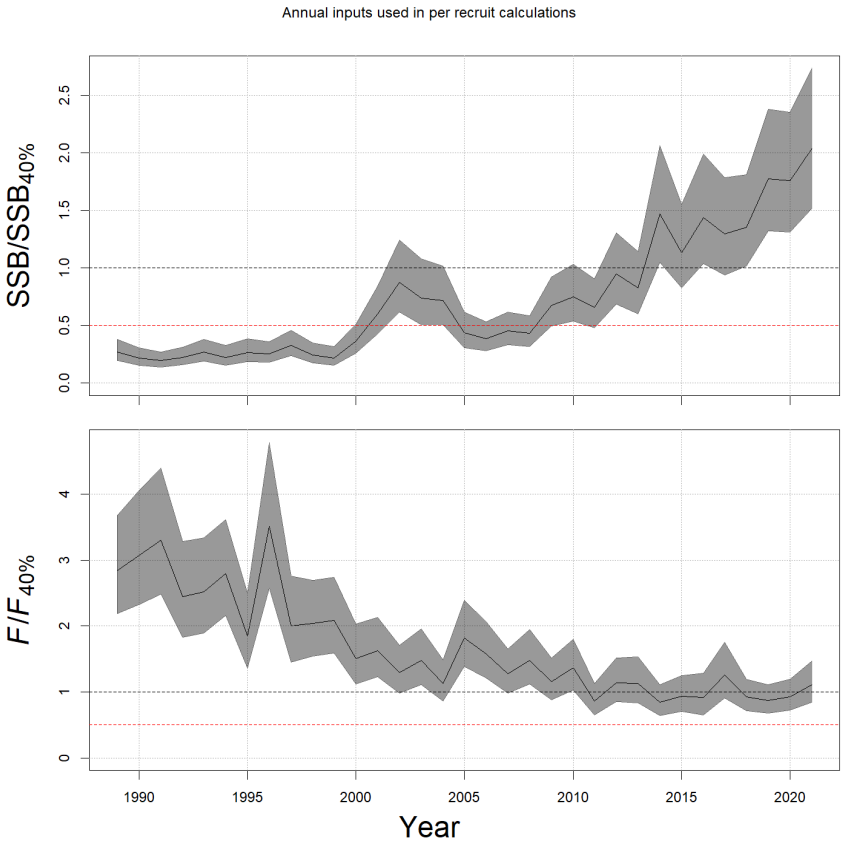


TORs 4-6: Model, reference points and projections

Annual reference points: Based on annual inputs instead of most recent 5-year average



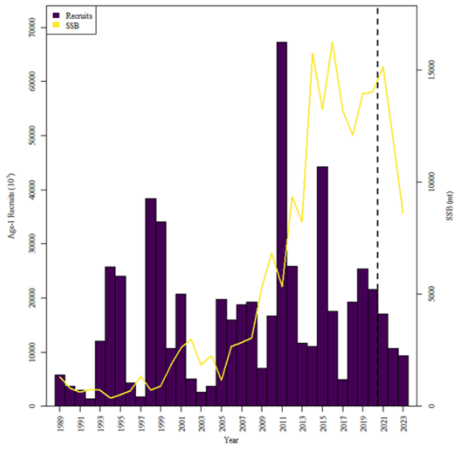




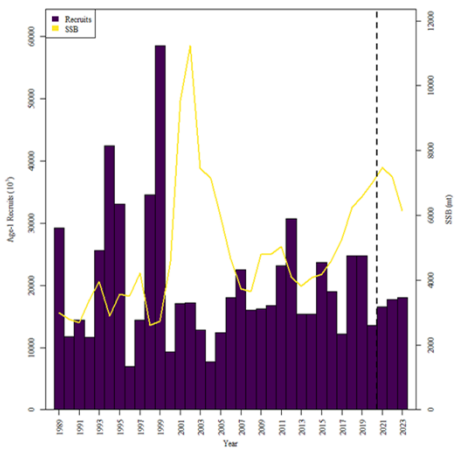
TORs 4-6: Model, reference points and projections

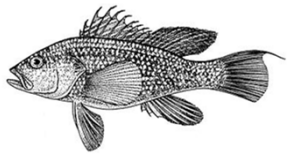
Short-term projections at $F_{40\%}$

North

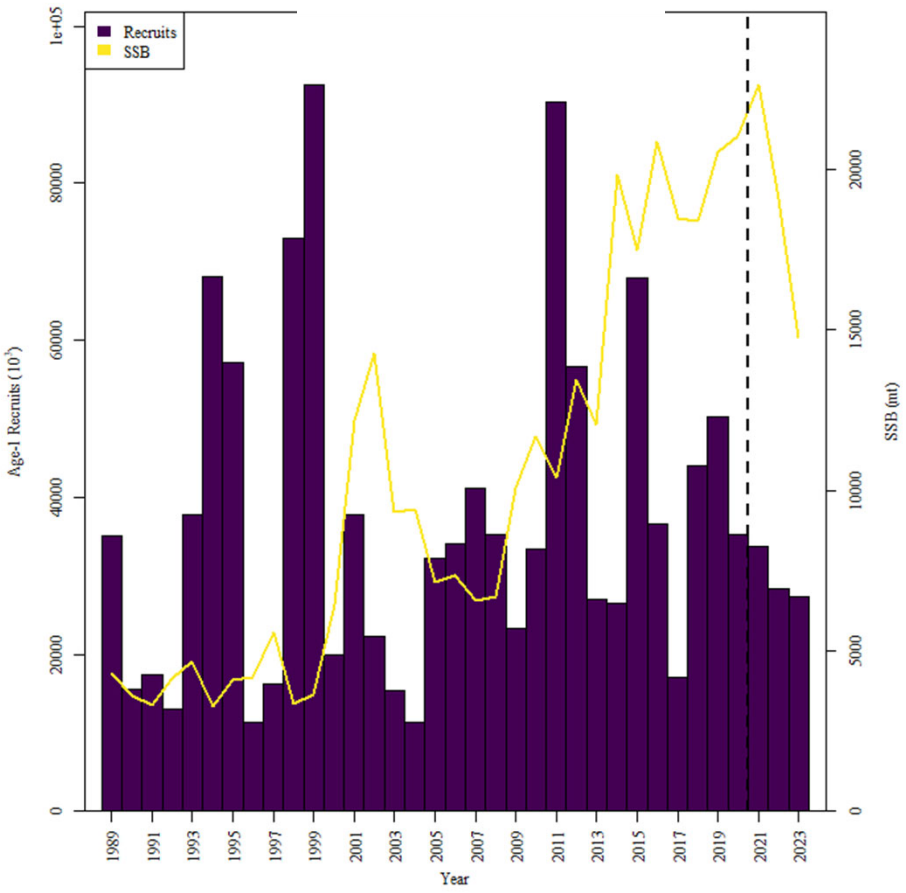


South



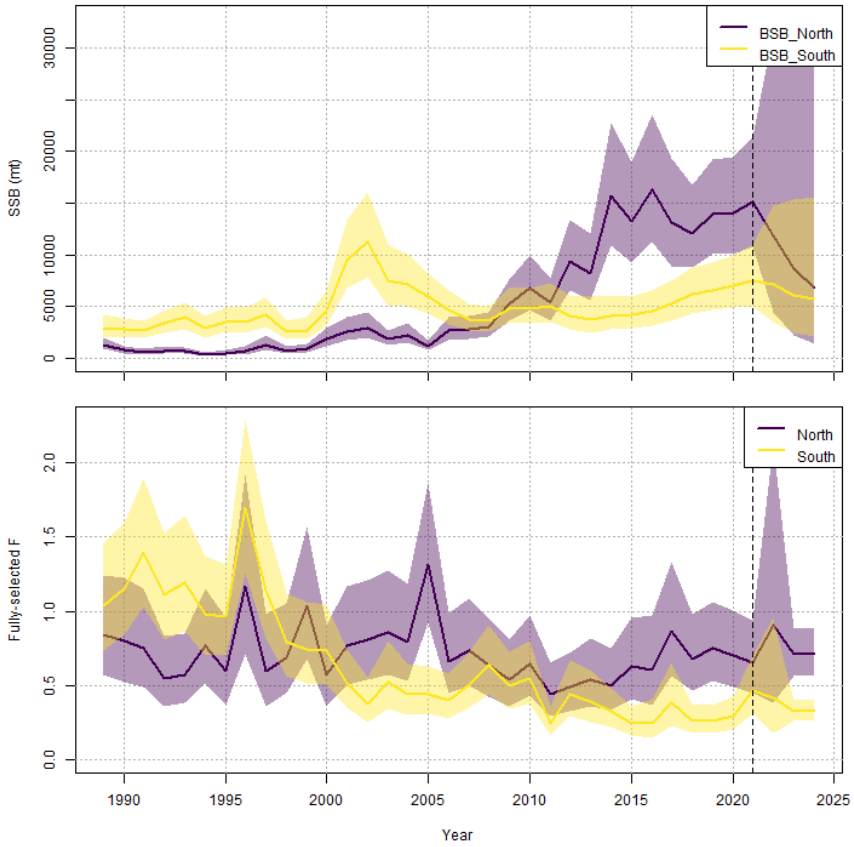


Combined regions

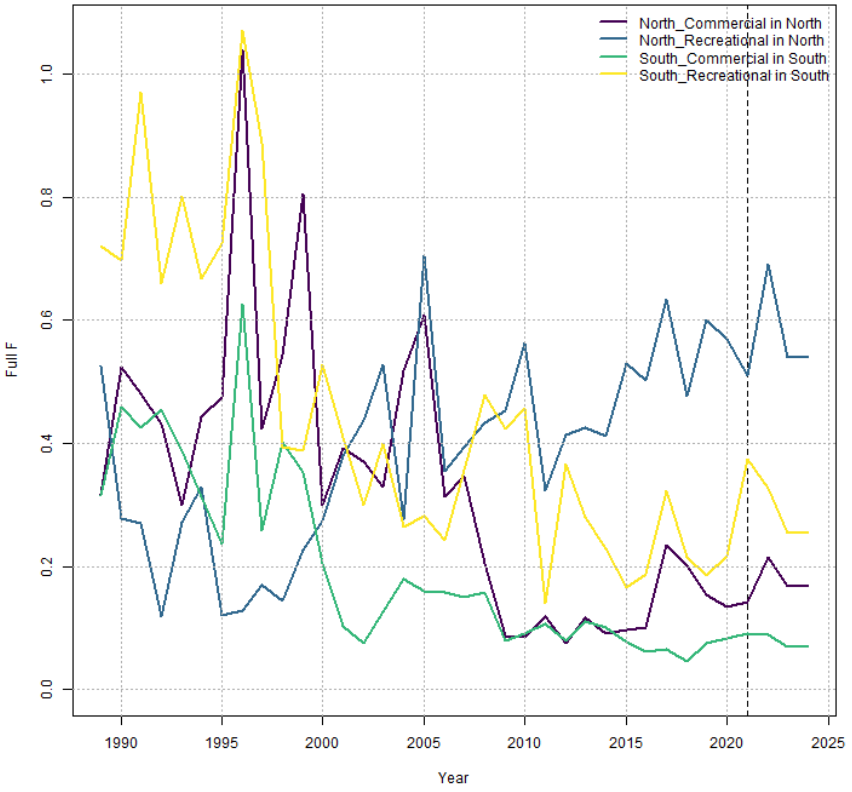


TORs 4-6: Model, reference points and projections

SSB and F by region



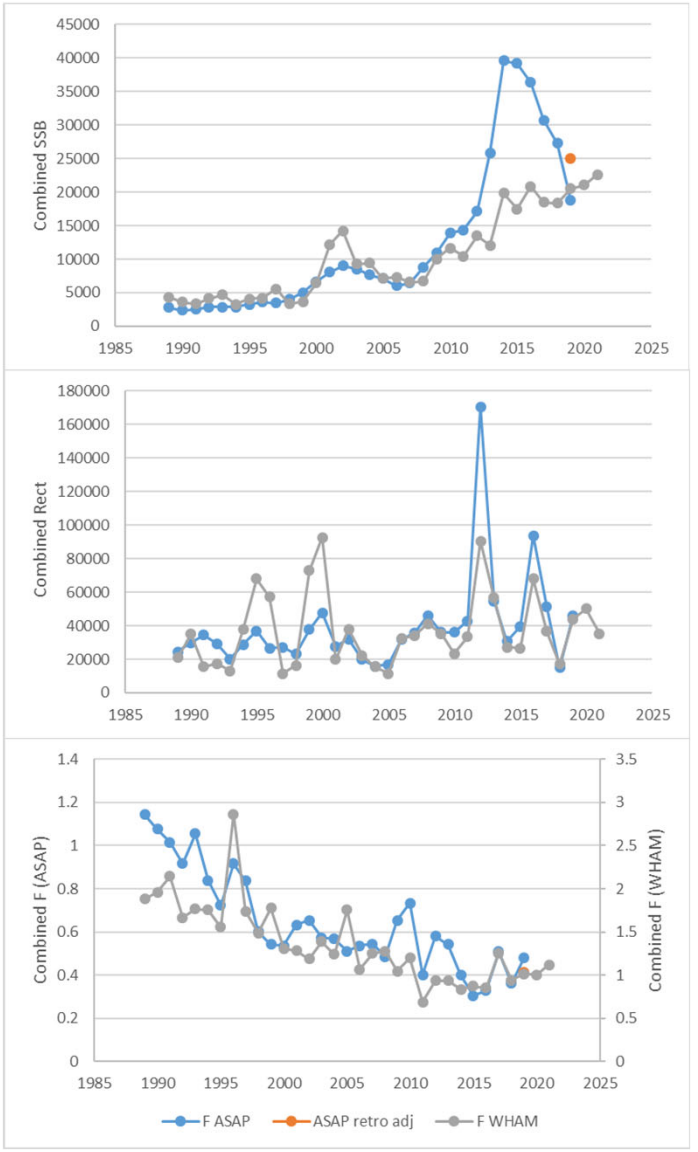
Fleet-specific F



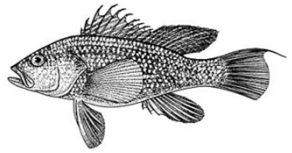
Model summary

Multi-region state-space model (Multi-WHAM)

- Regions: Northern, Southern with movement
- Fleets: Commercial, Recreational
- Indices: Spring VAST and RecCPA (with adjusted CVs)
- Random effects on survival and recruitment (2dAR1)
- Random effects on fishery (comm and rec) selectivity (2dAR1) and both VAST (2dAR1) and RecCPA (AR1) in the north
- Temperature covariate on recruitment
- Reference points: incorporate recruitment from 2000 onward
- Short-term projections: project AR1 process for recruitment



Peer Review Panel Recommendations



Peer review panel accepted the BSB Research Track Assessment

Required for 2024 Management Track

- Exploration of alternative parameterizations for natural mortality (e.g. different age-independent constant values, or age-dependent M)
- Profiles of the initial fishing mortality (i.e. initial depletion)
- An evaluation of which individual surveys should be included in the VAST index by comparing WHAM estimates (e.g., biomass time series) from the proposed run with individual fishery independent surveys. Surveys that do not appear to accurately reflect changes in stock size through this analysis should not be included in the VAST index.

Questions?