Butterfish 2021 Research Track Assessment

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Outline

- Model development in ASAP3
- Further development in WHAM
- Historical retrospectives
- Biological reference points
- Stock status
- Projections

Butterfish working group

- Charles Adams (NEFSC), assessment lead
- Carly Bari (GARFO)
- Kiersten Curti (NEFSC)
- Jonathan Deroba (NEFSC), chair
- Jason Didden (MAFMC)
- Andrew Jones (NEFSC)
- Timothy Miller (NEFSC)
- Alyson Pitts (GARFO)
- Laurel Smith (NEFSC)
- Brian Stock (NEFSC)
- Robert Vincent (MIT)

Background

- Last benchmark assessment for butterfish was in 2014 (SAW 58)
  - Status: not overfished, overfishing not occurring
- 2021 research track
  - Terminal year = 2019
  - Status: not overfished, overfishing not occurring
- Specifications for 2023 & 2024 will be set during July SSC meeting based on June 2022 management track using data through 2021

Model development in ASAP3

- The Age Structured Assessment Program (ASAP) is a statistical catch at age model (Legault & Restrepo, 1999)
- SAW 58 model used ASAP4
  - Catchability could be modeled as the product of availability and efficiency (the former specified with a thermal habitat availability index based on bottom temperature)
  - Estimation of natural mortality
  - 2020 management track estimate of $M = 1.278$

Model development in ASAP3

- ASAP4 no longer supported
  - Resources shifted to WHAM
- Thermal habitat availability index no longer updated since 2015
- Reverting back to ASAP3 model would allow potential development in WHAM
- Highlights of ASAP3 runs
  - Freely estimate catch selectivity (fix age 3 best)
  - Freely estimate survey selectivities
  - Standard data reweighting procedure (Francis 2011)

Model development in ASAP3

- Highlights of ASAP3 runs (continued)
  - Relaxing strong prior on Albatross *q* resulted in many highly correlated scale parameters and an unrealistic increase in SSB; prior deemed a necessity
  - Switch to annual maturity ogives
  - Dropped spring Albatross due to poor diagnostics
  - Model with start year = 1973 did not converge; suitable solution could not be found
  - A second selectivity block was considered due to patterns in the age composition residuals in the last six years of the time series; was set to 2014–2019

Model development in ASAP3

- ASAP3 run 36 configuration
  - Biological: M = 1.278; annual maturity ogives; fraction of year at spawning = 0.5
  - One fishing fleet, with two selectivity blocks (1989–2013 & 2014–2019)
  - Surveys: fall Albatross & Bigelow; fall NEAMAP; spring Bigelow; spring NEAMAP; and a young-of-the-year index that combines state survey data from ME, MA, RI, CT, NJ and DE

Why a state-space model?

- ASAP typically only considers F and recruitment as time-varying parameters
  - Other parameters are assumed constant primarily because there are not usually enough degrees of freedom to estimate them as time-varying
- ASAP can penalize the deviations, e.g., in recruitment
  - But the penalty terms must be fixed or iteratively tuned and are therefore subjective

Text from Stock & Miller 2021

Why a state-space model?

- State-space models that treat parameters as unobserved states can, in principle, avoid such subjectivity by estimating the penalty terms as variance parameters constraining random effects and maximizing the marginal likelihood
  - In this way, state-space models can allow processes to vary in time while simultaneously estimating fewer parameters

Text from Stock & Miller 2021

Why a state-space model?

- State-space models naturally predict unobserved states, and therefore handle missing data and short-term projections in a straightforward way
- State-space models have larger, more realistic, uncertainty and reduced retrospective patterns

Text from Stock & Miller 2021

Further development in WHAM

- The Woods Hole Assessment Model (WHAM) is a state-space model (Stock & Miller 2021)
- WHAM is a generalization and extension of Miller et al. (2016) in TMB
- Functionality built into WHAM to migrate ASAP3 input files to WHAM
- WHAM can implement random effects on: interannual transitions in numbers-at-age; M; and selectivity

Further development in WHAM

- Highlights of WHAM runs
  - Numbers-at-age (NAA) model options

Model	Description	Parms. estimated	No.
Base	As ASAP, recruitment estimated as fixed effects	R_y for $y > 1$	$n_{years} - 1$
NAA1	Recruitment deviations are independent random effects	σ_R	1
NAA2	Recruitment deviations are autocorrelated, AR(1), random effects	σ_R, ρ_{year}	2
NAA3	All NAA deviations are independent random effects	σ_R, σ_a	2
NAA4	All NAA deviations are random effects with correlation by year and age, 2D AR(1)	σ_R, σ_a, ρ_{year}, ρ_{age}	4
NAA5	All NAA deviations are random effects with correlation by year only, AR(1)	σ_R, σ_a, ρ_{year}	3

Further development in WHAM

- Highlights of WHAM runs (continued)
  - Estimating catchability (q) of the Fall Albatross; scale issues
  - Estimating M; lower (0.9–1.0) than ASAP4 estimate (1.278), but not supported by AIC
  - Age composition likelihood options; ASAP assumes multinomial likelihood; Dirichlet-multinomial did not converge; logistic-normal converged

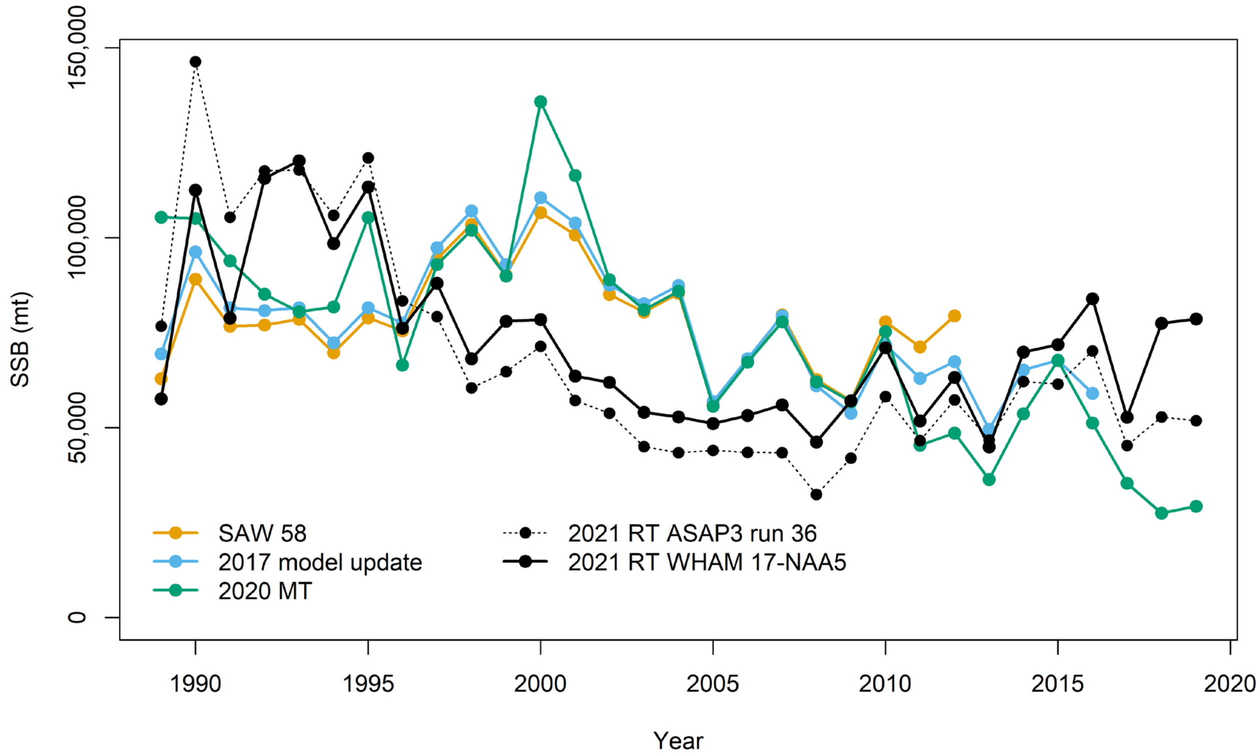
Further development in WHAM

- Highlights of WHAM runs (continued)
  - Estimating Beverton-Holt stock-recruitment; able to estimate Beverton-Holt parameters for some WHAM models; however, inappropriate because recruits in the butterfish assessment are age 0, and WHAM assumes age 1 recruits enter the population on January 1
  - Time-varying selectivity vs. 2 blocks for the fishery; model with time-varying logistic selectivity did not converge; model with time-varying age-specific selectivity was promising but did not have better diagnostic performance than 17-NAA5; retained two blocks from ASAP run 36 (1989–2013 & 2014–2019)

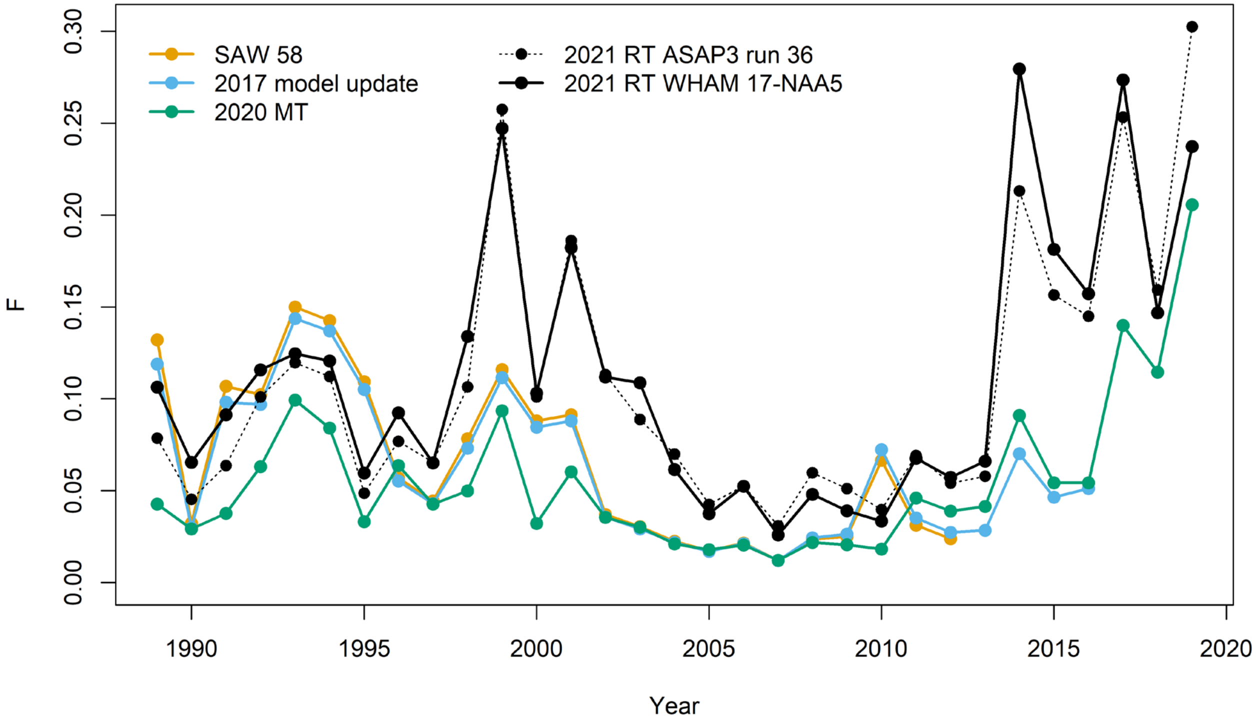
Further development in WHAM

- Summary of WHAM 17-NAA5
  - Input data file from ASAP3 run 36
  - Estimates all NAA as random effects with AR(1) correlation by year, but independent across ages
  - Logistic-normal age composition likelihood; self weighting; allows more general correlation structure than multinomial; and has outperformed the multinomial in simulation studies (Fisch et al., 2021; Francis 2014)

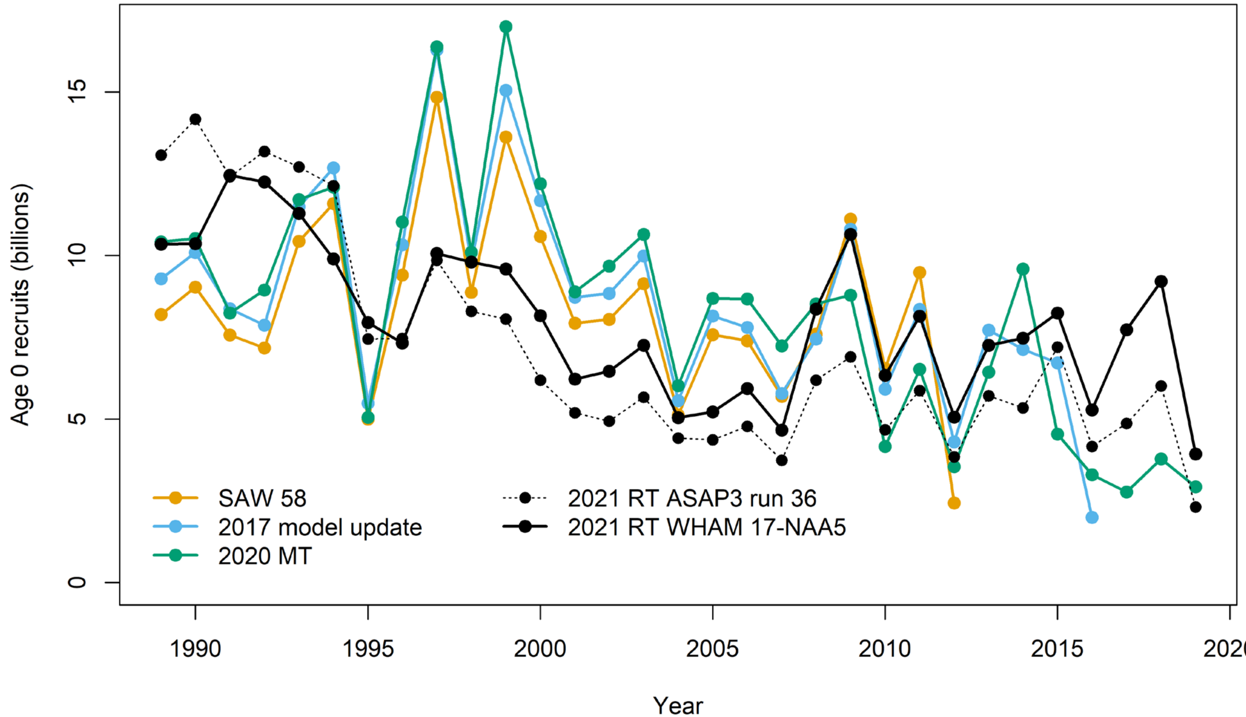
Historical retrospective



Historical retrospective



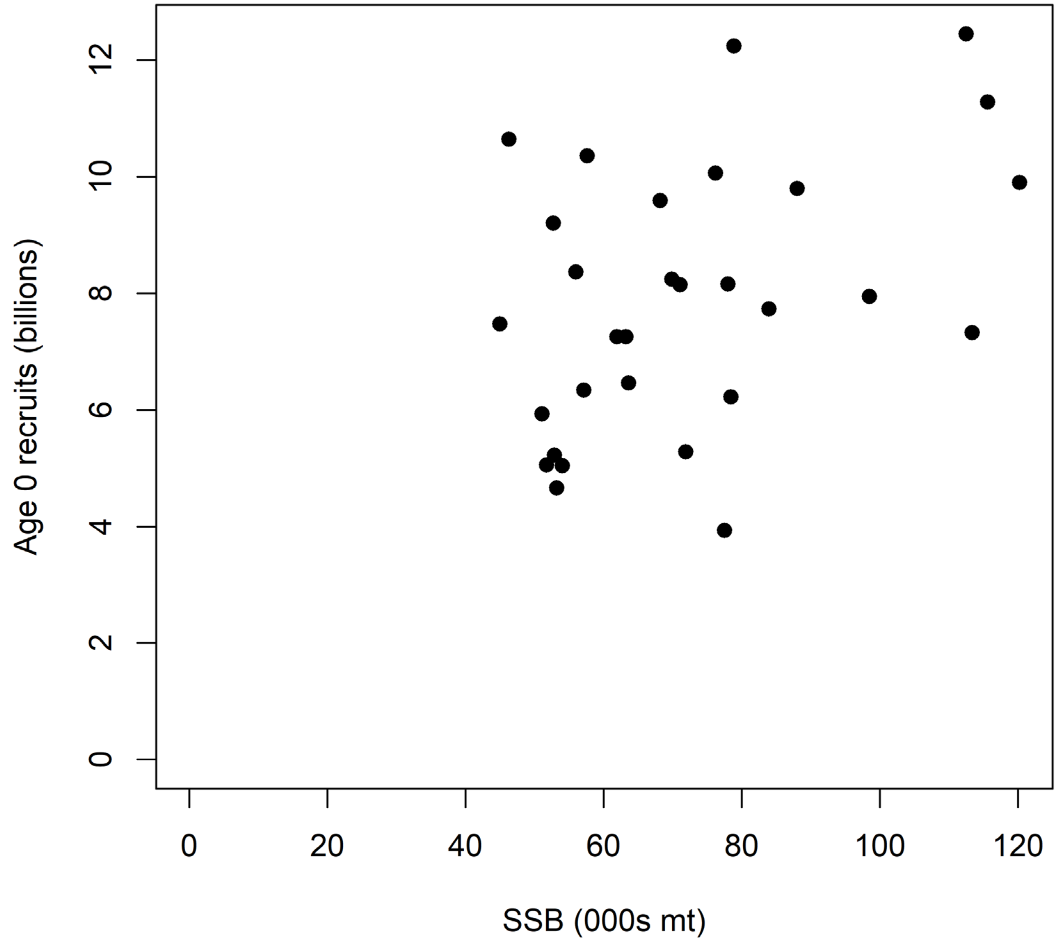
Historical retrospective



SAW 58 F_{MSY} proxy

I've got this slide in here because I'm getting the sense that the panel thinks 2/3M is preferable to the high F50% = 6.68

- Previous F_{MSY} proxy = 2/3*M* based on Patterson (1992)
- Concerns with Patterson (1992)
  - Methods used were intended to identify a reference point that would induce stability in biomass, and not necessarily identify an F_{MSY} proxy
  - Used VPA estimates of biomass and exploitation rate, which are known to produce spurious trends under many circumstances (Lapointe et al. 1989, 1992)
  - Use of stock assessment output as data without due consideration of uncertainty has also been criticized (Brooks and Deroba 2015)



This is to discuss some of the other F proxies we looked at

New BRPs

- Assume a symmetrical production curve
  - $B_{MSY} = 0.5 \times B_0$ (in the absence of a stock-recruit curve this equates to $B_{50\%SPR}$)
  - Overfished = $0.5 \times B_{MSY}$
  - Classical theoretical underpinnings
  - Generally in line with the MAFMC's Ecosystem Approach to Fisheries Management guidance for forage fish

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TOR4: New BRPs

- $F_{50\%SPR}$ and $B_{50\%SPR}$ calculated internally in WHAM assuming
  - Average recruitment over 2011–2019; regime shift in butterfish condition in 2011 (Smith WP)
  - Average SSB per recruit over 2015–2019 (selectivity, maturity, weights at age); standard practice in the region
- $F_{50\%}$ = 6.68
- $B_{50\%}$ = 37,597 mt

TOR5: Stock status

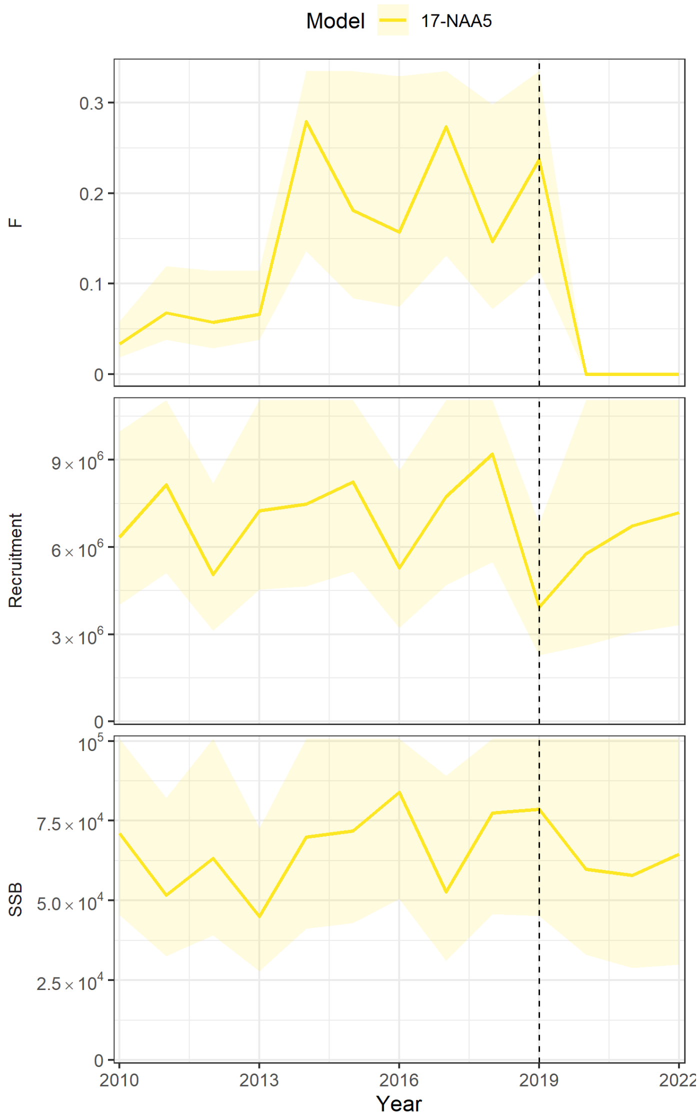
- In 2019 the butterfish stock was not overfished ($B_{2019}/B_{50\%} > 1$) or experiencing overfishing ($F_{2019}/F_{50\%} < 1$)

$F_{50\%}$	$B_{50\%}$	$F_{2019}/F_{50\%}$	$B_{2019}/B_{50\%}$
6.68	37597	0.04 (0.02-0.07)	2.09 (1.20-3.64)

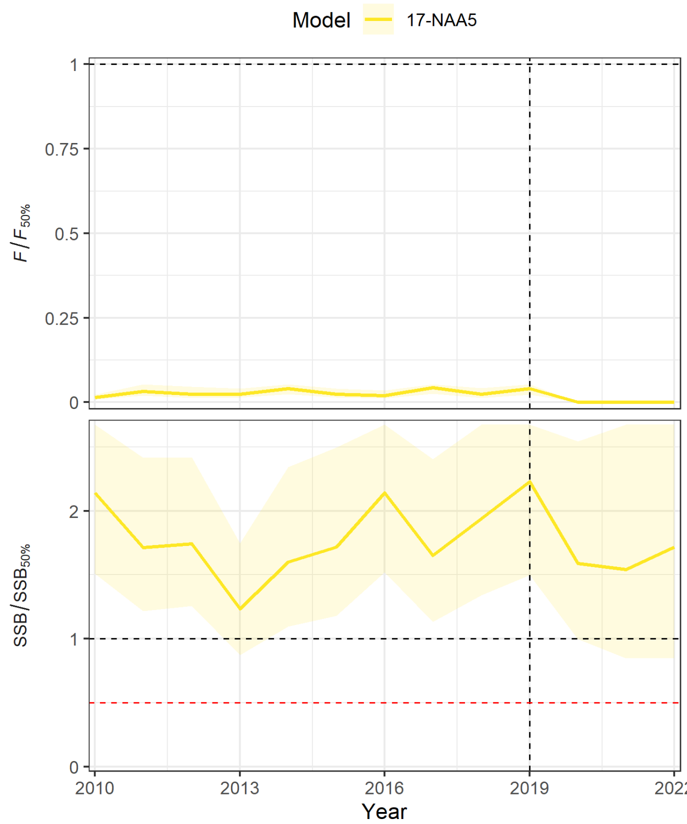
TOR6: Projections

- Assumption that the NAA deviations follow an AR(1) process is continued into the projection period for consistency
- Demonstrate how 3-year projections for catch advice this could be done in WHAM with three F scenarios:
  - $F = 0$
  - $F = F_{2019}$ (terminal year F)
  - $F = F_{50\%}$ (FMSY proxy)
- Assumed same selectivity, maturity, weights at age as reference points

F = 0

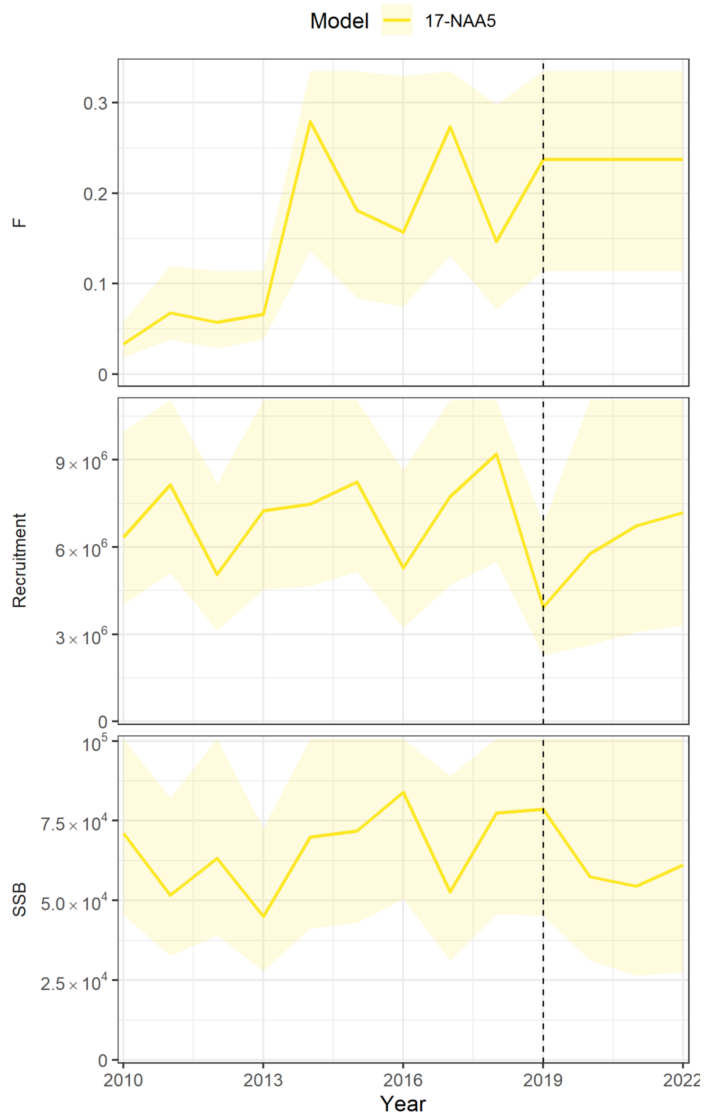


Model
17-NAA5
F
0.3
0.2
0.1
0
Recruitment
9 × 10^6
6 × 10^6
3 × 10^6
0
SSB
10^5
7.5 × 10^4
5.0 × 10^4
2.5 × 10^4
0
2010
2013
2016
2019
2022
Year

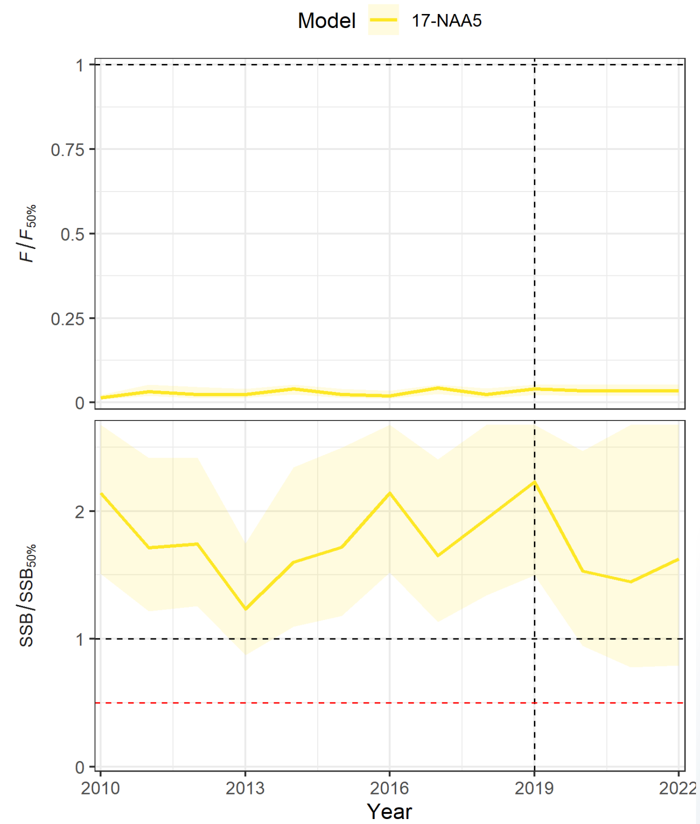


Model
17-NAA5
F / F50%
1
0.75
0.5
0.25
0
SSB/SSB50%
2
1
0
2010
2013
2016
2019
2022
Year

$F = F_{2019}$

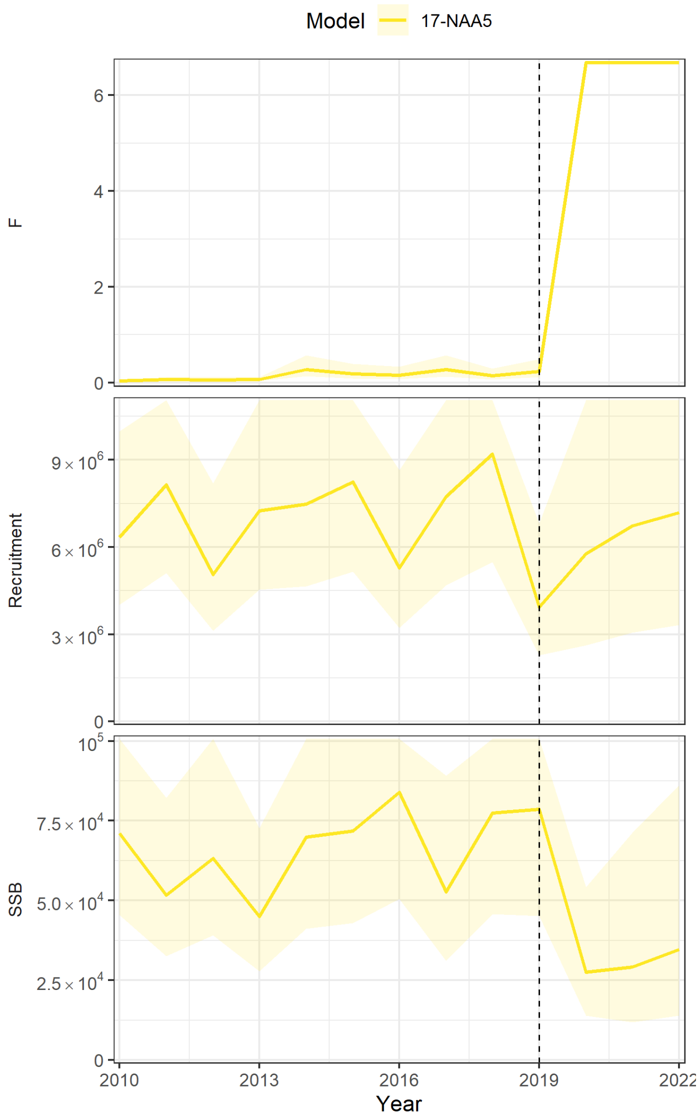


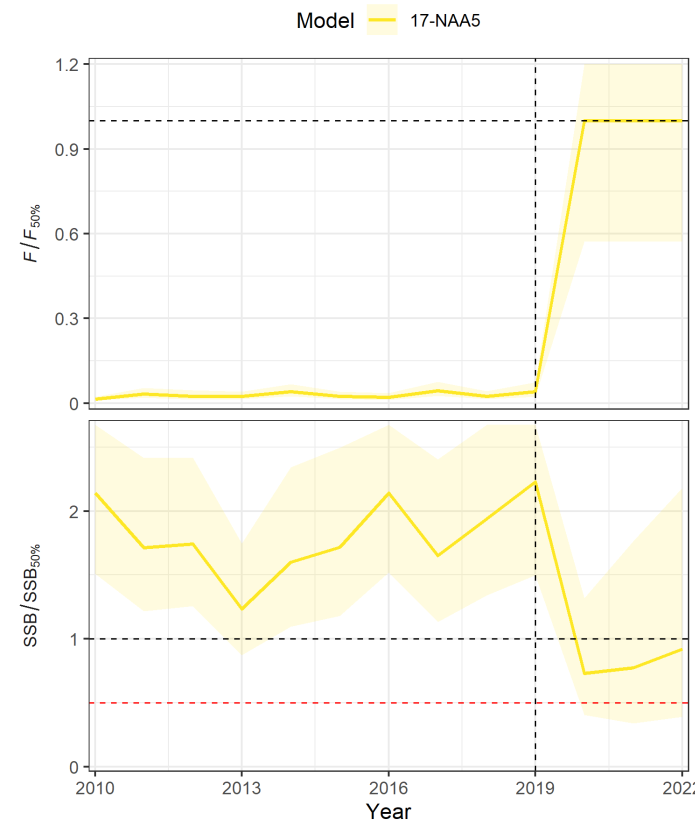
Model
17-NAA5
F
0.3
0.2
0.1
0
Recruitment
9 × 10^6
6 × 10^6
3 × 10^6
0
SSB
10^5
7.5 × 10^4
5.0 × 10^4
2.5 × 10^4
0
2010
2013
2016
2019
2022
Year



Model
17-NAA5
F / F50%
1
0.75
0.5
0.25
0
SSB/SSB50%
2
1
0
2010
2013
2016
2019
2022
Year

$F = F_{50\%}$


Model
17-NAA5
F
Recruitment
SSB
Year
2010
2013
2016
2019
2022


Model
17-NAA5
F / F50%
SSB/SSB50%
Year
2010
2013
2016
2019
2022

Research recommendations

- Conduct a new evaluation of survey catchability
- Development of a model with a subannual time step
- Consider alternative (area, or habitat, weighted) averaging for the aggregated state survey YOY index
- Develop a wider range of diagnostics for state-space models

Other considerations

Other considerations

- P* calculations
  - In AGEPRO the 50th percentile (median) of the simulated values for SSB and catch are what go into the Excel spreadsheet
  - WHAM currently gives a mean and standard deviation of predicted SSB in a given year
  - Code could be written to perform simulations for just the projection period in WHAM that would mimic AGEPRO if necessary
  - Easier and faster approach would be to use the posterior estimates of a value in a given year
- Next topic

Backup slides

SAW 58 model

- Surveys in SAW 58 model
  - NEFSC fall offshore
  - NEFSC fall inshore
  - NEAMAP fall
- Surveys in 2021 RT WHAM model
  - NEFSC fall Albatross
  - NEFSC fall Bigelow
  - NEAMAP fall
  - NEFSC spring Bigelow
  - NEAMAP spring
  - Young-of-the-year index (combines state survey data from EM, MA, RI, CT, NJ, DE)