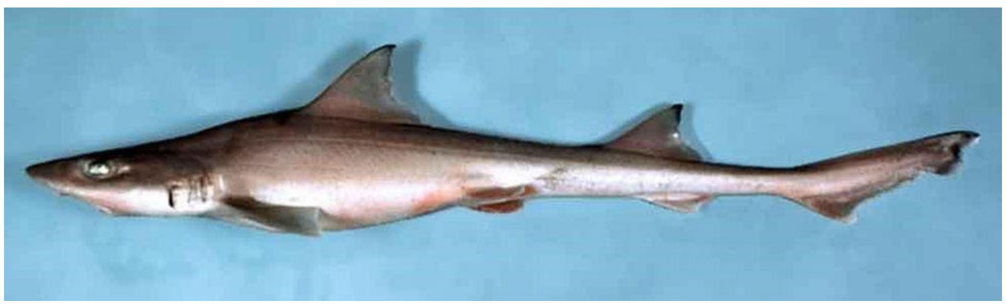
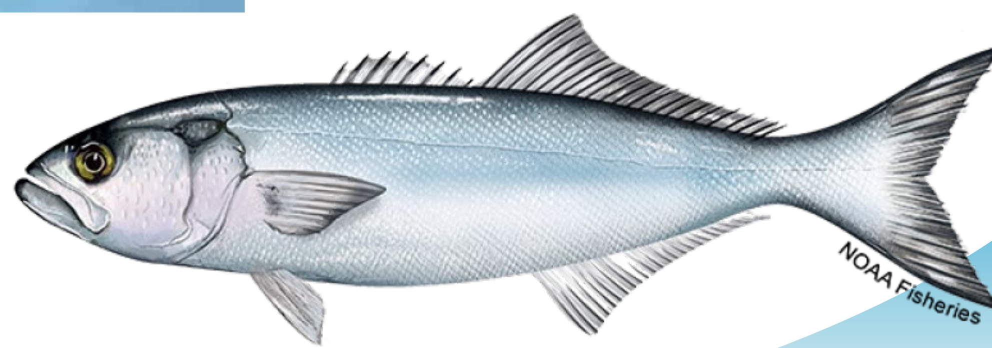
Spiny Dogfish and Bluefish Research Track Assessments





Spiny Dogfish Research Track Working Group

- **Co-Chairs:** Conor McManus & Cami McCandless
- **Lead:** Dvora Hart
- **Working Group Members:**
  - Jason Didden
  - Kristen Anstead
  - Halie O'Farrell
    Jui-Han Chang
  - Kathy Sosebee
  - Alex Hansell
  - Ben VanDine
- **June 30, 2021 – November 1, 2022**
- **Met 23 times**

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

Bluefish Research Track Working Group

- **Chair:** Michael Celestino
- **Lead:** Tony Wood
- **Working Group:**
  - Karson Cisneros - MAFMC
  - Katie Drew – ASMFC
  - Sam Truesdell – MADMF
  - Abigail Tyrell – NEFSC
  - Jessica Valenti - NEFSC/Rutgers
  - Samantha Werner – NEFSC
- **July 29, 2021 – October 11, 2022**
- **Met 21 times**

Research Track Peer Review

- **December 5-8, 2022**

- **Review Panel:**

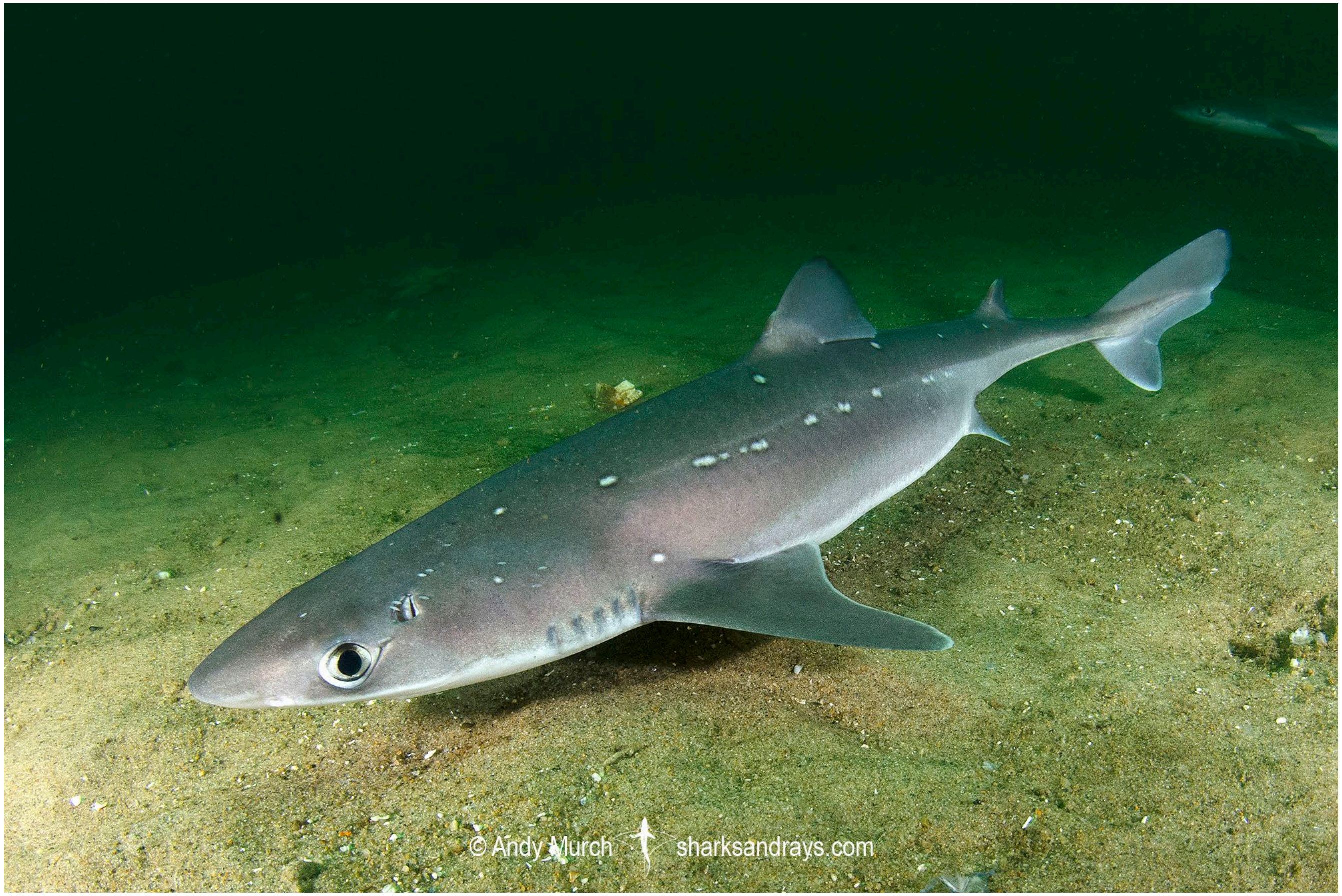
  Dr. Yan Jiao, Chair
  - MAFMC SSC Member: Virginia Tech University

  Dr. Robin Cook, CIE Reviewer
  - University of Strathclyde, United Kingdom

  Dr. Paul Medley, CIE Reviewer
  - Independent Consultant, United Kingdom

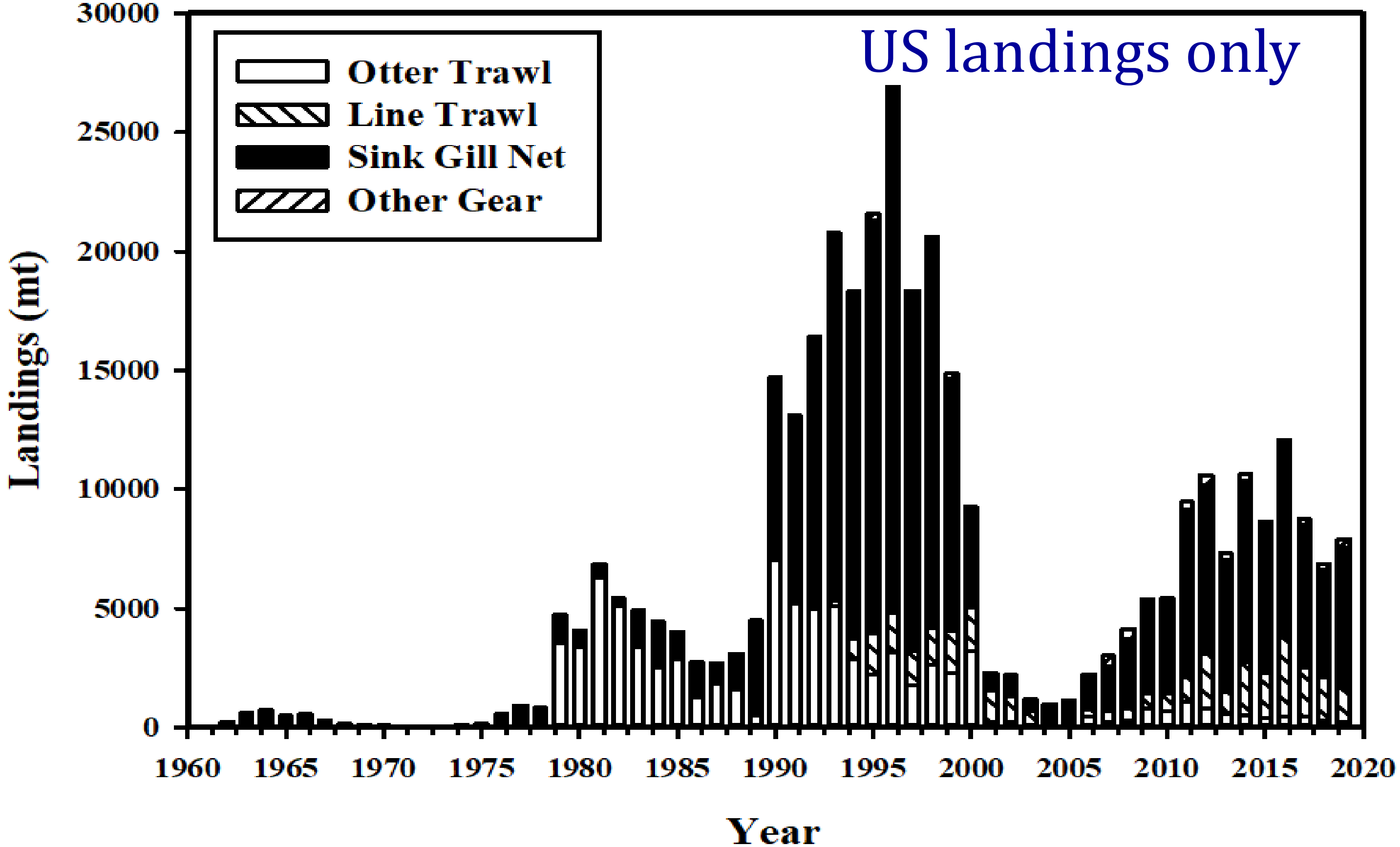
  Dr. Joe Powers, CIE Reviewer
  - Independent Consultant, United States

Spiny Dogfish Research Track Assessment



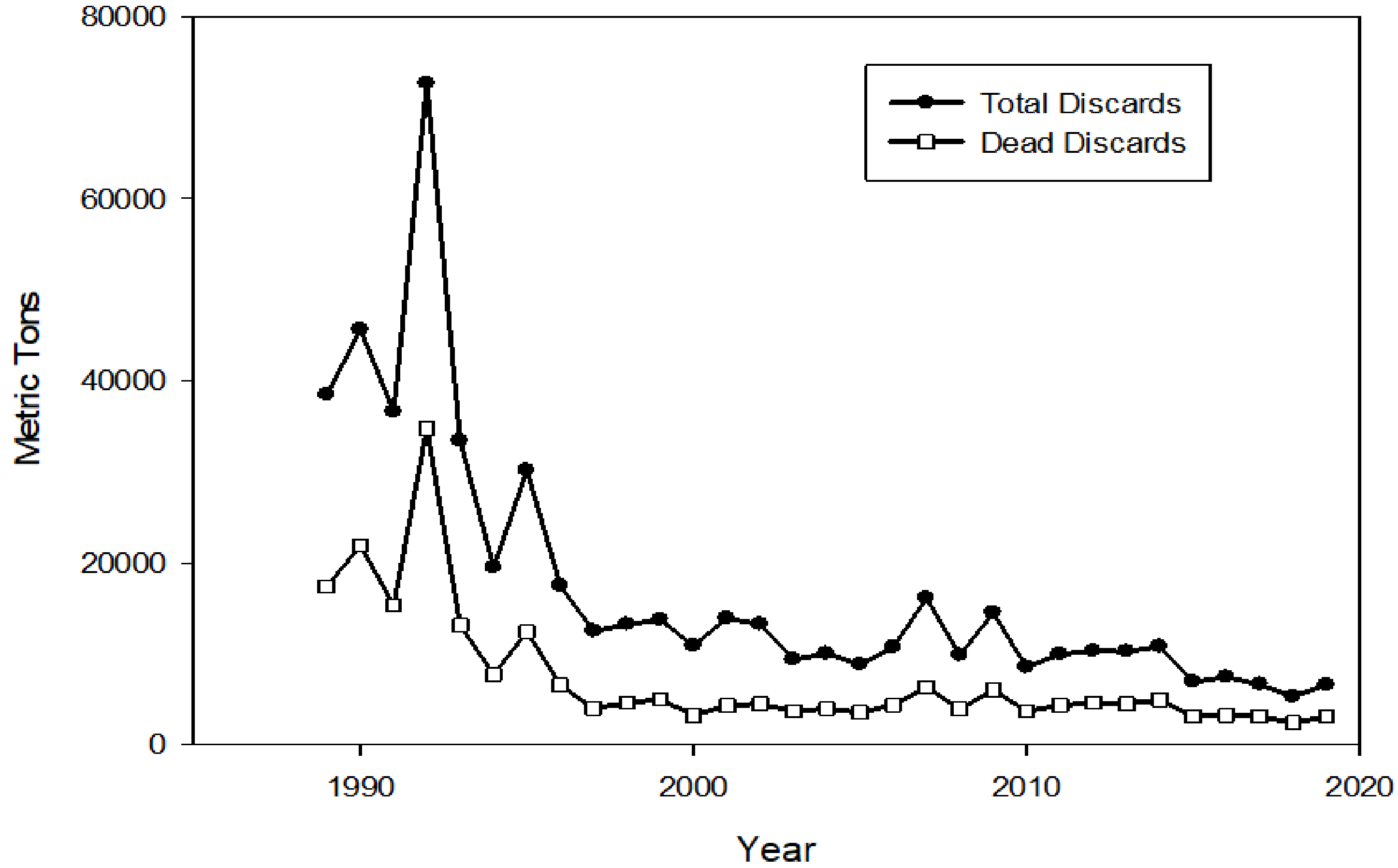
Landings

Gillnets have been the primary gear since 1989
Earlier landings were dominated by otter trawls, and in the 1960s and 70s, foreign trawlers

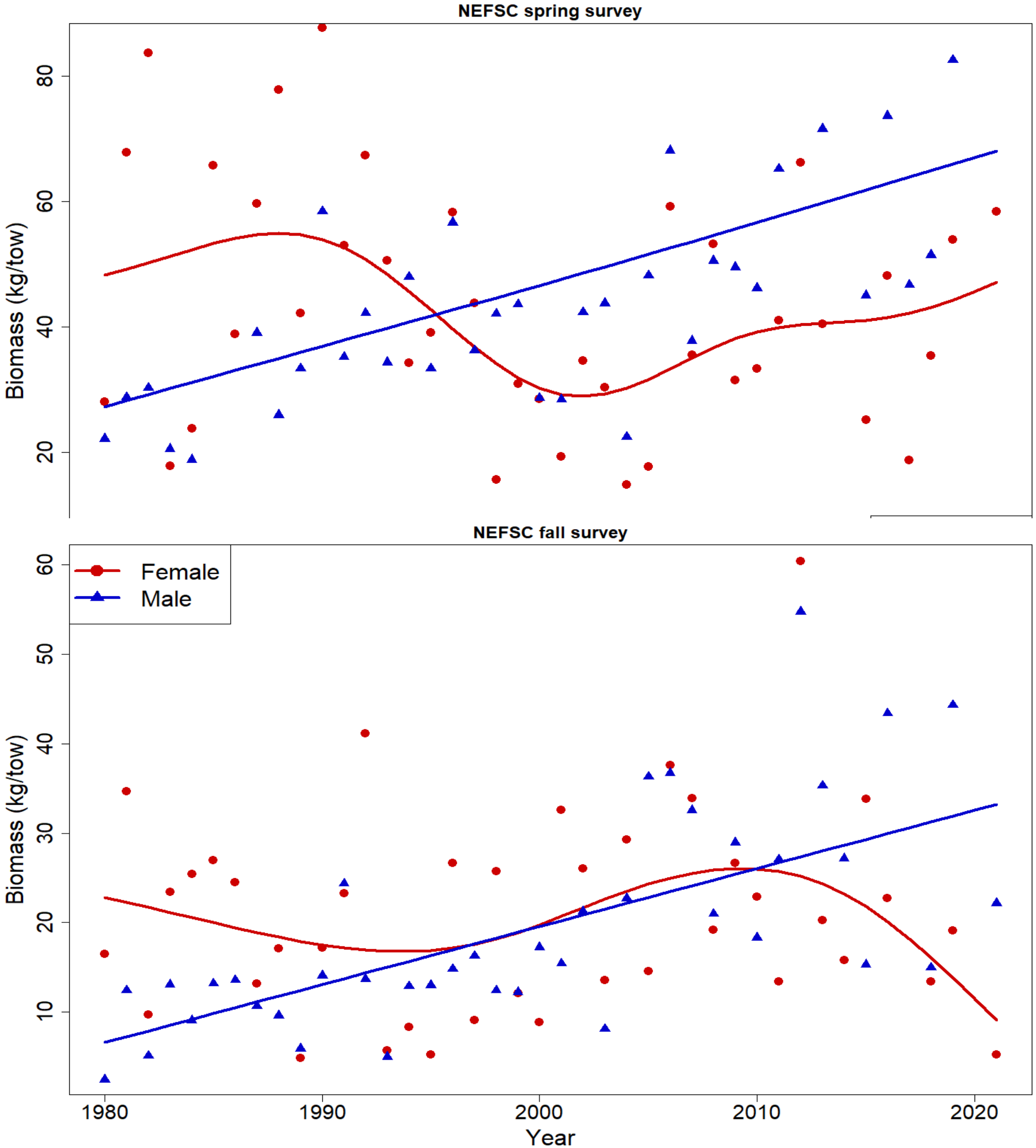


Discards

Discards have declined since the early 1990s but still comprise a substantial portion of the catch



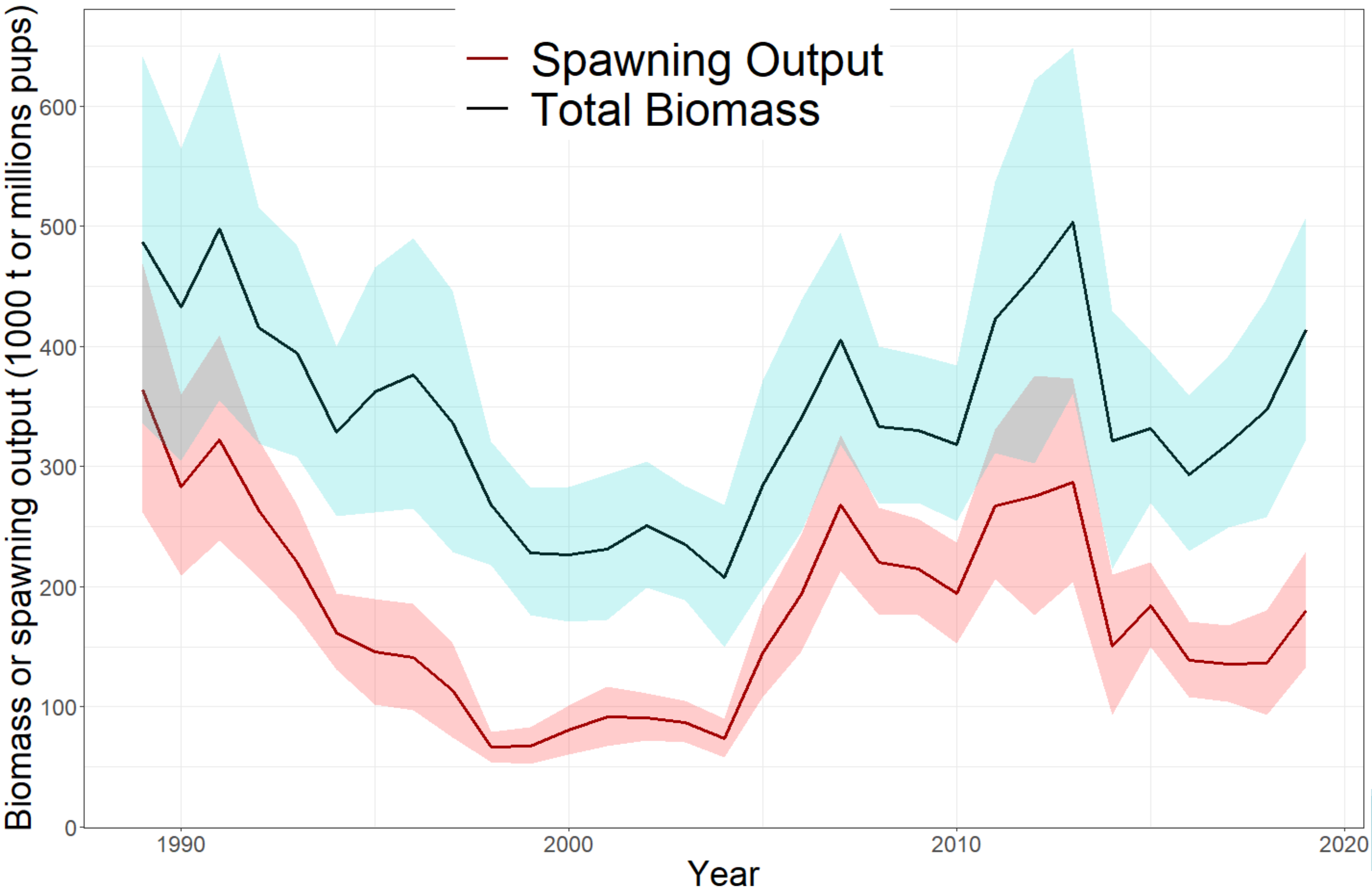
Surveys



Males increasing
Recent trend for females slightly increasing in the spring survey, decreasing in the fall survey

Surveys

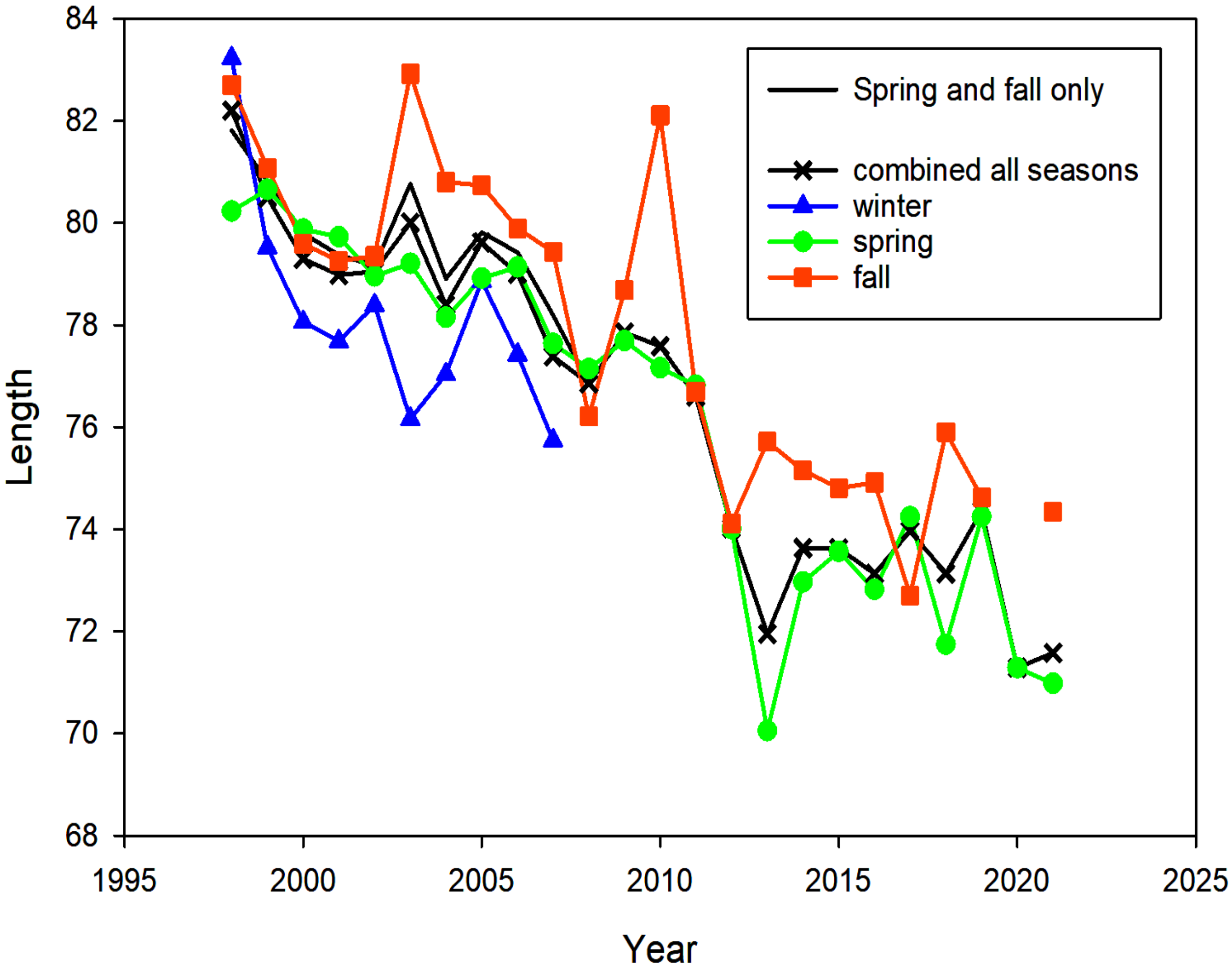
Spawning output (calculated pup production, similar to spawning stock biomass) has been low in recent years, based on the spring survey, due to the limited number of mature females. Consistent with this, recent recruitment has also been low.



Expanded spring survey trends, using a 3-year moving average smoother

Life History

Decreasing length at maturity



Female spiny dogfish are maturing at smaller lengths in recent years and are not growing as large (asymptotic female length reduced from 100.5 to 89.24 cm)

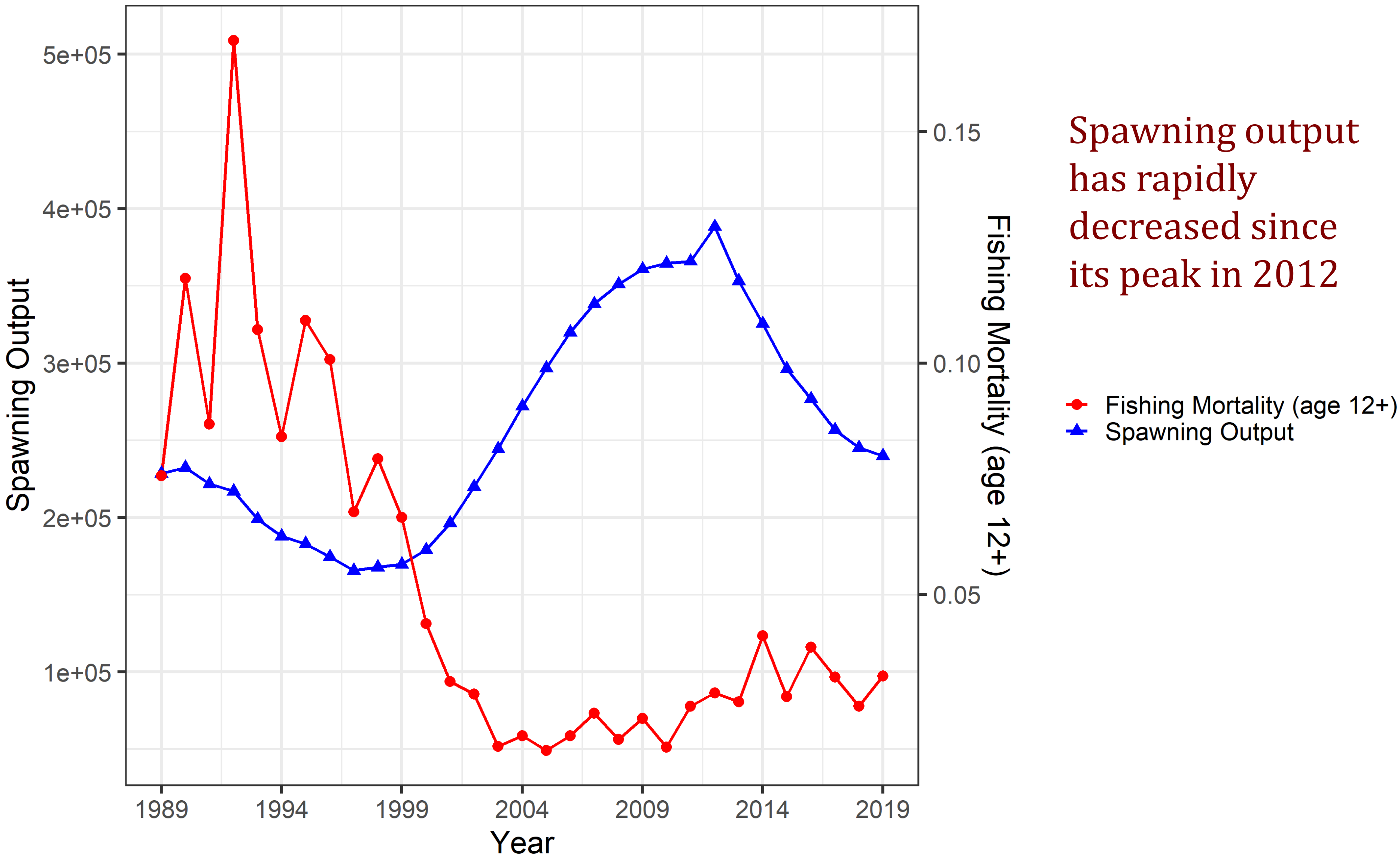
Stock Synthesis 3

- Stock assessment model commonly used on the US west coast. It was recently successfully used to assess Pacific spiny dogfish

- Does not require age data (not available for spiny dogfish) – can directly use length data instead

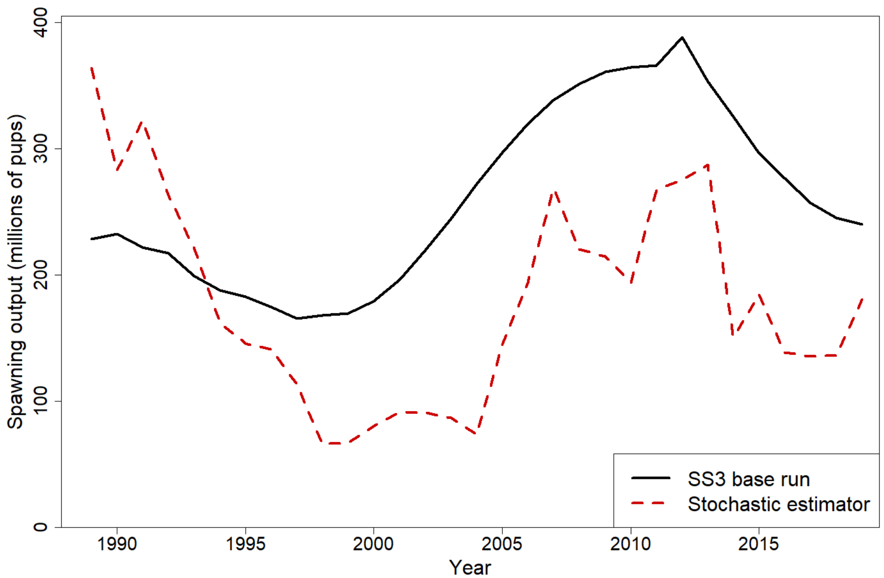
- Can model sexes separately:
    - important for spiny dogfish, which is sexually dimorphic and where only females are targeted

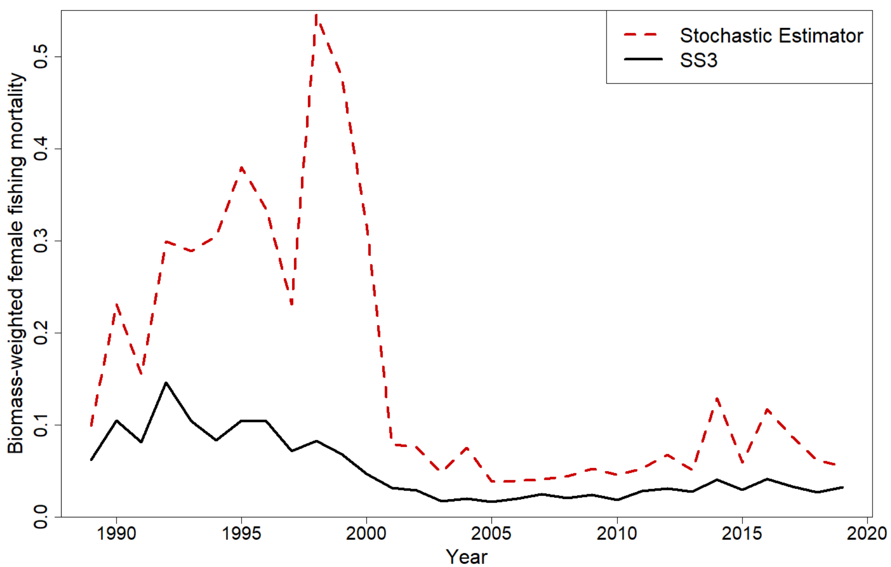
Stock Synthesis 3 - results



Spawning output has rapidly decreased since its peak in 2012

Stock Synthesis 3 – Comparison with the Stochastic Estimator (previous method)





- SS3 typically estimates higher biomass, spawning output, and lower *F*, since it is not assuming 100% catchability
- Trends during 2000-2019 are similar for the two models.
- However, spawning output and biomass declined much faster in the survey/stochastic estimator than in SS3 during 1989-1999.
- This indicates some misspecification during that time (e.g., underestimated catch, changes in growth).

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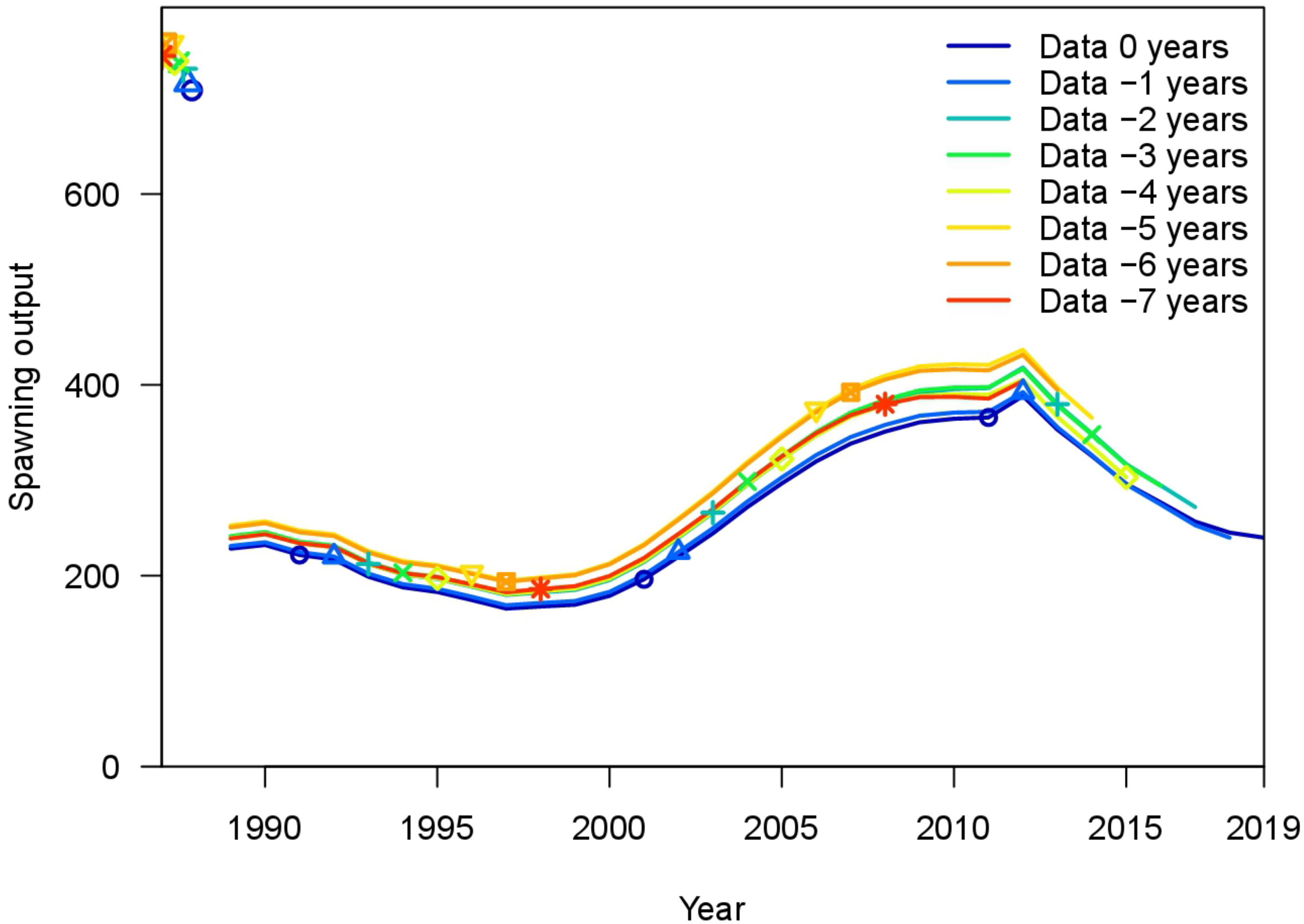
Stock Synthesis 3 – retrospective pattern

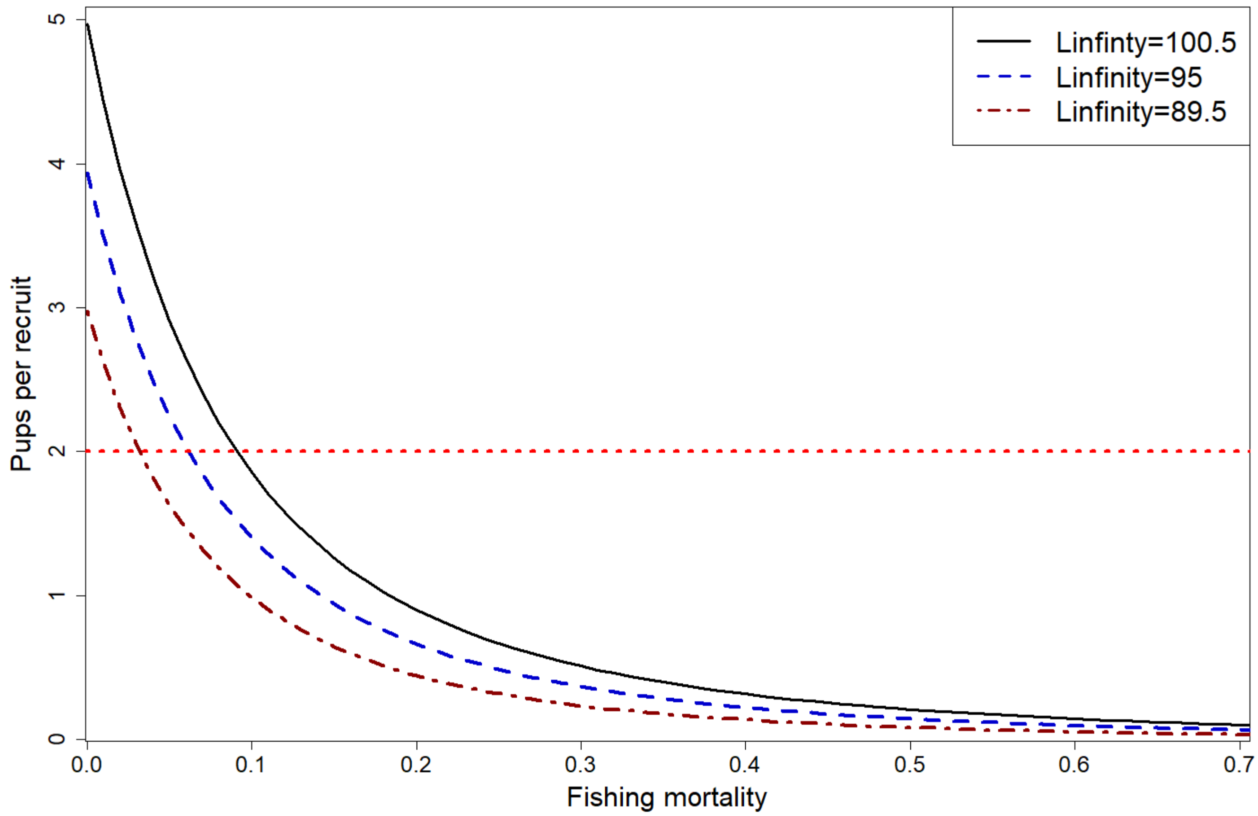


Model is stable, with very little retrospective pattern

(Mohn's ρ= 0.06)

Reference Points – Pups per recruit

Must have more than two pups per female recruit for sustainability. At current growth, this means $F < 0.03$



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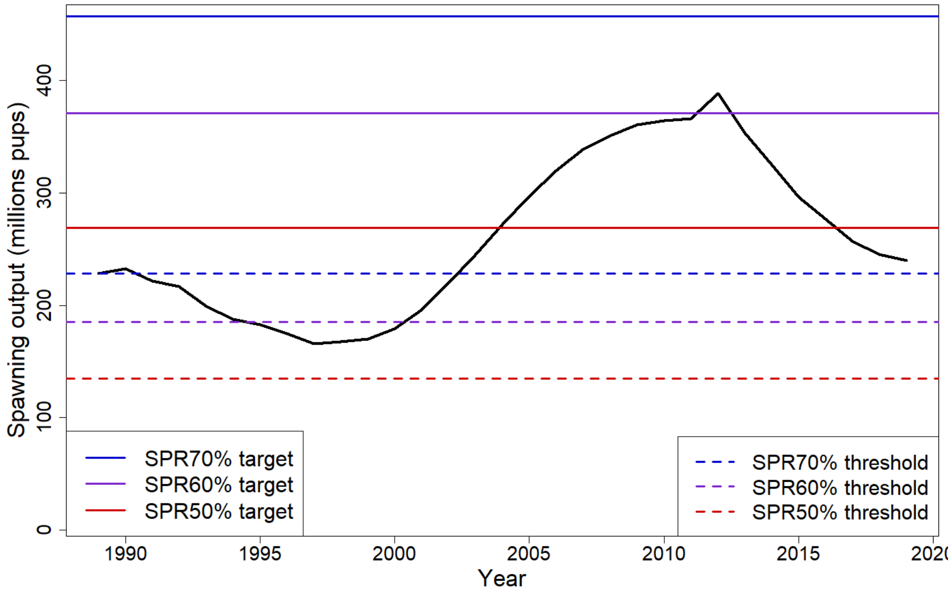
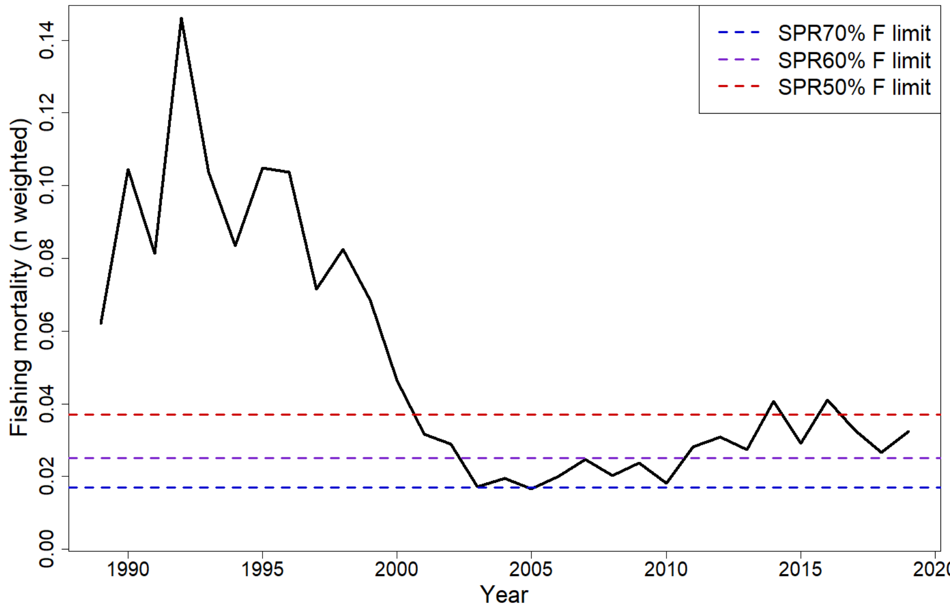
Spawner per Recruit Reference Points

Three spawner per recruit reference points were considered – 50%, 60%, 70%. Fishing at 50% SPR produced less than 2 pups per recruit. Also, *F* was typically below the 50% SPR *F* limit during 2013-2019 and yet spawning output decreased rapidly.

When F was below the 60% SPR *F* limit, spawning output increased whereas it decreased when *F* was above this limit. For these reasons, SPR60% reference points were chosen.





Reference Points using SPR60%

Target spawning output	370.8 million pups
Limit *F* rate (females)	0.025
MSY	16,792 mt

Using these reference points, and assuming spawning output threshold is half the target, overfishing was occurring in 2019 (0.032 > 0.025) but the stock was not overfished

Projections using SS3

SS3 predicts a large drop in spawning output between 2019-2020, and then gradual increases, as several stronger year classes begin to mature.

Uncertainties and Research Recommendations

- The working group was unanimous that the lack of age/growth data during the last 40 years was the most problematic aspect of this assessment.

  It recommended that an aging program for spiny dogfish should be established to allow for the continuous inclusion of such data and better inform growth in the assessment model.

Bluefish Research Track Assessment

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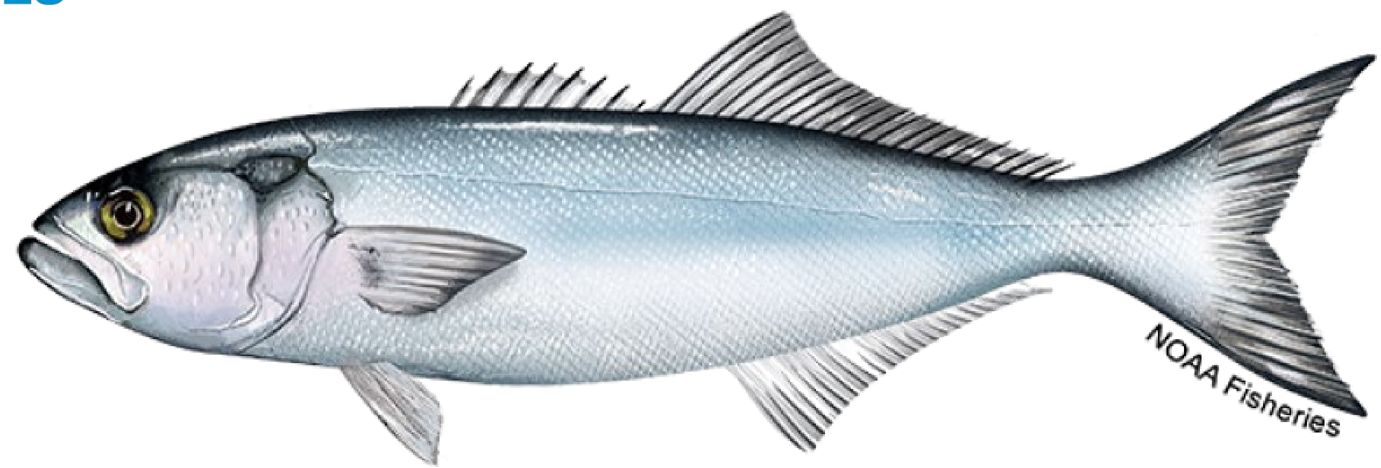
- NEFSC



Model Building Summary

- **Model building procedure was primarily carried out in ASAP**
  - First step was to update the SAW60 model through 2021: Continuity run
  - A base model was constructed by adding new data and indices to the continuity run WHAM is a flexible
- **A model bridge was then built through step wise changes in data (changes in calculation, addition of new data, removal of data), model specifications, and weights**
- **The final ASAP model was shifted into a new model framework, WHAM**
  - General state-space age-structured assessment model that is able to incorporate environmental effects on population processes
  - Models that included random effects on the NAA were explored and model selection was used to select the final model

Woods Hole Assessment Model (WHAM)

- WHAM is a flexible model framework that can be configured as a traditional statistical catch-at-age model, which allows for bridge building transitions from models like ASAP
- The RT2022 working group chose WHAM because of its flexible framework, specifically allowing for the estimation of random effects on recruitment and NAA
- State-space models tend to have lower retrospective bias in model results, and more realistic estimates of uncertainty
- Also shifted into WHAM to explore environmental covariate links on the catchability of different surveys indices
- The focus of the model exploration in WHAM was to investigate NAA RE with the final bluefish model from ASAP, and not continue building a model bridge

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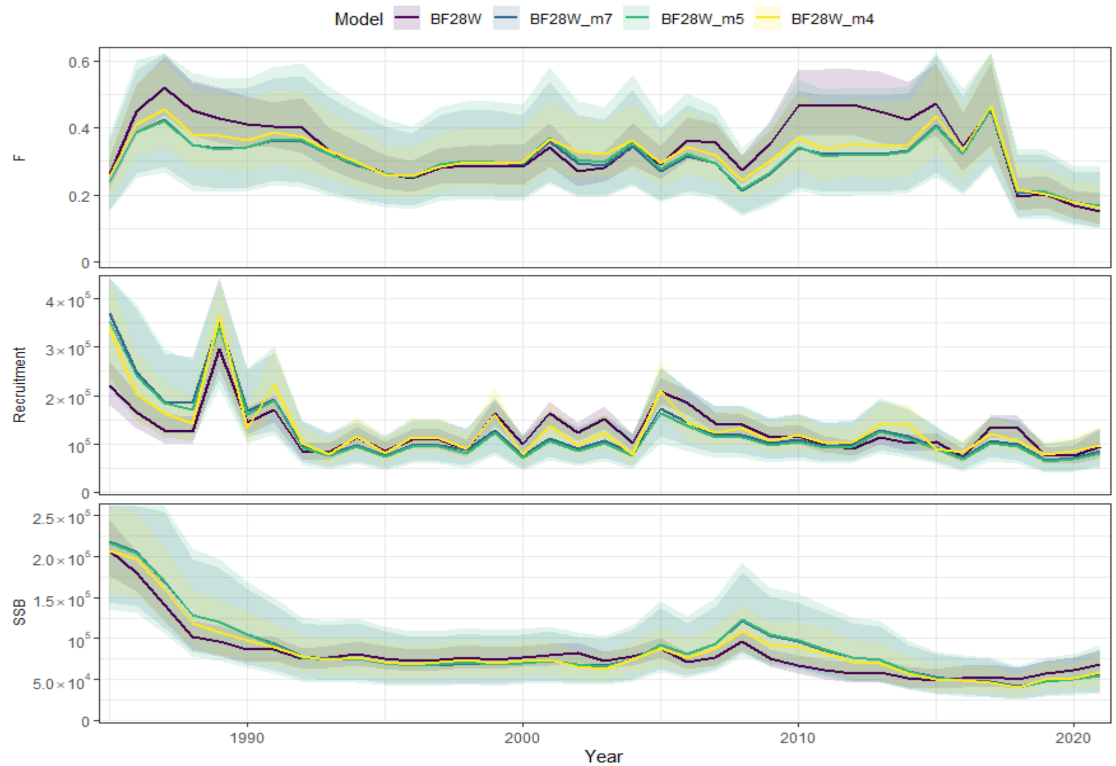
Final Bluefish Model: BF28W

- The Final model was explored with random effects on recruitment and numbers-at-age
- Each model explored different options for treating the yearly transitions in survival

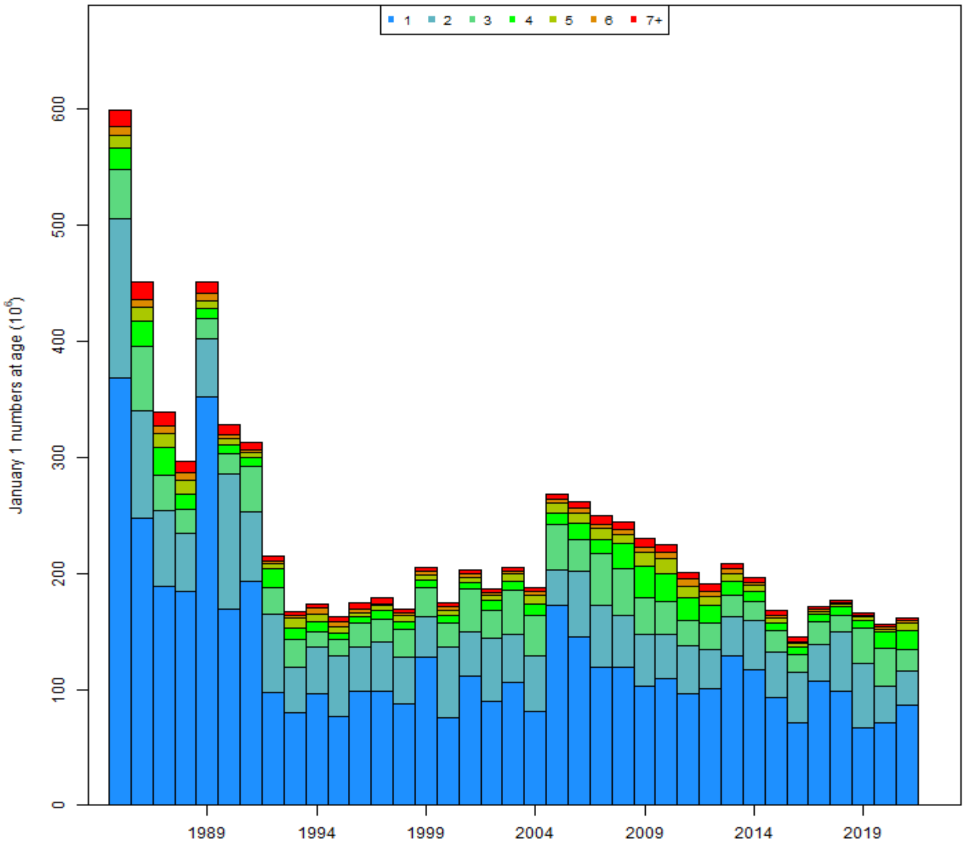
Best State Space Models: Results

- Results from the top 3 state-space models and the base statistical catch-at-age model show good agreement among the model results

- Final model chosen as full state-space model with NAA deviations on all ages and correlation

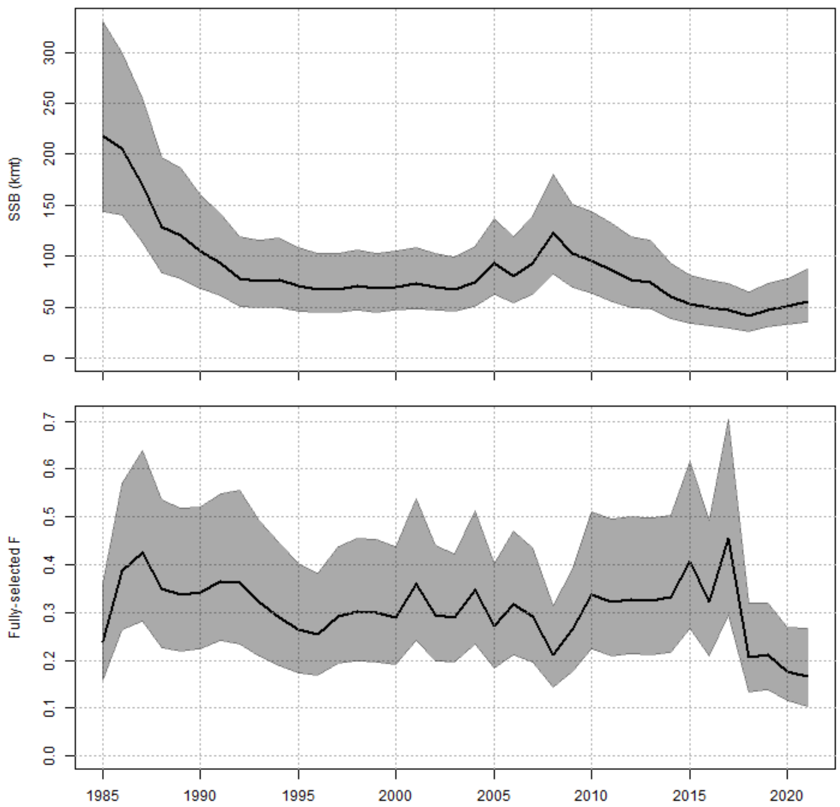


Final Model Abundance



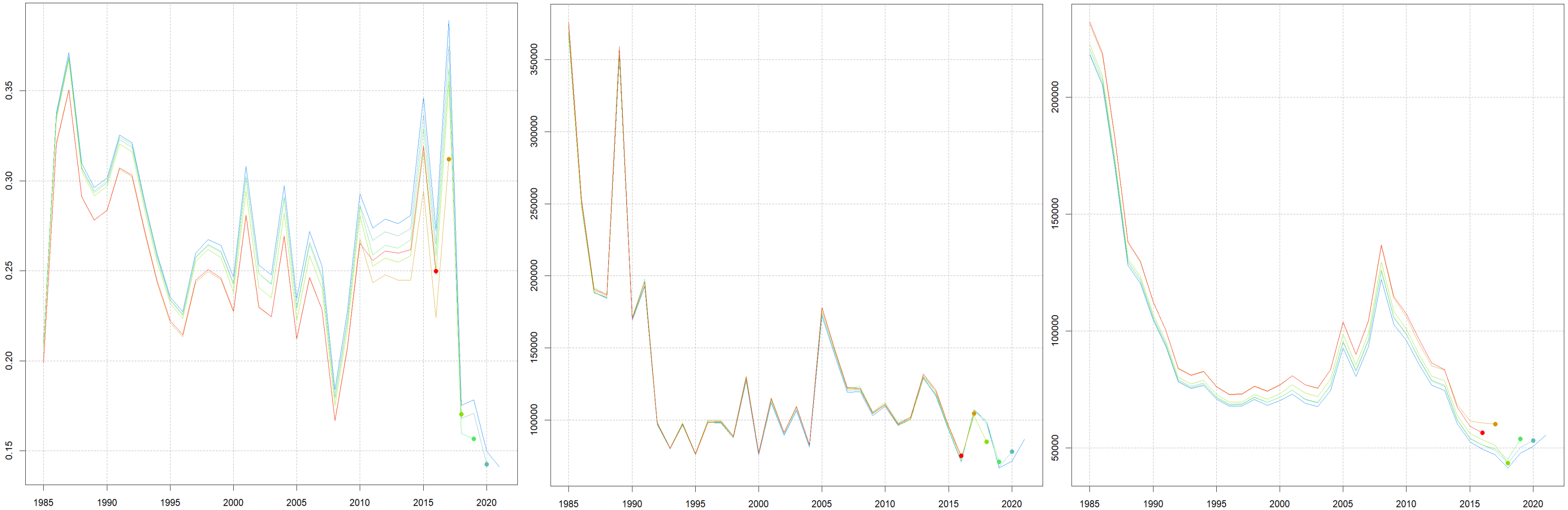
- Abundance estimates maximum of 599 million fish in 1985, declining to 162 million in 1995, increasing to a peak of 269 million in 2005, and the terminal year estimate of 162 million fish
- Estimates of recruitment have remained steady since 1992, fluctuating around a time-series average of 128 million fish.
- Recruitment has remained below average for the past 12 years, and was estimated at 87 million fish in 2021

Final Model SSB and F



- Spawning stock biomass started from a high of 218,291 MT in 1985, declined over the time-series to a low of 41,377 MT in 2018, and increased to a value of 55,343 MT in 2021
- The majority of the spawning stock biomass is ages 4, 5, and 6+ for the entire time-series
- Fully selected fishing mortality in 2021 was 0.166, compared to an average F from 1985 to 2021 of 0.309.
- Estimates of F have varied over the time series with a peak in 2018 of 0.456, and the lowest value of 0.166 in 2021

Final Model Retrospective



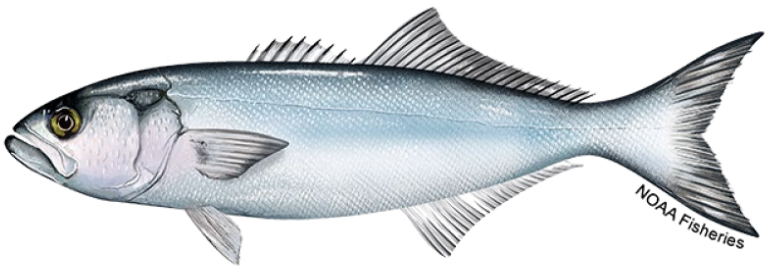
- Retrospective patterns for the final model are improved over the base model and were considered minor for:
  - fishing mortality (-0.096 vs -0.197)
  - recruitment (0.01 vs 0.06),
  - SSB (0.130 vs 0.248).

Environmental Co-Variate Companion Model

- One of the main reasons the bluefish assessment model was moved in WHAM was to explore environmental covariates on the catchability of different survey indices.
- Application of the forage fish index to the MRIP catchability was successful when implemented as an autoregressive process over the time-series with WHAM estimating the standard error
- Inclusion of the forage fish index improved the fit of all models (m2-m7), and model selection via AIC chose the environmental version of the base model as the best fitting model

Does prey drive availability of bluefish?

Bluefish, *Pomatomus saltatrix*



Bluefish diet in the Northeast US

Northeast Fisheries Science Center Diet Data Online: https://fwdp.shinyapps.io/tm2020/

We built a spatial "forage index" based on 20 prey groups using stomach contents of 22 predators

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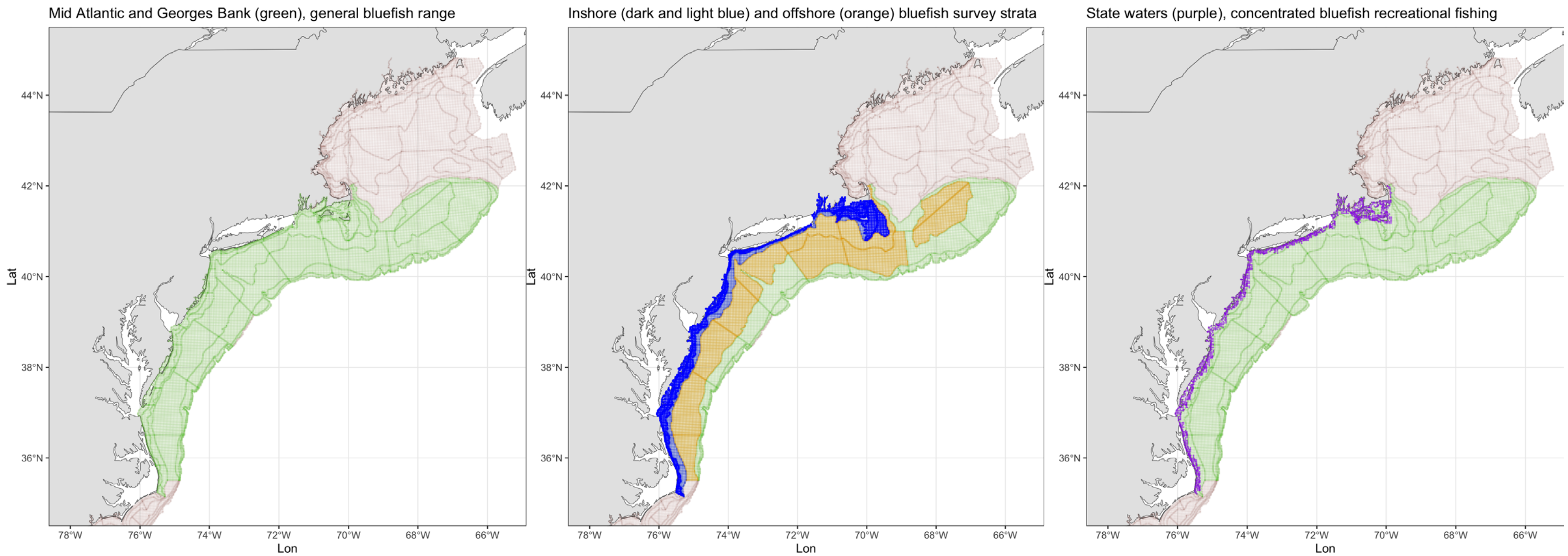
Aggregating predators: diet similarity to bluefish in gold

Aggregating predators: diet similarity to bluefish in gold

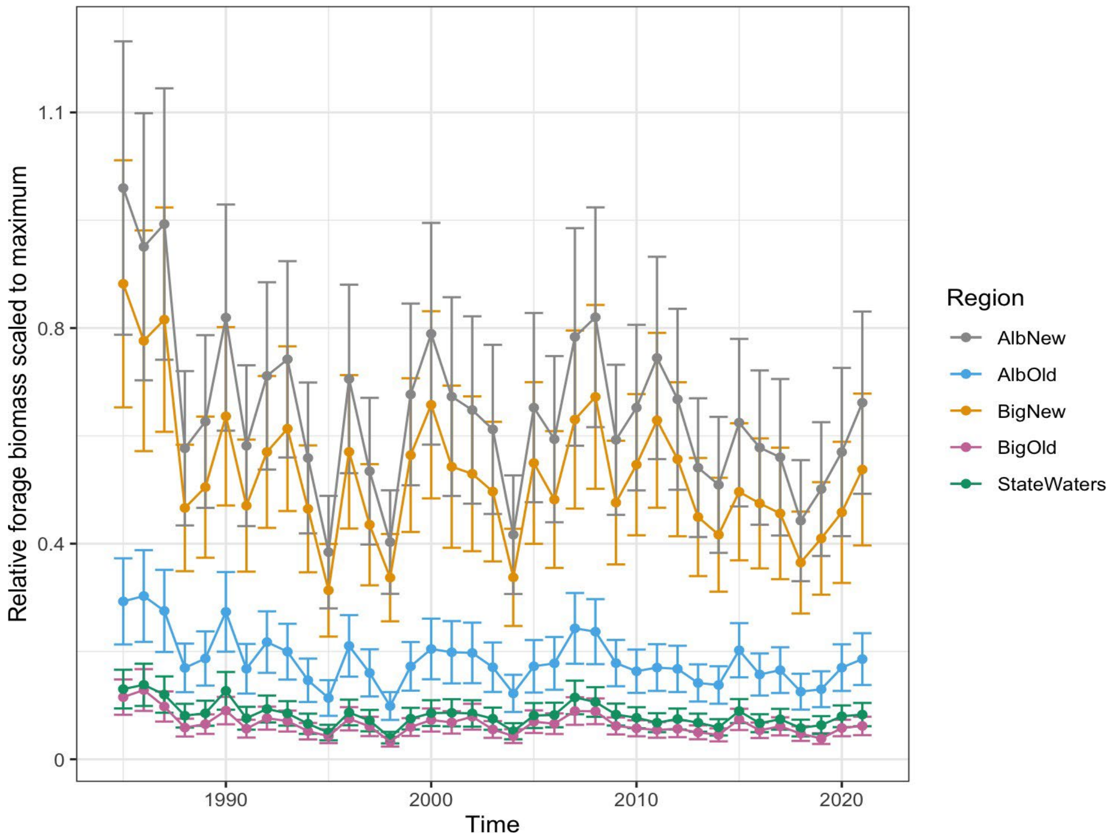
Spatial partitioning: examining forage trends at multiple scales



Maps of key areas for Bluefish assessment indices. The full VAST model grid is shown in brown.

Indices for aggregate small pelagics from piscivore stomachs can be calculated for any subset of the full model domain. Bias correction of the resulting indices is then applied (Thorson et al., 2016).

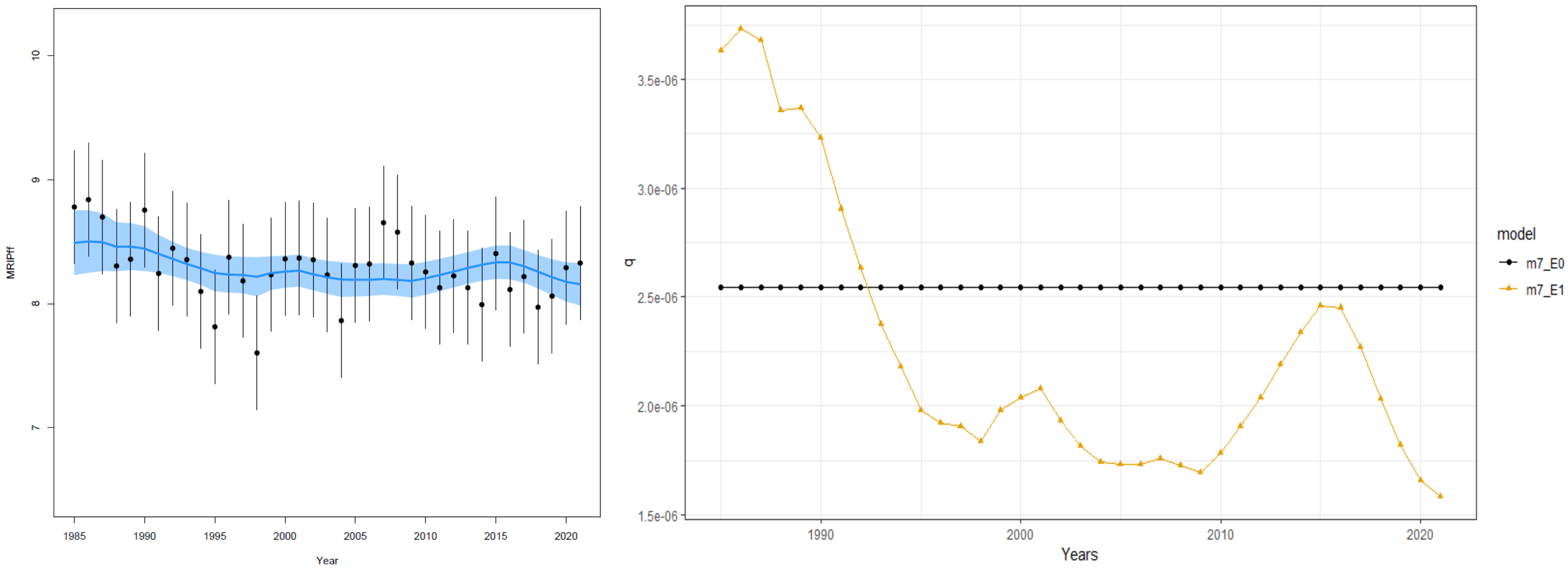
Results: Fall Forage Indices by area



Time series of VAST estimated fall forage indices for input into the bluefish assessment, 1985-2021

Northeast US VAST estimated Fall forage biomass density →

Environmental Covariate Companion Model

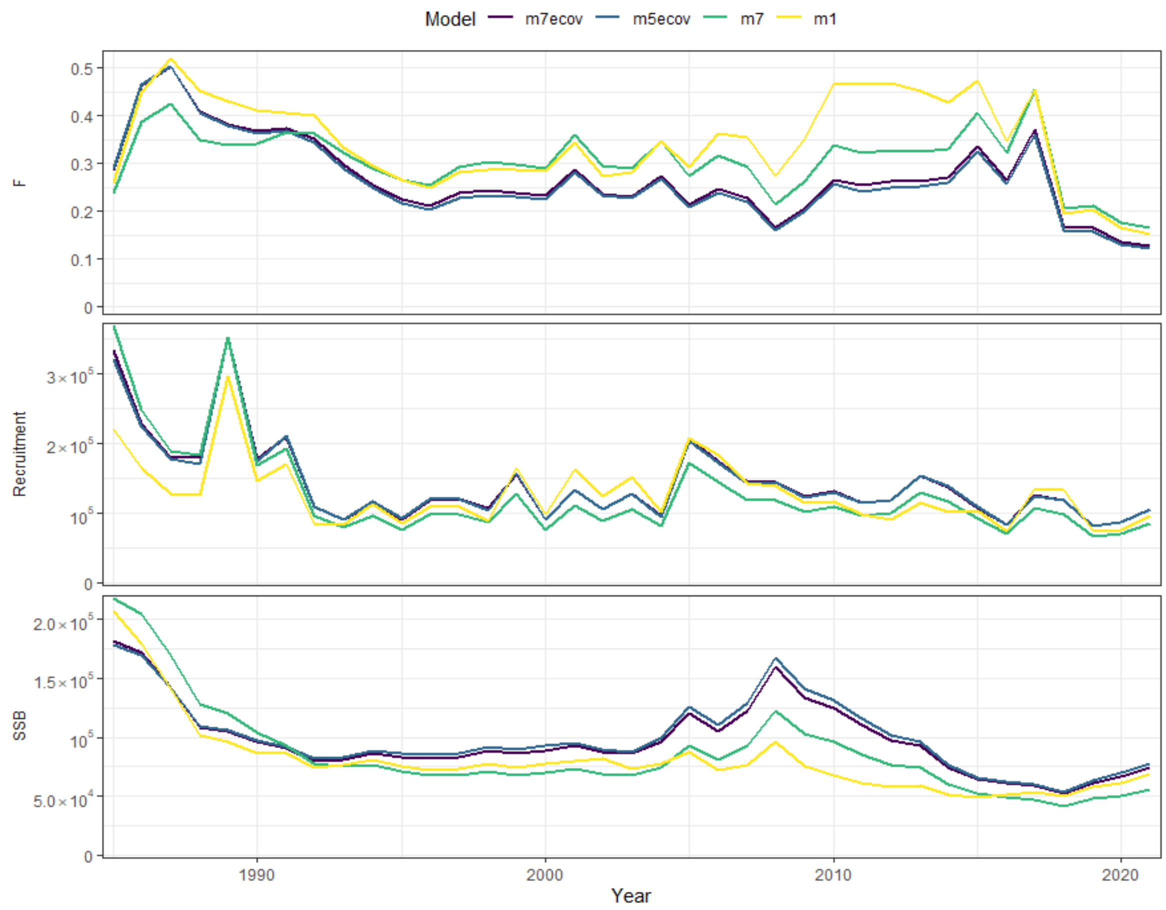


- Model fit to the forage fish index (Blue) shows a slight decline over-time, which results declining catchability (availability) over-time (Yellow) when fit as a covariate on MRIP CPUE

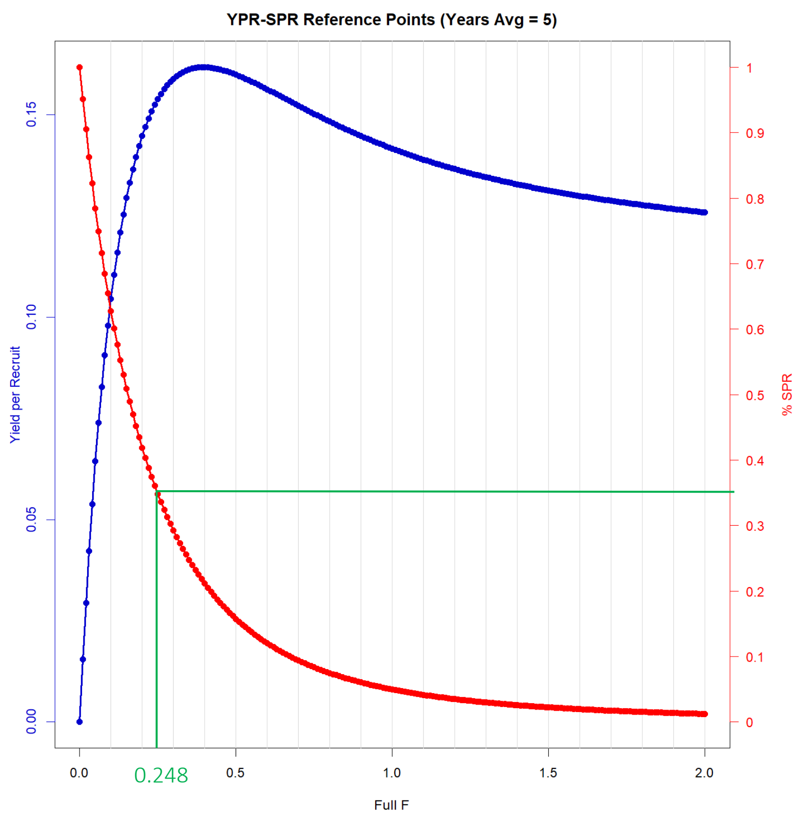
Environmental Co-Variate Companion Model

- Results from the two best ecov models, the final model, and the base model.

- There is good agreement in trend for all results, with the ecov models estimating a lower F and higher SSB for most of the time-series.



Final Model Reference Points



- Both $F_{35\%}$ and $SSB_{35\%}$ were calculated internally in WHAM using average recruitment over the time series (1985-2021), and 5 year averages for fishery selectivity, maturity and weights-at-age for SSB per recruit calculations
  - $F_{35\%} = 0.248$
- $SSB_{35\%}$ was calculated using SPR at 35% (0.718) and the mean of the full time series of recruitment (127,924 MT)
  - $SSB_{35\%} = 91,849$ MT

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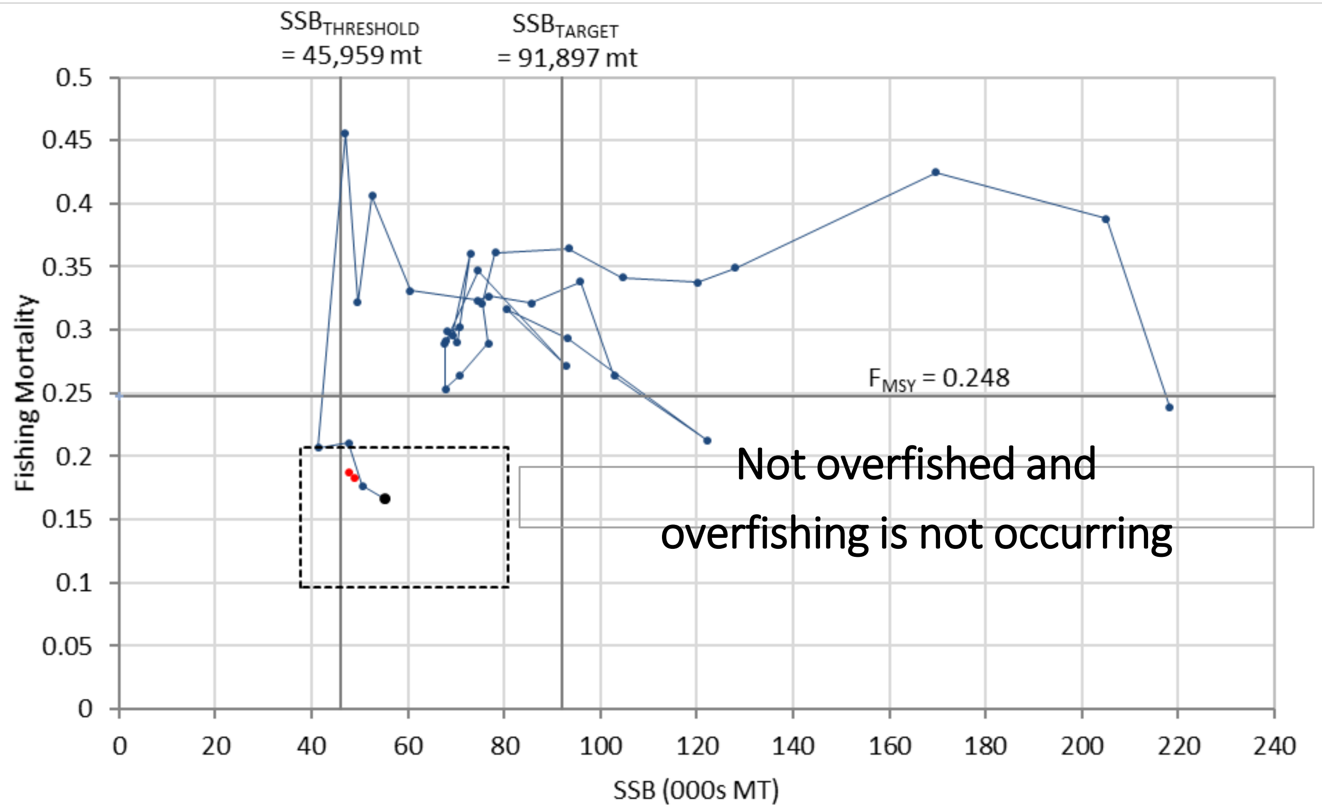
Final Model Stock Status



- Reference points from the final model:

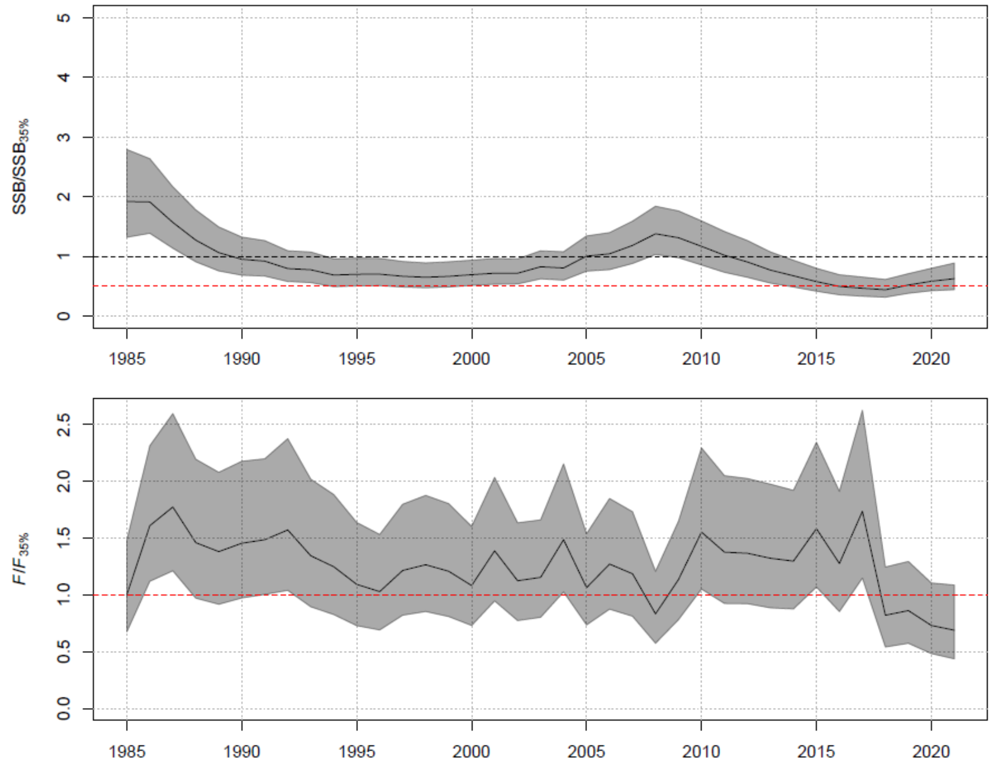
  $F_{35\%}$ = **0.248** (0.209 – 0.299)

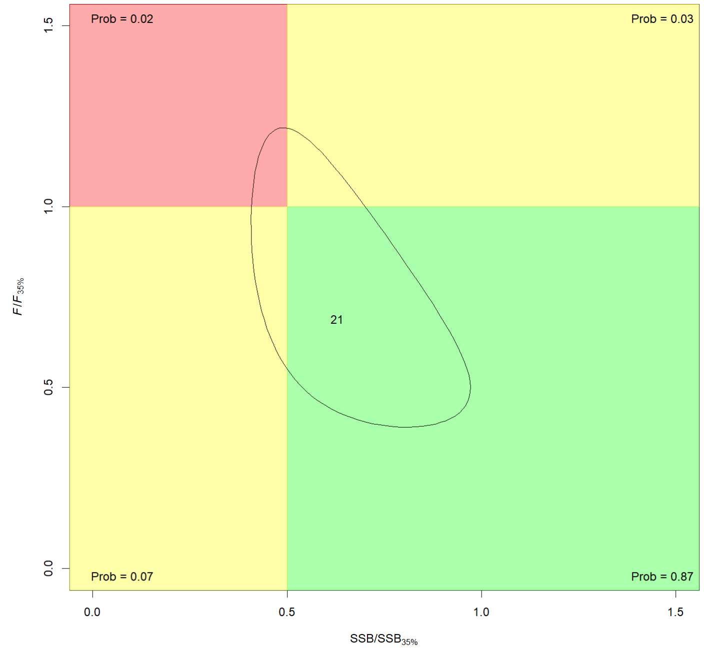
  $SSB_{35\%}$ = **91,897 MT** (66,219 – 127,534 MT)

  $SSB_{THRESHOLD}$ = **45,949 MT** (33,110 – 66,768 MT)

- Retrospective pattern minor for both F and SSB and adjustment not necessary

Final Model Stock Status





- 87% chance that the bluefish stock is currently not overfished and over-fishing is not occurring

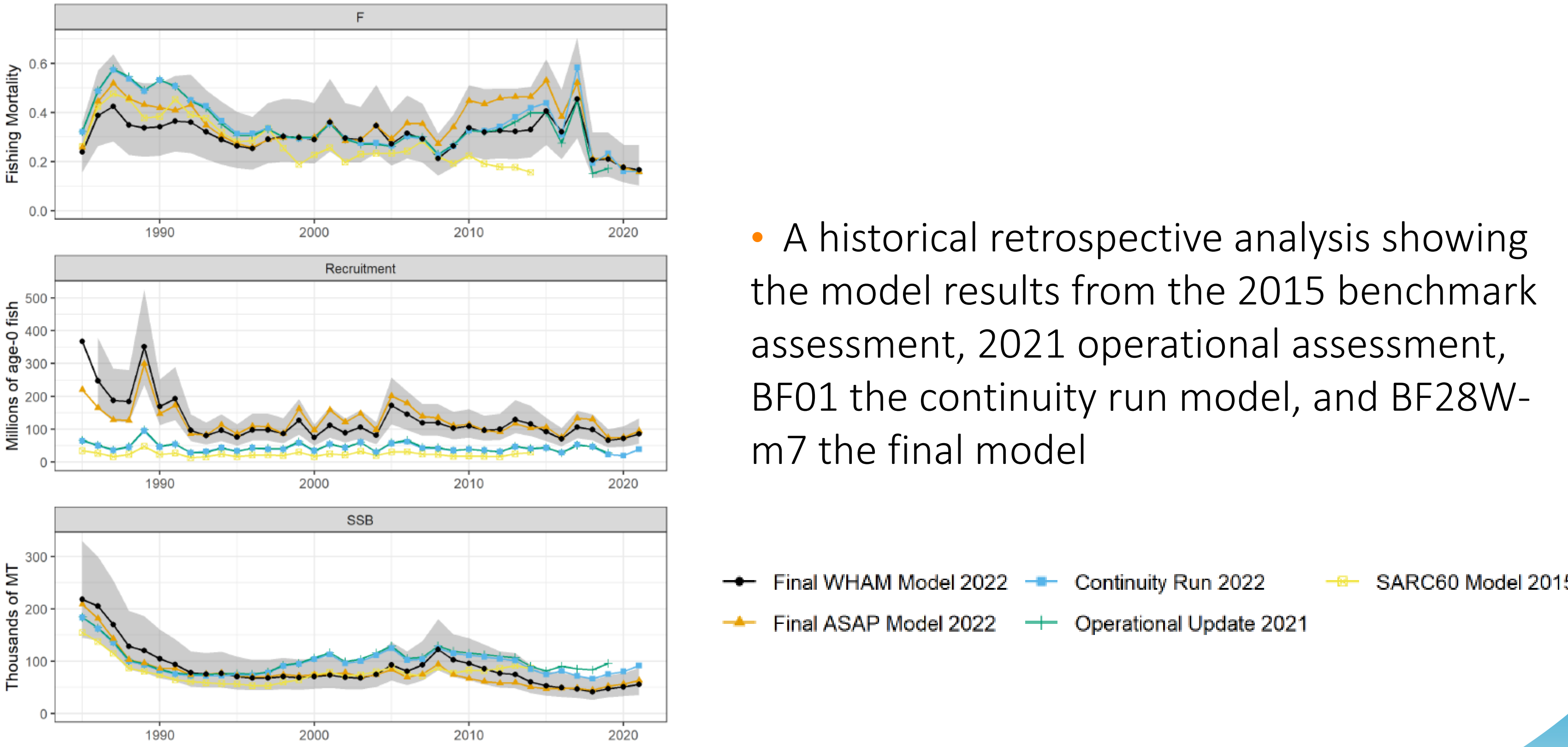
Questions

Candidate Model Results table

Model	Description	dAIC	AIC	2021 SSB (MT)	2021 R (mil)	2021 F	R ρ	SSB ρ	F ρ	Con-verged?	Positive definite Hessian?
BF28W	Base model: traditional statistical catch-at-age	~	~	68,631	96.4	0.152	-0.063	0.248	-0.197	TRUE	TRUE
m7	All NAA transitions are random effects correlated by year and age	0	3229	55,344	86.5	0.166	0.010	0.130	-0.096	TRUE	TRUE
m5	All NAA transitions are random effects correlated by year	3	3232	55,070	82.3	0.167	0.019	0.126	-0.097	TRUE	TRUE
m4	All NAA transitions are random effects independent, identically distributed	46.2	3275	58,114	98.6	0.160	-0.008	0.172	-0.144	TRUE	TRUE
m6	All NAA transitions are random effects correlated by age	46.9	3276	58,786	99.9	0.159	-0.004	0.177	-0.148	TRUE	TRUE
m2	Recruitment transitions are random effects independent, identically distributed	111	3340	73,843	104.1	0.144	-0.022	0.236	-0.195	TRUE	TRUE
m3	Recruitment transitions are random effects correlated by year	111	3340	72,329	101.3	0.146	-0.020	0.245	-0.198	TRUE	TRUE

- All state space models converged and had a positive definite hessian matrix
- Based on AIC selection, all of the top models were full state-space models, where survival of all ages were random effects
- The model with the lowest AIC was BF28W_m7, which included correlation in the random effects by year and age (2DAR1)

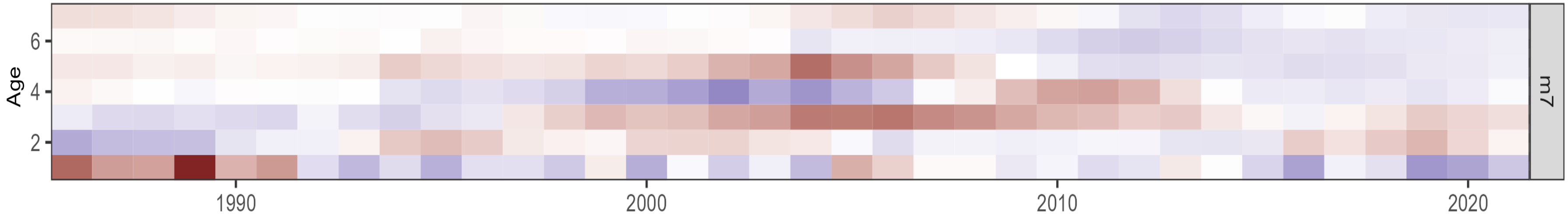
BF28W_m7 Historical Retrospective



- A historical retrospective analysis showing the model results from the 2015 benchmark assessment, 2021 operational assessment, BF01 the continuity run model, and BF28W-m7 the final model

BF28W_m7 Results: NAA deviations

	Estimate	Std. Error	95% CI lower	95% CI upper
NAA σ (age 1)	0.305	0.049	0.223	0.419
NAA σ (age 2-7+)	0.149	0.021	0.112	0.197
NAA residual AR1 ρ age	-0.310	0.130	-0.292	-0.019
NAA residual AR1 ρ year	0.800	0.063	0.362	0.617



- Correlation by age is low, and shows series of positive, negative and positive values from age-3 to age-5 in the middle of the time-series
- negative correlation between these ages is likely a result of the changing availability over time of this size class to the fisheries

BF28W_m7 Projections

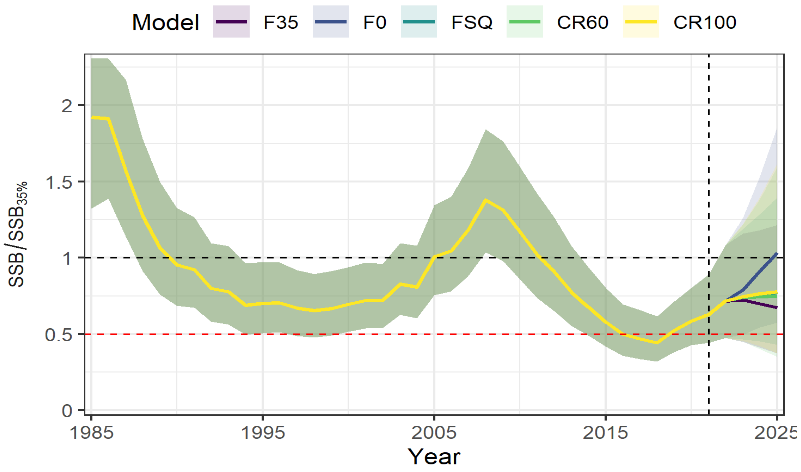
- Short-term projections were conducted in WHAM, and incorporate model uncertainty, auto-regressive processes and uncertainty in recruitment and numbers-at-age

- Removals in 2022 were assumed to be equal to the 2022 ABC (11,460 MT), and projections were carried forward for years 2023-2025 with different F and harvest assumptions:
  - $F = 0$, $F_{status\ quo} = 0.166$, $F_{35\%} = 0.248$, and that harvest in each year is equal to the acceptable biological catch (ABC) in each year
  - The annual ABC values were derived using projected OFL catch and applying the Mid-Atlantic Fishery Management Council (MAFMC) risk policy (CV = 60% and 100%)
- The projections use 5-year averages for natural mortality, maturity, fishery selectivity and weights-at-age

- The full time-series of recruitment (1985-2021) was chosen to fully capture the range of possible recruitment

BF28W_m7 Projections: SSB

Projection scenario	2022	2023	2024	2025	P (2025) > Bthreshold
$F_{MSY} = 0.248$	65,805 (39,305-110,170)	66,340 (37,604-117,034)	64,083 (35,017-117,275)	61,784 (32,086-118,971)	0.84
$F_0 = 0$	65,805 (39,305-110170)	72,637 (41,394-127,462)	83,806 (46,270-151,792)	94,956 (49,788-181,098)	0.99
$F_{status\_quo} = 0.166$	65,805 (39,305-110170)	68,357 (38,820-120,367)	70,009 (38,411-127,601)	71,150 (37,110-136,412)	0.93
MAFMC risk policy (60% CV)	65,805 (39,305-110170)	67,891 (37,217-123,847)	68,583 (33,654-139,765)	68,804 (29,551-160,198)	0.85
MAFMC risk policy (100% CV)	65,805 (39,305-110170)	68,514 (37,767-124,295)	70,385 (35,116-141,078)	71,553 (31,586-162,089)	0.88



- SSB increased for all of the projection scenarios except for fishing at $F_{MSY} = 0.248$
- Probability of being above $B_{THRESHOLD}$ in 2025 ranged from 0.84 (F_{MSY}) to 0.99 (F0)

BF28W_m7 Projections: Catch

Projection scenario	2022	2023	2024	2025
$F_{MSY} = 0.248$	11,460	13,909 (8,098-23,889)	13,957 (7,784-25,022)	13,584 (7,157-25,784)
$F_0 = 0$	11,460	0	0	0
$F_{status\_quo} = 0.166$	11,460	9,569 (5,564-16,458)	10,127 (5,628-18,223)	10,292 (5,399-19,623)
MAFMC risk policy (60% CV)	11,460	10,581 (P* = 0.311)	11,118 (P* = 0.314)	11,202 (P* = 0.316)
MAFMC risk policy (100% CV)	11,460	9,225 (P* = 0.311)	10,027 (P* = 0.321)	10,357 (P* = 0.327)

- Projected OFL catch decreased from 13,909 MT in 2023 to 13,584 MT in 2025
- Projected ABC from council risk policy (CV = 100%) increased from 9,225 MT in 2023 to 10,357 MT in 2025
- Most recent ABCs for bluefish: 2018-2019 = **9,895 MT**, 2020-2021 = **7,385 MT**

  2022 = **11,460 MT**, 2023 = **13,890 MT**