# ToR 7: Research Recommendations

## Yellowtail Flounder Research Track Stock Assessment Peer Review

November 18-22, 2024

Northeast Fisheries Science Center

Woods Hole, MA

# TOR 7: Research Recommendations

- Review, evaluate, and report on the status of research recommendations from the last assessment peer review, including recommendations provided by the prior assessment working group, peer review panel, and SSC.

- Identify new recommendations for future research, data collection, and assessment methodology. If any ecosystem influences from TOR 1 could not be considered quantitatively under that or other TORs, describe next steps for development, testing, and review of quantitative relationships and how they could best inform assessments.

- Prioritize research recommendations.

# Presentation Outline

1. Overview of WG approach to ToR 7
2. Status of Previous Research Recommendations
    1. By stock
    2. By TOR
3. New Research Recommendations

# Overview of WG Approach

1. Review of recommendations made to the WG from recent assessments and peer review reports.
2. Recommendations shaped WG work plan.
3. WG responded to recommendations.
4. WG identified new recommendations for future research, data collection, and assessment methodology.

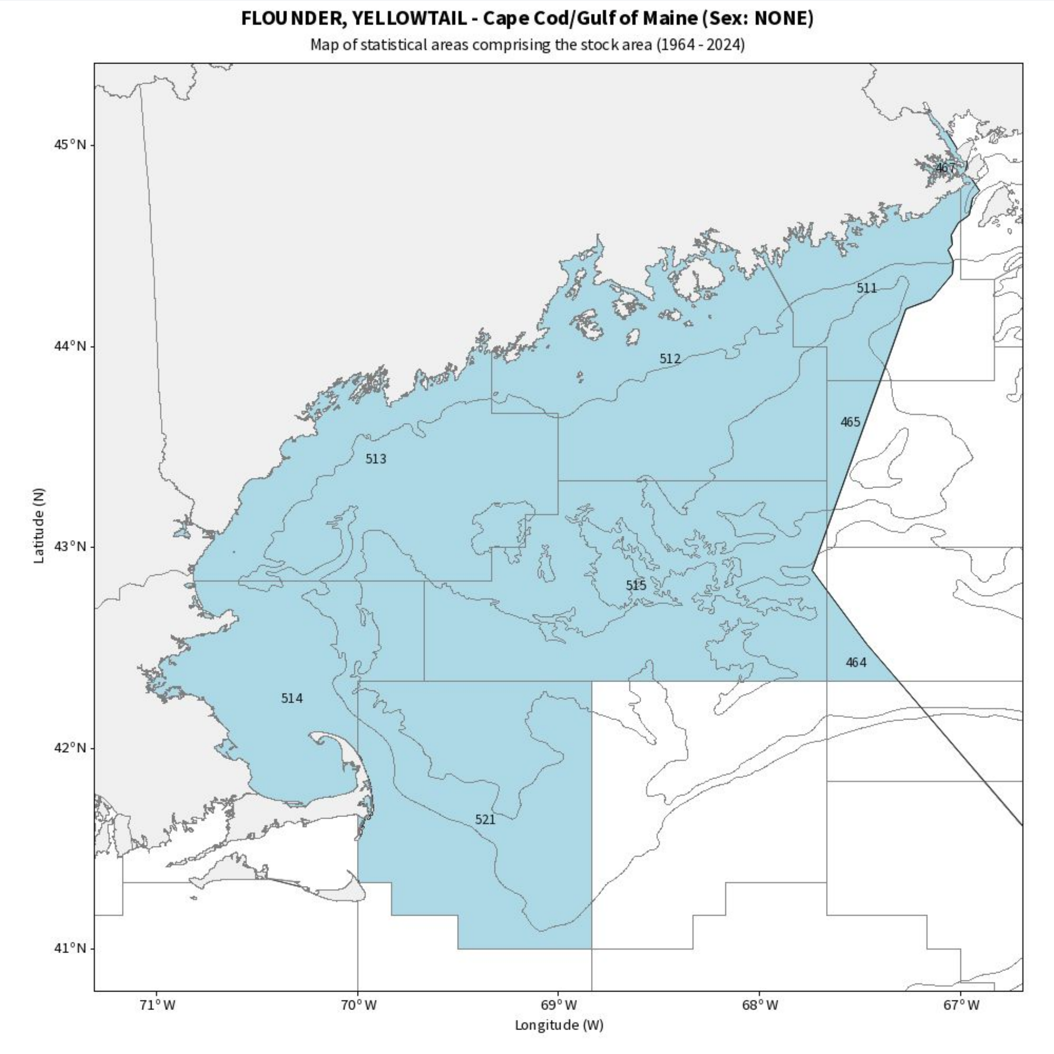
# Cape Cod Gulf of Maine

**Recommendations from:**

- 2022 Management Track Assessment (MT) Report

- 2019 Operational Assessment and peer review

- 2008 Groundfish Assessment Review Meeting (GARM III) and peer review



# Status of Previous Research Recommendations
## Stock Structure and Biology

**Growth and Maturity:** This assessment could benefit from updated growth and maturity studies. The current maturity and growth parameters are based on GARM III estimates (NEFSC 2008) which are over a decade old. [2022 MT, 2019 Operational Assessment]

- *A literature review of stock structure found faster growth and maturation in the southern stocks (Cadrin 2003).*
- *Updates to maturity were addressed with a white paper on geographic variation in maturity for all three yellowtail flounder stocks (Alade and Hansell WP).*
- *Life history parameters were updated for all three stocks.*

# White Paper on Maturity – Alade & Hansell

- In the US, yellowtail on Cape Cod were estimated to generally mature at later age and larger in size compared to Georges Bank, Southern New England and the Mid-Atlantic and those patterns were identified to persist for over three decades (Begg et al. 1999).
- In their working paper, Alade & Hansell reevaluated length and age specific patterns in yellowtail flounder maturation ogive to identify and capture any long-term changes in maturity for the yellowtail Research Track Assessment.

# White Paper on Maturity – Alade & Hansell

- The WG's proposed recommendations for 2024 research track are as follows:
  - For GB and SNEMA, use a time-series average proportion at age due to limited sample sizes.
  - For CCGOM, apply a 3-year moving average smoother to leverage the larger sample size for finer temporal resolution.

Table 9: Estimate of L50 of yellowtail by stock and sex

| Area | L50_Male (cm) | L50_Female (cm) |
|---|---|---|
| CCGOM | 19.71 | 26.30 |
| GB | 20.02 | 27.50 |
| SNEMA | 17.98 | 23.55 |
| All | 19.35 | 25.50 |

Table 10. Estimate of A50 of yellowtail flounder by stock and sex

| Area | A50_Male (cm) | A50_Female (cm) |
|---|---|---|
| CCGOM | 1.58 | 2.34 |
| GB | 1.49 | 1.96 |
| SNEMA | 1.42 | 1.90 |
| All | 1.41 | 2.00 |

# Comparing age and size at maturity from O'Brien et al. 1993 to 2024 Research values

| Stock | A_50 | | | | L_50 | | | |
|---|---|---|---|---|---|---|---|---|
| | O'Brien 1993 | | 2024 RT | | O'Brien 1993 | | 2024 RT | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| CCGOM | 1.3 | 2.6 | 1.6 | 2.3 | 26.8 | 27.3 | 19.7 | 26.3 |
| GB | 2.6 | 1.8 | 1.5 | 2.0 | 21.4 | 25.8 | 20.0 | 27.5 |
| SNEMA | 1.8 | 1.6 | 1.4 | 1.9 | 19.6 | 25.5 | 18.0 | 23.6 |

# Status of Previous Research Recommendations
## Stock Structure and Biology

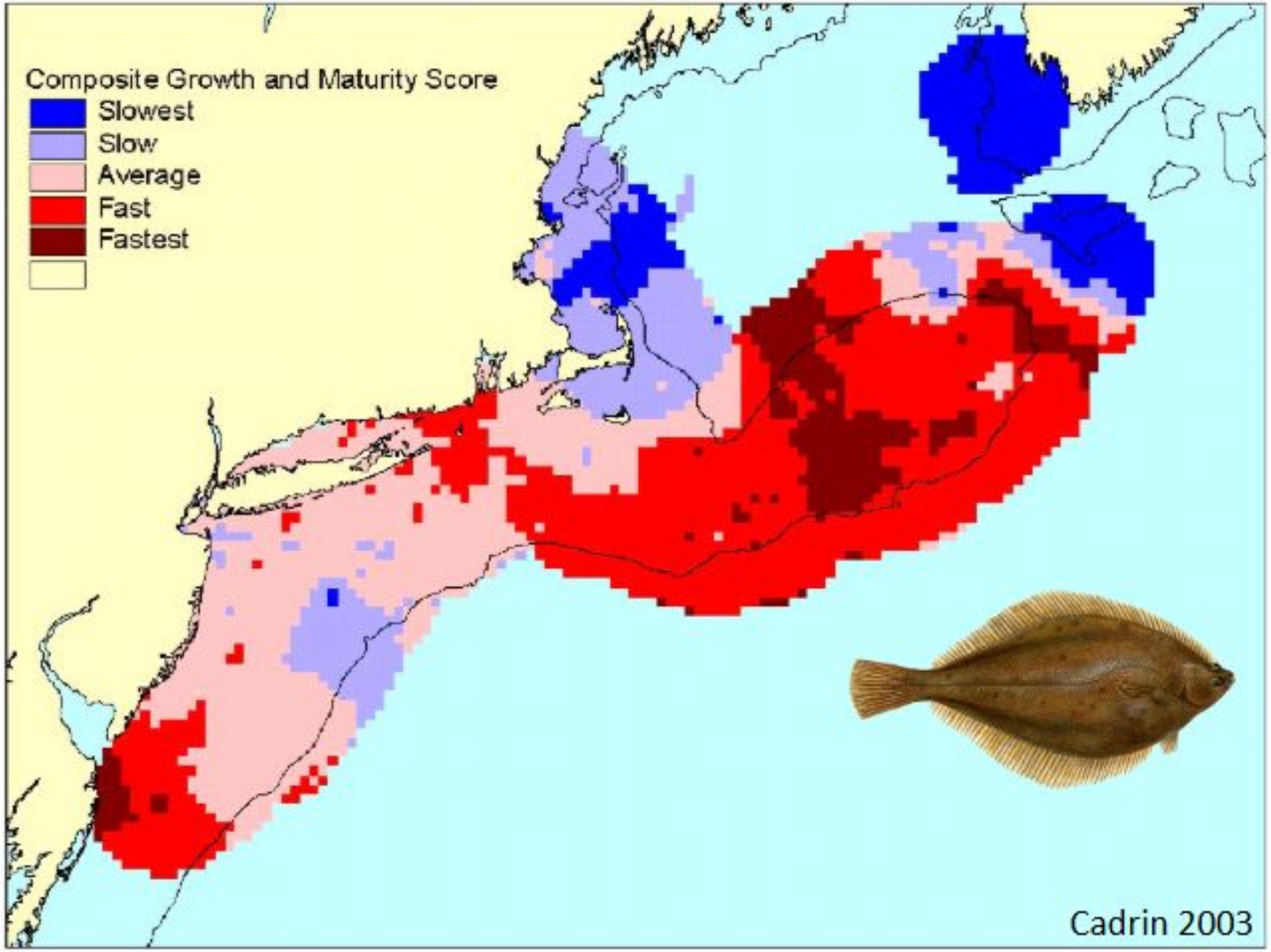
***Size-dependent distribution:*** Investigations to characterize spatial dynamics in age and size dependent distribution of yellowtail and any potential implications it may have on the survey catch. [2019 Operational Assessment]

- *Spatial dynamics in age and size-dependent distribution of yellowtail flounder were broadly characterized as part of the literature review on stock structure (Cadrin 2003), yet fine scale analyses are still needed.*

- *For state inshore surveys (MADMF and MEDMR) it is hypothesized that spatial aspects of spawning migration and shifting distribution may influence catchability as it relates to survey timing. <u>Future assessments could explore effects of these state surveys to evaluate this hypothesis more effectively</u>.*

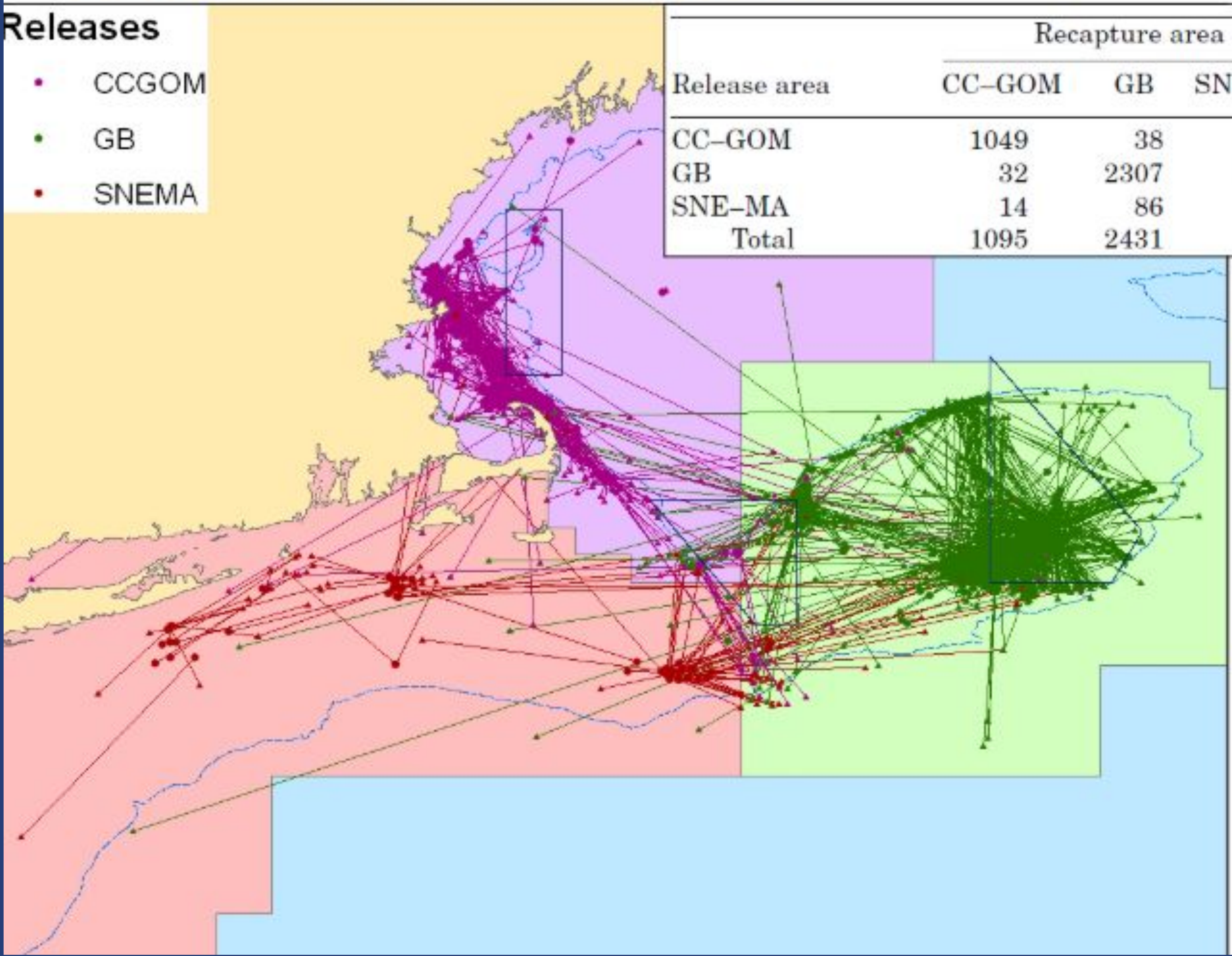
# Geographic Variation in Growth and Maturity

- Composite developmental rate index.
- Geographic patterns of size and proportion mature at age indicate two phenotypic stocks of yellowtail flounder.
- Spatial analysis indicates tha the area east of Cape Cod has a gradient with slower development to the north and faster development to the south.
- Slower development in Mid Atlantic cold pool.




Slide credit: S. Cadrin

# Yellowtail Movement




| | Recapture area | | | | Recapture percentage | | |
|---|---|---|---|---|---|---|---|
| Release area | CC–GOM | GB | SNE–MA | Total | CC–GOM | GB | SNE–MA |
| CC–GOM | 1049 | 38 | 10 | 1097 | 0.96 | 0.03 | 0.01 |
| GB | 32 | 2307 | 11 | 2350 | 0.01 | 0.98 | 0.01 |
| SNE–MA | 14 | 86 | 36 | 136 | 0.10 | 0.63 | 0.26 |
| Total | 1095 | 2431 | 57 | 3583 | | | |

- High residence in CC-GOM (96%) and GB (98%)
- Extensive movement from Nantucket Lightship to GB

Wood & Cadrin 2013

# **Status of Previous Research Recommendations**
## ToR1: Ecosystem and Climate Influences

***Catchability:*** Following the approach for the Georges Bank stock, it would be worthwhile splitting the survey time series to explore whether similar trends with survey catchability are present. If so, spatial differences in the survey selectivity and/or environmental covariates (temperature) should be investigated as potential causative processes. [2008 GARM III Peer review]

- *This research recommendation is less relevant as of the writing of this report, as it pertains to a potential approach for addressing the retrospective pattern in the VPA model platform, which no longer applies to this research track due to the use of the WHAM model platform for this stock.*
- *The current model splits the survey time series (into Albatross & Bigelow series, 2009) and updates natural mortality from 0.2 to 0.4, which is time and age invariant.*
- *Model runs were conducted to explore environmental covariates on natural mortality and recruitment. None of those model formulations were considered acceptable.*

***This research recommendation is less relevant as of the writing of this report, as it pertains to a potential approach for addressing the retrospective pattern in the VPA model platform, which no longer applies to this research track due to the use of the WHAM model platform for this stock.***

- This recommendation came from the GARM III Peer Review Panel report.
- The Transboundary Resource Assessment Committee (TRAC, 2005) could not identify the cause of the retrospective pattern in GB stock.
- TRAC developed a new assessment formulation, the "Major Change Model," which split the survey time series into pre- and post-1994 periods.
- This adjustment largely removed the retrospective pattern and was deemed suitable for management use.
- Splitting the time series might serve as a proxy for changes in survey catchability due to yellowtail habitat use.
- Hypothesis: Yellowtail may have moved to more preferred habitats, possibly increasing survey catchability due to environmental or other factors.

Table E9. Mohn's rho retrospective statistic for F, SSB, and R.

| Peel | F | SSB | R |
|---|---|---|---|
| 2000 | -56% | 67% | -45% |
| 2001 | -18% | 19% | -75% |
| 2002 | -22% | -11% | -31% |
| 2003 | 14% | -15% | -40% |
| 2004 | 56% | 4% | 21% |
| 2005 | 12% | 12% | -10% |
| 2006 | -8% | 18% | -2% |
| **Average** | **-3%** | **13%** | **-26%** |

Weak retrospective pattern present in GARM III 2008

***The current model splits the survey time series and updates natural mortality from 0.2 to 0.4, which is time and age invariant. Model runs were conducted to explore environmental covariates on natural mortality and recruitment. None of those model formulations were considered acceptable.***

- M was fixed at 0.4 across ages and years.
- Various configurations, including random effects models (ar1_y and 2dar1) or age-specific M were explored but did not improve model fit or retrospective patterns.
- Additionally, environmental covariates such as the Atlantic Multidecadal Oscillation (AMO) and spring bottom temperature were assessed for potential impact on M using linear and polynomial models with random walk and autoregressive processes.
- These, too, failed to enhance model performance. Consequently, the decision was made to retain the fixed M = 0.4 assumption in the candidate model.

# Status of Previous Research Recommendations
## ToR1: Ecosystem and Climate Influences

***Productivity:*** The Panel noted the need to investigate long-term changes in stock productivity given the severe decline of the resource. This has implications for the determination of biological reference points. [GARM III 2008 Peer review].

- *This research recommendation is less relevant as of the writing of this report as it was when it was written for GARM III. The stock is now increasing.*
- *Addressed via exploration of time-varying recruitment with and without a stock-recruit relationship. Beverton Holt S-R relationship did not perform as well as random about the mean.*
- *Environmental covariates like the Atlantic Multidecadal Oscillation (AMO) and spring bottom temperature were then tested, assuming recruitment might be influenced by prior-year conditions. However, none of these covariates improved model diagnostics.*
- *Directed research found CCGOM showed time-varying productivity, but that productivity was not influenced by the environmental covariates examined here (Tableau et al. 2019).*
- *Future studies could continue to reconsider environmental covariates on recruitment.*

## *Addressed via exploration of time-varying recruitment with and without a stock-recruit relationship.*

- Initial analyses tested recruitment assumptions, comparing random mean recruitment with a Beverton-Holt stock-recruitment model with IID process error.
- Although the Beverton-Holt model met convergence criteria, diagnostics, including Mohn's rho and residuals, were poor.
- Environmental covariates like the Atlantic Multidecadal Oscillation (AMO) and spring bottom temperature were then tested, assuming recruitment might be influenced by prior-year conditions.
- However, none of these covariates improved model diagnostics.
- Ultimately, the random deviation from the time series mean recruitment model without environmental covariates yielded the lowest AIC and best fit, leading to its selection for the candidate model with an autoregressive (ar1_y) process for recruitment.

## ***Directed research found productivity estimated from a stock-recruit relationship was not found to be significant for the CCGOM stock (Tableau et al. 2019).***

- This study found relatively few relationships between environmental drivers and stock productivity. Even the use of perfect predictions of environmental covariates provided a gain in forecast accuracy for only four of the 25 stocks.
- This study found that CCGOM yellowtail flounder showed time-varying productivity but that this productivity was not influenced by the environmental variables examined.
- However, incorporating environmental covariates did improve forecasts.

# Status of Previous Research Recommendations
## ToR2: Catch

***Length-weight conversion:*** The length-to-weight conversion should be examined in the future to determine if it has changed over time. [2019 Operational Assessment Peer Review].

- *This research recommendation was completed by transitioning to the Woods Hole Assessment Model (WHAM) which incorporates statistical fits and accounts for uncertainty within the model.*
- *The WG updated the length weight equations for all stocks using survey data from 1999 to 2021 to confirm differences across stocks.*

## *The length-to-weight conversion should be examined in the future to determine if it has changed over time.*

- CCGOM used NEFSC spring length-weight relationship as a basis for fishery weights to numbers (SAW 54).
- The WG updated the length weight equations for all stocks using survey data from 1999 to 2021 to confirm differences across stocks. Annual and seasonal length weight equations were calculated.
- A study is currently going on to update commercial length-weight equations from the commercial fishery (Pers comm. Wigley). If sample sizes are sufficient updated equations can be used for future catch at age expansions.

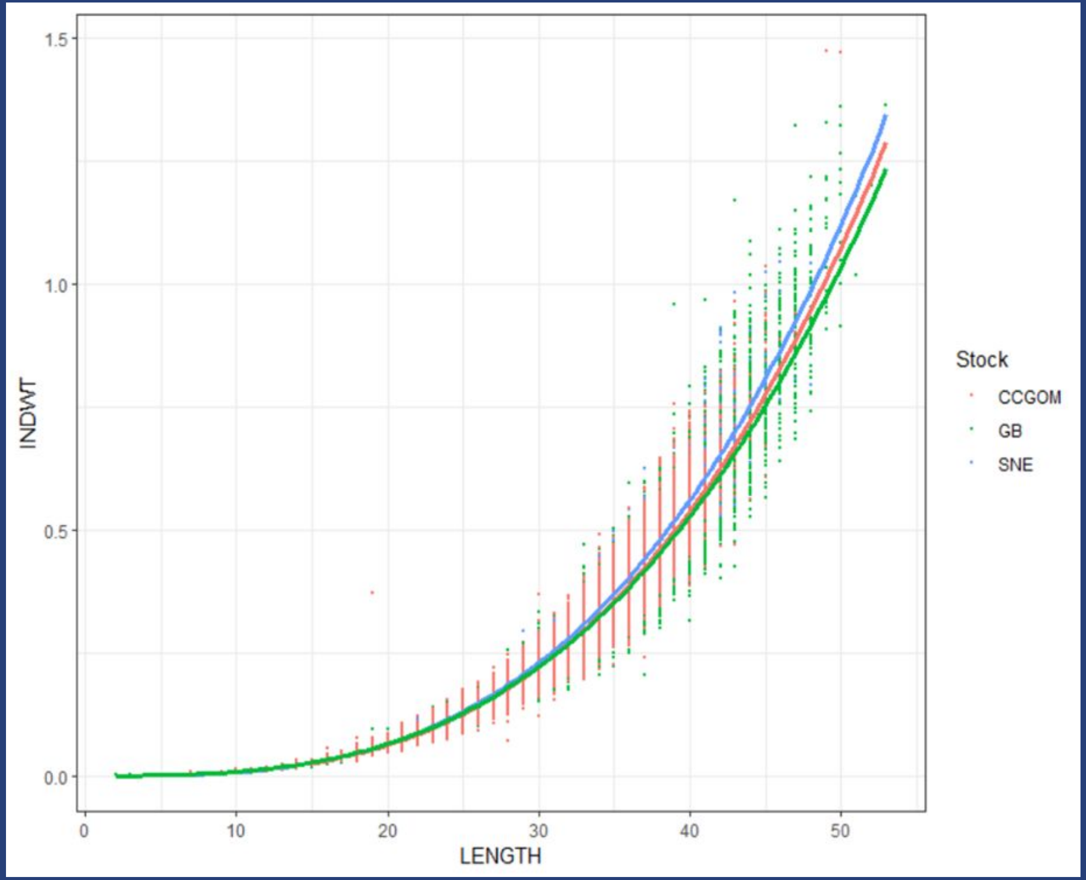



Figure 1: Updated annual length-weight relationships for the three stocks using NEFSC survey data from 2000-2021.

# Status of Previous Research Recommendations
## ToR4: Model

***Model Platform:***

The Cape Cod-Gulf of Maine yellowtail flounder assessment could be improved with a change in model platform that incorporates statistical fits and accounts for measures of uncertainty in the model. [2022 MT Assessment].

- *This research recommendation was completed by transitioning to the Woods Hole Assessment Model (WHAM) which incorporates statistical fits and accounts for uncertainty within the model.*

Future modeling efforts should consider forward-projecting statistical catch-at-age models to account for uncertainty in the data inputs. [2019 Operational Assessment]

- *Addressed. WHAM is an age-structured model that allows for projections.*

We are expecting that the remaining VPA stocks, which all have research tracks coming up, will be moving away from the VPA. [2019 Operational Assessment Peer Review]

- *Addressed by transitioning to WHAM.*

# Status of Previous Research Recommendations
## ToR4: Model

***Natural Mortality:***

A Lorenzen M is being used for SNE yellowtail, and it may be that a similar M should be considered for this stock. During the RT for all three yellowtail stocks in 2024, a consistent approach to determining natural mortality should be applied across yellowtail flounder stocks. [2019 Operational Assessment Peer Review].

- *This recommendation was addressed in a white paper on approximating the natural mortality rate for all three stocks (Cadrin WP). A suite of estimators, including Lorenzen M, were compared.*
- *Estimating M via the Lorenzen (1996) method was one setting that was explored in model comparison for the CCGOM stock but was not selected for the final model.*

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## Natural Mortality Options

✓*M*=0.4 for CCGOM and GB; and *M*=0.5 for SNEMA

?Alternative assumptions considered as candidate models using pre-agreed model selection criteria:

1. scalar *M* for all ages and years,
2. rescaled to age-specific *M* using time series size at age and maturity at age,
3. scalar *M* for exploration of annual process errors,
4. age-specific *M* for exploration of annual process errors, or

- priors for estimation by a stock assessment model.

?A range of estimates could be assumed for sensitivity analyses.

- Longevity-based confidence limits: *M*~0.2 to 0.6 for CCGOM and GB and *M*~0.3 to 0.7 for SNEMA

Slide credit: S. Cadrin

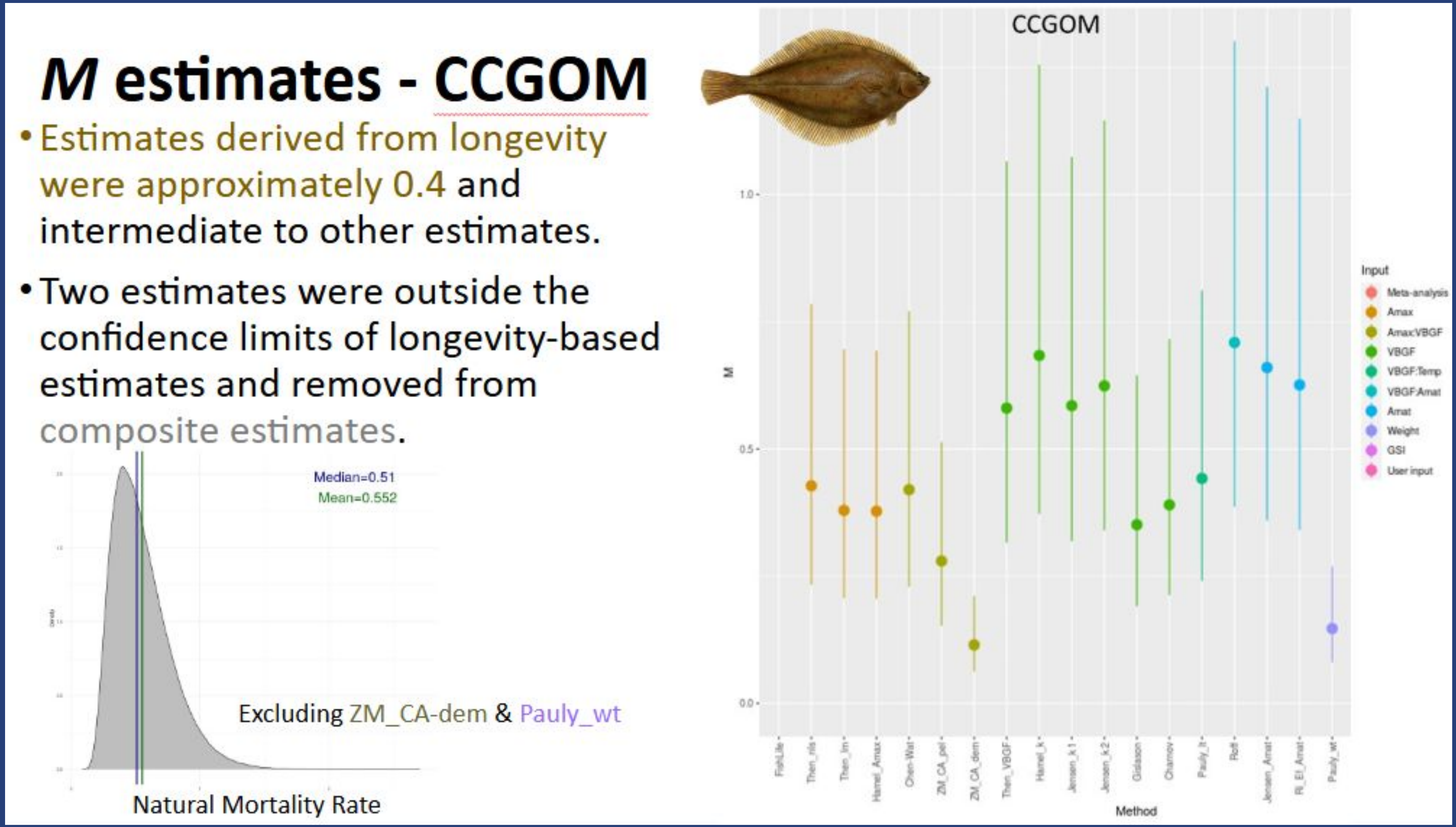
## *Estimating M via the Lorenzen (1996) method was one setting that was explored in model comparison for the CCGOM stock but was not selected for the final model.*

- These approximations of M=0.4 for CCGOM and GB and M=0.5 for SNEMA can be used in research track stock assessments as assumed values of M, rescaled to age-specific M, priors for estimation by a stock assessment model, or the time-series average for estimation of annual process errors.

- Inter-annual variation in size or maturity at age may not be reliable for estimating time-varying M for yellowtail flounder, because size at age was not well sampled for some years and ages, particularly for older ages and recent years.

- 1: Estimate age based
- 2 & 3: Estimate linear relationship with ecov
- 4 & 5: Estimate but non-linear relationship with ecov
- 6: Age specific (Cadrin, 2024)
- 7: Weight ate age (Lorenzen 1996; Miller and Hyun 2018)
- 8: Constant (0.4; Cadrin, 2024)
- 9: Constant but time varying (ar1_y)
- 10: Age specific but time varying (2dar1)
- 11 & 12: Constant but linear relationship with ecov - BT
- 13: Constant but non-linear relationship with ecov - NC
- 14: Estimate M (2dar1) - NC

*Estimating M via the Lorenzen (1996) method was one setting that was explored in model comparison for the CCGOM stock but was not selected for the final model.*




**Slide credit: S. Cadrin**

*Estimating M via the Lorenzen (1996) method was one setting that was explored in model comparison for the CCGOM stock but was not selected for the final model.*

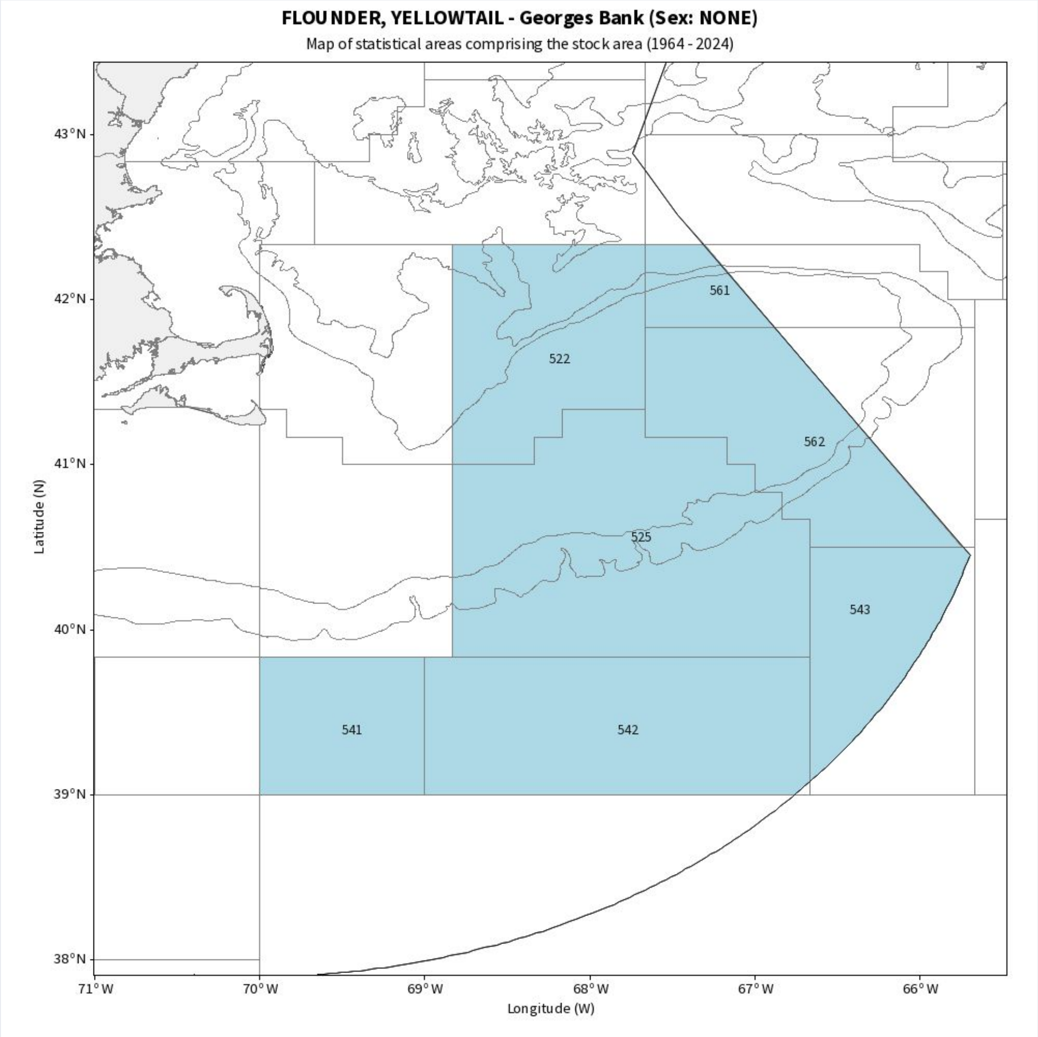
- NEFSC spring and fall trawl survey observations of length and maturity at age were the primary data used to update life history analyses.
- Maximum observed age for each stock was from survey or fishery monitoring data.
- Estimates of lifetime M were rescaled to age-specific M (Ma) based on the predicted length at age (e.g., La) and length at maturity (L50) using the simplified form of the Lorenzen (1996) as a pragmatic approach recommended by Brodziak et al. (2011)

# Georges Bank

**Recommendations from:**

- 2022 Transboundary Resource Assessment Committee Status Report and peer review

- 2008 Groundfish Assessment Review Meeting (GARM III) and peer review



# Status of Previous Research Recommendations
## Stock Structure and Biology

**Stock Structure:**

Consider all three stocks (Georges Bank, Cape Cod – Gulf of Maine and Southern New England – Mid Atlantic Bight) as a complex with migration between components. [GARM III Peer Review]

- *This recommendation was addressed by directed research (Goethal et al. 2015). Results indicated that movement among stocks was low, estimates of stock size and fishing mortality were similar to those from conventional stock assessments, and incorporating stock connectivity did not resolve residual patterns.*

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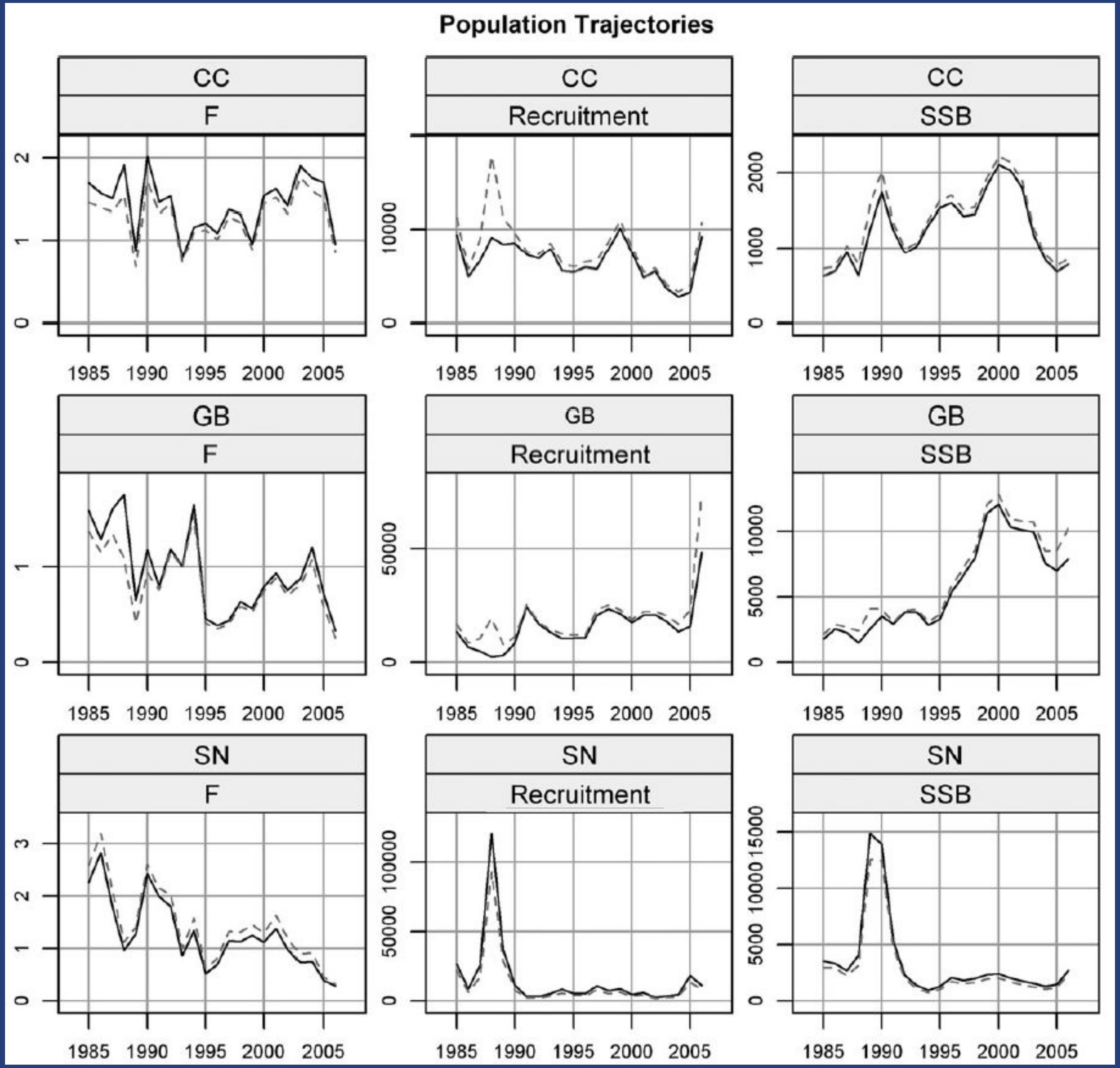
- Tag-integrated multi-stock statistical catch-at-age (Goethel et al. 2015)
  - Fit to fishery and survey data from 3 yellowtail assessments (NEFSC 2008) and 2003-2006 tag releases and fishery recoveries (Wood & Cadrin 2013)
  - Estimated recruitment, fishing mortality, selectivity, catchability and movement.
  - Minor differences between closed-stock (dashed) and 3-stock results (solid)
  - except 1987 recruitment




**Goethal et al. 2015**

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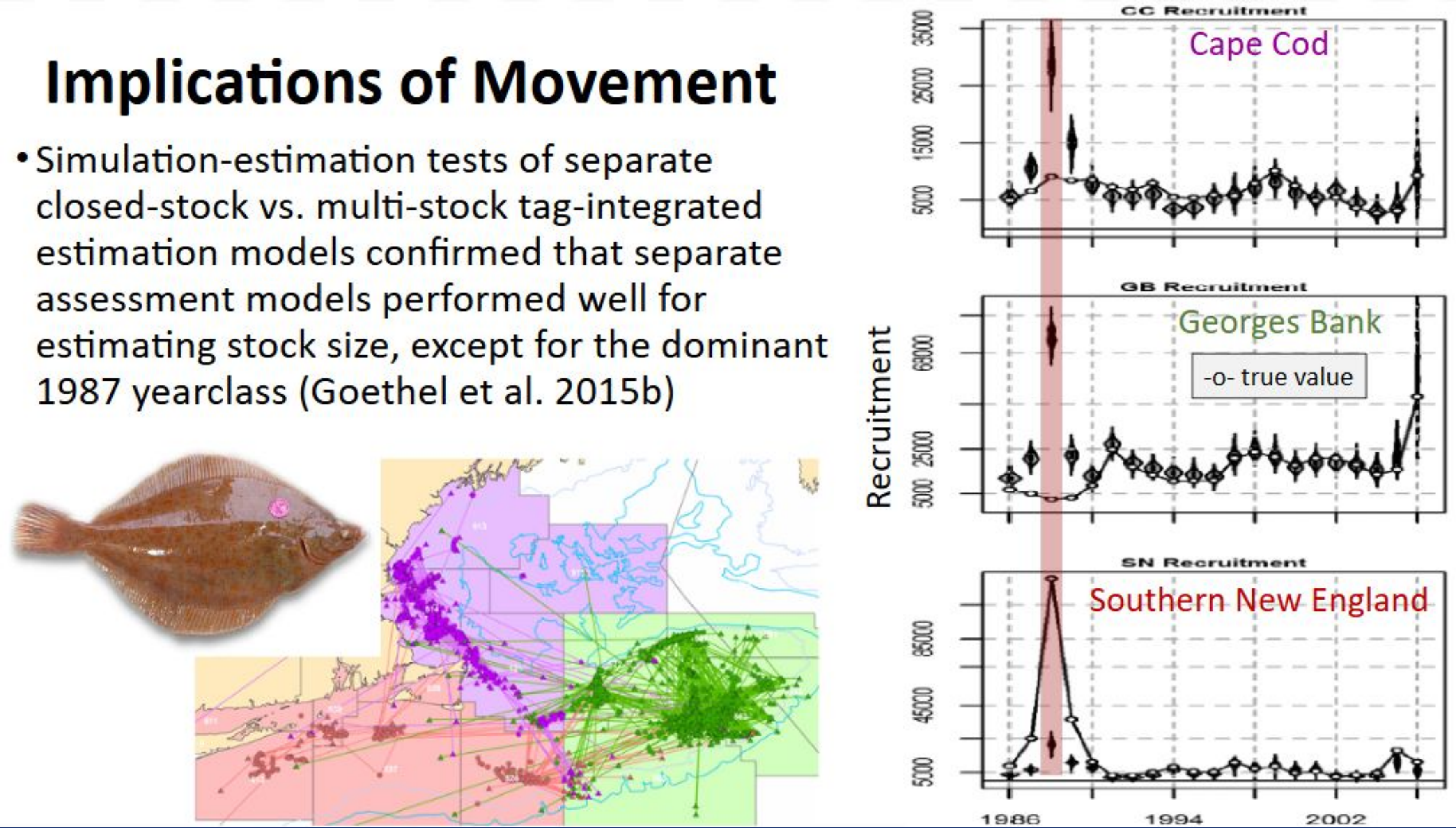



**Slide credit: S. Cadrin**

# Status of Previous Research Recommendations
## ToR2: Catch

***Discards:*** Clarify discard estimation procedures.[2022 TRAC]

- *Resolved within TRAC 2022.*

***Discards:*** Clarify discard estimation procedures.[2022 TRAC]

- Discard estimates in 2020 are uncertain due to lower observer coverage in semester two for the USA scallop dredge fleet.
- USA landings estimates for 2020 and 2021 are from the newly implemented Catch Accounting and Monitoring System (CAMS).
- In addition, USA discard estimates for 2020 have been revised since the 2021 TRAC meeting.
- Observed trips in 2020 were processed and an updated discard estimate was calculated.
- As a result, scallop dredge fleet discard estimates for 2020 were higher than prior estimates reported in the 2021 TRAC meeting.
- However, observer coverage was low in the scallop fleet in semester two, resulting in high coefficients of variation (Figure 6).

**GB Yellowtail Flounder** **TRAC Status Report 2022/01**

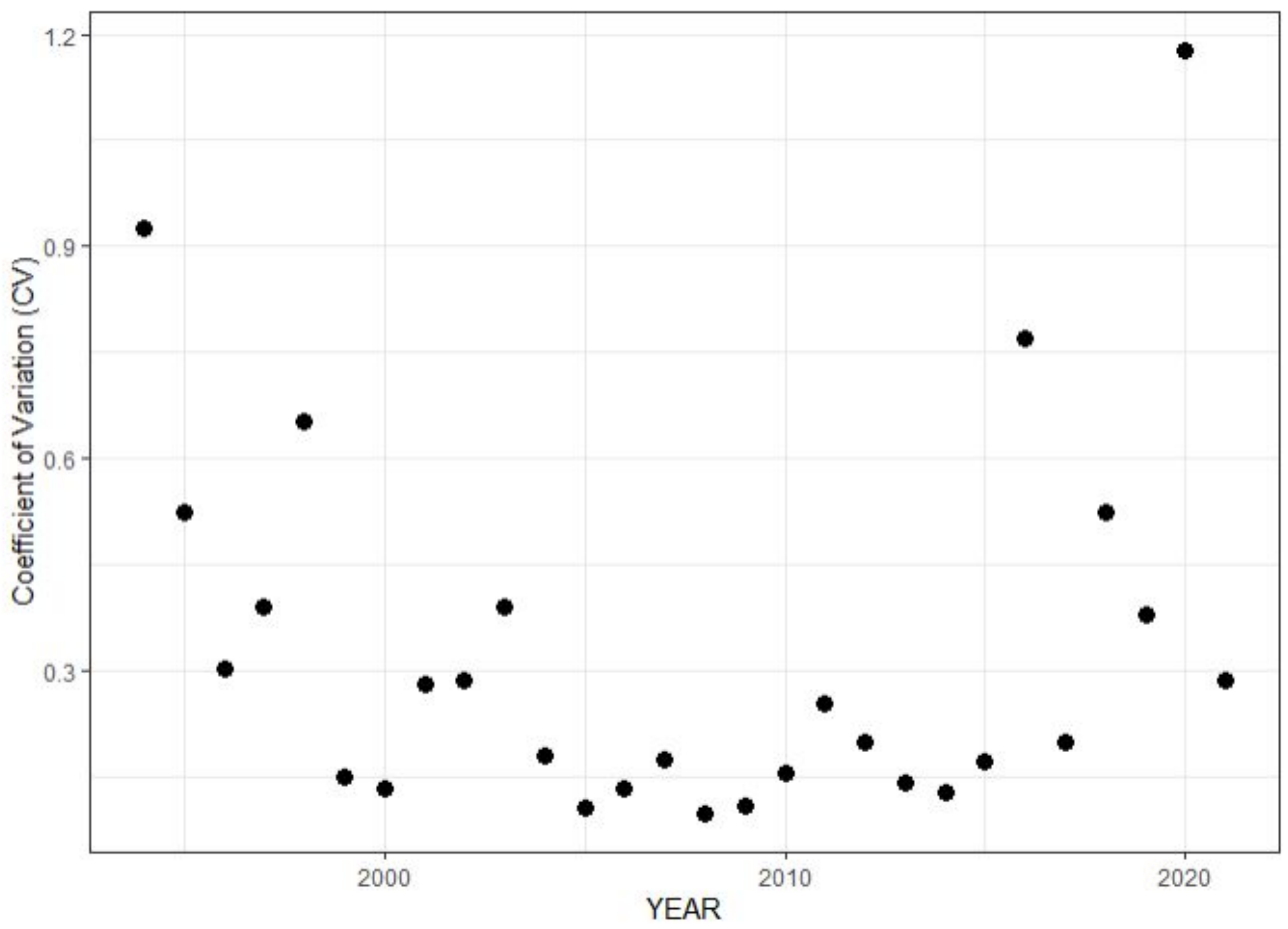



*Figure 6. Coefficients of variation for USA discard estimates of Georges Bank Yellowtail Flounder. Note the high value for 2020 due to limited observer coverage in the scallop dredge fleet as a result of COVID-19.*

# Status of Previous Research Recommendations
## ToR4: Model

***Model Platform:***

Investigate the limiter approach and note the lack of responsiveness in the stock. [2022 TRAC].

- *Resolved by transitioning to WHAM.*

***Age Composition:***

Examine tradeoffs in model specification regarding the likelihood of age composition data and fit to survey trend vs. commercial age. [2008 GARM III Peer Review]

- *After an exploration of tradeoffs, it was concluded that logistic normal age compositions were the most appropriate.*

## *Investigate the limiter approach and note the lack of responsiveness in the stock. [2022 TRAC].*

- Missing surveys in 2023 led to concerns about using the limiter approach because it was intended to be used with 3 surveys.
- “The average survey biomass for 2022, using the adjustment from Miller et al. (2021), was 1,500 mt. The average survey biomass for 2022 adjusted for the missing DFO survey was 1,211 mt. Both estimates are between the survey bounds of the Limiter Approach (lower limit: 1,000 mt; upper limit 7,300-8,500 mt). Thus, TRAC recommends the constant catch advice of 200 mt.”
- Low catches and poor condition of the stock, along with a desire to stop chasing survey noise, led to the development of the Limiter Approach, a tool to help make the decisions regarding the constant catch advice and average survey biomass limits.

*After an exploration of tradeoffs, it was concluded that logistic normal age compositions were the most appropriate.*

| Model | age_comp | opt_converged | NLL | dAIC | AIC | rho_R | rho_SSB | rho_Fbar |
|---|---|---|---|---|---|---|---|---|
| m1 | multinomial | Yes | 7489.378 | 17406.4 | 15216.8 | 1.0124 | 0.8392 | -0.4141 |
| m2 | dir-mult | Yes | 3785.416 | 10006.4 | 7816.8 | 2.0078 | 0.2031 | -0.182 |
| m3 | dirichlet-miss0 | Yes | -858.819 | 718 | -1471.6 | 2.2583 | 0.1956 | -0.179 |
| m4 | dirichlet-pool0 | Yes | -850.234 | 735.1 | -1454.5 | 2.2456 | 0.1992 | -0.1844 |
| m5 | logistic-normal-miss0 | Yes | -746.359 | 942.9 | -1246.7 | 3.7946 | 0.158 | -0.1313 |
| m6 | logistic-normal-ar1-miss0 | Yes | -1221.78 | 0 | -2189.6 | 3.2691 | 0.1102 | -0.173 |
| m7 | logistic-normal-pool0 | Yes | -745.244 | 945.1 | -1244.5 | 3.5926 | 0.1494 | -0.1283 |

Slide: A. Hansell, J. Kittel, C. Carano

# Status of Previous Research Recommendations
## ToR4: Model

***Catchability:*** Investigate survey catchability as it relates to habitat shifts. Consider splitting the survey time series in the mid-1990s. [2008 GARM III Peer Review]

- *Splitting the NMFS BTS survey in the mid-1990s was recommended to improve the diagnostics of the model used in GARM III and is not considered appropriate for the current model framework.*
- *However, in this RT splitting the survey for the change in vessel (2009) was explored (and ultimately not accepted).*
- *Additionally, process error was explored on survey catchability and selectivity.*

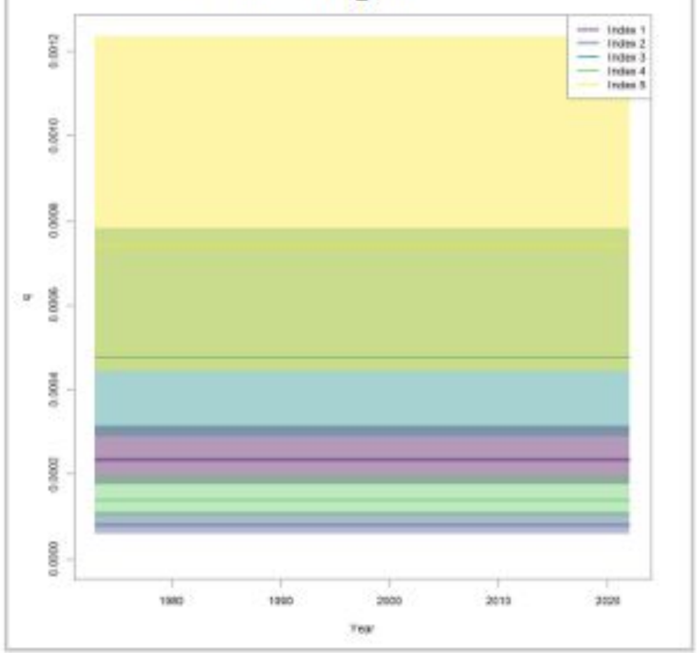
## *However, in this RT splitting the survey for the change in vessel (2009) was explored.*

Cole Carrano

# Albatross & Bigelow split

Index 1 = DFO
Index 2 = Alb Spring
Index 3 = Big Spring
Index 4 = Alb Fall
Index 5 = Big Fall

- Struggled with convergence
  - Remove RE on NAA
  - Change age-comps
- Did not improve diagnostics
- Random effects on q:
  - Did not demonstrate a clear breakpoint



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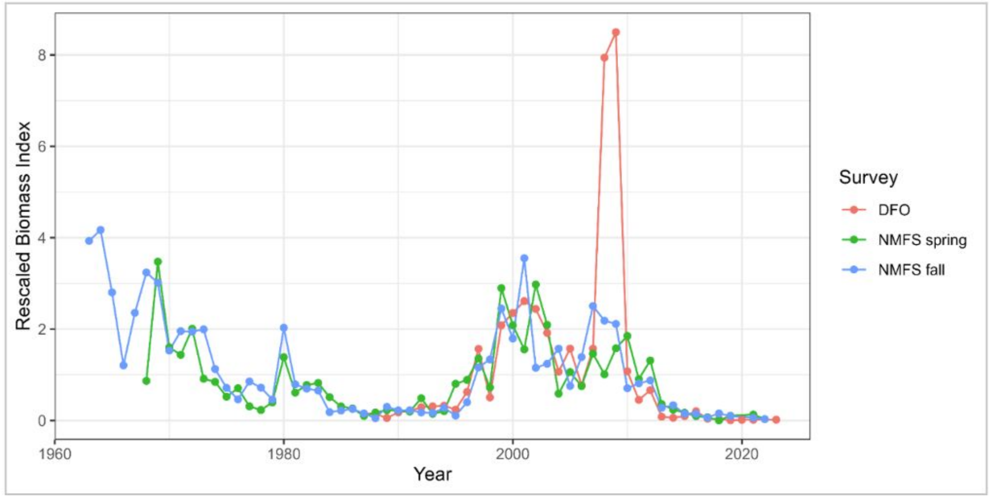
## *Additionally, process error was explored on survey catchability and selectivity.*

# Time varying catchability

- Used to account for changes in availability to the survey
- Hypothesis: Spatial shifts have occurred and fish are no longer as available to the survey (e.g., shifted deeper).
- Proposal: Not to explore time varying q



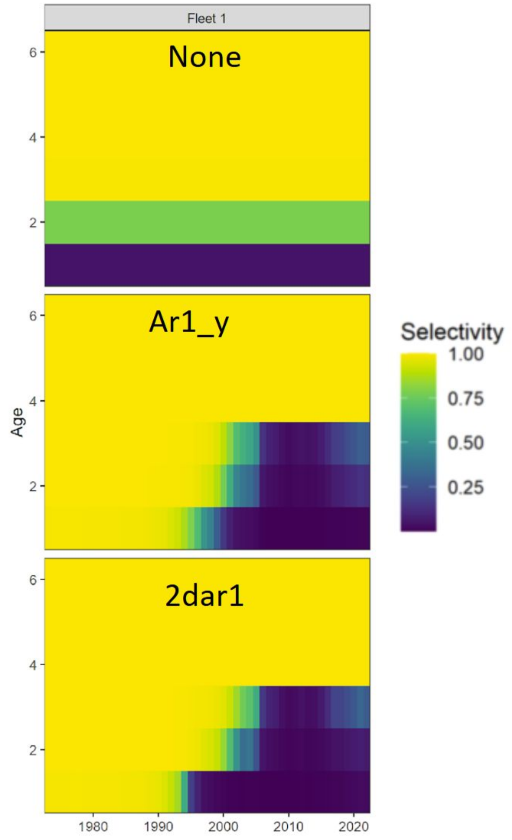

Slide: A. Hansell

# *Additionally, process error was explored on survey catchability and selectivity.*

## Selectivity

| Model | RE | conv | pdHess | dAIC | AIC | Rho R | Rho SSB | Rho Fbar |
|---|---|---|---|---|---|---|---|---|
| m3 | 2dar1 | TRUE | TRUE | 0 | -1496 | 2.7126 | 0.5645 | -0.3032 |
| m2 | Ar1_y | TRUE | TRUE | 2.4 | -1493.6 | 3.4697 | 0.6533 | -0.314 |
| m5 | block_1994 | TRUE | TRUE | 64.9 | -1431.1 | 6.3254 | 1.5862 | -0.4448 |
| m4 | block_ 2010 | TRUE | TRUE | 225 | -1271 | 4.0561 | 0.6666 | -0.1304 |
| m1 | None | TRUE | TRUE | 375.5 | -1120.5 | 1.6481 | 0.3487 | -0.2398 |
| m6 | iid | FALSE | FALSE | - | - | - | - | - |

Explored age based selectivity to allow the model to freely estimate older and younger ages. Age 4 was fixed at 1.

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Slide: A. Hansell

# Status of Previous Research Recommendations
## ToR4: Model

***Selectivity:***

The partial recruitment pattern on the ages four plus needs corroboration. Model fits presented at the meeting suggested dome partial recruitments in both the survey and commercial fishery which was at odds with the results of tagging analysis, which suggested no dome. [GARM III Peer Review]

- *This recommendation was addressed by changing the modeling platform to WHAM. There were no diagnostic issues that indicated further exploration was needed.*

Try catch and discards as separate fleets. [GARM III Peer Review]

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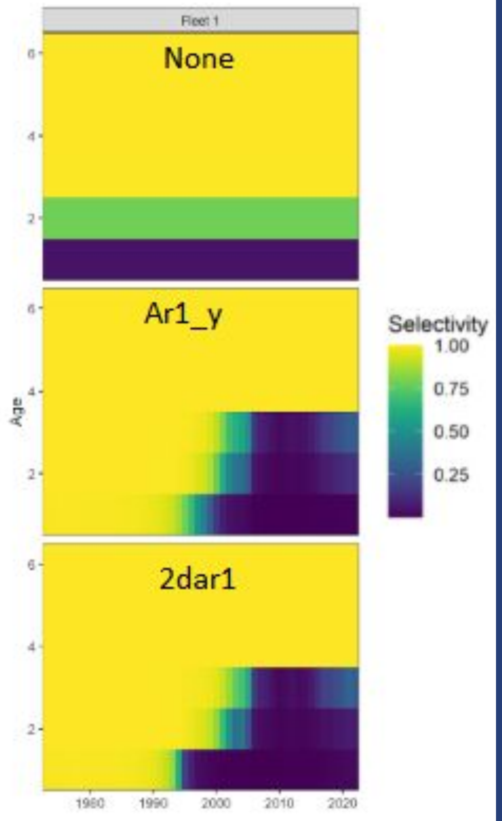
| m2 | Ar1_y | TRUE | TRUE | 2.4 | -1493.6 | 3.4697 | 0.6533 | -0.314 |
| m5 | block_1994 | TRUE | TRUE | 64.9 | -1431.1 | 6.3254 | 1.5862 | -0.4448 |
| m4 | block_2010 | TRUE | TRUE | 225 | -1271 | 4.0561 | 0.6666 | -0.1304 |
| m1 | None | TRUE | TRUE | 375.5 | -1120.5 | 1.6481 | 0.3487 | -0.2398 |
| m6 | iid | FALSE | FALSE | - | - | - | - | - |

Explored age based selectivity to allow the model to freely estimate older and younger ages. Age 4 was fixed at 1.



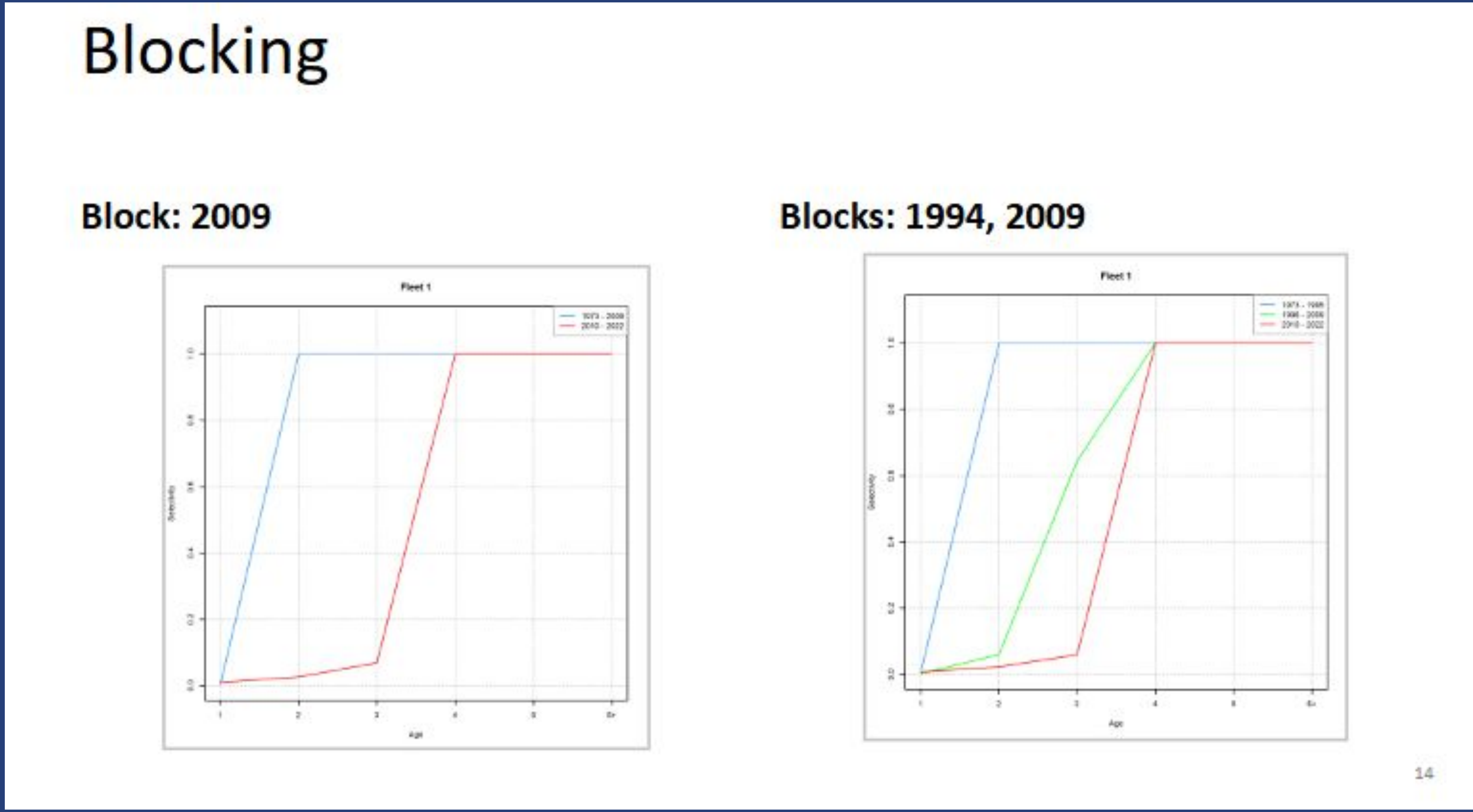

Runs 11-17



Slide credit:
A. Hansell

The partial recruitment pattern on the ages four plus needs corroboration. Model fits presented at the meeting suggested dome partial recruitments in both the survey and commercial fishery which was at odds with the results of tagging analysis, which suggested no dome. [GARM III Peer Review]

*This recommendation was addressed by changing the modeling platform to WHAM. There were no diagnostic issues that indicated further exploration was needed.*

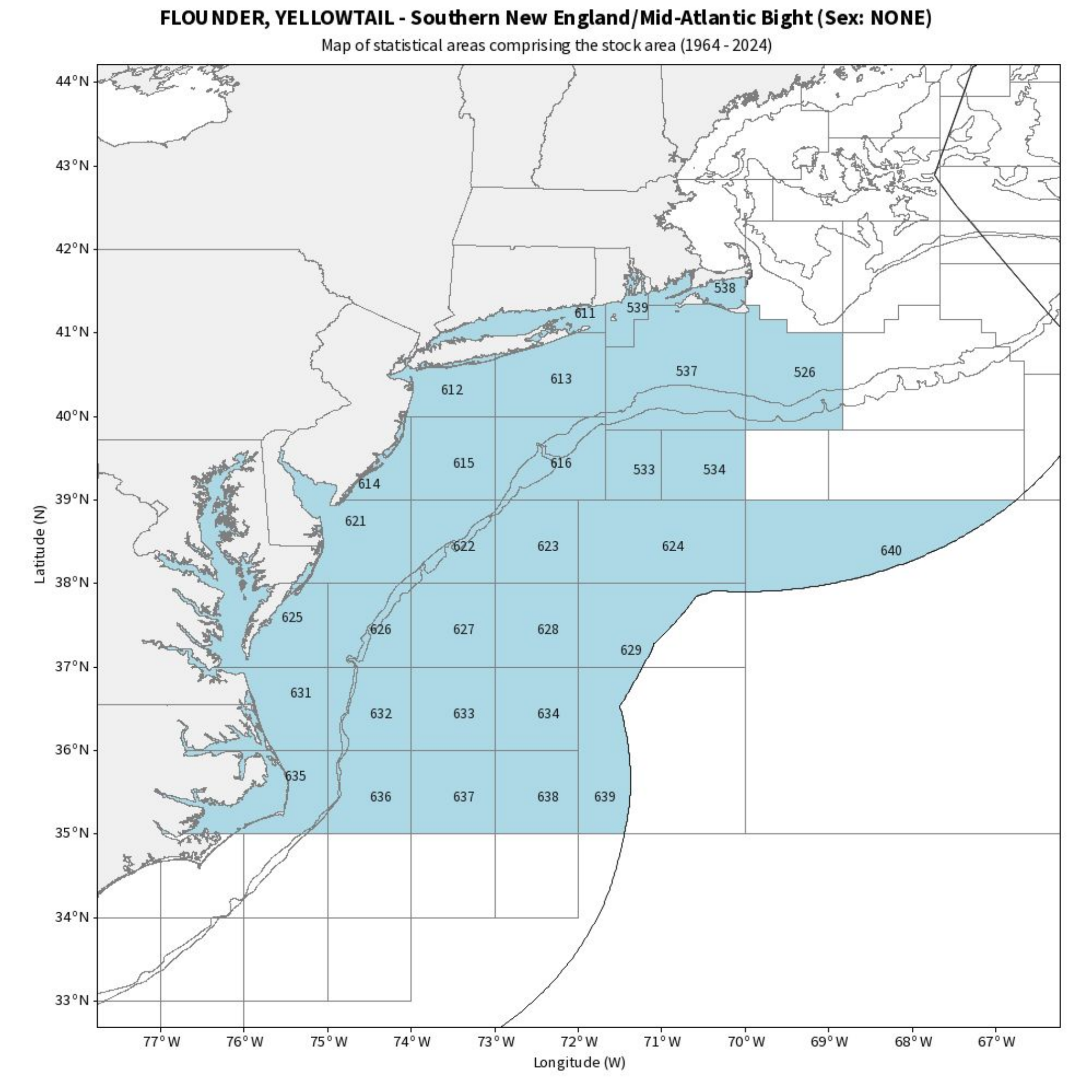



**Slide credit: A. Hansell**

# Southern New England/Mid-Atlantic

**Recommendations from:**

- 2022 Management Track Assessment
- 2019 Operational Assessment and peer review
- 2012 Stock Assessment Workshop and peer review (SAW/SARC 54)
- 2008 Groundfish Assessment Review Meeting (GARM III) and peer review



# Status of Previous Research Recommendations
## ToR1: Ecosystem and Climate Influences

***Environmental influences on recruitment:***

- Converting the modeling framework for this stock from ASAP to WHAM (or another state-space model) would allow estimation of the relationship between environmental factors and modeled recruitment. The long-term potential yield of this stock associated with climate change could then be considered. **[2022 MT]**
- Future studies should investigate some of the underlying ecological mechanisms of poor recruitment in the stock as it may relate to the physical environment. Recent studies on evaluating environmental effects on Southern New England yellowtail stock productivity suggest that oceanographic features, such as the cold pool and Gulf Stream are likely important predictors of recruitment (Miller et al., 2016; Xu et al., 2017), however the mechanisms driving these predictions are not well known. **[2019 Operational Assessment]**
- The work on the influence of the cold pool and associated environmental parameters on yellowtail population dynamics has not been fully developed, and merits further research. **[2012 SAW 54]**

# Status of Previous Research Recommendations
## ToR1: Ecosystem and Climate Influences

***Environmental influences on recruitment:***

- *SAW/SARC 54 explored the application of the cold pool index in ASAP. The present assessment transitioned to the WHAM*
- *Time-varying recruitment was modeled using several environmental covariates across model runs. Environmental covariates on recruitment evaluated included the Gulf Stream Index (GSI), Gulf Stream Index Spring, Atlantic Multidecadal Oscillation (AMO), North Atlantic Oscillation (NAO), Spring Bottom Temperature (BTS), and Cold Pool Index (CPI).*

# Environmental Covariate Effects on R, M, and q

**R**
- Atlantic Multidecadal Oscillation
- North Atlantic Oscillation
- Spring Bottom Temperature
- Cold Pool Index
- Gulf Stream Index
- Gulf Stream Index (Spring)

*(All lagged 1 year effects)*

**M**
- Atlantic Multidecadal Oscillation
- Spring Bottom Temperature
- Fall Bottom Temperature

**q**
- Paired Bottom Temperature

All based on work done for ToR 1



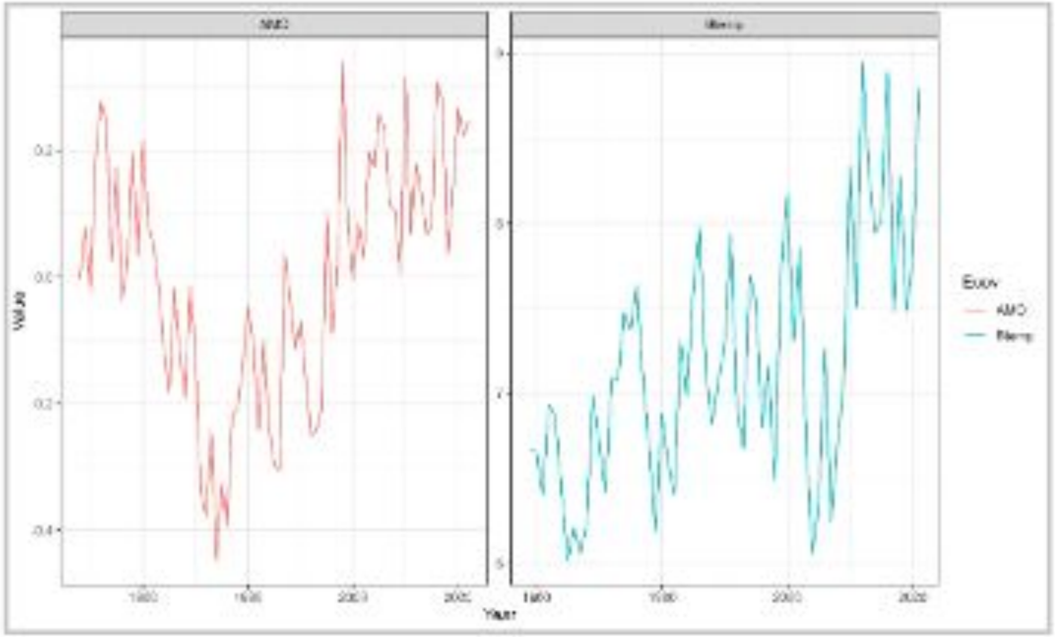
Slide: C. Hodgdon

# Ecov on recruitment

Jessie Kittle

- ToR 1 recommendations to explore the effect of:
  - AMO
  - Bottom temp

- Explore these for top models with RE on NAA:
  - 2dar1
  - Ar1y (coupled and decouple)
  - IID



**Controlling:** Density independent mortality

**Limiting:** Ecov determines the amount of suitable habitat

# Ecov: Btemp final models

| RE | Recruitment | Ecov process | Ecov how | conv | pdHess | NLL | daic | aic | rho R | rho SSB | rho Fbar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ar1_y | Random | rw | Controlling | TRUE | TRUE | -1095 | 0 | -2023 | -0.65 | -0.26 | 0.301 |
| Ar1_y | Random | ar1 | Controlling | TRUE | TRUE | -1094 | -4.2 | -2019 | 0.116 | -0.12 | 0.118 |
| IID | Random | rw | Controlling | TRUE | TRUE | -1041 | -104 | -1919 | 0.016 | -0.05 | 0.031 |
| IID | Random | ar1 | Controlling | TRUE | TRUE | -1040 | -108 | -1915 | 0.755 | 0.003 | -0.02 |

AR1 recruitment is preferred for projections

Slide credit: A. Hansell, J. Kittle, C. Carano

# Ecov: AMO

**NAA RE:** IID

| Recruitment | Ecov process | Ecov how | conv | pdHess | NLL | daic | aic | rho R | rho SSB | rho Fbar |
|---|---|---|---|---|---|---|---|---|---|---|
| Random | rw | --- | TRUE | TRUE | -1101.36 | 38.7 | -2042.7 | 1.1715 | 0.0054 | -0.0235 |
| Random | rw | Controlling | TRUE | TRUE | -1106.04 | 31.3 | -2050.1 | 1.0686 | 0.0036 | -0.0193 |
| Random | ar1 | Controlling | TRUE | TRUE | -1104.55 | 36.3 | -2045.1 | 1.1547 | 0.0065 | -0.0227 |
| Bev-Holt | rw | --- | TRUE | TRUE | -1115.92 | 11.6 | -2069.8 | 0.813 | 0.0188 | -0.0303 |
| Bev-Holt | rw | Controlling | TRUE | TRUE | -1122.34 | 0.7 | -2080.7 | 0.3504 | -0.0162 | 0.0097 |
| Bev-Holt | rw | Limiting | TRUE | TRUE | -1122.7 | 0 | -2081.4 | 0.0829 | -0.0385 | 0.0227 |
| Bev-Holt | ar1 | Controlling | TRUE | TRUE | -1120.93 | 5.5 | -2075.9 | 0.4362 | -0.014 | 0.0084 |
| Bev-Holt | ar1 | Limiting | TRUE | TRUE | -1121.22 | 5 | -2076.4 | 0.7276 | -0.0028 | -0.0057 |

**Takeaway:**

- Convergence is stable
- AIC supports including AMO
- Stock-recruit relationship is poorly estimated

Runs 65-72



Slide credit: A. Hansell, J. Kittel, C.

# Ecov: AMO

**NAA RE:** IID

| Recruitment | Ecov process | Ecov how | conv | pdHess | NLL | daic | aic | rho R | rho SSB | rho Fbar |
|---|---|---|---|---|---|---|---|---|---|---|
| Random | rw | --- | TRUE | TRUE | -1101.36 | 38.7 | -2042.7 | 1.1715 | 0.0054 | -0.0235 |
| Random | rw | Controlling | TRUE | TRUE | -1106.04 | 31.3 | -2050.1 | 1.0686 | 0.0036 | -0.0193 |
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**Takeaway:**
- Convergence is stable
- AIC supports including AMO
- Stock-recruit relationship is poorly estimated

Runs 65-72

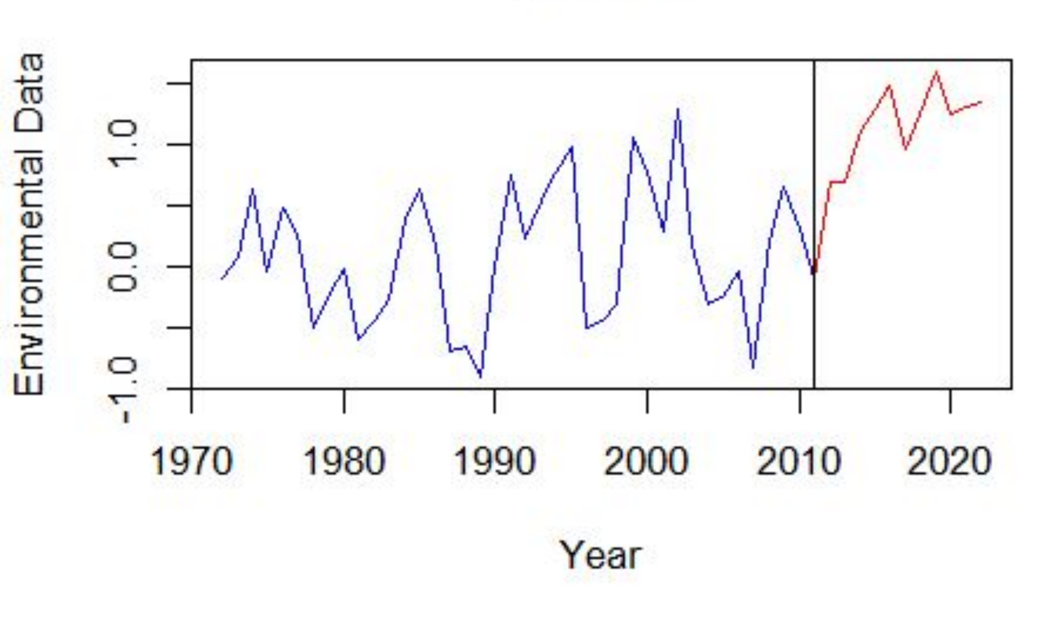


Slide credit: A. Hansell, J. Kittel, C. Carano

# Status of Previous Research Recommendations
## ToR1: Ecosystem and Climate Influences

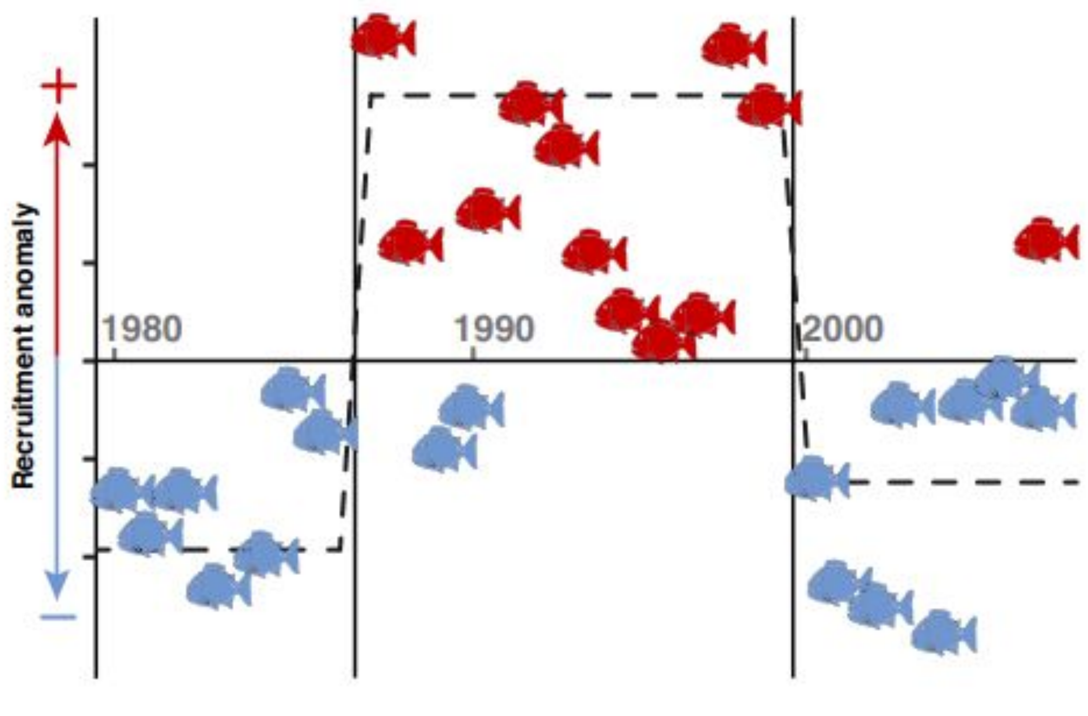
***Productivity:*** Investigate long-term changes in stock productivity given the severe decline of the resource. This has implications for the determination of biological reference points. [2008 GARM III]

- *Investigated through directed research (i.e., Perretti et al. 2017). A change point analysis was used in in this RT to capture recent environmental conditions and recruitment.*



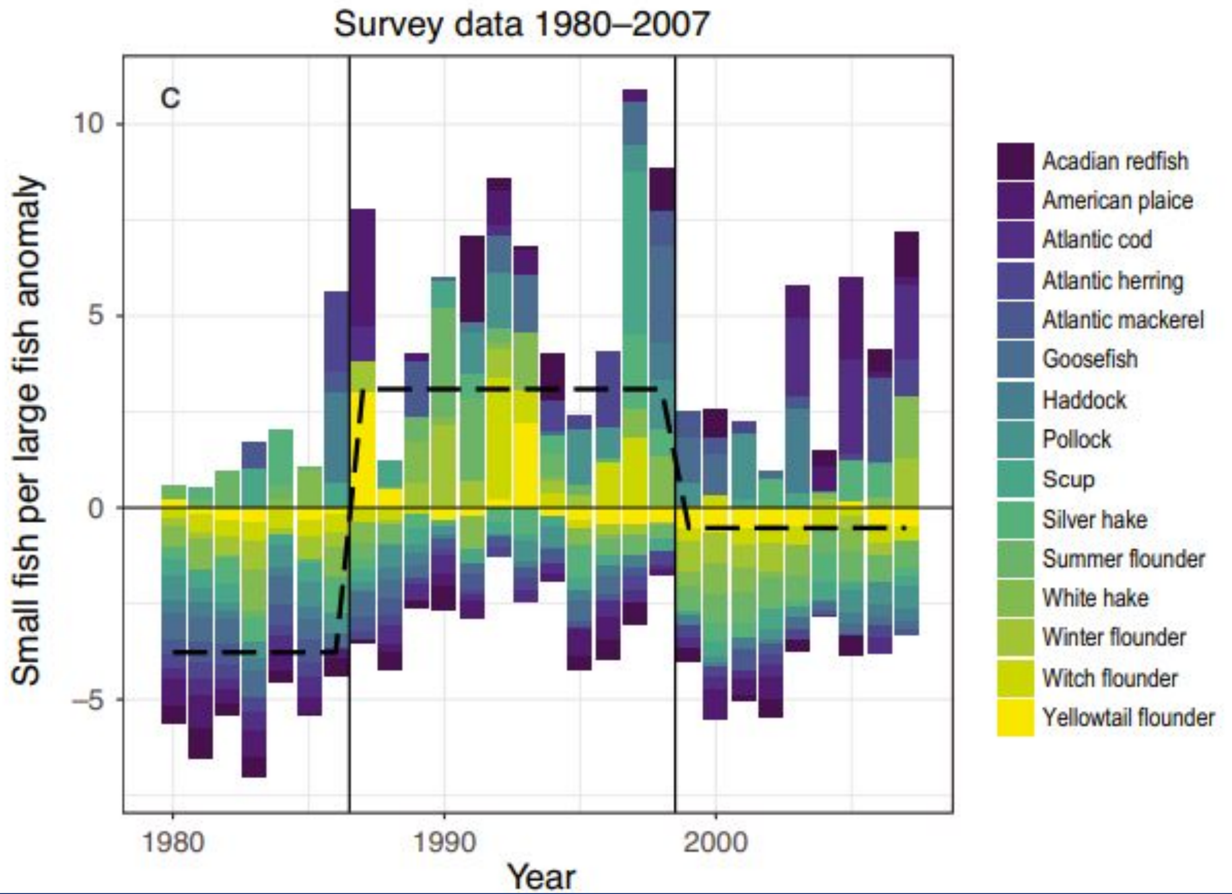

Example: Change point analysis led to the decision to project GSI using 2012-2022 period for projections.

# Perretti et al. 2017




Recruitment success regimes of fish on the Northeast US Continental Shelf.

*Graphic: C. Perretti and S. Schüller*



# Perretti et al. 2017

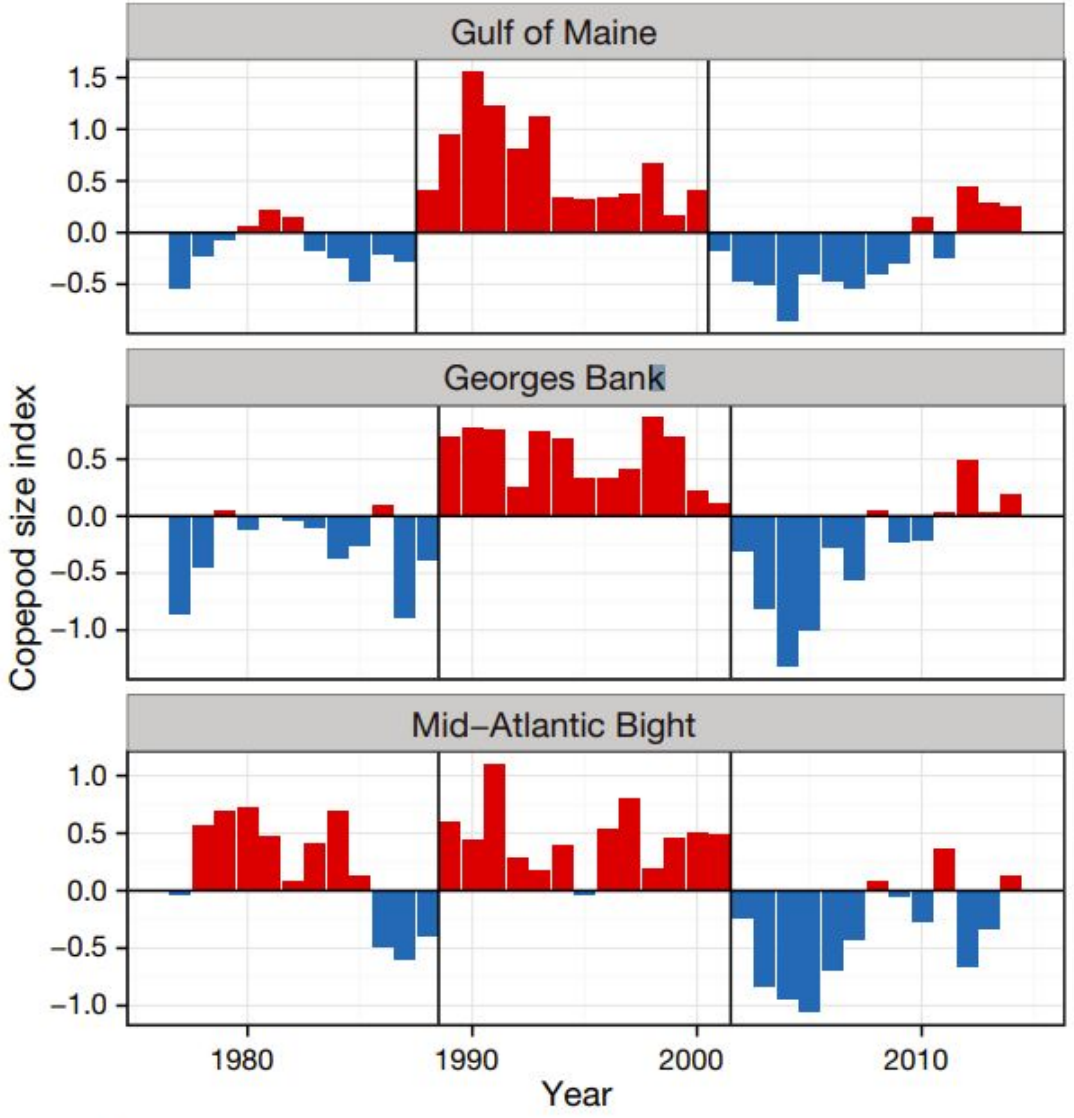



Fig. 4. Copepod size index (small copepod anomaly – large copepod anomaly) time series. Each bar represents the average annual anomaly, and vertical lines denote regime change points

# Status of Previous Research Recommendations

## ToR2: Catch

***Length-weight conversion:*** Update the length-weight parameters used to convert commercial landings (in weight) into numbers of fish. This could be accomplished by expanding existing data collection programs (e.g., Cooperative Research, Industry Based Surveys, NEFSC port sampling) to collect individual fish weights while collecting length and age data. This research recommendation is applicable to numerous species/stocks in the northeast, not just SNE/MA yellowtail flounder. [2012 SAW 54].

- *SAW/SARC 54 revised the existing length-weight relationship and adopted the spring length-weight relationship as a basis for fishery weights to numbers.*
- *The WG updated the length weight equations for all stocks using survey data from 1999 to 2021 to confirm differences across stocks. Annual and seasonal length weight equations were calculated.*

## ***Length-weight conversion:*** *SAW/SARC 54 revised the existing length-weight relationship and adopted the spring length-weight relationship as a basis for fishery weights to numbers.*

- The most recent length weight equations from survey data for SNEMA are from SAW 2012, which used data from 1992– 2010.
- The most recent length weight equation from the commercial data are from Lux (1969).
- The WG updated the length weight equations for all stocks using survey data from 1999 to 2021 to confirm differences across stocks. Annual and seasonal length weight equations were calculated.
- A study is currently going on to update commercial length-weight equations from the commercial fishery (Pers comm. Wigley). If sample sizes are sufficient updated equations can be used for future catch at age expansions.

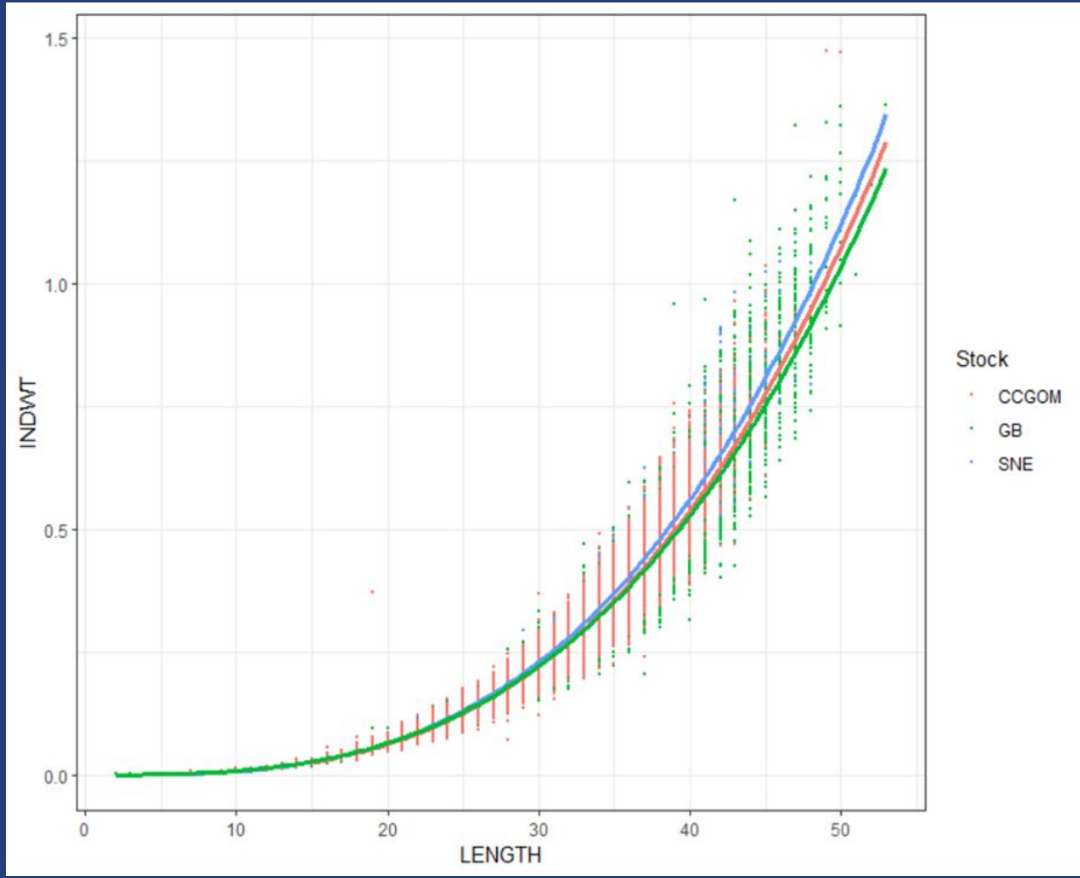



Figure 1: Updated annual length-weight relationships for the three stocks using NEFSC survey data from 2000-2021.

# Status of Previous Research Recommendations
## ToR2: Catch

***Sampling:*** If the volume of commercial landings increases in the future, ensure that adequate samples of the landings are obtained for all market categories on at least a quarterly basis. [2012 SAW 54].

- *Adequate port sampling remains an issue in the present assessment. Quarterly resolution was not explored in this assessment for deriving fishery catch data due to low landings.*

*Adequate port sampling remains an issue in the present assessment. Quarterly resolution was not explored in this assessment for deriving fishery catch data due to low landings.*

| Year | Landings (mt) | Number of lengths | Metric tons/100 lengths | Number of ages |
|---|---|---|---|---|
| 2012 | 323.931 | 6379 | 5.1 | 1602 |
| 2013 | 461.749 | 5367 | 8.6 | 1168 |
| 2014 | 516.589 | 4771 | 10.8 | 950 |
| 2015 | 284.111 | 5037 | 5.6 | 1315 |
| 2016 | 125.938 | 3442 | 3.7 | 728 |
| 2017 | 48.019 | 1055 | 4.6 | 260 |
| 2018 | 10.846 | 853 | 1.3 | 261 |
| 2019 | 2.187 | 3 | 72.9 | 3 |
| 2020 | 2.09 | 0 | 0 | 0 |
| 2021 | 0.566 | 0 | 0 | 0 |
| 2022 | 0.219 | 0 | 0 | 0 |

Number of biological samples (boxes of fish) and number of fish sampled annually from landings of yellowtail flounder from SNEMA (2012-2022).

# Status of Previous Research Recommendations
## ToR4: Model

***Retrospective bias:***

Future work should continue to address the retrospective bias, including further work on the sensitivity analyses (i.e., determination of appropriate input data weighting by evaluating the CV and effective sample sizes in the model). However, this update resulted in an improvement in retrospective diagnostics relative to the 2017 assessment [2019 Operational Assessment and Peer Review]

- *Transitioning to the WHAM framework led to a reduction in retrospective bias.*
  - 2022 ASAP: Mohn's ρSSB = 70; ρF = 0.082
  - 2024 RT: Mohn's ρSSB = 0.145; ρF = -0.014

*Transitioning to the WHAM framework led to a reduction in retrospective bias.*

- 2019: Mohn's ρSSB = 0.63; ρF = 0.31
- 2021: Mohn's ρSSB = 2.43; ρF = -0.62
- 2022 ASAP: Mohn's ρSSB = 70; ρF = 0.082
  - Major retrospective pattern because ρ  outside the approximate 90% confidence regions around SSB (148 - 405) and F (0.019 - 0.053). The retrospective adjustment changed the 2021 SSB from 241 to 70 and the 2021 FFull from 0.032 to 0.082.
- 2024 RT: Retrospective analysis revealed that the candidate model had minor tendencies to revise retrospective estimates of SSB downward (Mohn's ρ = 0.145) and revise retrospective estimates of F upward (Mohn's ρ = -0.014).

# Status of Previous Research Recommendations

## ToR4: Model

***Stock-Recruit Relationship:*** The use of ‘windows’ of biomass rather than the breakpoint should be explored to create the stanzas in the stock – recruitment relationship. This may better address inconsistencies in rebuilding plans that might arise as the biomass grows from the lower to the higher stanza. [2008 GARM III]

- *This recommendation is a remnant from the VPA modeling framework. Transitioning to the WHAM framework more accurately captures time-varying recruitment.*
- *Model runs with and without a stock-recruit relationship were explored.*
- *In some cases, ecological covariates captured the effects of a stock-recruit relationship. R was modelled as random around a mean.*
- *In other runs, the stock-recruit relationship was modeled explicitly and a BH SR led to the best diagnostics.*

## *Model runs with and without a stock-recruit relationship were explored.*

**Model 'homework':**

| Model | Delta AIC | Rho F | Rho SSB | Rho R |
|---|---|---|---|---|
| **Candidate Model**<br>R is random about mean and impacted by GSI | 0.0 | -0.014 | 0.145 | 0.671 |
| **Candidate Model Without GSI**<br>R is random about mean and NOT impacted by GSI | 13.6 | -0.019 | 0.175 | 1.572 |
| **Candidate Model with a BH SR**<br>R is informed by a BH SR. There is no effect of GSI. | 13.1 | -0.028 | 0.223 | 1.427 |

Slide credit: C. Hodgdon

# Status of Previous Research Recommendations
## ToR4: Model

***Catchability:***

Splitting the survey time series to explore whether trends in survey catchability are present in Southern New England. If so, spatial differences in the survey selectivity and/or environmental covariates (temperature) should be investigated as potential causative processes. [2008 GARM III]

- *Splitting the NMFS BTS survey in the mid-1990s was recommended to improve the diagnostics of the model used in GARM III and is not considered appropriate for the current model framework.*
- *The effect of environmentally-mediated annual deviations on survey catchability were explored but led to poor diagnostics.*
- *Specifically tested bottom temp effects on q (Bell et al. 2022).*
  - *With and without random effects*
  - *Modelled as a random walk or ar-1 process.*

## *The effect of environmentally-mediated annual deviations on survey catchability were explored but led to poor diagnostics*

- Bell et al. (2022) demonstrated that temperature fluctuations directly affect the location of yellowtail flounder’s preferred habitat.
- Spring, Fall and Winter bottom temperature were paired with the corresponding survey.
- If the survey had random effects on q already, tests were done with and without the random effects.
- Process modelled as either a random walk or an ar1
- **All ECOV effects on q performed worse than the base model.**

# Status of Previous Research Recommendations
## ToR4: Model

***Selectivity:***

Investigation of spatial differences in the survey selectivity and/or environmental covariates (temperature). [2008 GARM III]

- *The WG explored many different functional forms for survey selectivity, with and without random effects, and incorporated different selectivities for the NEFSC Spring, Fall and Winter surveys.*

Partial recruitment of the plus-age groups (particularly with regards to the uncertainty in the catch-at-age of the SNE stock). [2008 GARM III]

- *The WG tested the use of selectivity blocks for the NMFS BTS, separating the FRV Albatross IV and the FSV Henry B. Bigelow time series in 2009. Selectivity in the plus age group of the fishery data was also explored.*

***The WG explored many different functional forms for survey selectivity, with and without random effects, and incorporated different selectivities for the NEFSC Spring, Fall and Winter surveys.***

- Pre-ECOV candidate models had logistic fleet/NEFSC spring, fall and winter selectivity.

- For each of the original five surveys (NEFSC Spring, NEFSC Fall, NEFSC Winter, MARMAP Larval, ECOMON Larval), age-specific and logistic selectivities were tested.

- NEFSC Spring and Winter selectivities eventually ended up with **logistic** selectivity and the NEFSC Fall survey with **age-specific**.

- Random effects were tested similarly as was done for the fleet, but none led to better fitting models.

# Research Recommendations Developed during the 2024 Research Track Assessment

# 2024 RT Research Recommendations
## ToR 1: Ecosystem and Climate Influences

***Environmental Covariates (Low Priority):***

- Update and confirm that the relationships of environmental variables continue (bottom temperature for CCGOM and GB, GSI for SNEMA).
  - If relationships break down, consider alternative environmental metrics that may be more directly influencing yellowtail stocks.
  - In general, continue to explore the relationships of recruitment and other parameters with environmental covariates for all three stocks and continue to explore alternative projection methodologies for GSI (SNEMA) and bottom temperature (GB).

- Create a data product for salinity that could be explored in future models.

# 2024 RT Research Recommendations
## ToR 2: Catch

***Catch-at-Age estimates (High Priority):***

- Enhanced port sampling for improved catch-at-age estimates for all stocks.

# 2024 RT Research Recommendations
## ToR 4: Model

***Model Platform (High Priority):***

- Given the increasingly low survey catches for SNEMA and GB and the increasing chances of true zeroes in the survey data for this stock, it is imperative to modify WHAM to be able to more appropriately address zero values.

- WHAM configurations should follow guidance on lognormal adjustment bias correction contemporaneous to the assessment being conducted. The decisions and guidance on how and when to apply lognormal adjustment bias correction should be documented within the report.

# 2024 RT Research Recommendations
## TorR 5 Reference Points & ToR 6: Projections

***Environmentally-informed projections (High Priority):***

- Confirm that the assumptions of current conditions continue for projections and reference points (breakpoints for GB bottom temperature and SNEMA Gulf Stream Index).

- Explore near-term projections of environmental covariates to inform short-term catch projections.

# References


- Goethel DR, Legault CM, Cadrin SX. 2015. Testing the performance of a spatially explicit tag-integrated stock assessment model of yellowtail flounder (*Limanda ferruginea*) through simulation analysis. Can. J. Fish. Aquat. Sci. 72: 582-601. https://doi.org/10.1139/cjfas-2014-0244
- Miller, T.J., Hare, J.A., and L.A. Alade. 2016. A state-space approach to incorporating environmental effects on recruitment in an age-structured assessment model with an application to southern New England yellowtail flounder. *Canadian Journal of Fisheries and Aquatic Sciences*. **73**(8): 1261-1270. https://doi.org/10.1139/cjfas-2015-0339
- [NEFSC] Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dept Commer., Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. https://repository.library.noaa.gov/view/noaa/5227
- [NEFSC] Northeast Fisheries Science Center. 2012. 54th Northeast Regional Stock Assessment Workshop (54th SAW) Assessment Report. US Dept Commer., NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 12-18; 600 p. https://repository.library.noaa.gov/view/noaa/4193
- [NEFSC] Northeast Fisheries Science Center. 2022. Stock Assessment Update of 14 Northeast Groundfish Stocks Through 2018. U.S. Dept. Commer.., Northeast Fish. Sci. Cent. Ref. Doc. 22-06; 227 pp. https://repository.library.noaa.gov/view/noaa/39402/
- [NEFSC] Northeast Fisheries Science Center. 2022. Management Track Assessments Fall 2022. U.S. Dept. Commer., Northeast Fish. Sci. Cent. Tech. Memo. 305; 167 p.+xv. https://repository.library.noaa.gov/view/noaa/55264
- Perretti CT, Fogarty MJ, Friedland KD, Hare JA, Lucey SM, McBride RS, Miller TJ, Morse RE, O'Brien L, Pereira JJ, Smith LA, Wuenschel MJ. 2017. Regime shifts in fish recruitment on the Northeast US Continental Shelf. Marine Ecology Progress Series. Vol. 574: 1-11. https://doi.org/10.3354/meps12183
- Tableau A, Collie JS, Bell RJ, Minto C. 2019. Decadal changes in the productivity of New England fish populations. Canadian Journal of Fisheries and Aquatic Sciences. 76(9): 1528-1540. https://doi.org/10.1139/cjfas-2018-0255
- Ten Brink T, McIntyre T. 2022. Proceedings of the 2022 Transboundary Resources Assessment Committee for Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. Northeast Fisheries Science Center (U.S.); Canada. Department of Fisheries and Oceans. TRAC Proceedings Series 2022/001. https://doi.org/10.25923/fz29-n435
- Xu, H., Miller, T. J., Hameed, S., Alade, A. L., and Nye, J. 2017. Evaluating the Utility of the Gulf Stream Index for Predicting Recruitment of Southern New England-Mid Atlantic yellowtail flounder. Fisheries Oceanography. DOI: 10.1111/fog.12236.