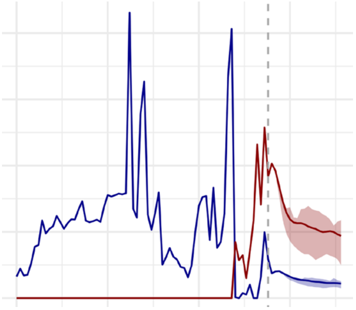
Management Strategy Evaluation for the South Atlantic Snapper-Grouper Fishery

Progress Report 2





SSC

9th February 2024

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bluematter

openMSE

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Objectives

1. Update on work done so far
2. Plan for next steps
3. Feedback from SSC

Outline

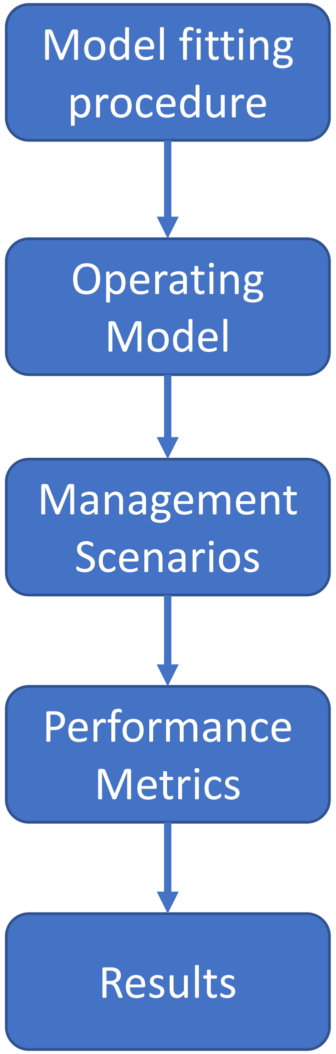
1. Project Overview
2. Model Structure
3. Recruitment Process Error in Projections
4. Additional Operating Models
5. Management Measures
6. Example Results
7. Challenges

Project Overview

Project overview

Objective: Develop a framework to:

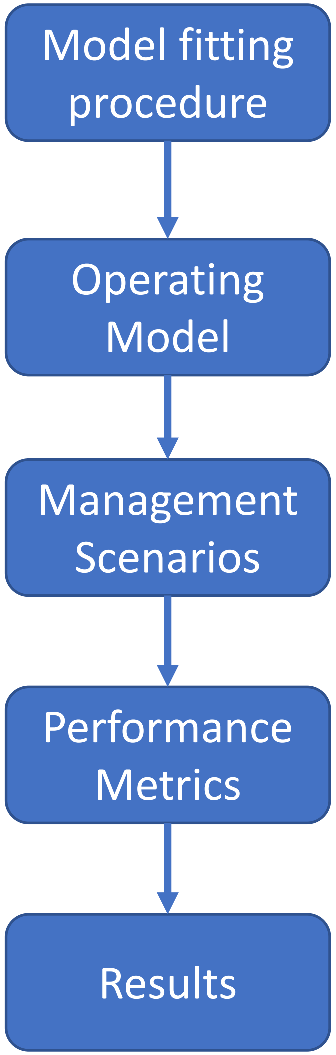
- construct multispecies operating models
- model potential management strategies for SAFMC fisheries
- evaluate results against established performance metrics
- extend analysis to additional species



Progress

<u>We have made a complete first pass at all of these steps</u>

We have a working MSE framework that can be used to demonstrate the effectiveness of various management options and show how performance can be evaluated.



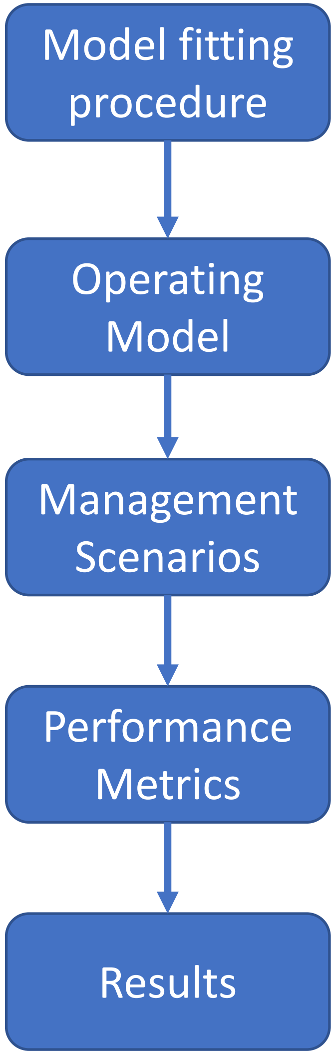
Progress

<u>We have made a complete first pass at all of these steps</u>

We have a working MSE framework that can be used to demonstrate the effectiveness of various management options and show how performance can be evaluated.

Next steps:

- identify specific management options to include in analysis
- finalize additional system hypotheses
- revise performance metrics as needed



Model Structure

Model Structure

1. Process for Generating Operating Models (OM)
2. Overview of Base Case OM
3. Spatial Structure
4. Assumptions for Projections
5. Alternative system hypotheses

Technical Specifications Document

SAFMC MSE Trial Specifications Document

1 Introduction

The South Atlantic Fishery Management Council has started a Management Strategy Evaluation (MSE) process for the Snapper-Grouper fishery, currently managed under the Snapper-Grouper Fishery Management Plan. The Snapper-Grouper fishery includes 55 species of snappers, groupers, and other species.

This document describes the technical specifications of the MSE process. It is a living document that will be continually updated to reflect the current state of the MSE work. Comments, questions, and feedback are welcome by contacting the MSE Technical Group Members.

More information on the MSE process can be found on the SAFMC Snapper-Grouper MSE homepage.

There are three main components in an MSE analysis:

1. **Operating Models (OMs)**

   Operating models contain a mathematical description of the fishery system, including the biology of the fish stock, the historical exploitation pattern by the fishing fleet(s), and the observation processes used to collect the fishery data. The OMs also include the assumptions for the data collection process in the forward projections, and any implementation error for implementing the management advice in the forward projections.

   An MSE process usually includes a number of different operating models, each representing a different hypothesis about the potential fishery dynamics. The OMs should span the key uncertainties in the fishery system. By including these uncertainties, the MSE can identify a management approach that is robust to these uncertainties.

2. **Management Procedures (MPs)**

   Management procedures are a set of rules that convert fishery data into management advice, e.g., a total allowable catch limit (TAC), a size limit, an effort control, a spatial closure, or some combination of different management measures. The main goal of MSE is to evaluate the performance of different MPs and identify the MP that is most robust to the uncertainty in the system.

3. **Performance Metrics (PMs)**

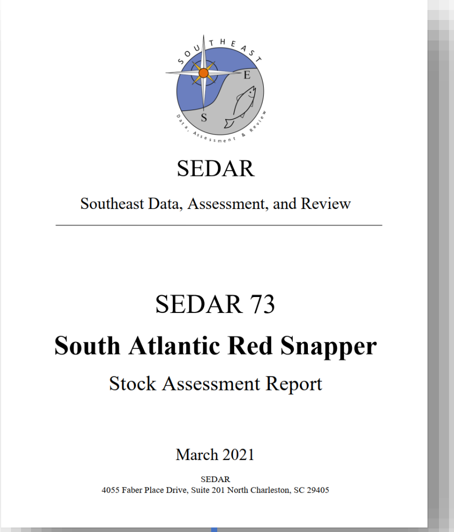
   Performance metrics are used to evaluate the performance of the management procedures. PMs are quantitative metrics than can be calculated within the MSE framework and be used to evaluate and compare the performance of the CMPs.

This document describes the OMs, MPs, and PMs that have been developed for the SAFMC Snapper-Grouper MSE.

https://safmc-mse.bluematterscience.com/ts/ts

Process for Generating OMs

Beaufort Assessment Model (BAM)


SEDAR

Southeast Data, Assessment, and Review

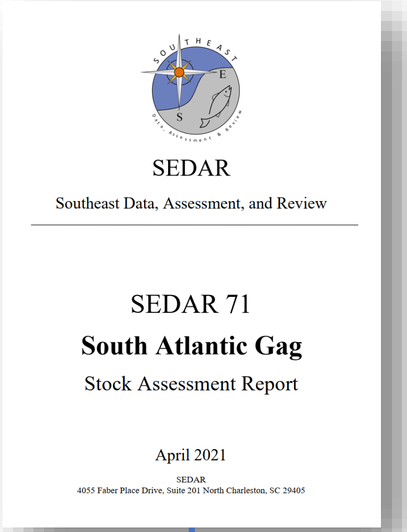
SEDAR 73

South Atlantic Red Snapper

Stock Assessment Report

March 2021

SEDAR
4055 Faber Place Drive, Suite 201 North Charleston, SC 29405


SEDAR

Southeast Data, Assessment, and Review

SEDAR 71

South Atlantic Gag

Stock Assessment Report

April 2021

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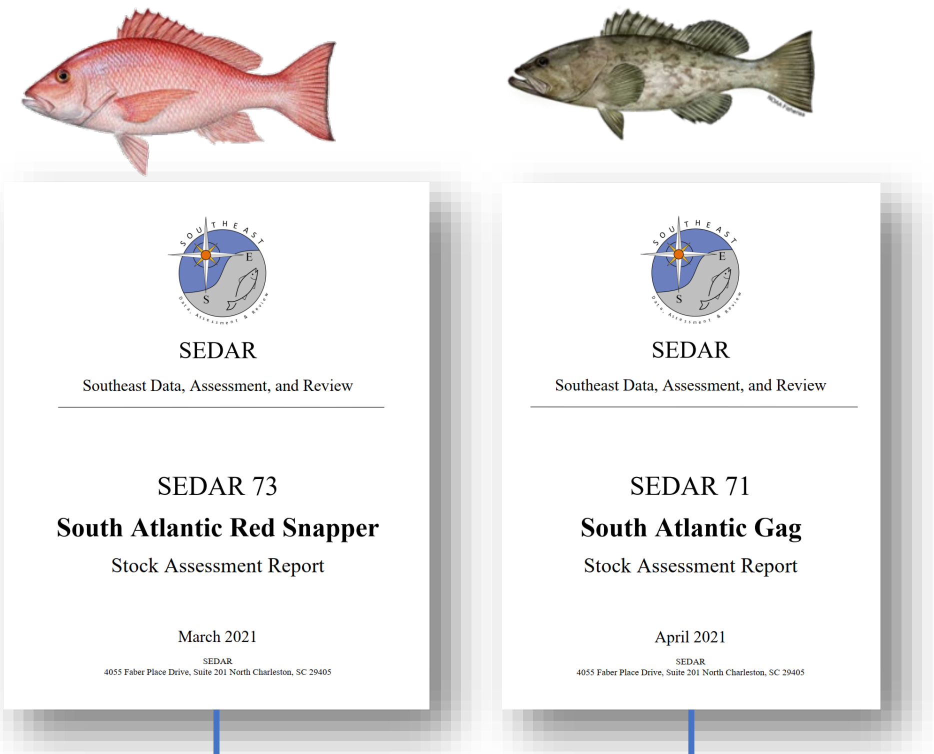
openMSE

Multi-Species Operating Model

Process for Generating OMs

Beaufort Assessment Model (BAM)



Assessment: Fleets structured into 'Landings' and 'Discards'

openMSE

Multi-Species Operating Model

Operating Model: Require structure for On- and Off-Season fleets (landings & discards through selectivity and retention curves)

Process for Generating OMs

Red Snapper

Assessment

1. Commercial Handline (cHL)
2. Commercial Handline - Discards (cHL.D)
3. Recreational Headboat (rHB)
4. Recreational Headboat - Discards (rHB.D)
5. General Recreational (rGN).
6. General Recreational - Discards (rGN.D).

Operating Model

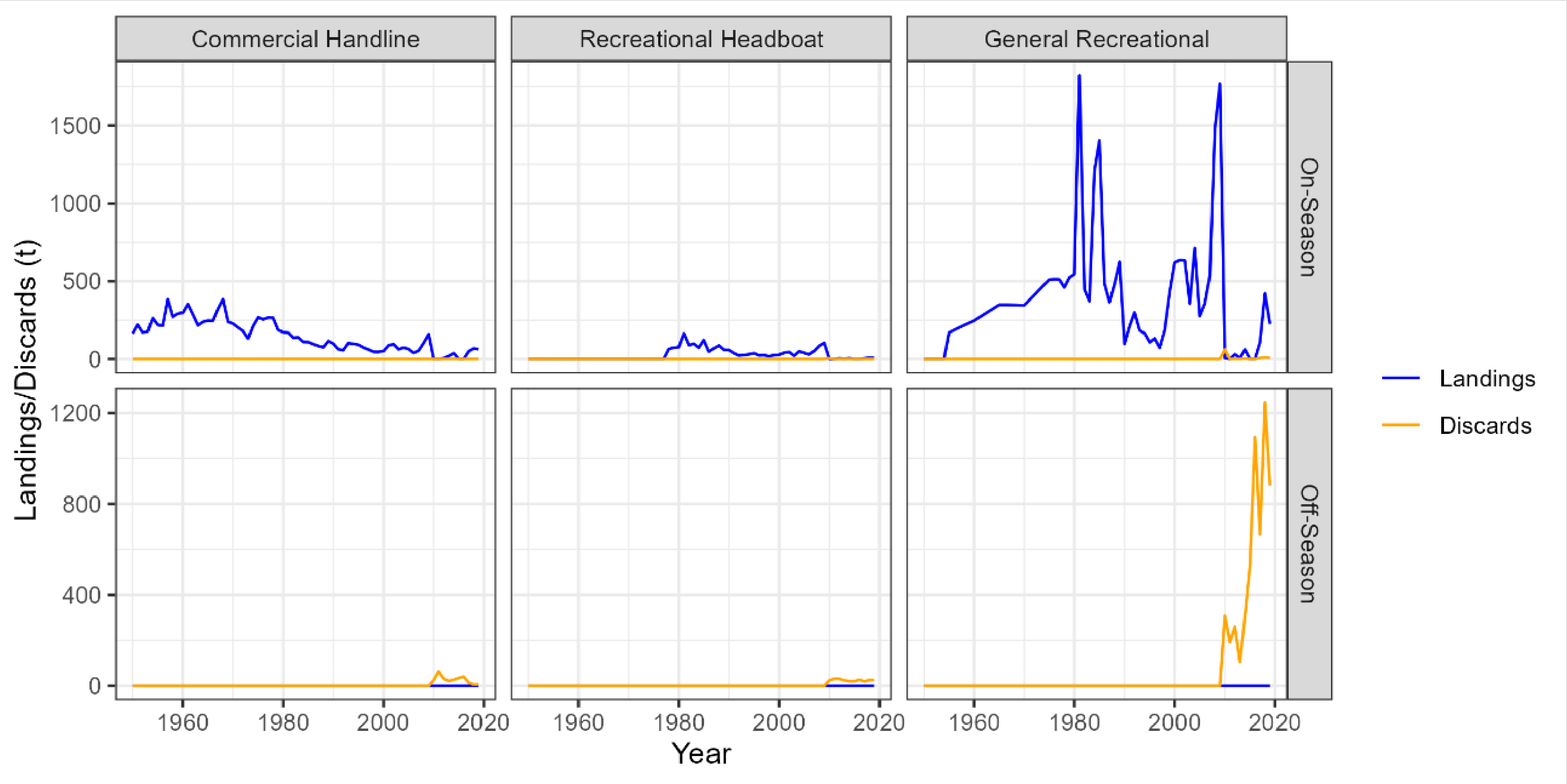
1. Commercial Handline - On-Season
2. Commercial Handline - Off-Season
3. Recreational Headboat - On-Season
4. Recreational Headboat - Off-Season
5. General Recreational - On-Season
6. General Recreational - Off-Season

For each fleet:

- calculated proportion of discards that occurred during the off-season
- On-Season: retained catch and discards
- Off-Season: all discarded

Process for Generating OMs

Red Snapper



Process for Generating OMs

Gag Grouper

Assessment

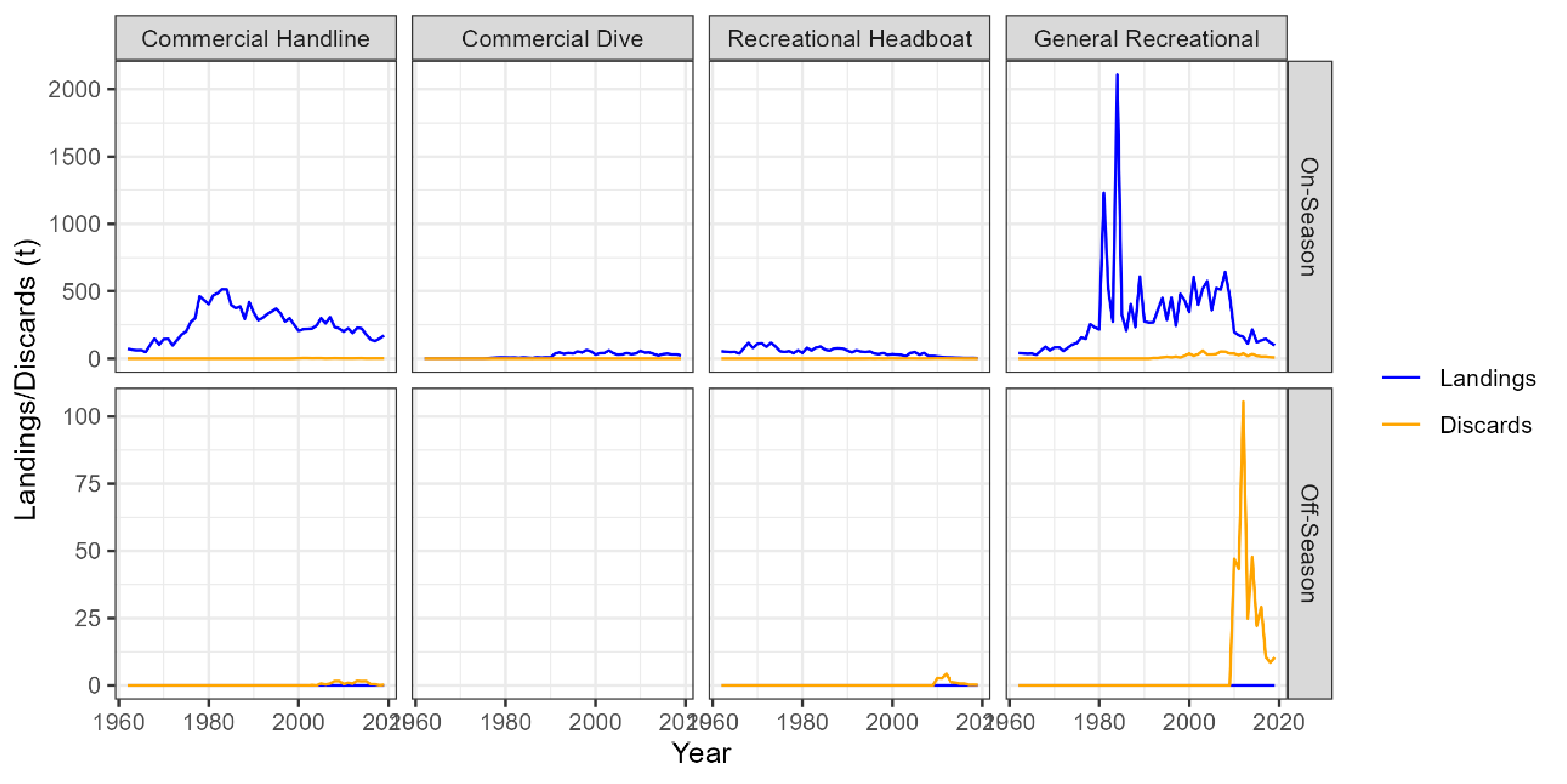
1. Commercial Handline (cHL)
2. Commercial Handline - Discards (cHL.D)
3. Recreational Headboat (rHB)
4. Recreational Headboat - Discards (rHB.D)
5. General Recreational (rGN).
6. General Recreational - Discards (rGN.D).
7. Commercial Dive (cDV)

Operating Model

1. Commercial Handline - On-Season
2. Commercial Handline - Off-Season
3. Recreational Headboat - On-Season
4. Recreational Headboat - Off-Season
5. General Recreational - On-Season
6. General Recreational - Off-Season
7. Commercial Dive - On-Season

Process for Generating OMs

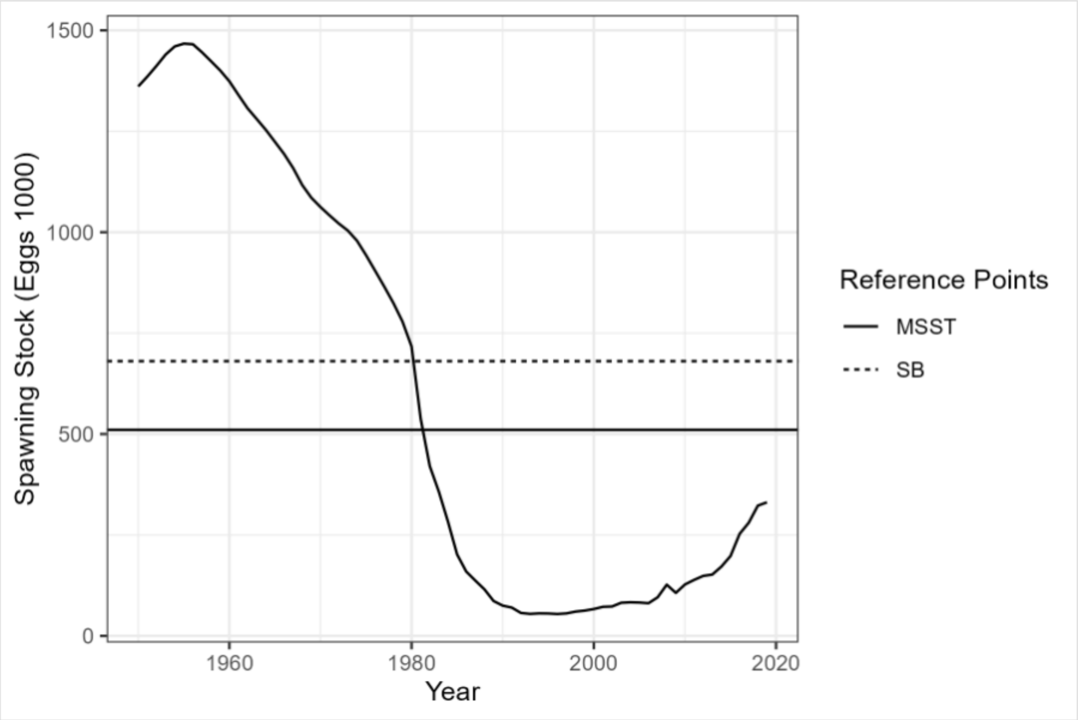
Gag Grouper

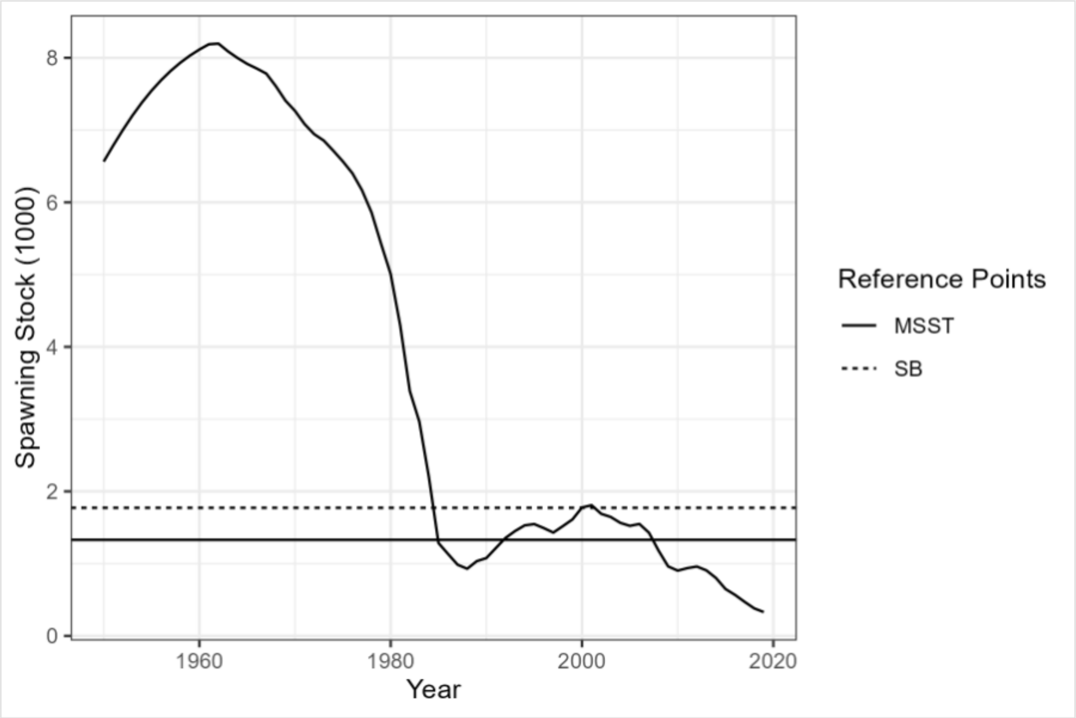


Note different scale on Y-axis

Overview of Base Case Operating Model

Biomass Trends

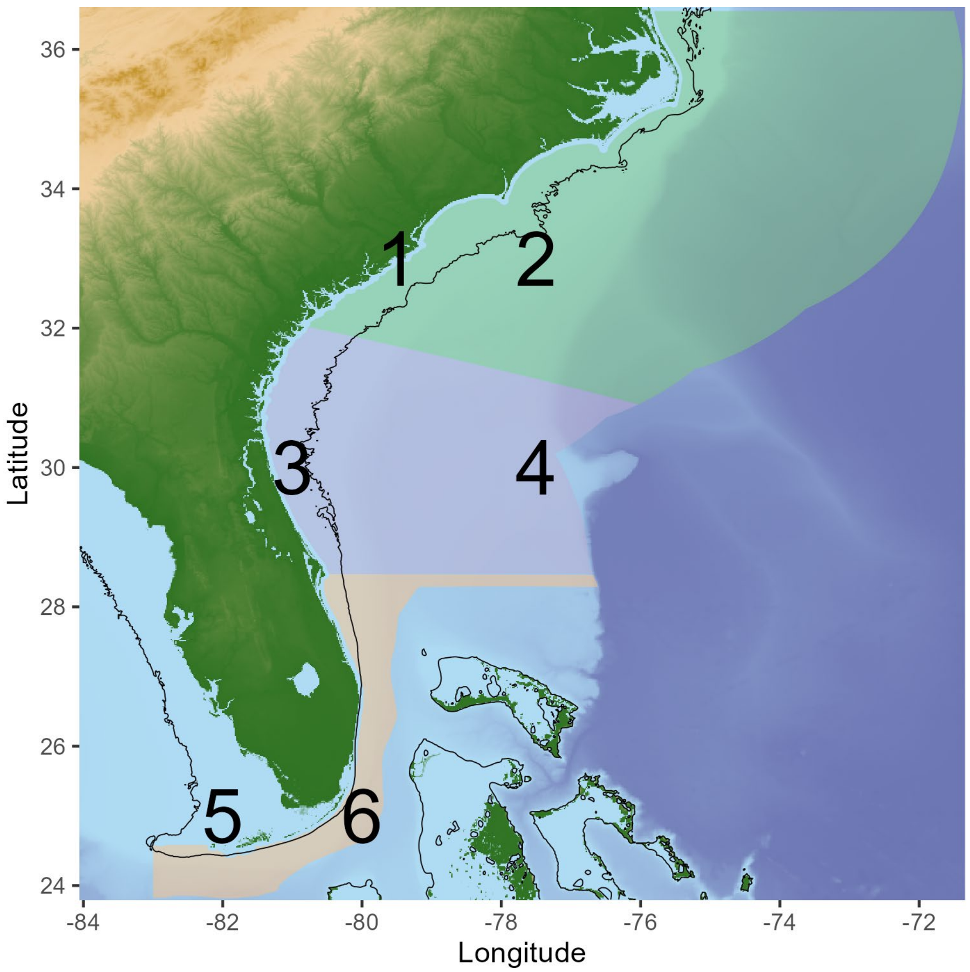




Confirmation OM reproduces dynamics from assessments

Spatial Structure

Definition of Areas



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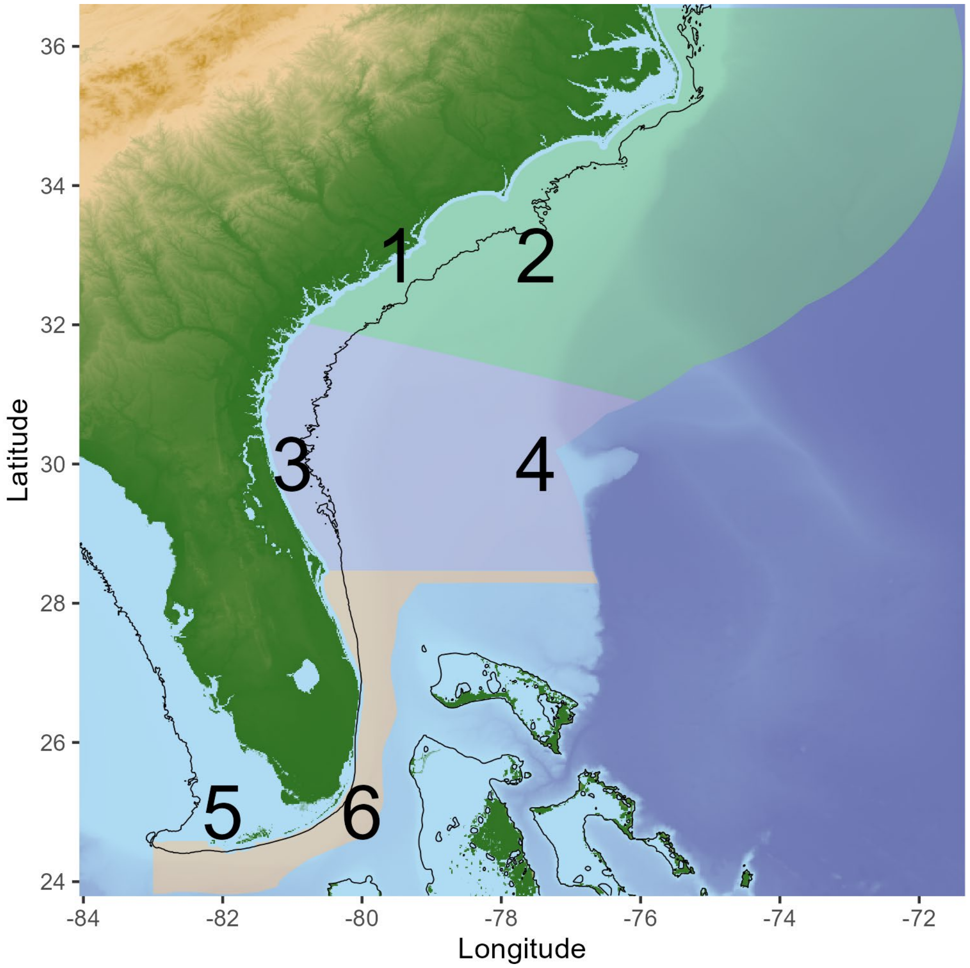


Area	Region	Depth	Relative Size %
1	North and South Carolina	Nearshore	6.3
2	North and South Carolina	Offshore	54.5
3	Georgia - Cape Canaveral	Nearshore	4.5
4	Georgia - Cape Canaveral	Offshore	24.5
5	Cape Canaveral - Florida	Nearshore	0.9
6	Cape Canaveral - Florida	Offshore	9.4

- 3 regional areas
- 2 depth areas: Nearshore < 100 ft

- Relative size calculated as proportion of total surface area

Spatial Structure

Latitudinal Distribution of Unfished Abundance

What is the natural (unfished) distribution of the stocks across the 3 latitudinal regions?

Spatial Structure

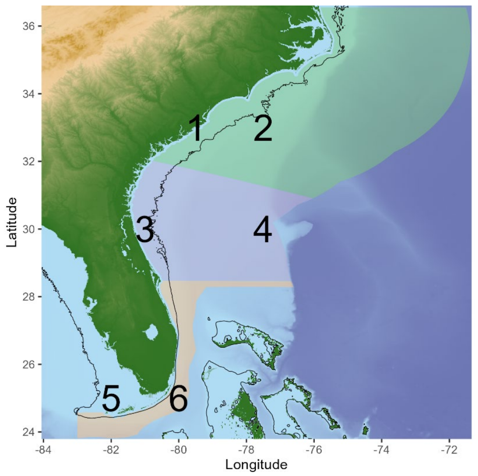
Latitudinal Distribution of Unfished Abundance

What is the natural (unfished) distribution of the stocks across the 3 latitudinal regions?

- Information on unfished distribution is not available
- Used available data and literature to estimated relative distribution of stocks
- Uncertainties can be evaluated in alternative OMs

Spatial Structure

Latitudinal Distribution of Unfished Abundance



South East Reef Fish Survey (SERFS) [(Bubley et al., 2023)]

- highest abundance in Georgia – Cape Canaveral region (3 & 4)
- abundance in NC & SC (1 & 2) ~ ¼ of that in 3 & 4

- SERFS data suggest abundance in areas 5 & 6 is about 7% of that in 3 & 4
- However, SERFS doesn't include entire area of 5 & 6

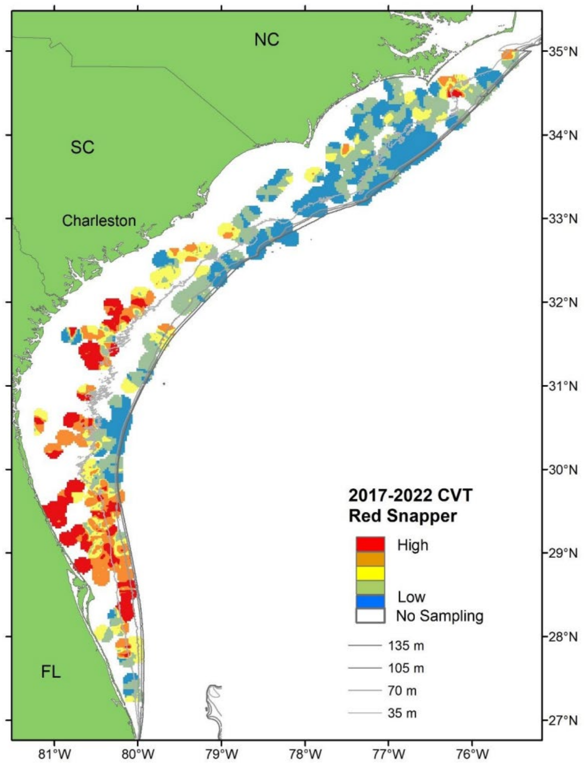


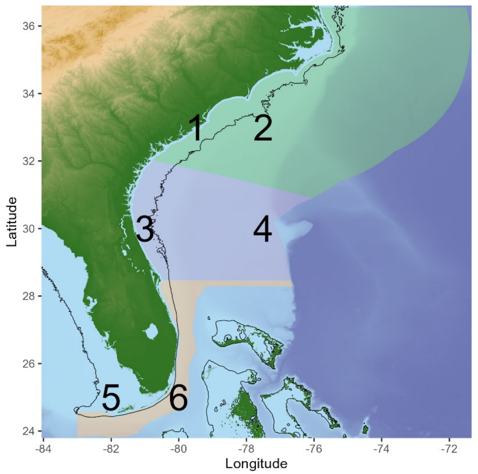
Figure 18. Distribution map of Red Snapper catch from CVT in 2017-2022.

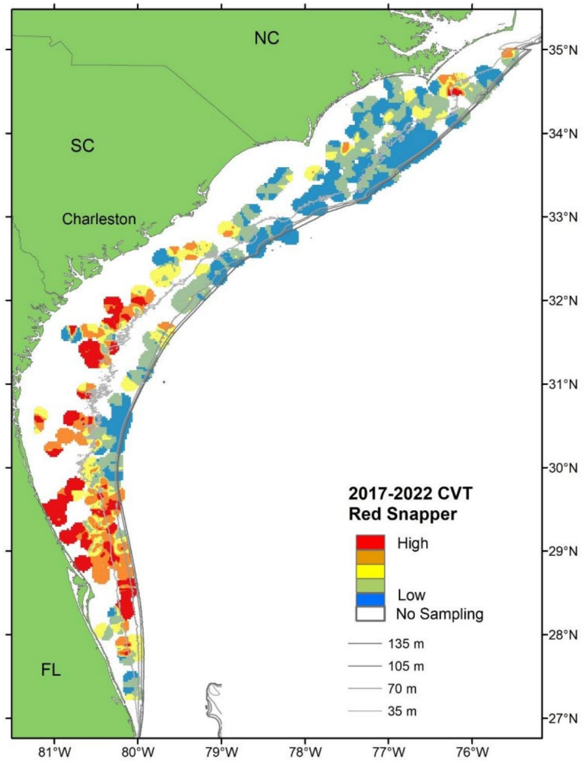
Spatial Structure

Latitudinal Distribution of Unfished Abundance

South East Reef Fish Survey (SERFS) (Bubley et al., 2023)

- GOM RS (SEDAR 52): unfished biomass in east GoM ~6 x higher than that estimated in the SAMFC region (SEDAR 73)
- Suggests decreasing abundance of RS with increasing latitude (supported by SERFS)





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Spatial Structure

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- GOM RS (SEDAR 52): unfished biomass in east GoM ~6 x higher thar that estimated in the SAMFC region (SEDAR 73)
- Suggests decreasing abundance of RS with increasing latitude (supported by SERFS)
- Based on this information, Base Case OM *assumes* relative abundance in areas 5 & 6 is **twice** as high as that in 3 & 4

Assumed Latitudinal Distribution

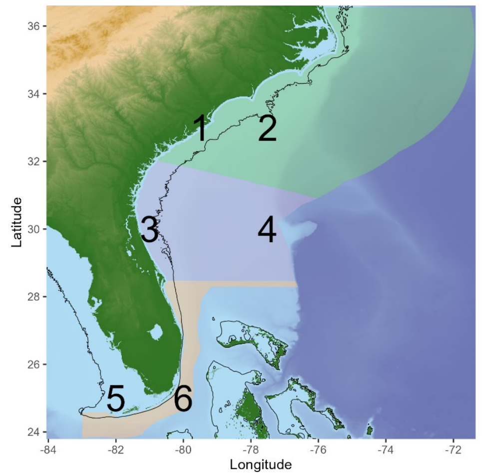
Region	Red Snapper
North and South Carolina	0.08
Georgia - Cape Canaveral	0.31
Cape Canaveral - Florida	0.62

Spatial Structure

Latitudinal Distribution of Unfished Abundance

South East Reef Fish Survey (SERFS) [(Bubley et al., 2023)]

- Highest abundance in NC & SC (1 & 2)
- Abundance in 1 & 2 about 2.5 times higher than 3 & 4
- Grüss et al. (2017) report Gag are most common in the NE region of the GoM compared to regions further south
- Suggests pattern of increasing abundance with increasing latitude



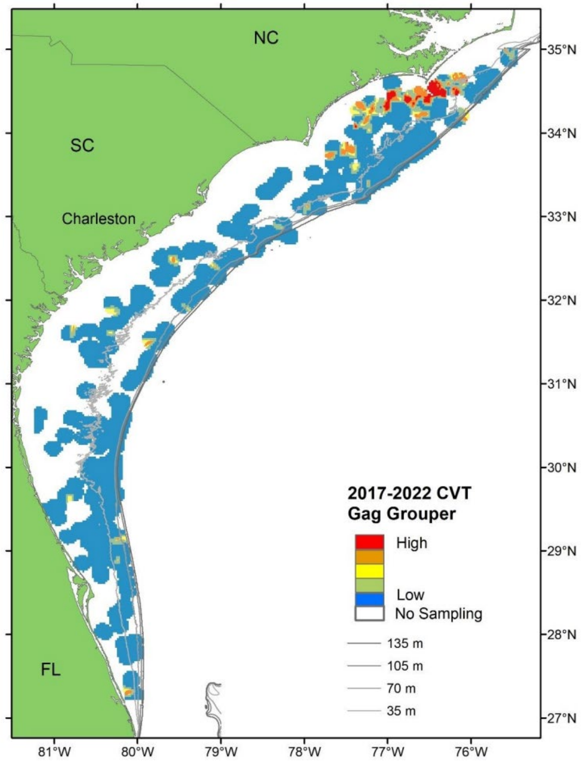


Figure 32. Distribution map of Gag catch from CVT in 2017-2022.

Spatial Structure

Latitudinal Distribution of Unfished Abundance

South East Reef Fish Survey (SERFS) (Bubley et al., 2023)

- Highest abundance in NC & SC (1 & 2)
- Abundance in 1 & 2 about 2.5 times higher than 3 & 4
- Grüss et al. (2017) report Gag are most common in the NE region of the GoM compared to regions further south
- Suggests pattern of increasing abundance with increasing latitude
- Based on this information, Base Case OM *assumes* relative abundance in areas 5 & 6 is **half** that in 3 & 4

Assumed Latitudinal Distribution

Region	Red Snapper	Gag
North and South Carolina	0.08	0.62
Georgia - Cape Canaveral	0.31	0.25
Cape Canaveral - Florida	0.62	0.12

Spatial Structure

Age-Specific Distribution by Depth

What is the natural (unfished) distribution of the stocks across Nearshore (< 100 ft) and (Offshore > 100 ft) areas?

Spatial Structure

Age-Specific Distribution by Depth

- Mitchell et al. (2014): estimated the depth distribution of RS from two fishery-independent surveys in SE US Atlantic
- Found most recruitment occurs in the shallow nearshore waters (higher density of recruits)
- After about 3 years (> 50 cm FL) there was no detectable difference in the depth-distribution of Red Snapper by age or length (equal density across depth areas)
- Following Mitchell et al. (2014), the Base Case OM assumes that recruits have higher density in NS, with a decline by age-4 to equal density in Nearshore and Offshore

Mitchell, W. A., Kellison, G. T., Bacheler, N. M., Potts, J. C., Schobernd, C. M., & Hale, L. F. (2014). Depth-Related Distribution of Postjuvenile Red Snapper in Southeastern U.S. Atlantic Ocean Waters: Ontogenic Patterns and Implications for Management. *Marine and Coastal Fisheries*, *6*(1), 142–155. https://doi.org/10.1080/19425120.2014.920743

Spatial Structure

Age-Specific Distribution by Depth

- Age-specific depth distribution for Gag based on Carruthers et al. (2015)
- They used a spatial populations dynamics model to estimate the fraction of unfished individuals by age-class in the nearshore and offshore regions of GoM
- Found juvenile Gag most likely to be in the nearshore region, but move offshore as they increase in age
- Base Case OM assumes the age-specific unfished distribution of Gag in the SAMFC management area is similar to that in the Gulf of Mexico

Carruthers, T. R., Walter, J. F., McAllister, M. K., & Bryan, M. D. (2015). Modelling age-dependent movement: An application to red and gag groupers in the Gulf of Mexico. *Canadian Journal of Fisheries and Aquatic Sciences*, *72*(8), 1159–1176. https://doi.org/10.1139/cjfas-2014-0471

Spatial Structure

Age-Specific Distribution by Area

Geographic distribution is combined with relative distribution by depth (Nearshore and Offshore) for each age-class to calculate the overall distribution across the 6 areas

Spatial Structure

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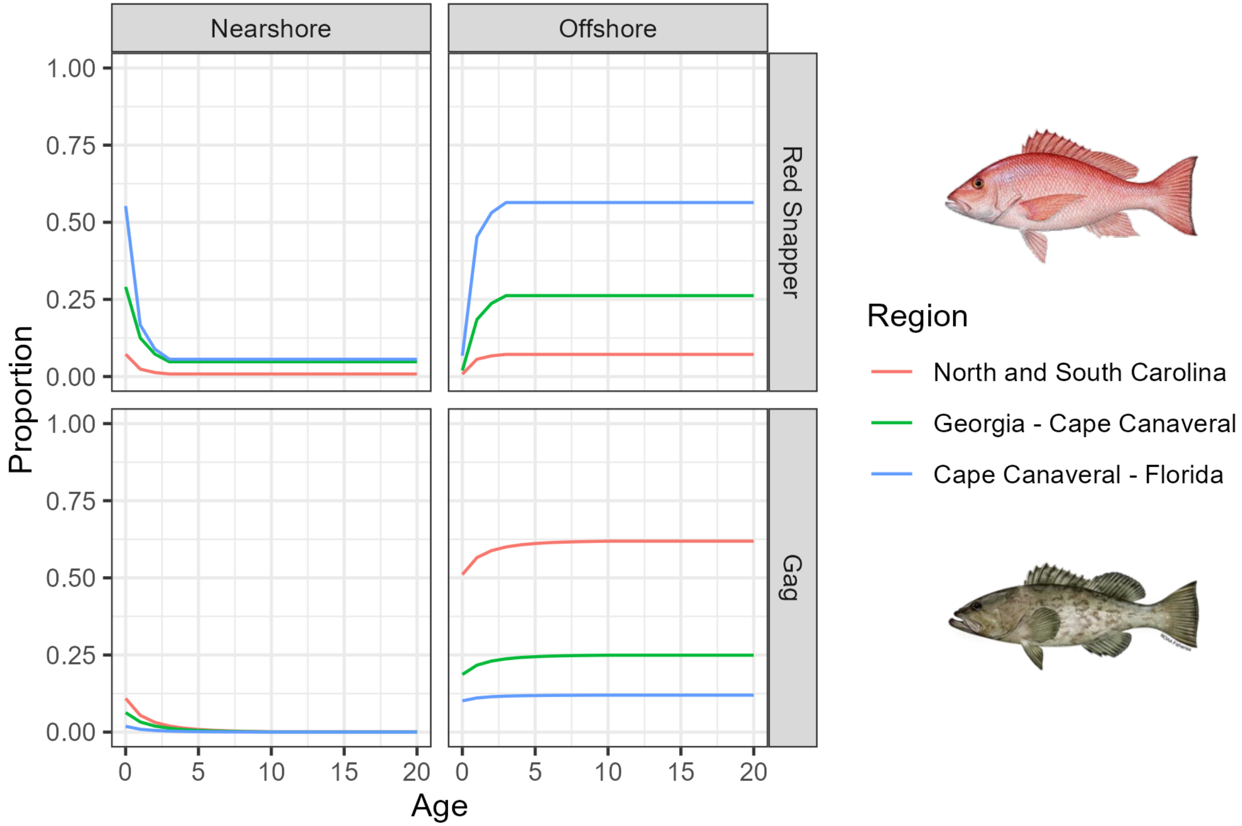
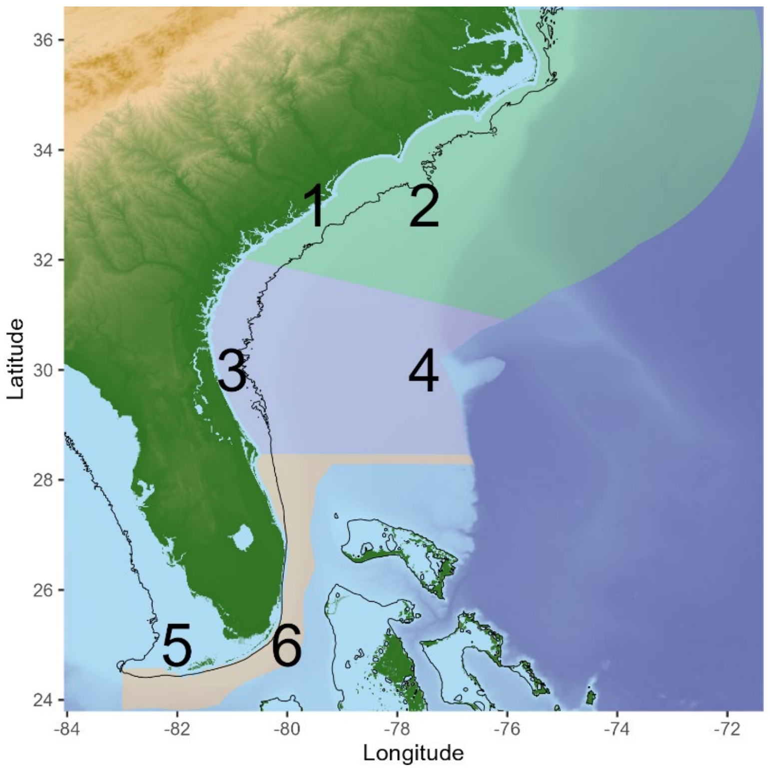




Note: Gag recruits more likely (higher density) in NS, but OF area is much larger so larger number of recruits in total in OF area

Recruitment Process Error in Projections

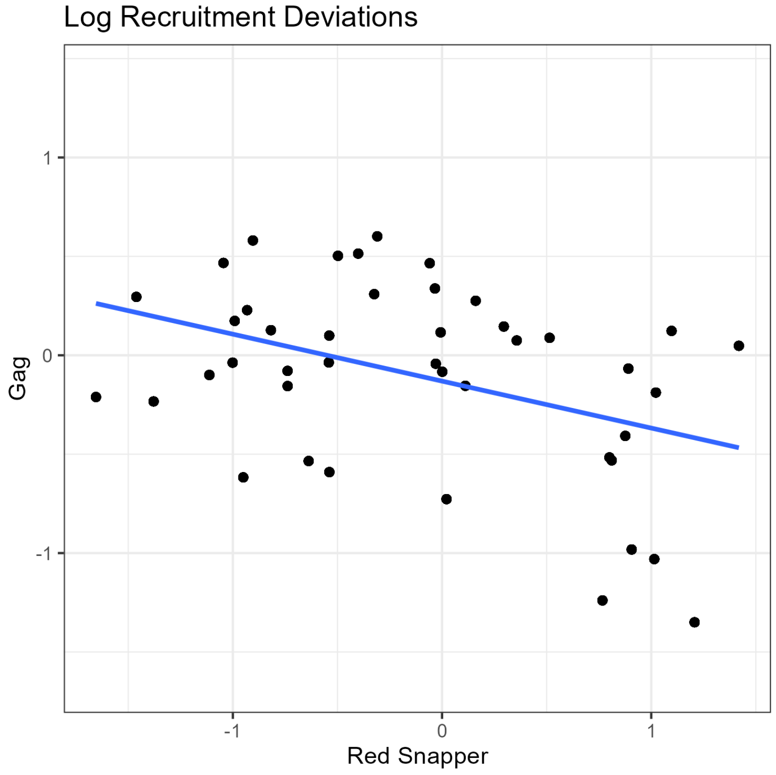
Recruitment Process Error in Projections

Recruitment process error is typically the biggest source of variation in the natural stock dynamics in the future projections

Base Case assumption:
Recruitment deviations in the projections have the same characteristics as those in the past (as estimated by assessments)

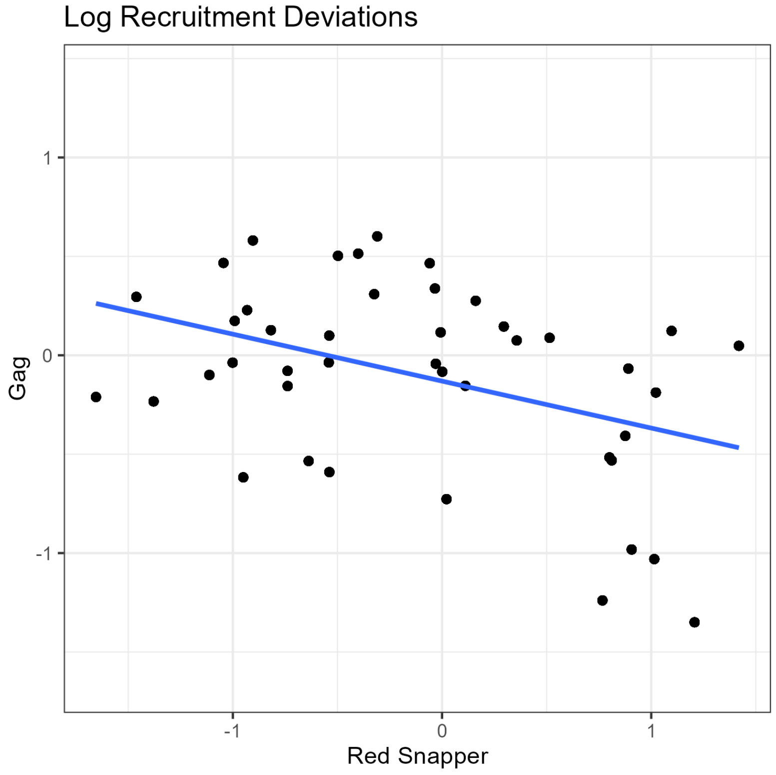
Recruitment Process Error in Projections

- Calculated the variance-covariance matrix of the log recruitment deviations estimated by the SEDAR assessments for RS and GG
- Some evidence that high RS recruitment is correlated with lower recruitment for GG



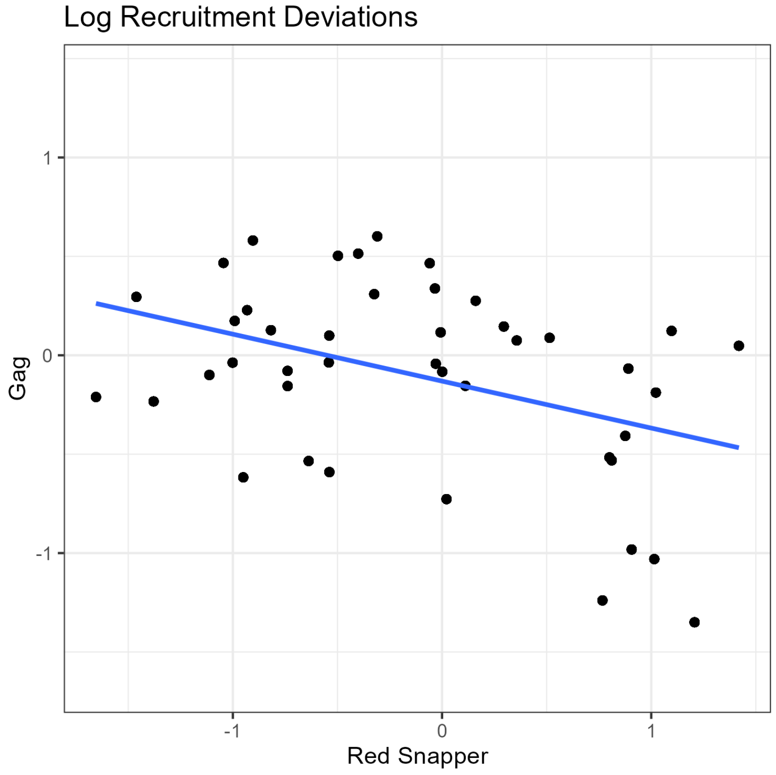
Recruitment Process Error in Projections

- Calculated the variance-covariance matrix of the log recruitment deviations estimated by the SEDAR assessments for RS and GG
- Some evidence that high RS recruitment is correlated with lower recruitment for GG
- Generated recruitment deviations for the projections by sampling from a truncated multivariate normal distribution
- Truncated at 2 s.d. to prevent values well outside those observed in the past



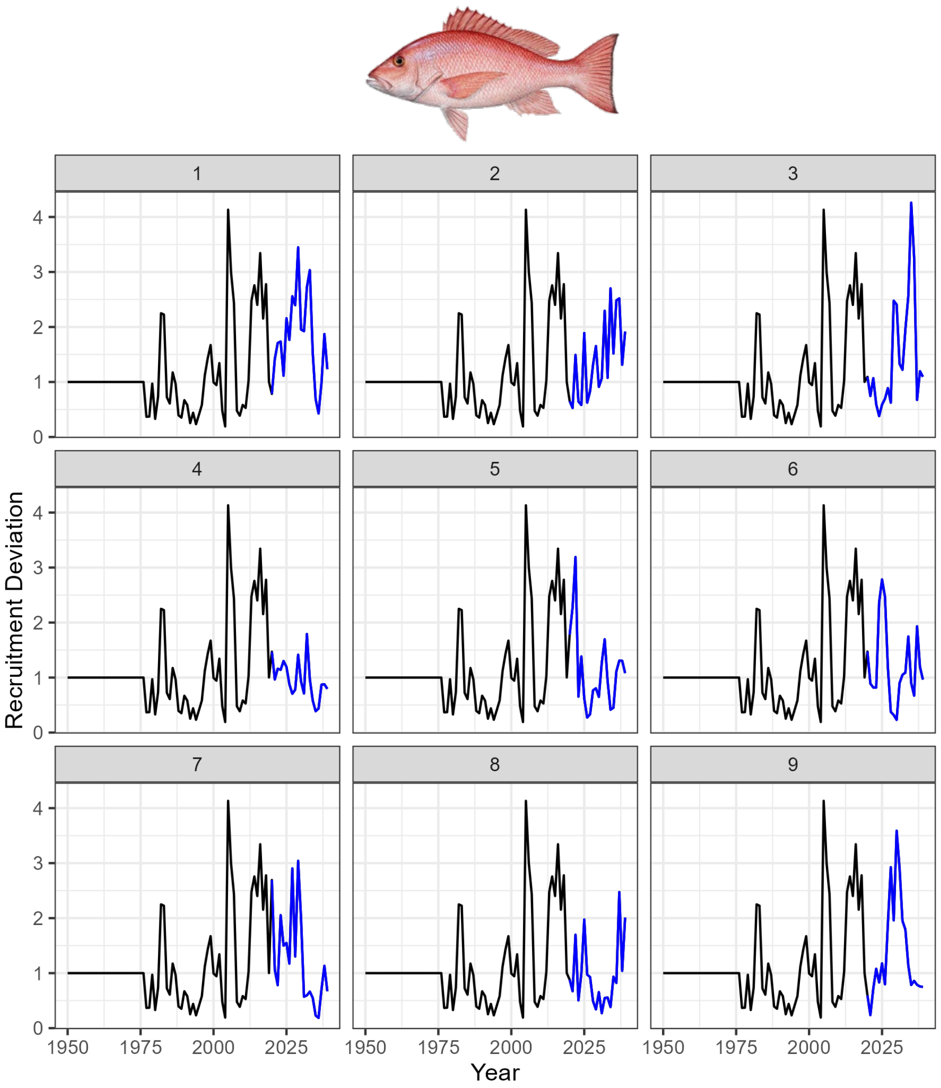
Recruitment Process Error in Projections

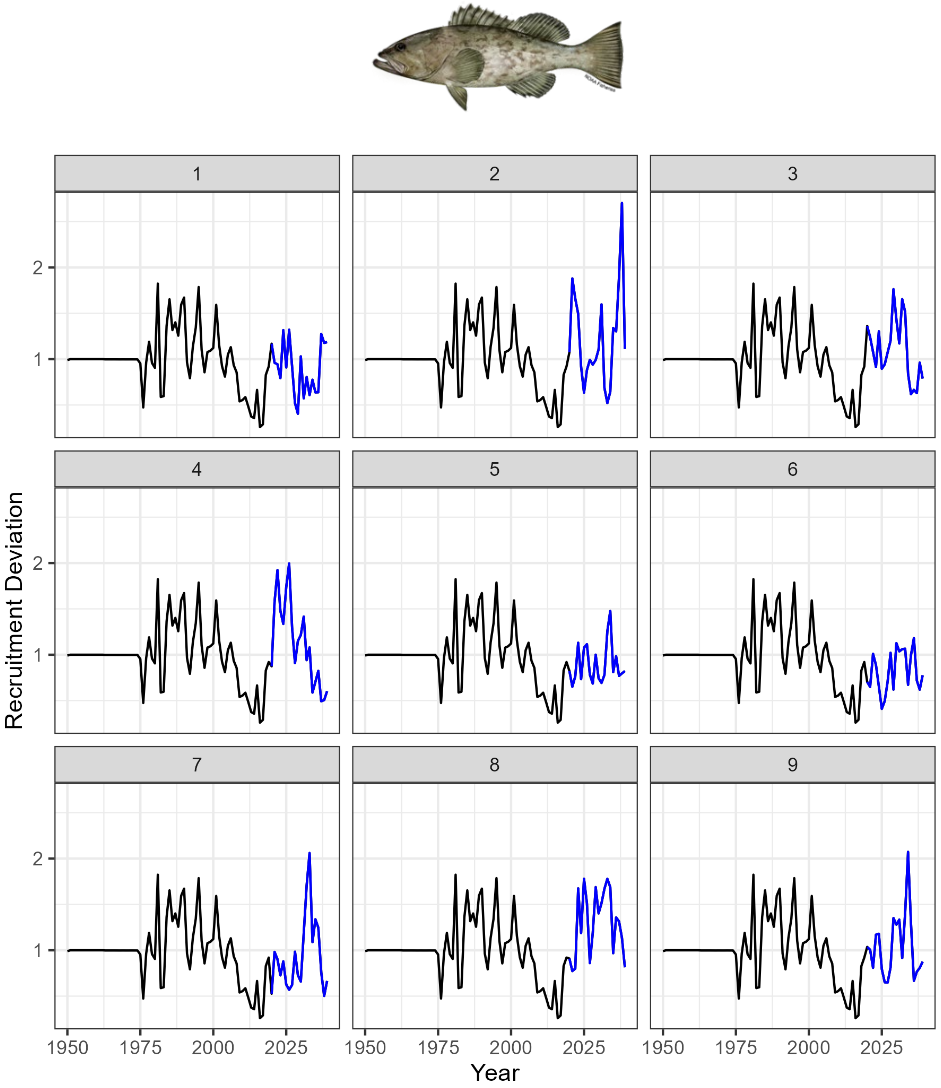
- Calculated the variance-covariance matrix of the log recruitment deviations estimated by the SEDAR assessments for RS and GG
- Some evidence that high RS recruitment is correlated with lower recruitment for GG
- Generated recruitment deviations for the projections by sampling from a truncated multivariate normal distribution
- Truncated at 2 s.d. to prevent values well outside those observed in the past
- Applied the lag-1 auto-correlation estimated from the historical rec devs



Recruitment Process Error in Projections

Examples of Recruitment Process Error in Projections (9 simulations)





Additional Operating Models

Additional Operating Models

Alternative OMs are intended to span the range of critical uncertainties in the knowledge of the system

Aims:

- identify uncertainties that have greatest impact on management performance
- find management options that are robust to these uncertainties
- prioritize research to reduce these uncertainties and/or detect if they occur in the future

Additional Operating Models

OM	Name	Uncertainty	Description
1	Base Case		Base Case Operating Model
2	Lower M	Important assessment sensitivity test	Re-run assessments with M-at-age reduced to the lower values considered in the assessment
3	Higher M	Important assessment sensitivity test	Re-run assessments with M-at-age reduced to the higher values considered in the assessment
4	Reduced Rec Landings	Possible over-estimation of recreational catch	Re-run assessments with Recreational landings decreased by 40%
5	Increased PE	Future productivity changes due to climate	Base Case with increased variability in recruitment process error in the projections
6	Increased Rec Effort	Future recreation capacity (latent effort or tech creep)	Base Case with Recreational effort is increased by 2% per year
7	Lower FL Biomass	Assumed fraction of stocks in southernmost region	Base Case with lower fraction of unfished biomass in southern FL
8	Higher FL Biomass	Assumed fraction of stocks in southernmost region	Base Case with lower fraction of unfished biomass in southern FL

Additional Operating Models

OM	Name	Uncertainty	Description
1	Base Case		Base Case Operating Model
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Next Steps: finalize specifications for priority uncertainty OMs (more can be developed later)

Management Measures

Management questions that can be addressed

MSE is generally focused on identifying robust rules for managing fisheries (a management procedure)

However, MSE can also inform other aspects of fishery management decision making:

- What complexity of assessment model is appropriate?
- What data should be collected?
- What is an appropriate assessment interval (yearly, once every 2 years etc)?
- What are appropriate management reference points for these stocks?

Management measures that can be evaluated

- Effort control (season opening, licenses, boat days etc)
- Spatial closures (where model and fleet structure allows)
- Size limits (minimum legal length, slot limits)
- Catch limits
- Gear selectivity
- Bag limits
- Release gear

(and combinations thereof)

Management measures that can be evaluated

- Effort control (season opening, licenses, boat days etc)
- Spatial closures (where model and fleet structure allows)
- Size limits
- Catch limits
- Gear selectivity
- Bag limits
- Release gear

(and combinations thereof)

Next Steps:
Identify the suite of management procedures (rules linking data to management) that will be evaluated in the MSE

Example Results

!! For demonstration only !!

Example Results: Four example management procedures

1. **Status Quo**: Fishing effort for all fleets fixed to mean of last 3 years
2. **Status Quo MLL:** As 1, but a 20" MLL for RS and 25" for GG
3. **SQ Rec 20:** As 1, but effort for General Rec. fleet is reduced by 20%
4. **Ftarget:** Overall effort reduce so that F = Ftarget for each stock (relative effort between fleets stays the same)

Example Results: Four example management procedures

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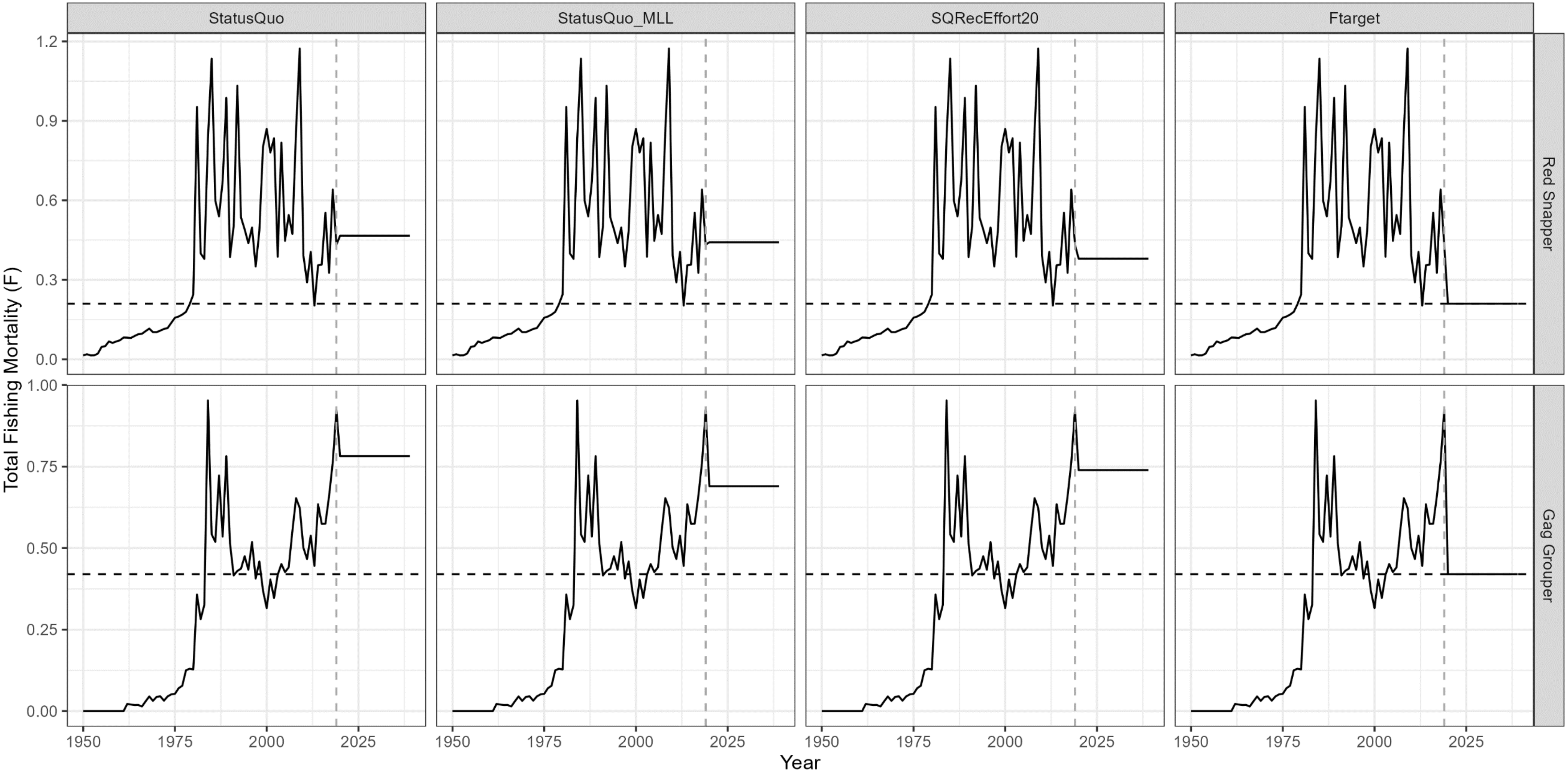
2. **Status Quo MLL:** As 1, but a 20" MLL for RS and 25" for GG
3. **SQ Rec 20:** As 1, but effort for General Rec. fleet is reduced by 20%
4. **Ftarget:** Overall effort reduce so that F = Ftarget for each stock
   (relative effort between fleets stays the same)

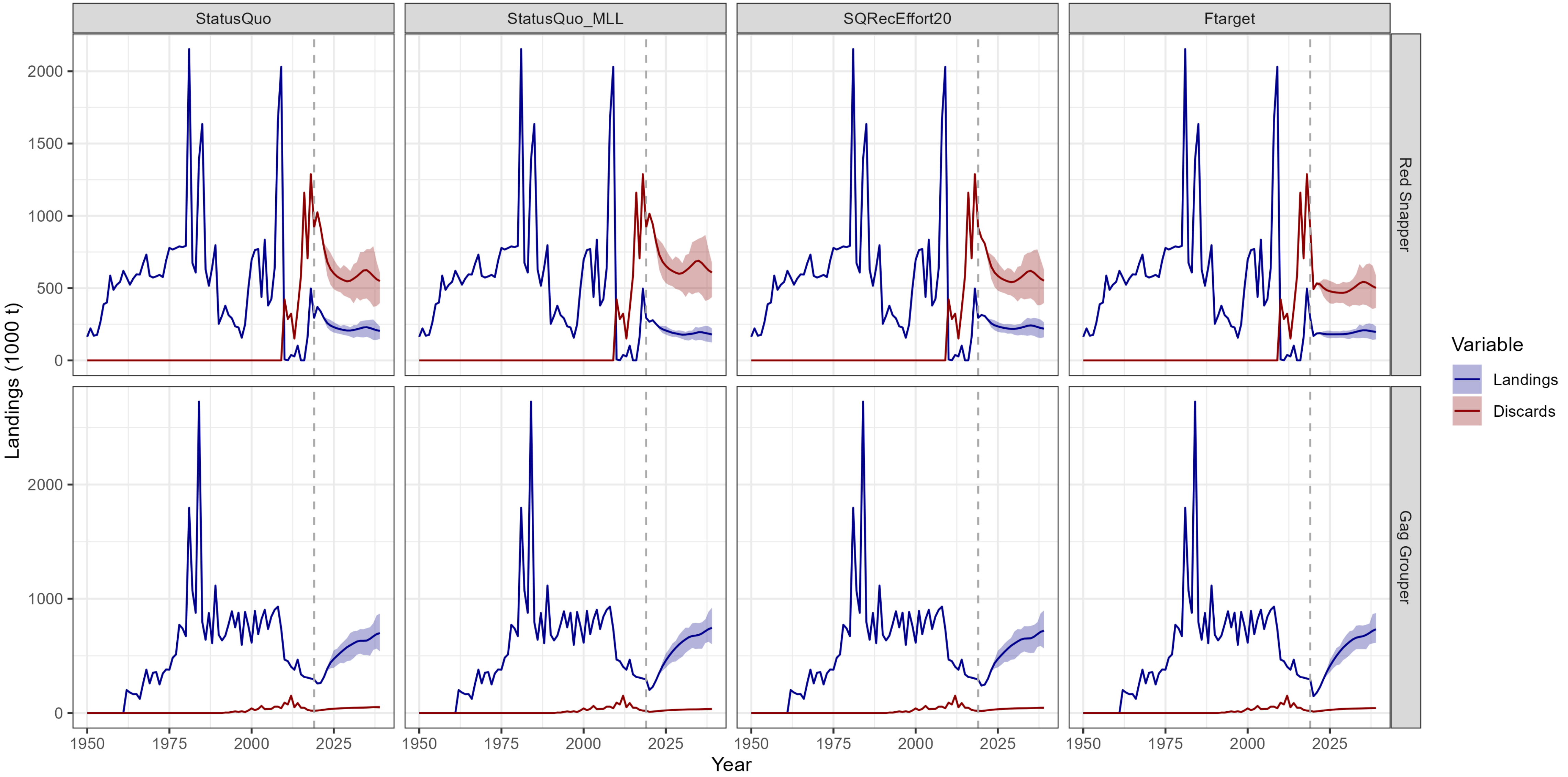
Static methods (don't change in response to data)

Useful for scoping out what sorts of management changes are required to meet objectives

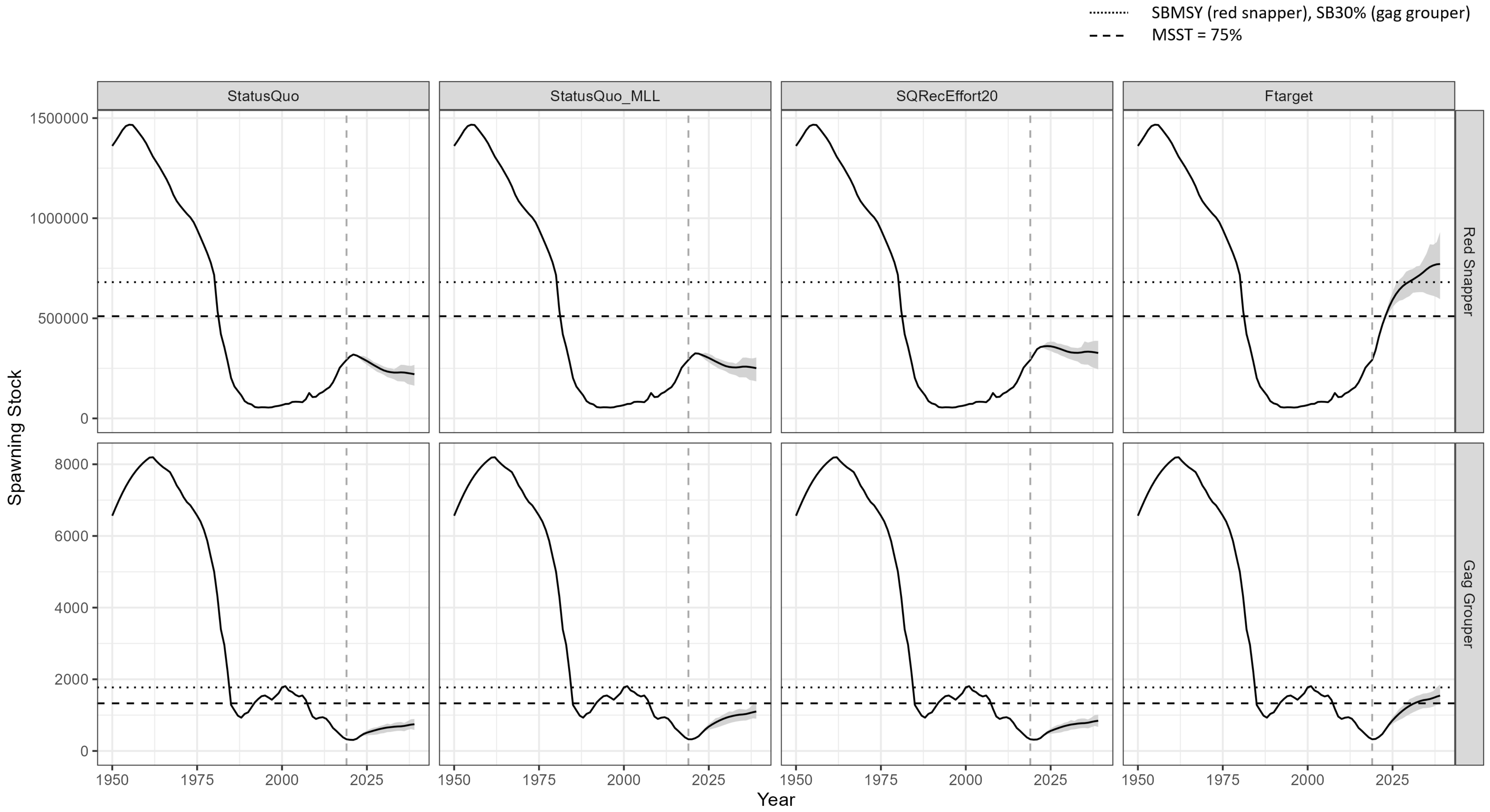
Example Results: Fishing Mortality



Example Results: Catch & Discards



Example Results: Spawning Biomass and Ref Points



Challenges

Challenges

- Realistic multi-stock fishing dynamics
  - Spatial targeting and switching behavior
  - Finer-scale fishery data required (CPUE by species by trip for example)
  - May need to include more species in analysis to characterize fleet targeting behavior
- Uncertainties in spatial distribution
- Defining a range of realistic management options (Management Procedures, MPs)

Next Steps

1. Consensus on Base Case OM structure
2. Finalize additional uncertainty OMs
3. Identify initial management procedures to evaluate in MSE
4. Run first round of analyses
5. Develop Shiny app to present results
6. Present to AP and Council for review and discussion
7. Re-run analyses based on feedback from AP and Council

Acknowledgements

Many thanks to the MSE technical team for their input on the MSE framework thus far:

Erik Williams

Allie Iberle

Cassidy Peterson

Chip Collier

Christina Wiegand

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Performance Metrics

Management Objective	Quantitative Metric	Category
Avoid stock being in an overfished state	Probability $SSB > MSST$	Biological
Avoid overfishing the stock	Probability $F < MFMT$	Biological
If overfished, rebuild stock to target within desired time-frame	Probability $SSB > SSB_{targ}$ by 2044 (red snapper; $SSB_{targ} = SSB_{F30\%}$) and 2040 (gag; $SSB_{targ} = SSB_{MSY}$)	Biological
Stability in catch	Average inter-annual variability in catch	Commercial
Maximize yield	Average landings	Commercial & Recreational
Reduce discards	Ratio of kept to discarded fish	Commercial & Recreational
Catch and keep enough to make the trip worthwhile	Average catch rate relative to current	Recreational
High probability of catching reasonably sized fish	Probability of catching a 10 lb fish	Recreational
High probability of catching trophy sized fish	Probability of catching a 30 lb red snapper and 45 lb gag	Recreational
Maximize fishing opportunity	Average fishing effort relative to recent historical	Recreational