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Recreational Summer Flounder Management Strategy Evaluation: Overview of Results and Potential Application for 2023 Recreational Measures

Summer Flounder, Scup, Black Sea Bass Monitoring Committee
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Introduction and Monitoring Committee Objectives

The Mid-Atlantic Fishery Management Council recently completed a recreational summer flounder management strategy evaluation (MSE) to 1) Evaluate the biological and economic benefits of minimizing discards and converting discards into landings in the recreational summer flounder fishery; and 2) Identify management procedures to effectively realize these benefits.

This MSE process involved an extensive public scoping and stakeholder engagement phase, followed by a management considerations and model development phase – each lasting about one year. A small core group of diverse stakeholders was formed to work collaboratively with an MSE technical work group on development of this initiative. Additional information about the MSE process can be found at: https://www.mafmc.org/actions/summer-flounder-mse.

This MSE does not specify a single outcome or strategy that will address all management issues or concerns associated with recreational summer flounder discards. It does, however, provide an opportunity to evaluate and balance different management procedures and their associated biological, social, and economic trade-offs that best address their management objectives. As discussed below, **results from the MSE suggest multiple management procedures outperform status quo management at reducing discards and converting those discards into harvest while limiting risk to the summer flounder stock.**

The Council and Board considered the MSE at their August 2022 joint meeting and were very supportive of and encouraged by the results of the MSE. They agreed to use the outcomes from the MSE to help inform potential recreational management options for summer flounder in 2023. In addition, they supported the use of the modeling approaches developed as part of the MSE (e.g., recreational demand model) to estimate recreational catch and harvest of summer flounder and other recreational species, such as black sea bass.

For Monitoring Committee Consideration

- Are there management procedures tested through the Summer Flounder MSE, or variations on these measures, that the MC believes should be prioritized for consideration when setting 2023 measures?
- Are there management procedures that should not be further considered for application in 2023?

- How should these management procedures be considered within the context of the Percent Change Approach (see briefing materials for October 26, 2022 MC meeting)?
- How can the results of the MSE be used by the MC for future recreational management considerations?

MSE Overview

The MSE evaluated the performance of eight different sets of management measures under three different states of the world (scenarios), using a suite of biological, social, and economic performance metrics (e.g., stock biomass and fishing mortality as well as angler welfare and ability to keep a fish), as described in more detail below. The MSE simulation framework utilizes two models:

- An **operating/biological model** which simulates the population dynamics of the summer flounder stock; and
- An **implementation/recreational demand model**. This is the Recreational Demand Model (RDM) that the MC will consider using to set recreational measures for 2023. While the broader MSE framework was designed to evaluate long-term performance of different management measures, the RDM developed within the framework can provide short-term (annual) recreational catch and harvest estimates for a given stock size and length structure. A summary of this model has been provided in the briefing materials for the October 2022 MC meeting and is available here.

These models are coupled within an MSE simulation framework that is designed to emulate summer flounder stock dynamics, both commercial and recreational fisheries, and the management system. Together these models and the MSE framework simulate the summer flounder population, its ecosystem, and different management procedures of interest while also considering key uncertainties and ecosystem drivers.

Additional details and information on the model structure, data elements, and assumptions of the operating model scenario configurations can be found in this document summarizing the MSE model specifications, as well as in the RDM model overview document linked above.

Management Procedures (Measures) Evaluated

"Management procedures" evaluated by the MSE represent example combinations of size limits (including slots), season length adjustments, coastwide options, and existing and different regional configurations.[1] The management procedures considered here are not intended to specify an exact set of recreational regulations that would necessarily be implemented in 2023 or a future date. Rather, these management procedures are examples intended to represent a realistic range and scope of regulations that may be of interest to management and stakeholders. In addition, it was important to consider management

[1] Other management tools or actions (e.g., reporting requirements, hook/terminal tackle) were discussed and proposed by stakeholders but not included in the analysis because there was either a lack of data to inform the impact of those regulations or not enough time for them to accurately and appropriately be modeled.

procedures that were different enough from one another to evaluate relative differences in performance.

The MSE model evaluates each management procedure over a 26-year projection period (assuming a new/updated stock assessments and specification cycle every other year).[2] Seven different alternative management procedures were evaluated and grouped into four different categories based on similar configurations. Details on each management procedure alternative are provided in the text below and in **Table 1**.

For several reasons, the 2019 regional regulations were specified as status quo and are the baseline regulations which other alternative management procedures are compared and evaluated against. Regulations remained relatively unchanged from 2019 – 2021 and managers and stakeholders likely have a good understanding of management performance and angler satisfaction with these regulations. In addition, when model development was started in 2020 and into 2021, the 2019 recreational data was the most complete dataset available. The 2020 data includes imputed data because of the loss of sampling due to COVID-19 and the 2021 data was not available until the spring of 2022.

- ***MPs 1-3: Status Quo/Current Region Breakdown Alternatives*. Management procedure #1** retains the regulations and regions from 2019. **Management procedure #2** keeps the 2019 regulations except that the minimum size within each state/region would be dropped by 1 inch to increase angler retention, reduce discards, and lower the proportion of female harvest. **Management procedure #3** would retain the same size and possession limits for each state/region as 2019 but would extend the season length, for most states, into April and October. This would allow for greater overlap in season with other fisheries and hopefully minimize discards of summer flounder when other fisheries are open and summer flounder are available to anglers.
- ***MP 4: Modified Regional Breakdown Alternative*. Management procedure #4** would consider the following three regions (based on the currently implemented regions for black sea bass), with states in each region implementing the same management measures: 1) Massachusetts through New York, 2) New Jersey, 3) Delaware through North Carolina. This alternative was developed to address feedback from stakeholders interested in reducing regulatory complexity and increasing angler equity across states while also allowing for some modifications and liberalizations from the 2019 regulations.
- ***MP 6: Coastwide Alternative*.**[3] Some stakeholders expressed interest in considering

[2] This was done for a few reasons. First, given the time scales at which summer flounder stock dynamics operate (e.g., growth, recruitment, sex ratios, generation time), it would be difficult to evaluate the benefits and/or effects on the summer flounder stock under continually changing regulations. In addition, the goal of the MSE is to provide strategic advice and information regarding the "long-term" performance of different management procedures on both the stock and fishery.

[3] Another coastwide alternative, **Management procedure #5** was initially considered by the core group as a potential lower bound option that would greatly minimize the possession and size limit in order to increase the potential that trips, for any sector, would produce a fish to take home. The 14-inch minimum size limit would align with the commercial minimum size for consistency across sectors and potentially reduce the harvest of female summer flounder. After reviewing the initial model results for this alternative, the core group agreed to

coastwide measures given real or perceived inequities in regulations between the states and different sectors. Coastwide measures would reduce management and enforcement complexity and may provide for more predictable stock responses to regulations. **Management procedure #6** represented a coastwide option that was generally in the middle of all the existing state regulations (pre-2022) with components in some states more liberal and some more restrictive. This option is also generally within the range of recent options considered for non-preferred coastwide measures.

- ***MPs 7 and 8: Slot Limit Alternatives:*** Two different types of slot limit options were developed for this MSE. These options were modeled as implemented at the coastwide level. **Management procedure #7** is based on management measures implemented in 2022 by New Jersey and modified based on feedback from the core group and comments made by the ASMFC Technical Committee when they reviewed New Jersey's proposal. This alternative would allow for one smaller fish between 16 and 19 inches and then two fish greater than 19 inches. Allowing for one small fish is intended to provide for increased opportunities for anglers to take home one fish across modes and states while retaining a two fish possession at a larger size could constrain harvest yet allow anglers the ability to take home a trophy fish. **Management procedure #8** would implement a true slot and would not allow for the harvest of summer flounder greater than 20 inches. This alternative is intended to provide for greater opportunities to retain a fish across states and modes, while also reducing the amount of larger female harvest.

remove this alternative given the extremely low possession limit and the likelihood that this option may lead to increased discards as anglers are likely to continue fishing despite catching a 14 inch in the hopes of retaining larger fish.

Table 1: Summary of the seven different management procedures tested as part of the EAFM recreational summer flounder MSE. Each MP is labeled with the shorthand used in the display of model results.

Management Procedure #	Procedure Explanation
1 (status quo)	**Status Quo:** 2019 regulations
2 (minsize-1)	**Status quo regions, modified size:** 2019 regulations but a 1 inch decrease in minimum size within each state to a minimum of 16 inches
3 (season)	**Status quo regions, modified season:** 2019 regulations but season of April 1 - Oct 31 for all states
4 (region)	**Modified regions:** MA-NY - 5 fish, 18 inch min, May 1 - Sept 31 NJ - 3 fish, 17 inch minimum, May 1 - Sept 31 DE-NC - 3 fish, 16 inch minimum, May 1 - Sept 31
6 (c3@17)	**Coastwide measures:** 3 fish possession limit, 17 inch minimum size, May 1 - Sept 30
7 (c1@16-19)	**Modified slot:** 1 fish from 16 inches - 19 inches, 2 fish 19 inches and greater, May 1 - Sept 30
8 (slot)	**True slot limit:** 3 fish possession limit between 16 inches and 20 inches, May 1 - Sept 30

[a] The numbering goes from 4 to 6 due to the removal of management procedure #5 from consideration. MP #5 included a 1 fish possession limit, 14 inch minimum size, and May 15-September 15 season.

Management Objectives and Performance Metrics

The Council identified the overall project objectives (see page 1) when originally agreeing to conduct an MSE; however, they were broad and didn't explicitly provide direction or guidance for other important management considerations. Additional management objective themes or categories were identified during public scoping and further refined by the core group and approved by the Council and Board. These expanded management objectives, listed below, are intended to help us define and understand what a successful recreational fishery would look like that minimizes discards and discard mortality.

1. Improve the quality of the angler experience
2. Maximize the equity of anglers' experience
3. Maximize stock sustainability
4. Maximize the socio-economic sustainability of the fishery

Quantifiable performance metrics are used to evaluate the success of a particular management procedure in achieving the desired management objectives. The metrics were compiled from survey responses, refined and prioritized by the core group, turned into measurable units by the technical work group, and calculated using the outputs from the different MSE models. Different metrics were specified for each of the four management objectives and calculated at either the trip, state/region, or coastwide level. In addition, several metrics are calculated relative to the modeled baseline (i.e., 2019 recreational) regulations to determine if an alternative management procedure represented an improvement or a less favorable outcome. In addition, these performance metrics were

calculated across three different operating model configurations (more information below) to test how robust the performance of these different management procedures will be under different ecosystem conditions and management drivers.

Figure 1 below lists the 17 final performance metrics, by management objective, that were prioritized by the core group and calculated by the technical work group.

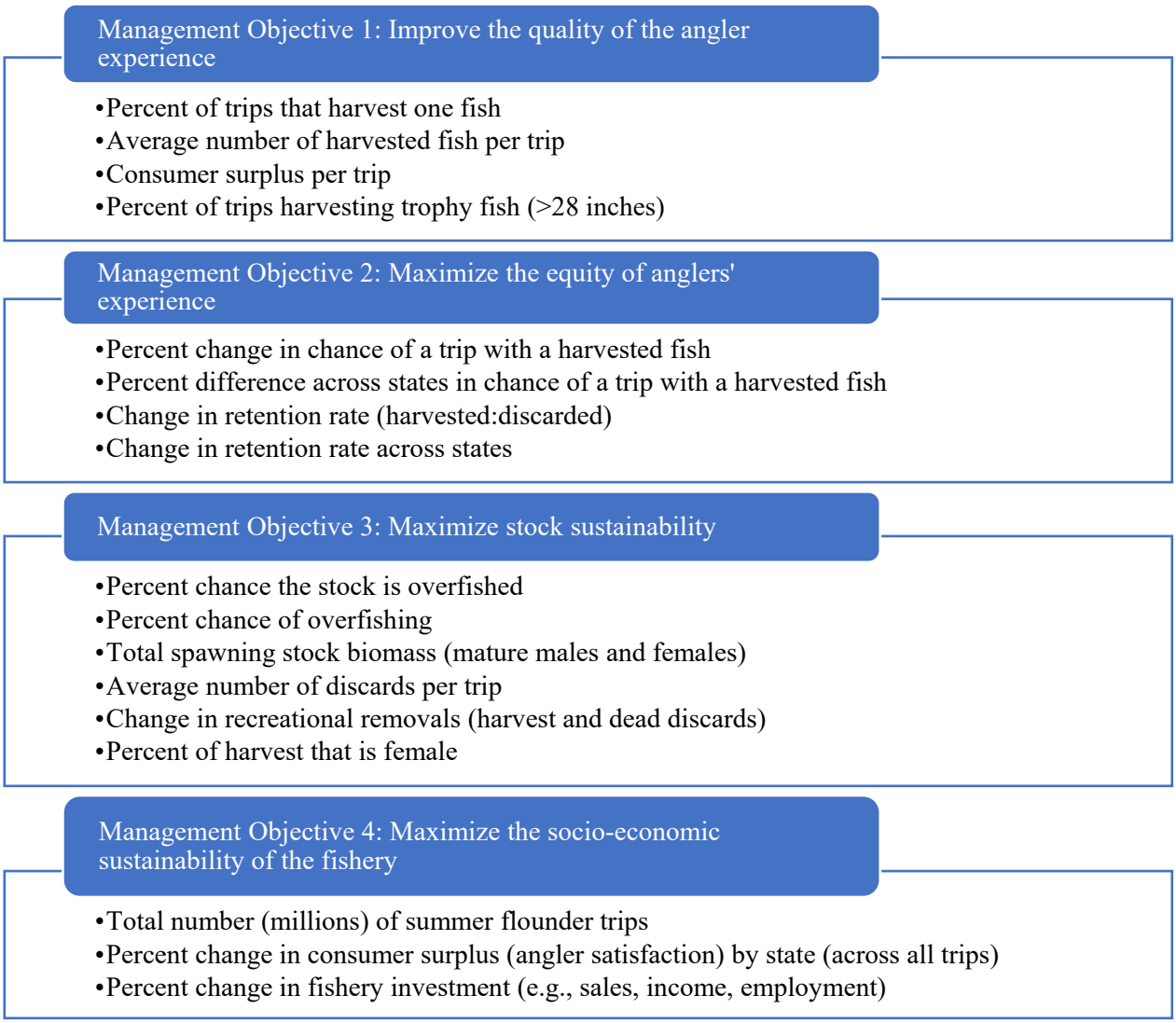

Figure 1: Management objectives and performance metrics used to evaluate summer flounder MSE management procedures.

These metrics, and the four management objectives, were also used in a trade-off based decision analysis designed to evaluate how well each management procedure achieves the stated management goals for the project. To determine the overall performance of a particular management procedure, an overall score for each management procedure was calculated by having core group members rank and weight the objectives and associated metrics to understand their overall relative importance. Objectives and metrics that were weighted more heavily (i.e., more important) contributed more to the overall score than those that were considered less important. The final score for each management procedure

was used to evaluate the relative performance and associated trade-offs a management procedure may have in meeting the overall management objectives.

Alternative Operating Model Scenarios

Three different operating model scenarios were developed for this MSE to incorporate some of the critical uncertainties (e.g., data, biology, climate, etc.) identified through stakeholder scoping and by the technical work group. They are intended to evaluate how different management procedures perform under these different assumptions about the "true" summer flounder population. All seven management procedures were run under each operating model scenario and the same 17 performance metrics were produced for each management procedure to allow for comparisons across the different operating model scenarios. In addition to the "baseline" model, the two alternative scenarios considered were:

(1) ***MRIP Bias Alternative:*** Stakeholders and the core group consistently raised concerns about Marine Recreational Information Program (MRIP) data and their belief that MRIP overestimates the total number of summer flounder trips, catch, and harvest. The MRIP bias model scenario was developed to understand the potential management and fishery implications under different recreational catch and effort assumptions. This scenario was not an evaluation of the MRIP program or the accuracy and reliability of the data. For model runs in this scenario, instead of using the catch and effort point estimate, the lower bound of the 95% confidence interval of the MRIP estimates were used. These lower catch and effort estimates were used to calibrate the recreational demand model and to adjust the stock dynamics in the biological model to account for the lower recreational catch history.

(2) ***Stock Distribution Change Alternative:*** As mentioned earlier, this MSE is part of the Council's implementation of its EAFM guidance document. Prior to initiating the MSE, the Council developed a conceptual model that considered risk factors and ecosystem elements affecting summer flounder and its fisheries[4]. The conceptual model identified stock distribution changes as the most linked risk factor with potential implications across the summer flounder ecosystem (e.g., stock productivity, science, and management). Historical stock distribution information by region was used to inform future potential changes in the spatial distribution of the stock over time and the implications for future availability of summer flounder to recreational anglers along the coast (Figure 2). This scenario provides an opportunity to evaluate if changes in summer flounder availability could undermine the effectiveness of implemented management measures.

[4] For more information about the summer flounder EAFM conceptual model, please visit: https://www.mafmc.org/eafm.

MSE Results

Results from the MSE suggest there are management procedures that outperform status quo management at reducing discards and converting those discards into harvest while limiting risk to the summer flounder stock.

Summary of Key Findings and Outcomes

- **Under the baseline operating model state of the world (scenario), all management procedures, except for one (MP 3), outperformed the status quo alternative across most performance metrics, including those that reduce recreational discards and provide for increased harvest opportunities.**
- No management procedure resulted in the stock becoming overfished within 26 years. Most had low risk of overfishing, while two had an increased risk of overfishing.
- Under different states of the world (scenarios), the performance of the management procedures relative to one another is the same as the baseline.
    - Relative to the outcomes from the baseline scenario, a given management procedure's performance will be slightly degraded with the MRIP bias scenario and more degraded with the distribution shift scenario.
- All management procedures, except for one (MP 3), reduce the proportion of females in the recreational harvest when compared to the status quo. However, reducing the harvest of females does not appear to result in increases to the overall population spawning stock biomass.
- All management procedures, except for one (MP 3), resulted in higher levels of angler welfare relative to the status quo. Angler welfare is measured by changes in consumer surplus, or the amount of money anglers would be willing to pay for a fishing trip under a given management procedure.
- According to trade-off analysis, relative to the performance of the status quo, the overall satisfaction provided by the fishery is expected to increase by 4 to 106% by implementing alternative management procedures.
    - This result is highly robust to both the range of weightings provided by stakeholders and the set of scenarios evaluated.
- The relative performance of a management procedure, particularly when comparing to the status quo, is highly variable at the state or regional level.
- Management procedures assessed season length, bag limit, and size limit; of these, size and bag limit were most influential on performance.

Overview of MSE Results

Here we present additional details regarding the key project results and outcomes and offer insight as to why these results may have occurred. Given the significant amount of information produced and the nuance in interpreting outcomes for the different management procedures and performance metrics across regions and states, not all results are provided here. The results presented below focus on the priority project areas requested by the Council and ASMFC Summer Flounder, Scup, and Black Sea Bass Board. All MSE results and outputs can be found at: https://bit.ly/fluke-mse-metrics. Here you can review results by performance metric, operating model scenario, and by state.

Table 2 summarizes the model outputs for performance metrics for the seven management procedures under the baseline operating model configuration.

Table 2: Summary of model outputs for select performance metrics across the seven different management procedures under the baseline operating model configuration.

Performance Metric	MP#1	MP#2	MP#3	MP#4	MP#6	MP#7	MP#8
Percent of trips that harvest one fish	0.193	0.284	0.197	0.279	0.301	0.35	0.357
Average number of harvested fish per trip	0.274	0.471	0.279	0.478	0.504	0.458	0.642
Harvest:Discards	0.102	0.207	0.104	0.202	0.24	0.189	0.39
Average number of discards per trip	2.91	2.45	2.89	2.55	2.29	2.58	1.84
Consumer surplus (angler satisfaction) per trip	3.703	12.896	4.001	13.1	13.502	14.352	19.873
Total recreational expenses (millions of $)	470.9	492.3	474.5	492.6	495.7	499.3	513
Total Spawning Stock Biomass (mature male & female) in metric tons	67,514	60,504	67,291	59,795	59,372	61,088	56,554
Percent of female harvest	0.676	0.607	0.677	0.608	0.591	0.602	0.49
Total catch (recreational+commercial) in metric tons	15,935	16,468	15,986	16,526	16,460	16,031	15,834
Total recreational removals (harvest+dead discards) in metric tons	6,331	8,157	6,498	8,337	8,263	7,685	8,085
Total number of recreational trips (millions)	11.22	11.72	11.31	11.74	11.82	11.91	12.22
Percent of trips harvesting a trophy fish (>28 inches)	0.017	0.008	0.018	0.008	0.007	0.008	0

Harvest and Discard Outcomes

As requested by the Council, the primary objective of the MSE was to evaluate management procedures that reduce the number of recreational discards and develop strategies that convert discards into increased harvest and recreational opportunities. This section provides an overview of the outcomes that provide insight on addressing this primary objective. Refer to **Table 1** above for a summary of the seven different management procedures included in the results below.

Overall/Coastwide results

All management procedures tested except MP#3 performed better across the discard related performance metrics (i.e., reducing the number of discards, increasing the keeper:discard ratio, and promoting recreational opportunities that would convert discards into landings) when compared to the status quo (MP#1) (Figure 2, Table 2).

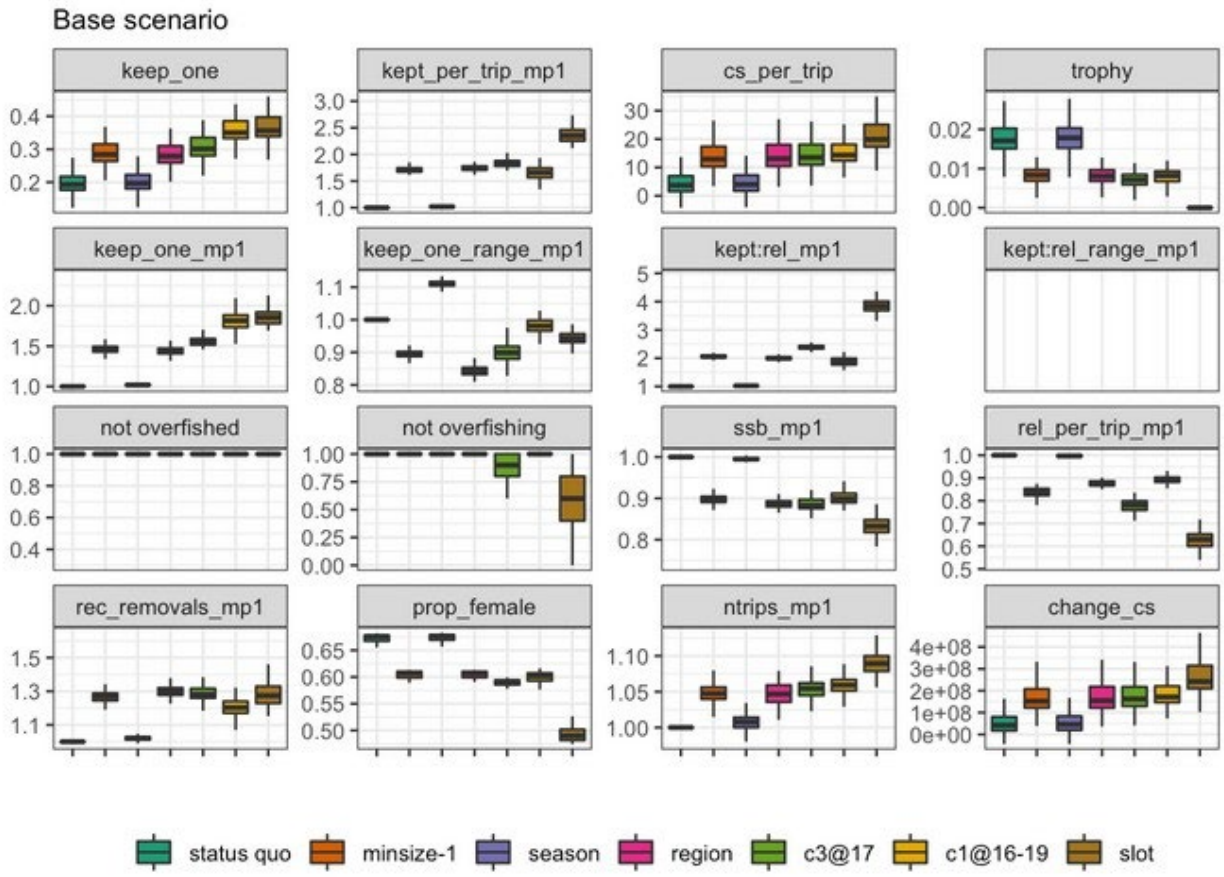

Figure 2: Coastwide results for a suite of biological, social, and economic performance metrics for seven different management procedures under the baseline operating model configuration.

- Kept:Discard ratio
  - MP#1 and #3 result, on average, in one keeper for every 10 fish caught.
  - MP #2, 4, and 7 double the keeper ratio with 2 fish kept for every 10 caught.
  - MP#6 was slightly better with 2.5 fish kept for every 10 caught.
  - MP#8 was nearly 4 times higher than status quo MP with 3.9 fish kept for every 10 caught.
- Percent of trips that keep a fish
  - MP#1 and #3 result, on average, in 19 percent of all trips keep a fish.
  - MP#2, 4, and 6 result in an approximately 29 percent of all trips keep a fish.
  - MP #7 and #8 result in the highest success rate with approximately 35 percent of all trips keeping a fish.

- Average # of fish kept per trip
    - MP #1 and #3 result in an average of 0.27 fish kept per trip.
    - MP #2,4,6 and 7 are nearly double with close to a half fish (0.5) kept per trip.
    - MP #8 has the highest average number of fish kept per trip and more than double MP #1 and #3 with 0.64.
- Average # of discards per trip
    - MP #1 and #3 had the highest discard per trip with just under three (2.9) summer flounder released per trip.
    - MP #2, #4, and #7 had similar discards per trip with an average of 2.5 summer flounder discarded each trip. This is a 16 percent reduction in the number of discards.
    - MP #6 had the second fewest discards per trip with an average of 2.29 summer flounder discarded per trip or a 24 percent reduction compared to the status quo.
    - MP #8 had the lowest discards per trip with 1.84 summer flounder discarded on average. This is slightly more than one fewer fish released than under the status quo alternative, or a 38 percent reduction in discards.

While not specific performance metrics, the core group was interested in how the different management procedures might result in changes to the average length of harvested fish and how those would compare to the status quo (Figure 3). This information is an additional piece of information to demonstrate how the different management procedures reduce discards and allow for increased harvest opportunities. The results show that most management procedures resulted in a noticeable decrease in the average size of harvested fish compared to the status quo.

- The average length of a harvested summer flounder under MP #1 and #3 was 19.8 inches.
- MP #2, #4, and #6 resulted in a decline in the average size by nearly 1.5 inches down to 18.4 inches.
- MP #7 reduced the average size of a harvested fish by nearly 2 inches down to 18.0 inches.
- MP #8 reduced the minimum size even further with the average size of a harvested summer flounder of 17.0 inches, nearly 3 inches smaller than the status quo measures.

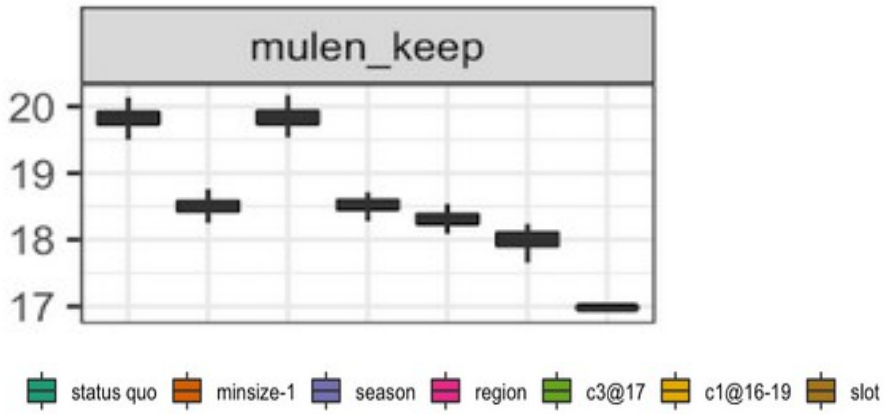

Figure 3: The average size (inches) of summer flounder harvested for the entire coast under the seven different management procedures.

The results also suggest that even with increasing total recreational removals, the total fishery removals, both commercial and recreational harvest and discards, are not very different across all management procedures (Figure 2, Table 2).

- For example, MP #2, #4, #6, #7, and #8 result in a 29% increase in total recreational removals, but only a 2% difference across all management scenarios when looking at total catch (commercial and recreational).

State specific results

Overall, the relative performance of a particular management procedure, particularly when comparing to status quo (MP#1) is highly dependent upon the state/region (Figure 4). For states New Jersey and north, MP#1 and #3 performed much worse (significantly worse in some cases) across most metrics compared to all other management procedures; while MP#1 and #3 performed better, or as well as, the other management procedures for the states Delaware and south.

This result is somewhat to be expected given that the states of DE through NC currently have more liberal measures (those associated with MP#1) compared to the states of NJ through MA and some management procedure alternatives would be more restrictive for certain measures compared to MP#1. Although MP#1 performed better for this region, there are a number of other management procedure alternatives that performed equally well, presenting possible opportunities to adjust management measures to meet other management objectives for this region.

There was also a difference in the relative consistency or variability in performance across management procedures across states (Figure 4).

For example, when evaluating the percentage of trips that keep one summer flounder, in CT, NY, and NJ there was a similar pattern with MP #1 and #3 performing the worst with about 20% of all trips keeping one summer flounder. There was a general increasing pattern in the percentage of trips keeping one summer flounder across the remaining management procedures with MP #2 and #4 twice as high as MP #1 and 2.5 times higher for MP #7 and #8. MA had the same range (i.e., 2.5 times) in the differences between the worst performing and best performing management procedure for this metric, but MP #2 performed the best and MP #4 and #6 performed the worst. In contrast, in VA there was only a 6 percent

difference in the percent of trips with a keeper summer flounder between the worst performing MP (#6) and the best performing MP (#2 and #4).

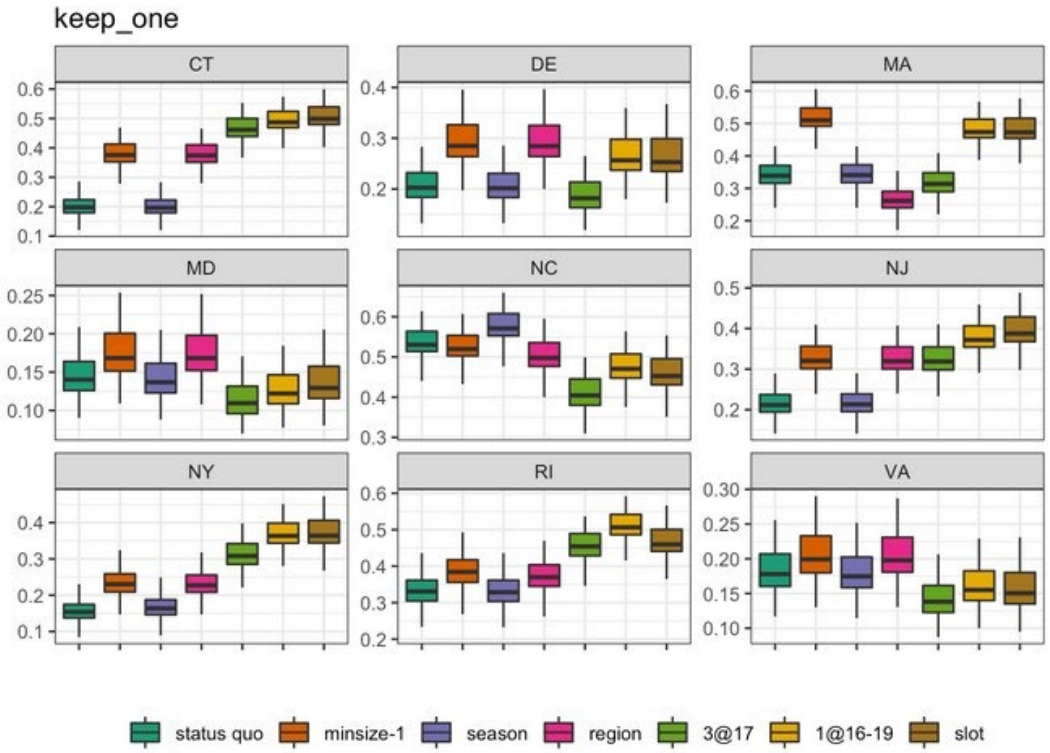

Figure 4: Comparison of the average number of trips where one summer flounder was kept across the seven different management procedures for each state under the baseline operating model.

We can also take a broader look at the performance of each management procedure at the state level by determining the number of states where a management procedure performed better/worse than the status quo (MP#1) for a particular metric. This type of evaluation allows us to determine if a particular management procedure benefited/disadvantaged a majority of states. It is worth noting that this evaluation does not consider the magnitude of improvement/decline.

The results indicate that MP #2 performed better for 8 of the 9 states across several metrics (Figure 5). This was followed by MP #4, #7, and #8 that performed better for a majority of states. MP #3 and #6 did not perform better for a majority of states for the metrics considered.

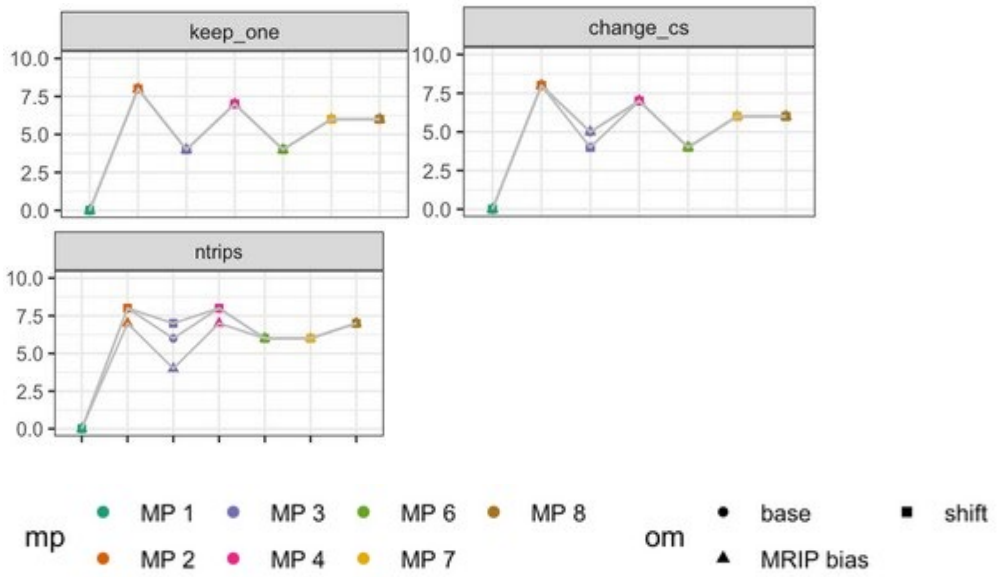

Figure 5: The number of states that perform better under different management procedures compared to status quo measures for three different metrics (keep_one is the percent of trips that keep at least one summer flounder; change_cs is the change in consumer surplus across all trips within state; ntrips is the total number of recreational summer flounder trips). This evaluation was also conducted across three different operating model configurations (baseline, MRIP bias, and stock distribution shift).

Biological Outcomes

Evaluating the biological impacts of implementing different management procedures was also a management objective of the MSE. Here we included metrics that focused on the Council's legal mandate under the Magnuson-Stevens Act (MSA) to prevent overfishing and a stock from becoming overfished. Other priority areas of interest from stakeholders included the proportion of female harvest and opportunities to catch and retain trophy summer flounder.

The results indicate that the risk of the stock becoming overfished during the last 10 years of the projection period (26 years) is very low regardless of the management procedure implemented. Results also indicate there is low risk of overfishing occurring across the different management procedures (Figure 6). It's worth noting that the fishing mortality estimated to determine the stock status metrics includes the removals of both the recreational and commercial sectors.

- MP #8 had the highest risk of overfishing, but below the 50% threshold, followed by a slight increase in risk associated with MP #6.

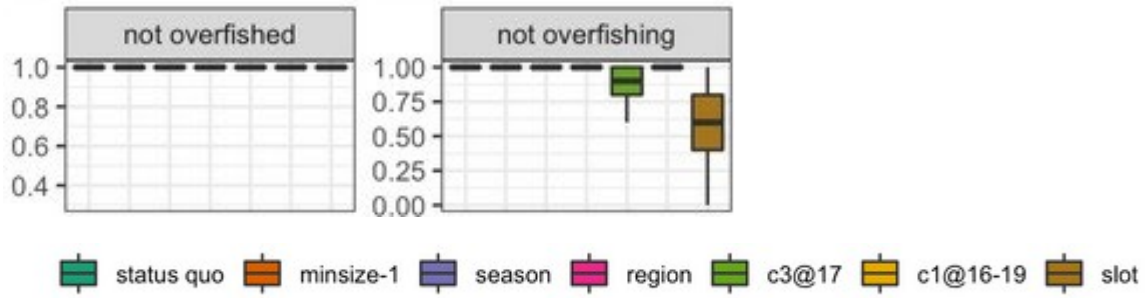

Figure 6: The percent chance that a particular management procedure results in the summer flounder stock not being overfished or not overfishing over the final 10 years of a 26 year projection period.

While there is little risk to the overall stock, there are differences across the different management procedures when evaluating the average total spawning stock biomass (SSB) over the last 10 years of the 26 year projection period (Figure 7, Table 2). Consistent with the stock assessment, total SSB is calculated as mature male and female summer flounder. MP #1 and #3 resulted in the highest average total SSB of approximately 67,400 metric tons (Table 2). These two management procedures resulted in total SSB that was about 10% higher than MP #2, #4, #6, and #7 and was about 16% higher than MP #8 with an average total SSB of 56,500 metric tons.

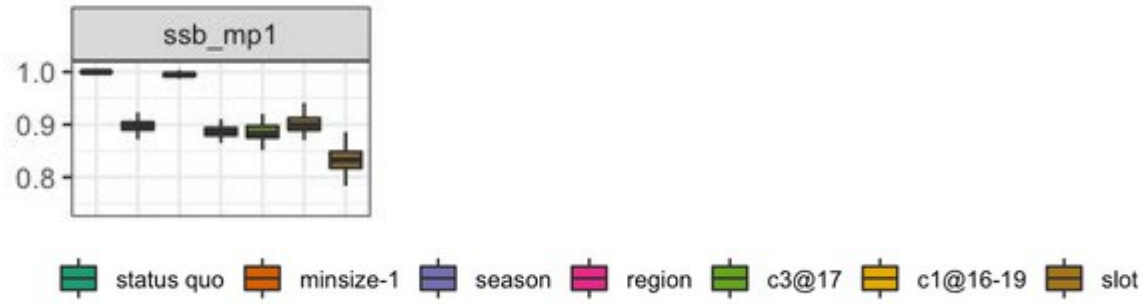

Figure 7: The relative difference in total spawning stock biomass (SSB) for the different management procedures compared to the status quo. SSB includes both mature male and female summer flounder.

There are management procedures that can reduce the percentage of females in the recreational harvest, some by as much as 33 percent (Figure 8, Table 2). Nearly 69 percent of the recreational harvest is comprised of females under MP #1 and #3. MP #2, #4, #6 and #7 reduce the proportion of female harvest to about 60 percent. MP #8 is the only alternative that reduces the proportion of female harvest to just below 50 percent. However, as discussed above, reducing the harvest of females does not appear to have much effect on increasing the total population SSB. In fact, MP #8 which had the lowest proportion of females in the harvest also had the lowest average total SSB.

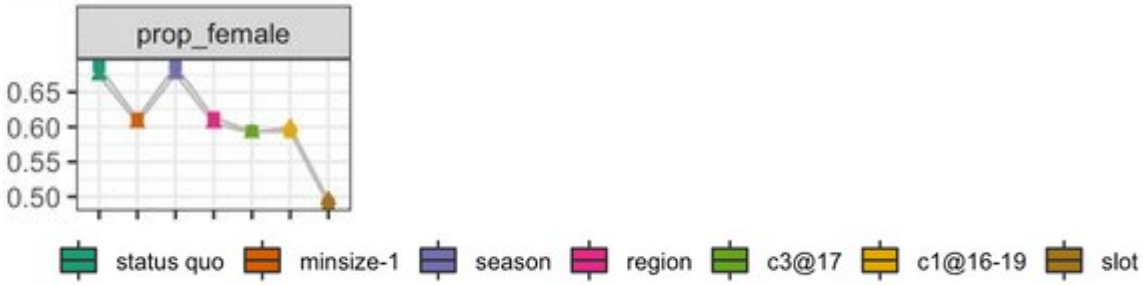

Figure 8: The average percentage of the recreational summer flounder harvest is female across the seven different management procedures.

While these results may seem counterintuitive, there are likely a number of reasons for this outcome and is consistent with previous analyses and with a review of the sex structure during the 2018 benchmark stock assessment. Many of the different management procedures, like MP #8 reduce the minimum size limit, which increases the harvest and fishing mortality rate on smaller male and female summer flounder. This results in removing more smaller and younger fish before they become a greater proportion of the total SSB. In addition, as recent management actions have set lower catches and reduced the total fishing mortality on the stock, sex ratios within the population are changing and more males are surviving to larger sizes and older ages and represent a greater contribution to the SSB. Lastly, consistent with the stock assessment, the operating model used for the MSE does not have a stock-recruit relationship, so there is no direct link between total SSB and stock productivity/recruitment.

Social and Economic Related Outcomes

One of the most significant advances associated with this MSE was the development and integration of the recreational demand model within the simulation framework. Not only did this advancement allow for the consideration of angler behavior in response to management and stock changes, but it also provided the opportunity to estimate the social and economic benefits associated with different management procedures. This was critical to ensure we could address the economic management objectives requested by the Council and Board.

<u>Overall/coastwide results</u>

In general, the economic metrics display a very similar pattern, at the individual trip level or across all trips, as the harvest and discard related metrics discussed earlier. Those management procedures with a higher percentage of trips with a keeper summer flounder, a greater the number of summer flounder kept per trip, and the higher harvest:discard ratio also had greater economic benefits (Figures 9 and 10).

- Angler welfare (consumer surplus) is a measure of an angler's willingness to pay for a fishing trip under a given set of regulations and generally reflects angler satisfaction. MP #1 and #3 had the lowest angler welfare across all seven management procedures evaluated. MP #2, #4, #6, and #7 performed equally well and increased angler welfare 3 times higher than the status quo (MP #1). MP #8 had the highest angler welfare and was nearly 5 times higher than MP #1. These results intuitively make sense, as angler welfare/satisfaction is positively and significantly related to harvest according to the analysis of angler preferences.

Figure 9: The estimated angler welfare (consumer surplus) per trip across all seven management procedures under the baseline operating model.

- Number of summer flounder recreational fishing trips is included as an economic metric because the more trips taken, the higher the angler welfare and the greater the economic benefit.
    - MP #1 and MP #3 resulted, on average, in 11.25 million directed summer flounder fishing trips per year.
    - MP #2, #4, #6, and #7 were all similar and resulted in approximately 11.8 million trips per year, which is a 5 percent increase over the status quo (Figure 10).
    - MP #8 resulted in the highest number of directed summer flounder tips at 12.22 million trips, or nearly a 9 percent increase compared to MP #1 (Figure 10).

Figure 10: The change in the average total number of directed summer flounder fishing trips per year for all management procedures compared to the status quo (MP#1) under the baseline operating model.

Fishery investment/expenses is closely linked to the total number of recreational trips and, therefore, the general pattern across the different management procedures is similar, particularly at the coastwide level with the status quo alternative (MP#1) performing the worst. The more trips taken, the more economic activity and greater investment and expenses. For reference, marine angler expenditures on fishing trips for all species totaled $3.6B across the study region in 2017.

- MP #1 resulted in the lowest fishery investment and expenses due to summer flounder activity totaling $470.9 million. This was followed by MP #3 with total fishery expenses estimated to be $474.4 million.
- MP #2, #4, #6 resulted in a 5 percent increase in total summer flounder expenses totaling $493.5 million, or $23 million more per year than the

status quo.
    - MP#7 had the second highest fishery investment totaling $499.3 million.
    - MP#8 had the greatest economic impact with a total fishery investment of $513.0 million, a 9 percent increase compared to MP #1 or nearly $43 million more per year.

State specific results

- Angler welfare
    - State-level angler welfare generally follows the same trends in state-level numbers of trips. Both of these metrics are driven by changes in expected harvest, which varies with regulations and state-specific catch-per-trip and catch-at-length distributions. Similar to the harvest and discard metrics, angler welfare is much more variable at the state or regional level with the states of NJ through MA displaying different patterns than those found in the states of DE through NC (Figure 11).

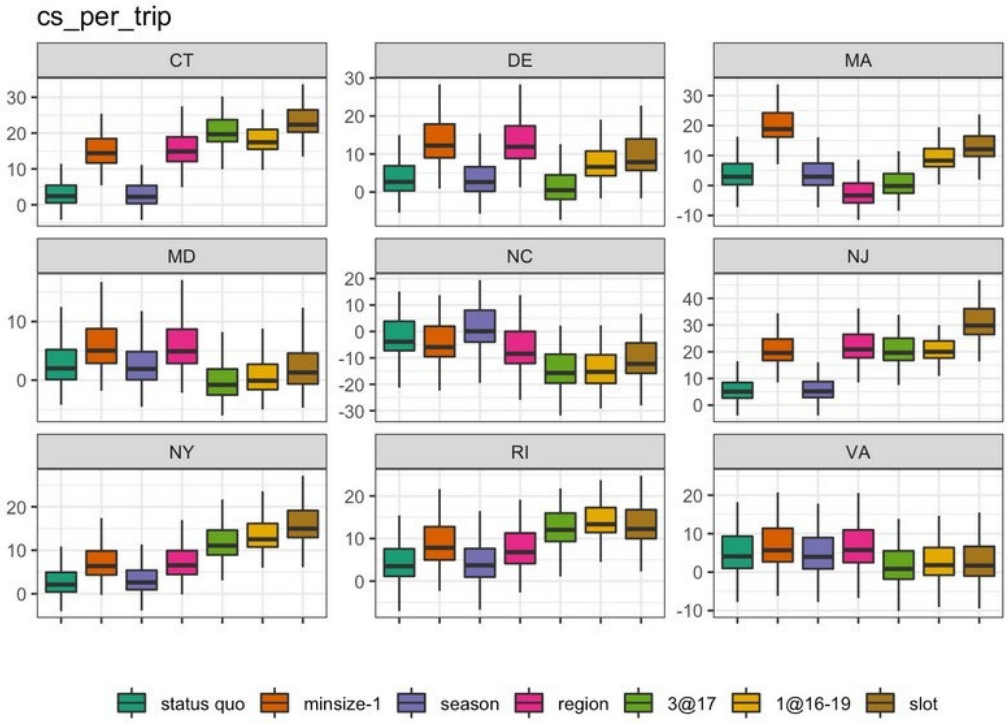

Figure 11: The estimated angler welfare (consumer surplus) per trip for each state across all seven management procedures under the baseline operating model.

- Fishery investment/expenses
    - Total fishery investment/expenses are more variable than the angler welfare at the state level and across the different management scenarios than at the coastwide level (Figure 12). For example, in Massachusetts MP #3 results in significantly higher fishery expenses but is one of the lowest performing management procedures when considering angler welfare. This is due to more variability between the combination of total number of recreational trips and the trip expenses at the state level (e.g, average trip expenses range from $22 per trip in RI to $70 per trip in NC).

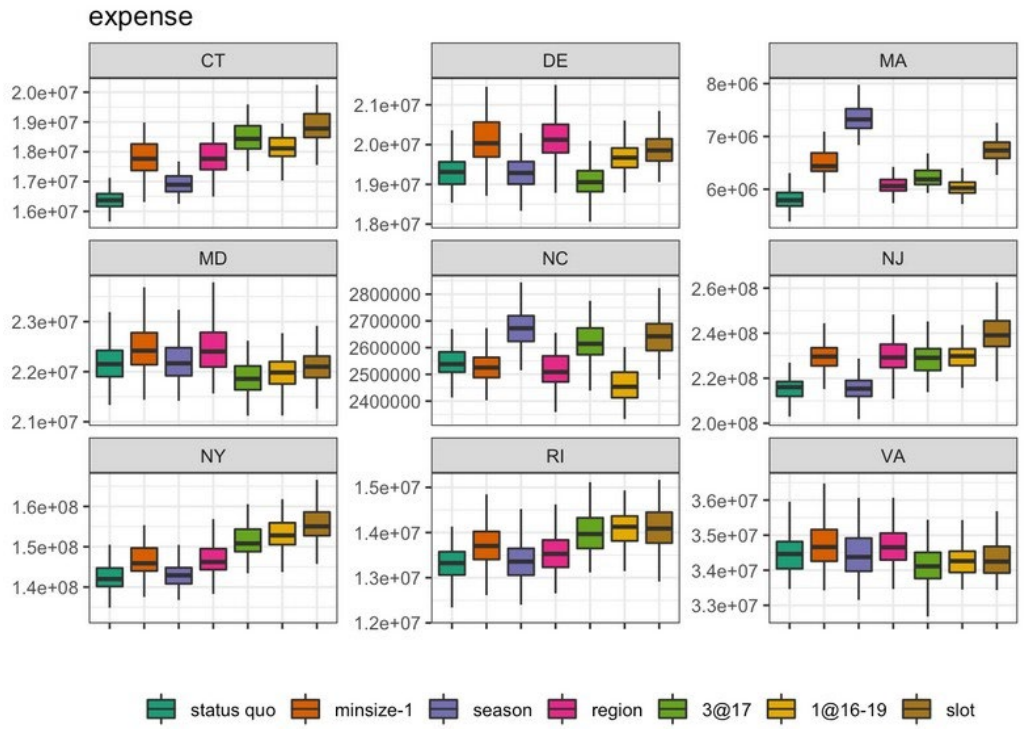

Figure 12. Total summer flounder fishery investment/expenses by state for each management procedure under the baseline operating model.

Outputs/results across operating model alternatives

A benefit of conducting an MSE is the ability to evaluate the performance of management procedures across different unknowns and uncertainties within the biological, fishery, or management system. Here we evaluate the relative performance of the same seven management procedures across two different states of the world (scenarios). One scenario assumes the Marine Recreational Information Program (MRIP) estimates of summer flounder effort and catch are lower than the point estimate used as the official measure. The second scenario considers the anticipated changes in the spatial distribution and availability of summer flounder along the Atlantic coast.

The results suggest that all seven of the management procedures are fairly robust and the relative performance was similar across the different operating model uncertainties (MRIP bias and stock distribution shifts). Those management procedures that performed better under baseline model also performed better under two operating model alternatives (Figure 13).

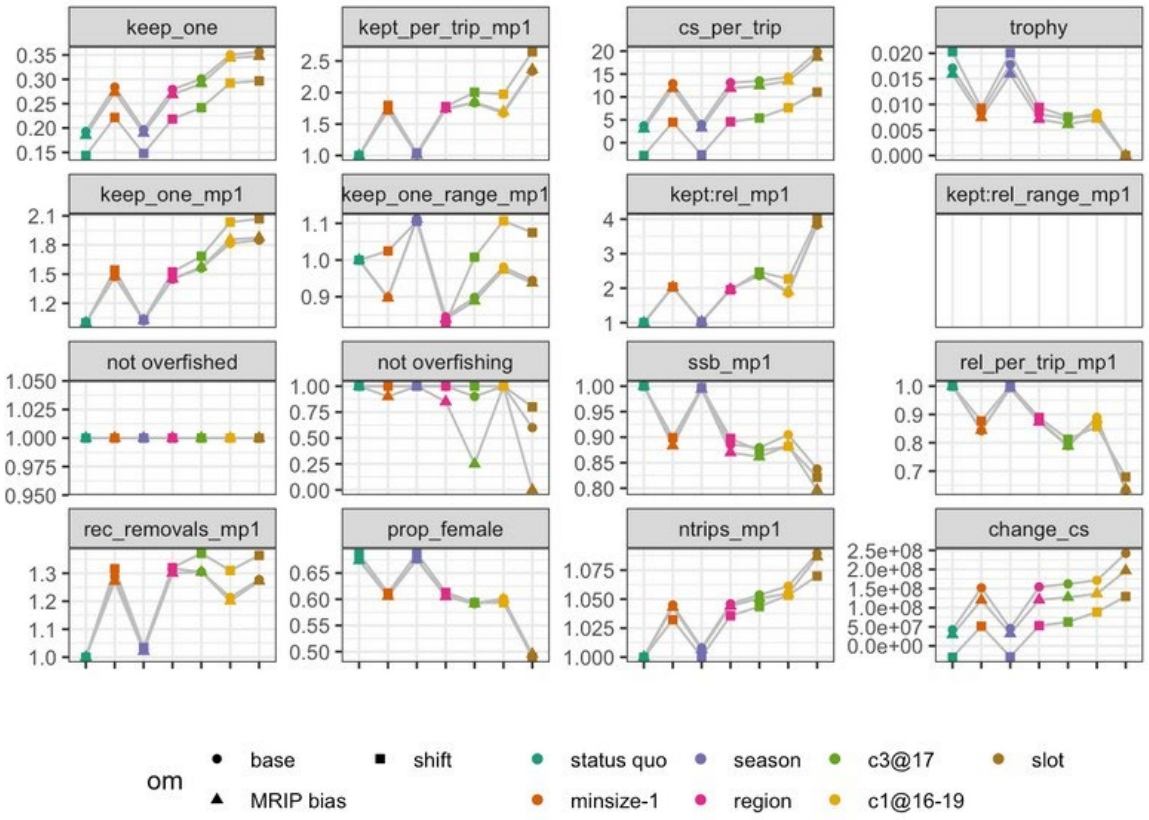

Figure 13. Comparison of the relative performance of seven different management procedures across a suite of biological, social, and economic performance metrics and three different operating model scenarios (baseline, MRIP bias, and stock distribution shift).

The MRIP bias operating model runs show a slightly higher risk of overfishing across many management procedure alternatives. MP#6 and #8 result in significantly higher risk of overfishing under these scenarios with overfishing occurring 75 percent of the time under MP #6 and in most years for MP #8. While MP #6 and #8 do result in fishing mortality rates higher than F_{MSY} threshold, they are not significantly higher and, while they result in lower stock biomass, it never falls below the overfished threshold.

The distribution shift operating model results in poorer performance across all management scenarios for several metrics: percent of trips that kept 1 fish, consumer surplus per trip, and total number of recreational trips (Figure 14). When first considering the MRIP bias results, they may seem counterintuitive since this operating model includes much lower effort and catch estimates; however, the lower recreational catch estimates also change our understanding of stock productivity when compared to the baseline and distribution change operating model scenarios. With the lower MRIP catch estimates being used, the total stock size is estimated to be lower and reference points would change given the changes in stock productivity.

In addition, the number of states where a metric performed better than MP #1 was also fairly robust and consistent across operating model alternatives (Figure 6). The exception was the MRIP bias alternative resulted in fewer recreational trips and recreational expenses under MP #3 and therefore, fewer states saw an improvement for those metrics compared to

the status quo alternative.

Tradeoff outputs/results

- Core group members have a diversity of preferences in terms of how important each objective and performance metric is, with the most agreement about the socio-economic objective's importance and a wide range of preferences in terms of the angler equity and stock sustainability objective. These preferences were captured through weights across objectives (Figure 14).
- On average core group members consider the Stock Sustainability and Quality of Angler Experience objectives as the highest priority. Equity of Angler Experience was third (quite a bit lower than stock sustainability) and lastly the Socio-Economic Sustainability objective was fourth.

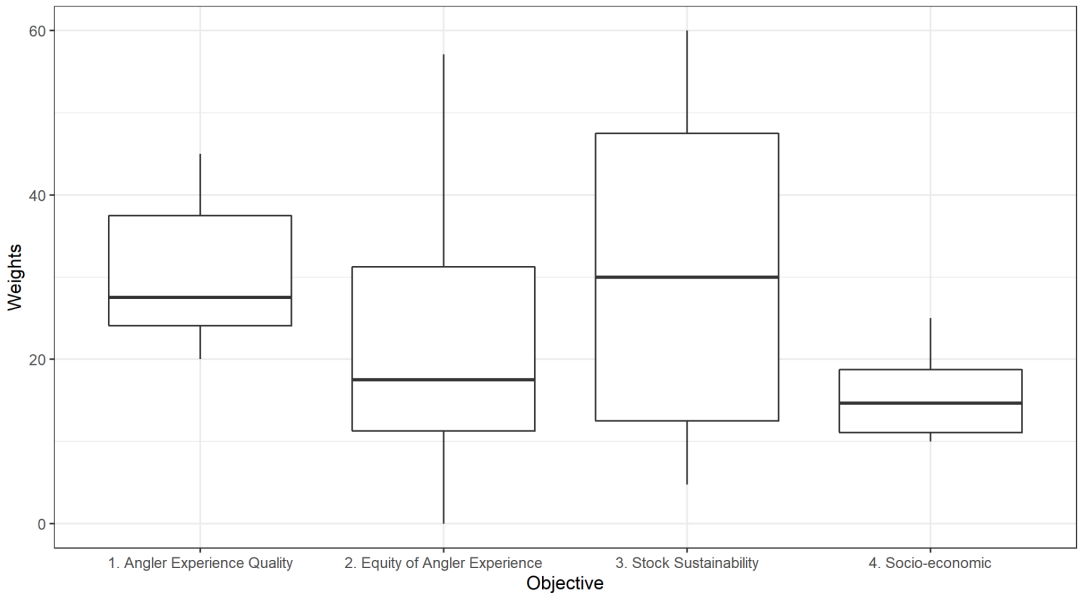

Figure 14. Stakeholder Objective Weights. This boxplot shows the range of relative importance that stakeholders placed on each of the four objectives. If all objectives were equally important, they would each receive a weight of 25 points (out of 100 total points), such that objectives with scores greater than 25 are relatively more important and those with scores less than 25 are relatively less important.

- Management procedures are fairly robust and relative performance was similar across the different weightings provided by the core group.
    - The relative ranking of the management procedures was consistent across the range of relative importance placed on each objective by the stakeholders.
- MP #8 had the highest score across weighting schemes, producing the greatest expected value for the management objectives considered (Figure 15).
    - MP #7, then MP #6, #2, and #4 had similar scores and MP #1 and #3 produced the lowest scores.
    - Relative to the status quo (MP #1), MP #8 represented an 106% increase in degree to which satisfaction is produced by these management objectives.

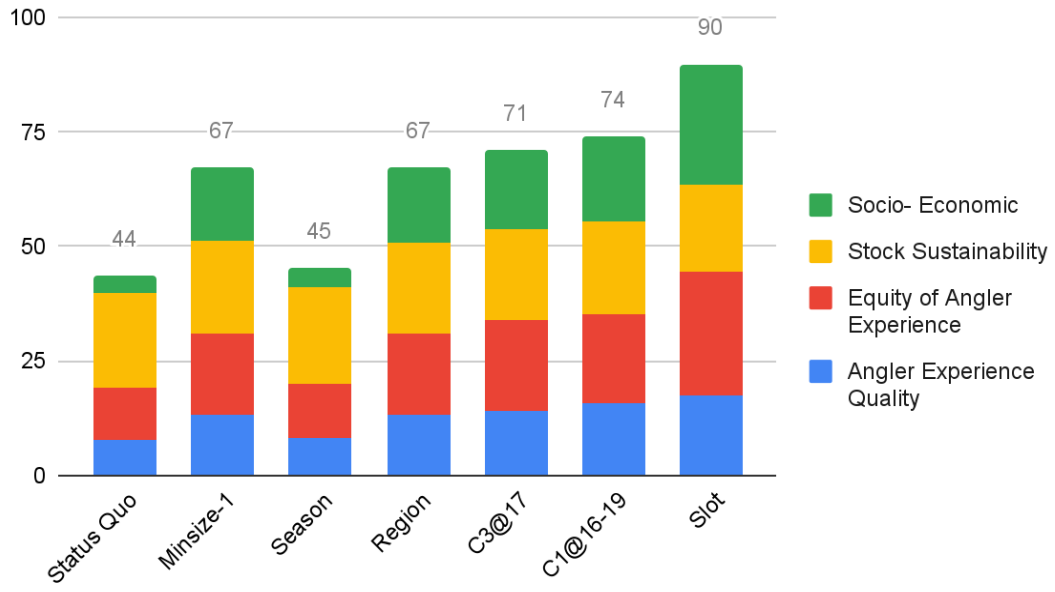

Figure 15. Total Performance of each management procedure. Management procedures are listed across the bottom axis and the total performance score is displayed by the height of the stacked bar on the vertical axis. Scores reflect the expected degree of satisfaction provided by a management procedure, such that a doubling of the score indicates the average stakeholder expects to be twice as satisfied by the change in management procedure. The four colored regions of each bar show the degree of contribution each management objective provides to the total score.

Another way to visualize tradeoffs is using a spider plot where the greater the area enclosed by a management procedure the better it performs (Figure 16). Note that the performance here is unweighted (i.e., the raw model outputs).

- This also shows that MP #8 performs best on most of the metrics (not overfishing is the exception).
- We can see there isn't any difference between the management procedures in terms of their performance at avoiding an overfished stock while the consumer surplus and kept:released ratios exhibit the greatest difference in performance across the management procedures.

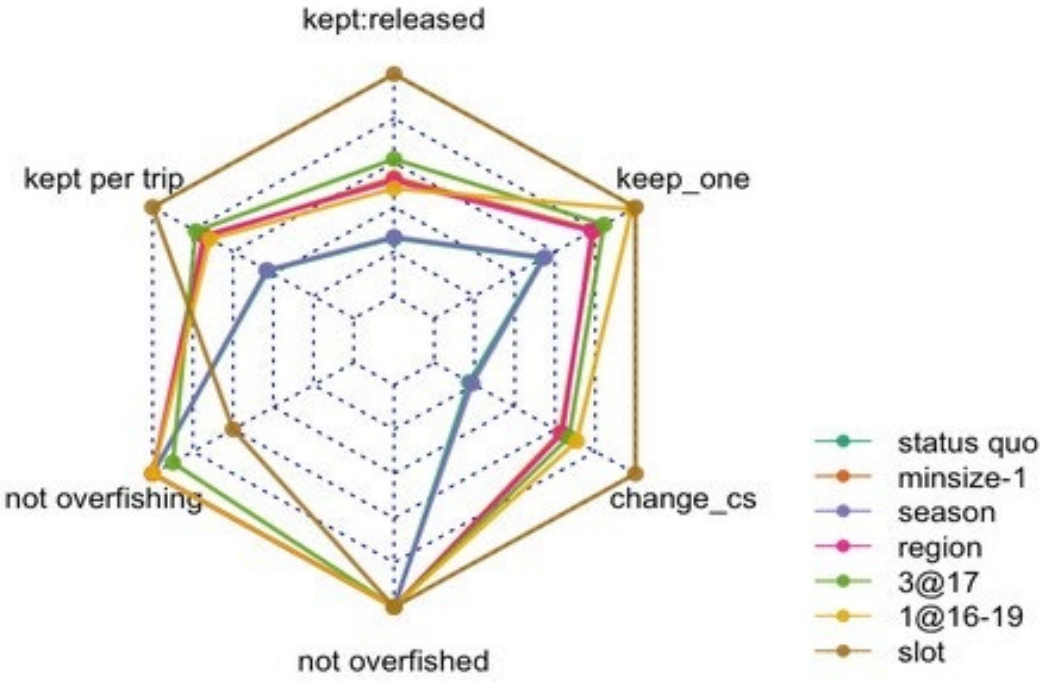

Figure 16. Spider plot of key performance metrics. Points closest to the center indicate poorer performance and those closest to the outside indicate better performance, respectively, for the metrics displayed. The color of the lines connected to the points indicate which management procedure the points are associated with