EAFM Recreational Summer Flounder Management Strategy Evaluation

Summary of MSE Results and Findings

Executive Summary

The Mid-Atlantic Fishery Management Council's (Council) Ecosystem Approach to Fisheries Management (EAFM) guidance document established a structured framework and process to incorporate ecosystem considerations into the evaluation of policy choices and trade-offs as they affect Council-managed species and the broader ecosystem. As part of this process, the Council requested a Management Strategy Evaluation (MSE) to "Evaluate the biological and economic benefits of minimizing discards and converting discards into landings in the recreational sector. Identify management strategies to realize these benefits."

Through a collaborative, stakeholder, and science driven process, the MSE successfully met its objectives and developed a modeling framework unique to the Mid-Atlantic region integrating a full summer flounder population dynamics model with an angler economic behavior model to understand how recreational behavior responds to changing regulations and stock availability. The performance of eight management procedures (MPs) were tested under three different states of the world (scenarios). A core group of stakeholders outlined objectives, developed performance metrics, and identified key uncertainties to test procedures against. The benefits of each management procedure were assessed 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) across four different management objectives.

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. In addition, the simulation framework and individual models developed as part of the MSE can help provide both strategic and tactical advice for a variety of potential management priorities. These models and results can be used to directly inform recreational management, through recreational harvest control rules and annual specifications, to achieve a range of Council objectives.

This document describes how the work undertaken achieved this task and summarizes the key outcomes and findings. The accompanying briefing memo outlines the details of the process itself.

Summary of key findings and outcomes

- Under the baseline operating model state of the world (scenario), all management procedures, except for one, outperformed the status quo alternative across a majority of

performance metrics, including those that reduce recreational discards and provide for increased harvest opportunities.

- No management procedure resulted in the stock becoming overfished. 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 we observed under 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, 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, 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.
- Due to stakeholder and technical team priorities, data availability, and time constraints, not all areas of interest raised by stakeholders were able to be considered within the timeline for this project.
- Overall, the core stakeholder group found the process to be very informative and positive, appreciated their ability to participate and contribute, and believe the results and outcomes will be useful for management. They also identified and suggested a number areas of improvement for any future MSE project.

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 of the 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. For those interested, 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.

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.

For reference, Table 1 provides a summary of the seven different management procedures included in the results below. An additional management procedure was evaluated (coastwide, 1 fish possession limit, 14 inch minimum size, and a season of May 15 - September 15) but removed by the core stakeholder group and those results are not included.

Table 1. Summary of the seven different management procedures tested as part of the EAFM recreational summer flounder MSE.

Management Procedure #	Procedure Explanation
1 (status quo)	Status Quo - 2019 regulations
2 (minsize-1)	2019 regulations but a 1 inch decrease in minimum size within each state to a minimum of 16 inches
3 (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)	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 31
8 (slot)	**True slot limit:** 3 fish possession limit between 16 inches and 20 inches, May 1 - Sept 31

Overall/coastwide results

Results demonstrate there are management tools and different management procedures that can reduce the number of discards, increase the keeper:discard ratio, and promote recreational opportunities that would convert discards into landings (Figure 1, Table 2). Nearly all of the management procedures tested performed better across the discard related performance metrics when compared to the status quo (MP#1).

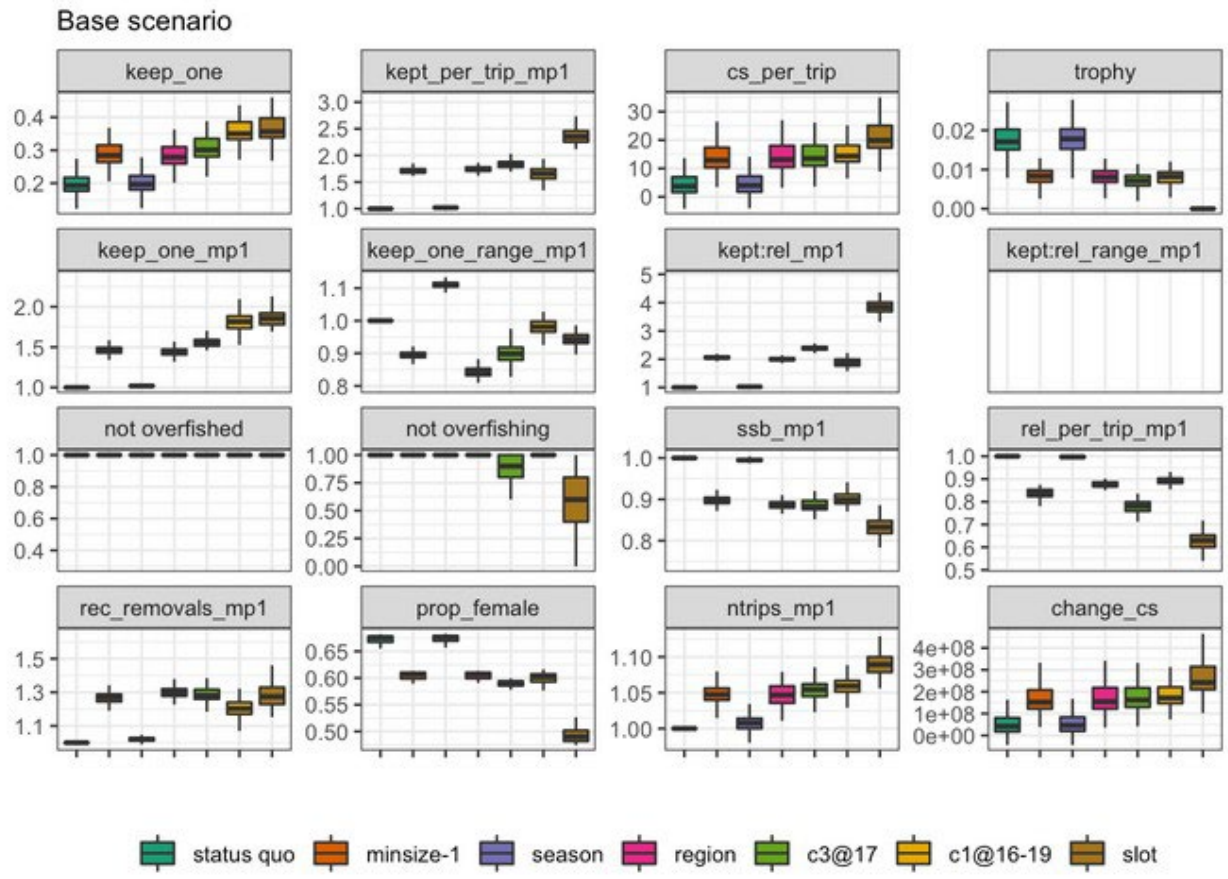


Figure 1. Coastwide results for a suite of biological, social, and economic performance metrics for seven different management procedures under the baseline operating model configuration.

- 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.

Table 2. Summary of model outputs for select performance metrics across the seven different management procedures under the baselines 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	0.350	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	0.240	0.189	0.390
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	13.100	13.502	14.352	19.873
Total recreational expenses (millions of $)	470.9	492.3	474.5	492.6	495.7	499.3	513.0
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	0.000

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 2). 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.

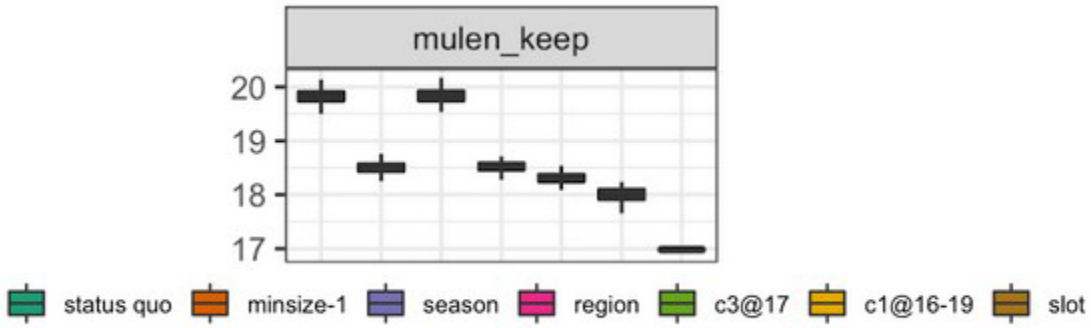


Figure 2. The average size (inches) of summer flounder harvested for the entire coast under the seven different management procedures.

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 1, Table 2).

- For example, MP #2, #4, #6, #7, and #8 result in a 29% increase in total recreational removals, but there is only 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 3). 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 3).

- 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).

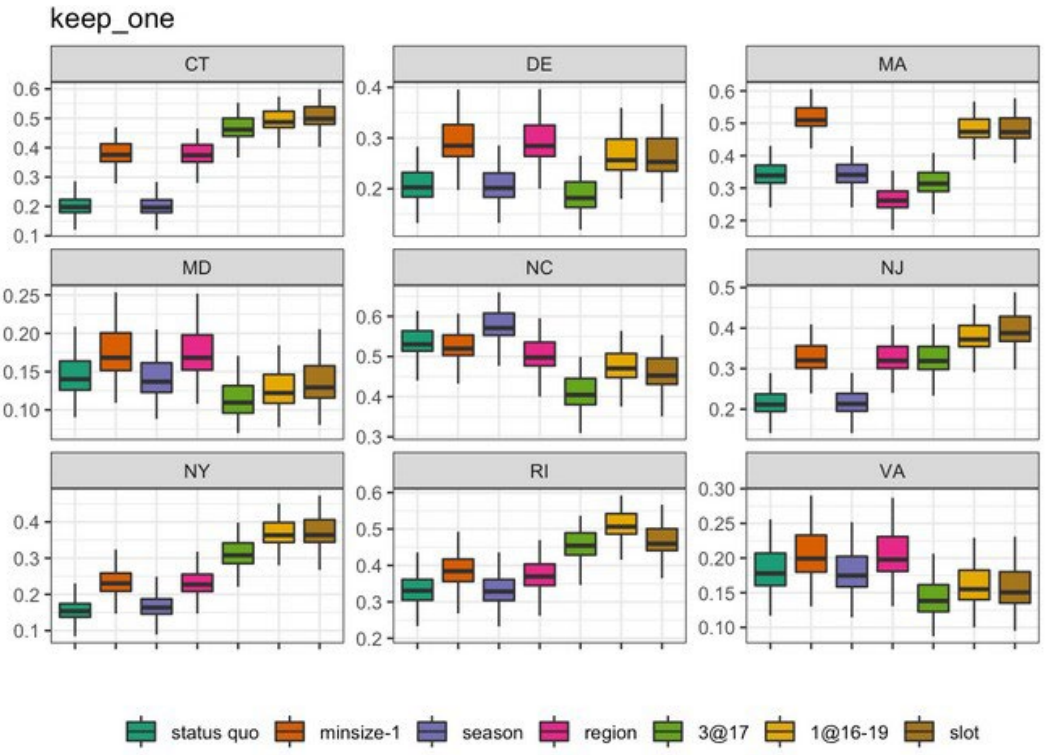


Figure 3. Comparison of the average number of trips where one summer flounder was kept across the seven different management procedures for each state under the baseline operating model.

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 4). 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.

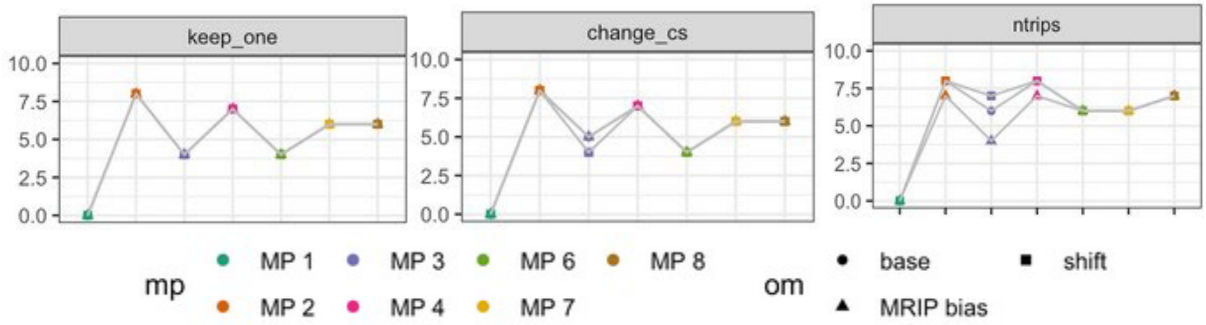


Figure 4. The number of states that perform better under different management procedures compared to status quo measures for three different metrics (keep_one is the percent of trips that keep at least one summer flounder; change_cs is the change in consumer surplus across all trips within state; ntrips 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 (Figure 5). Results also indicate there is low risk of overfishing occurring across the different management procedures (Figure 5). 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 did result in the highest risk of overfishing, but below the 50% threshold, followed by a slight increase in risk associated with MP #6.

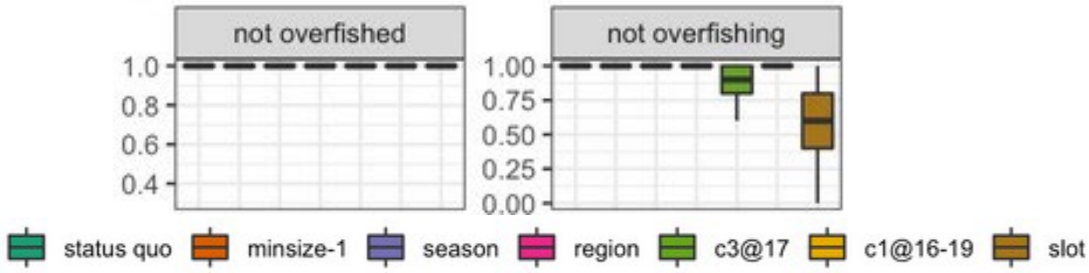


Figure 5. The percent chance that a particular management procedure results in the summer flounder stock not being overfished or not overfishing over the final 10 years of a 26 year projection period.

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 6, 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 1). 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.

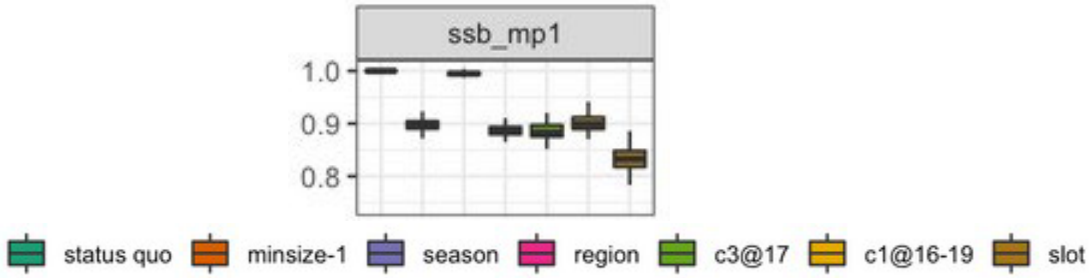


Figure 6. The relative difference in total spawning stock biomass (SSB) for the different management procedures compared to the status quo. SSB includes both mature male and female summer flounder.

There are management procedures that can reduce the percentage of females in the recreational harvest, some by as much as 33 percent (Figure 7, 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.

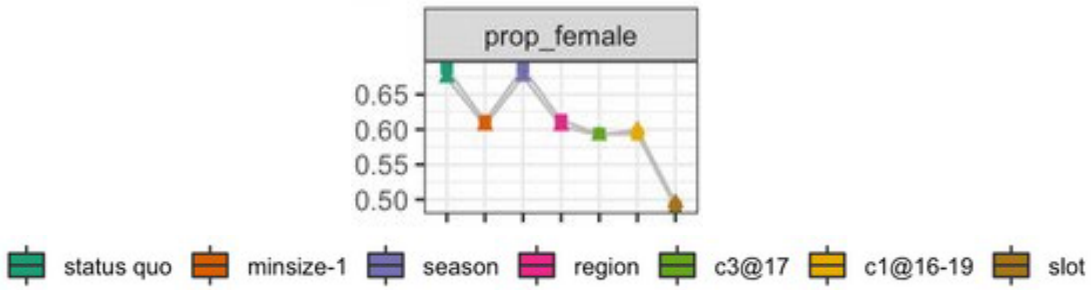


Figure 7. The average percentage of the recreational summer flounder harvest is female across the seven different management procedures.

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.

Overall/coastwide results

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 8 and 9).

- 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.

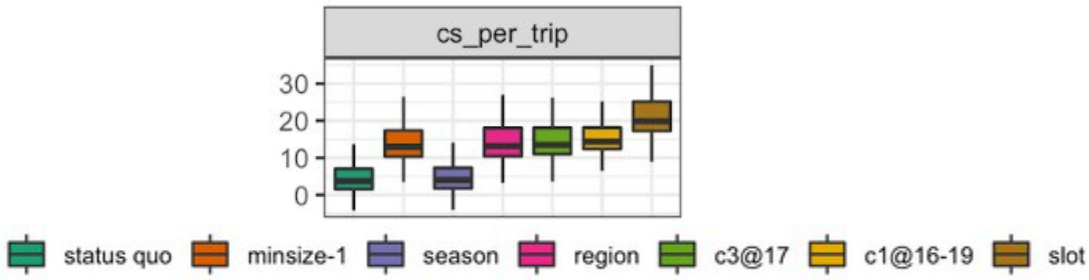


Figure 8. The estimated angler welfare (consumer surplus) per trip across all seven management procedures under the baseline operating model.

- 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 9).
    - 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 9).

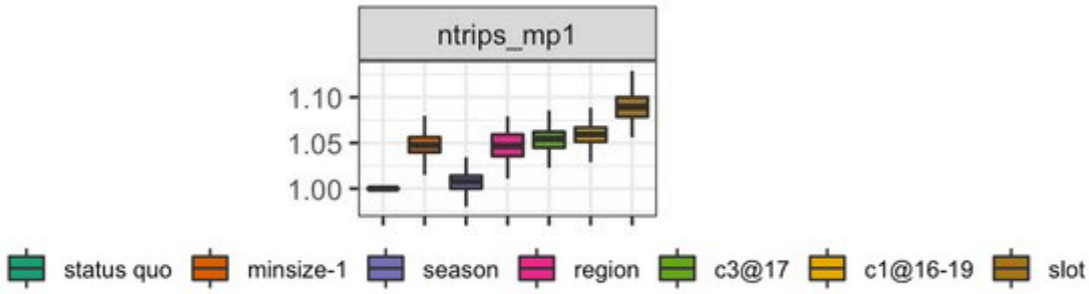


Figure 9. The change in the average total number of directed summer flounder fishing trips per year for all management procedures compared to the status quo (MP#1) under the baseline operating model.

- 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 10).

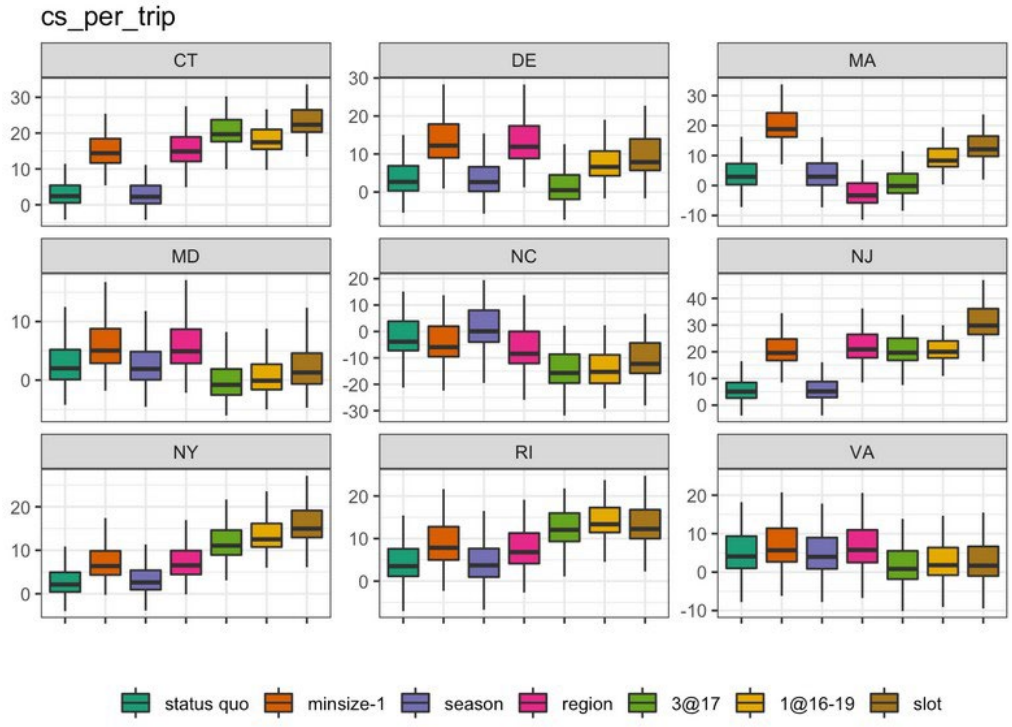


Figure 10. The estimated angler welfare (consumer surplus) per trip for each state across all seven management procedures under the baseline operating model.

- 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 11). 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).

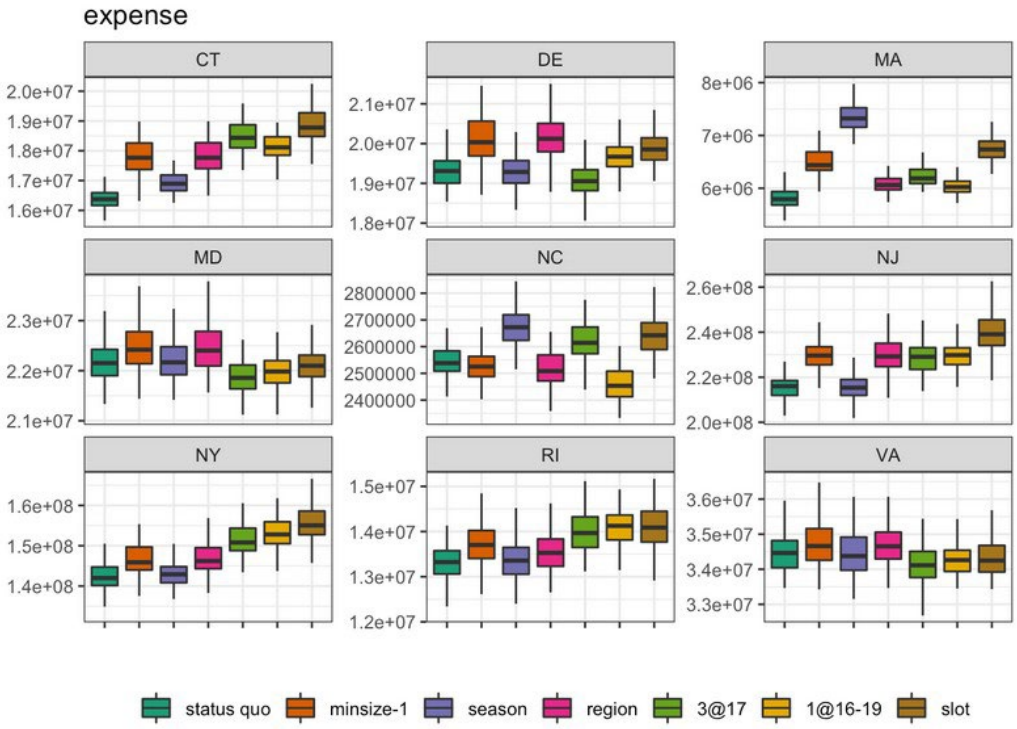


Figure 11. Total summer flounder fishery investment/expenses by state for each management procedure under the baseline operating model.

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 12).

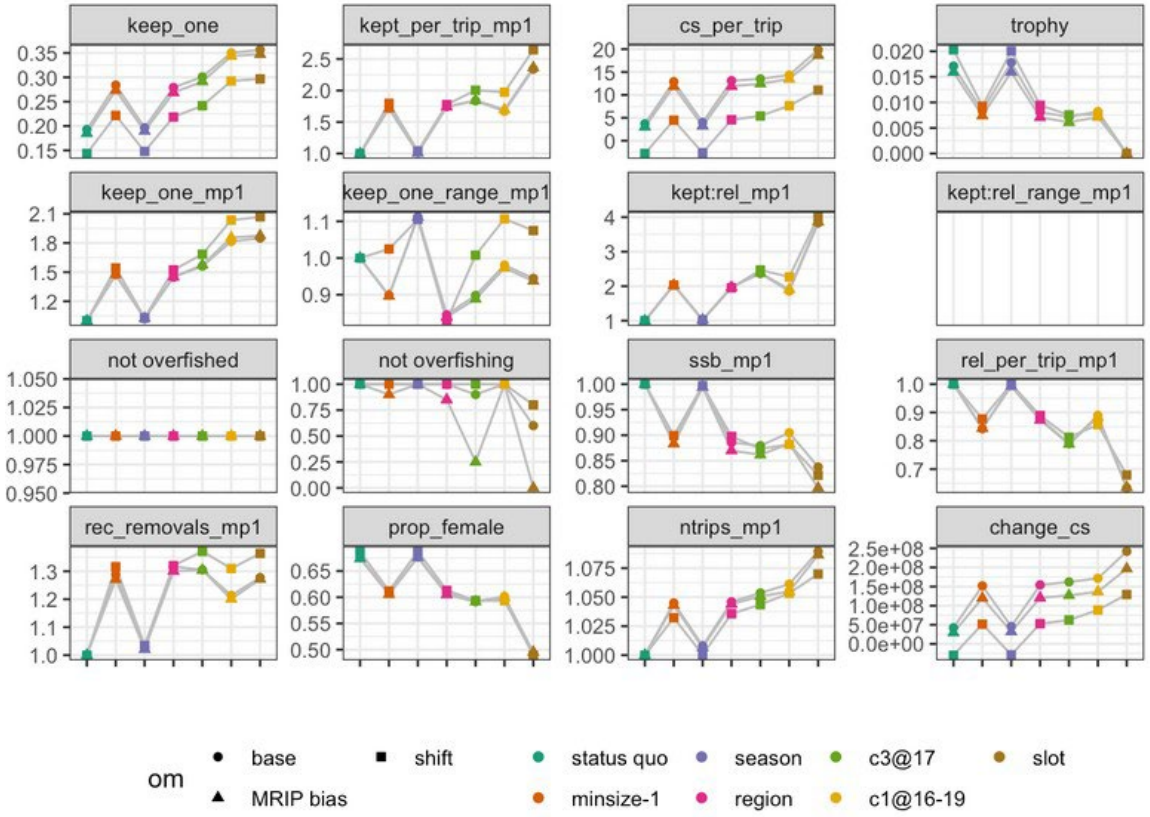


Figure 12. Comparison of the relative performance of seven different management procedures across a suite of biological, social, and economic performance metrics and three different operating model scenarios (baseline, MRIP bias, and stock distribution shift).

The MRIP bias operating model runs do 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.

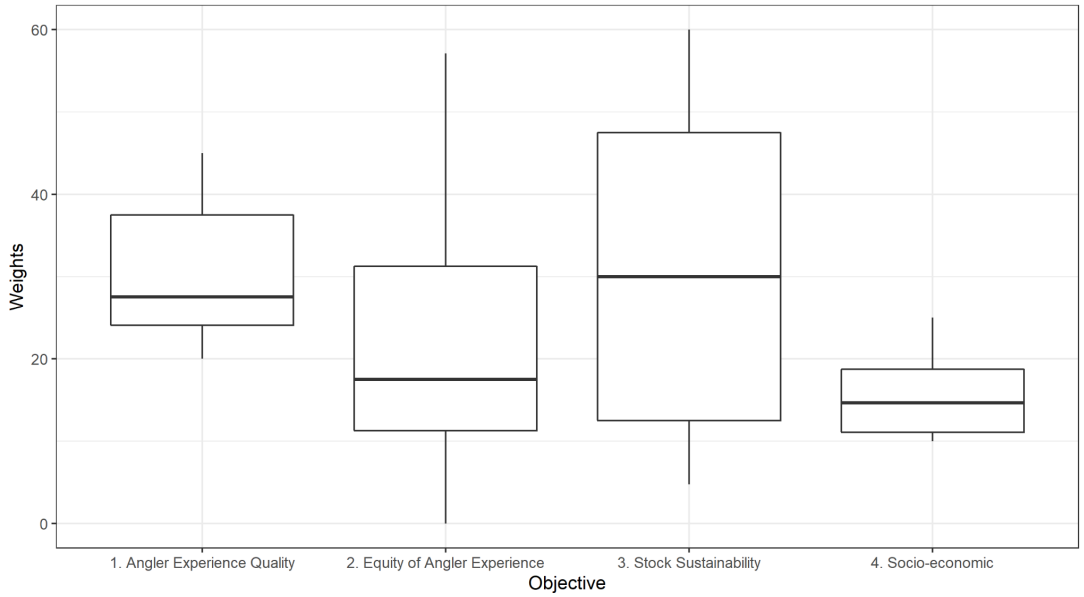
The distribution shift operating model results in poorer performance across all management scenarios for several metrics: percent of trips that kept 1 fish, consumer surplus per trip, and total number of recreational trips (Figure 13). When first considering the MRIP bias results, they may seem counterintuitive 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 5). 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.

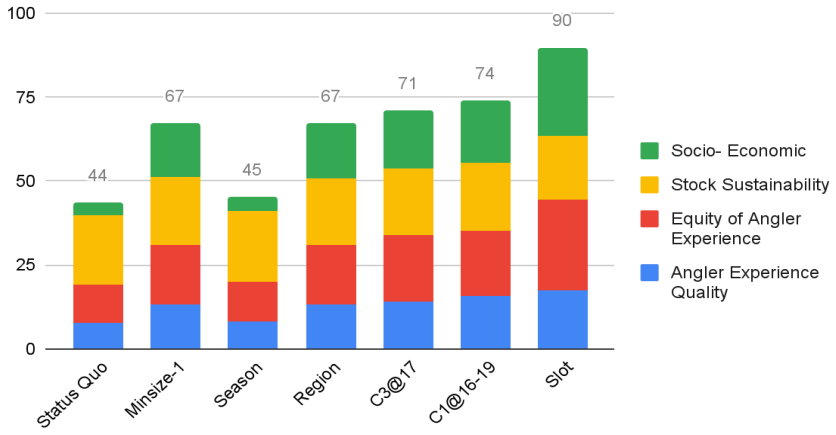
Tradeoff outputs/results

- 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.
- 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.



- 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.
    - 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.



Another way to visualize tradeoffs is using a spider plot where the greater the area enclosed by a management procedure the better it performs. 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.