Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: American Lobster Management Board

FROM: American Lobster Plan Development Team

DATE: September 10, 2021

SUBJECT: Technical Committee Recommendations for Development of Draft Addendum XXVII on Gulf of Maine/Georges Bank Resiliency

Background

At the February 2021 meeting, the Board reinitiated work on Draft Addendum XXVII, which aims to proactively address resiliency of the Gulf of Maine/Georges Bank (GOM/GBK) stock given recent declines in young-of-year indicators, despite the stock not experiencing overfishing and abundance being near time-series highs. The Board specified the scope of the action through the following motion:

> *"Move to re-initiate PDT and TC work on the Gulf of Maine resiliency addendum. The addendum should focus on a trigger mechanism such that, upon reaching of the trigger, measures would be automatically implemented to improve the biological resiliency of the GOM/GBK stock."*

To inform the development of the document, the Plan Development Team (PDT) requested the Technical Committee (TC) perform several analyses and make recommendations on the range of options to be considered in the draft addendum. The TC defined resiliency as the ability of the stock to recover from a disturbance, and their recommendations are based on the understanding that the Board is interested in increasing stock resiliency by adding an additional biological buffer to the stock through the protection of spawning stock biomass across LCMAs. This memo outlines these analyses and recommendations for the PDT's consideration.

Summary of Technical Committee Recommendations

Below are the key recommendations arising from the TC analysis and discussion. Specifically, the TC made recommendations on proposed options for Draft Addendum XXVII related to the trigger mechanism for implementing a change to management measures, the trigger levels, and the management measures that should be considered. The subsequent sections of the memo provide additional information on the analyses performed and rationale for each set of recommendations.

- ***Recommendation on trigger mechanism***
  - The TC recommends using an annual trigger index that can be used to establish whether relative abundance has reached a specific trigger level. This index will be calculated as the average of recruit (71-80 mm carapace length) indices from (1) the combined ME/NH and MA DMF spring trawl surveys, (2) the combined ME/NH and MA DMF fall trawl surveys, and (3) the combined Gulf of Maine Ventless Trap Survey. The three-year running average of the trigger index (using the current year being evaluated and two preceding years) would trigger management action when it falls below the selected trigger level(s).

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- ***Recommendations on trigger levels***
    - For trigger levels based on annual abundance indices, the TC recommends the document consider the following trigger levels:
        - Management triggered by the three-year running average of the trigger index (using the current year being evaluated and two preceding years) when it declines by 17% from the reference period. This trigger level approximates the Fishery/Industry Target reference point, calculated as the 25th percentile of the model abundance during the high abundance regime.
        - Management triggered by the three-year running average of the trigger index (using the current year being evaluated and two preceding years) when it declines by 32% from the reference period. This trigger level approximates the abundance level where the regime shift occurred from the moderate to high abundance regime, as defined in the 2020 stock assessment.
        - Management triggered by the three-year running average of the trigger index (using the current year being evaluated and two preceding years) when it declines by 45% from the reference period. This trigger level approximates the 75th percentile of the moderate abundance regime.
        - The TC does not recommend the PDT include the option for management to be triggered by a 51% decline in indices from the reference period in this addendum.
    - The TC recommends an option be added to the document for immediate action to increase minimum legal size while the stock conditions are favorable. The purpose of this option is to address the issue of growth overfishing, as demonstrated with the potential increase in catch weight in projections done for this memo, as well as to increase the proportion of females that reach maturity prior to the gauge.
- ***Recommendations on the range of management options for increasing resiliency***
    - The TC analyzed a broad range of changes to the minimum and maximum gauge sizes in the LCMAs within the GOM/GBK stock. The TC recommends the draft document only consider management measures that 1) are projected to increase SSB, and 2) result in the minimum gauge size increasing to or above the size at 50% maturity (L50) for each LCMA (LCMA 1: eastern GOM L50 = 88 mm, western GOM L50 = 83 mm, LCMA 3: Georges Bank L50 = 91 mm). See enclosed report for the projected impacts of gauge size combinations. The gauge sizes analyzed by the TC and the current gauge sizes by area are provided in Table 1.
    - It should be noted that for this addendum, the Board directed the PDT only to consider changes to biological management measures currently in place for the lobster fishery (e.g., gauge and vent sizes, v-notching rules, and seasons). The TC agreed that of these management tools, the measures most likely to provide increases to stock resiliency are the minimum and maximum gauge sizes. Therefore, the TC analysis focuses primarily on changes to the current minimum and maximum gauge sizes in the GOM/GBK stock.

Trigger Mechanism: Analysis and Recommendations

Recruit (71-80 mm carapace length) indices are used as model-free indicators of recruitment to the lobster fishery in the following year. During the 2020 stock assessment, recruit indicators were found to be correlated with the stock assessment model estimates of reference abundance (78+ mm carapace length), providing a reliable means to track abundance changes and potential need for management response more frequently than through intermittent stock assessments. There are eight GOM/GBK stock recruit indicators updated for each assessment: spring and fall indices for each of the ME/NH, MA DMF, NEFSC GOM, and NEFSC GBK bottom trawl surveys. The NEFSC indicators in the GOM and GBK regions are considered to be indicators of offshore recruitment which differs from the GOM/GBK stock-wide recruitment dynamics. Therefore, the TC recommends using only the inshore surveys (ME/NH and MA DMF) where the bulk of the population and fishery occur, which are assumed to be more representative of stock-wide recruitment. These trawl surveys employ similar methodologies and, along with selectivity and swept area calibration factors, can be combined into two indices, a spring index and a fall index. Additionally, the TC recommends using the standardized index from the Ventless Trap Survey as an indicator of recruitment during the summer.

To calculate a trigger index, each of the three individual indices were scaled to their 2017 reference levels so they are on the same scale. The one year lag expected between recruit indices and reference abundance due to growth results in 2017 recruit indices mapping to the terminal year reference abundance used in the 2020 stock assessment status determination (2018). The TC recommends linking the trigger index to the reference abundance in this way so the trigger index is an indication of proportional changes to the reference abundance since the 2020 stock assessment. Proportional changes in the trigger index are compared directly to proportional changes between the terminal year reference abundance and abundance reference points established in the assessment to provide an early indication of reference abundance falling below the reference points. Scaled indices were then averaged across surveys to generate a single trigger index. The final trigger index value represents proportional change from 2017 recruitment (and, therefore, expected proportional change from the reference abundance one year later in 2018 - the terminal year of the stock assessment). A value of one indicates no change, a value greater than one indicates an increase (e.g., 1.2 indicates a 20% increase), and a value less than one indicates a decrease (e.g., 0.8 indicates a 20% decrease).

During the 2020 stock assessment, the peer review panel supported using a smoothing algorithm, such as the running average used in past assessments, to determine stock status, but also recommended exploring alternatives (e.g., running median) to evaluate the robustness of status determinations. To evaluate performance of different methods for a trigger mechanism, akin to evaluating stock status in a stock assessment, a simulation analysis was conducted using the trigger index annual point value, three-year running average, and three-year running median to identify need for management action. For each method, all three individual indices were scaled to a 2017 reference level calculated with the same method used to calculate the index. That is, the 2017 reference level was the 2017 point value for the annual index trigger method, the 2015-2017 average for the three-year running average trigger method, and the 2015-2017 running median for the three-year running median trigger method. The scaled individual and combined indices are compared to various trigger points that have been discussed by the TC in Figure 1.

One potential trigger point discussed by the TC was 0.68 (i.e., a 32% decline) which represents the proportional change between the terminal year stock assessment reference abundance level and the boundary between the high and moderate abundance regimes. This trigger point was treated as the trigger for action in the simulation analysis. Each individual index was projected from 2018 to 2025 following a steady decline that reflected a 32% decline from the observed 2017 index value in 2021. This projected trend is hypothetical to evaluate the performance of the three calculation methods being considered and does not necessarily reflect the true status or projection of the population. It was unclear what impacts the method used to calculate the starting point of the projected trend would have on performance of each trigger mechanism, so declines projected from the (1) 2017 point value, (2) 2015-2017 running average, and (3) 2015-2017 running median were evaluated in three separate scenarios. Indices were then sampled from these simulated trends with CVs equal to the average CV over the respective index's time series, assuming a lognormal error structure. These simulations only consider observation error and do not account for process error. Indices were scaled to their reference level as described above, averaged across surveys, and the combined trigger index was evaluated for whether or not it would trigger action (≤0.68) in each year of the projection period. This was repeated 1,000 times for each scenario and action determinations were tallied by year for each of the methods.

Results show similar patterns between the scenarios using a simulated decline from the 2017 point value and from the 2015-2017 average (Table 2; Figures 2-3). The 2015-2017 running median was equal to the 2017 point value for all indices, so the results with a simulated decline from this value were identical to the 2017 point value scenario (Table 2; Figure 4). Incorrect action is triggered very infrequently (< 3% of the time) by the annual and running median methods in the first two years of the projection period and never by the running average method. On average, the annual and running median methods incorrectly triggered action about 9% of the time and about 15 times more frequently than the running average method the year before the decline reached the threshold (2020), but also correctly triggered action ≈38% of the time and roughly twice as frequently as the running average method in the year when the threshold was met (2021). The running average method then tended to perform as well as or better than the other methods from 2022-2025, albeit generally at smaller margins of difference, as all methods tended to perform relatively well in these later years when the decline is exacerbated. The delayed response of the running average method can be seen in Figures 5-7, where the median trigger index value across simulations tends to be slightly higher than the annual and running median methods. The variance in index values, however, is lower for the running average method resulting in more consistency across simulations in terms of guidance for management action, whereas the other methods result in mixed guidance for some of the more extreme simulations in more years than the running average method.

Based on these results, the trigger mechanisms using the annual point value and the running median may be considered precautionary methods that perform better for an immediate trigger, on average, but with more variable guidance than the running average method. The running average method may provide a less responsive trigger mechanism that is less likely to incorrectly trigger premature action, and performs well and more consistently after the initial risk of not triggering action when first needed.

<u>The TC recommends the running average method for calculating the trigger index.</u> The individual surveys display interannual variation that might be related to environmental impacts on catchability (for example), an issue that was identified in the stock assessment and is expected to continue to impact these indices index data sets into the future. This simulation analysis suggests the running average method is more robust to interannual variation than the other methods and therefore can be interpreted with higher confidence.

Trigger Levels: Discussion and Recommendations

At the May 2021 ASMFC meeting, the Lobster Board directed the PDT to include some relatively conservative trigger levels in the draft addendum document, such that a change to measures would occur before abundance falls significantly from current levels. Additional guidance was provided by the

Board at the August 2021 meeting. Board members agreed that they are interested in a tiered approach with multiple trigger levels. They also expressed that while they do want to consider trigger options that are proactive, they did not want to consider trigger levels that may have already been met. Based on this feedback, the TC discussed the risks and rewards associated with the trigger levels that have been suggested by the PDT. TC recommendations related to each option are included below.

Trigger level 1 = 17% decline in indices from reference period: The PDT suggested this trigger level to approximate the Fishery/Industry Target reference point. The fishery/industry target is calculated as the 25th percentile of the abundance during the high abundance regime. This trigger level is the most proactive and would likely result in a change to regulations occurring at a higher stock abundance than the other trigger options. The TC recommends its inclusion in the draft addendum.

Trigger level 2 = 32% decline in indices from reference period: The PDT suggested this trigger level to approximate the abundance level where the regime shift occurred from the moderate to high abundance regime, as defined in the 2020 stock assessment. This trigger level is the second-most conservative of the PDT's suggestions, and would likely trigger management action while stock abundance is relatively high. The TC recommends this option be included in the draft addendum.

Trigger level 3= 45% decline in indices from reference period: The PDT suggested this trigger level to approximate the 75th percentile of the moderate abundance regime. This is slightly less conservative than the previous trigger, but still provides an opportunity for action before reaching the abundance limit. The TC recommends this option be included in the draft addendum for public comment, but this is the least proactive trigger level that the TC recommends for inclusion in the draft addendum.

Trigger level 4 = 51% decline in indices from reference period: The PDT suggested this trigger level to approximate the abundance limit reference point. The abundance limit is calculated as the median abundance during the moderate abundance regime. The TC does not recommend the PDT include this trigger level in this draft addendum because it is inconsistent with the addendum's goal of increasing resiliency. If the stock abundance falls below this point, the stock is considered depleted and the stock's ability to replenish itself is diminished. At this level of abundance, management measures should focus on rebuilding strategies as opposed to increasing stock resiliency.

The TC agreed that in general, taking action to increase the minimum gauge size more immediately while abundance is at its highest levels has the potential to enhance the resiliency of the stock. Conversely, if action to increase the minimum gauge size is taken only after the stock has experienced a decline in abundance, the resulting improvement in resiliency is comparatively less. The negative impacts to lobster catch of implementing an increased gauge size (temporarily reduced catch) coupled with a decreased and declining population available to the fishery would be comparatively more detrimental to industry than if the management measures were implemented while stock abundance is greater. None of the above trigger options would allow for a change in management measures to occur before any decline in stock abundance. Therefore, the TC recommends that the document consider an additional option to change the legal gauge size immediately or within a short time-frame, rather than waiting for the change to be triggered by declines in abundance indices. This will have less of an impact to industry if it were implemented sooner, versus waiting until declining abundance is negatively affecting catch. Impacts to catch specifically resulting from an increase in minimum legal size will be temporary, and will result in increased weight of harvested individuals. This approach could also provide industry with more advance notice of an upcoming change in regulations.

Management Options: Analysis and Recommendations

Based on the stated objective of Draft Addendum XXVII "to increase the biological resiliency of the GOM/GBK stock", and Board guidance to focus on the types of biological management measures currently in place, the TC focused their analysis on evaluating the impacts of alternate minimum and maximum sizes for the LCMAs within the stock. The analysis involved updating existing simulation models with more recent data to estimate the impacts of specific minimum and maximum gauge size combinations on total weight of lobsters landed, number of lobsters landed, spawning stock biomass (SSB) and exploitation. Additionally, an analysis specifically for LCMA 3 was performed due to concerns that the offshore fishery in LCMA 3 is considerably different from the inshore (which tends to drive stock-wide modelling results), and, thus may not be accurately represented due to a misparameterized simulation model. The full report on these analyses is enclosed with this memo.

The TC made recommendations for management measures that could be considered to increase biological resiliency of the stock, but wanted to provide clarity on the premises for these recommendations. First, the TC defined resiliency as the ability of the stock to recover from a disturbance, and second, they based their recommendations on the understanding that the Board's intended approach to increasing stock resiliency is to add an additional biological buffer to the stock through the protection of spawning stock biomass across LCMAs.

Based on these premises and the analyses performed, for area-specific management measures, the TC provided the following recommendations for each LCMA in order to provide an increase to biological resiliency of the overall stock.

LCMA 1

Minimum Gauge Size

- The TC recommends the Addendum only consider options that <u>increase</u> the minimum gauge size in LCMA 1.
- The current minimum size in LCMA 1 is significantly below the stock-wide estimated size at 50% maturity (87 mm). Increasing the minimum legal size would allow more females to reproduce prior to harvest, providing a benefit to the stock.
    - There are spatial differences within LCMA 1 in the size at 50% maturity, ranging from 83 mm to 88 mm, from western to eastern GOM. While the magnitude of impacts of increasing minimum size may vary spatially, some level of resiliency should be provided throughout the region from an increase in minimum size for LCMA 1.
    - At the least, increasing the minimum legal size to 86 mm in LCMA 1 would standardize the minimum legal size for all inshore management areas, but this size would still be below the GOM/GB stock wide L50.
- Growth overfishing is occurring in LCMA 1; most of the catch consists of individuals within one molt of minimum legal size, which results in a much smaller yield per recruit than could be achieved if individuals were allowed to attain larger sizes. Increasing the minimum size in LCMA 1 will lessen the extent to which the stock is growth overfished.
- In general, the greater the increase to the minimum size, the greater the expected benefit to stock resiliency.
    - It should be noted that the effects of increasing SSB on recruitment are difficult to predict and are likely heavily influenced by other factors. The analysis conducted on changes to SSB did not attempt to model recruitment subsidies that may result, thus the

estimated increases in landings, abundance and SSB may be underestimated by not accounting for a positive feedback between spawners and recruits and should be considered a conservatively low bound on expected effect. Conversely, the negative influence of environmental factors (e.g. declining larval food resources) on recruitment processes may have a stronger impact on recruitment success than the number of spawners, thus it is not certain that increases to SSB resulting from gauge changes will result in subsequent increases to recruitment.

Maximum Gauge Size

- Increasing the maximum size in LCMA 1 is not expected to have a benefit to stock resiliency, since it would allow harvest of currently protected individuals. Therefore it is not recommended.
    - There is uncertainty on how changing maximum size in LCMA Area 1 would impact stock resiliency, and how.
    - There is uncertainty in how increases to maximum size inshore will influence population dynamics offshore.
- The TC did not analyze the impacts of decreasing the maximum size for LCMA 1, as it is currently the smallest maximum size across LCMAs in the stock.

LCMA 3

Minimum Gauge Size

- The addendum should not consider decreasing the minimum size in LCMA 3.
- Increasing the minimum size in LCMA 3 is not a high priority for increasing resiliency.
    - While the current gauge size is already close to the size at which 50% of females are mature (91 mm for Georges Bank); increases to the minimum legal size will ensure even more females are able to reproduce prior to becoming susceptible to harvest, providing additional benefits to the stock.
    - It is important to note that at the current minimum size, growth overfishing is occurring; lobsters still have very large scope for additional growth. There could be an industry benefit to increasing minimum legal size, but it is not a significant biological concern given the current stock condition. Currently, exploitation of smaller legal-sized lobsters appears to be relatively low, thus there may be less benefit to increasing the minimum gauge size.

Maximum Gauge Size

- Due to the complexities of growth and reproduction of larger lobsters, there is considerable uncertainty on the quantitative impact of decreasing maximum size in LCMA 3 on stock resiliency, but in general it is thought to have biological benefits. Some considerations are included below:
    - Decreasing the maximum size would have some benefit by putting forever protections on a small portion of the stock, including larger individuals of both sexes. Protecting larger individuals reduces the risk to the long-term sustainability of the population by increasing egg production as well as the diversity of breeders, which leads to more successful egg production under a variety of environmental conditions (DFO 2009). There is also evidence that in addition to fecundity, overall larval survival rates may also be increased as a result of increasing the duration and number of hatching locations (DFO 2009).

- Though there is a well-documented increase in clutch size with increased female size, reproductive dynamics of very large lobsters are not well understood. Unknowns include the frequency at which very large females produce clutches, and whether the currently skewed sex ratio is resulting in sperm limitation that may limit female reproductive output.
- The impact of decreasing the maximum size would depend greatly on the magnitude of the decrease.
- It is expected that a maximum size below 6 inches would result in greater negative impacts to catch (and the impacts will likely differ spatially within LCMA 3) but a larger portion of the population would benefit from forever protections.
    - There is some concern as to whether such a large change in the maximum size would intensify fishing mortality on the smaller or other harvestable size classes in an effort to compensate for the lost catch from a maximum size gauge change. A prospective shift could potentially truncate the size structure and increase the probability of lobsters being harvested from these previously less harvested size classes. This in turn would result in fewer lobsters surviving to subsequent molt stages and/or reproducing.

OCC

The TC recommends that measures within OCC should be standardized for state and federal permit holders.

- While the biological benefits of this will not be large due to the size of the fleet and relative amount of landings, there will be some benefit to standardizing the v-notch definition to ⅛" and to implementing the maximum size for all permit holders. This will apply a consistent conservation strategy within the management area.
- There is a clear benefit to law enforcement's ability to enforce conservation measures at the local dealers.

Minimum Gauge Size

- The TC does not recommend decreasing the minimum size in OCC.
- For increases to minimum size, in general, the greater the increase, the greater the benefit to stock resiliency.
    - OCC is considered a transitional area with most lobsters moving in from other locations. Size at maturity is not estimated for this area because of the mixed origins.

Maximum Gauge Size

- Similar to LCMA 3, there is significant uncertainty on how decreasing maximum size in OCC would impact stock resiliency.
- OCC represents a small component of the stock-wide fishery, therefore decreasing the maximum gauge size is unlikely to have a large positive impact to stock resiliency. However, decreasing maximum gauge size could have a minor benefit by putting forever protections on a small portion of the stock, including larger individuals of both sexes.

Additional Considerations

Though the primary focus of this addendum has shifted from the standardization of biological measures across LCMAs to increasing biological resiliency of the stock, the TC noted that there are some benefits to standardization that warrant consideration. Standardization of measures across areas would simplify the stock assessment and evaluation of management strategies, particularly since management areas do not align with stock boundaries (see for example the difficulties with predicting impacts to LCMA 3 and OCC in this document). In addition, there are benefits for enforcement and commerce. In particular standardization of v-notching requirements and definitions would provide a consistent conservation strategy and simplify enforcement across areas.

Based on the Board's guidance to focus primarily on current measures such as gauge changes, the TC had only limited discussions around alternatives to biological management measures. However, the TC feels it is important to note that other types of management strategies may also provide increases to stock resiliency and should be given more in depth consideration in the future.

Trap reductions have the potential to provide a means to reduce fishing mortality, however the relationship among trap limits, the number of traps in the water, haul frequency, and catch is complex and difficult to predict. It is highly likely that aggressive trap reductions would be necessary to meaningfully reduce fishing mortality. We believe there is considerable latent effort in the LCMA 1 fishery, in terms of both permits and individual traps, and efforts to address these issues in the short-term may increase the Board's ability to manage effort in the future. Note that LMCA 3 has already undergone considerable reductions in traps (both total and individual allocations), which was intended to remove latent effort. Similar efforts should be considered in LCMA 1.

Quotas are a traditional method to control fishing mortality. However, the Board has shown little interest in pursuing the use of quotas. Defining the appropriate level at which to set a quota would require significantly more work due to the current levels of uncertainty around the magnitude of abundance estimates. The current stock assessment model does well with estimating trends in abundance, but less so with magnitude estimates.

The TC emphasized that it may not be realistic to expect that changes to management measures will result in the maintenance of record high abundance levels. To address the Board's goal of increased resiliency, the TC recommendations are expected to partially address growth overfishing, mitigate some effects of a decline in productivity, and improve the stock's ability to rebound from future declines by increasing the proportion of females that can reproduce prior to harvest. This does not imply nor guarantee that the stock could recover to these record high levels, nor should it imply that this action alone is sufficient to ensure long-term sustainability of the fishery. The TC notes that increasing the minimum gauge size to the point where 50% of the population is mature at the minimum legal size is an improvement. However, given the American lobster's scope for growth, maternal effects (fecundity increases with size) and lifetime reproduction potential, further increasing the minimum gauge size to allow as many individuals as possible to reproduce prior to harvest would be beneficial. Additional measures as discussed above could provide the Board better options for managing fishing mortality if that becomes necessary, and should be considered as options for implementation in the future, especially if the stock abundance declines to lower levels of abundance.

Literature Cited

DFO. 2009. Biological Basis for the Protection of Large Lobsters in Lobster Fishing Areas 33 to 38. DFO Can. Sci. Advis. Sec. Sci. Resp. 2008/017.

Tables and Figures

Table 1. Gauge sizes analyzed by TC and current gauge sizes by LCMA.

Min size	inches	mm		Max size	inches	mm	
3 1/4	3.25	82.5	**LCMA 1 minimum**	**5**	5	127.0	**LCMA 1 Max**
3 5/16	3.31	84.1		**5 1/2**	5.5	139.7	
3 3/8	3.38	85.7	**OCC minimum**	**6**	6	152.4	
3 15/32	3.47	88.1		**6 1/4**	6.25	158.7	
3 17/32	3.53	89.7	**LCMA 3 minimum**	**6 1/2**	6.5	165.1	
3 19/32	3.59	91.3		**6 3/4**	6.75	171.4	**LCMA 3/OCC Max**
				9	9	228.6	

Table 2. Percentage of 1,000 simulated indices that triggered action for three simulated decline starting point scenarios, and the averages of these scenarios. The simulated stock was projected to decline 32% in 2021.

Simulated Decline Starting Point	Index Calculation Method	2018	2019	2020	2021	2022	2023	2024	2025
2017 Point Value	Annual	0%	2%	12%	50%	85%	97%	100%	100%
	Three-Year Running Average	0%	0%	1%	27%	86%	100%	100%	100%
	Three-Year Running Median	0%	2%	12%	44%	84%	98%	100%	100%
2015-2017 Average	Annual	0%	0%	3%	21%	59%	89%	99%	100%
	Three-Year Running Average	0%	0%	0%	3%	46%	95%	100%	100%
	Three-Year Running Median	0%	0%	3%	19%	60%	90%	99%	100%
2015-2017 Running Median	Annual	0%	2%	12%	50%	85%	97%	100%	100%
	Three-Year Running Average	0%	0%	1%	27%	86%	100%	100%	100%
	Three-Year Running Median	0%	2%	12%	44%	84%	98%	100%	100%
Average	**Annual**	**0%**	**2%**	**9%**	**40%**	**76%**	**94%**	**100%**	**100%**
	Three-Year Running Average	**0%**	**0%**	**1%**	**19%**	**73%**	**98%**	**100%**	**100%**
	Three-Year Running Median	**0%**	**1%**	**9%**	**36%**	**76%**	**95%**	**100%**	**100%**

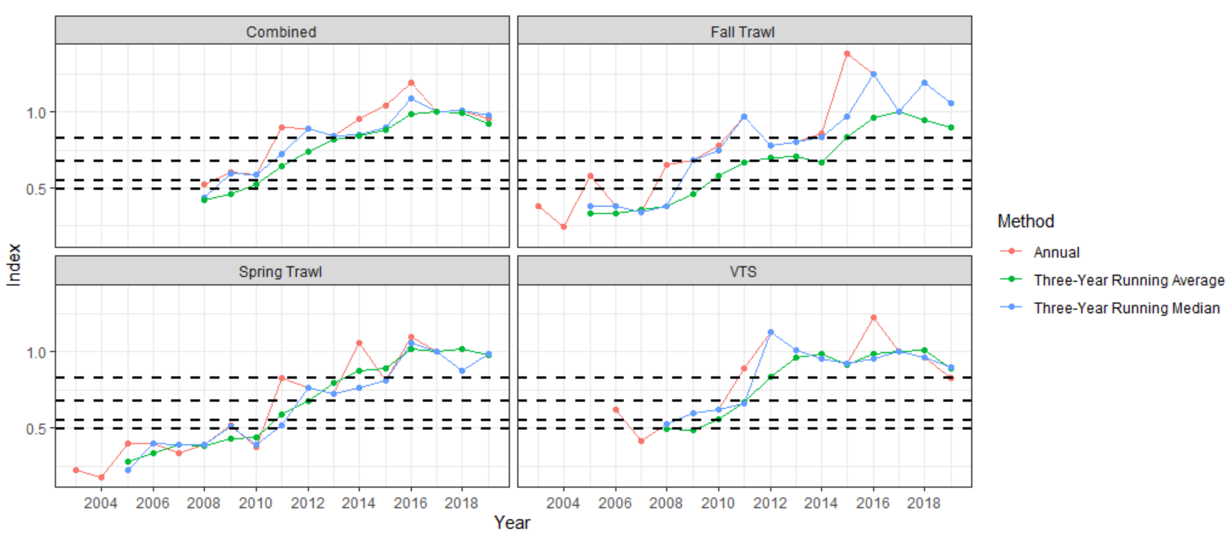

Figure 1. Scaled individual and combined indices using three calculation methods compared to four trigger levels (0.83 – Fishery/Industry Target, 0.68 – Moderate/High Abundance Regime Shift Level, 0.55 – Abundance Limit, 0.49 – Abundance Threshold) identified from potential reference abundance declines (dashed lines).

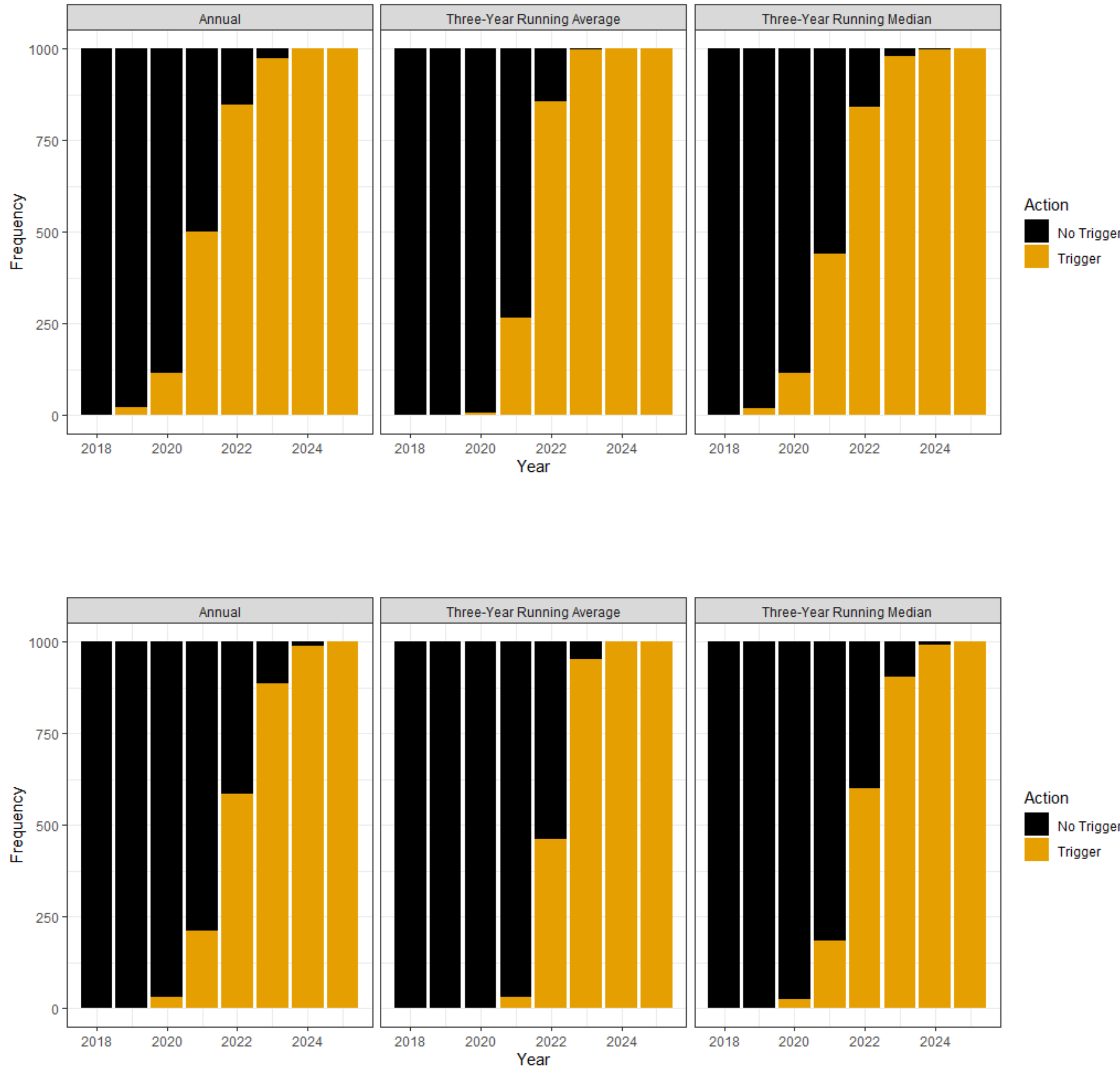

Figure 3. Annual action determinations by method from 1,000 simulated indices with the simulated population declining from the 2015-2017 average. The simulated stock was projected to decline 32% in 2021.

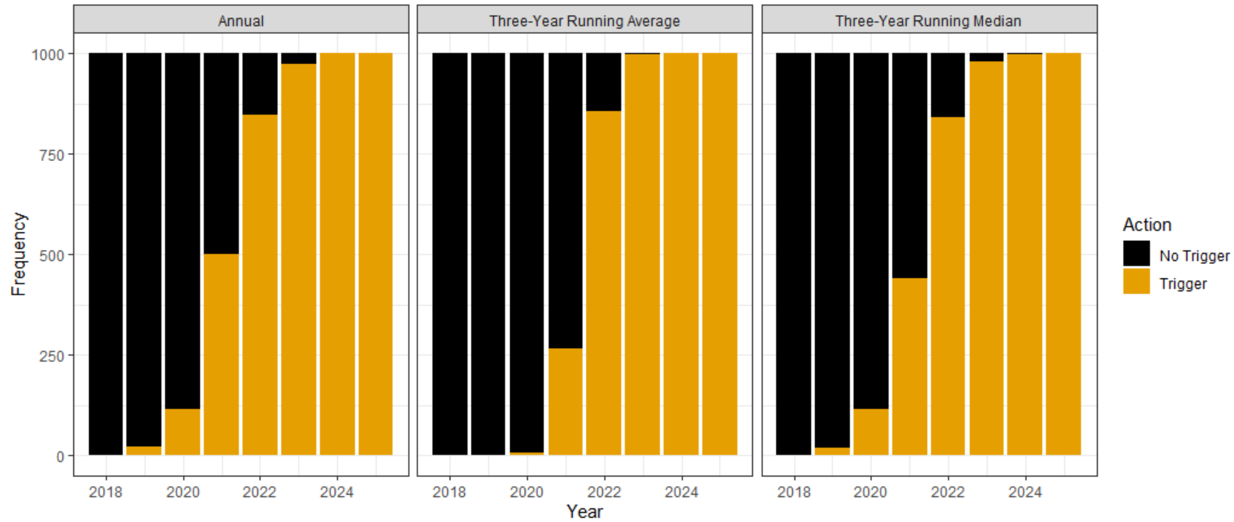

Figure 4. Annual action determinations by method from 1,000 simulated indices with the simulated population declining from the 2015-2017 median. The simulated stock was projected to decline 32% in 2021.

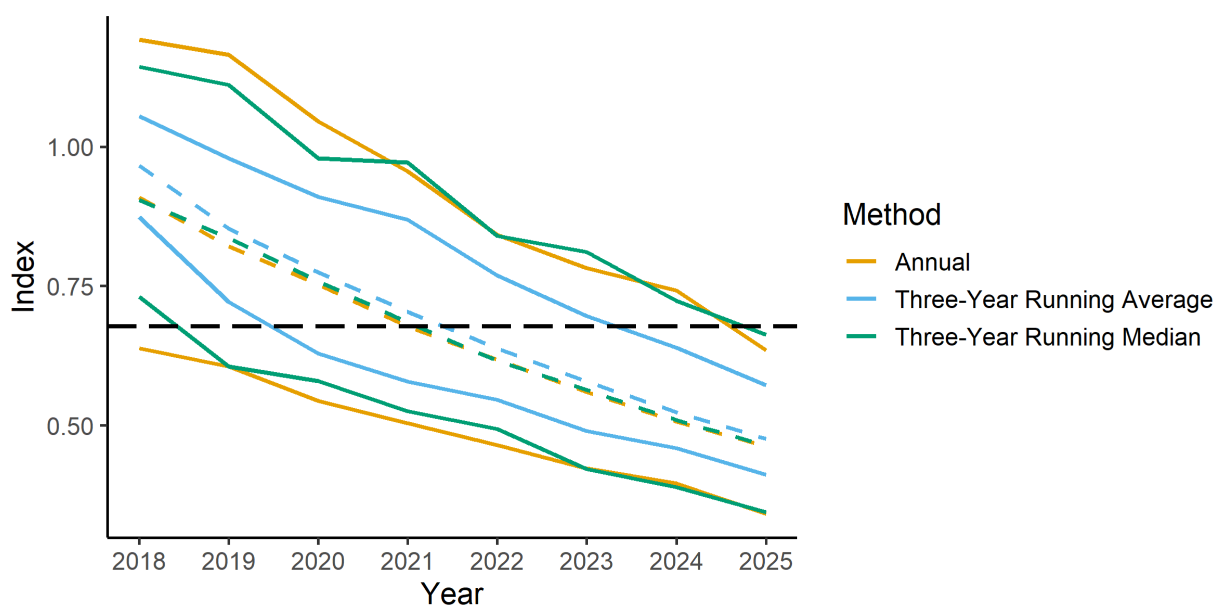

Figure 5. Distribution of index values by method from 1,000 simulations with the simulated population declining from the 2017 point value. The dashed colored lines are the median index values across simulations, the solid color lines are the minimum and maximum index values across simulations, and the dashed black line is the trigger level. The simulated stock was projected to decline 32% in 2021.

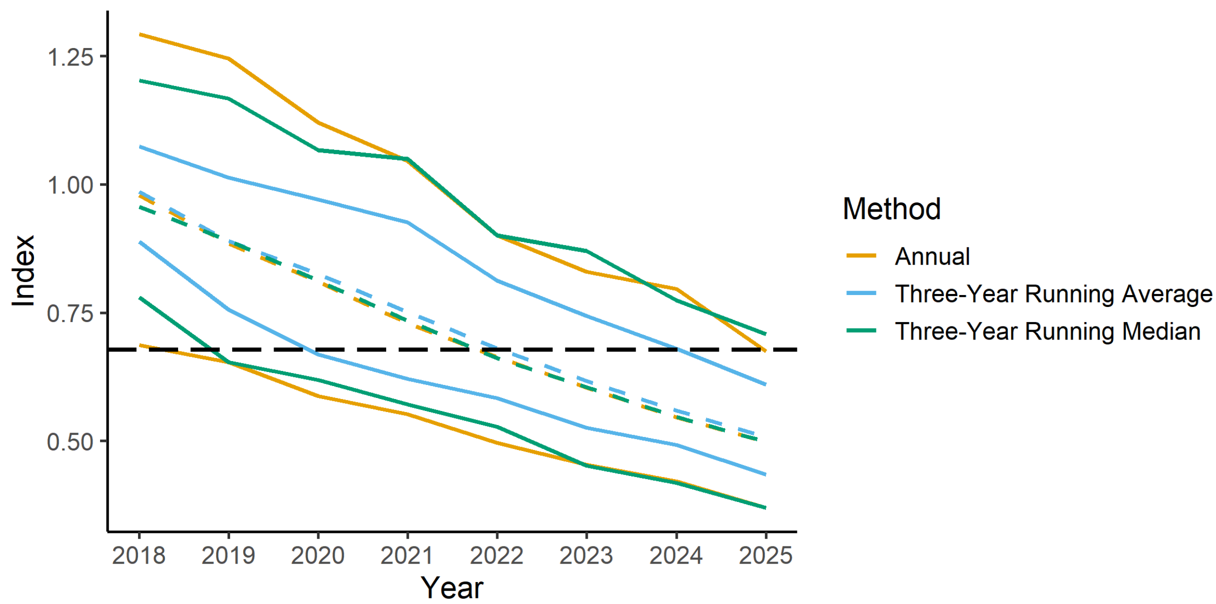

Figure 6. Distribution of index values by method from 1,000 simulations with the simulated population declining from the 2015-2017 running average. The dashed colored lines are the median index values across simulations, the solid color lines are the minimum and maximum index values across simulations, and the dashed black line is the trigger level. The simulated stock was projected to decline 32% in 2021.