Peer-review panel report for a traffic light index for judging forage balance of Atlantic Menhaden and resident Striped Bass in Maryland's portion of Chesapeake Bay

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A peer-review panel (hereafter panel) convened on August 21, 2024 to review the work conducted by Maryland (MD) Department of Natural Resources (DNR) that developed a traffic light index (TLI) for judging forage balance of Atlantic Menhaden and resident Striped Bass in Maryland's portion of Chesapeake Bay (Bay). Prior to convening, the panel was provided with a technical document, agenda, and terms of reference to address based on the technical work of the document. During the review, DNR staff also provided a presentation on the report to the panel.

The terms of reference for the panel to address were:

1. Given current data and modeling limitations, evaluate strengths and limits of the TLI methodology for depicting Menhaden and Striped Bass interactions in Chesapeake Bay.
2. Review and evaluate the choice of the 1995-2021 reference period to capture current prevailing environmental, management, and ecological conditions.
3. Review and evaluate the suitability of fishery-dependent and fishery-independent data used as indicators in the TLI. Were they sufficiently described?
    a) Were descriptions of each data source (e.g., geographic location, methodology of calculation of abundance indices sufficient?
    b) Were trends and associated uncertainty correctly identified for fishery-independent indices?
4. Review and evaluate the indicator boundaries for defining good, poor, and in-between conditions.
5. Was the use of core and supplemental indicators justified and their strengths and weaknesses (e.g., temporal and spatial scale, continuity over time, gear selectivity, sample size) fully discussed?
6. Review whether the TLI serves as an adequate data-driven communication tool to reflect the status of following 3 questions:
    a) What is the relative status or condition of Menhaden in Maryland's part of the Bay?
    b) Are there enough Menhaden for Striped Bass there?
    c) Are limits on menhaden harvesting within Chesapeake Bay, including the reduction fishery cap, having a positive effect on Menhaden and resident Striped Bass?

7. Each reviewer prepares a peer review report summarizing the panel's evaluation of TLI and addressing each peer review term of reference. Complete and submit the report within 4 weeks of workshop conclusion.

General Comments

This report documents feedback from the panel on theTLI developed by DNR. The intent of the TLI is to help DNR better understand and communicate the status and balance between striped bass and menhaden in the MD portion of the Bay. The materials presented represented significant work and synthesis on a wide range of information and data streams across time in the Bay. The panel greatly appreciated the work performed. The TLI advances our understanding of these two species and their fisheries in MD waters of the Bay, and provides a useful tool for communicating the current state of these resources in the Bay to both the general public and scientific community.

Responses to Terms of Reference

1. *Given current data and modeling limitations, evaluate strengths and limits of the TLI methodology for depicting Menhaden and Striped Bass interactions in Chesapeake Bay.*

The TLI approach represents a comprehensive accumulation of information on Atlantic menhaden and Atlantic striped bass in the Bay. A strength of the approach is that it is a thoughtful processing of existing data, allowing the ability to target portions of the populations of interest (namely striped bass and menhaden) in the Bay in the absence of a spatially explicit stock assessment. This thorough review of currently available data also allows for assessing and identifying data gaps and perhaps how current monitoring programs could be augmented to better inform a TLI. Additionally, the methods used are tractable, thereby increasing the ability to use the information for communication with the public.

The TLI also has some weaknesses. Many measures are indirect so to draw conclusions from the measure to the concepts of balance and/or status needs explanation. The Potomac River Fisheries Commission (PRFC) index needs to be soundly justified in its usage as this index had been rejected by the assessment analysts for use in assessment. One of the reasons for this rejection had to do with the effort estimates used in the development of the index, so if this is resolved in your treatment of the index, this should be clearly stated. There are potential alternative hypotheses for why the condition factor for striped bass changes over time (environmental drivers rather than diet) and why menhaden are or aren't in the Bay (migration as opposed to fishing), so these types of conflating factors need to be thoroughly explained. Ultimately, the accumulation of the measures is the primary value of the approach. Thus, this weakness should not distort the overall perspective for use in public communication. By accumulating these factors together, the strengths buffer the weaknesses and the overall trend of these two stocks can be effectively communicated.

The panel suggested that the TLI or other indicators be further compared to environmental conditions in the Bay in future analyses. The current report does not offer many climate change factors considered beyond Atlantic Multidecadal Oscillation (AMO) analysis. While previous work has shown correspondence between the AMO and menhaden in this region, it is unclear

what the mechanism is for this correlation. Better integrating other available environmental data from available water quality and fisheries monitoring programs (e.g. temperature, salinity, chlorophyll-a, dissolved oxygen) would be particularly insightful as to how climate or environmental conditions may be transforming habitat for menhaden and thus how they might influence TLI patterns. The panel acknowledged the primary goal of this review was to examine the TLI methods and inputs; however, with the inclusion of the AMO in the report, future work should aim to include other available environmental data time series. The panel also recommends DNR work with partners to develop environmental monitoring programs as needed that would allow for better understanding changes in fish and fisheries in the Bay.

The panel also appreciated the diet information being incorporated into the TLI. Given growth has been found to change over time for these species, using static age/size thresholds for deriving the indices should be evaluated in future TLI revisions to determine the importance of a static or time-varying size threshold.

2. *Review and evaluate the choice of the 1995-2021 reference period to capture current prevailing environmental, management, and ecological conditions.*

The justification of the reference period was well made and is aligned with the purpose of the TLI. If there was concern or question on the dependency of picking these specific years for the reference period for final results, the panel recommended as a sensitivity test to try shifting the period (e.g. 3 years forward or back) to see if conclusions change.

While this reference period works well for the current time series and short term use, the panel asked how DNR would modify the period moving forward as needed. For longer-term use, it was unclear if and how the reference period would be changed. Ultimately, the panel believed the reference period should be dynamic over time as needed (i.e. based on data or management objectives), and criteria should be established as to what prompts a change.Similar to the current framework, the reference period could be revised based on management periods or reference periods that were perceived to meet a societal goal. However, there are several analytical approaches that could be used. Various change point analyses are used in fisheries to identify changes in perceived regimes. These approaches have been used for various applications, such as defining reference periods or understanding significant breaks or changes in environmental or biological time series (e.g. recruitment, spawning stock biomass, sea temperature, climate indices). The panel suggests DNR evaluate some of the various change point methods (e.g., R packages ‘changepoint, and ‘rpart’, though there are many different methods) if an analytical approach to defining reference periods is more desirable than those based on management or other factors.

3. *Review and evaluate the suitability of fishery-dependent and fishery-independent data used as indicators in the TLI. Were they sufficiently described?*
    a) *Were descriptions of each data source (e.g., geographic location, methodology of calculation of abundance indices sufficient?*

b) *Were trends and associated uncertainty correctly identified for fishery-independent indices?*

Given the debate with using the PRFC index for assessing menhaden or not, careful discussion of how the data was handled and why this works for the application of the TLI is important to include in the documentation. There is also a statement made about catchability stability, which should be better justified. There is good work done on the distributional assumptions for some of the analyses, but a link or reference for the @Risk excel add-on would be helpful to include in the documentation.

One important item to explicitly state early in the documentation of the TLI is the philosophy of parsimony used in the final selection of the "core" indices. This is implicit in the text, but to state this directly and early in the documentation is important, as it provides insight into why many of the final decisions are made for what ends up in the core information.

The assumption made about landings, namely that the entire Bay cap is harvested in the most recent years, is understandable and defensible. It would be good to see if there is some corroborating method to support that this is a good assumption to make. For instance, we recognize the complications of data confidentiality in that there is only one operator prosecuting the reduction fishery, but perhaps there is a way to get an omnibus statement without divulging information that might express what landings actually are, such as getting an estimate of whether the landings are within some percentage of the cap during the period where data is not available from the ASMFC. Another potential idea along the same lines would be to see if you could combine the reduction landings with the bait landings for an overall removal level, assuming that this would then meet the confidentiality requirements. The panel also noted that recreational catch and prospective unreported catch were absent from fishery-dependent considerations. DNR staff indicated the commercial data included for the TLI represent over 99% of fishery removals, and thus prospective catch attributed to other sources is likely to be uninformative to the TLI or not result in changes in trends.

There is likely zero inflation in the fisheries-independent juvenile indices. This comment relates to the conjecture about parsimony being an important philosophy in how the indices were developed, but some justification about whether the simpler model performs as well as more complicated models would be helpful to give audiences comfort that the index is providing them reliable information. This carries through to the model using the AMO index as well. It appears that this work was done, it's just a matter of explicitly making statements about how the complicated and simple methods compare to each other.

Overall, the trends and uncertainty estimates were well defined and explained. One item that could use clarity is how (if at all) the uncertainty bounds of an index would interact with the traffic light boundaries. An important next step is to define if some level of the uncertainty distribution will trigger a finding of being in a new traffic light level, or if it would only be when the estimate crosses the threshold. If the latter, it would be useful to develop how you might use the uncertainty distribution in a qualitative manner. For instance, statements could be made to the effect of "the estimate of index X is still in the green level; however it's important to recognize

that 40% of the uncertainty of the index is in the yellow level, and therefore this metric is one to closely monitor in coming years…"

For future consideration, there are a suite of statistical tools that can be used to standardized indices (e.g. generalized additive models, generalized linear mixed models), multivariate time series approaches (e.g. dynamic factor analysis) and test causal relationships between indices (e.g., structural equation modeling) that could be used to help produce indices in the TLI. With that, the panel acknowledges the utility of the TLI as a communication tool using indices that can be understood by a broad audience, and that advancing the statistical approach should be done thoughtfully in the context of the primary goal.

4. *Review and evaluate the indicator boundaries for defining good, poor, and in-between conditions.*

The chosen boundaries were done thoughtfully, therefore the panel recommends moving forward with the current structure. The panel recommended re-evaluating the boundaries after experience is gained in applying the TLI. As an example, the menhaden fishery used a trigger system (akin to the traffic light approach), and over time it was found that some of the trigger boundaries were too sensitive, and others not sensitive enough. Setting up a cycle for evaluating how the TLI is operating will be a good process to establish so DNR can evaluate the performance of the TLI with empirical information, and also allow for adjustments to be made if new information becomes available that DNR wishes to incorporate in the TLI.

The panel recommends some simulation work and/or a retrospective analysis to occur a few years after the TLI's implementation to help understand how often these indicators might change between levels, thus allowing you to make a judgment on how effective the tool might be as it changes at different frequencies. This should not delay your implementation and can be performed while the tool is in use, assuming a process is established to review the TLI periodically.

5. *Was the use of core and supplemental indicators justified and their strengths and weaknesses (e.g., temporal and spatial scale, continuity over time, gear selectivity, sample size) fully discussed?*

The core and supplemental information was thorough and justified. The rationale for categorizing certain elements as core versus supplemental is clear, and it seems like a robust framework for the TLI. However, there is room for improvement in explaining exactly how DNR plans to use the supplemental information throughout the TLI process. Specifically, clarity on which elements DNR is using the supplemental data to corroborate would be helpful, as well as the criteria or thresholds to be applied in determining if they align with the core information. Additionally, it's unclear how DNR will proceed if discrepancies or contradictions between the core and supplemental data arise. A clear method for resolving these inconsistencies should be developed, additional qualification for how supplemental information should be viewed, or a commitment to revisiting such discrepancies as they arise, should be outlined. Outlining these

steps could strengthen the overall rigor of the TLI approach and how the information collected integrates into the communications that will come from the tool.

6. *Review whether the TLI serves as an adequate data-driven communication tool to reflect the status of following 3 questions:*
    a) What is the relative status or condition of Menhaden in Maryland's part of the Bay?
    b) Are there enough Menhaden for Striped Bass there?
    c) Are limits on menhaden harvesting within Chesapeake Bay, including the reduction fishery cap, having a positive effect on Menhaden and resident Striped Bass?

To best address 6a, the panel recommends DNR provide direct statements that clearly highlight the specific indicators leading to final agency interpretations or conclusions. A more direct and structured synthesis would be valuable for public-facing communication. This would help create a clearer picture for readers or stakeholders who may not have the same level of technical understanding. For example, direct statements such as 'Indicators X, Y, and Z had consistently positive trends and remained in the green zone, which leads us to conclude that the menhaden biomass in the Bay is currently in a healthy state.' Such straightforward statements can make complex data more accessible to audiences and reinforce the confidence in the agency's assessment. Including clear explanations of the selected indicators and their thresholds would further support transparency and ensure that your findings are easily understood by a wider audience.

With respect to 6b, the panel believes appropriate indicators have been used to elucidate menhaden's ecosystem services in the Bay. An important note of clarification to be made for the public's benefit is that the TLI incorporates bioenergetic assessments, which rely on indirect indicators rather than direct measurements. Making this distinction will help ensure that the audience understands the nature of the conclusions. With that in mind, DNR can communicate that based on the weight of the evidence from the information gathered and synthesized, it appears there should be sufficient menhaden to support striped bass populations or vice versa. This clarification strengthens the integrity of conclusions made while also fostering transparency. During the meeting, it was also mentioned that there will be a shift in indicator language from 'attack' to 'availability' to frame the issue more neutrally, which is a positive revision. However, the term 'attack' still appears in some of the figures. This small discrepancy could cause confusion, so it will be important to update the figures to align with the revised language, ensuring consistency across all parts of the report.

Question 6c represents a complex issue with several layers of challenge. One of the primary complications lies in accurately determining what is actually landed, as there are gaps between tracking, reporting, and confidentiality that limit the precision of our understanding with respect to what has been removed from the Bay. Additionally, the relationship between the Bay Cap and the indices used to assess fish populations remains fairly opaque. The lack of clarity in these connections makes it challenging to directly link the Bay Cap's effectiveness to measurable outcomes. Beyond these factors, other environmental and behavioral variables, such as fish migration and emigration patterns, further complicate the assessment. These natural movements can vary inter-annually and obscure the impact of the Bay Cap, as fish populations may fluctuate

independent of local harvest regulations. Taken together, these challenges make it difficult to definitively assess the effectiveness of the Bay Cap with a high level of certainty in the context of ecosystem services. To affirm this question, it assumes that the boundaries from the TLI directly correspond to equivalent metrics traditionally used to address this question (e.g. biological reference points, ecological reference points). The development of the TLI provides another tool for being able to frame this question; however, the tool individually may not be the only tool needed to answer this question.

Additional (Non-TOR) Comments

There were a few insinuations about potentially using this analysis as a tool for management, with some caveats on the challenges this might entail. Just by way of clarity in interpreting the comments in this document, the understanding going into the meeting was that this work would serve exclusively as a communication tool, so that has been the basis of the review comments provided above.

To improve clarity in a few sections, there are some specific points worth addressing. For instance, in Line 457 of the document provided for the review, the phrase "premature modeling" is used, though it's unclear what this is referring to and would benefit from further explanation. Additionally, there's substantial work on analyzing relationships within the data, with explorations of both linear and nonlinear models. It would be helpful if the selection process for the models chosen for the TLI were documented in one central location, like a table, to clarify why specific approaches were chosen. This would increase transparency and make it easier to follow the rationale behind these decisions. DNR did a good job of selection and justification; this recommendation is simply about identifying this information in a single, easily referenced spot.

Some of the relative calculations, such as relative F, seem slightly unconventional in how they were adjusted into a more standardized or interpretable range. This approach is analogous to methods used in data-limited groundfish studies on Georges Bank, particularly the "ISmooth" approach for calculating exploitation rates. In that context, biomass estimates are often scaled based on the index itself, rather than scaling other components like q or area swept (as done here). This might offer an alternative approach that could be more biologically meaningful. Furthermore, while correlation analysis appears in several places, it's not always clear what it is intended to signify; it would be beneficial to explicitly define its purpose, such as how significant correlations influence subsequent interpretations. Line 762 is a relevant example where this clarity could be improved.

There are also some structural adjustments that may improve the document's readability. For example, it might be helpful to describe the TLI outcome in the same section where the index is described for easier reference. In addition, Line 1030 includes an interpretation that attributes changes solely to fishing, but it might be worth noting that movement could also be a factor. You could clarify whether movement could explain the observed pattern or, alternatively, why it might not be a relevant factor. Similar observations about movement apply in Line 1298 regarding striped bass, as the current balance reached may be due to a decline in striped bass biomass rather than solely other factors. Line 1205 contains a slight discrepancy between the

numbers reported in the plot and those in the text, thus a quick check for consistency here would be worthwhile.

Some content (e.g. Line 1293) may need a more detailed explanation to clarify for stakeholders, particularly regarding how the reference period influences interpretation, as this concept could seem counterintuitive to some readers. Additionally, DNR staff might further consider alternative approaches for projecting future scenarios, such as dynamic linear modeling, as referenced in Line 1314. Lastly, if a decision rule structure is developed, it would be wise to accompany it with a risk policy (Line 1320) to account for potential uncertainties or risks in implementing those rules.

Conclusion

The panel acknowledges the extensive work done by the MD DNR and their comprehensive effort in developing the TLI for assessing the forage balance between Atlantic menhaden and resident striped bass in Maryland's portion of the Bay. This tool effectively consolidates a range of ecological indicators, offering a valuable data-driven framework for public communication on fishery status. The panel views this tool as an advancement in both the science and communication ability for the species in this region. Therefore, the panel recommends proceeding with the use of the TLI as a communication tool for the stakeholders in the Chesapeake Bay region. Moving forward, ensuring clear documentation of methodologies, refining and explicitly defining model selection processes, better understanding the tool's sensitivities to data and assumptions, and updating language for consistency will further enhance the TLI and its impact as a communication tool. Periodic evaluations will also support the tool's responsiveness to emerging data, environmental shifts, and stakeholder needs, fostering a sustainable balance between ecosystem health and resource management.

The panel appreciates the opportunity to review this work by MD DNR, and applauds the agency for their work to help foster the dissemination of objective, reliable, and timely information for communities. The stewardship of the Bay's resources is a primary mission of MD DNR, and the panel views this work as furthering the agency's mission.