



MEMORANDUM

DATE: June 17, 2022

TO: Tom Nies, Executive Director NEFMC
Chris Moore, Executive Director MAFMC

FROM: MAFMC and NEFMC Scientific and Statistical Committees (SSC) Sub-Panel

SUBJECT: **Findings of the SSC sub-panel review of the Northeast Regional Habitat Assessment (NRHA)**

Background

The New England and Mid-Atlantic Fishery Management Councils jointly convened a subpanel of members from both Scientific and Statistical Committees (SSC) to review and provide input on products compiled by the Northeast Regional Marine Fish Habitat Assessment (NRHA). The subpanel comprised six members: Dr. John Boreman, Dr. Michael Frisk (chair), and Dr. Ed Houde from the MAFMC SSC, and Dr. Jeremy Collie, Dr. Adrian Jordaan, and Dr. Samuel Truesdell from the NEFMC SSC. Staff members from both Councils convened the webinar review session on June 1, 2022, and the report was drafted via correspondence among subpanel members and staff. The subpanel was tasked with reviewing the NRHA workplan, considering the methods and results of NRHA models and decision support tools, reviewing how NRHA products can support the needs of fisheries management decision-making, and providing suggestions on communication of NRHA methods and findings. More specifically, the review centered around the following four Terms of Reference (TOR):

Terms of Reference

1. Review the approved NRHA workplan and the related fish habitat science products under development, including decision support tools.
2. Consider the modeling goals, methods used, and inferences made from the single species and community level basis function models. Provide input on whether:
 - a) Species responses to predictor variables conform with what would be expected given a species' biology, physiology and/or ecology.
 - b) Species' predicted spatial distributions are consistent with expectations and other sources of data.
 - c) Estimated between-species relationships (i.e., spatiotemporal correlations in their presence/absence or abundance) make sense from an ecological perspective.
 - d) Identify additional work that would improve analysis or interpretation of results.

3. Consider and comment on the overall utility of NRHA, including the use of specific products in stock assessment, habitat management and conservation (including Essential Fish Habitat and Habitat Area of Particular Concern designations), and ecosystem approaches for the Councils. Is the work sufficient and appropriate to support the habitat and ecosystem needs of both Councils? Is there additional work, enhancements to NRHA that would improve its utility?
4. Are there alternative ways to present and communicate the data and analyses to various end-users (Councils, assessment scientists, stakeholders and public, etc.) more effectively?

Part I Overview

The subpanel was able to review each of the Terms of Reference, appreciating not only the amount of work that went into conducting the analyses, but also the effort put into synthesizing and communicating the results effectively in preparation for the subpanel's review. The general themes of the review are given in this section while detailed comments are provided below.

TOR 1: Review the approved NRHA workplan and the related fish habitat science products under development, including decision support tools.

This discussion included a presentation by Chris Haak (Monmouth U / NOAA) that focused on the methods and results of a joint species habitat model with an in-depth presentation of results for summer flounder and winter flounder. This was followed by a presentation by Tori Kentner (MAFMC staff) describing an online tool geared toward supporting fishery management decisions.

The subpanel had questions and requested clarifications about the statistical framework of the joint species model. A more involved discussion of the characterization of the two-stage model could be useful, including the assumptions surrounding structural zeros and sampling zeros, how the modeling structure relates to the range of each species, and relating the two-stage design to the predictor variables that are included in each of the model components. During the meeting discussions it was clear that co-linearity of the selected variables had been quantified, but a table of Variance Inflation Factors would be useful to future reviewers. It could also be helpful to understand any assumptions surrounding catchability in a multispecies context and how differences in catchability from species to species may impact model results.

The subpanel made suggestions regarding the variables that were included in the model. The subpanel was interested in the approach the modelers took of breaking down the components associated with depth into more process-oriented pieces. The subpanel had reservations that some aspects of depth as an explanatory variable were lost; for example, depth is often related directly to predation risk which may not be reflected in the depth-related variables that were chosen for the modeling. The subcommittee suggests that the modelers continue to retain depth at least in parallel model runs, and flag any differences between the models that include or don't include depth as an explanatory variable. There were also additional suggestions including: evaluating degree-days rather than temperature (while noting potential issues with motile species); adding sediment type, as this has been a significant explanatory variable in previous research; including benthic invertebrates, as the distributional information in records for these

species may help inform assessments of finfish populations through the modeled correlations; examining traditional production-associated variables such as chlorophyll-a and annual integrated production (AIP); and discussing how seasonal observations reflect changes in production.

Finally, the subpanel had comments on the communication of results and implications of the multispecies model. The group was curious about how well the results of the model aligned with previous work on species distributions, such as research on empirical or modeled shifts in the centers of distribution of species in analyses that have used the same data set. The subpanel also noted that, because only the federal trawl survey data were employed, the results possibly would be less likely to be used by management agencies responsible for inshore waters, such as the Atlantic States Marine Fisheries Commission and individual coastal states. Nearshore and estuarine habitats can be critically important for spawning and as juvenile nurseries for some species.

The subpanel appreciated the demonstration of the R-Shiny app decision support tool. The subpanel suggested that it would be useful if the generated maps could be depicted by life stage. It was also suggested that information on the methods that were used to generate spatial maps could be provided. Finally, thorough explanations of uses and applications of the visualizations on the survey trend pages should be provided. Combining different gear types and time periods into a single figure could lead to interpretation issues.

TOR 2: Consider the modeling goals, methods used, and inferences made from the single species and community level basis function models. Provide input on whether: (a) Species responses to predictor variables conform with what would be expected given a species' biology, physiology and/or ecology; (b) Species' predicted spatial distributions are consistent with expectations and other sources of data; (c) Estimated between-species relationships (i.e., spatiotemporal correlations in their presence/absence or abundance) make sense from an ecological perspective; and (d) Identify additional work that would improve analysis or interpretation of results.

The subpanel was in agreement that, for the most part, the species responses to predictor variables for the presence-absence and count models, the species spatial distributions, and the estimated between-species relationships were consistent with expectations. There was some discussion about temperature effects. Both surface and bottom temperatures were included in the model and there was discussion about why surface temperatures were sometimes more important predictors than bottom temperatures for demersal species. This was not entirely resolved, but could be related to mixing rates in different regions. The panel noted that in some cases adult distributions appeared to be more realistic than those predicted for juveniles, and that there were some model artifacts that appeared on the shelf break for certain species.

The subpanel had suggestions for additional considerations. First, the group suggested examining whether it might be possible to build in a time-varying component for the partial correlations in the model. Second, climate change is expected to increase the frequency of coastal storms and if variables related to such events could be included in the model it would increase its capacity for longer-term projections.

TOR 3: Consider and comment on the overall utility of NRHA, including the use of specific products in stock assessment, habitat management and conservation (including Essential Fish Habitat and Habitat Area of Particular Concern designations), and ecosystem approaches for the Councils. Is the work sufficient and appropriate to support the habitat and ecosystem needs of both Councils? Is there additional work, enhancements to NRHA that would improve its utility?

The subpanel was supportive of NRHA work and believed it will have relevance to a variety of fishery management applications, including those referenced in TOR 3. In addition, the work could be a useful supplement for catch/landings allocation discussions, as it can project the co-occurrence of species given predicted future environmental conditions. Further, the model results could help inform stock structure and predict dynamic habitat. It should be noted, however, that results of this model are scale-dependent and, while the model may be highly informative at broad spatial scales, it may be less so at small scales (e.g., wind farm siting); it could be useful to think about scale relevance when developing communications associated with this work. Downscaled climate predictions could help the multi-species model answer small-scale research questions. Finally, it is not completely obvious how survey data inputs and model outputs will be linked with EFH material; NRHA data – especially the multi-species model results – tend to be broad in spatial scale while much of the EFH content is granular in nature; synthesizing these categories of information may be challenging.

TOR 4: Are there alternative ways to present and communicate the data and analyses to various end-users (Councils, assessment scientists, stakeholders and public, etc.) more effectively?

The subpanel was particularly appreciative that the framework employed here is able to incorporate ecological processes in a management context, and recognized that this type of information is different from what is typically presented to the SSC and Councils. Much of the material that was presented to the SSC subpanel (notably a technical audience) would be too technical for more general communications. It will be important to think critically about the audience when preparing material; it was noted that complex communications often discourage stakeholders and may limit their appetite to use the results of the work for management. Finally, there are many caveats associated with the modeling components of this project. It is essential that these are outlined up-front in communications with stakeholders to ensure that results are used effectively and in the manner for which they are intended.

Part II Detailed comments

TOR 1: Review the approved NRHA workplan and the related fish habitat science products under development, including decision support tools.

Community-level basis function model

- This analysis builds on an earlier study by DeLong & Collie (2004), which used Generalized Additive Models (GAMs) fitted to NMFS trawl-survey data to define EFH for three groundfish species. This precedent was important in that it showed the significance of sediment type in determining species distributions, and that EFH could be

mapped as percentiles of predicted population distribution. Finally, the pamphlet that resulted from that project (<https://nsgl.gso.uri.edu/riu/riut04002.pdf>) attempted to explain the modeling approach in language and graphs that could be understood by stakeholders and the interested public. However, that study did not attempt to model the residual spatio-temporal variation as has become possible in more recent applications.

- How are structural and sampling zeros distinguished? A hurdle model is necessary because the model is fit to all species at all stations, which will include locations where a given species/stock does not occur (i.e., structural zeros). The subpanel agrees that the same set of covariates should be included in both the presence/absence and count models because some zeros in the presence/absence model are actually sampling zeros.
- It may be useful to clarify whether all stations in the data set are considered, or only those stations within the range of the species where positive occurrence may be expected (and this may depend on whether the approach is single- or multi-species).
- It would be useful to have a table of Variance Inflation Factors to show the degree of collinearity among the predictor variables.
- Clarify how the catchability of different species or juveniles and adults of the same species is handled in the model (or the assumptions that are related to variability in catchability) and in what ways those differences (whether static or dynamic) may impact the model results.
- Does the model predict the shifts in Center of Gravity (CoG) that have been measured empirically? Early studies (Nye et al. 2009) and studies since then did not fully explain the observed shifts in CoG based on measured covariates. This question becomes especially important when making predictions or climate projections, and when considering effects from interannual variability in the timing of the trawl survey.
- Spring and fall are not explicitly modeled as explanatory variables; instead, temporal covariance was modeled within each year. Season is typically an important process that governs spatio-temporal patterns in observation. Seasonal differences in abundance can be especially distinct for young-of-the-year (YOY) that often recruit to survey gears during the fall. Project communications could benefit from more of an emphasis on how seasonal changes were modeled and especially the impacts on YOY.
- Consider a degree-day predictor variable. However, depending on the spatial scale, motile fish may have a different temperature history than the location where they were caught, and cumulative temperature may not always be a representative indicator for mobile species. Note that the temperature effect on vital rates is non-linear, and species dependent.
- This study partitions juveniles and adults using the size at 50% maturity; a different definition – such as a size partition that was closer to the young-of-the-year size could yield different results. Size at 50% maturity could be represented by large, immature fish that reside in the same habitats as “adults” for long-lived species.
- So far, this project has less emphasis on estuarine data, where important habitat dependencies are known to occur and which include EFH, especially for spawning areas and early-life habitats important for anadromous and migratory fishes. Does this make the products less relevant to the ASMFC?
- Nursery and spawning habitat for many species – whether the habitats are inshore or in areas that are difficult to sample for other reasons – are not included in the joint species

habitat model; it should be noted that some habitats are not sampled by certain surveys but are still critically important.

- Depth was considered to be a proxy variable and (in primary model runs) was instead replaced by other variables thought to be more closely tied to the processes impacting presence/absence and abundance. The subpanel suggested that depth may represent additional processes not captured by these other variables (e.g., predation risk) and that at least continuing to consider depth in parallel models is warranted. This was noted in part because there is a substantial proportion of variance captured by spatial basis functions but not explained by predictor variables.
- Inclusion of two of the depth proxy variables, PAR and hue, implies that light reaching the benthos accounts for variability in abundance among habitats. These variables are often included in productivity research and modeling. In the present case, they might correlate with abundance of fishes but they probably are acting through productivity pathways. It may be useful to examine more traditional measures of productivity, i.e., chl-a or AIP (annual integrated production) and determine whether those variables are correlated with the variables that are currently included or discuss why such variables were not selected for use.
- The subpanel suggested that it would be important to include benthic habitat covariates in the models, if possible, as this was found to be important in previous studies.
- It is important to consider and include benthic invertebrates in the multispecies model to potentially improve its explanatory power.
- What is the importance of the total species numbers/biomass when determining ecological relationships, including habitat dependency? Do those relationships change depending on stock biomass/numbers?
- How does abundance impact the spatial distribution predicted by the models? There have been contractions in the ranges of species as the populations declined; has density-dependent habitat selection been tested?

Decision-support tool

The subpanel appreciated the demonstration of the online decision support tool (i.e., the R-Shiny app). Specific comments included:

- It would be useful if distribution maps could be created for species by life stage.
- The tool can combine results from multiple surveys across different gears and spatial scales, which could lead to interpretation issues (for example, if one survey came online later in the time series). Stratified means are the most common baseline method to evaluate survey abundance trends for stock assessment purposes, but those results may differ substantially from iterations of the products that are provided here. This should be explained thoroughly in the text associated with the product.
- Information on the methods that were used to generate spatial maps should be provided.

TOR 2: Consider the modeling goals, methods used, and inferences made from the single species and community level basis function models. Provide input on whether: (a) Species responses to predictor variables conform with what would be expected given a species' biology, physiology and/or ecology; (b) Species' predicted spatial distributions are consistent with expectations and other sources of data; (c) Estimated between-species relationships (i.e., spatiotemporal correlations in their presence/absence or abundance) make sense from an ecological perspective; and (d) Identify additional work that would improve analysis or interpretation of results.

(a) Do species responses to predictor variables conform with what would be expected given a species' biology, physiology and/or ecology

- Summer Flounder results appear consistent with expectations, but somewhat surprising that the temperature effect was not consistent between surface temperature and bottom temperature (this was not the only example of this occurrence) and that sometimes the surface temperature effect was larger than the bottom temperature effect, which is surprising for demersal species. This could be related to mixing rates in the water column, which change with depth.
- The subpanel was in agreement that the relationships between presence / absence and abundance relative to ecological variables generally conformed with expectations.

(b) Are species' predicted spatial distributions consistent with expectations and other sources of data

- The subpanel was in agreement that the predicted spatial distributions were generally reasonable.
- In some cases the adult distribution appeared more realistic than the spatial distribution predicted for juveniles.
- In some cases there appeared to be model artifacts at the shelf break (a distance to shore explanatory variable may help with this).

(c) Do estimated between-species relationships (i.e., spatiotemporal correlations in their presence/absence or abundance) make sense from an ecological perspective

- The subpanel was in agreement that nothing in the between-species relationships in the presence / absence or abundance models seemed questionable.

(d) Identify additional work that would improve analysis or interpretation of results

- It would be interesting to consider whether the estimated partial correlations change over time.
- Warming waters will cause increases in coastal storms, which will impact abundance and / or distribution by affecting coastal habitats; can ecological variables related to coastal storms be incorporated in the model? Inclusion of such effects would enhance the utility of the model in terms of climate-based modeling.

TOR 3: Consider and comment on the overall utility of NRHA, including the use of specific products in stock assessment, habitat management and conservation (including Essential Fish Habitat and Habitat Area of Particular Concern designations), and ecosystem approaches for the Councils. Is the work sufficient and appropriate to support the habitat and ecosystem needs of both Councils? Is there additional work, enhancements to NRHA that would improve its utility?

- These models could be useful supporting tools for allocation discussions as species distributions change, as well as for stock delineation and stock structure considerations.
- Utility of these results is scale-dependent; they could be highly informative at broad spatial scales, but less informative at small scales (e.g., siting a windfarm). It could be useful to think about the applicability of the results at different spatial scales when developing communications, and if users get access to data in order to produce actionable products (dredging impacts, etc).
- Not obvious how survey data inputs and model outputs can be linked with EFH definitions. EFH descriptions have detailed, granular information (e.g., Summer Flounder sex-specific or maturity information), but the model outputs are broader. Spatial and life history stages will be critical when looking at EFH designations; for example, spatial habitat occupied by all adults may be much larger than the region occupied by spawning adults or early-life stages (this currently cannot be characterized in the models). Incorporating telemetry data could inform some of these key linkages.
- It may be possible to address some questions of scale using down-scaled climate model predictions.
- The working group could give further consideration to connectivity. Connectivity among habitats, especially for life-stage transitions can be critical and probably is evolving as climate changes.

TOR 4: Are there alternative ways to present and communicate the data and analyses to various end-users (Councils, assessment scientists, stakeholders and public, etc.) more effectively?

- The subpanel was particularly appreciative that the framework employed here is able to incorporate ecological processes in a management context, and recognized that this type of information is different from what is typically presented to the SSC and Councils.
- Outlining the caveats up-front will be essential to ensuring that the results are used effectively and as they are intended.
- When plotting the smooth functions it would be useful to back-transform the covariates to their original scale and include confidence limits.
- It would be useful if the basis functions could be visualized; can the sum of the basis functions be calculated (possibly weighted by their slopes) and plotted spatially?
- It would be useful to have a more extensive discussion of: (1) how annual temporal effects are treated and the implications of those modeling assumptions, especially since management applications are usually focused on annual trends; and (2) the sub-annual temporal basis functions.
- Sub-annual temporal basis functions account for substantially more variance than the predictor variables. Currently it appears substantial components of joint species distributions can be modeled but cannot be explained.

- Much of the current material is too technical for communication to stakeholders and the public. It would be helpful to develop a document that steps through the model framework, but uses plain language; when communication is overly complex it risks negative associations with the work that then may be less likely to be used. A plain-language document that clearly presents the work to stakeholders would generate support and help improve ongoing work.

Public comment

- There are additional applications for this work, e.g., reviewers of sustainability standards and certifications such as the Marine Stewardship Council.
- Models should consider deteriorating water quality (i.e., increasing chemical discharges from river systems) as an additional or alternative explanation for changing species distributions.