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Review Report: Swept Area Seabed Impact (SASI)

by

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Executive Summary:

In 1996, the U.S. Congress added new habitat conservation provisions to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). These changes came in response to concerns that habitat loss was threatening the viability of many of the nation's fisheries. The findings section of the MSFCMA states that "One of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats." Ironically, much of the habitat damage in offshore areas may be the result of fishing. Deleterious effects of fishing on habitat of course vary with the intensity of activity, the harvesting technology, the habitat type and oceanographic conditions. This creates an opportunity to reduce impacts without necessarily prohibiting the fishing that is causing habitat damage through regulations and incentives that change harvesting methods, gear and fishing locations.

The MSFCMA directs the National Marine Fisheries Service (NMFS) and the eight regional fishery management councils to identify and describe essential fish habitat (EFH) in each fishery management plan; minimize to the extent practical the adverse effects of fishing on EFH; and identify other actions to encourage the conservation and enhancement of EFH. However, the protection of EFH must be considered within the context of the rest of the Act, which requires consistency with several national standards. National Standard 1 states that "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry." Regulations promulgated by NMFS instruct councils to "consider the nature and extent of the adverse effect on EFH and the long and short-term costs and benefits of potential management measures to EFH, associated fisheries, and the nation" (50 CFR §600.815").

The benefits from habitat protection that are the focus of EFH management are primarily indirect benefits resulting from increases in the productivity of fisheries, reduction of variability in production, reduction in the risk of fishery depletion or collapse, and reduction in the risk of species extinctions. There is generally insufficient information to quantify the benefits of EFH or the benefits and costs of particular management actions oriented at EFH at this time. Thus the practical focus of EFH management is on determining what the impacts are and minimizing adverse impacts cost effectively.

To assist in planning and evaluating management actions of minimize habitat impacts the New England Fishery Management Council (NEFMC) through its habitat plan development team (PDT) constructed the Swept Area Seabed Impact (SASI) model which provides a tool to quantify fishery impacts on an important component of EFH - the seabed - which is arguably the part of EFH most affected by fishing. The model includes a spatially explicit representation of all seabed habitat in the US EEZ from Canada to North Carolina outside 3 miles from shore at a scale of 100 km^2 grid cells with higher resolution of habitat types in some grid cells. It incorporates a system for quantifying and tracking impacts on different habitat types and features in a common currency. The impacts of various gears on different habitat features and recovery times are based on an in-depth review of the literature carried out by the habitat plan development team (PDT) of the NEFMC. This system estimates the spatial extent (swept area) of impacts of different types of gear, the percentage of specific habitat features in that swept area that are adversely impacted (susceptibility) and the degree to which those impacts persist (recovery). The model quantifies past impacts, provides a means and a common currency to compare impacts on different habitat types and features in different locations, and is a platform for analyzing the impacts on EFH of future regulatory changes.

The model makes a useful contribution by providing an objective mechanism for synthesizing many of the complex interactions that take place between fishing activity and bottom habitat. While the model in its current form has substantial limitations, it does provide useful information to fishery managers, stakeholders and policy makers provided that the limitations and caveats of the analysis are made clear. It can usefully employed to explore and loosely quantify the potential impacts of specified changes in the quantity and spatial distribution of fishing effort by various gears. This can facilitate and guide discussion on how the alternative management strategies that may alter the amount and/or distribution of effort over space, gears, and potentially time, will impact seabed habitat and EFH.

However, the current SASI model and the spatial analysis and practicability extensions/applications presented in the document provided to the review panel are not yet developed to the point that they provide a reliable quantitative predictive tool to evaluate how changes to regulations that change the distribution of fishing effort across fishing gears and space will affect essential fish habitat for two primary reasons: (1) SASI does not translate adverse impacts into predictions about future habitat states but rather simply tracks cumulative adverse impacts and their persistence in a common currency ; and (2) SASI does not include a model that can be used to reliably predict changes in fishing behavior in response to changes in regulations or incentives. Extensions of SASI to predict fleet dynamics and futures states of habitat as a result of predicted fishing effort could substantially increase the value of the model but would also be extremely difficult to develop and, in the case of predicting habitat state, may require information that is not yet available and may not be for some time.

In the meantime the model can be productively used to guide discussion and provide limited but useful proxies for habitat impacts of fishing. It can and should be improved iteratively with the model being used to identify the remaining gaps and uncertainties about functional relationships and assumptions that are most critical to improving the reliability of model predictions.

Background

The Council initiated EFH Omnibus Amendment 2 in 2005 with two main goals, the first of which was to review and update EFH designations for all managed species. In most cases, the spatial distribution of EFH is based largely on the spatial distribution of the species/lifestage to which the designation applies. As might be expected, there is a high degree of overlap in the EFH designations of the various species managed by the Council. The second major goal of EFH Omnibus Amendment 2 was **to optimize the minimization of adverse effects across FMPs.** This requires both a method for estimating adverse effects, and a strategy for minimizing those effects. To facilitate this task the impacts the New England Fishery Management Council (NEFMC) through its habitat plan development team (PDT) constructed the Swept Area Seabed Impact (SASI) model which provides a tool to quantify fishery impacts on seabed habitat.

The SASI model is a method for spatially estimating the adverse effects of fishing on physical and biological features of seabed habitat in the US EEZ extending from Maine to the North Carolina by combining as inputs fishing effort data, seabed substrate and energy data, associations of biological habitat components with seabed substrate, and gear-specific habitat vulnerability parameters and producing as outputs an index representing the adverse effect of fishing effort on seabed habitat features (Z). This index can be configured to represent equilibrium impacts simulated under constant effort assumptions (Zinf), or to represent estimated impacts under historical distributions of fishing effort (Zrealized), or to represent estimated impacts under proposed distributions of fishing effort (Znet). The latter measure can be compared with total net revenues within a grid cell averaged across years to create an estimated ratio of habitat impacts per dollar of net revenue (e). Estimates are provided at the resolution of a 100 km^2 grid scale for a geographical region that extends from 3 nm offshore to the edge of the EEZ from the Maine/Canada border to the North Carolina/South Carolina boarder and includes the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight and the associated slope regions.

The Habitat Plan Development Team (PDT) developed this model over the years 2007 to 2010 at the request of the New England Fishery Management Council (the Council). This is considered to be Phase 2 of the EFH Omnibus Amendment 2. The model at various stages of development has been reviewed by the Council's Scientific and Statistical Committee (SSC). The SSC recommended that a formal peer review of the SASI model might benefit the process. This report is a product of that peer review process.

Review Activities

The Peer Review Committee (the Committee) met on February 15-17, 2011 to review the SASI model and supporting technical document which contains details of the SASI model as well as the two model extensions -- Local Indicators of Spatial Association (LISA) and the practicability analyses. Prior to the review meeting, the committee was given a document describing the model titled *Essential Fish Habitat (EFH) Omnibus Amendment "The Swept Area Seabed Impact (SASI) Model: A Tool for Analyzing the effects of Fishing on Essential Fish Habitat*". The committee had ample time to review this document before the meeting. A number of presentations on the model were made by developers of the model during the February 15-17 meeting and the committee was given a chance to ask questions about the model and its development. However, since many of the individuals involved in development were not present complete answers to questions could not always be provided. Also, since the model is quite complicated and the committee did not have the chance to review the model code, the review is limited to a critique of the model as described in the document and the meeting and is not a validation that the model is functioning as described and intended. The committee is preparing a consensus report and each individual committee member is also preparing an individual report of which this is one.

Summary of Findings

1. **Is the SASI approach a reasonable way to estimate the magnitude and location of adverse effects of fishing on EFH, as required by the MSA? In particular,**
    a. **Considering the availability of other tools used by Fishery Management Councils, is SASI -- without additional modification -- a valid approach to evaluate the adverse effects of fishing on EFH?**

The SASI model is a useful tool for estimating the magnitude and location of adverse effects of fishing on seabed habitat which is an important component of EFH though not the only component that is potentially affected by fishing. While the model in its current form has substantial limitations, it does provide useful information to fishery managers, stakeholders and policy makers provided that the limitations and caveats of the analysis are made clear. It can usefully employed to explore and loosely quantify the potential impacts of specified changes in the quantity and spatial distribution of fishing effort by various gears. This can facilitate and guide discussion on how the alternative management strategies that may alter the amount and/or distribution of effort over space, gears, and potentially time, will impact seabed habitat and EFH.

The committee report provides a more extensive response to this question. I am in full agreement with that response. I do however wish to stress the implications of two key assumptions of the model: (1) that impacts are additive, and (2) that they are independent. These are very important assumptions that, while perhaps as reasonable and supportable as alternative assumptions such as decreasing marginal impacts of effort, nevertheless have profound implications for evaluating both absolute and relative impacts of different spatial allocations of fishing effort. The implication of these assumptions is that there is no benefit from concentrating fishing effort spatially or of maintaining long term closures of particular areas. The impact of a unit of fishing effort on a particular type of habitat is deemed to be the same regardless of whether that habitat is pristine or has been fished heavily and continuously. In contrast, if marginal damage were assumed to be declining with cumulative effort (e.g. the first cut is the deepest hypothesis) then the model would predict reduced damages from a given level of effort as that effort became more concentrated in space. This would tend to suggest benefits of long term area closures in terms of EFH protection though these gains might be offset if fishery biomass became concentrated in area closures such that more effort was required for a given catch total relative to what would be required if fishing were allowed in the closed areas.

2. **Is the SASI approach, including the geostatistical and practicability analyses, a reasonable way to develop and analyze spatially-based management alternatives to minimize the adverse effects of fishing on EFH? In particular:**

    a. **Have uncertainties in SASI inputs and resulting limitations of SASI been appropriately characterized for the Committee, Council, and members of the public?**

The committee report notes a number of ways that the description of the model could be improved to clarify the mechanics of the model and to describe the limitations of the model and the uncertainty associated with model inputs and assumptions and model outputs. I agree with the committee report with regards to this question. I do think that sensitivity analyses aimed at illustrating the consequences of key assumptions are probably more useful than estimates of uncertainty associated with monte carlo analysis that quantify the range of projected impacts give different draws of susceptibility and recovery rates. These latter measures of uncertainty are the product of unverified assumptions about the range and distribution of susceptibly and recovery rates.

    b. **Is the spatial scale of the model outputs (i.e. 100 km^2 grid) appropriate for fishery management applications? What ecological processes are missed by estimating adverse effects at a 100 km^2 grid resolution? What implications does this have for development of alternatives?**

The spatial scale of the model is currently defined at a resolution of 100 km^2 grid cells because the VTR input data by geartype can currently only reasonably be disaggregated to that level. As the committee report discusses this seems to be a reasonable choice of spatial definition given the data constraints, and it is probably an acceptable level of spatial definition for specifying and evaluating policy measures. However, moving to a finer scale would allow for improvements of the model as better data becomes available and would make if more feasible to test the implications of key assumptions about additively and independence of fishing impacts on habitat. Modeling at a finer spatial scale would allow the model to differentiate impacts based on the level of effort already applied to the specific area, allowing for decreasing (or perhaps in some cases increasing) rates of marginal impact if the empirical data supported that parameterization. Even in the absence of fine scale effort data it would allow for the exploration of the consequences of alternative assumptions about heterogeneous concentration of effort within a grid cell and application of effort to areas previously fished that year.

c. **Are the practicability analyses appropriate to use for eliminating options at the alternatives development stage, or should they be reserved for a later stage when the impacts of various alternatives are being compared?**

The habitat model is only now being exercised with the idea of how this might result in fleet impact in terms of practicability. There were two particular practicability explorations given in the document: 1) Opening and closing areas. 2) Relative differences of gear. The committee report, with which I agree, opines that the practicability analyses are not ready for use in their present form and in particular with regard to predicting impacts of opening and closing areas (particularly with reopening areas). With regard to gears, the analyses might be of greater utility particularly with regard to changes in effort level by gear type. These results would still be subject to the caveats that the results may be sensitve area swept assumptions. Some validation of area swept for fixed gear would be advisable. The practicability analysis, and perhaps simpler stylized examples of them, are useful in illustrating how the model works, how it could be used, and the implications of key assumptions of the model.

3. **Existing gaps in data and theoretical understanding of habitat-related processes have been identified during model development.**
    a. **Review and evaluate research priorities that have been identified during the model development process.**
    b. **Review and evaluate updates to the structure of the model that could be made in the future, given additional data or understanding of habitat-related processes.**

The committee report, with which I agree, finds the research priorities and future work specified by the PDT to be reasonable but suggests some additional priorities as well. I would like to stress here that one of the most productive uses of SASI, like any other model that is subject to a high degree of uncertainty, is to help prioritize and guide empirical research. Sensitivity analyses done with the model can identify the parameters and assumptions that are both uncertain and have the most impact on predicted results and thus should be the focus of research. It can also identify parameters and assumptions that may be highly uncertain and may be of great interest to some individuals in the research community but have little impact on predictions of the model of outcome of concern to stakeholders. These may then be given a lower priority when allocating limited research money.

Conclusions

The SASI model makes a useful contribution by providing an objective mechanism for synthesizing many of the complex interactions that take place between fishing activity and bottom habitat. While the model in its current form has substantial limitations, it does provide useful information to fishery managers, stakeholders and policy makers provided that the limitations and caveats of the analysis are made clear. However, the current SASI model and the spatial analysis and practicability extensions/applications presented in the document provided to the review panel are not yet developed to the point that they provide a reliable quantitative predictive tool to evaluate how changes to regulations that change the distribution of fishing effort across fishing gears and space will affect essential fish habitat. Extensions of SASI to predict fleet dynamics and futures states of habitat as a result of predicted fishing effort could substantially increase the value of the model. In the meantime the model can be productively used to guide discussion and provide limited but useful proxies for habitat impacts of fishing. It can and should be improved iteratively with the model being used to identify the remaining gaps and uncertainties about functional relationships and assumptions that are most critical to improving the reliability of model predictions.

Appendix A: Terms of reference

1. Is the SASI approach a reasonable way to estimate the magnitude and location of adverse effects of fishing on EFH, as required by the MSA? In particular,
    a. Considering the availability of other tools used by Fishery Management Councils, is SASI -- without additional modification -- a valid approach to evaluate the adverse effects of fishing on EFH?
2. Is the SASI approach, including the geostatistical and practicability analyses, a reasonable way to develop and analyze spatially-based management alternatives to minimize the adverse effects of fishing on EFH? In particular:
    a. Have uncertainties in SASI inputs and resulting limitations of SASI been appropriately characterized for the Committee, Council, and members of the public?
    b. Is the spatial scale of the model outputs (i.e. 100 km^2 grid) appropriate for fishery management applications? What ecological processes are missed by estimating adverse effects at a 100 km^2 grid resolution? What implications does this have for development of alternatives?
    c. Are the practicability analyses appropriate to use for eliminating options at the alternatives development stage, or should they be reserved for a later stage when the impacts of various alternatives are being compared?
3. Existing gaps in data and theoretical understanding of habitat-related processes have been identified during model development.
    a. Review and evaluate research priorities that have been identified during the model development process.
    b. Review and evaluate updates to the structure of the model that could be made in the future, given additional data or understanding of habitat-related processes.