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Individual Review Report

Swept Area Seabed Impact (SASI) Model

Prepared for the New England Fishery Management Council (NEFMC)

by

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April 14, 2011

Executive Summary

The Swept Area Seabed Impact (SASI) model and its extensions (geostatistical and practicability analyses) are an approach to assess the adverse effects of fishing on seabed habitat. This approach links a fishing gear-specific vulnerability assessment of the physical and biological features of the seabed with a model of fishing effort. This approach synthesizes and integrates a wide variety of data sources including fishing effort data, seabed substrate and energy data, associations of biological habitat components with seabed substrate, and gear-specific vulnerability parameters. The model domain includes waters extending from 3 NM offshore to maximum depths that vary from 82 to 302 meters for different gear types from the US/Canada border to the North Carolina/South Carolina border. Thus, the geographic region covers the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, and associated slope regions.

The SASI model generates an index (Z) of the adverse effects of fishing effort on seabed habitat features. The general index (Z) can be varied to represent:

- equilibrium adverse fishing effects under constant fishing effort assumptions (Z_{inf}),
- estimated adverse fishing effects under historical distributions of fishing effort ($Z_{realized}$),
- estimated adverse fishing effects under proposed distributions of fishing effort (Z_{net}).

Estimates of habitat impacts per dollar of net revenue (e) are generated by comparing Z_{net} with total net revenues within a grid cell averaged across years. These estimates are provided at the resolution of a 100 km^2 grid across the geographic region.

The Habitat Plan Development Team (PDT) developed the SASI model from 2007-2010 at the request of the New England Fishery Management Council (the Council) as Phase 2 of the Essential Fish Habitat (EFH) Omnibus Amendment 2 to the habitat management plan. The Council's Scientific and Statistical Committee (SSC) reviewed the model in 2009 and 2010 during different stages of its development. The SSC recommended the SASI model for a formal peer review.

The Peer Review Committee (the Committee) met in early 2011 to review the SASI model, its extensions, and supporting technical documentation. As stated in the Committee report, I reiterate my appreciation for the efforts by the PDT to develop the SASI model and thank the PDT for this approach which can promote the discussion of the impacts of fishing activity on marine habitat.

As summarized in the Committee report, the SASI approach is a good first step toward evaluating the adverse effects of fishing on EFH. In its current form, it can facilitate discussion of alternative management strategies (for example spatial management, effort reduction, redistribution of effort in time, reallocation of effort by gear type, and modification of existing gear types) to minimize adverse fishing gear effects on seabed habitat. The next steps should include continued development and improvement of the SASI model to:

- reduce uncertainty,
- improve model formulations, and
- verify assumptions and input parameter values.

The Council should work together with the PDT and the National Marine Fisheries Service (NMFS) to foster this evolution. Such an evolution should also address several areas of particular concern as specified in the Committee report including:

- the assumption that adverse fishing impacts on habitat are additive and independent;
- the need for improved understanding of impacts that fishing gear has on habitat;
- the need for a better understanding of the impacts that different types of fishing gear have on habitat;
- the need for better understanding of fishing fleet behavior under alternative management scenarios;
- the need for better understanding of the link between the geological indexes in the model to the systems and structures representing biological habitat in marine systems;
- the anticipated use of the model and its outputs beyond its current intended capabilities, despite the warnings and caveats provided by the PDT.

Review Activities

The Committee was provided with several documents prior to the review:

1) A Council memo to the Committee, *Terms of reference for SASI peer review*, dated January 21, 2011 (see Appendix for terms of reference)
2) A Habitat PDT report, *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*, dated April 12, 2011
3) Three SSC memos to the Council:
    a. *Review of EFH Omnibus 2, Phase II, Analytical Tool (FiGSI)*, dated March 26, 2009
    b. *Review of EFH Omnibus 2, Phase II, Analytical Tool (SASI)*, dated January 27, 2010
    c. *Technical Review of the Analyses to Support Essential Fish Habitat (EFH) Omnibus Amendment* 2, dated September 20, 2010

The Committee had sufficient time to review these materials.

The review has held from February 15-17, 2011 in Providence, Rhode Island. The Committee reviewed the Council request, presentations by the PDT, and background documents. Presentations included:

1) An introduction to adverse effects from fishing and the Swept Area Seabed Impact (SASI) model
2) Vulnerability assessment
3) Understanding vulnerability spatially: geological information
4) Natural disturbance
5) Fishing effort
6) Combining effort and vulnerability
7) Spatial analysis
8) Practicability analysis
9) Research priorities and future work

During the review, the Committee with the assistance of the PDT explored several stylized examples in order to better understand the model and its assumptions.

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 Committee report explains that the SASI approach is a good first step toward evaluating the adverse effects of fishing on EFH. The SASI approach does fulfill its initial design objectives, but in doing so it does not evaluate all aspects of fishing activities on EHF. At its core, the SASI approach fills an information gap by providing a framework for synthesizing available peer reviewed literature and professional judgment about the effects of fishing on benthic habitat features in the region. This approach serves as a flexible platform that can inform decision making and upon further development can be expanded, improved, and used later to answer a broader set of questions. It offers a different insight from the approaches that other management councils have taken, but the model will not necessarily provide definitive answers to all questions. It should therefore be viewed as a useful approach for discussing alternative management scenarios.

I am in full agreement with the response to this question in the Committee report. I wish to stress that, in its current form, the SASI approach ignores other potentially adverse effects of fishing on EFH such as those in the water column (for example ghost gear, noise, and prey displacement) and on prey removal (for example pelagic fish like herring and benthic organisms like polychaetes). In addition, improvements should focus on testing the assumptions of additivity and independence of fishing events and on specification of the fishing behavior model. For these reasons, the Committee report notes that the SASI model may not be fully adequate for examining the impact of opening previously 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 provides an extensive discussion on improving model specification in the technical document and possible approaches to better quantify uncertainty. I agree with the Committee report.

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?

I fully agree with the response to this question in the Committee report. The spatial scale of the model outputs is limited by the inputs of the vessel trip reports (VTRs). The 100 km^2 grid is an appropriate scale for fishery management applications, and at this resolution spatial management units could be configured from several of these grid cells. Clearly, finer scale ecological processes are missed as this resolution. Smaller scale studies could be used to test assumptions in the SASI model. At the same time, special consideration should be given to ecologically important areas that may not be detected by the SASI model.

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 and 2) relative differences of gear. As the Committee report describes, 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). I fully agree with the response to this question in the Committee report. Currently, the practicability analyses need improvement and likewise at this stage cannot be used for elimination options. They can be used for generating discussion on what alternatives may be developed. The practicability analysis could be improved by using a bioeconomic model that relates fishing location choice[1] to associated costs and the availability of the resource. I add that as appropriate, proxies for fishing gear specific adverse impacts on seabed habitat should be explored. For example, European studies of beam trawls seabed impacts could be used as a proxy for parameterization of scallop dredges in the SASI 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.

I agree with the Committee report response to this question. In addition, I stress these research priorities:

- To place the results of the SASI model into the context of ecological processes in the region;
- To explore the linkage between habitat and fisheries productivity in the region;

[1] Haynie, A. C. and F. F. Layton. 2010. An expected profit model for monetizing fishing location choices. *Journal of Environmental Economics and Management* 59: 165-176.

- To add a seasonal component to the SASI model in order to further facilitate the discussion of alternative management scenarios;
- To compare the SASI model results with historical sources[2,3,4] of information to examine potential changes in habitat;
- To compare the SASI model results with historical[2] and recent[5,6] information on fishing grounds to examine the assumptions that adverse fishing impacts on habitat are additive and independent.

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.

I agree with the Committee report response to this question. I add that additional modeling efforts should explore the relationship between habitat and fisheries productivity. One possible approach could be to add a *species affinity index* to the vulnerability assessment. For example, this index would indicate a species' preference for a certain habitat types relative to other habitat types. These species by species affinity scores could be developed by existing PDTs (Groundfish, Herring, Monkfish, Skates, etc) through an approach similar to the vulnerability assessment which implored professional judgment and literature review methods. In addition, maps of gear specific vulnerability (Phase 2) could be overlaid with the EFH component for all species and life stages (Phase 1) to make comparisons of where potential adverse impacts are likely to occur.

Conclusions

In summary, the SASI approach is a good first step toward evaluating the adverse effects of fishing on EFH. In its current form, it can facilitate discussion of alternative management strategies to mitigate adverse fishing gear effects on seabed habitat. However, the SASI approach (including the model and its extensions), provided to the Committee, is not ready to evaluate or predict how changes to fishery management regulations change fishing behavior. Near term improvements to the SASI model should focus on reducing uncertainty, strengthening model formulations, and verifying assumptions and input parameter values. Although challenging, the next phase of this work should explore the linkage between habitat and fisheries productivity in the region.

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[2] Claesson, S., A. A. Rosenberg, K. Alexander, A. Cooper, J. Cournane, E. Klein, W. Leavenworth, and K. Magness, 2010. *Stellwagen Bank Marine Historical Ecology*. Marine Sanctuaries Conservation Series ONMS-10-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 221 pp.

[3] Wigley, R and R. Theroux. 1981. Macrobenthic invertebrate fauna of the middle Atlantic Bight region: faunal composition and quantitative distribution. US Geological Survey Professional Paper, 529-N; 198 pp.

[4] Theroux, R and R. Wigley. 1998. Quantitative composition and distribution of macrobenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States.

[5] St. Martin, K., and M. Hall-Arber. 2008. Creating a place for "community" in New England fisheries. Human Ecology Review 15: 161-170.

[6] St. Martin, K., and M. Hall-Arber. 2008. The missing layer: geo-technologies, communities, and implications for marine spatial planning. Marine Policy 32: 779– 786.

Appendix: 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.