

Summary Report

Review on

**Evaluation of Fishing Activities That May Adversely Affect Essential
Fish Habitat (EFH) in Alaska**

Draft of Appendix B

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Executive Summary

The Magnuson-Stevens Fishery Conservation and Management Act requires that every fishery management plan describe and identify Essential Fish Habitat (EFH) for the fishery and minimize to the extent practicable the adverse effects of fishing on EFH. The National Marine Fisheries Service (NMFS) and the North Pacific Fishery Management Council recently developed a draft environmental impact statement (DEIS) that considers the impacts of fishing on EFH for multiple species of managed fish stocks. Appendix B of the DEIS contains the technical details of the evaluation including a habitat reduction model. A review of the model and its application, as well as the assessment of the impacts of fishing on habitat was carried out.

The quantitative model to assess the impact of fishing on different habitat types was dependent upon the number of times the fishing gear impacted the habitat type, the damage done by the gear to the habitat and the recovery rate of the habitat. In addition to the model, the criterion of the abundance relative to Minimum Stock Size Threshold (MSST) was used to assess whether the loss of habitat was affecting the fish productivity by species. Assessment scientists then carried out evaluations on the effects of fishing on spawning and breeding, on feeding, and on growth to maturity for the commercial species. For all species examined the evaluation was either that the effects were minimal or temporary (MT, approximately 58%) or unknown (the remaining 42%).

While the habitat reduction model was considered a reasonable approach, uncertainties in parameter values together with the lack of information on sediments, habitat types, and fishing effort distribution, meant that the model results must be considered as very approximate. Validation of the model using data from Alaskan waters as well as other regions is essential to confirm the usefulness of the model.

The use of the stock abundance relative to MSST to assess the possible influence of habitat degradation on fish stocks was not considered to be appropriate for several reasons, including that habitat effects are only one of many factors that influence the stock abundance, the criterion provides no spatial information, and the expected lag between habitat destruction and detection of its effect on the stock productivity is expected to be long, such that the habitat may be destroyed before mitigation could be implemented.

Since the MSST criterion is not considered to be an appropriate measure, a systematic and quantitative approach to the evaluation of possible impacts of trawling on managed species is proposed. It includes examination of indices that are immediately reflected in the individual fish (e.g., condition, growth, fecundity, gut fullness), consideration of the spatial patterns in, for example, the distribution of recruits and CPUE and their relation to the distribution of fishing effort, the estimated loss of habitat and its rate from the habitat reduction model and then integrative measures, including the history of the stock abundance, recruitment and growth. Finally, a precautionary approach needs to be applied because of the large uncertainties in our knowledge of the links between habitat and the life stages of the various fish species.

Several short-term suggestions were aimed at improving the quantitative assessment of evaluations; some of the more important recommendations are:

- (1) Attempt to validate the habitat reduction model with observations.
- (2) Compare the spatial pattern of length-weight relationships for different species with the fishing effort pattern.
- (3) Test the assumption of random spatial distribution of fishing effort.
- (4) Determine the temporal changes in the affected habitat through model hindcasts.
- (5) Provide time series of the stock size of each species relative to its current MSST level.
- (6) Improve the surficial sediment map on which to apply the model.
- (7) Compare the spatial pattern in the CPUE from the surveys and the commercial fishery to the pattern of fishing effort.
- (8) Integrate the results from on-going fishing gear impacts research into the habitat reduction model.
- (9) Investigate the rate of destruction of hard corals and sponges from the groundfish survey data.
- (10) Broaden the scope of the evaluators of habitat effects by including the opinions, information and data of stakeholders.
- (11) Explore spatially explicit models of growth, fecundity, condition etc. in different habitat types.
- (12) Use the spatially explicit models along with the habitat reduction model and a population index (e.g. abundance relative to the MSST) to re-assess the possibility of habitat degradation affecting commercial fish stocks.
- (13) Use the precautionary approach especially where the data are unclear, where recovery times are long (e.g. for corals and sponges), or where habitat reduction is high even if the abundance levels are above MSST.
- (14) Review the work being done elsewhere on ways of assessing the health of an ecosystem and develop relevant indices to help monitor the health of the Alaskan ecosystem.

The following are some longer-term activities and research that should be carried out as a means of improving the knowledge base.

- (15) Determine the habitat associations (temperature, depth, type of habitat, etc.) for various species from the groundfish survey data.
- (16) Produce Essential Fish Habitat Source documents on at least the major species.
- (17) Monitor habitats and fish abundances in the present closed and open areas.
- (18) Consider the establishment of new closed areas in regions with high habitat loss.
- (19) Establish field programs to measure the recovery rates of different types of habitat.
- (20) Carry out surficial sediment surveys.
- (21) Establish observational programs to identify the influence of habitat on different life history stages for the major commercial species, especially in the Gulf of Alaska and the Aleutian Islands.
- (22) Convert invertebrate data from scientific trawl surveys, fishing vessel logbooks, and any other relevant data available into electronic format.

1. Background

The Magnuson-Stevens Fishery Conservation and Management Act requires that every fishery management plan describe and identify Essential Fish Habitat (EFH) for the fishery, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other measures to promote the conservation and enhancement of EFH. NMFS and the North Pacific Fishery Management Council recently developed a draft environmental impact statement (DEIS) to consider the impacts of incorporating new EFH provisions into the Council's fishery management plans. The DEIS evaluates three actions: (1) describing and identifying EFH for fisheries managed by the Council; (2) adopting an approach for the Council to identify Habitat Areas of Particular Concern within EFH; and (3) minimizing to the extent practicable the adverse effects of Council-managed fishing on EFH. Most of the controversy surrounding the level of protection needed for EFH concerns the effects of fishing on sea floor habitats. Substantial differences of opinion exist as to the extent and significance of habitat alteration caused by bottom trawling and other fishing activities. Although an increasing body of scientific literature discusses the effects of fishing on habitat, there is no consensus within the scientific community on an appropriate methodology for analyzing potential adverse effects.

The national EFH regulations (50 CFR 600.815(a)(2)) require an evaluation of the effects of fishing on EFH, and this evaluation appears in Appendix B to the DEIS for Alaska. The evaluation has two components: a quantitative mathematical model to show the expected long term effects of fishing on habitat, and a qualitative assessment of how those changes affect fish stocks. The model estimates the proportional reductions in habitat features relative to an unfished state, assuming that fishing will continue at the current intensity and distribution until the alterations to habitat and the recovery of disturbed habitat reach equilibrium. The model provides a tool for bringing together available information on the effects of fishing on habitat, such as fishing gear types and sizes used in Alaska fisheries, fishing intensity information from observer data, and gear impacts and recovery rates for different habitat types. Due to the uncertainty regarding several input parameters, the results of the model are displayed not only as point estimates but also as a range of percentage habitat reduction.

After considering the available tools and methodologies for assessing effects of fishing on habitat, the Council and its Scientific and Statistical Committee concluded that the model provides a good approach to understanding the impacts of fishing activities on habitat. Nevertheless, the model and its application have many limitations. Both the developing state of this new model and the limited quality of available data to estimate input parameters prevent drawing a complete picture of the effects of fishing on EFH. The model incorporates a number of assumptions about habitat effect rates, habitat recovery rates, habitat distribution, and habitat use by managed species. The quantitative outputs of the analysis may convey an impression of rigor and precision, but the results actually are subject to considerable uncertainty.

One major limitation of the model is that it does not consider the habitat requirements of managed species or the distribution of their use of habitat features. Therefore, DEIS analysts were asked to use the model output to address whether continued fishing at the current rate and intensity is likely to alter the ability of a managed species to sustain itself over the long term. In other words, are the fisheries, as they are currently conducted, affecting habitat that is essential to the welfare of each managed species? To help answer that question, the analysts considered available information about the habitats used by managed species. The analysts also considered the ability of each stock to stay above its minimum stock size threshold (MSST), after at least thirty years of fishing at equal or higher intensities. MSST is the level below which a stock is in jeopardy of not being able to produce its maximum sustainable yield on a continuing basis.

The DEIS analysis for Alaska concludes that despite persistent disturbance to certain habitats, the effects on EFH are minimal because there is no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term. The DEIS finds that no Council-managed fishing activities have more than minimal and temporary adverse effects on EFH, which is the regulatory standard requiring action to minimize adverse effects under the Magnuson-Stevens Act. Additionally, the analysis concludes that all fishing activities combined have minimal, but not necessarily temporary, effects on EFH. These findings suggest that no additional management actions are required pursuant to the EFH regulations.

2. Review Panel and its Terms of Reference

In order to provide an independent assessment of the DEIS and its conclusions, NMFS contracted with the Center for Independent Experts (CIE) to conduct a peer review of the evaluation of the technical aspects and assessment methodology used in determining the effects of fishing on Essential Fish Habitat (EFH) in Alaska, which were contained in Appendix B of the DEIS. Given the newness of the model, the importance of this analysis for Alaska's fisheries, and the controversial nature of the subject matter, NMFS determined that an outside peer review would be a prudent step.

The review panel consisted of:

- Dr Asgeir Aglen (Institute of Marine Research, Bergen, Norway)
- Dr Ken Drinkwater (Institute of Marine Research, Bergen, Norway) (Chair)
- Dr Ken Frank (Bedford Institute of Oceanography, Halifax, Canada)
- Dr Tony Koslow (CSIRO Marine Research, Perth, Australia)
- Dr Pierre Pepin (Northwest Atlantic Fisheries Centre, St. Johns, Canada)
- Dr Paul Snelgrove (Memorial University, St. Johns, Canada)
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with expertise in benthic ecology, fisheries oceanography, fishery biology, fisheries assessment, fishing gear technology and biophysical modeling.

2.1 Terms of Reference

The panel was asked, in view of the Magnuson-Stevens Act requirements and the EFH regulations, to address the following issues:

1. Does the model incorporate the best available scientific information and provide a reasonable approach to understanding the effects of fishing on habitat in Alaska?
2. Does the DEIS Appendix B analysis provide a reasonable approach for identifying whether any Council-managed fishing activities adversely affect EFH in a manner that is more than minimal and not temporary in nature? (For purposes of this question, the terms “temporary” and “minimal” should be interpreted consistent with the preamble to the EFH regulations: “Temporary impacts are those that are limited in duration and that allow the particular environment to recover without measurable impact. Minimal impacts are those that may result in relatively small changes in the affected environment and insignificant changes in ecological functions.”) To answer this question, the panel shall address at least the following issues:
 - a. Does the DEIS Appendix B analysis apply an appropriate standard (including the consideration of stock status relative to MSST) for determining whether fishing alters the capacity of EFH to support managed species, a sustainable fishery, and the managed species’ contribution to a healthy ecosystem?
 - b. Does the DEIS Appendix B analysis give appropriate consideration to localized habitat impacts that may reduce the capacity of EFH to support managed species in a given area, even if those impacts do not affect a species at the level of an entire stock or population?
3. What if any improvements should NMFS consider making to the model, or to its application in the context of the DEIS, given the limited data available to use for input parameters?

2.2 Review Process

The review process contained several steps. First, advance material was provided by CIE through their website, which allowed the panel members to download the relevant documents (see reference list). Reviewers read these documents as well as related papers and reports they felt would be helpful in the review. Upon the request of Dr. Jon Kurland, the panel members provided a list of questions that they wished to see addressed by the authors of the report.

The panel members had an on site visit to the Alaska Fisheries Science Center (AFSC) at the National Marine Fisheries Service Laboratory at 7600 Sandpoint Way in Seattle on June 29. Dr. Jon Kurland chaired the meeting. The agenda for the meeting was:

1. Welcome and introductions (Jon Kurland)
2. Panel chair's opening remarks (Dr. Ken Drinkwater)
3. Scope and schedule for the CIE review (Jon Kurland)
4. Background behind the EFH Environmental Impact Statement (Jon Kurland)
5. Fishing Effects Model (Dr. Jeff Fujioka and Dr. Craig Rose)
 - Development and evolution of the model
 - Application of the model to the EFH EIS
6. Analytical approach for assessing the effects on EFH and managed species (Dr. Craig Rose and Dr. Anne Hollowed)
7. Discussion and question from the CIE panel

Other members of the AFSC and NMFS also attended, some of whom were involved in the preparation of the DEIS. The meeting was opened to the public and although there was no opportunity for public testimony or questioning, members of the public did have a chance to talk with the panel members during the morning and afternoon breaks.

PowerPoint presentations summarizing key aspects of the model and the subsequent evaluation of fishing effects took up the morning. Although there was no formal response to the questions that had been submitted by reviewers prior to the meeting, it was clear that many of the questions had helped to shape the talks that were given. Paper copy summaries of all presentations were supplied to reviewers as well as copies of Section 3.4.3 that was referred to in Appendix B but not previously made available to the panel. The afternoon completed the presentations and was followed by a question and answer period, first on the model and second on the assessment methodology. All members of the review panel had the opportunity to seek clarification on the EFH document and to challenge the authors on aspects of the document and presentation that they felt required closer scrutiny. Although the question period occupied only half a day, there was sufficient time to cover all of the questions raised, and when the question period ended, all members of the review panel felt satisfied that the discussion had been productive and thorough. The review panel greatly appreciated the effort and patience of the NMFS scientists involved.

The following day, June 30, the panel members met in executive session at the Best Western University Towers Hotel to discuss the DEIS and the results from the previous day's meeting. Dr. Drinkwater chaired the session, which went through the each of the review panel's terms of reference. Although the panel had requested that the authors of the report be available to respond to any additional questions, it was not found to be necessary to query them any further. During the course of the session it was clear that there was general agreement by the review panel on the major points related to the terms of reference. The panel disbanded at approximately 15:30 having felt that they had covered all of the major issues.

Upon returning home, each panel member wrote a review, which addressed the terms of reference and related topics. These were submitted to the CIE on or before July 15th. As already stated there was general agreement amongst all of the panel members on the larger issues. This summary report represents many of the panel's findings and the highlights of individual reviewer's comments. It is based upon the discussions and

written reports of each of the panel members; however, it represents the chair's view. The format of this report addresses each term of reference (TOR) in order.

Before presenting our findings, I want to state that the panel all agreed that the NMFS team who prepared Appendix B produced a well-written document with a logical progression of ideas that was easy to follow. It was clear that they had put a tremendous amount of work and thought into the report.

3. Summary of Findings

3.1 TOR 1: Does the model incorporate the best available scientific information and provide a reasonable approach to understanding the effects of fishing on habitat in Alaska?

The model, developed by the NMFS and presented in the DEIS, estimates the long-term reduction in habitat due to fishing. It is applied to 3 regions: the Eastern Bering Sea (EBS), Gulf of Alaska (GOA) and Aleutian Islands (AI). The model itself is elegant in its simplicity being a balance between the loss of organisms or structures due to direct effects of fishing gear (I) and the recovery rate of the organisms or habitat structures (ρ). The gear impact (I) is the product of the number of times fishing gear hits bottom (f) times the amount of damage done during each hit (q). The approach is to use the mean or mid-point of the range of values collated from the literature and the lower 25th and upper 75th percentiles of the distribution of the collated data as measures of the uncertainty. The model is applied to a spatially resolved grid of habitats (5 km by 5 km) with a constant fishing effort. The decision to use blocks of 25 km² represents a reasonable compromise to investigate the local scale of the impact of fishing while providing enough resolution over the large scale of the regions of interest to identify the general patterns of fishing intensity. The model further assumes that within each grid point, the spatial distribution of fishing activity and habitats is random. The steady state solution (i.e., the long-term effect impact or LEI) is estimated for each gear type and habitat category. It represents the percent reduction in the fishing habitat that existed under unfished conditions. The predicted LEIs from the model are scaled versions of the fishing intensity patterns. Consistent with intuition, the model predicts that the long-term impact of trawling is less on organisms or substrate that sustain minimum damage by the direct contact with the gear or have high recovery rates while it is greater for those habitat types that are more heavily impacted by fishing activities and have long recovery times.

The panel felt that the model was well conceived and is useful in providing estimates of the possible effect of fishing on benthic habitat. However, as acknowledged in the DEIS, the parameter estimates are not well resolved and have high uncertainty, due in large part to a paucity of data. Thus the results must be viewed as rough estimates only. In regards to whether the model incorporated the "best available scientific information", the panel concluded that additional information could have been used. There were also concerns about the lack of model validation.

I begin with comments on the model parameters, then comment on validation and model testing and finally provide other related concerns. Recommendations are imbedded into the discussion.

3.1.1 Fishing intensity parameter, f

A key assumption in the application of the model is that of random distribution of fishing effort within each 5 km x 5 km block. It is expected, however, that patchiness in habitat will lead to patchiness in fish concentrations and hence fishing effort. The assumption of random fishing effort was not validated.

Recommendations: Quantitatively assess the assumption of random fishing effort using the observer database and, for those vessels that did not have observers, use either logbook data or vessel monitoring systems (VMS), if available. Determine the difference in the model results using the observed fishing effort distribution within a block rather than a random distribution.

If the fishing effort were non-random, then a key question would be whether this effort is associated with a specific habitat feature. This is important because if habitat structure within the block were random, non-random fishing would tend to lessen the overall impact since some habitat areas would remain largely unaffected. However, if habitat type and fishing intensity were strongly associated, the impact would be underestimated.

Recommendation: Using gear effect studies by NMFS, estimate whether the potential impacts of fishing on essential fish habitats represent conservative (i.e., overestimates) or optimistic (i.e., underestimates) projections of the impacts of fishing in the different regions and general habitat designations.

Using the end position to assign a trawl to a particular 5 km x 5 km block underestimates the effects of fishing on habitat due to the non-linearity in the model (as discussed in the comments by J. Tagart). The relative bias will increase with increasing fishing intensity and with decreasing recovery rates.

Recommendation: Proportionally assign the tows to the different areas under simple assumptions and determine the quantitative difference this would make to the model results.

Observer data forms the primary basis for quantifying the distribution and intensity of fishing effort. Observer coverage was 100% for vessels > 125 ft but was generally less than 30% for vessels < 125 ft. The statement is made in the report that vessels <60 ft in length take less than 1% of the fish so their effect on habitat is considered negligible.

Recommendations: Map the catch per unit effort (CPUE) of the fishery data by vessel class/gear type combination. Within the report, explicitly state all assumptions regarding the location of unobserved effort.

Vessel speeds tend to be dependent on the target species being sought, yet a single value is given for speed in Table B.2-4. Depending on the composition of the fisheries in various areas, vessel speeds could vary widely.

Recommendation: Construct frequency distributions of vessel speeds for each gear/vessel class combination. Determine what effect this has on the estimates of area swept.

Another key assumption of the model is that fishing effort is constant in time. The effort was calculated from the observer data for 1998 to 2002. The assumption of constant fishing effort was not addressed in the report although there appears to be considerable information on overall fishing effort over the past decades from the historical database of trawl data for the Bering Sea (www.afsc.noaa.gov/race/groundfish/habitat/histdrawldata.htm). These data should provide not only an indication of changes in fishing intensity within the region but also changes in the spatial patterns of allocation.

Recommendations: The report should contain time series of fishing effort (as far back in time as possible) as well as temporal changes in the spatial pattern of the effort. Explore the effects of non-constant fishing effort on the model results.

3.1.2 Gear effect parameter, q

Estimates of q for bottom trawl gear were determined from the literature. As noted in Appendix B, the uncertainty in these parameter values is high.

The adjustment for multiple contacts (B-12) does not consider the frequency of contact. The frequency relative to the recovery time is the critical consideration.

For scallop trawls and other gear besides bottom trawls the report states that “professional judgment” was used to assess their effect on habitat. It is unclear what this means and hence how reliable the estimates are. The report also indicates that studies on the effects of bottom trawl gear on the habitat that did not meet the necessary criteria were examined for consistency with the excepted studies but there was no indication of what the examination consisted of nor whether these studies were consistent or not with those that met the criteria.

Recommendations: Clarify in the report what is meant by “professional judgment” and note the results of the comparison of the studies that did not meet the criteria with those that did.

3.1.3 Recovery Rate, ρ

The recovery rates, ρ , for the different habitats were also determined from the literature. A reasonable description of the procedure was presented in Appendix B, although again, as acknowledged in the report, these parameters have high uncertainty. Recovery rates

are relative to some post-impact state, although the truly pristine status of habitats is effectively unknown (e.g. Jackson et al., 2001).

The ρ values were based upon the duration from time of impact to time of recovery however little was said in Appendix B of how the recovery varies in time, i.e. linear, asymptotic, etc. In cases where the recovery is an asymptotic process, the time to full recovery is difficult to ascertain.

Recommendations: Briefly discuss within the report the temporal changes in the habitat recovery. Explore the possibility of assuming an asymptotic (or sigmoid) recovery in order to obtain a more precise estimate of recovery rate, for example using the time to say 50% recovery.

The model views benthic communities as if they were single populations, for which simple intrinsic rates of mortality and growth (or fishing impact and recovery rate) can be specified. The community is expected to reach equilibrium, given a particular level of fishing. However, benthic communities, even on relatively soft bottoms, are diverse and complex. Studies on Georges Bank have shown that trawling leads not only to reduced benthic biomass and diversity, but a shift in community structure and habitat complexity: from epifauna (e.g. bryozoans, hydroids, worm tubes) that provide complex habitat for shrimps, polychaetes, brittle stars and small fish, to sites dominated by hard-shelled molluscs, scavenging crabs and echinoderms (Collie et al. 1997, 2000). Intensively fished areas are likely to be maintained in a permanently altered state, inhabited by only those organisms adapted to frequent disturbance (de Groot 1984, Jones 1992, Collie et al. 2000). Thus, how were the recovery rates determined? Are they based upon the quality or the quantity of the habitat or both?

3.1.4 Literature Survey

The chosen criterion for selecting literature studies pertinent to the determination of gear impacts, recovery rates and fishing impacts was that the habitat had to be similar in nature to those in the EBS, GOA or AI. This approach is very conservative. Relatively few studies satisfied the criteria and considerable information from Georges Bank, the North Sea and Australia were excluded from the parameter set. Whether the net consequences of increasing the breadth of information collated from previous studies on the overall estimates of the impact of fishing would have lead to an increase or decrease in the estimated impact of fishing activity on EFH is unclear. However, the additional information would have lead to a more broadly based range of outcomes that would have lessened the overall uncertainty about the calculations general applicability.

The reviewed literature appeared in the DEIS (Chapter 3) and was supplied to the panel during the review meeting. It covered many recent papers, but neglected a surprising number of key studies and reviews. Environmental groups present at the review meeting provided the panel with a list of 198 papers on the impacts of fishing that were not cited or utilized in the DEIS. Indeed, many of the leading scientists working in the field were not cited (e.g. Auster, Collie, Dayton, de Groot, Fossa, Gislason, Hall, Hutchings,

Jennings and Kaiser), as well as several important studies from the Alaska region (Freese 2004, Krieger 2001, Witherell and Coon 2001, Stone 2004). For example, in the case of hard corals, only one study (Krieger 2001) was found which satisfied the criteria set by NMFS scientists. Although the impact observed in that study was substantial, other sources of information could have been used to build a more extensive data set that would have provided greater confidence in the rate of impact, such as Fossa et al (2002) off Norway, Koslow et al (2001) off Tasmania, and Clark and O’Driscoll (2003). Although not satisfying the criteria applied in the DEIS, they could have been used to address how realistic the value derived from the single study by Krieger was relative to studies where the impact of trawling on coral had been considered.

Recommendations: Review the papers identified by the panel members and the environmental groups. Where considered relevant, add them to the list of references and discuss their results and implications with regard to impacts of fishing on habitat.

Research on the effects of fishing gear on essential fish habitat, as well as research aimed at defining essential fish habitat has been on-going within the AFSC for several years, (see Heifetz 2002, 2003; Stone 2003). This literature was not cited, however.

Recommendations: Cite the literature from the AFSC studies. Integrate, where possible, the research results from these studies with the development and testing of the habitat reduction model and the qualitative evaluations of effects on managed species. Where results are not yet forthcoming from these studies, the report should note what research is being carried out.

3.1.5 Surficial Sediment Data

Appendix B concludes that comprehensive substrate datasets do not exist for the study area and that “insufficient amount of data on types, proportion, and distribution of substrates should engender great caution in the application of the analysis results.” As a result of the lack of data broad habitat categories were defined: 5 for the EBS region and 3 for each of the GOA and AI regions. In large part, habitat designation closely reflected the bathymetry of a region. In the GOA and AI, the high degree of bathymetric complexity within and among blocks is very likely to be associated with variations in habitat structure.

Finer detail substrate data do exist, however, for the eastern Bering Sea, particularly Bristol Bay and a number of mapping initiatives are underway of major fishing grounds (see Heifetz 2002, 2003) that could have provided high-resolution substrate data for sub-areas of the model domain. Instead, the report adopted the coarsest resolution everywhere.

Recommendations: Determine if the high-resolution sediment data support the broad scale characterization of habitats. Run the model within the Bristol Bay area (or any other region where there are sufficient data) using coarse versus highly resolved

substrate data to examine the sensitivity of the model to the assumption about lack of substrate complexity/heterogeneity.

Have all avenues been exhausted for surficial sediment data, e.g. from the US Geological Survey? Are there preliminary data that could be used to better resolve the sediment types? Were the data from the paper by McConnaughey and Smith used? Current meter data from models can be used to help refine the sediment information. Was this attempted?

3.1.6 Model Validation

A critical step in the application of any model is its validation against available sources of data. There was no attempt within the DEIS to validate the impact model. There are, however, two obvious sources of information with which the model could have been validated. The first comes from published studies, which have attempted to assess the impacts of trawling on local ecosystems, for example from Georges Bank or the North Sea. Even if the application of the model to other regions might be slightly different from that for Alaska, assessment, analysis and interpretation of the model's application would provide confidence in its validity as a predictive tool. A second source is from NMFS own research in the Alaska Region (Heifetz 2000, 2002, 2003). Some of the work on the impacts of trawling have been published (e.g., McConnaughey et al. 2000) and together with the 2002 and 2003 progress reports of the research program in closed areas of Bristol Bay could have served as a tool for the validation of the modelling approach.

Recommendations: Undertake validation of the model's predictive capabilities by applying it to other regions outside of Alaska and to at least the Bristol Bay region within Alaska.

3.1.7 Model Exploration

The model was not used to explore past conditions or possible future scenarios. These could easily be done with little effort.

The habitat reduction model in Appendix B, it is an equilibrium model, with estimates of H_{equil} being estimated based upon recent fishing effort. The change in habitat is relative to a pristine state, unaffected by trawling and other methods of fishing. However, we know that fishing, including trawling, has been ongoing for some time. Are we near equilibrium for any of the habitat types or are we continuing to lose habitat? The model should be used to back calculate where we might be relative to H_{equil} by using whatever data are available from the past or by making assumptions on the amount of trawling and the impacts of trawling in the past. Where are we relative to pristine conditions, based upon the data and/or reasonable assumptions?

Recommendations: (1) Apply the model as a retrospective tool to determine how far the current environments are from conditions 10-30 years ago. (2) Given the model has a time component (equation 4, appendix B) and there are estimates of past fishing

effort, back calculate the changes in percent of the habitat unaffected by fishing over time. (3) Use the model to predict the possible effects of different fishing efforts on habitat reduction in the future.

3.1.8 Shester Model

The NMFS model estimates habitat reduction due to fishing but does not address the question of what affect this has on fish. G. Shester, in his comments on the DEIS, presented a model that did attempt to do this. He assumed that the estimated reduction in habitat features could be (linearly) translated into a reduced carrying capacity for the fish. He argues that habitat quality could be determined by the relative densities of fish associated with each habitat type. However, this neglects any consideration that different species may show long-term changes in distribution that may be determined by factors other than the benthic habitat or that changes in habitat occupation may not be proportional to overall population abundance among different species. Although the concept is an interesting one, the characterization of “environmental carrying capacity”, and any possible anthropogenic or environmental modifications, has been nearly impossible to carry out in practice. Having said that, the Shester model at least attempts to assess the affects of habitat loss on the fish stocks.

3.1.9 Closed Areas

The areas that have already been closed to trawling could serve as valuable reference sites to parameterize the sensitivity of habitat features to trawling and recovery rates. For example, Stone examines the epibenthic communities inside and outside of two closed areas around Kodiak Island but little, if any of this information was incorporated into Appendix B.

Reference is made to two large area closures in the eastern Bering Sea that were closed to bottom trawling to protect red king crab habitat (see pg. B-20). How was this decision reached? It should be noted that the conclusions on page B-29 that fishing had no or unknown effects on this species are inconsistent with the area closures to protect red king crab.

3.1.10 Habitat Dependency

Habitat dependency of the various managed stocks was generally not quantitatively evaluated. However, the bottom trawl survey database provides the necessary information to conduct such an evaluation, in terms of species distributions and abundances, relative to bottom depth, substrate type, temperature and salinity conditions. There are well-developed methods involving use of survey data to derive cumulative distribution functions of the unweighted and catch weighted sampled habitat (Perry and Smith, 1994; Smith and Page, 1996) and commercial fisheries data (Reynolds, 2003).

Recommendation: Conduct habitat association analyses on fisheries data (both survey and commercial) for the various areas and species.

3.1.11 Other Issues and Concerns

The model does not consider possible indirect effects such as perturbations to food availability or productivity for the benthos, or changes in fish behaviour due to disturbance in habitat status.

There was no assessment and little discussion on the effects of fishing on the spawning beds or the spawning aggregations. If trawling, or any other form of fishing, disrupts fish during spawning over extended periods, this would likely cause a reduction in spawning success. Some species have demersal eggs that might be destroyed or buried by contact with fishing gear. The possibility of these effects will depend upon the seasonal distribution of the fishing. These effects are not assessed by the model but should be evaluated.

Recommendation: Compare seasonal fishing locations with known spawning aggregations, especially for those species that have geographically limited spawning.

During the questioning by the review panel, the NMFS team indicated that other Fisheries Councils are wrestling with these same issues. They further stated that as far as they know, the AFSC is as far along in the development of a fish habitat model, or in fact further ahead, compared to most other councils.

Recommendations: (1) Describe briefly in the report any other state of the art models and explain why the AFSC selected the one they have. (2) Given that each of the councils are attempting to deal with this issue, the councils should monitor each other's progress and share information on the development of such models, if they are not already doing so.

3.1.12 Conclusion

The habitat reduction model is essentially an intuition-building tool that provides approximate inferences about the potential impact of fishing on EFH. Validation of the model is a high priority through application in Alaskan waters where available data exists and in other regions where more extensive data exists. Many recommendations have been made to improve or better quantify the model or model parameters and these should be undertaken. While the panel recognizes that several of these likely represent minor sources of bias that may not be of great significance to the overall projections from the model, this needs to be confirmed.

3.2 *TOR 2: Does the DEIS Appendix B analysis provide a reasonable approach for identifying whether any Council-managed fishing activities adversely affect EFH in a manner that is more than minimal and not temporary in nature?*

3.2.1 TOR 2a: Does the DEIS apply an appropriate standard for determining whether fishing alters the capacity of EFH to support managed species either for a sustainable fishery or to contribute to a healthy ecosystem.

An evaluation was carried out of whether fishing impacted the EFH to such an extent that it influenced the ability to support sustainable fisheries for managed stocks. This evaluation was done on a species by species basis. The process outlined in the DEIS states that they were based on (1) the results from the habitat reduction model; (2) literature and other information on habitat requirements to accomplish successful spawning, breeding and growth to maturity; (3) knowledge of the responses of the recruitment, biomass and growth of the species during periods with similar fishing intensities; and (4) the professional judgment of scientists that manage and study the species of interest. The sustainability criteria used by the scientists was the abundance level relative to the Minimum Stock Size Threshold (MSST). If the stock was above or equal to the MSST, or projected to be above within 10 years, the stock was considered to be in good shape. The MSST was based upon data since the late 1970s. Where MSST could not be estimated, other proxies were used or baring these, the MSST was considered as being unknown.

3.2.1.1. Model application

The habitat reduction model was run for almost all species and the DEIS discusses the results by species. However, the model results appeared to be seldom used in the evaluation, with almost exclusive reliance placed on the abundance level of the stocks relative to MSST.

3.2.1.2. MSST

The panel felt strongly that the MSST was not an appropriate index to evaluate the effects of habitat reduction. Many reasons were given.

- (a) MSST is a population measure that embodies and integrates many different processes. Habitat degradation is most often probably a second-order effect, with the abundance of the stock likely responding more to changes in water mass, changes in predator or prey fields, or to direct fishing, including effects on the spawning stock biomass. In regards to environmental conditions, the report notes, and it was further elaborated during the presentations, that Alaskan waters are subject to regime shifts. These shifts occur roughly simultaneous throughout the North Pacific due to changes in large-scale atmospheric forcing. In the late 1970s, there was a shift in the Bering Sea from an invertebrate dominated fishery to an explosion of groundfish. If another major shift occurred such that we were to shift back again to invertebrates and the groundfish abundances decreased, the strict application of the MSST criterion would require that the habitat be protected when in fact they would have played little role in the decline.

- (b) Because the MSST approach works on a population level, it is likely to be an extremely insensitive measure of EFH loss. Moderate effects due to habitat degradation might be difficult to detect due to “noise” from the additional controlling factors discussed above. Also, a decline in stock productivity below MSST due to extensive and irreversible damage to EFH would likely be gradual and only be detectable well after the habitat had been affected, i.e. the lag between cause and effect is probably quite long. The result being that many years of observation would be needed to detect a trend with reasonable statistical significance.
- (c) The MSST criterion is poorly matched with the output of the spatially explicit fishing effects model. For example, it provides no information about stock structure, i.e. the number of sub-stocks distributed within the management unit and how they may have changed over time. This can be serious as serial depletion of sub-stocks eventually led to the collapse of several managed stocks in the North Atlantic (Frank and Brickman, 2001).
- (d) MSST is an empirically determined threshold and therefore sensitive to the length of the time series. For those long-lived managed species, the time series can be less than one generation (< 30 y). Also, with the addition of new data, the MSST threshold level changes. What are the calculated virgin biomass estimates for some of the species? Consideration should be given to theoretically based thresholds based on life history characteristics.
- (e) The corollary of the MSST applied criterion used in the report is that habitat degradation due to fishing is an issue if the stock is below MSST. However, in the case of blue king crab for which the stock was reported to be below MSST, the DEIS stated that the reason for the low stock was not habitat related but due to other factors. While this may be easily justified (but was not in Appendix B), it makes it very unclear as to what conditions will be required before an effect of fishing on habitat will not be classified as MT or U. There is no indication of what other conditions are necessary when the stock is below MSST in order to be interpreted as indicating an effect of habitat reduction on stock sustainability.
- (f) MSST is inappropriate with regard to the impact of fishing on sensitive habitats, such as corals and sponges, where any habitat impact is unlikely to be temporary and reductions > 50% cannot be regarded as minimal.

Since the MSST criterion is most often insensitive to habitat changes, then clearly an alternative approach is needed. Ideally, this approach should take advantage of existing data, and preferably a data time series.

Recommendations: Examine data on size-at-age, the size structure of the population, condition (e.g. liver indices), fecundity and gut fullness in a spatially structured format that more closely resembles the design of the habitat model. These types of data are routinely collected during the stock surveys that are conducted by regulatory agencies.

These, or other indices, could be used in combination with the results from the habitat reduction model and a population-based criterion to assess habitat effects on fish.

B_{MSY} is the spawning stock size that maximizes production (usually estimated as the equilibrium spawning stock corresponding to the fishing mortality that generates the highest long-term yield). The 10 yr prediction does therefore not contain any additional observations as compared to the assessment of the current stock situation. As apart of a management plan it might be good reasons for including this 10 yr test for classifying the stock, but for evaluating the current production the information is blurred by the assumption about future recruitment. For this purpose B_{MSY} is a better measure than MSST and would be more transparent and consistent among stocks.

3.2.1.3 Species Evaluations

There was general concern that the species evaluations were heavily reliant upon a single or few expert opinions from the NMFS. It is essential that the evaluators of the effects of fishing on EFH for the various species be broadened.

Recommendation: Carry out opinion surveys with stakeholders. (Well-designed, statistically based opinion surveys can be very informative and have been used extensively for fisheries assessment purposes in eastern Canada.) Also, seek the opinion of researchers involved in the various fishing impact studies reviewed in Heifetz (2002, 2003).

Over 40% of the evaluations by species and category (spawning, feeding, growth) were classified as U (unknown), yet there appears to be an implicit assumption throughout that if it is unknown, that there is no effect, or at least nothing needs to be done until more data are available (burden of proof argument). For example, even if one or two of the evaluations are listed as U for a given species, it is often stated that fisheries are unlikely to adversely affect the EFH of the species in question.

3.2.1.4 Precautionary Approach

In recent years, fisheries science has been applying the precautionary approach. That is, in the absence of conclusive proof, one should proceed cautiously. Yet, there is little to no discussion within Appendix B of the precautionary approach with regards to EFH. Since it is likely difficult to detect an influence on the stock until after the habitat is damaged, perhaps even until much of the habitat is destroyed, the use of the precautionary approach is paramount. This is especially true for those habitats with long recovery times, e.g. hard corals and sponges.

Recommendation: Apply the precautionary approach to the evaluation of the effects of fishing on habitat and their subsequent influence on the sustainability of commercial fish stocks especially where the model suggests the habitat is heavily reduced and/or the recovery times are long, as well as where little is known about the role of habitat in the life history stages.

3.2.1.5. Corals and Sponges

Corals and sponges are of particular concern because of their long recovery times. The areas of greatest alarm are where the model results indicate a reduction of order 50–100% in the coral habitat.

The recovery rate of sponge habitat may be greatly underestimated, as noted in the comments by Shester and confirmed by studies on the Northwest Shelf of Australia (Sainsbury 1997). Indeed, the recovery times will be species dependent.

Recommendation: Reassess the recovery times for sponges through a more extensive literature survey and by consultation with those working on sponges and rerun the model if the recovery rates are revised.

Since the fine-scale distribution of fishing effort is not known, the actual impact on corals and sponges may be significantly biased upwards or downwards, depending on whether trawlers avoid or focus effort on those habitats. If fishes aggregate in these sensitive habitats, then fishing effort typically soon follows, facilitated by improvements in fishing technology. The development of rock-hopper gear, GPS, track-plotters, net sondes, etc. enables trawlers to advance continually onto grounds once considered untrawlable.

Levels of coral, sponge and bryozoan by-catch in the Alaskan trawl fisheries, particularly in the Aleutian region, based on observer records are a matter of concern, but these data were not analyzed or incorporated into the model formulation or validation process. Anderson and Clark (2003) show that coral by-catch from new orange roughy fishing grounds declined sharply after the first year of fishing. The continued coral and sponge by-catch from certain segments of the Alaskan trawl fisheries may therefore indicate continued advance of the fleet into previously unfished grounds containing sensitive habitat.

Recommendation: Analyze catch and effort data, observer by catch data, field studies and consult with the industry to assess the damage done to the long-lived corals and sponges as well as the possible encroachment of fishing trawls into new areas containing corals and sponges. .

3.2.1.6. Healthy Ecosystem

A standard for a “healthy” ecosystem was never addressed in Appendix B. During the presentations, the NMFS team indicated that they were given little guidance on how to address this issue and it appeared that either they did not quite know how to proceed or did not have the time to explore the possibilities.

Measuring the health of an ecosystem is a topic that is presently receiving much attention throughout the marine science community. In Paris during March-April 2004 a major symposium was held entitled Quantitative Ecosystem Indicators for Fisheries Management (<http://www.flmnh.ufl.edu/fish/organizations/ssg/ecosymp2004.pdf>). Many

other sources on this same topic of ecosystem indicators are available on the web. Examples of indicators include biodiversity indices, trophic level changes, condition factors, the demersal to pelagic ratio, habitat complexity, etc. Apex predators have often been considered sensitive to ecosystem health thus marine mammal productivity could perhaps be another potential indicator of ecosystem health.

Recommendations: Review the literature and web-based information to determine the state-of-the-art in regards to assessing the role of the managed fish stocks in a healthy ecosystem. Based on this review, define and generate time series of ecosystem indices for Alaskan waters.

3.2.2. TOR 2b: Does the DEIS Appendix B analysis give appropriate consideration to localized habitat impacts that may reduce the capacity of EFH to support managed species in a given area, even if those impacts do not affect a species at the level of an entire stock?

It was the unanimous opinion of the panel that adequate consideration was not given to localized habitat impacts in Appendix B. Instead the report focused almost exclusively on population indices, e.g. total abundance relative to MSST. There was little discussion in Appendix B of whether localized habitat was being destroyed at a rate that was unsustainable. In no case was it recommended that specific habitat be protected even where the model indicated substantial local habitat had been lost. The impression was given that these more local effects would be dealt with under Habitat Areas of Particular Concern (HAPC).

It is unclear and was not discussed in Appendix B whether it would be better to concentrate fishing in particular locations and sacrifice some local habitat while protecting other areas, or to spread the effort out as evenly as possible.

Recommendation: Clearly state what the philosophy should be in regards to spatial allocation of fishing effort and its impact on habitat.

In regards to localized habitat impacts, there was no discussion of substructure in the populations. Are there sub-populations of some or all of the species and if so are some of these sub-populations threatened by habitat destruction? For example, Atka mackerel has been suggested as possibly consisting of several sub-populations. This is, in part, because the fishery tends to focus on limited fishing grounds, although genetic studies have not been able to confirm the existence of distinct sub-populations.

Recommendations: (1) Analyze the spatial distribution of CPUE and condition indices to determine if they provide any evidence for localized impacts of fishing. (2) Examine the long-term changes in abundance in relation to habitat types. For example, if there were a strong requirement by a species for habitat structures that could be impacted by trawling (e.g., corals), one would expect the greatest changes in abundance estimates from standardized trawls to occur in such habitats.

In regards to local habitats the destruction of corals and sponges with their long recovery times are of particular concern. In keeping with the precautionary approach, these should receive special consideration.

Recommendations: Discuss further within Appendix B vulnerable local habitat features and possible connections to those managed species that might tend to aggregate in such habitats.

3.3 TOR 3: What improvements could be made to the model, or to its application?

A number of suggestions have already been made in the form of recommendations in discussions of the previous terms of reference. Some of the more important bear repeating.

Model validation is required with an independent dataset. The data could come from a comparison of trawled and untrawled areas of the EBS or from other areas where long-term impacts of trawling have been studied.

The model should be applied in backward projections of EFH status to assess the current state of the regions of interest (EBS, GOA, AI) relative to projected conditions from 10-30 years before present.

Temporal dependence should be introduced in the fishing impacts. In the present model formulation there is no seasonal time dependency in the fishing effort data, yet the recovery rate parameters are explicitly so. Estimates of the average time interval between overlapping fishing effort relative to the recovery rates of the habitat are needed.

A precautionary approach needs to be applied to the evaluation of fishing effects on EFH. This is especially important given that many of the stock collapses or severe declines around the world could have been avoided or lessened by following a precautionary approach. It is also important given that many of species in Alaskan waters have unknown life history characteristics. In spite of this lack of knowledge these species were not listed as requiring any sort of special concern. The bar seems to be set rather high for “proving” a link between EFH and fish production and the burden of proof is clearly shifted to those who believe EFH is important.

Outside consultation with interested groups is needed to obtain their input, information and data. One mechanism might be a public consultation that embraces fishing groups. Such an approach would serve the dual function of filling some of the gaps in data (particularly as it pertains to habitat) and also help to create a spirit of cooperation with fishermen.

Additional protected areas could be very useful in terms of potentially enhancing adjacent fisheries and ensuring healthy ecosystem functioning. Establishing protected habitat may

be much easier to achieve if there are areas that are *not* currently fished and fishermen are involved in the process. Such an approach has worked successfully in Australia and resulted in a large increase in the proportion of protected marine habitat and therefore a much stronger buffer in the long term for fish production.

The assumptions of random allocation of effort within model blocks needs to be tested in selected sub-regions where the impact of fishing on EFH has been predicted to be significant (e.g., > 20% long term impact) using observer or other fishing effort data.

4. Main Conclusions/Recommendations

4.1 Conclusions

As review panel members, we have been asked to examine and comment on the model and methods described in Appendix B of the DEIS to assess the effects of fishing on habitat. The assessment is restricted to the effects on managed species and their long-term productivity or sustainability as a fishery. The task given to the NMFS scientists was a difficult one because there is a general lack of data and knowledge on both how and when fish use particular habitats and how important habitat is relative to other issues such as environmental conditions, food, predators, etc.

The habitat reduction model in the present DEIS, as acknowledged in the report, suffers from several factors including assumptions of constant fishing pressure and random distribution of fishing effort, coarse resolution of sediment and habitat types, as well as the high uncertainty in the damage done by the trawls, the number of times the trawls touch bottom, and the recovery rate of the habitat. As a result, the model should only be considered an intuition-building tool and the absolute value of the predicted impacts a relative index of the potential impact of fishing activities on EFH. A major criticism is the lack of any attempt to validate the model. The model needs to be tested against observations, using data from Alaskan waters, if available, and other regions such as Georges Bank or the North Sea where major studies of trawling impacts have been undertaken.

The use of additional available data and further analyses could improve the model. These include among others (1) analysis of the spatial and temporal patterns of the fishing effort and their relation to habitat type, (2) back calculations to determine the state of the habitat relative to previous conditions, and (3) better resolution of the surficial sediments, if only in certain areas. However, even if the model were improved by better resolving the model parameters, obtaining finer spatial resolution of the fishing effort and sediments, and accounting for temporal changes, especially in effort, it was felt that the pattern of habitat reduction produced by the model would unlikely be significantly altered from that shown in the present draft of Appendix B. The additional data and analyses should still be used and undertaken to confirm the robustness of the model.

Many of the leading researchers and several key recent papers in the field of fisheries impacts on habitat were not cited nor are their results incorporated into Appendix B. Also, many of the excellent field research programs on Alaskan regional fishery habitats, including those being conducted by the NMFS, were not cited or acknowledged. Consequently, more information on the roles that biogenic structures on both soft and hard benthic environments in the Alaska region may play in the ecology of commercial species is available than is presented in the DEIS.

The model estimates the percent reduction in habitat due to fishing but does not provide a measure of the effect of habitat destruction on the sustainability of the fish stocks. To assess the latter, evaluators relied heavily upon the population abundance relative to MSST to determine if there has been a measurable effect on the stocks from habitat loss. The assumption was that if habitat loss negatively affected stock productivity, then it would be reflected in the state of the stock relative to MSST. The panel felt this criterion is not an appropriate one because it is largely insensitive to habitat changes. One of the difficulties with this approach is that the variability in abundance of the stock responds to many factors besides habitat changes, including water masses fluctuations, predator and prey fields, and fishing directly. Also, massive and virtually irreversible damage to some habitats (e.g. coral and sponge gardens) may occur before species decline below their MSST or it is detected.

The heavy reliance on the population-based criterion resulted in little attention being paid to the local effects of habitat loss. Even in areas where the model indicated that the habitat was severely reduced, there were no mitigation procedures proposed.

Given the high parameter uncertainties, the assumptions in the model and the dependence of the stock levels relative to MSST to factors besides habitat, the panel concluded that it is premature to conclude that there the current level and pattern of fishing activity has minimal or temporary effects on the habitat and the capacity of managed species to remain about a threshold biomass levels that would ensure long term productivity and sustainable fishing of the stocks in the EBS, GOA and AI. This is further emphasized by the over 40% of the evaluations labeled as “Unknown”. The conclusions of the report are also at odds with the overall conclusions of the NRC (2002) report on the effects of trawling and dredging on seafloor habitat. Therefore, NMFS should provide a detailed discussion of the reasons for these differences of opinion once further analyses (see below) have been carried out.

Since the use of the abundance of the stock relative to MSST is not considered to be an appropriate measure, there has to be a systematic and quantitative approach to the evaluation of possible impacts of trawling on managed species that must focus more on the potential for localized impacts predicted from the model. Emphasis should be placed on analysis of proximate variables that are immediately reflected in the individual fish (e.g., condition, growth, fecundity, gut fullness). Once these have been assessed one can start to make substantive conclusions about the potential effect of fishing activities on EFH on the capacity of stocks to maintain productivity. Also, spatial patterns in secondary processes (e.g., changes in the distribution of recruits, CPUE) can be

considered in relation to the distribution of fishing effort to determine if the patterns of change that are connected with the current patterns of fishing effort. These could then be combined with the model results of habitat loss as well as integrative measures of stock production to address the potential impact of fishing on EFH. In the latter case, it is important to consider the history of the stock and how it has responded to changes in management practices aimed at ensuring stable biomass levels above threshold levels. If the response had not been anticipated, particularly if management measures have proven to be less effective, then it may not be possible to exclude the cumulative impact of trawling on EFH as a possible cause for the reduced response, even if other environmental factors may appear to be at play.

Because of the large uncertainty in our understanding of the processes linking habitat and life history stages of fish, in the habitat reduction model and the factors influencing stock productivity, a precautionary approach needs to be applied to the evaluation of fishing effects on EFH. Research closures or other precautionary management measures should be utilized to protect potential EFH while research is carried out to assess these habitats, their ecological role, and the impacts of fishing.

Although the requirements were to assess the effects of habitat changes due to fishing on both the sustainability of the fishery and the health of the ecosystem, the latter was not addressed in Appendix B. Several marine scientists and organizations are presently struggling with this issue and it is suggested that a review of this work be undertaken along with the development of ecosystem indicators as a first step in assessing the health of the Alaskan ecosystem.

Finally, while Appendix B was generally well written, it occasionally suffers from a lack of information, details or quantification. These need to be corrected in the final version. Some examples include the following. What is the level of loss of habitat that would be considered unacceptable or at least significant enough to warrant concern? What is exactly meant by the term “professional judgment”? Provide justification for the assumptions made.

4.2 Recommendations

4.2.1 Short term

Within the timeframe in which NMFS is required to publish a completed EIS, the following activities would provide a stronger basis for conclusions about the potential impact of fishing on EFH:

- Validate the habitat reduction model in regions or areas where data are available.
- Compare the spatial pattern of length-weight relationships for different species with the fishing effort pattern. If the fish in the heavily fished areas are in poorer condition (less weight for the same length fish) then this might argue for an affect of fishing through habitat degradation.

- Test the assumption of random spatial distribution of fishing effort using a combination of observer, logbook and VMS data. Show the temporal distribution of fishing effort and discuss possible effects of fishing on the spawning process. It should also examine the time between multiple trawls in relation to the recovery time for the habitat.
- Use the model to determine the time dependent nature of the loss of habitat for each of the species. How long does it take to reach “equilibrium”? Has “equilibrium” been reached? Back-calculate the time to pristine conditions given reasonable assumptions about the fishing effort. How does this compare with when trawling began?
- Provide time series of the stock size of each species relative to its current MSST level.
- Take advantage of existing substrate data to provide a better surficial sediment map on which to apply the model.
- Use the model in hindcast mode to examine past history of trawled areas and to obtain a better understanding of how the existing equilibrium status of populations relates to historical patterns.
- Compare the spatial pattern in the CPUE from the surveys and the commercial fishery to the pattern of fishing effort. Has the CPUE been declining in areas of heaviest fishing and where the habitat has been most affected?
- Integrate the results from on-going research associated with fishing gear effects on the seafloor as much as possible into parameterization and testing of the model, and in the qualitative evaluations of the effects of fishing on EFH of the various managed stocks.
- The rate of destruction of hard corals and sponges should be checked from the groundfish survey data to determine the reliability of I in the habitat reduction model for these habitats.
- Broaden the scope of the evaluators of habitat effects by including the opinions, information and data of stakeholders.
- Explore alternative models that take advantage of existing data on growth, fecundity etc. in different habitat types as an alternative to the MSST analysis. Specifically, a spatially explicit examination of parameters other than population abundance (e.g., growth rates, size at age, fecundity, condition etc.) is preferable. These analyses may not be possible for all stocks and populations but the development of detailed case studies which cover a representative range of life histories (e.g., spawning patterns, level of parental care, feeding habitats, migratory requirements, taxonomic categories, etc.) would provide a more comprehensive evaluation of the potential impacts of fishing on EFH based on past patterns in fishing activity.
- The evaluations of the effects of fishing on habitat need to be reconsidered after the above suggestions are completed. The alternative model results and information from other regions should be taken into account along with the MSST and the model results to assess the possibility of habitat degradation affecting commercial fish stocks. Where the data are unclear, or where habitat reduction is high even if the abundance levels are above MSST, the precautionary approach should be used. This may result in some habitats being classified as potentially impacted by fishing.
- Reduce the total number of species/stocks examined in Appendix B and examine the data rich stocks in greater detail.

- Review the work being done elsewhere on ways of assessing the health of an ecosystem and develop relevant indices to help monitor the health of the Alaskan ecosystem.

4.2.2 *Long-term*

The following are longer-term activities and research that should be carried out as a means of improving the knowledge base.

- The habitat associations of the various species should be determined from the groundfish survey data. The habitat features should include at least temperature, depth and type of habitat. This would help to determine what, if any, feature most affects the distribution of the various fish species.
- Use the above associations and other available information and data to produce Essential Fish Habitat Source documents similar to those produced for some of the fish stocks in the US Northeast.
- The presence of closed areas to trawling offers the potential for research on the influence on trawling on habitat. These should include monitoring of the closed and open areas and comparisons carried out between the two. Experimental field programs should be established to determine the recovery rates of different types of habitat to known trawling.
- Surficial sediment surveys need to be carried out throughout Alaskan waters.
- The influence of habitat on the life history of different species needs to be identified. This should be carried out through observational programs that would include the use of manned and unmanned submersibles.
- More detailed investigations into the fish-habitat associations and requirements is required in regions where there are important small scale (<10 km) variations in habitat structure, especially in the Gulf of Alaska and the Aleutian Islands because of the paucity of information there. The association of the fishing activity with these habitat features must be investigate as well.
- The efforts on EFH should be closely linked with research and management efforts dealing with habitats of particular concern (HAPC). Scientifically the two subject areas cannot be viewed in isolation and the lack of inclusion of information that was clearly available within NMFS appears to point to a breakdown in logic and communication.
- Significant investment should be directed toward making the invertebrate data from scientific trawl surveys, fishing vessel logbooks, and any other relevant data available and in electronic format.

References

Reviewed Documents

- Enticknap, B. 2004. Letter providing comments on Draft Environmental Impact Statement for Essential Fish Habitat identification and conservation in Alaska, Submitted on behalf of the Alaska Marine Conservation Council, p. 20.
- NMFS. 2004a. Executive Summary of the *Draft Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska*, 11 p. plus tables and figures
- NMFS. 2004b. Appendix B: The evaluation of fishing activities that may adversely affect Essential Fish Habitat. Draft Environmental Impact Statement, 76 p. plus tables and figures
- North Pacific Fishery Management Council. 2002. Essential Fish Habitat, p. 6, *In* Draft Minutes of the Scientific Statistical Committee for September 30-October 2, 2002.
- North Pacific Fishery Management Council. 2003. Essential Fish Habitat, p. 3-4, *In* Draft Minutes of the Scientific Statistical Committee for December 2-4, 2002.
- North Pacific Fishery Management Council. 2003. Essential Fish Habitat, p. 4-6, *In* Draft Minutes of the Scientific Statistical Committee for January 27-29, 2003.
- North Pacific Fishery Management Council. 2003. Minutes of the Scientific Statistical Committee, Conference Call for June 26, 2003. 3 p.
- North Pacific Fishery Management Council. 2003. Essential Fish Habitat, p. 2-4, *In* Draft Minutes of the Scientific Statistical Committee for March 31-April 2, 2003.
- North Pacific Fishery Management Council. 2003. Essential Fish Habitat, p. 1-5, *In* Draft Minutes of the Scientific Statistical Committee for October 6-7, 2003.
- Shester, G. 2004. Comments on Alaska Region Essential Fish Habitat Draft Environmental Impact Statement, p. 24.
- Tagart, J.V. 2004. Technical Review of Appendix B: The evaluation of fishing activities that may adversely affect Essential Fish Habitat, part of the January 2004 Draft Environmental Impact Statement for Essential Fish Habitat identification and conservation in Alaska, Submitted on behalf of Marine Conservation Alliance, p. 26.
- Section 303(a)(7) of the Magnuson-Stevens Act;
- Pertinent excerpts from the NMFS regulations for EFH (50 CFR 600.10 and 600.815(a)(2)) and the associated preamble (67 FR 2354-2355);
- Pertinent excerpts from the Magnuson-Stevens Act National Standard 1 Guidelines (50 CFR 600.310(d));

Associated Papers and Documents Read and/or Referenced

- Anderson, O.F. and M.R. Clark. 2003. Analysis of bycatch in the fishery for orange roughy, *Hoplostethus atlanticus*, on the South Tasman Rise. *Marine Freshwater Research* **54**: 643-652.
- Clark M. and R. O'Driscoll R (2003) Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fisheries Science* **31**: 441-458.
- Collie, J.S., G.A. Escanero and P.C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. *Marine Ecology Progress Series* **155**: 159-172.

- Collie, J.S., G.A. Escanero and P.C. Valentine. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. *ICES Journal of Marine Science* 57: 987-1001.
- Collie, J.S., S.J. Hall, M.J. Kaiser and I.R. Poiner. 2000. Analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology* 69: 785-798.
- de Groot, S.J. 1984. The impact of bottom trawling on benthic fauna of the North Sea. *Ocean Management* 9: 177-190.
- Fossa, J.H., P.B. Mortensen and D.M. Furevik. 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia* 471: 1-12.
- Frank, K.T. and D. Brickman. 2001. Contemporary management issues confronting fisheries science. *J. Sea Res.* 45: 173-187.
- Freese, L.J. 2004. Trawl induced damage to sponges observed from a research submersible. *Marine Fisheries Review*. (In press)
- Heifetz, J. 2002. Effects of fishing gear on seafloor habitat. Progress report for FY 2002. Alaska Fisheries Science Center. October 2002.
- Heifetz, J. 2003. Effects of fishing gear on seafloor habitat. Progress report for FY2003. Alaska Fisheries Science Center. October 2003.
- Heifetz, J. 2000. Effects of fishing activities on benthic habitat: proposed research plan for the Alaska region (revised May 2003). Available at: www.afsc.noaa.gov/abl/marfish/geareffects.htm.
- Heifetz, J. 2002. Effects of fishing gear on seafloor habitat: progress report for FY 2002. Alaska Fishery Science Center. Available at: www.afsc.noaa.gov/abl/marfish/geareffects.htm
- Heifetz, J. 2003. Effects of fishing gear on seafloor habitat: progress report for FY 2003. Alaska Fishery Science Center. Available at: www.afsc.noaa.gov/abl/marfish/geareffects.htm
- Kreiger, K. 2001. Coral impacted by fishing gear in the Gulf of Alaska. Proceedings of the first international symposium on deepwater corals. (Ecology Action Centre and Nova Scotia Museum, Halifax, NS 106-117).
- Jackson, J.B.C., M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B.J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner and R.R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293: 629-638.
- Jones, J.B. 1992. Environmental impact of trawling on the seabed: a review. *New Zealand Journal of Marine and Freshwater Research* 26: 59-67.
- Koslow, J.A., K. Gowlett-Holmes, J.K. Lowry, T. O'Hara, G.C.B. Poore and A. Williams. 2001. Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series* 213: 111-125.
- McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. *Canadian Journal of Fisheries and Aquatic Sciences* 57: 2410-2419.
- McConnaughey, R.A., K.L. Mier and C.B. Drew 2000. An examination of chronic trawling effects on soft-bottom benthos of the eastern Bering Sea. *ICES Journal of Marine Science* 57: 1377-1388.

- Perry, R.I. and S.J. Smith 1994. Identifying habitat associations of marine fishes using survey data: an application to the Northwest Atlantic. *Canadian Journal of Fisheries and Aquatic Sciences* 51: 589-602.
- Reynolds, J.A. 2003. Quantifying habitat associations in marine fisheries: a generalization of the Kolmogorov-Smirnov statistic using commercial logbook records linked to archived environmental data. *Canadian Journal of Fisheries and Aquatic Sciences* 60: 370-378.
- Sainsbury, K.J., R.A. Campbell, R. Lindholm, A.W. Whitelaw. 1997. Experimental management of an Australian multi-species fishery: examining the possibility of trawl-induced habitat modification. *American Fisheries Society Symposium* 20: 107-112.
- Smith, S.J. and F. Page. 1996. Associations between Atlantic cod (*Gadus morhua*) and hydrographic variables: implications for the management of the 4VsW cod stock. *ICES Journal of Marine Science* 53: 597-614.
- Stone, R. 2004. Depth distribution, fisheries interactions, and habitat of deep-sea corals in the Aleutian Islands of Alaska-Preliminary research data. Presentation at AAAS, Seattle WA.
- Witherell, D. and C. Coon. 2001. Protecting gorgonian corals off Alaska from fishing impacts. p. 117-125. *In* Willison, J. H. M. and et al. +5 other editors. *Proceedings of the First International Symposium on Deep-Sea Corals*. Halifax, N.S., Canada, Ecology Action Centre.

Appendix: Statement of Work

Background

The Magnuson-Stevens Fishery Conservation and Management Act requires that every fishery management plan describe and identify Essential Fish Habitat (EFH) for the fishery, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other measures to promote the conservation and enhancement of EFH. NMFS and the North Pacific Fishery Management Council recently developed a draft environmental impact statement (DEIS) to consider the impacts of incorporating new EFH provisions into the Council's fishery management plans. The DEIS evaluates three actions: (1) describing and identifying EFH for fisheries managed by the Council; (2) adopting an approach for the Council to identify Habitat Areas of Particular Concern within EFH; and (3) minimizing to the extent practicable the adverse effects of Council-managed fishing on EFH. Most of the controversy surrounding the level of protection needed for EFH concerns the effects of fishing on sea floor habitats. Substantial differences of opinion exist as to the extent and significance of habitat alteration caused by bottom trawling and other fishing activities. Although an increasing body of scientific literature discusses the effects of fishing on habitat, there is no consensus within the scientific community on an appropriate methodology for analyzing potential adverse effects.

The national EFH regulations (50 CFR 600.815(a)(2)) require an evaluation of the effects of fishing on EFH, and this evaluation appears in Appendix B to the DEIS. The evaluation has two components: a quantitative mathematical model to show the expected long term effects of fishing on habitat, and a qualitative assessment of how those changes affect fish stocks. The model estimates the proportional reductions in habitat features relative to an unfished state, assuming that fishing will continue at the current intensity and distribution until the alterations to habitat and the recovery of disturbed habitat reach equilibrium. The model provides a tool for bringing together all available information on the effects of fishing on habitat, such as fishing gear types and sizes used in Alaska fisheries, fishing intensity information from observer data, and gear impacts and recovery rates for different habitat types. Due to the uncertainty regarding some input parameters (e.g., recovery rates of different habitat types), the results of the model are displayed as point estimates as well as a range of potential effects.

After considering the available tools and methodologies for assessing effects of fishing on habitat, the Council and its Scientific and Statistical Committee concluded that the model incorporates the best available scientific information and provides a good approach to understanding the impacts of fishing activities on habitat. Nevertheless, the model and its application have many limitations. Both the developing state of this new model and the limited quality of available data to estimate input parameters prevent drawing a complete picture of the effects of fishing on EFH. The model incorporates a number of assumptions about habitat effect rates, habitat recovery rates, habitat distribution, and habitat use by managed species. The quantitative outputs of the analysis

may convey an impression of rigor and precision, but the results actually are subject to considerable uncertainty.

One major limitation of the model is that it does not consider the habitat requirements of managed species or the distribution of their use of habitat features. Therefore, DEIS analysts were asked to use the model output to address whether continued fishing at the current rate and intensity is likely to alter the ability of a managed species to sustain itself over the long term. In other words, are the fisheries, as they are currently conducted, affecting habitat that is essential to the welfare of each managed species? To help answer that question, the analysts considered available information about the habitats used by managed species. The analysts also considered the ability of each stock to stay above its minimum stock size threshold (MSST), after at least thirty years of fishing at equal or higher intensities. MSST is the level below which a stock is in jeopardy of not being able to produce its maximum sustainable yield on a continuing basis.

The DEIS analysis concludes that despite persistent disturbance to certain habitats, the effects on EFH are minimal because there is no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term. The DEIS finds that no Council-managed fishing activities have more than minimal and temporary adverse effects on EFH, which is the regulatory standard requiring action to minimize adverse effects under the Magnuson-Stevens Act. Additionally, the analysis concludes that all fishing activities combined have minimal, but not necessarily temporary, effects on EFH. These findings suggest that no additional management actions are required pursuant to the EFH regulations.

Expertise Needed for the Review

The review panel shall comprise six individuals. Panelists shall have expertise in benthic ecology, fishery biology, fishing gear technology, ecological modeling, and/or closely related disciplines.

Information Reviewed

I reviewed the following materials:

- The Executive Summary from the *Draft Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska* (11 pages plus tables and figures);
- The evaluation of fishing activities that may adversely affect EFH (Appendix B to the DEIS; 76 pages plus tables and figures);
- Section 3.4.3 of the DEIS, 20 pages plus 1 table and 5 figures.
- EFH sections of the minutes of the Council's Scientific and Statistical Committee meetings in October 2002, December 2002, February 2003, April 2003, June 2003, and October 2003 (each is approximately 2 pages);
- Section 303(a)(7) of the Magnuson-Stevens Act;

- Pertinent excerpts from the NMFS regulations for EFH (50 CFR 600.10 and 600.815(a)(2)) and the associated preamble (67 FR 2354-2355);
- Pertinent excerpts from the Magnuson-Stevens Act National Standard 1 Guidelines (50 CFR 600.310(d)); and
- Selected public comments on the DEIS that are pertinent to Appendix B, including criticisms of the analytical approach (comments to be selected by NMFS after the close of the public comment period on April 15, 2004).

Panelists should refer to the following website to access all background material.

<http://www.fakr.noaa.gov/habitat/efh.htm>

Questions to be Answered

Given the context of the Magnuson-Stevens Act requirements and the EFH regulations, the CIE reviewers shall address the following issues:

1. Does the model incorporate the best available scientific information and provide a reasonable approach to understanding the effects of fishing on habitat in Alaska?
2. Does the DEIS Appendix B analysis provide a reasonable approach for identifying whether any Council-managed fishing activities adversely affect EFH in a manner that is more than minimal and not temporary in nature? (For purposes of this question, the terms “temporary” and “minimal” should be interpreted consistent with the preamble to the EFH regulations: “Temporary impacts are those that are limited in duration and that allow the particular environment to recover without measurable impact. Minimal impacts are those that may result in relatively small changes in the affected environment and insignificant changes in ecological functions.”) To answer this question, the panel shall address at least the following issues:
 - a. Does the DEIS Appendix B analysis apply an appropriate standard (including the consideration of stock status relative to MSST) for determining whether fishing alters the capacity of EFH to support managed species, a sustainable fishery, and the managed species’ contribution to a healthy ecosystem?
 - b. Does the DEIS Appendix B analysis give appropriate consideration to localized habitat impacts that may reduce the capacity of EFH to support managed species in a given area, even if those impacts do not affect a species at the level of an entire stock or population?
3. What if any improvements should NMFS consider making to the model, or to its application in the context of the DEIS, given the limited data available to use for input parameters?

Review Process, Deliverables, and Schedule

The review panel shall consist of six members, one of whom shall serve as the Chair, as specified below.

Duties of the Chair

1. The Chair shall moderate the June 29 meeting with the NMFS scientists as well as other meetings the panel may have to conduct its work.
2. The Chair shall compile all of the panelists' input from the meeting and from their review reports to prepare a summary report, and shall provide the summary report to Dr. David Die via e-mail at ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani via email at mshivlani@rsmas.miami.edu. This summary report shall accurately present all the opinions and findings of each individual panelist in an easily read summary, and shall not represent a consensus report. The Chair shall provide the summary report to the CIE no later than July 23, 2004.
3. The Chair shall present the results of the review to the Council and its Advisory Panel and Scientific and Statistical Committee at a meeting on or about October 6, 2004, in Sitka, Alaska.

Signed _____

Date _____