External Peer Review of Ecosystem-Based Fishery Management Strategy

April 30 – May 3, 2018

Clark Conference Room
NEFSC Woods Hole Laboratory
Woods Hole, MA

Individual Peer Review Report prepared for the Center for Independent Experts

by
Dr. Keith Brander

DTU Aqua, Technical University of Denmark, Kongens Lyngby, Denmark

Table of Contents

EXECUTIVE SUMMARY

The Panel were given a very detailed and cogent series of presentations on the proposed ecosystem-based fisheries management (EBFM) strategy and conceptual framework that aims to provide information needed for fisheries management by the New England Fisheries Management Council (NEFMC) The standard of the work described was excellent and gives a very good basis for moving forward to the next stage in implementing EBFM. Specifically, the proposed Ecological Production Units (EPU) are founded on consistent and objective methods and appropriate data to define ecological regions for which integrated management plans can be developed. The proposed Fishery Functional Groups (FFGs) will help to address problems arising from technical and biological interactions in the mixed fishery and to reduce the cost and complexity of management. However, they will not solve these problems on their own and are best regarded as a starting point from which to test and improve.

The EBFM strategy performance framework that we were tasked to evaluate includes objectives, management strategy (including harvest control rules), simulation (operating) models and performance statistics. The framework employs state-of-the-art methods and builds on the impressive body of knowledge about the marine ecosystems, productivity, fisheries and history of Georges Bank and the NEFMC area. The simulated stock assessments should be compared with current single species stock assessments as a step towards carrying out full management strategy evaluation, bearing in mind that the first step towards EBFM is to show that it is an improvement on current management.

The development of EBFM for the area is framed by national regulations and is to a greater or lesser extent constrained by the status quo in terms of current structure of fisheries enterprises and fish stocks but also other social, economic and conservation interests. The strategy performance framework and the ‘‘strawman” objectives are designed principally to maintain high biomass productivity of a range of species and sufficient biomass of species that may become overfished. Extensions to the framework (and its simulation models) or evaluation of other models with different structures would help to explore a wider range of objectives, and would also provide comparisons to highlight the strengths and weaknesses of different simulation models and approaches. In particular I would suggest the use of other models that include the full-size spectrum of fish life histories, and therefore take account of early life interactions. For example, a recently published size-based model of the Northeast (NE)US shelf fisheries ecosystem explores ecosystem-level efficiency of trade-offs between yield and conservation impacts using a size-based 24 species model and concludes that gains in both yields and conservation are possible.

BACKGROUND

The Ecosystem Based Fishery Management Strategy Review Panel (hereafter referred to as the "Panel") was convened by the New England Fishery Management Council (NEFMC) on April 30 – May 3, 2018 in Woods Hole, MA. The goal of the review was to evaluate a proposed strategy for implementing Ecosystem Based Fishery Management (EBFM) for the New England Fishery Management Council. This was a research-track review, focused on evaluating the conceptual framework of the proposed EBFM strategy and a worked example of its application to the Georges Bank ecosystem. The work reviewed by the Panel was conducted by Northeast Fisheries Science Center (NEFSC) scientists in collaboration with the NEFMC Ecosystem Plan Develop Team, and with input from the NEFMC. The review included a simulation study to evaluate the appropriateness of the strawman objectives, operating models, assessment models, reference points, harvest control rules, and performance metrics of the EBFM management procedure. The reviewers were asked to provide feedback on the EBFM strategy and to make recommendations that could improve performance of the EBFM strategy. The goal was not to evaluate the output of the EBFM procedure for use in management specification setting at this stage. If the review is favorable, subsequent steps will be necessary before the procedure can be used in specification setting. These subsequent steps include: definition of management objectives by the NEFMC, potential changes in regulations and fishery management plans, clarification from NMFS on the application of functional group overfishing limits (OFLs), potential changes in management units, etc.

REVIEW PANEL

The Panel consisted of Dr. Lisa Kerr (Chair), and Center for Independent Experts (CIE) reviewers: Dr. Keith Brander, Dr. Villy Christensen, and Dr. Daniel Howell. Dr. Lisa Kerr is currently Vice Chair of the NEFMC Science and Statistical Committee and a research scientist with the Gulf of Maine Research Institute, Portland, Maine. Dr. Keith Brander is a Senior Researcher at Technical University of Denmark, Lyngby, Denmark, with a background in integrating ecosystem effects into fisheries assessment and management. Dr. Villy Christensen is a Professor the University of British Columbia specializing in ecosystem modelling. Dr. Daniel Howell is a Fisheries Mathematical Modeller at the Institute of Marine Research, Bergen ,,Norway, with expertise in multi-species modeling and management strategy evaluation. More information about each panelist's research and scientific expertise can be found at: https://www.nefsc.noaa.gov/program_review/reports2018.html.

As Chair of the Panel, Dr. Kerr facilitated the meeting and made sure that all the terms of reference were reviewed by the Panel. She also led the preparation of the Peer Review Panel Summary Report. Drs. Keith Brander, Villy Christensen, and Daniel Howell served as independent and impartial reviewers. The reviewers each completed independent peer review reports in accordance with the requirements specified in the Statement of Work and terms of reference (Appendix A), in adherence with the required formatting and content guidelines; reviewers were not required to reach a consensus. Reviewers submitted Individual Peer Review Reports and contributed to the Peer Review Panel Summary Report.

REVIEW ACTIVITIES

During the review, the NEFMC tasked the Panel with two objectives: 1) review a proposed implementation of Ecosystem Based Fishery Management for the New England Fishery Management Council (NEFMC), and 2) review the proposed strategy for implementing EBFM on Georges Bank. Under objective two, the Panel was asked to address nine terms of reference (Appendix A):

1) Evaluate the approach used to identify Ecological Production Units on the Northeast Shelf of the United States and the strengths and weaknesses of using these Ecological Production Units as the spatial footprint for Ecosystem Based Fisheries Management in the region.
2) Evaluate the methods for estimating ecosystem productivity for the Georges Bank Ecological Production Unit and advise on the suitability of the above methods for defining limits on ecosystem removals as part of a management procedure.
3) Evaluate the approach and rationale for specifying Fishery Functional Groups as proposed management units.
4) Comment on the applicability and utility of the strawman management objectives and associated performance metrics which were used to guide the development of operating models.
5) Evaluate the utility of the proposed management reference points as part of a management control rule for ecosystem-based fishery management. These include: an overall catch cap at the Ecological Production Unit level conditioned on environmental conditions, ceilings on catch for each Fishery Functional Group (defining overfishing) conditioned on aggregate properties, and biomass floors at the single species level (defining overfished conditions).
6) Review harvest control rules embodying the proposed floors and ceilings approach using the ceiling reference points in ToR 5 to cap removals at the Ecological Production Unit and Functional Group levels, while ensuring that no species biomass falls below the single species floor reference points.
7) Review the structure and application of operating models for Georges Bank.
8) Review ecosystem assessment models and required data sources, as applied to the simulated data from the operating models in ToR 7.
9) Review simulation tests and performance of the proposed management procedure incorporating the floors and ceilings approach, given the set of EBFM goals and objectives.

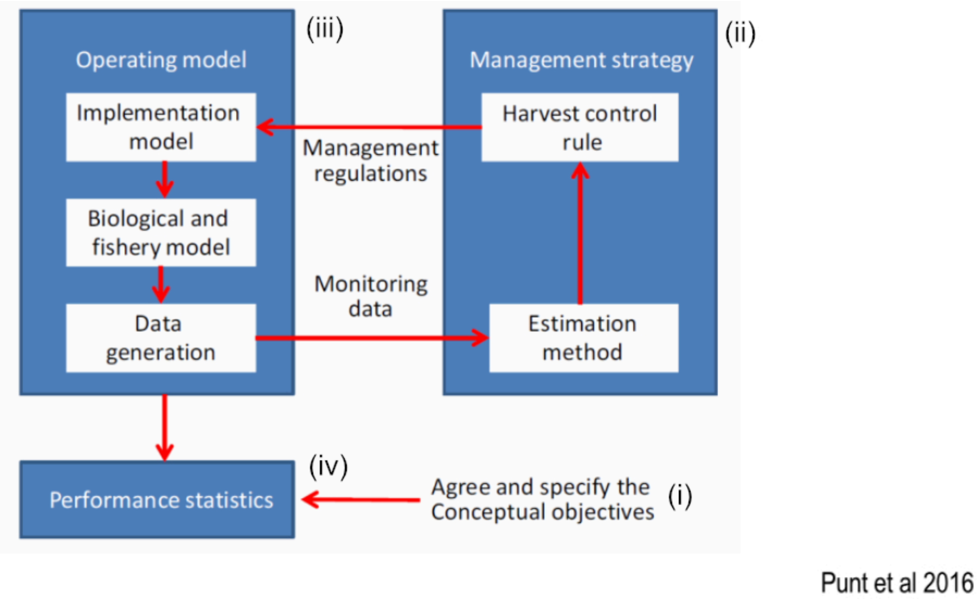
Prior to the in-person meeting, the Panel was provided written materials to review describing the EBFM strategy. During the meeting, the NEFSC EBFM technical team and NEFMC EBFM Plan Development Team (PDT) (including Drs. Mike Fogarty, Rob Gamble, Sean Lucy, Andy Beet, Andy Applegate) presented on model details and results of model simulations under different harvest control rules (see meeting agenda, Appendix B). The review was a public meeting that had several designated times on the agenda for public comment and was open for participation through webinar (Appendix C). All written materials and presentations were made available at the NEFMC website (https://www.nefsc.noaa.gov/program_review/).

INDEPENDENT EVALUATION OF THE NINE TERMS OF REFERENCE

Preamble on interdependence of objectives and tools

The stated goal of our review is "to illustrate how the proposed EBFM strategy and conceptual framework would be applied to provide the information needed for fisheries management by the NEFMC". The strategy and framework (Figure 1) includes (i) objectives ("strawman objectives" since they are yet to be decided by NEFMC), (ii) a management strategy to achieve those objectives, (iii) the "operating model" (or multispecies fishery simulation model), which is "in this case a multi-model suite that can include empirical approaches as well as simulation models" to represents the fisheries system being managed, and (iv) performance statistics.

Figure 1: Strategy and framework. Performance statistics relate the output of the operating model



to conceptual objectives.

We were also provided with Figure 2 that shows the design and implementation sequence for the strategy and framework (in Hydra). Figure 2 shows that ecosystem reference points are derived from both the simulated assessments, and the satellite derived primary production. It also shows modules within the multispecies fishery (operating) and assessment models.

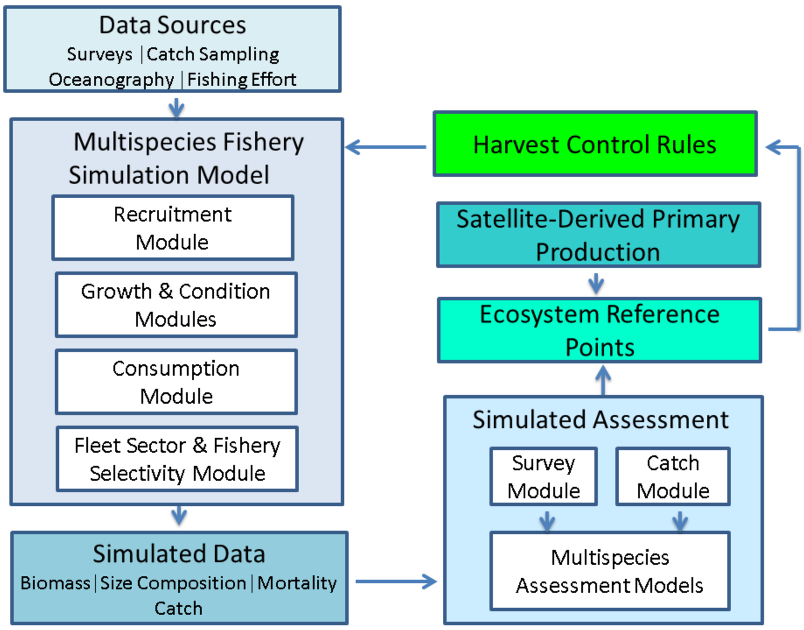


Figure 2: Modular design and implementation sequence in *Hydra.*

Reviewers were asked to evaluate selected operating models in relation to some "strawman objectives". Had different "strawman objectives" been chosen, these would have to be evaluated against different performance statistics, which may require different operating models. I would postulate that the NEFMC debate and decision about objectives may be substantially influenced by the kinds of operating models that are presented to simulate the multispecies fishery. For example, if only single species models were available to simulate the actual multispecies fishery of the region (in the real world, species interact and the fisheries are part of a coupled social-biological system, whether or not we have models that include interactions and other components of the system), then the chosen objectives would, out of necessity, be single species objectives. A variety of operating models will help to provide a broad range of options for debating and choosing objectives for EBFM and the process of choosing may require several iterations. Intercomparisons among models, that represent the same system in different ways, help to show up their strengths and weaknesses and may also reveal alternative or additional strategic and operational objectives. Once the objectives for EBFM are specified and agreed by the NEFMC, then operating models must obviously be capable of producing performance statistics to measure how well the chosen objectives are achieved.

ToR 1: Evaluate the approach used to identify Ecological Production Units on the Northeast Shelf of the United States and the strengths and weaknesses of using these Ecological Production Units as the spatial footprint for Ecosystem Based Fisheries Management in the region.

In contrast to current management, which has evolved a patchwork of management areas for different species, Ecosystem Based Management (EBM) requires defined ecological regions (Ecological Production Units-EPU) for which integrated management plans can be developed. The question asked was whether one can identify a reasonably small number of spatial management units (EPU) using objective and consistent methods. The answer is broadly yes and the work presented provides a coherent spatial aggregation into EPUs, based on well established physical and biological characteristics that are suitable for the development of integrated management plans.

The variables used to determine EPU include bathymetry, surface sediment, temperature, salinity, stratification, chlorophyll and primary production (Table 1). Variables to represent higher trophic levels or fishing activity were not included, as they reflect human choices and activities that may not be related to the underlying ecological production systems. The data were standardised to annual means within spatial units of 10' latitude by 10' longitude, resulting in over 1000 spatial points, but omitting inshore (<27m) areas due to sampling limitations. A multivariate (Principal Component) analysis showed that the first component, accounting for 36.3% of the variance, was dominated by variablity in mean primary production, depth, fall salinity and mean chlorophyll. The second component (25.6% of variance) was dominated by temperature and salinity.

Table 1. The variables used as input for the PCA and clustering analysis showing their original data type, source, units, and time period.

Variables	**Sampling Method**	**Units**
Bathymetry	Soundings/Hydroacoustics	Meters
Surficial Sediments	Benthic Grab	Krumbein Scale
Sea Surface Temperature	Satellite Imagery (4km grid)	^{0}C annual average
Surface Temperature	Shipboard Hydrography (point)	^{0}C (Spring and Fall)
Bottom Temperature	Shipboard Hydrography (point)	^{0}C (Spring and Fall)
Surface Salinity	Shipboard Hydrography (point)	psu (Spring and Fall)
Bottom Salinity	Shipboard Hydrography (point)	psu (Spring and Fall)
Stratification	Shipboard Hydrography (point)	Sigma-t units (Spring and Fall)
Chlorophyll-a	Satellite Imagery (1.25km Grid)	mg C/m^3 (annual average)
Chlorophyll-a gradient	Satellite Imagery (1.25km Grid)	dimensionless
Primary Production	Satellite Imagery (1.25 km)	gC/m^2 /year (cumulative)
Primary Production gradient	Satellite Imagery (1.25 km)	dimensionless

Cluster analysis was used to group the >1000 spatial points initially into seven clusters. Nesting of nearshore and continental slope regions within adjacent shelf regions further reduced the number of clusters to four (Mid-Atlantic Bight, Georges Bank, Western-Central Gulf of Maine, and Scotian Shelf-Eastern Gulf of Maine).

The methods used to produce these EPUs are fairly standard, objective and consistent, and the outcome is reassuringly similar to previous mapping of EPUs for the NEFMC area (e.g.The Northeast Regional Ecosystem Plan (1988)). It is inevitable that mapping a wide range of biological and fisheries diversity (sizes, life histories, taxonomy, fishing methods, seasonal patterns) onto these EPU will result in some problems and misfits that require special treatment. However, the EPU are to be regarded as interconnected and having open boundaries that will be subject to periodic updates and reanalysis (5-10 year time scale) as climate, human use patterns, and other factors change.

Some specific, but by no means insoluble, problems are likely to arise within the NEFMC area where fishing activities frequently straddle the EPU boundaries (e.g., across the N boundary of Georges Bank), and where highly migratory species have ranges that extend well beyond those boundaries. My recommendation would be to agree on an outline strategy for tackling such problems as may arise before they become a major point of disagreement or conflict.

Future changes, including climate-induced changes, that are likely to affect the boundaries of EPUs were discussed. Since the boundaries are largely determined by elements that will not change over the next decades (e.g., bathymetry, coastal influence, tidal mixing, cross-shelf nutrient flux) the EPU boundaries should persist. Nevertheless, it is a fact that many of the most intractable fisheries disputes have arisen, because species distributions have, quite predictably, shifted across management boundaries (e.g., Dankel et al. 2015). Such disputes, arising from attempts to impose fixed boundaries on changeable biological entities (typically migratory species), could be regarded as self-inflicted problems. They can be avoided or mitigated by increasing the size of the spatial management units (EPUs) or by anticipating change and agreeing management procedures that will allow for time-varying EPUs or measures to deal with trans-boundary issues. While the proposed periodic update of EPU boundaries seems sensible it is also likely that time-varying EPUs would create their own set of problems for management. For example, it may be difficult to re-assign historic fisheries information (both commercial and research surveys) and to re-allocate historic catch shares to fit within new EPU boundaries.

Summary, conclusions and recommendations

The methods used produce a coherent spatial aggregation into EPUs that are consistent with earlier biogeographic regions and can be used as the spatial footprint for EBFM. There are likely to be some problems with species that migrate across boundaries and fishing activities that straddle them. I recommend agreeing on a strategy for dealing with migratory species in advance of any management problems that may arise from such migration.

Dankel, D. et al., 2015. *Allocation of Fishing Rights in the NEA*, Nordic Council of Ministers. Available at: http://urn.kb.se/resolve?urn=urn:nbn:se:norden:org:diva-3942.

ToR 2: Evaluate the methods for estimating ecosystem productivity for the Georges Bank Ecological Production Unit and advise on the suitability of the above methods for defining limits on ecosystem removals as part of a management procedure.

This evaluation of ToR2 will consider first the methods used to estimate ecosystem productivity for the Georges Bank EPU, and second the suitability of these estimates for defining limits on ecosystem removals.

The estimates of ecosystem productivity for the Georges Bank EPU presented here build on a long and impressive history of research into primary and secondary productivity for this area. It is fair to say that many of the methods developed here represent the global state-of-the-art, and are emulated in other parts of the world. Fisheries production depends on the primary and secondary production (quantity and quality) that fish feed on. The aim is to determine the fisheries production *potential* of Georges Bank conditioned on the input of primary production and specified levels of trophic transfer efficiency. This aim is intuitively simple to grasp, but difficult to achieve for a number of reasons that can introduced with a terrestrial analogy.

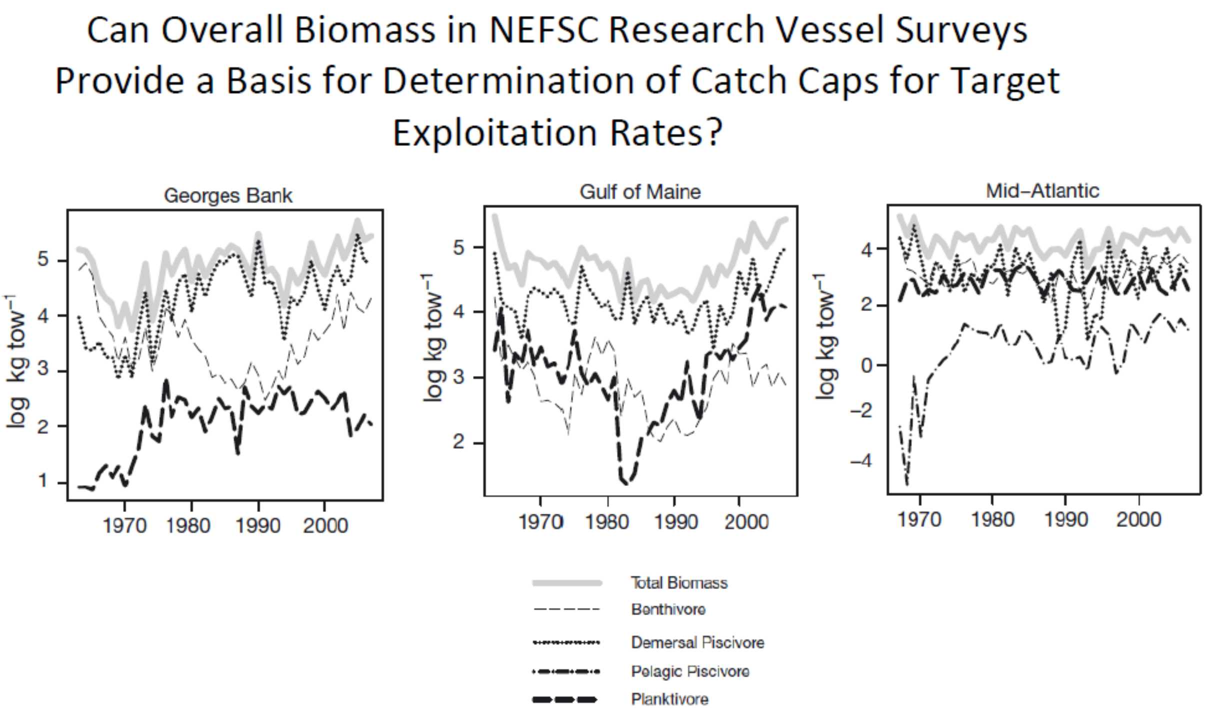
Until the advent of agriculture about 15K years ago, humans hunted and gathered their food from natural ecosystems. Planting and harvesting crops (agriculture) entailed (i) harvesting at the lowest trophic level (ii) harvesting a small number of species (iii) getting rid of predators and pests (iv) enclosing (owning) and cultivating. These actions can be regarded as forms of management that simplified and reduced the variability of the ecosystem in order to make it easier to control and predict, and also to increase the quantity of food produced. Of course none of these simplifying actions are proposed as part of EBFM here; rather, fisheries production potential of Georges Bank, and the consequent limits on removals, have to take account of explicit (e.g., mandated by law) and implicit constraints, which include (i) conservation of ecosystem structure, functioning and diversity (ii) maintaining existing species and size composition of fisheries catches (iii) maintaining viabilty of existing fisheries sectors.

All fisheries are a form of ecological engineering; we may regard the existing pattern of fishing and its concommitant ecological impacts as representing the “status quo” that we wish to persist, but this is a choice. Optimum yield, as defined for National Standard 1 (further discussed later under ToR 4) should take account of food production, recreational opportunities, intrinsic (existence) value, profitability, stability of biological and social systems, and protection of marine ecosystems. These affect the definition of limits on ecosystem removals, and also the species that are included in calculating those limits from the bottom-up trophic model. Such effects on limits are alluded to in the EBFM Summary Document when discussing “currently latent resources”: “Although the ecosystem risks of exploiting currently latent resources would need to be carefully evaluated, diversification of the exploitable resource base holds the potential to reduce pressure on the system overall if carefully implemented (Fogarty and Murawski 1997).” Similarly, a recently published study (Jacobsen et al. 2016) explored ecosystem-level efficiency of trade-offs between yield and conservation impact using a size-based 24 species model of the NE US Continental Shelf fisheries ecosystem and concluded that gains in both yields and conservation were possible with more efficient fisheries.

Jacobsen, N.S., Burgess, M. & Andersen, K.H., 2016. Efficiency of fisheries is increasing at the ecosystem level. *Fish and Fisheries*, 18(2), pp.199–211. Available at: https://doi.org/10.1111/faf.12171.

Moving on from the general issue of what is meant by “ecosystem limits on production” to the specific question of whether the methods of estimating ecosystem productivity presented here are suitable for defining limits on ecosystem removals as part of a management procedure, this is a matter of judgement and I would give a qualified yes. These productivity estimates are a very good starting point for EBFM and they can be used to establish guide values on the likely limits to fisheries production. An impressive effort has gone into quantifying the uncertainties associated with the estimates of ecosystem and species guild (functional group) production, but it is clear from the medians and quartile ranges in Tables 2.1 and 2.2 of the EBFM Summary Document that while the results may have sufficient precision for strategic guidance, they are probably insufficiently accurate and precise for shorter term use. Similarly, I would question whether the claimed secular trends in species guild production, arising from apparent increases in primary production are sufficiently well established to form part of the narrative on future harvest limits, at least until the processes (e.g., role of horizontal, cross shelf nutrient fluxes, role of transport processes along the Scotian Shelf and onto Georges Bank, long term effects of NAO, etc.) are well established, credible and predictable.

As a qualification on the previous paragraph, I note that the secular trends in primary production and consequent bottom-up trophic model estimated trends in fish guild production are not the only evidence that we have. NEFSC research vessel(RV) surveys show comparable trends for fish guilds; the question of whether these could provide a basis for defining limits on fisheries production will be addressed under ToR5.



Very extensive historic sampling of stomach contents from trawl surveys is used to estimate feeding preference and trophic levels, and to define membership of feeding guilds of fish. Detailed feeding data is a key component of the models used here. The feeding interconnections (as predators and prey) between species are complex, but in spite of their detail and complexity, the feeding data used here also constrain the domain of the model to species and sizes that are captured by the stomach surveys. Early life history stages (often referred to as pre-recruit stages), which may play an important role in biological interactions between species, are omitted. Many species of fish undergo ontogenetic shifts in their trophic status, so for example first feeding cod larvae are planktivores, with a requirement for food that will fit their jaw gape. Juvenile cod settle to the seabed and become benthivores switching gradually to an increasing proportion of fish in their diet. Furthermore in the current models, when species A eats species B this causes mortality on species B, but does not affect the growth or survival of species A. The consequences of these limitations for both the models of ecosystem production and the operating models for the multispecies system are hard to evaluate, but intercomparison with models that represent the dynamics in different ways, such as the one refererred to above that uses a simpler, size-based representation of trophic interactions, will help to show up relative strengths and weaknesses. Models with a small number of empirical and mechanistic (physiological) parameters lack detail, but will run faster than models containing a large number of mainly empirical parameters, making it easier to explore the limits and behaviour of the coupled social-biological fisheries ecosystem.

Summary, conclusions, and recommendations

Bottom-up estimates of ecosystem productivity for the region are based on state-of-the-art methods and excellent monitoring, but estimates of limits for ecosystem removals at higher trophic levels (including piscivorous fish) are inevitably subject to considerable uncertainty. Regular RV fishing surveys provide estimates of fish biomasses, and I recommend that these should be used to enhance confidence in the bottom-up estimates of limits. I also recommend evaluating other types of model (e.g. size and trait based ecosystem models) to provide alternative views on the limits for ecosystem removals.

ToR 3: Evaluate the approach and rationale for specifying Fishery Functional Groups as proposed management units.

The approach and rationale for specifying Fishery Functional Groups (FFG) stem from the technical and biological interactions in mixed fisheries and the purpose of the FFG is to help address the problems that these interactions give rise to. They are also intended as a possible means to reduce the cost and complexity of managing mixed fisheries. The technical interactions mean that particular fishing gears and fleet sectors exert a fairly set pattern of exploitation across a range of species. The biological interactions mean that species interact with each other due to predation and competition.

FFG are defined as comprising species that are caught together by specified fleet sectors and that play similar roles in the ecosystem with respect to energy transfer. FFG include both fleet (sectors, metiers) and species variables, with the latter being nested in the former i.e., particular fleet sectors that catch particular groups of species.

One can postulate that there is a pattern or set of values of fishing mortality that would result in some desirable optimal yield from the ecosystem. However, that pattern may not be attainable unless there is a combination of effort by existing FFG that achieves it. In using FFG as management units, it may nevertheless be possible to get closer to the desired optimum than with alternative management units, and they may also offer a simpler form of management. Such optimisation would of course also be constrained by conservation limits (e.g., minimum biomass limits on vulnerable species).

The idea of using FFG as management units entails aggregation of species with similar trophic and life history characteristics (e.g., benthos, planktivores, benthivores, piscivores) which brings with it the possibility of managing their aggregate yield instead of (or as well as) setting targets or limits for individual species. Benefits in terms of simplification and stability could result from management of aggregate yields of FFG, with lower (assessment and regulatory) costs and improved stability of aggregate catches due to trade-offs between species that average out the natural variability in individual species productivity (e.g., due to recruitment) from year to year.

Some of the information needed to evaluate ToR3 will be covered by ToR 4, which applies performance metrics to evaluate the performance of FFG aggregate management in combination with fixed and ramped biomass limit rules. It would additionally be interesting to see a comparison using the same performance metrics with existing single species management. However, such a comparison may be limited by the current single species coverage.

Summary, conclusions and recommendations

The approach and rationale used here to specify FFG are well thought through and appropriate for the purpose they are to serve. Further testing both in simulations and in practice will be needed to determine how effective they are and in what ways they may require adjustment. I recommend development of performance metrics specifically to measure the effectiveness of FFG in relation to technical and biological interactions, since this is a key issue in dealing with problems of multispecies fisheries in the area.

ToR 4: Comment on the applicability and utility of the strawman management objectives and associated performance metrics which were used to guide the development of operating models.

The Georges Bank EBFM summary document does not mention "strawman objectives" other than in citing ToR4, however they were explained in the presentation and subsequent discussion as being strategic and operational objectives that will be used in preliminary testing of the fishery ecosystem plan (FEP) and that are linked to performance metrics. "Our objectives are to maintain overall system resilience and to optimize yield and revenues subject to conservation constraints." System resilience and conservation constraints are to be maintained by setting a floor for biomass at the FFG or individual species level, with management action triggered at or before this threshold is reached. Yield is optimised by setting limits on the catch in order to maintain biomass above the level needed to maintain that level of production. The "strawmen" have not been formally adopted by the Council, nor have stakeholders yet been involved in the development of objectives at this stage.

In reviewing the proposed implementation of EBFM, and specifically in addressing ToR4, one can distinguish between (i) commenting on the applicability and utility of the particular strawman objectives identified above from the material provided and the subsequent discussion, and (ii) commenting on the role of these strawman objectives as a contribution to the development and adoption of objectives by the Council and also in informing the debate with stakeholders.

This matters, because the development of particular operating models is guided by how well they perform (using agreed metrics) in relation to agreed objectives, but the development and choice of objectives also depends on the kinds of operating models which are used to represent the real world. For example, if the only operating models available are single species models, then the choice of objectives will reflect that. The "**Preamble on interdependence of objectives and tools"** above discusses the mutual and iterative relationship between tools (including models) and objectives.

The presentation explained that "optimal yield" was defined in National Standard 1 as applying to a "fishery", and that optimal yield should take account of food production, recreational opportunities, intrinsic (existence) value, profitability, stability of biological and social systems, and protection of marine ecosystems. A "fishery" was defined as "one or more stocks of fish which can be treated as a unit for purposes of conservation and management and which are identified on the basis of geographic, scientific, technical, recreational, and economic characteristics". NS1 thus permits an aggregate approach to estimating the maximum sustainable yield of a fishery and also the use of EBFM.

The "strawman objectives" took account of the state of the ecosystem, functional groups and individual species and were based on the following Strategic Objectives:

1. Maintain/restore sustainable production levels (ecosystem, functional group emphasis)
2. Maintain/restore biomass levels (functional group/species scale emphasis)
3. Maintain/restore functional trophic structure

and the following Operational Objectives:

1. Ecosystem and community/aggregate fishing mortality and/or total catch is below established dynamic threshold
2. Fishing-related mortality for threatened/endangered/protected species is minimized
3. Managed and protected species biomass is above established minimum threshold
4. Maintain ecosystem structure within historical variation, recognizing inherent dynamic properties of the system; Ecosystem structure includes size structure, trophic structure, and functional group structure
5. Maintain habitat productivity and diversity
6. Habitat structure and function are maintained for exploited species
7. Minimize the risk of permanent (>20 years) impacts; e.g. Corals and sponges; Other vulnerable biogenic habitats; Coastal habitats vulnerable to Aquatic Invasive Species (AIS); Vulnerable physical habitats (e.g. relict glacial gravel banks)

These lists of potential management objectives will ultimately inform the debate and selection of objectives by stakeholders in collaboration with the NEFMC.

The performance metrics presented were:

1. Functional Group Status (Proportion overfished/depleted)
2. Species Status (Proportion overfished/depleted)
3. Landings
4. Biomass at Species and Functional Group Levels
5. Stability of Landings
6. Large Fish Index (Population)
7. Large Fish Index (Landings)
8. Revenue

Summary, conclusions and recommendations

If optimal yield (as defined for National Standard 1) is to take account of food production, recreational opportunities, intrinsic (existence) value, profitability, stability of biological and social systems, and protection of marine ecosystems, then the strategic and operational objectives listed above fall short, since they deal mainly with maintaining and restoring biological structure and productivity. It is not very clear how performance metrics 5 and 8 emerge from the presented strategic and operational objectives, but they undoubtedly address attributes of NS1 optimal yield ("profitability", "stability of biological and social systems").

It is not obvious how operational objective 7 relates to the strategic objectives, nor does it appear to have an associated performance metric, but it does clearly relate to the attributes "intrinsic value" and "protection of marine ecosystems".

The "strawman objectives" will likely contribute to framing the debate on objectives among stakeholders and the Council; therefore, it is important that (within the frame already established by legislation and the status quo) they should be reasonably neutral and comprehensive so that other options are not precluded. It is inevitable that there will be conflicts and trade-offs between different attributes of "optimal yield" (e.g., between conservation and profitability attributes) and the scope of the performance metrics should be broad enough to allow such trade-offs to be quantified. I recommend additional "strawman" objectives dealing with economic, social and conservation attributes in order to broaden the framing of the debate and subsequent choice of objectives.

ToR 5: Evaluate the utility of the proposed management reference points as part of a management control rule for ecosystem-based fishery management. These include: an overall catch cap at the Ecological Production Unit level conditioned on environmental conditions, ceilings on catch for each Fishery Functional Group (defining overfishing) conditioned on aggregate properties, and biomass floors at the single species level (defining overfished conditions).

The rationale for proposing a management control rule (MCR) or rules for ecosystem-based fishery management is well presented and compelling. Proposed management reference points, which are part of the MCR, are specified in ToR 5 and include catch ceilings for each EPU and FFG and minimum permitted biomass levels (floors) for each individual species. The catch ceilings are intended to limit the rate of removal to a level below overfishing and the biomass floors are intended to maintain all species within safe conservation limits.

As with any ceiling and floor reference points, there are questions about how they are estimated, whether they change over time, and if so, how frequently they should be updated, whether they may inadvertently act as targets rather than limits (especially the catch ceiling), whether all species are included (e.g., rare and vulnerable species), whether they are affected by environmental changes (e.g., direct and indirect climate impacts), how and when action to avoid breaching them is triggered, etc. Some of these will be considered further.

Methods for estimating ecosystem productivity and limits on removals for EPU and fish guilds were evaluated under ToR 2. While the accuracy and precision of the limits estimated from trophic models raise questions about their utility as part of a management control rule, they could be used to complement data provided by regular fishing survey to make them fit for purpose. The phrase "conditioned on environmental conditions" in ToR5 may cover a range of possible conditions, but one which has been mentioned is the apparent increasing trend in primary production and in survey indices of some fish guilds on Georges Bank. A well established and credible explanation of the causes of the apparent increase in primary production would strengthen the case for allowing these trends to influence catch caps.

The utility of biomass floors as part of the MCR depends on how such floors are defined and estimated, and on how effective the management control rule is in preventing them from being breached. This is a very complex issue that cannot be addressed briefly, so only a couple of suggestions will be presented. If the MCR is intended to simplify management and operate at an aggregate level (EPU and FFG), then, other things being equal, it could be regarded as retrograde to introduce biomass limits on each individual species. An alternative would be to identify a (regularly updated) subset of particularly vulnerable species to act as the "canary in the coalmine" for biomass limits. Focusing the conservation effort on particularly vulnerable species or groups may also pave the way for special protection of those species, based on seasonal and/or area controls that take into account their life histories, seasonal distribution and fisheries that exploit them accidentally or deliberately (e.g. Dedman 2016).

Summary, conclusions and recommendations

The case for these "ceiling and floor limits" to prevent overfishing and to avoid any stock being overfished is well made. However, I express a number of concerns about how the limits will be estimated, whether and how often they will change and how they would be applied.

Dedman, S. et al., 2016. Towards a flexible Decision Support Tool for MSY-based Marine Protected Area design for skates and rays. *ICES Journal of Marine Science: Journal du Conseil*, 74(2), pp.576–587. Available at: http://icesjms.oxfordjournals.org/content/early/2016/08/26/icesjms.fsw147.abstract.

ToR 6: Review harvest control rules embodying the proposed floors and ceilings approach using the ceiling reference points in ToR 5 to cap removals at the Ecological Production Unit and Functional Group levels, while ensuring that no species biomass falls below the single species floor reference points.

The harvest control rules (HCR) were evaluated by applying three "threshold" and three "ramp-down" exploitation rate scenarios to the multispecies fisheries simulation (operating) model. For each scenario, system based exploitation rates ranging from 0.05 to 0.4 were applied. The evaluation used performance metrics for revenue, functional group status, species status, landings, biomass, stability of landings, the proportion of large fish in the population, and the proportion of large fish in the landings. Results were presented for years 21-30 and 41-50 of the simulations.

Threshold scenarios performed significantly worse for all metrics than ramp-down scenarios, except at low exploitation rates. At high exploitation rates, the performance of the threshold scenarios was poor, even with enhanced protection for the most vulnerable species. The ramp-down scenarios in which exploitation is progressively reduced once defined trigger levels of biomass are reached and in which biomass floors were implemented for functional groups, rather than for individual species, result in greater resilience to higher exploitation rates and higher revenues, landings, and stability of landings. Highest revenues occurred at an exploitation rate of 0.25 under this scenario. The ramp-down strategy with biomass floors for individual species performs better for metrics related to conservation status than when protections are implemented only at the functional group level as nominal exploitation rates increased.

Summary, conclusions and recommendations

Applying the various scenarios of the HCR to the operating model produces simulations that are intuitively sensible. Implementing HCR at aggregate (EPU and FFG) level seems a viable option and the results provide guidance on adopting HCR in the real world, for example, showing the benefits of ramped rather than threshold limitation of exploitation rates. It is likely that other options for HCR will be put forward during discussions with stakeholders, and the operating model should be able to deal with these in a flexible way. One option which would clearly be useful to evaluate for comparison would be to emulate the existing management strategy.

It is recommended that ramped reduction in exploitation that is triggered in steps, should be avoided. A smooth rather than stepped response should help to avoid arguments about whether or not the estimated biomass falls above or below the level for triggering the next stepped reduction in exploitation.

ToR 7: Review the structure and application of operating models for Georges Bank.
ToR 8: Review ecosystem assessment models and required data sources, as applied to the simulated data from the operating models in ToR 7.
ToR 9: Review simulation tests and performance of the proposed management procedure incorporating the floors and ceilings approach, given the set of EBFM goals and objectives.

The two operating models under review were Hydra (a multispecies-multifleet length-structured simulation model) and Kraken (a multispecies production model).

The example of Hydra here included ten species (Atlantic cod, haddock, silver hake, winter flounder, yellowtail flounder, monkfish, spiny dogfish, winter skate, Atlantic herring, and Atlantic mackerel) and three fishing fleets (demersal trawl, fixed gear (longline and gillnet), and pelagic trawl).

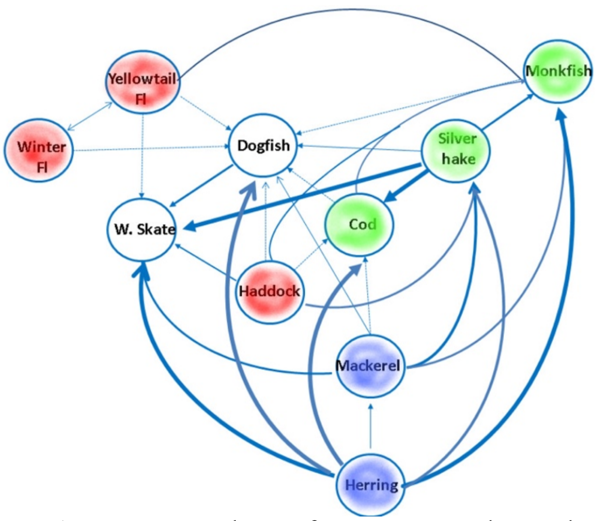


Figure - Arrows trace pathways from prey to predators; the width of the lines indicates the relative average importance of a prey species to a predator based on an extensive compilation of food habits data obtained during standardized NEFSC research-vessel surveys. red – benthivores, white – elasmobranchs, green – piscivores, blue – planktivores.

I commented under ToR 2 on the constraints that arise from the using only trophic data from the NEFSC standardized RV surveys to represent feeding relationships, and this can be illustrated by the Figure above. For example, cod is predated on by herring and mackerel in early life stages, and is a planktivore and a benthivore during early life before shifting mainly to piscivory, but these ontogenetic trophic changes are not included in Hydra. The consequences of these early life trophic interactions are in effect included in the stock-recruitment part of the Hydra model, but it would be worthwhile using other models to explore possible consequences of dealing with such early life interactions more explicitly than via the stock-recruit relationships.

The Kraken model framework was implemented here as a multispecies surplus production, used to simulate the annual biomasses of ten Georges Bank species using logistic equations. It shows promise in exploring some of the economic attributes of optimum yield by coupling with portfolio analysis to trade-off yield maximisation against risk, which shows how important risk management is for sustainable fisheries. It was also used to evaluate management procedure using ceilings on system removals, and showed that most of the variability in performance metrics is explained by catch ceilings, with lower catches traded off against reduced frequency of collapse and increased diversity. This and other relatively simple multispecies simulation models can be used to explore dynamics in relation to economic and social attributes, but they also require further evaluation to test their performance against historic data and trends.

In relation to assessment methods, the alternatives presented included outputs from simulated surveys, multispecies production models and multispecies delay-difference model. The models require biomass and catch data as inputs.

Summary, conclusions and recommendations

There are inevitable trade-offs in modelling between on the one hand detail and seeking to represent the real word closely, and on the other hand going for the simplest representation that captures the dynamics that matter for the question at hand. The Hydra and Kraken simulations could be regarded as an example of each. It would be worthwhile also to use other models that include the full size spectrum of fish life histories and therefore take account of early life interactions.

The simulated stock assessments should be compared with current single species stock assessments as a step towards carrying out full management strategy evaluation, bearing in mind that the first step towards EBFM is to show that it is an improvement on current management.

Critique of the NMFS review process

The review process was detailed thorough, and open, with ample opportunities for discussion and input from scientists, Council members and the panel. The presentations were uniformly excellent, and our questions were dealt with fully and clearly. In retrospect, there were questions that at the time seemed naive, but should have been asked, such as “can we have a short clear statement of what the “strawman management objectives” referred to in ToR 4 are

The provision of documents and web-based information, including access to the meeting wi-fi and access to the timetable and presentation material, could have been better. Given the long delay between the initial and final review dates, this material could usefully have been made available sooner. The delay that resulted from the US Government shutdown in January wasted a lot of time for a lot of people.

APPENDIX A

Documents for Review

The main document provided for reviewed by the Panel was an overview of the EBFM management procedure:

NEFSC Fishery Ecosystem Dynamics Assessment Branch. 2018. Ecosystem-Based Fishery Management Strategy, Georges Bank Prototype Study. Summary Document. April 20-May 2, 2018, Woods Hole, MA. https://www.nefsc.noaa.gov/program_review/docs/Georges%20Bank%20EBFM%20Summary%20Document.pdf.

In addition, the following background materials were reviewed by the Panel:

Ecosystem Based Fishery Management PDT. 2017. A Framework for Providing Catch Advice for Prototype Georges Bank, Fishery Ecosystem Plan. Catch Advice Framework, a Worked Example #2. New England Fishery Management Council. September 26-28, 2017. http://s3.amazonaws.com/nefmc.org/2_A-Framework-for-Proividing-Catch-Advice-for-a-Prototype-Georges-Bank-FEP.pdf.

Ecosystem Based Fishery Management PDT. 2017. A Framework for Providing Catch Advice for a Fishery Ecosystem Plan (FEP). New England Fishery Management Council. January 2017. http://s3.amazonaws.com/nefmc.org/Document-2b.-Providing-catch-advice-for-a-fishery-ecosystem-plan-eFEP.pdf.

Ecosystem Based Fishery Management PDT. 2017. DRAFT: Example application of operation models for Georges Bank ecosystem production unit (EPU) strategy evaluation. New England Fishery Management Council. January 2017. http://s3.amazonaws.com/nefmc.org/Document-3.-Example-application-of-operating-models-for-Georges-Bank-ecosystem.pdf.

Fogarty, M. J., Overholtz, W. J., Link, J. S. 2012. Aggregate surplus production models for demersal fisher resources of the Gulf of Maine. Marine Ecology Progress Series, 459:247-258. https://www.nefsc.noaa.gov/program_review/docs/b4-fogarty%20et%20al%20MEPS.pdf.

Gaichas, S., Gamble, R., Fogarty, M., Benoît, H., Essington, T., Fu, C., Koen-Alonso, M., Link., J. 2012. Assembly rules for aggregate-species production models: simulations in support of management strategy evaluation. Marine Ecology Progress Series, 459:275-292. https://www.nefsc.noaa.gov/program_review/docs/b5-Gaichas%20et%20al%20MEPS.pdf.

Gamble, R. J., Link, J. S. 2012. Using an aggregate production simulation model with ecological interactions to explore effects of fishing and climate on a fish community. Marine Ecology Progress Series, 459:259-274. https://www.nefsc.noaa.gov/program_review/docs/b-6Gamble%20and%20Link%20MEPS.pdf.

Hennemuth, R. C., Rothschild, B. J., Anderson, L. G., Kund, Jr., W. A. 1980. Overview Document of the Northeast Fisher Management Task Force, Phase 1. NOAA Technical Memorandum NMFS-F/NEC-1. October 1980. https://www.nefsc.noaa.gov/program_review/docs/b3-tm-1-hennemuth.pdf.

Link, J. S., Gamble, R. J., Fogarty, M. J. 2011. An Overview of the NEFSC's Ecosystem Modeling Enterprise for the Northeast US Shelf Large Marine Ecosystem: Towards Ecosystem-based Fisheries Management. Northeast Fisheries Science Center Reference Document 11-23. October 2011. https://www.nefsc.noaa.gov/program_review/docs/b2-crd-1123.pdf.

Lucey, S. M., Cook, A. M., Boldt, J. L., Link, J. S., Essington, T. E., Miller, T. J. 2012. Comparative analyses of surplus production dynamics of functional feeding groups across 12 northern

hemisphere marine ecosystems. Marine Ecology Progress Series, 469:219-229. https://www.nefsc.noaa.gov/program_review/docs/b-7Lucey%20et%20al%20MEPS.pdf.
NEFMC Scientific and Statistical Committee. 2010. White paper on Ecosystem-Based Fishery Management for New England Fishery Management Council. October 2010. https://www.nefsc.noaa.gov/program_review/docs/b1NEFMC%20EBFM%20White%20Paper_report_15%20oct%202010.pdf.

Presentations for Review

Presentations covered the following topics were reviewed by the Panel during the in-person meeting:

1. Objectives for the Review (Mike Simpkins, NEFSC)
2. Logistics (Rob Gamble, NEFSC)
3. NEFMC Ecosystem-Based Fisheries Management Plan Development Team (Andrew Applegate, NEFMC)
4. Background and Overview of Proposed Management Procedure (Mike Fogarty, NEFSC)
5. Defining Ecological Production Units (Robert Gamble, NEFSC)
6. Ecosystem Production Potential (Michael Fogarty, NEFSC and Kimberly Hyde, NEFSC)
7. Defining Fisheries Functional Groups (Sean Lucey, NEFSC and Mike Fogarty, NEFSC)
8. Strawman Management Objectives and Performance Metrics (Richard Bell, The Nature Conservancy)
9. Ecosystem-Based Reference Points (Mike Fogarty, NEFSC)
10. Harvest Control Rules (Mike Fogarty, NEFSC)
11. Structure and Application of Operating Models -- Part 2 Hydra (Andy Beet, NEFSC and Mike Fogarty, NEFSC)
12. Structure and Application of Operating Models --Part 2 Kraken (Robert Gamble, NEFSC and Geret DePiper, NEFSC)
13. Structure and Application of Assessment Models (Charles Perretti, NEFSC and Mike Fogarty, NEFSC)
14. Simulation Tests and Performance Management Procedure -- Part 1 Hydra (Andy Beet, NEFSC and Mike Fogarty, NEFSC)
15. Simulation Tests and Performance Management Procedure -- Part 2 Kraken (Andy Beet, NEFSC and Mike Fogarty, NEFSC)

APPENDIX B

Final Terms of Reference
Ecosystem Based Fishery Management Strategy Review
April 30-May 3, 2018
NOAA Fisheries/Clark Conference Room
Woods Hole MA

Objective 1
Review a proposed implementation of Ecosystem Based Fishery Management for the New England Fishery Management Council (NEFMC).

The review is essentially a research-track review, the goal of which is to illustrate how the proposed EBFM strategy and conceptual framework would be applied to provide the information needed for fisheries management by the New England Fishery Management Council. The review will focus on the management procedure performance relative to a specified set of metrics related to NEFMC strawman management objectives as well as evaluate a worked example intended to simulate the performance of the EBFM procedure. (The strawman objectives were used to develop the EBFM strategy and framework; final objectives will be developed and approved by the NEFMC at a later date.)

The reviewers will be asked to provide recommendations that could improve EBFM strategy performance, as well as potential data inputs, operating model structures, and performance metrics. The goal is not to evaluate output of the procedure for use in specification setting (e.g., this is not a SAW/SARC assessment review).

The review will encompass the EBFM procedure, the potential operating models used to test the procedure, and a worked example of the relative performance of the EBFM procedure for providing quota advice as they pertain to fisheries management of Georges Bank fisheries.

If the review is favorable, subsequent steps will be necessary before the procedure can be used in specification setting. These subsequent steps include: definition of management objectives by the NEFMC, potential changes in regulations and fishery management plans, clarification from NMFS on the application of functional group OFLs, potential changes in management units, etc. The identification of the management changes needed to use the model results are not part of the review.

Objective 2
Review the proposed strategy for implementing EBFM on Georges Bank

Terms of Reference

1) Evaluate the approach used to identify Ecological Production Units on the Northeast Shelf of the United States and the strengths and weaknesses of using these Ecological Production Units as the spatial footprint for Ecosystem Based Fisheries Management in the region.

2) Evaluate the methods for estimating ecosystem productivity for the Georges Bank Ecological Production Unit and advise on the suitability of the above methods for defining limits on ecosystem removals as part of a management procedure.

3) Evaluate the approach and rationale for specifying Fishery Functional Groups as proposed management units.

4) Comment on the applicability and utility of the strawman management objectives and associated performance metrics which were used to guide the development of operating models.

5) Evaluate the utility of the proposed management reference points as part of a management control rule for ecosystem-based fishery management. These include: an overall catch cap at the Ecological Production Unit level conditioned on environmental conditions, ceilings on catch for each Fishery Functional Group (defining overfishing) conditioned on aggregate properties, and biomass floors at the single species level (defining overfished conditions).

6) Review harvest control rules embodying the proposed floors and ceilings approach using the ceiling reference points in ToR 5 to cap removals at the Ecological Production Unit and Functional Group levels, while ensuring that no species biomass falls below the single species floor reference points.

7) Review the structure and application of operating models for Georges Bank.

8) Review ecosystem assessment models and required data sources, as applied to the simulated data from the operating models in ToR 7.

9) Review simulation tests and performance of the proposed management procedure incorporating the floors and ceilings approach, given the set of EBFM goals and objectives.

APPENDIX C

Agenda, Documentation, and Presentations for 2018 Ecosystem Based Fishery Management (EBFM) Strategy Review

Date	***Time***	***Topic and Related Documents***	***Presenter/Lead***	***Theme Area***
Monday April 30	9:00 AM	**Welcome and Objectives for the Review** Background Documents **Ecosystem-Based Fishery Management Strategy** **Georges Bank Prototype Study Summary Document** **White paper on Ecosystem-Based Fishery Management for New England Fishery Management Council (2010)** **An Overview of the NEFSC's Ecosystem Modeling Enterprise for the Northeast US Shelf Large Marine Ecosystem: Towards Ecosystem-based Fisheries Management** **Overview of the Northeast Fishery Management Task Force Phase 1 (1980)** **Aggregate surplus production models for demersal fishery resources of the Gulf of Maine** **Assembly rules for aggregate-species production models: simulations in support of management strategy evaluation** **Using an aggregate production simulation model with ecological interactions to explore effects of fishing and climate on a fish community** **Comparative analyses of surplus production dynamics of functional feeding groups across 12 northern hemisphere marine ecosystems**	Jon Hare *NEFSC Science and Research Director* Mike Simpkins *Resource Evaluation and Assessment Division Chief*	
	9:15 AM	**Logistics**	Robert Gamble, NEFSC	
	9:30 AM	**NEFMC Ecosystem-Based Fisheries Management Plan Development Team** Background Documents **A Framework for Providing Catch Advice for a Prototype Georges Bank Fishery Ecosystem Plan** **A Framework for Providing Catch Advice for a Fishery Ecosystem Plan** **DRAFT: Example application of operating models for Georges Bank ecosystem production unit (EPU) strategy evaluation**	**Andrew Applegate**, NEFMC	
	10:00 AM	**Background and Overview of Proposed Management Procedure**	**Michael Fogarty**, NEFSC	
	10:30 Break			
	11:00 AM	**Defining Ecological Production Units**	**Robert Gamble**, NEFSC	TOR 1
	11:30 AM	**Ecosystem Production Potential**	**Michael Fogarty**, NEFSC Kimberly Hyde, NEFSC	TOR 2
	12:00 Lunch			
	1:30 PM	**Defining Fishery Functional Groups**	**Sean Lucey**, NEFSC Mike Fogarty, NEFSC	TOR 3

	2:00 PM	**Strawman Management Objectives and Performance Metrics**	Richard Bell The Nature Conservancy	TOR 4
	2:30 PM	**Ecosystem-Based Reference Points**	Michael Fogarty, NEFSC	TOR 5
	3:00 Break			
	3:30 PM	**Open Question Period**		
	4:30 PM	**Public Comment Period**		
	5:00 PM	**Review Panel Discussion (private)**		
Tuesday May 1	9:00 AM	**Harvest Control Rules**	Mike Fogarty, NEFSC	TOR 6
	9:30 AM	**Structure and Application of Operating Models -- Part 1 Hydra**	Andy Beet, NEFSC Mike Fogarty, NEFSC	TOR 7
	10:30 Break			
	11:00 AM	**Structure and Application of Operating Models -- Part 2 Kraken**	Robert Gamble, NEFSC Geret DePiper, NEFSC	TOR 7
	12:00 Lunch			
	1:30 PM	**Structure and Application of Assessment Models**	Mike Fogarty, NEFSC	TOR 8
	2:00 PM	**Simulation Tests and Performance Management Procedure -- Part 1 Hydra**	Andy Beet, NEFSC Michael Fogarty, NEFSC	TOR 9
	3:00 PM Break			
	3:30 PM	**Open Question Period**		
	4:30 PM	**Public Comment Period**		
	5:00 PM	**Review Panel Discussion (private)**		
Wednesday May 2	9:00 AM	**Simulation Tests and Performance of Management Procedure -- Part 1 Hydra, continued**	Andy Beet, NEFSC Mike Fogarty, NEFSC	TOR 9
	10:00 AM	**Simulation Tests and Performance of Management Procedure -- Part 2 Kraken**	Amanda Hart, UMASS Dartmouth Geret Depiper, NEFSC Robert Gamble, NEFSC	TOR 9
	10:30 Break			
	11:00 AM	**Simulation Tests and Performance of Management Procedure -- Part 2 Kraken,continued**	Geret Depiper, NEFSC Robert Gamble, NEFSC Amanda Hart, UMASS Dartmouth	TOR 9
	12:00 Lunch			
	1:30 PM	**Open Question Period**		
	3:00 PM Break			
	3:30 PM	**Public Comment Period**		
	4:30 PM	**Review Panel Discussion (private)**		

Thursday May 3	9:00 AM	**Review Panel Report Writing (private)**		

APPENDIX C

Name	Affiliation	E-Mail
Robert Gamble	NEFSC/EDAB	robert.gamble@noaa.gov
Mary Kavanagh	Kavanagh Fisheries	MBYPAT@aol.com
Laurel Smith	NEFSC/EDAB	laurel.smith@noaa.gov
Robert Hildermith	UMass Dartmouth	rhildreth@umassd.edu
Sean Lucey	NEFSC/EDAB	sean.lucey@noaa.gov
Charles Adams	NEFSC/EDAB	charles.adams@noaa.gov
George Lapointe	Fisheries Survival Fund	georgelapointe@gmail.com
Wendy Morrison	NMFS/SF HQ	wendy.morrison@noaa.gov
Anne Richards	NEFSC	anne.richards@noaa.gov
Scott Large	NEFSC	scott.large@noaa.gov
Andrew Applegate	NEFMC	aapplegate@nefmc.org
Rich Bell	TNC	rich.bell@tnc.org
Jason Boucher	NEFSC	jason.boucher@noaa.gov
Chris Kellogg	NEFMC	ckellog@nefmc.org
Charles Perretti	NEFSC	charles.perretti@noaa.gov
Andy Best	NEFSC	andrew.best@noaa.gov
Amanda Hart	UMass Dartmouth	ahart1@umassd.edu
Geret DePiper	NEFSC	geret.depipes@noaa.gov

APPENDIX D

Statement of Work
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

Ecosystem Based Fishery Management Strategy Review

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf). Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

Ecosystem Based Fishery Management (EBFM) Strategy Review

Objective: Review a proposed implementation of EBFM for the New England Fishery Management Council (NEFMC).

The review is essentially a research-track review, the goal of which is to illustrate how the proposed EBFM strategy and conceptual framework would be applied to provide the information needed for fisheries management by the NEFMC. The review will focus on the management procedure performance relative to a specified set of metrics related to NEFMC management objectives, as well as evaluate an "operating model" intended to simulate the performance of the EBFM procedure. The "operating model" in this case is a multi-model suite that can include empirical approaches as well as simulation models. The reviewers will be asked to provide recommendations to improve EBFM strategy performance, as well as potential data inputs, operating model structures, and performance metrics. The goal is not to evaluate output of the procedure for use in specification setting (e.g., this is not a Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) review process).

The review will encompass the EBFM procedure, the suite of operating models, and a worked example of quota advice as they pertain to fisheries management in the Northeast region.
If the review is favorable, subsequent steps will be necessary before the procedure can be used in specification setting. These subsequent steps include: potential changes in regulations and fishery management plans, clarification from NMFS on the application of functional group Overfishing Limits (OFLs), potential changes in management units, etc. The identification of the management changes needed to use the model results are not part of the review.

Reviewer Requirements

NMFS requires three reviewers to conduct an impartial and independent peer review in accordance with the SOW, OMB Guidelines, and the TORs below. The reviewers should have working knowledge and recent experience in ecosystem-based fishery management particularly in areas of Management Strategy Evaluation/Management Procedures, Fishery Ecosystem Plans, Integrated Ecosystem Assessments, ecosystem models, multi-species models, population dynamics, harvest strategies, and fisheries management regulations as they apply to EBFM. We prefer having at least one international reviewer and at least one reviewer from the U.S. The third reviewer can be an international or U.S reviewer.

Tasks for Reviewers

1. Review background materials and reports prior to the review meeting related to the Terms of Reference.
2. Attend and participate in the panel review meeting
    a. The meeting will consist of presentations by NOAA and other scientists, and other experts to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers
3. After the review meeting, reviewers shall conduct an independent peer review in accordance with the requirements specified in this SOW, OMB guidelines, and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus
4. Each reviewer may assist the Chair of the meeting with contributions to the summary report, if required by the TORs
5. Deliver their reports to the Government according to the specified milestone dates

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and
http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-

registration-system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance
The place of performance shall be at Northeast Fisheries Science Center Woods Hole, MA

Period of Performance
The period of performance shall be from the time of award through March 2018. Each reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Within two weeks of award	Contractor selects and confirms reviewers
Approximately 2 weeks later	Contractor provides the pre-review documents to the reviewers
January 2017	Panel review meeting
Approximately 3 weeks later	Contractor receives draft reports
Within 2 weeks of receiving draft reports	Contractor submits final reports to the Government

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards:
(1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each ToR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $12,000.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

NMFS Project Contact:

Robert Gamble
166 Water Street
Woods Hole, MA 02543
robert.gamble@noaa.gov

Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether or not the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.

a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.

b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.

d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

Appendix 1: Bibliography of materials provided for review
Appendix 2: A copy of this Statement of Work
Appendix 3: Panel membership or other pertinent information from the panel review meeting.