EXTERNAL PEER REVIEW OF ECOSYSTEM-BASED FISHERY MANAGEMENT STRATEGY

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Individual Peer Review Report prepared for the Center for Independent Experts

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Table of Contents

Executive summary

Overall the core of the work presented for review, coupling a multispecies "Hydra" model with a Management Strategy Evaluation (MSE) framework, represents a valuable and thorough first step towards a flexible multispecies and mixed fisheries MSE tool. This work has the potential to produce a viable tool for assessing a wide range of potential management strategies, both multi-species management strategies and single species strategies evaluated against a multispecies world. The problems the tool is being asked to solve are focused on mixed fisheries issues, therefore future work should focus on refining the mixed-fisheries abilities of the Hydra model.

This review gives a number of specific technical recommendations for improving the modelling tools, as well as more generic recommendations to guide the approach. The reviewed results represent a work in progress, and several simplifications have been made to get the work moving. This is appropriate given the early stage of this work, but it is important to work on testing (and possibly refining) these simplifications as the model is developed, and critical that a further review be undertaken before the tool be used to guide operational management.

The Harvest Control Rules (HCRs) developed in the work presented for review represent a viable starting set to begin the analysis. It is important that as the HCR set is expanded, care be taken to examine the impacts of making system wide simplifications rather than using detailed species-specific knowledge in setting harvest rates and breakpoints. There are a number of recommendations within this review for specific improvements to the fisheries side of the model, but the main outstanding concern represents the ability of the modelling tool to adequately simulate the proposed management structure. There is a currently major mismatch between the simplified three-fleet structure of the Hydra model and the multiple "fisheries functional groups" (FFG) proposed for management. The proposed management structure is one of setting overall quotas for a number of "fisheries functional groups" (FFGs) covering similar fleet segments targeting a number of different species, with protections included for individual species. Fishers within each FFG could then allocate their overall quota between the species they catch as desired. This is a novel approach, and would need thorough testing, with focus on the degree to which the approach provides protection for individual species within each group. It seems likely that the success or failure of the management will likely hinge on the changing behavior of fishers within each FFG. Therefore, although all models are simplifications, it is critical that the tool be able to simulate the proposed management structure of the fleet. To date, the analysis conducted is rather preliminary, and based on the assumption that the allocation of catches within a FFG will remain the same as in the historical data. This is essentially equivalent to setting species specific quotas, and does not reflect the likely behavior of the fisheries under this scheme. It is critical that the model be used to test out, for example, higher fractions of catch being high value or choke species (e.g., cod) than in the historical split. Given the difficulties in modelling and implementing such a novel approach, it would be valuable to evaluate a wider range of HCRs. As an aside, it should be noted that the multispecies quota implied in the FFG approach does not remove the need for species level stock assessments to monitor the status of the individual stocks.

One of the issues in dealing with managing fisheries in a multispecies context is that it implies choices and trade-offs between species and especially between trophic levels. It should be noted that this issue does not go away under the approach with FFG (or any other Ecosystem Based Fisheries Management [EBFM] scheme). The tool being developed cannot, in itself, address this, but does provide a platform to provide information to decision makers about the impacts of different management scenarios.

The choice of the Georges Bank as a modelling unit (an "Ecosystem Production Unit", EPU) is reasonable, both *a priori* and based on the analysis presented. However, no finite area will completely contain all species for all of their life cycle. It is therefore important to consider stocks (or fisheries) that cross EPUs in the analysis as the modelling is developed. The modelling has focused on a subset of species in the ecosystem. One could not include all components in a given model, but there are several limitations in the set at present. On the commercial side, it would be valuable to include harvested benthos (scallops, lobsters) in a future analysis. On

the ecosystem side, while the current species set represents the majority of the commercial fin-fish catches, it does not include a majority of their food. As a result, the tool is currently better developed to deal with missed fisheries issues than exploring trophic dynamics in the ecosystem.

In terms of the modelling tools, it is encouraging to see two different models (a Kraken production model and a Hydra length structured model) being employed. To date they have been used for different purposes, with the Kraken model being coupled to the portfolio analysis economic simulations, and the Hydra model being coupled to the HCR evaluations. This is a reasonable first step, but the real strength of having multiple models is to compare their results, and it is therefore recommended that the two models be used for both HCR evaluation and the economic analysis. In general, given the "work in progress" nature of this project, there are a number of areas which would benefit from tighter integration of, and comparison between, different parts of the project.

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 Development 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 Expert 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 in 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 at the University of British Columbia specializing in ecosystem modelling. Dr. Daniel Howell is a Fisheries Mathematical Modeller at the Institute of Marine Research in 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 (Appendix D) 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 (Appendix B). 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/).

Introduction

The review covered several distinct, though, related topics. The review covers both the development of a multispecies and mixed fisheries MSE tool in general, and the specific formulation proposed to deal with the mixed fisheries challenges in the Georges Bank. Therefore, the review must cover both the overall flexibility and power of the MSE tool, as well as how well the mechanics of the MSE tool and associated HCRs match up with the proposed management structure for the fishery; both are critical. These are distinct issues, but cannot be considered in isolation from each other, because the degree of realism required is based on the needs of the

other parts of the system. Consequently, designing both the underlying toolbox, and the specifics for the Georges Bank fisheries will require an iterative process.

This review will therefore attempt to address both of the issues discussed above. Since this is a review of work in progress, the review will focus on evaluating if the general approach is sound, and providing both general and specific recommendations on how the work might best be developed. In order to place the HCR approach into a broader global context, the review begins with a brief summary of how the issue of mixed fisheries has been handled in the North Sea. In many ways, this is the closest European parallel to the Georges Bank fisheries.

Global context

The approach described here, of using fishery function groups (FFGs) as the unit of management, is one possible approach to ecosystem management, but it is not the only approach, and other methods are in use or under development around the world. It is valuable to compare this to the somewhat different approach that has been adopted in the North Sea. This review, therefore, gives a brief overview of the North Sea management procedures, in order to highlight the similarities and differences between the two.

The North Sea is co-managed between the EU (under the Common Fisheries Policy) and Norway, and is based on single species quotas. However, the assessment and quota setting procedure incorporates both multispecies (predation) and technical (mixed fisheries) interactions. There is a procedure involving extended single species assessments (mostly using "SAM" Statistical-Catch-At-Age models), a multispecies model to produce predation mortalities ("SMS"), HCRs to translate stock estimates to quota advice, and a mixed fisheries model to assign quotas considering the bycatch in different fleet sectors ("F-cubed"). The procedure is that every three years the multispecies SMS model is run, based on the biomass time series from the assessment models. The SMS model produces time series of partial predation mortalities (M2 values), which are then used in the annual update single species assessments. The annual single species quotas are then fed to the mixed fisheries F-cubed model, which analyses the fishing fleets at a fine scaled "métier" basis in order to try and assign quotas in a way that avoids overfishing bycatch of "choke species". This procedure is somewhat cumbersome, and there has been initial work towards a closer integration of some of the parts. However, it does provide a coherent structure, in which the SMS model integrates the single species models via predation, and the F-cubed tool essentially conducts a linear programming exercise to allocate quota given the constraints imposed by fleet structure.

Although the mechanics are different, the overall rationale is in many ways similar to the approach presented in this review. The underlying issues, of separate stocks related through predation and extensive technical interactions, are similar. The key difference is that the North Sea sets individual species quotas, and then invests a large amount of effort in allocating these between "métiers", whereas the work presented here sets quotas for groups of species within a fishing sector, allows the fishers to allocate that overall quota between species as they choose, and then attempts to find ways to protect individual species biomass. This approach clearly sidesteps some of the implementation difficulties, but requires thorough evaluation to be able to foresee the likely outcomes. As the work progresses, it would therefore seem sensible to develop links with the ICES North Sea Working Group to compare approaches and solutions.

Specific comments on each ToR

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.

The practice of dividing the oceans into manageable scale sectors (such as the EPUs in this work) for modelling and management is a necessary simplification. There are, however, limitations and weaknesses of doing this, notably that some components (fishing and biological) will move between the areas, and it is therefore important to choose area boundaries to minimize these issues. The method chosen, PCA on a range of physical, oceanographic and lower trophic level datasets, seems a reasonable one. Having a hierarchy within each area to account for coastal and shelf break areas is also a good structure, giving flexibility while minimizing complexity. It is reassuring that the PCA analysis corresponds to previous understanding of the spatial structure in the region.

The degree to which a particular EPU description is appropriate cannot be answered in the abstract, but will depend on the use to which it is put. In the present context, this means that an EPU is appropriately defined if it lends itself to simulating and managing the fisheries within that region. The key determinant of how suitable the choice of area structure is likely to be is how well it conforms to the biological and human impact dynamics in the simulation model. It is therefore **recommended** that the spatial structure is refined over time, informed by the modelling studies and other knowledge.

It is also important to be clear that the proposed EBFM structure does not handle well stocks or fisheries that cross EPU boundaries, and this should be made clear when reporting the outcomes of any analysis. It should be noted that these issues are not exclusive to the modelling structure presented here, they exist with current management (so called "straddling stocks" or wide-ranging fisheries), but by imposing a fixed (if broad) spatial structure, the difficulties for advice and management are made more acute. It is therefore likely that if this approach were made operational, then an additional layer of analysis and management to deal with these wide-ranging stocks or fisheries would be required. Consequently, it is **recommended** that there be research into how such cross-EPU stocks or fisheries could be managed under the proposed management schemes.

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 review section does not deal with the specifics of the lower trophic level energy flow model, as this reviewer has limited experience on this topic. Rather the text will focus on the uncertainties and how they impact on the overall results of the management strategy evaluation.

The question of "is the model fit for purpose" depends largely on what the intended purpose is. If it is providing numerical input into the fisheries operating model or to provide absolute estimates of reference points, then the model would need further development and verification before it could be used. On the other hand, the modelling tool would be much more suitable for giving a qualitative understanding of trends or providing order-of-magnitude values for "sanity checking" other models. There is a mis-match issue where the estimation methods are based on harvesting the whole system, with some defined split between trophic levels. In practice, fisheries will target only a fraction of the available fish stocks, and the overall trophic level of the fisheries may differ from those used in the calculations.

The uncertainty range of the outputs is rather large. This is not surprising given the difficulties of modelling lower trophic levels and energy transfer. The model can therefore be used to give "order-of-magnitude" style results to compare against overall fishing, and for describing trends in overall productivity, but exact estimates should be used with care. It is **recommended** that care be taken to ensure that this uncertainty is made clear, not just when presenting the details of the work, but also in the headline results. This is not done consistently within the review document. For example, table 2.1 of the review document gives detailed uncertainty estimates, but the discussion session simply quotes point estimates. It would seem likely that as the results are used in more distant contexts (e.g., management summaries), more of the uncertainty information would get lost. It is therefore critical that whenever point estimates are quoted, the uncertainty estimates are included.

It is **recommended** to compare the results with those from other approaches (e.g., Ecopath) available in the area. There will be differences involved, depending on exactly what is being compared (e.g., "fish stocks" vs. "fished stocks"), but it should be possible to make the model outputs comparable and give bounds on uncertainty ranges.

It is not clear to this reviewer how such an approach can set limits for ecosystem removal in the context of proposed changing fisheries patterns, both by trophic level and what fraction of the ecosystem. Acceptable total removals will vary with the average trophic level of the catch, so it is difficult to see how this can form a fixed limit to system removals.

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

The rationale of the fishery functional groups combines fish caught in similar fleets, grouping within feeding guilds, and life history traits. Combining fishing and biology in this way at this scale is a novel approach to fisheries management. In principle, this provides a good mix between fisheries and biological traits. It maps the groups to manageable fishery units, as well as considering ecosystem function and avoids grouping very dissimilar species. Note that it is important to also consider the individual species within each group, and monitor the status of the different species.

One would note that the patterns of catches between different fisheries may not be constant over time. These changes may arise spontaneously from changing biology or fisher behavior, or could arise in response to specific management action to influence fishing patterns. Consequently, the behavior of FFGs should not be considered constant over time. Both the behavior within each FFG, and the relationship between them, is likely to vary over time. Considering the boundaries between FFGs, it should not be expected that these will be fixed over time either. Rather, the definition of FFGs will likely vary with changing social, environmental, biological and management environments. Within each FFG, the model will, of necessity, have been conditioned on historical fishing patterns, but if the fishermen are given quotas for a group of species, they are likely to change their fishing pattern, targeting various species to different degrees than in the historical fishing. Such changed fishing patterns would reduce the applicability of the modelling studies conducted without accounting for this. It is **strongly recommended** that extensive effort be placed on evaluating the impacts on management performance of such changes in fisher behavior. This reviewer considers that *without such investigations the simulation tool cannot be considered suitable for investigating grouped FFG-based quotas.*

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 overall approach is sound, producing a tentative list of objectives and performance metrics. However, in the discussion, it was notable that the list of objectives was described as not being complete (specifically in relation to the use, or not, of F reference points for target species). Furthermore, the applicability of different metrics is something that will need to be tested during the development of the modelling approach. It is therefore not feasible to evaluate the appropriateness of the list of objectives and performance metrics, as requested by the ToR. Rather, the review can state that the approach of building out from the initial set provided is appropriate, and give recommendations to guide further development.

The overall set of strategic objectives is reasonable, but a more detailed list of operational objectives is required. The success or failure of the objectives will depend on the method of quantifying the details within each category, and the metrics which are chosen. One key concern is that the only metric of reduced single species stock status is being reduced below 20% of unfished biomass (Blim). This gives information on reduced stock reproduction potential, but does not give information on reduced yield potential. It is **strongly recommended** that all results also report the fraction of stocks falling below the higher trigger point at which fishing is reduced (e.g., the current Btrigger set as 40% of unfished biomass). Such a trigger may or may not be included in the HCRs, but should always be a performance metric. More generally, as work proceeds it is **recommended** that the utility of the different metrics is evaluated and refined as the work proceeds.

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).

Once again, the utility of the management reference points is difficult to evaluate without knowing the more general management structures and results of the final simulation analysis.

For the overall removal cap, it not clear what purpose this serves. According to the presentations, it was unlikely that this could be achieved in practice, and a separate analysis presented at the review (by Amanda Hart) indicated that at moderate to high levels, the choice of value of the removal cap had little impact on the management.

The reference points at the FFG and single species levels do serve a clear purpose, and the simplified generic values (e.g., 20% of unfished biomass) used in this study are adequate for an initial exploratory analysis such as this, but it is **strongly recommended** that they be replaced with species-specific reference points before the system becomes operational. Furthermore, it is not clear how the ceiling on removals at the FFG level would be quantified for actual fisheries. The fraction of unfished biomass is both appropriate and easy to calculate in a simulation framework, but may be neither in an operational setting. Before moving to operational management, care is needed to ensure that the reference points are appropriate to each species (and, in sexually dimorphic species it may need gender specific reference points), and to move to more realistic limit points.

One concern is that the only species-specific reference points are biomass floors, and these are likely substantially lower than current Bmsy targets (the proposed limits are more analogous to precautionary fishing avoiding recruitment overfishing). Given the reference point set proposed, a fishing strategy could be counted as "successful" even though it resulted in a number of the key species (for example, cod) being fished consistently to a level only slightly above the biomass floors. This is likely to result in reduced yield of these species, and it is an open question if this would be acceptable. This problem is largely avoided by use of a higher trigger biomass below which fishing is reduced (set at 40% of unfished in the examples here). Regardless of whether these higher trigger points in the HCR (below) are used in a given simulation, it is **recommended** that the fraction of stocks below this Btrigger value be used as a reference point for single species status (reflecting reduced yield potential rather than reduced recruitment potential).

Note that the simulation model can evaluate if any reference points are breached, but the presentations seem to indicate that the only action being taken in the model simulations at present are dropping below floors. It appears as if there is no current capability to adjust fishing within each FFG if the ceilings are breached, and the current HCRs do not seem written to take this into account. If this is the case, then model development may be required to address this.

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 HCRs put forward at the review represent an initial attempt at a suite of candidate rules to be able to conduct initial simulations and inform future discussions. In this context, the HCRs can be said to fulfil the ToR, covering a range of different management measures to protect fish stocks at different degrees of aggregation. One would expect that this suite of HCRs would be expanded and refined as the approach is developed.

The HCRs implement both a threshold level below which landings are not permitted (and catches set to some levels), and potentially a higher (Btrigger) level below which exploitation is linearly reduced. For the initial runs these were set at 20% and 40% of the unfished biomass. As the approach is developed more fully, one would expect that alternative reference points would be evaluated, including some using best available science for the individual species. The full suite (the floor and the high level) approximates to a traditional MSY "hockey stick" HCR, while simply using the lower floor level corresponds to an "avoid recruitment overfishing" precautionary approach. Any choice to move between these two approaches is independent of any move to EBFM. It is therefore **recommended** that if there is a proposal to remove this higher Btrigger value, the implications of this be thoroughly investigated.

The work has been phrased as an academic exercise, without reference to operational management procedures. At the current stage this is a valid approach, providing a semi-concrete example to spur further discussion. However, it is important to note that there must be an interaction between the management structures and the simulation studies, where management must be informed by what is scientifically feasible and where the scientific work must fit into the management requirements. In this context, the work presented here represents a valuable first step in an iterative process.

The work to date has incorporated step-wise reductions in fishing below a Btrigger value. This is acceptable in a simulation environment, but is likely to prove problematic in an operational setting. Such discrete steps give rise to situations where small changes in assessment produce large changes in quotas, which places a high stress on the reliability of the assessment and can lead to implementation difficulties. It is therefore **strongly recommended** that the step functions within the HCRs be replaced with smooth ramps before this work gets closer to operational management.

The HCRs examined to date have been exclusively phrased around grouped FFG quotas. This is not a requirement for EBFM, and the system being developed is able to evaluate a wider range of HCRs, including evaluating single species quotas against a multispecies reality. It is therefore recommended that the system be used to evaluate the performance of single species HCRs against the grouped FFG quota ones. Furthermore, there need not be a binary distinction between these two regimes, and there may well be large gains to be made by moving to grouped quotas for some but not all species. It is therefore **strongly recommended** that hybrid HCRs be evaluated, where in addition to overall quotas for a fishery group there is a more specific constraint

on one (or several) key species. For example, a rule of the form "X tonnes of quota, but no more than Y of it can be of species Z".

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

The approach of using two structurally distinct Operating Models (OMs) is a good one. The Hydra model is, in principle, a good tool for use as an OM, combining detail and potential realism with moderate run times. As the model is still under development, this section outlines the main areas of remaining work, and gives recommendations for improvements.

There are two issues that are of most concern with outstanding issues with development of the Hydra OM. One is the need for evaluating the model against real world historical observations in order to demonstrate that the model can produce credible results. One would not expect such a model, without optimization to annual recruitment deviations, to track actual stock history. However, it would be reasonable to expect that stock dynamics, stock biomasses, and catches under approximations to historic fishing conditions should approximate to historic observation. For example, putting catches of similar levels to those which resulted in stock declines in the 1970s should result in stock declines in the model, while catches similar to those in the 2000s should keep the modelled stocks roughly stable. The second outstanding issue is the need to evaluate the fleet structure against the requirements of evaluating the proposed management actions. For example, testing the robustness of the proposed FFG quotas would need to involve simulating the effects of changing species catchabilities within the fleet. The model must therefore be able to simulate this, and it is not clear that the structure is currently capable of doing this. It is not necessary that the model completely matches the "real world", but it may be necessary to increase the level of detail in the fishing model in order to realistically evaluate the fisheries. It is therefore **strongly recommended** that as the modelling develops, work is focused on ensuring that the model is able to model the fishing dynamics of importance for the HCRs being evaluated. Additionally, the current fishing selectivities are all flat topped logistic curves, which may not well model some of the fisheries. It is **recommended** to investigate allowing dome shaped selectivity in the OM, especially if the fleet structure is made more detailed than at present.

One issue which arises within any multispecies model is the extent to which the results are sensitive to the amount of "otherfood" (i.e., external to the model). Ideally, the key food components for critical species within the model should all be fully modelled. If this is not possible, then care should be taken with the external "otherfood", giving as much realism as possible and checking for model sensitivity to this input. As "otherfood" is typically not well specified, it is **recommended** to investigate the sensitivity of the model to this parameter.

The approach of having a family of recruit curves is interesting, and represents a possible way to model recruitment uncertainty. However, it was concerning that all the additional curves were to the left of the fitted function – this gives additional ability to recover from poor stock size beyond that implied by the data. This raises the possibility that the model could add spurious robustness to some stocks. If this approach is pursued, then it is **recommended** that using families of recruitment curves that are symmetrically distributed around the fitted function is investigated. It seems likely that the families of recruitment functions are being investigated in order to compensate for the functional forms of the interannual variability ("noise") being unable to handle species with sporadic recruitment, and it is likely that this could be better achieved by adjusting the functional form. The "noise" on the recruitment functions are currently lognormal. This is likely to be too restrictive for some stocks, and it is **recommended** that this be expanded. For those with erratic recruitment (e.g., haddock or herring), a joint distribution method might be preferable, with the majority of year-classes being drawn from one distribution, and a minority being drawn from a second distribution. For some stocks it might be necessary to include the possibility of having runs of good or bad recruitment. This could be modelled simply by applying a sin-curve multiplier to the recruitment success, or more realistically as a Markovian process.

At present the overfished metric tracks the fraction of time spent in a depleted state. This is problematic as it is influenced by the recruitment at low stock sizes, and this part of the function is typically poorly constrained by data. A simpler metric, just counting how many stocks crash at least once in any given 10-year reporting period, would avoid this uncertainty. It is therefore **recommended** that the overfished metric be changed to the simpler version tracking how many stocks crash at least once within a reporting period. It can be noted that this would also be consistent with the ICES approach.

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

At present, the system uses simple "truth plus specified cv noise" for assessment. This is one possible approach, which is used in many actual MSE exercises, and it aids in rapidly building a working model. There was work presented on using multispecies assessments, although this was not integrated into final the HYDRA model simulations presented. A range of methods were presented (index, production model, delay-difference model), which gives the possibility to produce reasonable assessments for a range of stocks. However, these methods do not replicate well the existing assessment methods, and it is not clear why they are being used instead of single species assessments. Single species assessments would be both easier to implement, and better match the actual management systems being simulated. Furthermore, while the Hydra tool is suitable for testing new assessment methods (e.g. multispecies assessments), this should be kept separate from testing new HCRs (e.g., ones based on FFGs).

It is **recommended** that care be taken to ensure that the assessments replicate the error structure seen in the actual assessments used in management. This could be done by replicating the existing single species assessment methods (full assessment and index-based), or by approximating these with defined error structures, either in multispecies or "truth plus noise" assessments.

It is **strongly recommended** that the model not be used to evaluate new assessment methods and new HCRs simultaneously, as this would make it difficult to evaluate what was causing any successes or failures in the simulated management. This should not be taken to argue against evaluating either, merely that they be evaluated separately.

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.

Given the preliminary state of the work, the simulation work is rather limited. The scenarios run have been designed around the proposed management structure, but cannot at this stage be said to fully evaluate the management. However, the simulations conducted do begin to test out the management proposals, and can be considered to represent a good starting set which will be developed in parallel with model development.

The major limitation in the simulations conducted to date is that the model fleet structure does not simulate well the proposed management structure, and thus further model development is required to be able to realistically model the proposed structure. As the model is developed and refined in this regard, the set of simulations will need to develop in parallel.

It was clear during the review that the work was at an early stage, with a number of the graphs being difficult to interpret (for example some, but not all, vertical axes on the stock trends graphs starting at zero). It is anticipated that the graphs presented will evolve as the work proceeds.

A point of confusion arose from the presentations on the simulations, where it appeared as if a fixed exploitation rate was being applied across multiple species. Further discussions identified that this is not the case. A flat multiplier was being applied (at different levels), but this was multiplied by species specific catchability rates. It is critical that this distinction be made clear in future reports and presentations, and that realized fishing pressure on each stock be reported.

Given the limitations described in this section, the preliminary simulations do begin to address the performance of the modelling system, and begin to show interesting results. The absolute levels of catches are broadly in line with historical ones, suggesting a degree of realism in the proposed fishing pressures. For example, the HCRs which included "hockey stick" style reductions in fishing below some biomass trigger (but above the biomass floor) performed better than HCRs without this precautionarity.

Specific recommendations for future work

The current metric of "overfished" status measures the fraction of years the stocks are below a reference level. This is a valid metric, but has the unfortunate implication that the fraction of time a stock spends in a deplete state becomes sensitive to the recruitment at low stock size (how fast the stock recovers from overfishing). A significant amount of effort has been placed on this part of the stock-recruitment function during model development, but it remains highly uncertain. It is therefore **recommended** that a simple metric, just counting how many stocks crash at least once in any given 10-year reporting period be investigated. This is an ICES standard, and largely avoids having an overfishing metric being sensitive to the most uncertain part of the recruitment function.

It is **recommended** that realized F, and the ratio of realized F/nominal F be investigated as metrics. This would give better information on what fishing pressures were actually applied (which is difficult to determine from the results presented to date). These (and especially the ratio) would help identify the degree to which catch in a given FFG was being reduced by the single species protections within the HCRs.

As discussed in previous sections, simulations that address the behavior of fishers within each FFG (for example, switching fishing pressure between species) are **strongly recommended**. In order to do this, the modelled fleet structure will need to be further developed. At present the model could change to something like "the fraction of cod in the trawl fleet catches", but not "the fraction of cod in the catches of FFG7".

There is clear potential to parallelize the model runs. Since many simulations are required, each simulation can be assigned to a given thread or processor. This makes the parallelization process both simple and effective, and it is r**ecommended** that this be developed.

It is **recommended** that simulations be conducted examining the difference between system-wide limits (e.g., 20% of unfished biomass) and species-specific ones (e.g., using the reference point from the assessment).

It is **recommended** that a wider range of selectivities (e.g., dome shaped) be included in the simulations, to best replicate actual fishing patterns.

More generally, wherever there is a simplification (e.g., thresholds, trigger points, global exploitation rates, FFG structure) in the model, it is **recommended** that the effects of adding realism are investigated for each simplification separately. It may be that some of the current simplifications are justified, increasing speed and robustness without harming accuracy, but this needs to be tested.

It is **recommended** that "sanity checks" are applied to different levels within the model (stock size, species removals, group removals, …). The aim would be to rapidly identify anything which is outside the realistic range (based on historical knowledge). This is important, as an unrealistic biomass in one species within the model may impact on the reliability of results from other species.

APPENDIX A

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.
28

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 B

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

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-hennemuith.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 that 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)

Agenda for 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	**Defining Fishery Functional Groups**	**Sean Lucey**, NEFSC	TOR 3

	PM		Mike Fogarty, NEFSC	
	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	**Public Comment Period**		

	PM			
	4:30 PM	**Review Panel Discussion (private)**		
Thursday May 3	9:00 AM	**Review Panel Report Writing (private)**		

APPENDIX C

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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

- Review background materials and reports prior to the review meeting related to the Terms of Reference.
- Attend and participate in the panel review meeting
    - 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
- 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
- Each reviewer may assist the Chair of the meeting with contributions to the summary report, if required by the TORs
- 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
April/May 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
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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.