# Independent Peer Review Report


## Georges Bank and Eastern Georges Bank Haddock
## Research Track Review


Prepared for:
The Center for Independent Experts

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**EXECUTIVE SUMMARY**
*The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations and specify whether the science reviewed is the best scientific information available.*

The Georges Bank (GB) and eastern Georges Bank (EGB) (*Melanogrammus aeglefinus*) Research Track Stock Assessment Peer Review Panel met virtually using WebEx from 28-31 March 2022. The review was very well organized, and the Panel was assisted in advance and throughout by NEFSC staff. The Haddock Working Group prepared all documentation and clear and concise presentations were made. All materials and presentations were of a high standard. The Peer Review Panel meeting was well chaired and provided excellent opportunities for public comment. A Summary report was finalized within a week of the meeting ending.

The GB haddock stock assessment using VPA was last updated in 2019. The last benchmark assessment was conducted in 2008. The 2022 Research Track assessment which is the subject of this review is exploratory and the WG-proposed state-space model implemented using WHAM is a major development based on excellent bridging work from VPA to a statistical-catch-at-age model and model building using WHAM. At the Management Track assessment to be considered later in 2022, data will be updated, and model selection completed. It is possible that conclusions drawn by the Research Track WG, and this review could be affected.

The EGB haddock stock assessment has been problematic, and it is unclear if treating EGB separately, when it is most probably a sub area of a wider GB stock, is robust. Previous problems with retrospective patterning led to model rejection and the Research Track assessment WG attempted to build a new model using WHAM. Scientists from NEFSC and Canada separately attempted to build state-space models that could accommodate the highly variable and episodic nature of recruitment to EGB. It is unclear if these models will survive through the Management Track and TRAC processes.

The state-space models developed for both GB and EGB followed meticulous model building which was well argued, described and presented. The proposed base case models are converged and have reasonable goodness-of-fit. However, while the GB model is best fit with an assumed, fixed natural mortality rate, M, of 0.2, the EGB model is best fit when M is estimated for the most recent ten years. The estimate is 0.47. Given the EGB is a subset of the GB stock this higher M estimate could represent genuinely higher mortality or could be confounded with movement away from the EGB. Either is possible on grounds of density dependence and/or environmental drivers.

The utility of the GB model is clear within the management context and the recommended BRPs and projections are sound. For EGB this is less clear, and the inconsistent treatment of natural mortality raises issues around how to estimate BRPs but particularly how to make projections. Consideration of BRPs for the EGB has been made in the context of potential management procedures. This approach is well suited for jointly managed stocks where different nationally legislated or regulated approaches may not be possible but where jointly agreed objectives might be.

The WG also considered all information available that relates to stock structure. The conclusion that GB is likely a single stock spanning EGB, western GB and the Great South Channel appears well founded. Relating this to stock assessment is difficult. While the WG clearly views a single GB stock assessment as meaningful and viable, there is no consensus on the EGB stock assessment being either meaningful (biologically) or viable. However, while the EGB stock assessment might most ideally be consolidated into a wider GB assessment from a biological perspective, there remains a strong management imperative for an EGB assessment and unless and until this need can be met by consolidated modelling, separate stock assessments are not unreasonable.

**BACKGROUND**

*The main body of the reviewer report shall consist of a **Background**, Description of the Individual Reviewer's Role 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*

The stock assessments of GB and EGB haddock in 2022 which are now subject to review are Research Track assessments. The Northeast Region Coordinating Council (NRCC) assessment process, including Research and Management Track variations is described at https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/fishery-stock-assessments-new-england-and-mid-atlantic. A good summary is provided at https://apps-nefsc.fisheries.noaa.gov/saw/sasi/uploads/Background_Stock-assessment-process-June2020.pdf. It is sufficient here to note that Research Track assessments do not directly inform management decision-making but are rather developmental with an aim to providing the basis for Management Track assessments which feed directly into decision-making processes. Importantly, Research Track assessments do not update status determinations.

Later, there will be Management Track stock assessments for GB and EGB haddock which will update the assessment considered at this review with up-to-date data, though it is noted that 2020 data are compromised due to the Covid-19 pandemic. The Management Track assessment can in principle, also build on considerations and recommendations from this review. At the Management Track assessment, status determination will be made, and final catch projections run. The EGB haddock assessment will also be considered as part of the Transboundary Resources Assessment Committee (TRAC) process (https://www.bio.gc.ca/info/intercol/trac-cert/index-en.php#:~:text=of%20TRAC%20Results-,Overview,of%20Maine%2DGeorges%20Bank%20region).

The Georges Bank (GB) (*Melanogrammus aeglefinus*) stock assessment was last updated in 2019 using data up to 2018. That update was of the 2017 VPA (NEFSC, 2017). The last benchmark stock assessment was in 2008 (Brooks et al, 2008). The 2019 assessment is available at the NOAA Institutional Repository. The stock was then characterized as neither overfished nor experiencing overfishing. Retrospective patterning led to (Mohn's) rho adjustments being used in short-term projections. During this Research Track assessment, the WG explored bridging from the VPA to a statistical catch-at-age model implemented in ASAP (Legault and Restrepo, 1998) and then development of a state-space model implemented using the Woods Hole Assessment Model (WHAM; Stock and Miller, 2021).

The eastern Georges Bank (EGB) stock assessment history has been largely unsuccessful and in 2019 it was rejected due to large retrospective patterns. As noted by TRAC (2021), the assessments have been "empirical". As part of Research Track efforts, the WG has attempted to develop state-space models for EGB using WHAM. Alternative model development has been conducted by the NEFSC, as reported in the WG Report, and by Blue Matter Science Fisheries Consulting (https://www.bluematterscience.com/) on behalf of the Canadian government. Model development and exploration by Blue Matter Science was not included in the WG Report but was presented at the Review meeting.


**REVIEWER'S ROLE IN THE REVIEW ACTIVITIES**

*The main body of the reviewer report shall consist of a Background, **Description of the Individual Reviewer's Role 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*

The role of the reviewer is set out in the CIE Statement of Work (SoW), Attachment A, attached here in Appendix 2.

The GB and EGB haddock Research Track Stock Assessment Peer Review Panel (the Panel) met virtually using WebEx from 28-31 March 2022 and followed the final agenda as shown Appendix 3. A full participants list is included at Appendix 4. The Panel was co-chaired by Richard Merrick (NEFMC SSC) and Rob Kronlund (Interface Fisheries Consulting Ltd), and included three CIE appointees: Joseph Powers, Anders Nielsen and Kevin Stokes.

The review was very well organized, and the Panel was assisted in advance and throughout by Michele Traver (NEFSC's Stock Assessment Process Lead) and Russ Brown (Chief, NEFSC Population Dynamics Branch). The Panel met remotely in advance with Michele Traver and Russell Brown to discuss the agenda, reporting requirements, and logistics. As for the GoM haddock Research Track Peer Review meeting, I am grateful to the Panel and organizers for delaying the daily start of the meeting such that it started at 4am New Zealand time.

The Haddock Working Group prepared all documentation and clear, well-structured presentations were made by a number of presenters, most notably by Liz Brooks (NEFSC) and Tom Carruthers (Blue Matter Science). The majority of documentation and presentations were made available one week in advance using a NEFSC repository website (see Appendix 1). For EGB, some of the files, including presentation files, were provided later but still in time for the meeting. As for the GoM haddock Research Track Peer Review meeting, the NEFSC supplied rapporteurs for the meeting with notes appearing in near real time using Google Docs. This is an excellent system, and the rapporteurs should be congratulated for a job well done.

In advance of the review, in addition to meeting virtually with the Panel and NEFSC staff, I reviewed the background documents provided (Appendix 1). During the review, I participated fully in the discussions during and after the presentations provided. Additionally, along with other CIE panelists I suggested edits and commented on the draft Summary report prepared by the Panel co-chairs to reflect Panel discussion and recommendations. I am grateful to the co-chairs for leading on the Summary Report; this was efficient and effective and is a good model for future reviews. The summary Report is in fact a larger and more detailed document than is usual and the co-chairs did an exceptionally good job at capturing substance, nuance and recommendations; very little editing was necessary by the Panel. As ever, I took continuous notes for my own use in developing this report.

As already noted, the materials presented were exceptional and the presentations themselves were clear. However, apart from extensive reports, a quick count of presentation slides is EGB:409 and GB:671. If presentations were to take about half of the available review hours (15) then nearly 1100 slides had to be shown in roughly 900 minutes. Many of the slides were complicated and using very small text though they and the reports were available in advance. The review organizers may wish to assist presenters in streamlining presentations.

## SUMMARY OF FINDINGS BY ToR

*The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role 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*

NB. ToR for the Review are highlighted in *purple italics* to distinguish them from the CIE ToR highlighted in *blue italics*.

**ToR 1**   *Review existing research efforts, data, and habitat information in the Gulf of Maine and Georges Bank, identify any findings relevant to influences of ecosystem conditions on haddock, and consider those findings, as appropriate, in addressing other TORs.  For processes that the working group deems important and promising that are not currently feasible to consider quantitatively, describe next steps for development, testing, and review of quantitative relationships and how they could best inform assessments.*

The Panel agreed that this TOR has been met. I agree with that finding. I note also comments made in a review of the GoM stock assessments. My comments here are similar as for the GoM review.

As for the Gulf of Maine (GoM) WG which shares this ToR, the GB and EGB WG described in detail how it approached the ToR and provided a good discussion on its reservations. The reports state that the WG considered species distribution models based on machine learning methodologies and cite Friedland *et al* (2020). Friedland *et al* applies machine learning (random forest classification and regression trees) to a dataset for the US northeast shelf for a range of species and concludes species ranges and overlaps have expanded over time with potential for increased between-species interactions. It is unclear if the WG is using the haddock-related outputs from the Friedland *et al* analysis or has applied the same methods with the same covariates but just to haddock with no other species included. I think the latter. It is also unclear if the WG analysis is for the whole or a subset of the region included in the Friedland *et al* analysis. I think the former.

The WG discussion is good, and the results are well presented and explained. As discussed during the GoM and GB/EGB Reviews, and suggested by the WGs, the results are hard to interpret, and it is unclear if the analysis is simply reflecting a change in haddock spatial abundance in the surveys rather than finding habitat drivers for abundance changes. The WGs considered this carefully and are honest about the lack of a mechanistic explanation and the need for further work.

During the GoM Review it was noted that if the stock assessment in future is done using the Woods Hole Assessment Model (WHAM; Stock and Miller, 2021) then environmental indices could be included directly. This is true and was discussed during the GB/EGB Review which explicitly considered a WHAM implementation for EGB though not with environmental indices integrated. It was noted in the GB/EGB Review that there is potential to consider varying natural mortality, M, based on habitat use. I agree with this but am wary of allowing the models to soak up uncertainty without understanding causal mechanisms and without any clear way then of projecting to inform decision-making. As I noted during the GoM Review, it is potentially more illuminating to explore important environmental correlates externally, as started by the WG and as seen in such work as by Friedland *et al*. External exploration can not only aid understanding of causality but in principle would make future stock assessment including ecosystem variables more efficient.

ToR 1 ends by saying "…*and how they could best inform assessments*". The GB and EGB WG Reports on ToR 1 both start (p13 and p14 respectively) by saying "*Ecosystem variables are important drivers of the spatial distribution of fish, therefore the working group developed and reviewed habitat models which might explain changes in the spatial distribution of haddock over time*." It is unclear in the WG Reports how the WGs envisage any habitat models will actually be used to inform the assessment directly as required by the ToR (e.g., using WHAM with relevant covariates) or more qualitatively but it is clear from discussions during the Reviews that the WGs have considered the issues. It would be useful for the WG to be clearer on this at ToR 1 summaries for future reference.


**ToR 2** *Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.*

The Panel agreed that this TOR has been met. I agree with that finding.

The WG described in detail how the catch components were compiled, with clear and extensive explanations building on historical and more recent analyses and processing. For each of GB and EGB the WG has provided a thoughtful summary of uncertainties with most identified as minor though some are unknown. The WG recommendations are related to this list.

One minor uncertainty identified is due to the conversion factors (gutted:whole weight) applied to US commercial landings. Conversion factors have not been updated since the 1930s and although identified as a minor uncertainty it would be good practice to update the factors as recommended by the WG and the review Panel.

There are no or few recreational fisheries on GB/EGB haddock and commercial landings appear to be generally well sampled despite the episodic recruitment, mixed-species fisheries and varying species mix. There is some uncertainty related to misreporting as highlighted by the WG and which might be considered if further information becomes available.

Canadian landings and discards are from EGB only but comprise the majority of all GB catch. Canadian landings and discards have varied through time as management measures have changed, target fishing has changed, gear use has changed and even vessel size has changed. The EGB WG Report provides a good account of this as well as a considered appraisal of how landings and discards have been estimated. Canadian landings have been subject to dockside monitoring since 1992 and at-sea observers have been used since 1978. Observation rates have been higher since 2006 though responsive to haddock recruitment into the fishery following large recruitments. In 2006 the proportion of observed catch (by weight) exceeded 30% before dropping. Only since 2013 has the observer coverage by weight consistently exceeded 30%. The average coverage since 2013 is 37%.

Discarding by Canadian vessels has varied greatly with a move from most haddock being bycaught in scallop fisheries to being targeted by small trawlers. While discarding was high (up to 26% estimated in 1974) it has been low (less than 1%) since 2003. The Canadian management measures have had a major impact on discarding. The Review Panel commented on this in relation to at-sea observer coverage but the package of measures including by-catch quotas, voluntary avoidance protocols, effort reductions and gear modifications (e.g., mesh size regulations) is the underlying driver for discard reduction.

Overall, though noting the minor uncertainties identified by the WG such as in US landings and discards given low observer coverage, I agree with the Review Panel that both the US and Canada have implemented procedures sufficient for commercial catch and discard estimation.

Finally, during the Review Meeting, there was considerable discussion on the changes to estimating the length-weight relationship used to calculate catch-at-age. This issue was identified as an unknown source of uncertainty for the US and as a minor one for Canadian catch estimates given that no individual fish are weighted from catch samples in the US. The Review Panel nevertheless agreed that at this time the issue is more important for Canadian catch-at-age because Canadian catches are a significant portion of total catch.  In my view, the WGs considered this issue in detail and with care and I am comfortable with the 3-year moving average approach adopted for Canadian landings and discards.


**ToR 3**   *Present the survey data being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty in these sources of data.*

The Panel agreed that this TOR has been met.  I agree with that finding.

All survey operational matters are described in detail in both the GB and EGB WG Reports, together with data and associated uncertainties. I note that the GB Draft report at ToR 3 starts with consideration of biology which seems misplaced. In my view, the WGs have done an excellent job of considering in detail the NMFS and DFO surveys used in the GB and EGB assessment and have well justified the indices used.

During the Review Meeting, a presentation was made that examined the impact of breaking the NEFSC time series into two segments. The presentation was an excellent combination of technical analysis and wit (Brooks_HaddockWG_TOR3_Calibrate_Your_Expectations_March_29_2021) and I note it no longer seems to be available on the NEFSC Portal. This may need to be checked.

The Review Panel supported the WG's decision not to split the NEFSC survey time series and was reassured that the surveys showed consistent trends between DFO and NEFSC based on their matching cohort tracking.  I agree with the Review Panel conclusion that the survey time series would provide robust data to support the assessment modeling. I note that in the GB haddock Draft report in the final sentence of the section on **Maintaining a single NEFSC time series versus breaking at the H.B. Bigelow years**, it says "…*the working group agreed not to treat the NEFSC indices as a single time series for the purposes of assessment modeling*". The "*not*" seems to be in error.


**ToR 4**   *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Compare the time series of these estimates with those from the previously accepted assessment model, and evaluate the strength and direction of any retrospective pattern(s) in both the current and the previously accepted model. Enumerate possible sources of the retrospective patterns and characterize plausibility, if possible.*

The Panel agreed that this TOR has been met. I agree and consider the Review Panel Summary report at ToR 4 to be an excellent summary of discussions. I have one possible reservation as raised below.

The Review Panel commented on the excellent analyses and clear presentations. I think that the model building, and careful, sequential analyses were of the highest order and am grateful to the stock assessment analysts for such clarity of work, reporting and presentation.

The GB stock assessment modeling built logically from the previously used VPA, bridging and exploration through a catch-at-age implementation in ASAP to a new state-space model implemented in WHAM. All diagnostics were shown, and clear arguments made for decisions made on the way to the proposed base case model. All standard model fitting and basic tests were performed. Final model selection based on diagnostics is well argued. Sensitivity testing was rigorous. The proposed base case model was selected first because constant M=0.2 models provided more credibility based on retrospective peels and second because it provided the least biased relative errors in simulation self-testing (between two models with differing correlation structure on numbers at age).

During the Review Meeting, there was concern expressed about the simulation self-testing and the Review Panel recommended a short-term check on this, i.e., prior to the Management Track meetings. This concern was based on Figure B134 of the GB haddock Draft Report (Figure 1):
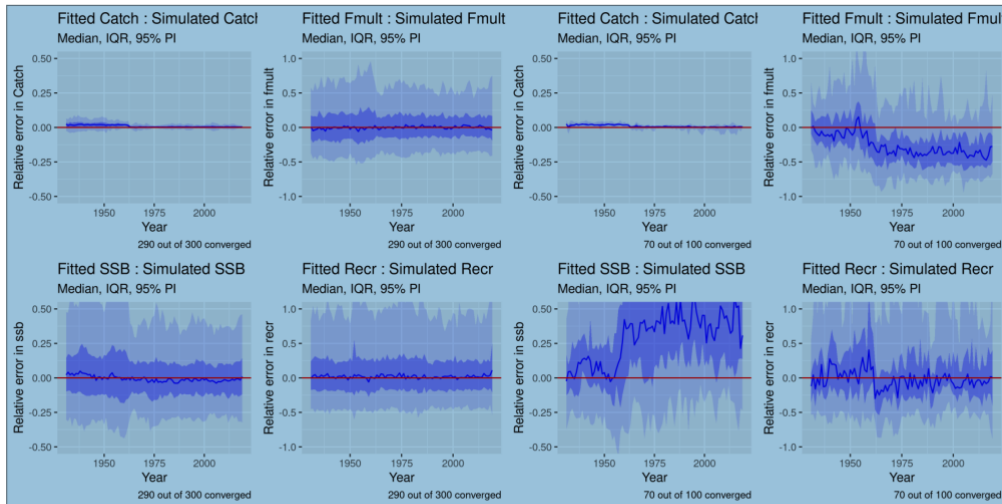
**Figure B134.** Relative error in aggregate catch, average F ("fmult"), SSB, and recruitment for the WHAM_BASE model (left 2 columns) and the WHAM_BASE_AR1y_NAA model (right 2 columns).

*Figure 1: Relative error in aggregate catch*

The concern was also backed up by reference to Figure B135 (Figure 2) which does not show any bias in the WHAM-BASE model compared to the other stock assessment approaches:
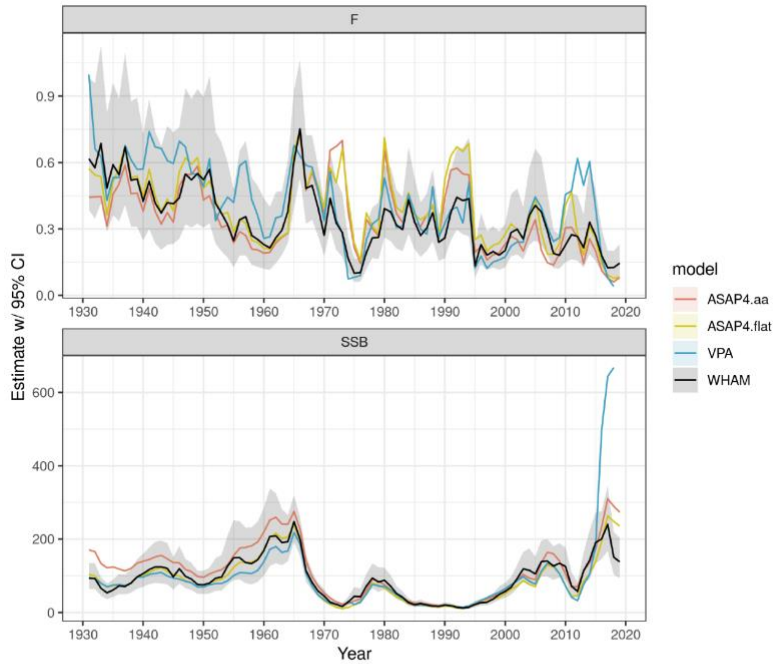


**Figure B135.** Comparison of final model for each modeling environment (ASAP, VPA, and WHAM). Two final ASAP models, ASAP_4Block_ADJCV_NEFF (age-specific fleet selectivity) and ASAP_4Block_Flat_ADJCV_NEFF (logistic fleet selectivity), the final VPA model that incorporated all working group data decisions, and the WHAM model is WHAM_BASE. Time series estimates are plotted for all 4 model, and the 95% confidence interval for WHAM_BASE.

*Figure 2: Comparison of final model for each modeling environment.*

However, the bias referred to by the Review Panel seems to relate to the right hand two columns of Figure B134 rather than the left two columns which are the diagnostics for the proposed base case. Indeed, the final selection criterion used for the selection was that this model showed the least bias. I am not sure if this is a misunderstanding on my part or the review Panel's but am comfortable that the analysts will be able to check in good time before the Management Track meetings.

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The EGB stock assessment followed a similarly rigorous approach to model building both by NEFSC and Blue Matters Science. The model is similar but differs not just in the restricted data set used but most notably in that it includes M estimation for recent years. The M estimation was motivated by WG analyses suggesting an increase in recent years and because of improved model fitting of survey trends. The M estimation model (Mest) also showed lesser bias than a fixed M variant (similar to the GB proposed base case). The choice of year for the break between a fixed M period (at 0.2) and a recent M estimation period was based on a grid search using different levels of M and different break points. The fixed M levels ranged from 0.3 to 0.45 and spanned 7, 10 or 13 years. The best fit to the data was with a fixed M of 0.45 and a break point of 10 years. The Mest model was also preferred because it allows uncertainty in M to be carried forward into reference point calculations and projections.

The final model fitted well though with some noted issues, particularly around the model's inability to capture aspects of the DFO spring survey. As for the GB model, standard fitting tests were performed as well as numerous sensitivity analyses. The estimate of M for the most recent ten years is 0.473 (0.431, 0.527), significantly higher than the earlier period fixed value of 0.2. I am impressed by the model development fitting and agree with the analysts that the models to date are both an improvement on the older VPAs but are a good place to start exploring further. It is a concern that the GB and EGB models provide different interpretations of data in recent years, the one fixing M for the duration and the other estimating M for the recent period. Given the likelihood of a single GB stock, modeling the EGB as a single stock is clearly wrong and it may well be that the high estimated M is a reflection of migration out to the western GB (and perhaps Scotian Shelf) at high density or prevailing environmental conditions. This leads naturally to consideration of a consolidated GB model as recommended by the Review Panel.

**ToR 5**   *Update or redefine status determination criteria (SDC point estimates or proxies for BMSY, BTHRESHOLD, FMSY and MSY) and provide estimates of their uncertainty.  If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs.*

This ToR relates only to GB haddock, not to EGB haddock. The Panel agreed that this TOR has been met.  I agree with that finding.

As a Research Track assessment, the WG has not definitively estimated biological reference points (BRP) but has focused on explaining and justifying the continued use of proxy BRPs and how uncertainty around these proxies can be generated using the proposed state-space model using WHAM. The WG has considered in detail how to deal with the highly variable nature of the GB haddock stock and with reference to the National Standard 1 Guidelines on the need to consider prevailing conditions has advised on data/estimate windows to be used. In general, 5-year windows have been advised. In my view, the WG advice is sound.

A key issue raised by the WG is how frequently Management Track assessments might be needed to update BRPs and catch advice for stocks showing strong retrospective patterns (as is typical for GB haddock). I would add that for stocks with such strong biological and selectivity changes, regardless of retrospective patterning in stock assessments, the frequency of review will need to be high. Dynamic BRPs are devices to underpin management decision-making and meet regulatory needs but they present conceptual and technical challenges. This issue (Management Track frequency, potential to change from Research Track advice, and revised BRPs, etc) also relates to what in the GoM haddock Review was referred to as the "off ramp". That GoM discussion was driven by the potential advice by WGs to move to "Plan B" assessments given rejection of analytical stock assessments but with the possibility that incorporation of new data and retuning might lead to acceptable assessments and the lack of need to move to Plan B. Also in mind was the highly variable nature of haddock fisheries and the utility of dynamic BRPs.

**ToR 6**   *Define the methodology for performing short-term projections of catch and biomass under alternative harvest scenarios, including the assumptions of fishery selectivity, weights at age, maturity, and recruitment.*

The Panel noted that this ToR relates primarily to GB haddock and agreed that the TOR has been met.  I agree with that finding. Note that ToR 11 (below) is specifically about reference points for providing advice to the Transboundary Management Guidance Committee (TMGC).

Haddock has great variation in growth and weight-at-age (WAA), especially following the recruitment of large year classes. The WG explored in detail the skill of log-linear prediction models and various length window averages at predicting WAA. The WG conclusion was that for ages up to age 8, a simple 2-year average provides the best skill and that for ages 9+ the best approach is to use the minimum of a 2-year average or the mean ratio of age 9 to 8. The analyses leading to the conclusions are well explained and convincing. I note that in the GoM Research Track Review, discussion also turned to linear prediction along the cohorts to estimate more accurately WAA in coming years. I understood in that discussion that work on linear prediction along cohorts has been carried out in ICES and may be considered by other reviewers but note papers on Northern cod which may be of interest (Cadigan, 2013 and 2016).

The other key assumption required for short term projections is on selectivity. The WG has assumed 5-year averaging, consistent with how BRPs are also proposed to be calculated (ToR 5). This is reasonable but as at ToR 5, the WG advice on Management Track frequency and the potential need for BRP and projection assumptions needs to be considered. Of course, selectivity assumptions may need to be changed depending not just on whether the recent model estimates are sound but also on potential changes in management measures for haddock or interacting fisheries.

**ToR 7**   *Review, evaluate and report on the status of the Stock Assessment Review Committee (SARC) and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports.  Identify new research recommendations.*

The Panel agreed that this TOR has been met. I agree with that finding.

The WG was tasked with reviewing and evaluating a number of recommendations from Management Track and TRAC and of developing a set of research recommendations. Both GB and EGB Draft Reports, at various ToR, provide concise responses to progress on recommendations to be responded to.

The WGs recommendations are also concise though some of them (for both GB and EGB) are potentially large in scope. For example, both sets of recommendations include the need for work on understanding natural mortality, on density-dependent processes, and seasonal and longer-term changes in condition. These are inarguably important from a scientific perspective and potentially so from a management one if the advisory and decision-making processes are not robust to the uncertainties. In my view, the recommendations would be more useful if each were to be more focused on what specifically might be done and how this would reduce uncertainty in advice. A focus on why each recommendation is important and how it impacts on advice would provide a basis for prioritization.

Notwithstanding the comment above, the recommendations from both WGs are considered and are supported by the considerations across the ToR.

**ToR 8**   *Develop a "Plan B" for use if the accepted assessment model fails in the future.*

The Panel agreed that this TOR has been met and noted that it was particularly relevant for GB haddock but not for EGB haddock. I agree with that finding.

As for ToR 5 and 6, this ToR has wider issues to consider than the adoption of a specific Plan B model to be used if the assessment model fails in the future: *inter alia* i) when is it appropriate to reject a stock assessment and move to Plan B, especially for a data rich stock such as GB haddock?; ii) the use of more than one model to test robustness of stock assessment conclusions; and iii) if Plan B were advised at the Research Track stage or following peer review, how would the Management Track process potentially allow for reinstatement of the analytical assessment? The Review Panel understanding is that a Plan B is intended as a precautionary measure for potential future use and recommended NOAA establish clear guidance for conditions that would lead to the failure of a peer reviewed analytic model. I agree with this recommendation.

Plan B Smooth was one of a group of index-based methods tested during a workshop in 2020. The details of that workshop are available at the NEFSC Repository website, including a draft report. In addition, three CIE reviews are available at CIE Reports for 2021. The workshop simulation tested index-based methods to determine performance in providing catch advice in the absence of an accepted analytical stock assessment. Plan B Smooth was found to perform well. The GB WG considered the index-based model Plan B Smooth for catch updating. The WG analysis was comprehensive and resulted in specific recommendations for the Plan B Smooth implementation (use of only NMFS spring and fall survey indices for the past 33 years and with a smoother span of 0.27). As an implementation of Plan B smooth I think this is reasonable.

For EGB haddock, though the potential use of Plan B is unclear, the WG considered index-based methods such as Plan B Smooth, an age composition index, and performed closed loop testing of 12 management procedures (MP). In the closed loop testing using the proposed state-space model as an operating model, only the Plan B Smooth had fixed parameters while all other MPs were tuned (control parameters were estimated to achieve a performance outcome comparable to applying an F40%SPR strategy). The work reported in the EGB Draft Report and in a presentation to the Review Meeting (*TOR8 EGB Carruthers animated*) is comprehensive and led to a recommendation for a simple index-based method (I2) which calculates TAC advice as a fixed ratio of the mean survey indices of the previous two years.

While the recommendation of a Plan B may not be as obviously relevant to the management process as that for GB, the work on the EGB Plan B is impressive and the approach to testing is of general interest and could be applied more widely.


**ToR 9**    *Review and present any research related to recruitment processes (e.g., spawning and larval transport, and retention), and potential hypotheses for large recruitment events.*

The Panel agreed that this TOR has been met. I agree with that finding.

The WG considered an updated analysis of Friedland *et al* (2015) which had found support for the hypothesis that haddock recruitment on Georges Bank may be influenced by provisioning effects of the fall-bloom on pre-spawning adults. The re-analysis confirmed those conclusions for Georges Bank. It was suggested that the influence is *via* detritus fall out leading to increased benthic prey being available to haddock. The original analysis did not include the large 2013 YC of haddock but this was included in the reanalysis which confirmed support for the provisioning hypothesis. The WG also considered egg retention and reported on drifter studies on GB.

My impression is that the WG has done what it can to respond to the ToR but has limited and largely circumstantial information. It has presented and reviewed research related to stock and recruitment but as yet there are no definitive hypotheses for large recruitment events that can be tested or used predictively in providing advice.

**ToR 10** *Review and present any research related to density-dependent growth.*

The Panel agreed that this TOR has been met.  I agree with that finding.

The GB WG did not present any new research related to density-dependent growth but did consider how to deal with trends in growth when estimating BRPs and making short-term projections under ToR 5 and 6. The EGB WG reported on an analysis of age-length samples collected from 1988-2018 from DFO winter surveys. I would note also that the GoM haddock Research Track WG Report and Review Meeting presentations included a clear description of work undertaken to describe changes in GoM haddock weight-at-age (WAA) over time as well as by cohort. The GoM WG did a solid job of distinguishing changes in growth over the long-term and by cohort, the latter presumably being caused by density-dependent mechanisms even though detailed causality is elusive. That work may also be applicable to GB haddock.

For EGB, the analyses of DFO survey age-length data suggests that there are density dependent effects on haddock growth and that variability in growth is higher when cohorts are large. There are implications for growth, natural mortality, and size- or age-based selectivity as cohort size varies - from a perspective of understanding the mechanisms and how stock assessment models may need to account for short-term and longer variations in natural mortality and selectivity, but also in terms of how BRPs may be applicable or estimated and how to make short-term projections. All of these issues have arisen for GB and EGB at ToRs 4, 5, and 6.

**ToR 11** *For eastern Georges Bank, provide advice to TMGC on appropriate reference points.*

The Panel agreed that this TOR has been met.  I agree with that finding.

The work conducted for this ToR is related to that reported at ToR 6. Both use the same OpenMSE framework (https://openmse.com/) and use closed loop simulation of management procedures (MP) using an underlying simulation operating model. At ToR 6 a single operating model was used but at this ToR alternative operating models with low or high M were used, both based on the proposed base model (ToR 4). Management procedures (i.e., consistently applied catch control rules with given data and assessment inputs) tested included catch setting based on the existing strategy of Fref=0.26, which by coincidence is also F0.1 and current F40%SPR. The TMGC has expressed concern that a fixed F=0.26 strategy may be inappropriate.

Various procedures tested a retrospective forecasting approach using different Fs, including F=0.26, and F40%SPR calculated on different year-averaging and updating intervals. The performance of the tested management procedures was evaluated in terms of catch, catch variability and biomass achieved. The "tentatively" proposed management procedure includes using an F40%SPR control rule with 4-yearly updating and using the mean calculated over the most recent ten years. As stated in the EGB Draft Report: *the approach provides amongst the highest yields, dominates other MPs with regard to biomass outcomes, has intermediate variability in yield, the 10-year average reflects perceptions of the resolution of fishery changes, and it does not require updating on a very regular basis (a two or a three year update)*.

This is impressive work. I note, however, that it effectively adopts a single control parameter of F40%SPR and then tests alternative management procedures that include how that control parameter is updated. The

reference point of F40%SPR is widely used and is supportable but the WG has not actually argued why it should be adopted as a control parameter and has not as such advised on appropriate reference points as required at this ToR. Rather, it has adopted one for testing how using it as a control parameter can result in trade-offs in biomass and yield outcomes.

As an advocate for the management procedure approach (see, e.g., Bentley and Stokes, 2009) I support this work and think it is a useful way forward. Given the ToR, however, it would have been interesting to see arguments made for other control reference points but, more importantly, definition of the outcomes desired by management. I would hope that this work would be presented to TMGC with an emphasis on outcome performance and objectives. There is considerable confusion over BRPs used as control parameters (which is common) as to BRPs that might be performance outcome requirements – using the management procedure approach would emphasize the latter.

**ToR 12** *Review data related to stock structure of haddock on Georges Bank (including eastern Georges Bank management area) and implications for assessments conducted on the whole bank and on subareas of the bank.*

The Panel agreed that this TOR has been met.  I agree with that finding.

The WG Draft report (for both GB and EGB haddock) summarizes extensive work that relates to stock structure. In addition, further work was presented to the review meeting during consideration of this ToR.

The summary of biological and operation information suggests that there is a single GB wide stock, encompassing both EGB and western GB as well as the Great South Channel. There is no indication that young fish move to the GoM but there is a connection with older fish moving westward. There is also a weak connection to the Scotian Shelf. The WG focused on implications for stock assessment and there is clearly a diversity of views on whether stock assessment can be applied at the subcomponent (e.g., EGB) level or needs to be applied to the whole GB stock only.

An updated presentation (*GBHaddock_TOR12_Stock_Structure_v2*) was made available prior to the meeting that contains analyses not included in the WG Draft Reports. That updated presentation considered whether the EGB stock assessment might show signs of hyperstability by not accounting for range expansion to the west at times of high abundance, in line with the widely accepted conception of GB haddock as consistent with McCall's Basin hypothesis. The analysis gave mixed results by survey, but the overall analysis did not support a conclusion of hyperstability.

My interpretation of the multiple analyses and strands of evidence is that the haddock stock is complex and while it is likely a single biological stock across the GB and potentially wider, the connectivity between areas is also complex and dependent on environmental conditions and density. However, simple conceptions such as the Basin Model do not adequately support the lack of movement from EGB even at times of high recruitment. There is not currently sufficient understanding to underpin a complex stock assessment that accounts for environmentally and density driven movement, and given the high variability in natural mortality, attempts to estimate movement would in any case be confounded.

Stock assessments need to capture the whole as well as possible and estimate uncertainty as best as possible. A GB-wide stock assessment is the best way of doing this and the current GB state-space modelling approach seems well adapted to make progress. I do not readily see the benefit in a separate EGB model. Not included in WG or Review Meeting materials, the WG attempted to gather information and views from its members through a short survey. There is apparently a clear view that GB-wide stock assessment is meaningful and

viable. An EGB-specific stock assessment is less clearly supported as meaningful or viable but the overall conclusion by the WG is that currently both GB and EGB assessments need to be carried out.

While I am not entirely sure that a separate EGB stock assessment is strictly needed, I do note that the EGB model developed by Blue Matters Science has been converted to use in Open MSE for work on EGB reference points and on developing Plan B management procedures – this could have been done using the NEFSC proposed state-space model for EGB or for GB as a whole. The work was done not because a separate stock assessment was required for biological reasons but because a second assessment group was involved due to the need for developing advice on EGB for Canada and the TRAC/TMGC rather than GB as a whole for domestic advice undertaken to meet statutory needs. There is a need to consider carefully not just biological rationales for developing stock assessments but also practical management needs. Given that the management of GB and EGB is jointly overseen by Canada and the USA and the TRAC/TMGC system is separate to either national management system, I would support the current approach for practical purposes.

## CONCLUSIONS AND RECOMMENDATIONS
*The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role 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***

These are embedded in the responses at individual ToR.

The GB and EGB haddock Research Track WG attended to all its ToR. The processing of catch data and surveys are well described and the WG has responded to specific needs for improvement where necessary. The state-space models developed for both GB and EGB followed meticulous model building which was well argued, described and presented. The proposed base case models are converged and have reasonable goodness-of-fit. However, while the GB model is best fit with an assumed, fixed natural mortality rate, M, of 0.2, the EGB model is best fit when M is estimated for the most recent ten years. The estimate is 0.47. Given the EGB is a subset of the GB stock this higher M estimate could represent genuinely higher mortality or could be confounded with movement away from the EGB. Either is possible on grounds of density dependence and/or environmental drivers.

The utility of the GB model is clear within the management context and the recommended BRPs and projections are sound. For EGB this is less clear, and the inconsistent treatment of natural mortality raises issues around how to estimate BRPs but particularly how to make projections. Consideration of BRPs for the EGB has been made in the context of potential management procedures. This approach is well suited for jointly managed stocks where different nationally legislated or regulated approaches may not be possible but where jointly agreed objectives might be.

In addition to data preparation, stock assessment model development, and BRPs and projections, the WG also considered information and research related to recruitment processes for, and habitat use by, the GB and EGB stock assessment modeling. The work on both issues was inconclusive and did not feed into the stock assessment or any explicit future stock assessment plans. Research recommendations made by the WG that relate to these issues could be more specific to assist in prioritization.

The WG also considered all information available that relates to stock structure. The conclusion that GB is likely a single stock spanning EGB, western GB and the Great South Channel appears well founded. Relating this to stock assessment is difficult. While the WG clearly views a single GB stock assessment as meaningful and viable there is no consensus on the EGB stock assessment being either meaningful (biologically) or viable. However, while EGB stock assessment might most ideally be consolidated into wider GB assessment from a biological perspective, there remains a strong management imperative for an EGB assessment and unless and until this need can be met by consolidated modelling, separate stock assessments are not unreasonable.

# APPENDIX 1

**Bibliography of materials provided for review**

Prior to the Workshop, the majority of materials were provided using the excellent NOAA Fisheries Stock Assessment support Information (SASINF) website *(*https://apps-nefsc.fisheries.noaa.gov/saw/sasi/sasi_report.php). Additional materials not reported in the WG Report were provided for eastern Georges Bank stock assessment runs using Github: https://github.com/Blue-Matter/EGB_Haddock. All presentations were made available using before or during the meeting using SASINF.

**Additional references are:**

- Bentley, N. and K. Stokes (2009) Contrasting Paradigms for Fisheries Management Decision Making: How Well Do They Serve Data-Poor Fisheries? Marine and Coastall Fisheries: Dynamics, Management, and Ecosystem Science 1:391-401
- Brooks, E.N, M.L. Traver, S.J. Sutherland, L. Van Eeckhaute, and L. Col. 2008. In. Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. http://www.nefsc.noaa.gov/publications/crd/crd0815/
- Cadigan, N. (2013) An evaluation of growth models for predicting 2J3KL cod stock weights-atage. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/053. v + 27 p. https://waves-vagues.dfo-mpo.gc.ca/Library/349796.pdf
- Cadigan, N. (2016) Weight-at-age growth models and forecasts for Northern cod (Gadus morhua). DFO Can. Sci. Advis. Sec. Res. Doc. 2016/016. v + 19 p. https://waves-vagues.dfo-mpo.gc.ca/Library/363966.pdf https://www.sciencedirect.com/science/article/pii/S0165783621000874
- Friedland, K. et al (2015) Layered effects of parental condition and larval survival on the recruitment of neighboring haddock stocks. - Can J Fish Aquat Sci 72: 1672– https://cdnsciencepub.com/doi/10.1139/cjfas-2015-0084
- Legault, C.M., Restrepo, V.R., 1998. A Flexible Forward Age-Structured Assessment Program (No. 49).
- NEFSC (Northeast Fisheries Science Center). 2017. Operational Assessment of 19 Northeast Groundfish Stocks, Updated Through 2016. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-17; 259p. doi: 10.7289/V5/RD-NEFSC-17-17.\
- NOAA Fisheries NEFSC (2020) Description of New England and Mid-Atlantic Region Stock Assessment Process https://apps-nefsc.fisheries.noaa.gov/saw/sasi/uploads/Background_Stock-assessment-process-June2020.pdf
- Northeast Region Stock Assessment Support Materials (data portal) https://apps-nefsc.fisheries.noaa.gov/saw/reviews_report.php
- NOAA Fisheries. Fishery Stock Assessments In New England and the Mid-Atlantic https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/fishery-stock-assessments-new-england-and-mid-atlantic
- K. D. Friedland, J. A. Langan, S.I. Large, R.L. Selden, J.S. Link, R.A. Watson, and J.S. Collie (2020) Changes in higher trophic level productivity, diversity and niche space in a rapidly warming continental shelf ecosystem. Science of The Total Environment 704:

https://www.sciencedirect.com/science/article/abs/pii/S0048969719352623?via%3Dihub

- Stock, B.C. and T.J. Miller (2021) The Woods Hole Assessment Model (WHAM): A general state- space assessment framework that incorporates time- and age-varying processes via random effects and links to environmental covariates. Fisheries Research 240: https://reader.elsevier.com/reader/sd/pii/S0165783621000953?token=DC7F8D5918D85DD4F317299C2662894B0CA9E1548C232D0017F71CCC836116A8C49CCE8C33D1DC170694C1DFE909EB60&originRegion=us-east-1&originCreation=20220207022051

- TRAC (Transboundary Resources Assessment Committee). 2021. Eastern Georges Bank haddock. TRAC Status Report 2021/01. https://www.fisheries.noaa.gov/resource/peer-reviewed-research/transboundary-resources-assessment-committee-documents

# APPENDIX 2

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

***Eastern Georges Bank and Georges Bank Haddock***
***Research Track Peer 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[1]. Further information on the Center for Independent Experts (CIE) program may be obtained from www.ciereviews.org.

**Scope**

The Research Track Peer Review meeting is a formal, multiple-day meeting of stock assessment experts who serve as a panel to peer-review tabled stock assessments and models.  The research track peer review is the cornerstone of the Northeast Region Coordinating Council stock assessment process, which includes assessment development, and report preparation (which is done by Working Groups or Atlantic States Marine Fisheries Commission (ASMFC) technical committees), assessment peer review (by the peer review panel), public presentations, and document publication.  The results of this peer review will be incorporated into future management track assessments, which serve as the basis for developing fishery management recommendations.

The purpose of this meeting will be to provide an external peer review of Eastern Georges Bank and Georges Bank and haddock stocks. The requirements for the peer review follow.  This Performance Work Statement

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[1] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2005/m05-03.pdf

(PWS) also includes: **Appendix 1**: TORs for the research track, which are the responsibility of the analysts; **Appendix 2:** a draft meeting agenda; **Appendix 3:** Individual Independent Review Report Requirements; and **Appendix 4:** Peer Reviewer Summary Report Requirements.

## Requirements

NMFS requires three reviewers under this contract (i.e. subject to CIE standards for reviewers) to participate in the panel review. The chair, who is in addition to the three reviewers, will be provided by either the New England or Mid-Atlantic Fishery Management Council's Science and Statistical Committee; although the chair will be participating in this review, the chair's participation (i.e. labor and travel) is not covered by this contract.

Each reviewer will write an individual review report in accordance with the PWS, OMB Guidelines, and the TORs below. All TORs must be addressed in each reviewer's report. The reviewers shall have working knowledge and recent experience in the use and application of index-based, age-based, and state-space stock assessment models, including familiarity with retrospective patterns and how catch advice is provided from stock assessment models. In addition, knowledge and experience with simulation analyses is required.

## Tasks for Reviewers

- Review the background materials and reports prior to the review meeting
  - Two weeks before the peer review, the Assessment Process Lead will electronically disseminate all necessary background information and reports to the CIE reviewers for the peer review.
- Attend and participate in the panel review meeting
  - The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers
- Reviewers shall conduct an independent peer review in accordance with the requirements specified in this PWS and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.
- Each reviewer shall assist the Peer Review Panel (co)Chair with contributions to the Peer Reviewer Summary Report
- Deliver individual Independent Reviewer Reports to the Government according to the specified milestone dates
- This report should explain whether each research track Term of Reference was or was not completed successfully during the peer review meeting, using the criteria specified below in the "Tasks for Peer Review Panel."
- If any existing Biological Reference Points (BRP) or their proxies are considered inappropriate, the Independent Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRPs are the best available at this time.
- During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments and research topics may be raised. Comments on these questions should be included in a separate section at the end of the Independent Report produced by each reviewer.
- The Independent Report can also be used to provide greater detail than the Peer Reviewer Summary Report on specific stock assessment Terms of Reference or on additional questions raised during the meeting.

## Tasks for Review panel

- During the peer review meeting, the panel is to determine whether each research track Term of Reference (TOR) was or was not completed successfully.  To make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable.  If alternative assessment models and model assumptions are presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted. Where possible, the Peer Review Panel chair shall identify or facilitate agreement among the reviewers for each research track TOR.
- If the panel rejects any of the current BRP or BRP proxies (for $B_{MSY}$ and $F_{MSY}$ and MSY), the panel should explain why those particular BRPs or proxies are not suitable, <u>and</u> the panel should recommend suitable alternatives.  If such alternatives cannot be identified, then the panel should indicate that the existing BRPs or BRP proxies are the best available at this time.
- Each reviewer shall complete the tasks in accordance with the PWS and Schedule of Milestones and Deliverables below.

**Tasks for Peer Review Panel chair and reviewers combined:**
Review the Report of Haddock Research Track Working Group.

1) The Peer Review Panel (co)Chair, with the assistance from the reviewers, will write the Peer Reviewer Summary Report.  Each reviewer and the (co)chair will discuss whether they hold similar views on each research track Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the peer review meeting.  For terms where a similar view can be reached, the Peer Reviewer Summary Report will contain a summary of such opinions. Reviewers are not required to reach a consensus.

The (co)chair's objective during this Peer Reviewer Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The (co)chair will take the lead in editing and completing this report. The (co)chair may express their opinion on each research track Term of Reference, either as part of the group opinion, or as a separate minority opinion. The Peer Reviewer Summary Report will not be submitted, reviewed, or approved by the Contractor.

**Place of Performance**
The place of performance shall be held remotely, via WebEx video conferencing.

**Period of Performance**
The period of performance shall be from the time of award through June, 2022.  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 2 weeks of award | Contractor selects and confirms reviewers |

| Approximately 2 weeks later | Contractor provides the pre-review documents to the reviewers |
|---|---|
| March 28-31, 2022 | Panel review meeting |
| Approximately 2 weeks later | Contractor receives draft reports |
| Within 2 weeks of receiving draft reports | Contractor submits final reports to the Government |

*  The Peer Reviewer Summary Report will not be submitted to, reviewed, or approved by the Contractor.

**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**
No travel is necessary, as this meeting is being held remotely.

**Restricted or Limited Use of Data**
The contractors may be required to sign and adhere to a non-disclosure agreement.

**NMFS Project Contact**
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**Appendix 1. Haddock Research Track Terms of Reference**

1.  Review existing research efforts, data, and habitat information in the Gulf of Maine and Georges Bank, identify any findings relevant to influences of ecosystem conditions on haddock, and consider those findings, as appropriate, in addressing other TORs.  For processes that the working group deems important and promising that are not currently feasible to consider quantitatively, describe next steps for development, testing, and review of quantitative relationships and how they could best inform assessments.

2.  Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort.  Characterize the uncertainty in these sources of data.

3.  Present the survey data being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty in these sources of data.

4.  Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Compare the time series of these estimates with those from the previously accepted assessment model, and evaluate the strength and direction of any retrospective

pattern(s) in both the current and the previously accepted model. Enumerate possible sources of the retrospective patterns and characterize plausibility, if possible.

5. Update or redefine status determination criteria (SDC point estimates or proxies for $B_{MSY}$, $B_{THRESHOLD}$, $F_{MSY}$ and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs.

6. Define the methodology for performing short-term projections of catch and biomass under alternative harvest scenarios, including the assumptions of fishery selectivity, weights at age, maturity, and recruitment.

7. Review, evaluate and report on the status of the Stock Assessment Review Committee (SARC) and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports. Identify new research recommendations.

8. Develop a "Plan B" for use if the accepted assessment model fails in the future.

9. Review and present any research related to recruitment processes (e.g., spawning and larval transport, and retention), and potential hypotheses for large recruitment events.

10. Review and present any research related to density-dependent growth.

11. For Eastern Georges Bank, provide advice to TMGC on appropriate reference points.

12. Review data related to stock structure of haddock on Georges Bank (including Eastern Georges Bank management area) and implications for assessments conducted on the whole bank and on subareas of the bank.

### Research Track TORs:

**General Clarification of Terms that may be**
**used in the Research Track Terms of Reference**

**Guidance to Peer Review Panels about "Number of Models to include in the Peer Reviewer Report":**

In general, for any TOR in which one or more models are explored by the Working Group, give a detailed presentation of the "best" model, including inputs, outputs, diagnostics of model adequacy, and sensitivity analyses that evaluate robustness of model results to the assumptions. In less detail, describe other models that were evaluated by the Working Group and explain their strengths, weaknesses and results in relation to the "best" model. If selection of a "best" model is not possible, present alternative models in detail, and summarize the relative utility each model, including a comparison of results. It should be highlighted whether any models represent a minority opinion.

**On "Acceptable Biological Catch" (DOC Nat. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):**

*Acceptable biological catch (ABC) is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of Overfishing Limit (OFL) and any other scientific uncertainty…" (p. 3208) [In other words, OFL ≥ ABC.]*

*ABC for overfished stocks.* For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*

NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year.  (p. 3180)

ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, Optimal Yield (OY) does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept.  (p. 3189)

**On "Vulnerability" (DOC Natl. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):**

*"Vulnerability.* A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce Maximum Sustainable Yield (MSY) and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

**Participation among members of a Research Track Working Group:**

Anyone participating in peer review meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting.  Source code for NOAA Toolbox programs is available on request.  These measures allow transparency and a fair evaluation of differences that emerge between models.

**Appendix 2. Draft Review Meeting Agenda**
{Final Meeting agenda to be provided at time of award}

**Eastern Georges Bank and  Georges Bank Haddock**
**Research Track Assessment Peer Review Meeting**

**April 4 – April 7, 2022**

WebEx link:  TBD Phone:  TBD

**DRAFT AGENDA*  (v. 1/6/2022)**
*All times are approximate, and may be changed at the discretion of the Peer Review Panel chair.  The meeting is open to the public; however, during the Report Writing sessions we ask that the public refrain from engaging in discussion with the Peer Review Panel.*

Monday, April 4, 2022

| Time | Topic | Presenter(s) | Notes |
|---|---|---|---|
| 9 a.m. - 9:30 a.m. | Welcome/Logistics Introductions/Agenda/ Conduct of Meeting | Michele Traver, Assessment Process Lead Russ Brown, PopDy Branch Chief TBD Panel Chair | |
| 9:30 a.m. - 10:30 a.m. | TOR #2 | Liz Brooks, Monica Finley | Catch data |
| 10:30 a.m. - 10:45 a.m. | Break | | |
| 10:45 a.m. - 11:45 a.m. | TOR #2 cont. | Liz Brooks, Monica Finley | Catch data |
| 11:45 a.m. - 12:15 p.m. | Discussion/Summary | Review Panel | |
| 12:15 p.m. - 12:30 p.m. | Public Comment | Public | |
| 12:30 p.m. - 1:30 p.m. | Lunch | | |
| 1:30 p.m. - 3 p.m. | TOR #3 | Liz Brooks, Monica Finley | Survey data |
| 3 p.m. - 3:15 p.m. | Break | | |
| 3:15 p.m. - 4:15 p.m. | TOR #3 cont. | Liz Brooks, Monica Finley | Survey data |
| 4:15 p.m. - 4:45 p.m. | Discussion/Summary | Review Panel | |
| 4:45 p.m. - 5 p.m. | Public Comment | Public | |
| 5 p.m. | Adjourn | | |

Tuesday, April 5, 2022

| Time | Topic | Presenter(s) | Notes |
|---|---|---|---|
| 9 a.m. - 9:15 a.m. | Welcome/Logistics | Michele Traver, Assessment Process Lead TBD, Panel Chair | |
| 9:15 a.m. - 10:30 a.m. | TORs #1 and #9 | Kevin Friedland, Liz Brooks, Scott Large | Ecosystem and Recruitment Processes |
| 10:30 a.m. - 10:45 a.m. | Break | | |
| 10:45 a.m. - 11:45 a.m. | TORs #1 and #9 cont. | Kevin Friedland, Liz Brooks, Scott Large | Ecosystem and Recruitment Processes |
| 11:45 a.m. - 12:15 p.m. | Discussion/Summary | Review Panel | |
| 12:15 p.m. - 12:30 p.m. | Public Comment | Public | |
| 12:30 p.m. - 1:30 p.m. | Lunch | | |
| 1:30 p.m. - 3 p.m. | TORs #10 and #12 | Liz Brooks, Steve Cadrin, Yanjun Wang | Density Dependent Growth and Stock Structure |
| 3 p.m. - 3:15 p.m. | Break | | |
| 3:15 p.m. - 4:15 p.m. | TORs #10 and #12 cont. | Liz Brooks, Steve Cadrin, Yanjun Wang | Density Dependent Growth and Stock Structure |
| 4:15 p.m. - 4:45 p.m. | Discussion/Summary | Review Panel | |
| 4:45 p.m. - 5 p.m. | Public Comment | Public | |
| 5 p.m. | Adjourn | | |

Wednesday, April 6, 2022

| Time | Topic | Presenter(s) | Notes |
|---|---|---|---|
| 9 a.m. - 9:15 a.m. | Welcome/Logistics | Michele Traver, Assessment Process Lead TBD, Panel Chair | |

| Time | Topic | Presenter(s) | Notes |
|------|-------|--------------|-------|
| 9:15 a.m. - 10:30 a.m. | TOR #4 | Liz Brooks, Tom Carruthers | Mortality, Recruitment and Biomass Estimates |
| 10:30 a.m. - 10:45 a.m. | Break | | |
| 10:45 a.m. - 11:45 a.m. | TOR #4 cont. | Liz Brooks, Tom Carruthers | Mortality, Recruitment and Biomass Estimates |
| 11:45 a.m. - 12:15 p.m. | Discussion/Summary | Review Panel | |
| 12:15 p.m. - 12:30 p.m. | Public Comment | Public | |
| 12:30 p.m. - 1:30 p.m. | Lunch | | |
| 1:30 p.m. - 3 p.m. | TORs #5, #6, and #11 | Liz Brooks, Tom Carruthers | BRPs, Projections and EGB Reference Points |
| 3 p.m. - 3:15 p.m. | Break | | |
| 3:15 p.m. - 4:15 p.m. | TORs #5, #6, and #11 cont. | Liz Brooks, Tom Carruthers | BRPs, Projections and EGB Reference Points |
| 4:15 p.m. - 4:45 p.m. | Discussion/Summary | Review Panel | |
| 4:45 p.m. - 5 p.m. | Public Comment | Public | |
| 5 p.m. | Adjourn | | |

Thursday, April 6, 2022

| Time | Topic | Presenter(s) | Notes |
|------|-------|--------------|-------|
| 9 a.m. - 9:15 a.m. | Welcome/Logistics | Michele Traver, Assessment Process Lead<br>TBD, Panel Chair | |
| 9:15 a.m. - 10:30 a.m. | TOR #8 | Liz Brooks, Tom Carruthers | Alternative Assessment Approach |
| 10:30 a.m. - 10:45 a.m. | Break | | |
| 10:45 a.m. - 11:45 a.m. | TOR #7 | Brian Linton | Research Recommendations |
| 11:45 a.m. - 12:15 p.m. | Discussion/Summary | Review Panel | |
| 12:15 p.m. - 12:30 p.m. | Public Comment | Public | |

| Time | Topic | Presenter(s) | Notes |
|------|-------|--------------|-------|
| 12:30 p.m. - 1:30 p.m. | Lunch | | |
| 1:30 p.m. - 2:30 p.m. | Follow-ups/Key Points | Review Panel | |
| 2:30 p.m. - 5 p.m. | Report Writing | Review Panel | |
| 5 p.m. | Adjourn | | |

Friday, April 7, 2022

| Time | Topic | Presenter(s) | Notes |
|------|-------|--------------|-------|
| 9 a.m. - 5 p.m. | Report Writing | Review Panel | |

**Appendix 3. Individual Independent Peer Reviewer Report Requirements**
1. The independent Peer Reviewer report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

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. The independent report shall be an independent peer review, and shall not simply repeat the contents of the Peer Reviewer Summary Report.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), 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 Peer Reviewer Summary Report that they believe might require further clarification.

d. The report may include recommendations on how to improve future assessments.

3. The report shall include the following appendices:

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

**Appendix 4. Peer Reviewer Summary Report Requirements**

1. The main body of the report shall consist of an introduction prepared by the Research Track Peer Review Panel chair that will include the background and a review of activities and comments on the appropriateness of the process in reaching the goals of the peer review meeting. Following the introduction, for each assessment /research topic reviewed, the report should address whether or not each Term of Reference of the Research Track Working Group was completed successfully. For each Term of Reference, the Peer Reviewer Summary Report should state why that Term of Reference was or was not completed successfully.

To make this determination, the peer review panel chair and reviewers should consider whether or not the work provides a scientifically credible basis for developing fishery management advice. If the reviewers and peer review panel chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

The report may include recommendations on how to improve future assessments.

2. If any existing Biological Reference Points (BRPs) or BRP proxies are considered inappropriate, include recommendations and justification for alternatives. If such alternatives cannot be identified, then indicate that the existing BRPs or BRP proxies are the best available at this time.

3. The report shall also include the bibliography of all materials provided during the peer review meeting, and relevant papers cited in the Peer Reviewer Summary Report, along with a copy of the CIE Performance Work Statement.

The report shall also include as a separate appendix the assessment Terms of Reference used for the peer review meeting, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panel advice.

## APPENDIX 3

## Final Agenda

**Monday, March 28, 2022**

| Time | Topic | Presenter(s) | Notes |
|---|---|---|---|
| 11 a.m. - 11:15 a.m. | Welcome/Logistics Introductions/Agenda/Conduct of Meeting | Michele Traver, Assessment Process Lead<br>Russ Brown, PopDy Branch Chief<br>Richard Merrick and Rob Kronlund, Panel Co-Chairs | |
| 11:15 a.m. - 12:45 p.m. | Term of Reference (TOR) #2 | Liz Brooks<br>Monica Finley | GB Catch data (US/Can)<br>EGB Catch data (US/Can) |
| 12:45 p.m. - 1:15 p.m. | Discussion/Summary | Review Panel | |
| 1:15 p.m. - 1:45 p.m. | Break | | |
| 1:45 p.m. - 3:45 p.m. | TOR #3 | Liz Brooks<br>Monica Finley | GB Surveys<br>EGB Surveys |
| 3:45 p.m. - 4 p.m. | Break | | |
| 4 p.m. - 4:30 p.m. | Discussion/Summary | Review Panel | |
| 4:30 p.m. - 4:45 p.m. | Public Comment | Public | |
| 4:45 p.m. | Adjourn | | |

**Tuesday, March 29, 2022**

| Time | Topic | Presenter(s) | Notes |
|------|-------|--------------|-------|
| 11 a.m. - 11:05 a.m. | Welcome/Logistics | Michele Traver, Assessment Process Lead<br>Richard Merrick and Rob Kronlund, Panel Co-Chairs | |
| 11:05 a.m. - 1 p.m. | TORs #1 and #9 | Kevin Friedland<br>Yanjun Wang<br>Liz Brooks | Ecosystem and Recruitment Processes |
| 1 p.m. - 1:30 p.m. | Discussion/Summary | Review Panel | |
| 1:30 p.m. - 2 p.m. | Break | | |
| 2 p.m. - 4 p.m. | TORs #10 and #12 | Yanjun Wang<br>Steve Cadrin<br>Brian Linton | Density-Dependent Growth and Stock Structure |
| 4 p.m. - 4:15 p.m. | Break | | |
| 4:15 p.m. - 4:45 p.m. | Discussion/Summary | Review Panel | |
| 4:45 p.m. - 5 p.m. | Public Comment | Public | |
| 5 p.m. | Adjourn | | |

**Wednesday, March 30, 2022**

| Time | Topic | Presenter(s) | Notes |
|---|---|---|---|
| 11 a.m. - 11:05 a.m. | Welcome/Logistics | Michele Traver, Assessment Process Lead<br>Richard Merrick and Rob Kronlund, Panel Co-Chairs | |
| 11:05 a.m. - 1 p.m. | TOR #4 | Liz Brooks<br>Tom Carruthers<br>Brian Linton | Mortality, Recruitment and Biomass Estimates<br>GB Models<br>EGB Models<br>WG Opinion Survey |
| 1 p.m. - 1:30 p.m. | Break | | |
| 1:30 p.m. - 4 p.m. | TOR #4 cont. | Liz Brooks<br>Tom Carruthers<br>Brian Linton | Mortality, Recruitment and Biomass Estimates<br>GB Models<br>EGB Models<br>WG Opinion Survey |
| 4 p.m. - 4:15 p.m. | Break | | |
| 4:15 p.m. - 4:30 p.m. | Discussion/Summary | Review Panel | |
| 4:30 p.m. - 4:45 p.m. | Public Comment | Public | |
| 4:45 p.m. | Adjourn | | |

**Thursday, March 31, 2022**

| Time | Topic | Presenter(s) | Notes |
|---|---|---|---|
| 11 a.m. - 11:05 a.m. | Welcome/Logistics | Michele Traver, Assessment Process Lead<br>Richard Merrick and Rob Kronlund, Panel Co-Chairs | |
| 11:05 a.m. - 1 p.m. | TORs #5, #11 and #6 | Liz Brooks<br>Tom Carruthers | BRPs<br>EGB Reference Points Projections |
| 1 p.m. - 1:30 p.m. | Break | | |
| 1:30 p.m. - 3:30 p.m. | TORs # 8 and #7 | Liz Brooks<br>Tom Carruthers<br>Brian Linton | Alternative Assessment Approach Research Recommendations |
| 3:30 p.m. - 4 p.m. | Discussion/Summary | Review Panel | |
| 4 p.m. - 4:15 p.m. | Public Comment | Public | |
| 4:15 p.m. - 4:30 p.m. | Break | | |
| 4:30 p.m. - 5:30 p.m. | Panel Wrap-up and report discussion | Review Panel | |
| 5:30 p.m. | Adjourn | | |

# APPENDIX 4

**Georges Bank and eastern Georges Bank Haddock Research Track Peer Review Attendance**
March 28-31, 2022
Attendance

NEFSC - Northeast Fisheries Science Center
GARFO - Greater Atlantic Regional Fisheries Office
NEFMC - New England Fisheries Management Council
MAFMC -  Mid-Atlantic Fisheries Management Council
DFO - Department of Fisheries and Ocean
SMAST - University of Massachusetts School of Marine Science and Technology
MADMF - Massachusetts Division of Marine Fisheries
MEDMR - Maine Department of Marine Resources
MAMFI - Massachusetts Marine Fisheries Institute
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*Richard Merrick - US Co-Chair*
*Allen (Rob) Kronlund - Canadian Co-Chair*
*Joe Powers - CIE Panel*
*Anders Nielsen - CIE Panel*
*Kevin Stokes - CIE Panel*

Russ Brown - NEFSC, Population Dynamics Branch Chief
Michele Traver - NEFSC, Assessment Process Lead

Abigail Tyrell - NEFSC
Alain d'Entremont - Scotia Harvest Inc., TMGC Canadian co-chair
Alex Hansell - NEFSC
Alicia Miller - NEFSC
Angela Forristall - NEFMC Staff
Anthony Wood - NEFSC
Brian Linton - NEFSC
Cate O'Keefe - Fisheries Applications Consulting Team
Catriona Regnier-McKellar - DFO
Charles Adams - NEFSC
Charles Perretti - NEFSC
Irene Andrushchenko - DFO
Jamie Cournane - NEFMC Staff
Jason Boucher - NEFSC
Kathryn Cooper-MacDonald - DFO
Kathy Sosebee - NEFSC
Kevin Friedland - NEFSC
Kris Vascotto - Atlantic Groundfish Council, Executive Director
Larry Alade - NEFSC
Libby Etrie - NEFMC Member
Liz Brooks - NEFSC
Liz Sullivan - GARFO

Lottie Bennett - DFO
Mark Terceiro - NEFSC
Melanie Griffin - MAMFI
Michelle Greenlaw - DFO
Mike Simpkins - NEFSC
Monica Finley - DFO
Paul Nitschke - NEFSC
Robin Frede - NEFMC Staff
Sarah Salois - NEFSC
Scott Large - NEFSC
Steve Cadrin - SMAST
Tara McIntyre - DFO
Tara Trinko Lake - NEFSC
Tim Miller - NEFSC
Tom Carruthers - Blue Matter Science, consultant for DFO
Tom Nies - NEFMC, Executive Director
Toni Chute - NEFSC
Yanjun Wang - DFO