Center for Independent Experts (CIE) Independent Peer Review Report

On

Butterfish and Shortfin Squid Research Track Stock Assessments

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Contents

I. Executive Summary

The External Independent Peer Review for the 2022 Research Track Stock Assessments for Butterfish (*Peprilus triacanthus*) and Northern shortfin Squid (*Illex illecebrosus*) was held via WebEx from March 7th to March11th, 2022. The Butterfish and *Illex* Working Groups (WG) prepared the documentation, and the members of the butterfish and *Illex* WGs made the presentations to address all Terms of Reference. Members of the WGs and public also provided valuable discussion. The butterfish and *Illex* WGs were open to suggestions and provided additional information upon request. The whole process was open and constructive.

The Review was conducted based on a set of predefined Terms of Reference aiming to evaluate fisheries-dependent and fisheries-independent data, stock assessment model configuration and parameterization, stock assessment outputs, stock status determination, model projection, alternative approaches, ecosystem consideration, and uncertainty associated with the assessments. The Review also determines if each of the ToRs is adequately addressed, and whether the stock assessments are appropriate and adequate for providing advice for the management of the butterfish and *Illex* stocks, in addition to making recommendations to improve the stock assessment modeling and assessment process.

Using fisheries-dependent and fisheries-independent data and compiled key life history information, the butterfish WG designed a series of structured simulation scenarios and conducted an extensive analysis to evaluate various model configurations using ASAP 3.0. The best-performing ASAP model configuration was used to help parameterize the initial WHAM model. The butterfish WG identified the best WHAM model configuration based on the defined statistical and biological criteria. The preferred WHAM model was used to provide estimates of stock biomass, fishing mortality, recruitment and biological reference points and to determine the stock status. The previous butterfish stock assessment was assessed using ASAP, and the current assessment is the first WHAM-based assessment for butterfish. The *Illex* WG carefully evaluated relevant fisheries-dependent and fisheries-independent data, life history parameters, and ecosystem factors. The *Illex* WG explored a wide range of models with different assumptions and data needs for the *Illex* stock assessment. The Review Panel and WG extensively discussed the challenges of assessing a species like *Illex* with multiple intra-annual cohorts, and evaluated possible uncertainties associated with the modeling process. The *Illex* WG also identified data and model needs in addition to management regulations required for the possible implementation of in-season management. As a CIE reviewer, I am charged to evaluate the 2022 Butterfish and *Illex* Research Track Stock Assessments with respect to the Terms of Reference I was provided.

I would like to commend both the butterfish and *Illex* WGs for their excellent work. I was impressed by the breadth of expertise in the review; the amount of effort spent to compile all the data for the assessment; the considerations of plausible scenarios; the openness of discussion on stock assessment uncertainty; the consideration of ecosystem factors, the discussion of alternative approaches and suggestions; and the constructive dialogues among the WGs, the Review Panel and other participants during the review.

Overall, based on the stock assessments presented and the materials provided, I believe that the butterfish WG has adequately addressed most of the ToRs. For butterfish, there might be a scale issue in estimating stock biomass because the modeling results tend to be sensitive to assumed values for survey catchabilities. The assessment model time step (yearly) may not be appropriate for the short-lived butterfish. A shorter time step (e.g., semi-annual or quarterly) may

better capture the strong seasonality in the butterfish biology and fishery. More studies are needed to better understand its stock structure and spatial variability in life history parameters. The criteria used to identify the best WHAM model configuration need to be better developed and defined. The fishing mortality BRP may be inappropriately high. More sensitivity analyses need to be conducted and better documented to improve our understanding of the impacts of alternative model configurations and the modeler's decisions on the stock assessment, stock status determination, and projection. It is very likely that the butterfish stock is currently NOT undergoing overfishing and is NOT overfished. Comprehensive analyses suggest that this conclusion is rather robust to the uncertainty in the data and stock assessment models. I conclude that the assessment is scientifically sound and adequately addresses management needs.

For *Illex*, I believe the WG has adequately addressed most of the ToRs. The *Illex* stock structure and spatial variability in the fishery and life history need to be better defined. Simulation studies are needed to evaluate the performance of the various models used in the *Illex* assessment. More studies are needed to further improve our understanding of the spatial dynamics of the *Illex* stock and its impacts on the fishery and stock assessment. Continued research efforts will be necessary to improve key life history and biological information. A cost-benefit analysis needs to be conducted before initializing the implementation of the *Illex* in-season management. Given *Illex*'s sensitivity to environmental changes, its very short-life span with multiple intra-annual cohorts, and its large inter-annual variability in life history and recruitments, developing traditional models for the *Illex* stock assessment and projection is difficult. The multiple data-limited models currently used can provide the possible boundary estimates for stock biomass and/or fishing mortality, but more studies are needed to evaluate their temporal consistency and performance. The generalized depletion model (GDM) is promising, but tends to be subject to large uncertainty in the model configuration and parameterization. A transparent and structured protocol needs to be developed and documented for the GDM configuration and parameterization. A well-designed simulation study will also improve our understanding of performance of the GDM and other data-limited stock assessment methods currently included in this review. For *Illex*, it may be difficult to conduct traditional age/size-structured stock assessments, develop model-based BRPs, and make short-term projections. Developing modeling approaches for projections using environmental correlates seems to be a more sensible solution. A "traffic light approach" that includes the fishery, survey and environmental conditions may be a good alternative to traditional model-based BRPs to determine stock status. Although there are large uncertainties in the assessment and the lack of model-based BRPs, the *Illex* stock was likely subject to low fishing mortality, and the total removal in the fishery was likely relatively low compared with available stock biomass in 2019. Thus, although I may be unable to determine the stock status using the stock assessment and model-based BRPs, I believe overfishing was unlikely occurring and the *Illex* stock was unlikely to be overfished in 2019.

I support the research recommendations suggested by the two WGs and also provide research recommendations to further improve the butterfish and *Illex* stock assessments. My specific research recommendations/comments can be found in ToR 10 for both butterfish and *Illex*.

II. Background

Butterfish (*Peprilus triacanthus*) can be found along the waters of Newfoundland all the way to Florida, with its primary stock area location between Cape Hatteras and the Gulf of Maine. They are short-lived, with few surviving past the age of three years. Butterfish grow rapidly and become sexually mature at one year. Spawning mainly occurs during June and July. They are semi-pelagic and often form loose schools feeding on small invertebrates. Butterfish tend to have a high natural mortality.

Butterfish are mainly caught with otter trawl and landed in Point Judith and North Kingsown, Rhode Island; Montauk, New York; and New Bedford, Massachusetts. They are generally exported to Japan. In 2019, commercial landings of butterfish totaled more than 7.6 million pounds and were valued at more than $5.9 million. Butterfish are managed by the Mid-Atlantic Fishery Management Council and NOAA Fisheries under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan.

The 2020 management track stock assessment suggests that butterfish are not overfished and not subject to overfishing. The previous stock assessment was conducted with ASAP 4.0, integrating temperature and habitat information, which improves the quality of the stock assessment.

Shortfin squid (*Illex illecebrosus*) inhabit the continental shelf and slope waters of the Northwest Atlantic Ocean from Newfoundland to the east coast of Florida. They are usually found along the continental shelf break at depths between 150 and 275 meters. They are short-lived, with a life span of less than one year. *Illex* is semelparous and females spawn and die within several days of mating. Spawning occurs throughout the year with seasonal peaks from October to June. The first several months of the U.S. fishery are mainly supported by the winter cohort. The onset and duration of the fisheries occur in relation to annual migration patterns on and off the continental shelf. *Illex* have extremely variable birth, growth, and maturity rates, which appear to be highly influenced by environmental conditions and climate-driven changes. They undergo daily vertical migrations between cooler deep waters during the day and warmer surface waters during the night. *Illex* are visual predators of crustaceans, fishes, and other squid, and they are the prey of many varieties of fish, including tunas, hakes, bluefish, goosefish Atlantic cod, spiny dogfish and swordfish.

Illex are mainly landed in ports in Rhode Island and New Jersey from June 1 through October 31. They are predominantly harvested using small-mesh bottom trawls and used as bait domestically, in addition to being exported for baits and human consumption. *Illex* are managed by the Mid-Atlantic Fishery Management Council and NOAA Fisheries under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan.

This review is a CIE review for the Research Track Stock Assessment for butterfish and *Illex*. I was provided with all the necessary logistical support, documentation, data, and background information. The Review Panel was composed of three scientists selected by the Center for Independent Experts (CIE): Yong Chen (SUNY Stony Brook), Robin Cook (University of Strathclyde, U.K.) and Robin Thomson (CSIRO, Australia). The Review Panel was chaired by Mike Wilberg, as a member of the Mid-Atlantic Fishery Management Council's Scientific and Statistical Committee. The Panel was assisted by Michele Traver (NEFSC's Stock Assessment Process Lead) and Russ Brown (Chief, NEFSC Population Dynamics Branch). Documentation was prepared by the Butterfish and *Illex* Working Groups (WG), and presentations were made by Charles Adams, Andrew Jones, Jason Didden, Tori Kentner, Eric Robillard, Laurel Smith, and Rob Vincent for butterfish and Lisa Hendrickson, Brooke Lowman, Jessica Jones, Sarah Salois, Paul Rago, John Manderson, and Anna Mercer for *Illex*. Members of the Working Groups and public also provided valuable discussion. Jason Boucher, Tony Wood, Russ Brown, Ben Levy, Brian Linton, Toni Chute, Laurel Smith, and Abigail Tyrell (all from the NEFSC) acted as rapporteurs throughout the review (see Appendix 5 for meeting attendees).

The NOAA NEFSC WGs for butterfish and *Illex* were open to suggestions and provided additional information upon request. The Butterfish and *Illex* WGs engaged in collegial discussion and worked hard to accommodate each one of the Review Panel's requests. The whole process was open and constructive.

As a CIE reviewer, I am charged to evaluate the 2022 Research Track Stock Assessments for butterfish and shortfin squid with respect to the Terms of Reference. This report includes an executive summary (Section I), a background introduction (Section II), a description of my role in the review activities (Section III), my comments on each item listed in the Terms of Reference (ToRs, Section IV), a summary of my comments and recommendations (Section V), and references (Section VI). The final part of this report (Section VII) includes a collection of appendices including the Performance Work Statement.

III. Description of the Individual Reviewer's Role in the Review Activities

My role as a CIE independent reviewer is to conduct an impartial and independent peer review of the 2022 Research Track Stock Assessments for butterfish and *Illex* with respect to the defined Terms of Reference.

Prior to the meeting, assessment documents were made available to me through a NEFSC website (https://apps-nefsc.fisheries.noaa.gov/saw/sasi/sasi_report_options.php). Panel members met with Michele Traver and Russell Brown before the meeting to review and discuss the meeting agenda, reporting requirements, meeting logistics and overall process. Additional information and all presentation slides were provided during the review.

I read the 2022 Research Track Stock Assessment reports for the butterfish and *Illex* stocks, background information papers and reports, and other relevant documents (e.g., previous review reports) that were sent to me (see the list in Appendix I). I also researched and organized references relevant to the topics covered in the reports and the Performance Work Statement (PWS) prior to the WebEx review.

The review was held from March 7th to March 11th, 2022 via WebEx (see Appendix II for the schedule). The five days of review were attended by the NEFSC scientists, Mid-Atlantic

Council representatives, MAFMC SSC member (Review Chair), three CIE reviewers, industry representatives, and other stakeholders (see the List of Participants in Appendix III).

Presentations were given during the Review on stock assessment input data, information on model configuration and parameterization, management, stock assessment modeling outputs and results, Biological Reference points (BRP) and stock status determination, model projections, and ecosystem consideration (see the list of presentations in Appendix I). I was actively involved in the discussion during the Review by (1) asking for clarification on data quality and quantity, statistical analyses, stock assessment models, model configuration, assumptions, BRPs, uncertainties of various sources and interpretations; (2) commenting on the assessment and review processes; (3) providing constructive comments and suggestions for alternative approaches and additional analyses; and (5) contributing to the development of the Review Panel summary report. I had also been interacting with relevant scientists and other panel members regarding issues raised during the review process and for further clarifications and discussion during the Review.

IV. Summary of Findings

My detailed comments on each item of the ToRs are provided under their respective subtitles from the ToRs (see below).

Butterfish (*Peprilus triacanthus*)

1. ***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.***

This ToR has been adequately addressed. The estimation of landing and discard data is appropriate, justified and well-documented.

Overall, the data were carefully evaluated for quality and quantity, and the choices made for the estimation of landing and discard data were appropriate, justified, and informed. Protocols were well-documented to filter and analyze the data, with the filtered data carefully evaluated for their biological/fishery realism. The butterfish Working Group (WG) also adequately described the spatial-temporal distributions of landings, discards, and fishing effort. The WG should be commended for their excellent job in identifying, developing, and reconstructing the historical landing and discard data.

Rebuilding historical landings and discards is always challenging. I suggest that the assumptions associated with the approaches used to develop landings and discards be explicitly outlined. The alternative approaches (e.g., model-based approach for estimating discards) should be explored and some sensitivity analyses should be developed to evaluate the possible impacts of the assumptions made in the estimation of landings and discards. Given the importance of landings and discards in stock assessment, it is important to evaluate the uncertainty of all sources, including assumptions associated with the approaches selected for estimation.

However, given the results of this stock assessment, such an uncertainty is unlikely to change the assessment conclusion for the stock status.

The landings were found to have shifted from SA 537, off the coast of Rhode Island, to SA 526, off the coast of MA in recent years. This shift is interesting because butterfish landings mainly occurred at Rhode Island ports. The potential causes for this (e.g., shifts in stock distributions) could be examined to better understand the changes in the distributions of butterfish and fishing effort.

The gap-filling procedure was used to develop the length and age composition data, and the age-length key. The current approach likely leads to blending of cohorts. This might introduce biases in developing catch-at-age data. I recommend a careful evaluation of the current gap-filling procedure to better quantify the age composition data and understand possible errors resulting from the gap-filling procedure. Alternatively, the gaps could simply be treated as missing data in the assessment model. I also recommend that catch-at-age data be separately characterized for landings and discards.

2. ***Present the survey data available (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), and describe the basis for inclusion or exclusion of those data in the assessment. Characterize the uncertainty in these sources of data.***

This ToR has been adequately addressed. The approach used and the survey abundance indices developed are appropriate for the assessment.

The WG developed criteria to pre-screen and filter available federal and state survey data. The WG used the proportion of positive tows as one of the key factors to determine if a survey program should be included in the assessment. Based on the criteria, the WG identified the following survey abundance indices for the butterfish assessment: Albatross Fall, Bigelow Spring and Fall, NEAMAP Spring and Fall, and coastal YOY, which is developed based on six coastal state surveys. In general, the uncertainties associated with the survey abundance indices are well-quantified.

The butterfish stock structure is not well understood. Because of climate change, the spatial-temporal distribution of butterfish has likely changed over the last few decades (and will likely continue to do so in the future). The impacts of stock structure and distributional changes on the effectiveness and catchability of fisheries-independent survey programs should be carefully evaluated.

The six coastal state survey programs included in the development of coastal YOY index cover different areas and habitats. They were implicitly weighted by their CVs, but no consideration was given regarding their spatial coverage relative to stock distribution.

Although structured criteria were developed and used to select the survey programs for the inclusion in the stock assessment, some criteria are still somewhat subjective. For example, the cut-off values for the proportion of positive tows might be too high, and its impacts should be evaluated (e.g., via a sensitivity analysis). The positive tow criterion is mainly for tracking availability (the spatial distribution on the shelf in spring has changed), but does not necessarily index population abundance. I also suggest that the Albatross spring surveys be included for a sensitivity analysis and that the results of such an analysis be documented, because the availability of butterfish at this season has appeared to change over time.

I also would like to recommend that the life history data derived from different survey programs be compared to identify possible spatial variability, which may improve our understanding of the stock structure of this species and possible variability in life history parameters over its large distribution areas.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include retrospective analyses (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit.

This ToR has been adequately addressed. The assessment models used are properly applied for this stock assessment.

Butterfish is a short-lived species, with most catch-at-age for both fisheries and surveys younger than four years old (most are the 0, 1, and 2 years old). The age-structured statistical models with year as the time step may not be able to accurately capture key biological processes determining their population dynamics. A short time step (e.g., semi-annual or quarterly) may be better for capturing the biological realism of the butterfish population and the seasonality of the fishery. A shorter time step may also likely rectify the current mismatch resulting from the model year starting in January. On the contrary, spawning occurs mid-year, which means that zero-year-old fish must be modelled as part of the population 6 months before hatching, which raises questions about the way natural mortality is modeled for this age group.

The scale for the butterfish stock biomass/abundance is likely to have large uncertainties in this assessment because strong constraints are needed for at least one survey catchability. Additionally, changes in assumed catchability constraints can result in large changes in the estimation of stock abundance/biomass. Different fishing mortalities also show little impact on the stock abundance.

Age-specific selectivities were estimated freely in modeling, which may hide or be used to compensate for the impacts of wrongly assumed natural mortality. Functional selectivity-at-age (e.g., logistic or double logistic) may overcome this issue and can be explored.

The WHAM model estimates selectivity-at-age by fleet. Surveys and the estimated weight of discarded fish are added to the landings to give total observed catch. I suggest that the catch be grouped in retained and discarded components, and that a retention function be used to separate landings from discards. The age structure of the retained and discarded catches clearly shows that smaller fish are much more likely to be discarded.

Many model configuration scenarios were considered in the ASAP and WHAM model runs. However, only brief comments on the statistical properties (and some on biological realism) are provided, with little information provided on the estimates of fishing mortality and stock abundance/biomass for these model runs. This lack of information prevented me from further examination on the possible implications of different model configurations on the stock assessment. It would be helpful to have a summary table with sensitivity runs that all included F, recruitment and stock abundance/biomass in the terminal years and biological reference points. For the selected base-case model, I recommend conducting a series of sensitivity analyses to evaluate the robustness of the model with respect to key assumptions and choices including: (1) a range of plausible values for the catchability of the Albatross surveys; (2) exclusion of the Albatross surveys; (3) age-dependent natural mortality and alternative natural mortality values; and (4) the use of functional selectivity (e.g., logistic and double logistic).

Given the large number of explicit and implicit biological and statistical assumptions in the assessment, I recommend including a table that summarizes key assumptions and identifies whether these assumptions were evaluated for the final WHAM model.

4. ***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. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.***

This ToR has been partially addressed. Although biomass and fishing mortality BRPs were estimated, the value for the fishing mortality BRP is unrealistically high, raising concerns of its utility in determining the stock status.

Several candidates were considered and evaluated for potential fishing mortality and stock biomass reference points. The WG decided to use $B_{50\%}$ as the target stock biomass reference point and $F_{50\%}$ as the limit fishing mortality reference point. Both $B_{50\%}$ and $F_{50\%}$ are *ad hoc*. The $F_{50\%}$ is extremely high (approximately 99.9% mortality for fully selected ages), which is rather biologically unrealistic. No uncertainties were estimated for the biological reference points.

The WG did not provide the percentage for the biomass reference point corresponding to the previously used F reference point of 2/3M. This latter reference point may be more appropriate given the extremely high value calculated for $F_{50\%}$.

The $B_{50\%}$ calculated in the assessment seems reasonable given the very low fishing mortality. However, the approach used for calculating the target biomass reference point may be only appropriate for butterfish, and may not be suitable for other species with a stock biomass much lower than historical levels.

The uncertainty in the reference points was not fully considered and evaluated. Given the large uncertainties associated with the scale for the stock biomass (heavily dependent on the assumed catchability of the NEFSC fall survey in the assessment), the BRP uncertainties should be more carefully evaluated, and their implications more thoroughly discussed. Given the uncertainty in the scale, it may be more appropriate to estimate the uncertainty associated with the ratios of terminal year biomass and fishing mortality versus relevant biomass and fishing mortality reference points in determining the stock status.

Ecological service consideration was discussed during the review, given that butterfish is a forage species. This would call for a high target biomass reference point and use of the total biomass in the reference point instead of the spawning stock biomass. However, the studies presented during the review identified limited dependency from other fish species, marine mammals, and sea birds on the butterfish. This situation may change in the future. The butterfish may be a good candidate for dynamic reference points.

5. ***Make a recommended stock status determination (overfishing and overfished) based on new modeling approaches developed for this peer review.***

This ToR has been adequately addressed.

Although there remains large uncertainty in the stock assessment, all evidence supports the WG conclusion that the stock is not overfished and that overfishing is not occurring. This conclusion tends to be robust with regard to the uncertainties and assumptions discussed above, including the uncertainties associated with the biological reference points.

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, and maturity.***

This ToR has been adequately addressed.

Short term projections were based on the final model (i.e., 17-NAA5 WHAM model) which assumes an AR(1) process for recruitment. This model configuration captures information on the level of recent recruitment and variability, and projects this information into the future. Other biological parameters such as weights and maturities are based on a recent 5-yr average, which is standard practice and commonly used in the region and many jurisdictions.

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, as well as the most recent management track assessment report. Identify new research recommendations.***

This ToR has been adequately addressed.

The WG provides a list of research recommendations. I support them and suggest the following additional research recommendations:

- Study the stock structure and distribution and movement of butterfish in different life history stages, and evaluate climate-change induced changes in their phenology, suitable habitat, and abundance distribution.
- Evaluate survey catchability. The current survey catchability was based on an analysis of thermal habitat distribution to estimate availability to the survey. A catchability of 0.2 implies that 80% of the stock is not within the survey area, which seems potentially problematic given that butterfish are widely caught throughout the surveys over the stock area.
- Provide a table to summarize key biological and statistical assumptions used in stock assessment modeling.
- Consider age- and/or size-dependent natural mortality. Small/young butterfish tend to have higher mortalities. Ignoring age/size-dependent natural mortality may lead to biased estimates of selectivity, and hence, BRPs. The Lorenzen natural mortality M can be used for age-specific natural mortality rates.
- Continue stomach content analyses for butterfish predators using isotope or genetic methods to better quantify butterfish consumption of potential predators. This may help inform possible temporal variability or trends in natural mortality.
- Evaluate the possible time-varying catchability for the Albatross/Bigelow spring surveys in the stock assessment.
- Continue samples for ageing from different survey programs to better understand spatial variability in growth.
- Evaluate an alternative approach to estimate total discards. Current estimates raise observations based on a ratio estimator that uses total fish catch as the denominator. Raising observations using the number of trips or shots (or other effort measures) is a possible alternative. Applying a time series smoother to the ratio estimator may allow information to be fully utilized across years to improve estimates.
- Consider an age- and length-structured stock assessment model that allows increased use of the state survey data (by including all length data). This may help avoid the need for gap-filling. The derived data used to fill gaps may give a false sense of precision and are likely to over-smooth estimates of recruitment.
- Consider alternative (e.g., survey area, habitat, or weighted) averaging for the aggregated state survey YOY index. The Conn method (Conn 2010) used by the WG assumes a common signal across multiple areas and therefore cannot take into account important spatial effects.
- Keep the assessment model structure and configuration relatively stable over time and run future models in parallel with older models to identify changes in stock assessment results resulting from different model configurations.
- Better quantify differences in assessment results between the base case and sensitivity scenarios.

- Develop diagnostic analyses suitable for state-space models (e.g., plots of the random effects predictions).
- Estimate and quantify the uncertainties for biomass and fishing mortality BRPs.
- Consider and evaluate alternative model selection criteria that are more appropriate for mixed-effects models. AIC was used to inform model selection in the current stock assessment, but this may not be appropriate where random walk models reduce the number of effective parameters. DIC and WAIC are likely to be more appropriate in these circumstances.
- Consider a wider range of assessments/data processing to provide a basis for ensemble modeling.

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

This ToR has been partially addressed. There was some discussion about possible "Plan B" approaches, but there was no specific discussion about a "Plan B" if the assessment model fails in the future.

It is unlikely that a "Plan B" will be needed. However, if the accepted assessment model fails in the future, a "Plan B" (e.g., "Plan B" smooth approach) used in the region can be considered for this species.

Additional Terms of Reference

1. Describe life history characteristics and the stock's spatial distribution, including any changes over time. Describe ecosystem and other factors that may influence the stock's productivity and recruitment. Consider any strong influences and, if possible, integrate the results into the stock assessment.

This ToR has been adequately addressed.

The WG presented the work on stock spatial distribution and evaluated how key life history parameters (e.g., weight-at-age) might be influenced by changes in environmental conditions. The WG also evaluated possible impacts of the shifts in copepod size structure on the butterfish. The relevant information was used to help determine recruitment stanza from 2011-2019. However, more studies will be needed to integrate the results of these analyses into the stock assessment.

2. Evaluate consumptive removals of butterfish by its predators, including (if possible) marine mammals, seabirds, tunas, swordfish and sharks. If possible, integrate results into the stock assessment.

This ToR has been adequately addressed.

The WG analyzed stomach contents data from the NEFSC trawl surveys and assessed some marine mammals and birds for their diets. In general, butterfish did not make significant contributions to the diets of the species studied, with estimated consumption consisting of a small amount of the assumed losses due to natural mortality. It is conspicuous that for a forage fish, butterfish seem to be eaten by relatively few species. Few new analyses were provided for tunas (little to no evidence of butterfish in bluefin tuna diets), swordfish, and sharks. Given the current results, informing M using predation data in the assessment is not a high priority, but I would like to encourage the WG to continue exploring potential sources of natural mortality and evaluating possible size/age-specific natural mortality. The WG can consider alternative approaches to estimate butterfish consumption such as DNA and isotopes. If no additional sources of natural mortality can be identified, these consumption study results suggest that the estimated scale of the butterfish stock may be too high.

Northern shortfin squid (*Illex illecebrosus*)

1. Estimate catches from all sources, including landings and discards, and characterize their uncertainty.

This ToR has been adequately addressed. The estimation of landings is appropriate, justified and well documented. The restructured historical fisheries data are adequate for the stock assessment.

Overall, the fisheries data included in the assessment were carefully evaluated for their quality and quantity, and the choices made for the assessment input data were appropriate, justified, and well documented. Landings since 1997 for the U.S. domestic fishery are considered to be of good quality. Discards are relatively low compared with the landings and are adequately quantified. There is a large uncertainty in catch estimates (likely an under-estimation) for the international catch. The recreational catch of this species in Newfoundland Canada remains unknown, but is likely low compared to the catch in the U.S. fisheries. The assessment team should be commended for their excellent job in identifying, developing, and reconstructing historical fisheries data.

2. Evaluate indices used in the assessment, including annual abundance and biomass indices based on research survey data and standardized industry CPUE data. Characterize the uncertainty of the abundance and biomass index estimates. Explore the relationship between fishing effort and economic factors (e.g., global market price) in order to determine whether the addition of an economic factor will improve the fit of the CPUE standardization model.

This ToR has been adequately addressed. The approach used and the abundance indices developed are appropriate for the assessment.

The WG carefully evaluated various state, regional and federal surveys and developed criteria to screen and filter the survey programs and their data. The WG identified possible temporal-spatial, fishery, and environmental variables that might influence LPUEs to be included in the LPUE standardization. The LPUE standardization process is well-structured and followed the best practice guidelines. The data filtering, variable selections, diagnostic analysis to evaluate various statistical assumptions (Maunder and Punt 2004) and modeling approaches (GAM and GLM) were appropriate, and the modeling runs were well executed. Economic factors were considered in the GAM modeling, and the average weekly price one-week prior was the only factor found to be significant in the GAM model. Environmental factors were considered in a third LPUE model using the data from the study fleet and found to be important in the LPUE standardization. The GLM standardized LPUE largely agreed with the NEFSC fall survey biomass indices for years after 2008.

3. Utilize the age, size and maturity dataset, collected from the 2019 landings, to identify the dominant intra-annual cohorts in the fishery and to estimate growth rates and maturity ogives for each cohort. Also use these data to identify fishery recruitment pulses.

This ToR has been adequately addressed.

Relevant data were collected in 2019 and 2020. However, sample sizes of mature females collected were too small to estimate cohort-specific maturity ogives. Although it is important to estimate cohort-specific key life history parameters, only several cohorts were sampled and measured. The estimates may not be very informative for future cohorts because key life history parameters are likely to vary among cohorts, and cohorts in future years may have life history parameters that differ from cohorts where the samples were taken.

4. ***Characterize annual and weekly, in-season spatio-temporal trends in body size based on length and weight samples collected from the landings by port samplers and provided by Illex processors. Consider the environmental factors that may influence trends in body size and recruitment. If possible, integrate these results into the stock assessment.***

This ToR has been adequately addressed.

The WG analyzed the data collected from processors and port samples. Large increases were observed over recent years in the average body weight in the fishery, which is inconsistent with the decreasing trends shown in the NEFSC fall survey. This inconsistency may result from the impacts of various factors such as differences in selectivity and sampling protocol between the fishery and the survey, and variability in life history (e.g., recruitment and growth). Additional information and more studies are needed to identify the cause for this discrepancy in the temporal trend in average body weight between the fishery and NEFSC fall survey. The projection of future average body weight may be difficult because of extremely large inter- and intra-annual variability in life history and vital rates for *Illex*, in addition to the difficulty of teasing apart impacts of recruitment, growth and fishery for their impacts on average body weight.

5. ***Develop a model that can be used for estimation of fishing mortality and stock biomass, for each dominant cohort that supports the fishery, and estimate the uncertainty of these estimates. Compare the results from model runs for years with low, medium and high biomass estimates.***

This ToR was partially addressed.

The WG applied and evaluated a wide range of models requiring alternative data and assumptions to assess the *Illex* stock, including the Leslie-Davis Depletion model, Envelop Model, Mass Balance Model, Escapement Model, and the VMS Spatial Analysis. Each of these models required strong assumptions, with no single model able to provide reliable estimates for stock biomass and fishing mortality. Thus, without a well-defined simulation study and a good understanding of these models' performance, any one of these models is not appropriate to be used alone for the stock assessment. However, these models have very different data needs and biological and statistical assumptions. They provide a range of estimates for fishing mortality and stock biomass, which can be considered as the feasible bounds for the "true" fishing mortality and stock biomass.

A general depletion model (GDM) was proposed and implemented. Although the GDM used can relax the close-population assumptions, significant immigration and emigration (which were shown to be not necessarily pulsed in the *Illex* fishery) pose a significant challenge to the application of a GDM. The application of a GDM requires the modeler to make many subjective decisions for the model configuration and parametrization, making the estimated model parameters less robust. The application of GDM also had issues including problematic convergence diagnostics and the lack of reliable estimates of uncertainty for the model parameters. These challenges facing the GDM application may be difficult to address with changes in time step from week to day. I do see the potential of GDM and suggest that the WG design a simulation study to assess the performance of the GDM (and all other models) for the *Illex* fishery under different scenarios for key modeling assumptions. I suggest the WG develop a transparent and structured decision-making criteria in configuring and parameterizing the GDM model, which should also be included in the simulation study. Such a practice can improve the consistency of the assessment over time and among stock assessment modelers. I also recommend that the WG conduct a cost-benefit analysis of moving to daily data collection to support the GDM (to see if it is worthwhile).

Given the large number of explicit and implicit biological and statistical assumptions for all models used in the assessment, I recommend including a table that summarizes key assumptions and identifies whether these assumptions are evaluated for all models.

Overall, the modeling and data analyses all suggest that fishing pressure has been relatively low for the years considered in this assessment. This result was consistent over the years with low, medium and high fishery performance.

Because of the unique biology of *Illex*, it may be difficult to conduct traditional age/size-structured stock assessment, develop model-based BRPs and make short-term projections. It is likely more sensible to develop modeling approaches for projections using environmental correlates. A "traffic light approach" including the fishery, survey and environmental conditions may be more appropriate than traditional model-based BRPs in determining the stock status. The BRPs in such an approach can be established based on historical trends of selected indicators for stock status determination (ASMFC 2015). Although there are large uncertainties in the assessment and lack of model-based BRPs, the *Illex* stock was likely subject to low fishing mortality and the total removal in the fishery was likely relatively low compared with available stock biomass in 2019. Thus, although I am unable to determine the stock status using the stock assessment and model-based BRPs, I believe that overfishing was unlikely occurring and that the *Illex* stock was unlikely to have been overfished in 2019.

6. ***Describe the data that would be needed to conduct in-season stock assessments for adaptive management and identify whether the data already exist or if new data would need to be collected and at what frequency.***

This ToR has been adequately addressed.

The WG conducted a comprehensive evaluation of the requirements for the GDM implementation, data and monitoring needs, and required changes in management systems and procedures. Some data were already available or in process to be collected. However, more data are still needed. More work is needed to further develop, evaluate, modify, and implement the assessment models, monitoring programs and management regulations for adaptive management.

Although I did not endorse the current version of the GDM for use in real-time management, I would like to encourage the WG to continue developing and testing the performance of the GDM. A well-designed simulation study can help better understand the performance of the GDM under different scenarios in developing adaptive management.

A traffic light approach and relevant harvest control rules may be considered for in-season adaptive management. A comprehensive cost-benefit analysis of moving from the current management strategy to in-season management may be necessary.

7. ***Update or redefine Biological Reference Points (BRP point estimates for BMSY, BTHRESHOLD and FMSY) or BRP proxies, for each dominant cohort that supports the fishery, and provide estimates of their uncertainty. If analytical model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing and recommended BRPs or their proxies.***

The WG attempted to address this ToR. However, not enough mature females were available to use the Hendrickson and Hart (2006) per-recruit model to develop BRPs. Because there was no accepted and reliable analytic stock assessment, no BRPs were defined and accepted.

8. ***Recommend a stock status determination (i.e., overfishing and overfished), for each dominant cohort supporting the fishery, based on new modeling approaches developed for this peer review.***

This ToR has been addressed adequately given the available analyses.

Given the lack of accepted stock assessment and BRPs, a formal determination of stock status is impossible. However, the stock assessments based on different models with different data needs and biological/statistical assumptions indicated that the stock was unlikely to be overfished and overfishing was unlikely to have been occurring in 2019 (terminal year in this stock assessment).

9. ***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, and maturity.***

This ToR has been adequately addressed.

It is difficult to make short-term projections for *Illex*, given its unique biology. The current assessment models for the *Illex* stock does not provide a framework for future stock projection.

The WG suggested using "Plan B" smooth as an alternative to provide catch advice. The "Plan B" smooth approach was used together with multiple abundance indices to estimate the catch multiplier for 2019. The application of all the abundance indices resulted in a catch multiplier close to 1, implying that the best approximation of next year's catch is the last observed catch. Given our understanding of this stock and fishery, this seems a reasonable catch advice. However, such an approach may not be ideal for future projection. Because of the importance of environmental conditions in regulating the dynamics of *Illex* stock, it is critical to include key environmental variables in the projection models. Habitat suitability index models and species distribution models (e.g., Tanaka et al. 2020) may be useful in projecting the spatial dynamics of the *Illex* stock.

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

This ToR has been adequately addressed.

The WG compiled and prioritized a list of research recommendations. I support the suggested research recommendations. Based on the discussion during the review, I would like to add the following additional research recommendations:

- Develop an operating model and condition it with different sets of hypotheses for *Illex* stock and fishery dynamics with regard to simulating the stock and fishery and evaluating potential assessment models and simple harvest control rules based on abundance indices that would promote sustainable exploitation.
- Develop modeling approaches for projections using environmental correlates and assess their potential performances using an operating model.
- Improve understanding of stock structure, connectivity, and adult movement via statolith microchemistry and genetics analyses.
- Conduct a comprehensive cost-benefit analysis of real-time management.
- Continue key life history studies including updating maturity ogives and growth.
- Continue samples for ageing to better understand spatial-temporal variability in growth.
- Design and conduct a simulation study to evaluate and optimize the ability for the current survey design to capture the spatial-temporal dynamics of the *Illex* stock. This can be accomplished by using historical data to simulate the spatial dynamics of the *Illex* stock distribution, and then applying different monitoring strategies to sample the simulated stock and identify a monitoring program that is both cost-effective and yields the highest quality of data (e.g., Cao et al. 2014, Li et al. 2019).
- Evaluate changing fleet dynamics in relation to changes in market and environmental conditions to better understand temporal changes in catchability.
- Examine the distribution of spawning grounds and dynamics of spawning aggregations.
- Continue to improve data quality and quantity of fishery-dependent, fishery-independent, and life history data.
- Compare "study fleet" statistics to those of fishermen not participating in a "study fleet" in order to cross-check data quality for commercial fisheries.

*11. **Develop a "Plan B" alternate assessment approach to providing scientific advice to managers if the analytical assessment does not pass review.***

This ToR was adequately addressed given the limitations of the analyses available.

The WG noted that the MAFMC SSC has used the indirect approach developed by Dr. Rago to provide annual ABC and OFL advice. With the lack of a clearly acceptable alternative approach, I suggest this approach continues to be used for providing catch advice before the ongoing research tests and identifies an alternative approach that is acceptable for developing catch advice.

The "Plan B" smooth method is commonly used for many species in the northeast US as a fall back approach when an analytic method is rejected or fails. However, such an approach is only useful when the updated abundance indices are available for this short lived species. Using previous years' indices for the catch advice of the project years may be inappropriate for the *Illex*. Thus, the commonly used "Plan B" smooth method is not suitable for the *Illex*. A more responsive approach to make the best use of the current data is required.

V. Conclusions and Recommendations

Overall, based on the stock assessment presented and the information provided prior to and during the review, I believe that the butterfish and *Illex* WGs have adequately addressed the majority of the ToRs for both butterfish and *Illex*. However, there remain concerns regarding the performance of stock assessment models and the identification of appropriate biological reference points for both species. Analytical stock assessment results tend to have large uncertainties regarding different model configurations and parameterizations, in addition to the choices of assessment models. Based on all the evidence provided in the review, it is likely that both stocks are currently NOT undergoing overfishing and are NOT overfished. The comprehensive research done by the WGs suggests that this conclusion is likely to be rather robust regarding uncertainty in the data and stock assessment modeling. Although I have some concerns (see my comments for each ToR), I conclude that overall, the assessments are scientifically sound and reflect the best available scientific information. I provide a list of research recommendations for butterfish and *Illex* that the WGs may consider to further improve the butterfish and *Illex* stock assessments. My specific research recommendations/comments can be found in the ToR 10 for Butterfish and ToR 10 for *Illex*.

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VII. Appendices

VII-1. Bibliography of materials provided for review

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Additional TOR 1: Butterfish Condition

Additional TOR 1: Butterfish Habitat

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Working paper: Analyses of *Illex* Weight frequencies for evidence of cohorts
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Presentations given during the review

BUTTERFISH

- Adams, C. et al. Butterfish Research Track Peer Review TOR1.
- Adams, C. et al. Butterfish Research Track Peer Review TOR2
- Adams, C. et al. Butterfish Research Track Peer Review TOR3
- Adams, C. et al. Butterfish Research Track Peer Review TOR4, TOR5, TOR6
- Adams, C. et al. Butterfish Research Track Peer Review TOR7
- Adams, C. et al. Butterfish Research Track Peer Review TOR8
- Butterfish Peer Review Introduction
- Butterfish Industry Perspectives
- Dayton J and E. Robilard. Preliminary age validation of Atlantic butterfish (Peprilus triacanthus) using marginal increment analysis
- Smith, L. Butterfish Condition and Environmental Drivers
- Smith et al. Consumptive removals of butterfish by marine mammals
- Vincent, R. Seabird predation on butterfish in the Gulf of Maine region**.**

SHORTFIN SQUID

- Hendrickson, L. *Illex illecebrosus* (Northern shortfin squid) Research Track Assessment
- Mercer, A. *Illex* Research track Stock Assessment: TOR 6 Data needs for in-season assessment.
- Lowman et al. *Illex* standardized LPUE indices.
- Jones, J. Introduction to ageing and trace element analysis.
- Jones, J. Summary of Falkland Islands *Illex argentinus* Fishery: Assessment and Management
- Rago, P. TOR 5: Stock size and F for *Illex*
- Salois and Hyde. Oceanographic Indicators for Northern Shortfin Squid, *Illex illecebrosus*, in the Northwest Atlantic TOR 4
- Manderson J. Evaluation of generalized depletion modeling of the US *Illex* fishery

Appendix VII-2. Performance Work Statement

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

Butterfish and Northern Shortfin Squid (Illex)
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

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

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 butterfish and northern shortfin squid (*Illex*) stocks. The requirements for the peer review follow. This Performance Work Statement (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. Modifications to the PWS and ToRs cannot be made during the peer review, and any PWS or ToRs modifications prior to the peer review shall be approved by the Contracting Officer's Representative (COR) and the CIE contractor. 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 both index-based and age-based 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, and 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 Reports of the Butterfish and *Illex* Research Track Working Groups.

The Peer Review Panel 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.

The 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 chair will take the lead in editing and completing this report. The 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 May 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.

Schedule	**Milestones and Deliverables**
Within 2 weeks of award	Contractor selects and confirms reviewers
Approximately 2 weeks later	Contractor provides the pre-review documents to the reviewers
March 7-11, 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. Research Track Terms of Reference

Butterfish

1. 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.

2. Present the survey data available (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), and describe the basis for inclusion or exclusion of those data in the assessment. Characterize the uncertainty in these sources of data.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include retrospective analyses (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit.

4. Update or redefine status determination criteria (SDC point estimates or proxies for BMSY, $B_{THRESHOLD}$, FMSY and MSY) and provide estimates of their uncertainty. If analytic model based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

5. Make a recommended stock status determination (overfishing and overfished) based on new modeling approaches developed for this peer review.

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, and maturity.

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, as well as the most recent management track assessment report. Identify new research recommendations.

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

Additional Terms of Reference

1. Describe life history characteristics and the stock's spatial distribution, including any changes over time. Describe ecosystem and other factors that may influence the stock's productivity and recruitment. Consider any strong influences and, if possible, integrate the results into the stock assessment.

2. Evaluate consumptive removals of butterfish by its predators, including (if possible) marine mammals, seabirds, tunas, swordfish and sharks. If possible, integrate results into the stock assessment.

Illex

1. Estimate catches from all sources, including landings and discards, and characterize their uncertainty.

2. Evaluate indices used in the assessment, including annual abundance and biomass indices based on research survey data and standardized industry CPUE data. Characterize the uncertainty of the abundance and biomass index estimates. Explore the relationship between fishing effort and economic factors (e.g., global market price) in order to determine whether the addition of an economic factor will improve the fit of the CPUE standardization model.

3. Utilize the age, size and maturity dataset, collected from the 2019 landings, to identify the dominant intra-annual cohorts in the fishery and to estimate growth rates and maturity ogives for each cohort. Also use these data to identify fishery recruitment pulses.

4. Characterize annual and weekly, in-season spatio-temporal trends in body size based on length and weight samples collected from the landings by port samplers and provided by *Illex* processors. Consider the environmental factors that may influence trends in body size and recruitment. If possible, integrate these results into the stock assessment.

5. Develop a model that can be used for estimation of fishing mortality and stock biomass, for each dominant cohort that supports the fishery, and estimate the uncertainty of these estimates. Compare the results from model runs for years with low, medium and high biomass estimates.

6. Describe the data that would be needed to conduct in-season stock assessments for adaptive management and identify whether the data already exist or if new data would need to be collected and at what frequency.

7. Update or redefine Biological Reference Points (BRP point estimates for BMSY, $B_{THRESHOLD}$ and FMSY) or BRP proxies, for each dominant cohort that supports the fishery, and provide estimates of their uncertainty. If analytical model-based estimates are unavailable, consider

recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing and recommended BRPs or their proxies.

8. Recommend a stock status determination (i.e., overfishing and overfished), for each dominant cohort supporting the fishery, based on new modeling approaches developed for this peer review.

9. 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, and maturity.

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

11. Develop a “Plan B” alternate assessment approach to providing scientific advice to managers if the analytical assessment does not pass review.

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

***Illex* and Butterfish**
Research Track Assessment Peer Review Meeting

March 7 - 11, 2022

WebEx link: https://www.google.com/url?q=https://noaanmfs-meets.webex.com/noaanmfs-meets/j.php?MTID%3Dm8a1062743b689f38d340622b4c9367ff&sa=D&source=calendar&ust=1646591056258287&usg=AOvVaw3rFDmh4DLEfDF0VFfJvy57
Meeting number (access code): 2761 523 2146
Meeting password: vNhr8Y75tBu

Phone: +1-415-527-5035 US Toll

AGENDA* (v. 3/7/2022)

**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, March 7, 2022

Time	Topic	Presenter(s)	Notes
12 p.m. - 12:15 p.m.	Welcome/Logistics Introductions/Agenda/ Conduct of Meeting Butterfish	Michele Traver, Assessment Process Lead Russ Brown, PopDy Branch Chief Mike Wilberg, Panel Chair	
12:15 p.m. - 1:45 p.m.	TORs #1 and A1	Charles Adams, Andrew Jones, Jason Didden, Tori Kentner, Eric Robillard	Life history Catch Spatial Distribution Industry Perspective and Outreach Aging
1:45 p.m. - 2 p.m.	Break		
2 p.m. - 3:15 p.m.	TORs #2 and A2	Charles Adams, Laurel Smith, Rob Vincent	Survey Data Consumptive Removals
3:15 p.m. - 3:45 p.m.	Break		
3:45 p.m. - 5:15 p.m.	TOR #3	Charles Adams	F, R, SSB Productivity

Time	Topic	Presenter(s)	Notes
5:15 p.m. - 5:35 p.m.	Discussion/Summary	Review Panel	
5:35 p.m. - 5:45 p.m.	Public Comment	Public	
5:45 p.m.	Adjourn		

Tuesday, March 8, 2022

Time	Topic	Presenter(s)	Notes
12 p.m. - 12:10 p.m.	Welcome/Logistics	Michele Traver, Assessment Process Lead Mike Wilberg, Panel Chair	
12:10 p.m. - 1:30 p.m.	TORs #4, A1 and 5	Charles Adams, Laurel Smith	BRPs Stock Determination
1:30 p.m. - 2 p.m.	Break		
2 p.m. - 3 p.m.	TOR #6	Charles Adams	Projections
3 p.m. - 3:45 p.m.	TORs #7 and 8	Charles Adams	Research Recommendations Alternative Approach
3:45 p.m. - 4 p.m.	Break		
4 p.m. - 4:45 p.m.	TOR #7 and 8 cont.	Charles Adams	Research Recommendations Alternative Approach
4:45 p.m. - 5:05 p.m.	Discussion/Summary	Review Panel	
5:05 p.m. - 5:15 p.m.	Public Comment	Public	
5:15 p.m. - 6 p.m.	Wrap Up/Key Points on Butterfish	Review Panel	
6 p.m.	Adjourn		

Wednesday, March 9, 2022

Time	Topic	Presenter(s)	Notes
12 p.m. - 12:10 p.m.	Welcome/Logistics *Illex*	Michele Traver, Assessment Process Lead Mike Wilberg, Panel Chair	

Time	Topic	Presenter(s)	Notes
12:10 p.m. - 2 p.m.	TORs #1 and 2	Lisa Hendrickson Brooke Lowman	Landings and Discards Surveys and Fishery CPUE
2 p.m. - 2:30 p.m.	Break		
2:30 p.m. - 3:25 p.m.	TOR #3	Lisa Hendrickson Jessica Jones	2019 age, size and maturity, trace element data
3:25 p.m. - 3:40 p.m.	Break		
3:40 p.m. - 5:40 p.m.	TORs # 4 and 5	Lisa Hendrickson Sarah Salois Paul Rago	Fishery body size Environmental effects Stock size and Fishing mortality
5:40 p.m. - 6 p.m.	Discussion/Summary	Review Panel	
6 p.m. - 6:10 p.m.	Public Comment	Public	
6:10 p.m.	Adjourn		

Thursday, March 10, 2022

Time	Topic	Presenter(s)	Notes
12 p.m. - 12:10 p.m.	Welcome/Logistics	Michele Traver, Assessment Process Lead Mike Wilberg, Panel Chair	
12:10 p.m. - 1:10 p.m.	TOR #5 cont.	John Manderson	Stock size and Fishing mortality
1:10 p.m. - 2:10 p.m.	TOR #6	Anna Mercer	In-season data
2:10 p.m. - 2:40 p.m.	Break		
2:40 p.m. - 3:40 p.m.	TORs #7 - 9	Lisa Hendrickson	BRP’s Stock Status Projections
3:40 p.m. - 3:55 p.m.	Break		
3:55 p.m. - 5:55 p.m.	TORs #10 and 11	Lisa Hendrickson	Research Recommendations

Time	Topic	Presenter(s)	Notes
			Alternative approach
5:55 p.m. - 6:10 p.m.	Discussion/Summary	Review Panel	
6:10 p.m. - 6:20 p.m..	Public Comment	Public	
6:20 p.m.	Adjourn		

Friday, March 11, 2022

Time	Topic	Presenter(s)	Notes
12 p.m. - 6 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 VII-3. List of participants

Illex/Butterfish Research Track Peer Review Attendance
March 7-11, 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
SMAST - University of Massachusetts School of Marine Science and Technology
MIT - Massachusetts Institute of Technology
VIMS - Virginia Institute of Marine Science
SSC - Science and Statistical Committee
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Mike Wilberg - Chair
Robin Cook - CIE Panel
Robin Thomson - CIE Panel
Yong Chen - CIE Panel

Russ Brown - NEFSC
Michele Traver - NEFSC

Abigail Tyrell - NEFSC
Alan Bianchi -North Carolina Department of Environmental Quality
Alex Hansell - NEFSC
Andrew Jones - NEFSC
Anna Mercer - NEFSC
Ben Levy - NEFSC
Brandon Muffley - MAFMC Staff
Brian Linton - NEFSC
Brian Smith - NEFSC
Brooke Lowman - Virginia Marine Resources Commission
Carly Bari - GARFO
Charles Adams - NEFSC
Chris Legault - NEFSC
David Richardson - NEFSC
Eric Reid - Fisheries Consultant
Eric Robillard - NEFSC
Greg DiDomenico - Lunds Fisheries
Jason Boucher - NEFSC
Jason Didden - MAFMC Staff
Jeff Kaelin - Lunds Fisheries
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Jessica Jones - NEFSC post doc
Jim Gartland - VIMS
Jon Deroba - NEFSC
John Manderson - Open Ocean Research
Katie Almeida - Town Dock
Kathy Sosebee - NEFSC
Kiersten Curti - NEFSC
Kim Hyde - NEFSC
Larry Alade - NEFSC
Laurel Smith - NEFSC
Lisa Hendrickson - NEFSC
Mark Terceiro - NEFSC
Meghan Lapp - Sea Freeze Ltd.
Michelle Duval - MAFMC Member/private consultant for Mellivora Consulting
Mike Simpkins - NEFSC
Noelle Olsen - Maryland Sea Grant
Paul Rago - MAFMC SSC
Rob Latour - VIMS
Rob Vincent - MIT
Sam Schiano - Maryland Sea Grant
Sarah Salois - NEFSC
Steve Cadrin - SMAST
Tim Miller - NEFSC
Thomas Swiader - NEFSC
Toni Chute - NEFSC
Tony Wood - NEFSC
Victoria Kentner - NEFSC