Independent Peer Review Report of the Review of the Benchmark Assessment of Atlantic Mackerel (SARC 64)

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Contents

Executive Summary

i. A peer review of Atlantic mackerel stock assessment was conducted at the Northeast Fishery Science Center (NEFSC) from the 28th-30th November 2017 by a panel of experts from the Center for Independent Experts. Members of the public attended the meeting and made constructive contributions.

ii. The assessment working group fully met its terms of reference and provided a timely, comprehensive, and clearly written report.

iii. Analyses were provided on the distribution of the stock, any relationship to environmental variables, the performance of the NEFSC spring survey, and the new egg survey index. These provided valuable information on the data used in the assessment and the interpretation of the results.

iv. The main assessment used a well-established statistical catch at age model, ASAP. The assessment included catch at age data from the main components of the US and Canadian fisheries. Two fishery independent indices were also included in the analysis. Of these, the egg survey is new and a critical data source that improves the reliability of the assessment.

v. Sensitivity runs explored a variety of model configurations and tested, *inter alia,* critical assumptions about selectivity. Additionally, two alternative models, SAM and CCAM, were used to investigate model uncertainty. All the runs produced qualitatively similar trends in SSB, recruitment and fishing mortality with many of the sensitivity runs lying within the 95%CI of the chosen base run. Retrospective analysis did not reveal any systematic error.

vi. The base run assumed constant flat topped selectivity over the full time series. It was accepted as the basis for management advice and used in the calculation of BRPs and projections. It shows a long term decline in SSB from a high of over 1 million metric tonnes in the 1970s to values less than 50,000mt in recent years. Fishing mortality increased to a very high peak in 2010, but has subsequently declined.

vii. Short term projections conditioned on the base run indicate an increase in biomass resulting from somewhat higher recruitment in 2014 and 2015. However, as these year classes are subject to greater estimation error, the strength of any increase is uncertain.

viii. No previous BRPs exist for this stock. The working group proposed BRPs based on the $F_{40\%}$ criterion. This implies an F of 0.26 and an SSB MSY proxy of 196,894 mt. The biomass calculations are based on the time series of recruitment from 1975, and do not consider any relationship between SSB and recruitment. At present, the proposed BRPs are appropriate.

ix. Using the proposed BRPs, the stock is over-fished and experiencing overfishing. This status determination is insensitive to model choice and therefore considered robust.

x. Future work should focus on maintaining the egg survey series, improving the NEFSC survey index, and evaluating the most appropriate way to handle missing catches in the assessment. Consideration should also be given to relaxing the assumption of fixed selectivity in the ASAP model to more realistically capture changes in the fishery.

xi. In view of the distribution of the stock in both US and Canadian waters it is important that collaboration with Canadian experts is maintained, and preferably undertake a joint assessment.

Background

The purpose of the work was to provide an external peer review of a benchmark stock assessment for Atlantic mackerel (*Scomber scombrus*). It forms part of the Northeast Regional Stock Assessment Review Committee (SARC) process that includes a formal meeting of stock assessment experts. In this case, the assessment done by a SAW Working Group was reviewed by a panel of three independent experts provided by CIE and facilitated by a SARC chair. The review was intended to determine whether or not the scientific assessment is adequate to serve as a basis for developing fishery management advice.

Reviewer's role

Approximately two weeks before the SARC meeting, documents for review were made available electronically. These included the main stock assessment report that included twelve appendices which addressed the working group (WG) terms of reference directly. In addition, a number of background documents were provided that covered relevant biology and assessment methodology used in the assessment. These documents were reviewed prior to the meeting, which took place at the Northeast Fishery Science Center (NEFSC), Wood's Hole from the 28th-30th November. During the meeting the lead assessor presented the results of the assessment. Along with other members of the panel, the reviewer discussed aspects of the assessment with the assessor, and requested clarifications on the assessment and additional analyses to support the results. Following the conclusion of the assessment review discussions, the reviewer worked with the SARC chair and other panel members to prepare a SARC summary report. A first draft was completed on the final day of the meeting. The summary report was finalised by correspondence on the 8th December.

Findings

Documentation for the review was extremely well presented and comprehensive. The main assessment document was structured to address the ToRs directly, which greatly facilitated the review process. The appendices in the assessment document also provided important and valuable supporting analyses.

The review meeting was conducted in a constructive and positive manner with helpful interventions from the public. Cooperation from the lead assessor was excellent with good support from the working group and SAW chairs. The work of the review was greatly helped by the presence of experts from Canada, who were able to explain and expand on aspects of the fishery and data outside the US. Important and useful contributions were made by industry representatives that assisted in interpreting the assessment results.

TOR 1. *Spatial and ecosystem influences on stock dynamics:*

a. *Evaluate possible spatial influences on the stock dynamics. Recommend any need to modify the current stock definition for future stock assessments.*

The TOR was fully met.

Work by Secor et al. (WP#1, Appendix 1) looked at otolith microchemistry to identify stock structure showing that the population comprises two spawning "contingents" that mix during the winter. A paper by Adams (WP#1, Appendix 4) examines the distribution of mackerel in the NEFSC spring survey. These show that there have been changes in the distribution of mackerel, as well as the relative contributions of the northern and southern contingents to the fisheries. The areas where mackerel eggs are found has also shown changes over time.

While there are distinct spawning contingents, the winter mixing means that attributing fishery catches to contingents is not possible and the WG could not therefore suggest an improved stock definition. It was decided to use the existing definition of a single stock with two contingents.

Defining the stock this way is a practical necessity given the limitations of the available data. If there is the potential for the fishery to selectively exploit one contingent, this could have important implications for management, since in theory a catch control set for the whole stock might be extracted from one contingent alone. However, this seems unlikely given the transboundary nature of both the stock and the fishery.

b. *Describe data (e.g., oceanographic, habitat, or species interactions) that might pertain to Atlantic mackerel distribution and availability. If possible, integrate the results into the stock assessment (TOR-4).*

This TOR was fully met.

The available data on predation of mackerel was limited to information collected on the NEFSC survey (WP#1, Appendix 3). These data are confined to predation mainly by other fish. Spiny dogfish (*Squalus acanthias*) was identified as the species with the greatest predation on mackerel. However, even this predation was very small and not considered sufficiently important to include in the assessment. Predation by marine mammals is likely to be more important, but there are no data to make a reliable quantitative estimate of such predation mortality, and the WG therefore did not attempt to include it explicitly in the assessment. Predation would be expected to be accounted for in natural mortality (M) which was assumed by the WG to be a constant by age and year with a value of 0.2. Unless there have been systematic changes in the level of predation over time, this assumption should be adequate.

Papers by Friedland (WP#1, Appendices 7 and 8) consider suitable mackerel habitat distribution in relation to environmental variables. While it is clear that both the environment and hence suitable habitat have changed, it has not been possible to relate these changes explicitly to the distribution of mackerel.

Manderson et al. (WP#1, Appendices 5 and 6) considered changes in the spatial structure of Atlantic Mackerel and thermal habitat during the spring NEFSC bottom trawl survey. The analysis shows that the distribution of mackerel has shifted north and east, but this could not be explicitly explained by a thermal model.

These analyses provide important contextual information for the assessment, especially in the interpretation of assessment results for management purposes. However, the analyses do not yet provide a robust quantitative basis for inclusion in the stock assessment model.

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 TOR was largely met.

The WG report provides a detailed overview of the catch components. Maps showing the distributions of USA catch and discards temporally and spatially are provided. These show changes to the distribution over time. The fishery has shifted from a mainly first quarter fishery to one operating in the fourth quarter.

Descriptions are given for age and lengths compositions for all the major components of the catch. This includes commercial landings and discards as well as the recreational fishery.

Quarterly catches were aggregated into semesters due to small sample sizes. As growth of fish above 3 years is slow, and little growth occurs over the winter, this aggregation is justified. The low level of age readings for landings meant that the age compositions were reliant on research vessel survey age samples. Furthermore, as most age readings come from the spring survey, second semester lengths were converted to age using the following spring age data. This is a source of uncertainty that may merit some analysis. However, it is clear that year classes can be tracked through the catch at age matrix suggesting any problem may be minor.

The WG report provides tables showing sampling levels. These are fairly low, but have improved in more recent years. Greatest uncertainty affects the discard estimates and the recreational catch, which is derived from surveys of recreational vessels. For the discards, CVs of the estimates are provided, and these are very large. However, both the discards and recreational catch account for a relatively small part of the total catch and will not unduly degrade the total catch estimates.

Collaboration with the Canadian scientists enabled accounting for the major sources of catch from the entire stock. Commercial catches from the last Canadian assessment were added to the US catches to obtain an estimate of the total international catch of mackerel. Some components of the Canadian catch are, however, not accounted for and include recreational and bait fisheries. The Canadian assessment model attempts to estimate these missing components, but they were not included in the assessment data used here. This was in part because it was believed some of the "missing" Canadian catch was taken in the US fishery. It was suggested that the missing catches amount to approximately 6,000t, which in some years may represent a significant proportion of the total and may be an important source of potential bias in these years.

No spatial or temporal information on effort was provided, due to absence of records of effort distribution in one of the major US fleets. Maps showing the distribution of catches do, however, provide a rough indication of the distribution of effort.

While the principal areas of uncertainty are covered in the WG report, characterization of the uncertainty in the final total catch at age data is not explicitly described. This is a difficult task and should not be seen as a major omission.

TOR 3. *Evaluate fishery independent and fishery dependent indices being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.*

The TOR was largely met.

The WG considered a range of state and federal surveys. State surveys were excluded on the grounds of limited area coverage and low occurrence of mackerel in samples. This is appropriate as an *a priori* decision, but there may be some merit in comparing the final assessment results with these surveys to see if there is any similarity in estimated abundance which might justify their inclusion in future assessments. They may, for example, be able to provide an index of recruitment.

The NEFSC survey was regarded as suitable for use. It provided age composition and abundance information. This is a well-stablished survey with good area coverage over a long time period. Changes in the survey vessel meant that the time series of data was split into two with the second coinciding with the introduction of a new vessel in 2009.

Indices derived from the NEFSC survey are based on a simple stratified mean catch per tow. Such an index does not explicitly address the problem of zero tows (i.e. tows with zero catch of mackerel) and this may be a source of bias in the index. It is common practice to model zero tows using a binomial distribution and a lognormal for positive tows to account for "count" data at low abundance. There is an additional issue for this survey, because it is clear that proportion of zero tows has changed over time (Figure 50 in the WG report) and this is probably related to changes in mackerel distribution rather than abundance. Manderson et al. (WP#1, Appendix 5) also note that the NEFSC samples are likely to reflect the abundance of schools of mackerel rather than the population abundance of mackerel itself. The ASAP model results also show a very poor fit to the index. These issues all undermine the NEFSC index as an effective index of abundance. Nevertheless, the continuity of the survey and the paucity of other surveys would suggest that attempting to improve the index may be a valuable area for further research effort.

While the NEFSC survey may not provide a good index of abundance, it appears to adequately sample the age composition of the population. It may be preferable to fit the assessment model to the age compositions only without the use of the abundance component.

An important new development for this assessment compared to earlier assessments is the derivation of an egg survey index of spawning stock biomass (Carter and Richardson, Appendix 2). This was achieved by analyzing US samples from historical icthyoplankton surveys to derive a combined egg index using the Canadian egg survey. Apart from the NEFSC survey, this is the only source of fishery independent data available for the assessment and is therefore critical in tuning the assessment, especially for the most recent years. Given the problems noted above relating to the NEFSC survey, the egg index needs to be continued into the future if the quality of the assessment is to be maintained.

Many of the major factors which might have affected uncertainty in the survey indices were discussed in the WG report, and are further addressed in the assessment modeling. CVs are provided for both the trawl survey and egg survey index. The latter are likely to be minimum estimates of precision that do not account for process error. The assessment procedure of iteratively re-weighting the data should in principle account for such error.

Perhaps one area of uncertainty that merits discussion is the accuracy of age reading. This applies to both the catch at age data and the survey age compositions, since the same aging data are applied to both. One issue that emerged during discussion at the review meeting was whether the truncation in the age range manifest in recent years was the result of fishing or age reading error. It seems much more likely to be the former, but an indication of the accuracy of age reading would be useful to rule out such errors as a source of bias.

TOR 4. *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Develop alternative approaches which might also be able to estimate population parameters. Include a comparison of new assessment results with those from previous assessment(s).*

The TOR was fully met.

The base assessment (run 118) uses the ASAP model to provide an integrated assessment that uses the catch at age data, the NEFSC index, and the egg survey index. ASAP is a fully age structured statistical model that treats fishing mortality as separable into an age (selectivity) effect and a year ("effort") effect. Recruitment is treated as a random variable and no stock-recruitment model is estimated within the assessment. ASAP is a well-established modelling approach and appropriate for the mackerel assessment.

In the base run the selectivity is fixed for the whole time period and the fishery is treated as a single fleet. In addition selectivity is assumed constant from age 6 and above forcing a flat-topped selection pattern. These are clearly strong assumptions given the multi-fleet nature of the fishery and the fact that fleets have changed in importance over the period of the assessment.

In fitting the model, the data were weighted initially according to their estimated precision. These weights were adjusted to account for process error using the Francis approach. The resulting weights meant that the NEFSC survey received low weight compared to the egg survey. Weighting the data can have a major influence on the model fit. A more extensive set of sensitivity tests on the weights would have been informative. Nevertheless, the weights chosen appear to be consistent with the *a priori* uncertainty in the surveys, where there are good reasons to expect the NEFSC index to be of low precision.

While the base model was accepted as the best science available, it should be noted that there are systematic patterns in the residuals both for the NEFSC survey and the egg survey which should not be over-looked. Furthermore, the NEFSC survey shows little or no correlation with the estimated biomass and one may question whether it really contributes much to the assessment. A sensitivity run without this survey did not show much difference to the base run and may actually be preferred on the grounds of parsimony. Fits to the catch at age did not show strong residual patterns, although there is an indication of cohort effects which may have some relevance to the assumption of constant selectivity. Clearly if the fishery is able to target stronger year classes (as is possible with schooling species), then the age invariant selectivity assumption is violated and some work is needed to evaluate the importance of this question.

As well as the ASAP model, the WG carried out assessments using two state-space models, SAM and CCAM. The former differs from ASAP mainly in relaxing the assumption of a fixed exploitation pattern and allows selectivity to evolve over time. CCAM is designed specifically to account for the missing Canadian catches, but is only able to include the egg survey index. These alternative models provide a valuable sensitivity test for model uncertainty.

In addition to the alternative assessment models, a wide range of sensitivity tests on the ASAP model were carried out. Importantly these included different assumptions about selectivity. They included variants of multiple fleets, time blocks of different selectivity, and dome shaped selection for the commercial fleet.

Results from the base model and the sensitivity runs all show similar trends in F, SSB and recruitment. The SSB declined from very high values in the 1960s, and while there were brief periods of recovery when large year classes appeared, the long-term trend has been downward. Fishing mortality shows a peak in the mid1970s, and then an accelerating increase from 1980 to an extreme peak around 2010 followed by a rapid decline. The peaks in F are directly related to increased catches occurring at the time. Recruitment was high in the early period, but subsequently varied at a low level with occasional large year classes.

The similarity of the stock trends estimated from the different models indicate that they are robust. Furthermore, retrospective runs performed by sequentially dropping recent data did not show any retrospective pattern. There seems, therefore, good reason to have confidence in the assessment.

With regard to the selectivity assumption, the base model is perhaps the least realistic in assuming constancy over time and only considers a single fleet. However, it is also the most parsimonious selectivity assumption and given the similarity of the estimates from different more parameter rich assumptions, it is to be preferred.

When the model was allowed to estimate dome-shaped selectivity the resulting values differed very little in shape from the asymptotic selection pattern. This is perhaps important in interpreting the absence of older fish in the catch age compositions from recent years. Clearly the model does not interpret the absence of older fish in the catch as reduced selectivity, and supports the view that these fish have been fished out by very high fishing mortality in the preceding period and are simply not there.

The very high fishing mortality estimated for 2010 implies that the fishery can extract over 90% of the stock in a single year. Additional analyses performed at the review meeting indicated that this estimate was associated with the Canadian catch data, and if correct, has important implications for management. While all the assessment models estimated a peak around that time, the SAM model gave a very much lower value (about half the ASAP value). The difference is likely to be the result of the time series smoothing effect of the SAM model, but perhaps indicates that while the peak is real, its true magnitude is uncertain.

Uncertainty in the estimates of fishing mortality, recruitment, and stock biomass was characterized by using model estimates of precision. In addition, an extensive sensitivity analysis, which included alternative assessment models (SAM and CCAM), gave estimates that tended to lie within the 95% CI of the base model values. It should be noted, however, that these runs all use essentially the same age structured population model and differ mainly in their assumptions about the error structure. Models that make a structural assumption about the stock-recruitment relationship, or simple models that consider only biomass (such as a Schaefer model) might provide additional insight into model uncertainty and provide alternate approaches to the development of BRPs.

MCMC was used to characterize the distributions of critical model outputs from the base model. These fed into reference point calculations and projections. They will characterize estimation error from the base model and will not, therefore, provide a comprehensive estimate of uncertainty that includes model uncertainty.

The current assessment was compared to previous assessments in 2005 and 2009 that did not provide an accepted basis for advice. Earlier assessments showed retrospective patterns. The current assessment gives lower estimates of recent SSB and higher estimates of F. The 2017 assessment differs mainly from the 2009 assessment in the very high estimates of F around 2010. Recruitment estimates from the three assessments are all similar. Given the consistency of the sensitivity runs and retrospective analysis, the current assessment appears to provide an appropriate basis for advice. The newly available egg survey also fits the model reasonably well, adding to confidence in the results.

TOR 5. *State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; 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. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.*

The TOR was fully met. As there are currently no agreed reference points for the stock, BRPs were not updated or redefined.

The WG proposed MSY proxy reference points based on $F_{40\%}$, which is a widely used definition. B_{MSY} was estimated by drawing samples from the time series of recruitment to scale SPR to absolute values. This gave ranges for B_{MSY}, and $B_{THRESHOLD}$ ($0.5*B_{MSY}$). These ranges are not strictly measures of uncertainty in the estimate as they derive only from the base run values. They represent the distribution of biomass expected when fishing at F40% and essentially acknowledge the fact that B_{MSY} does not have a unique value. The variability is the result of differing year class strength.

There are perhaps two points to make in relation to the estimation of the MSY proxy. Firstly, because no stock-recruitment relationship is assumed, the value of any biomass reference point is conditioned on the range of years used in the recruitment data. In this case, the WG excluded data from the early period when recruitment (and stock biomass) was much higher. This is likely to be a sensible choice. Secondly, the uncertainty incorporated into the calculation of B_{MSY} differs between the recruitment data and the SPR input data used. In the case of recruitment, only process error is considered, not estimation error resulting from the assessment model fit. This means the range for B_{MSY} is underestimated. For the SPR data, it is only measurement error (not process error) that is considered. This issue is likely to be minor because recruitment process error will dominate the distribution.

While concurring with the choice of recruitment model used in the derivation of BRPs, there may be some advantage in revisiting the stock-recruitment relationship. When plotted on a log-log scale there does seem to be some dependence of recruitment on SSB (Figure 1, below). It further suggests that the early year classes, which were very large, are not outliers. This may be important in the calculation of MSY BRPs, because the mean value of recruitment used by the WG in the estimate of SSB_{MSY} will have a lower value than the expected recruitment at SSB_{MSY}. This arises because the WG assumption is that all observed recruitment is equally likely at MSY, whereas a stock-recruitment relationship would imply higher recruitment is more likely at MSY. The consequence of this is that the current estimate for the SSB_{MSY} proxy may be too low (see Figure 2, below).

TOR 6. *Make a recommended stock status determination (overfishing and overfished) based on new results developed for this peer review. Include qualitative written statements about the condition of the stock that will help to inform NOAA Fisheries about stock status.*

The TOR was fully met.

Assuming that the proposed BRPs are accepted, then the stock is overfished and experiencing over-fishing. The result is robust to the choice of model, since all the sensitivity runs classed the stock with this status.

TOR 7. *Develop approaches and apply them to conduct stock projections.*

a. Provide numerical annual projections (3 years) and the statistical distribution (e.g., probability density function) of the catch at F_{MSY} or an F_{MSY} proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

The TOR was largely met.

Projections were provided under the assumptions of F_0, $F_{40\%}$, and $F_{status\ quo}$. These were conditioned on the base run only and used MCMC samples of stock size for the start year (2016). Recruitment was sampled from an empirical distribution of the observed values from 1975 onward. It was assumed that the 2017 catch was equal to the sum of the ABC plus a 2,000mt allowance for Canadian catches. It would have been useful to report the value of F corresponding to this catch assumption, in order to see whether the proposed $F_{40\%}$ reference point was exceeded.

Interval estimates of the projected SSB, catch and recruitment are provided, but not the probability of exceeding the BRPs. The interval estimates will be dominated by the recruitment variability.

The working group did not undertake a sensitivity analysis that considered "other states of nature". Uncertainty in the projections is conditioned on the base run estimates of recruitment (process error) and measurement error in the initial population size. Alternative projections that considered, for example, different assumptions on catch in 2017 and lower or higher mean recruitment would have been useful to bracket the range of uncertainty.

b. *Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions. Identify reasonable projection parameters (recruitment, weight-at-age, retrospective adjustments, etc.) to use when setting specifications.*

The TOR was met.

Projection parameters were drawn, correctly, from the base run as this formed the agreed assessment. There was no need to make retrospective adjustments as there was no indication of retrospective problems with the base run.

The projections are influenced by the 2014 and 2015 year classes that are estimated to be higher than other recent years. However, these year classes will be subject to the greatest estimation error as they are informed by less data than historical recruitment estimates. Although the uncertainty in these year classes is captured in the projections, they nevertheless assume a stationary mean centered on the point estimate of the terminal year in the assessment. This underlines the need to run projections that consider alternative recruitment assumptions.

c. *Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.*

The TOR was not explicitly addressed in the assessment, because the stock is considered currently overfished.

It is clear from the stock assessment that the stock is vulnerable to over-fishing as the SSB in 2012 was less than 2% of is 1972 value. Furthermore, the instantaneous fishing mortality reached a peak in 2010 of over 2.0 per year at a time when the SSB was close to its lowest observed value. This implies the fishery is capable of removing nearly 90% of the stock in a single year. The schooling behavior of mackerel is likely to make them vulnerable to fishing as schools can easily be located regardless of the overall stock abundance.

Projections show the potential for recovery assuming the current productivity is maintained. However, it would have been useful to see more discussion of how the biological characteristics of the species affects its vulnerability to the existing fisheries.

TOR 8. *Review, evaluate and report on the status of the SARC and Working Group research recommendations*
listed in most recent peer reviewed assessment and review panel reports. Identify new research recommendations.

The TOR was fully met.

The working group report lists progress on research recommendations made at the last TRAC meeting. The most important of these recommendations show substantial progress, notably the development of the egg survey index.

The WG proposed a new set of recommendations which were reviewed and discussed with the Panel. Some of these continue the work already in progress, such as the need to further develop the egg survey for future assessments. The Panel supported the proposed recommendations, but felt unable to prioritize all the suggestions. There was some discussion of the need to identify higher level recommendations that might focus work in critical areas. For example, maintaining the capacity to provide good quality fishery independent surveys is a high priority. This might translate into more specific proposals best made by relevant experts. It might include investment in egg survey work or further analysis on the NEFSC survey to develop an improved abundance index, but the important priority is to ensure an adequate index for the assessment.

The recommendation to continue engagement with the industry in working group meetings might be regarded more as a principle of good practice rather than a research recommendation. It should include routine collaboration with Canadian scientists given the magnitude of the fishery in Canadian waters and the expertise available in DFO.

Formulating research recommendations is a routine part of many assessment processes and is a specific term of reference here. It is relatively straightforward to identify research needs, but more difficult to assign some level of importance to them. Apart from the obvious issue of cost and human resources, there are issues of feasibility and likely impact. It should be part of the process of identifying research needs to also score these according to agreed criteria, so that decision makers are provided with material to make informed choices. To that end some assessment of feasibility, relevance and impact (on the assessment and management) should be provided by working groups.

Conclusions and Recommendations

Documentation for the review was extremely well presented and comprehensive. The review meeting was conducted in a constructive and positive manner with helpful interventions from all participants.

The stock assessment of Atlantic mackerel reviewed by SARC 64 represents an important advance over earlier assessments and provides a sound basis for management advice. Catch at age data appear adequate, though sampling levels could be higher. The egg survey appears to be a critical fishery independent source of data, which may be instrumental in the reliability of the assessment.

Recommendation: Priority should be given to maintaining the egg survey time series. If this cannot be done annually, then a periodic survey may be adequate, especially if it is timed to coincide with benchmark assessments.

The ASAP model did not fit NEFSC survey well and more work is required on the index especially in relation to abundance. At present, it may be better to use only the percentage age compositions in the model rather than as an index of biomass.

Recommendation: Work should be directed at improving the NEFSC index to account for zero tows and schooling behaviour of mackerel in developing an abundance index. It appears that the survey can provide an index of the number or schools encountered, but a way of scaling these to abundance is necessary. Estimates of school size may be obtainable from the commercial fishery.

A potentially important aspect of the assessment is the handling of missing catches in the Canadian fishery. These were not explicitly considered in the ASAP model, partly because it was believed some of these catches may already be accounted for in the US fishery. As these catches are thought to be around 6,000mt, they may represent a significant proportion of the catches in some years. Further consideration needs to be given to this issue to determine its importance for the assessment and management.

Recommendation: Consideration needs to be given to the importance of missing catches for the assessment and management of mackerel.

The ASAP model base run makes strong assumptions about fishery selectivity. While this assumption appears robust in the light of sensitivity runs, it is not convincingly realistic, and consideration should be given to relaxing this assumption. Currently, ASAP appears to require specified blocks of constant selectivity. A submodel that allows selectivity to evolve over time may be more realistic, and be less costly in the effective number of parameters to be estimated.

Recommendation: An assessment model that relaxes the assumption of constant selectivity should be investigated. Modelling selectivity as a time series may offer advantages in terms of the number of model parameters.

Biological reference points were based on the $F_{40\%}$ standard and biomass reference points calculated on the period of lower recruitment from 1975. There are tentative indications of a stock recruitment relationship (Figure 1) that merit further investigation which may provide the basis for full MSY calculations.

Recommendation: Consideration should be given to modelling a stock-recruitment relationship in order to calculate MSY reference points.

The Atlantic mackerel stock is shared with Canada, and historically the catches in the US and Canada have been of a similar magnitude. Any assessment of the stock therefore requires data from both countries for a credible analysis. It is essential that the scientific process, at least, is performed in a collaborative way with Canadian experts, preferably to reach a consensus assessment. Collaboration was clearly very good for the assessment reviewed here, but it is important to ensure this is retained for the future.

Recommendation: Future assessments of Atlantic mackerel should be done as a collaborative exercise with Canada to ensure best use of data and expertise.

Formulating research recommendations is a routine part of many assessment processes. While it is relatively straightforward to identify research needs, it is more difficult to assign some level of importance to them. Part of the process of identifying research needs should also include assessing these according to agreed criteria, so that decision makers are provided with material to make informed choices. To that end some assessment of feasibility, relevance and impact (on the assessment and management) should be provided by working groups.

Recommendation: Consideration should be given to providing working groups with criteria to evaluate the importance of research recommendations. This should include reference to feasibility, relevance and impact both on the assessment and management.

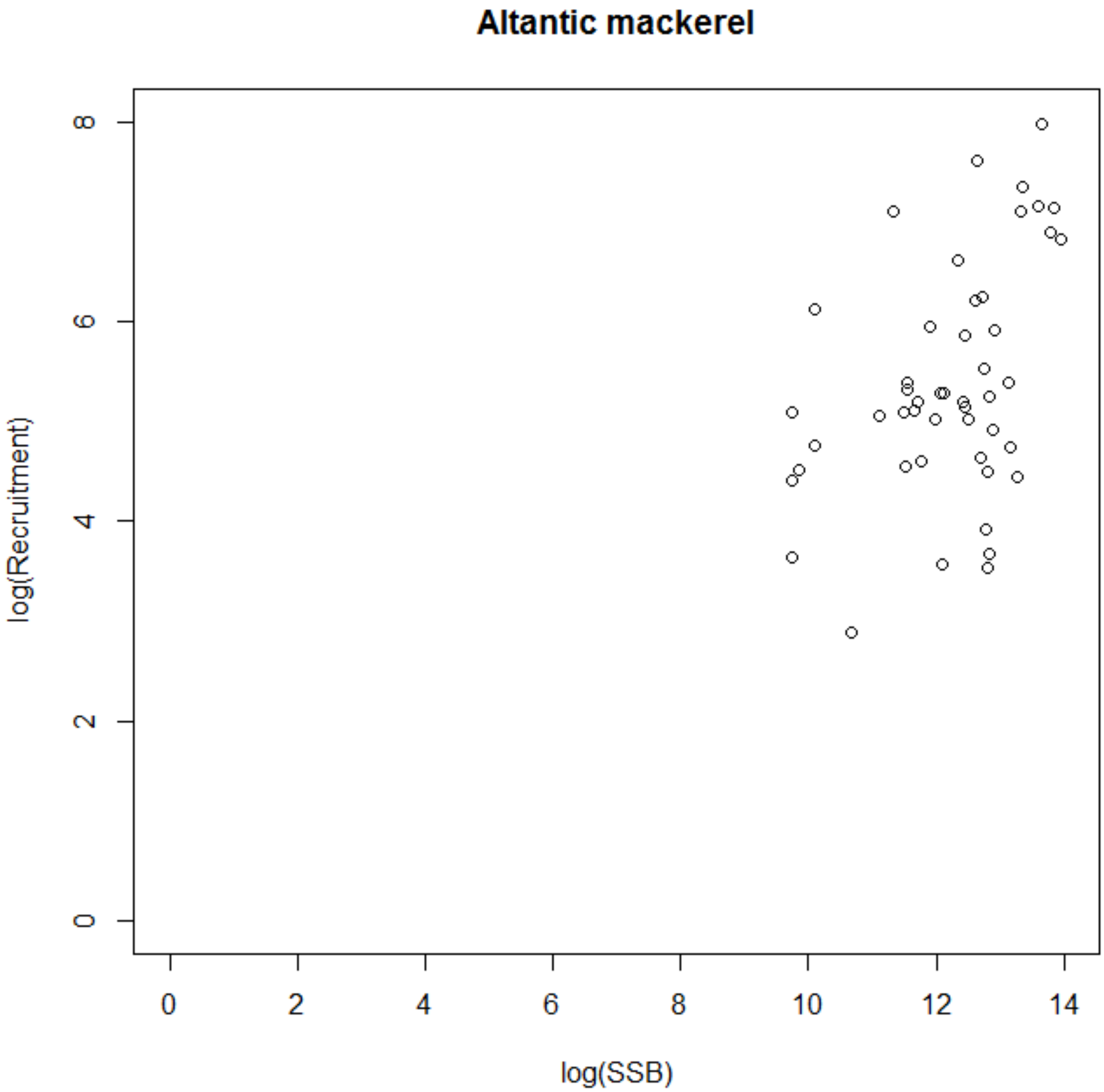

Figure 1. Stock recruitment relationship plotted on a log-log scale.

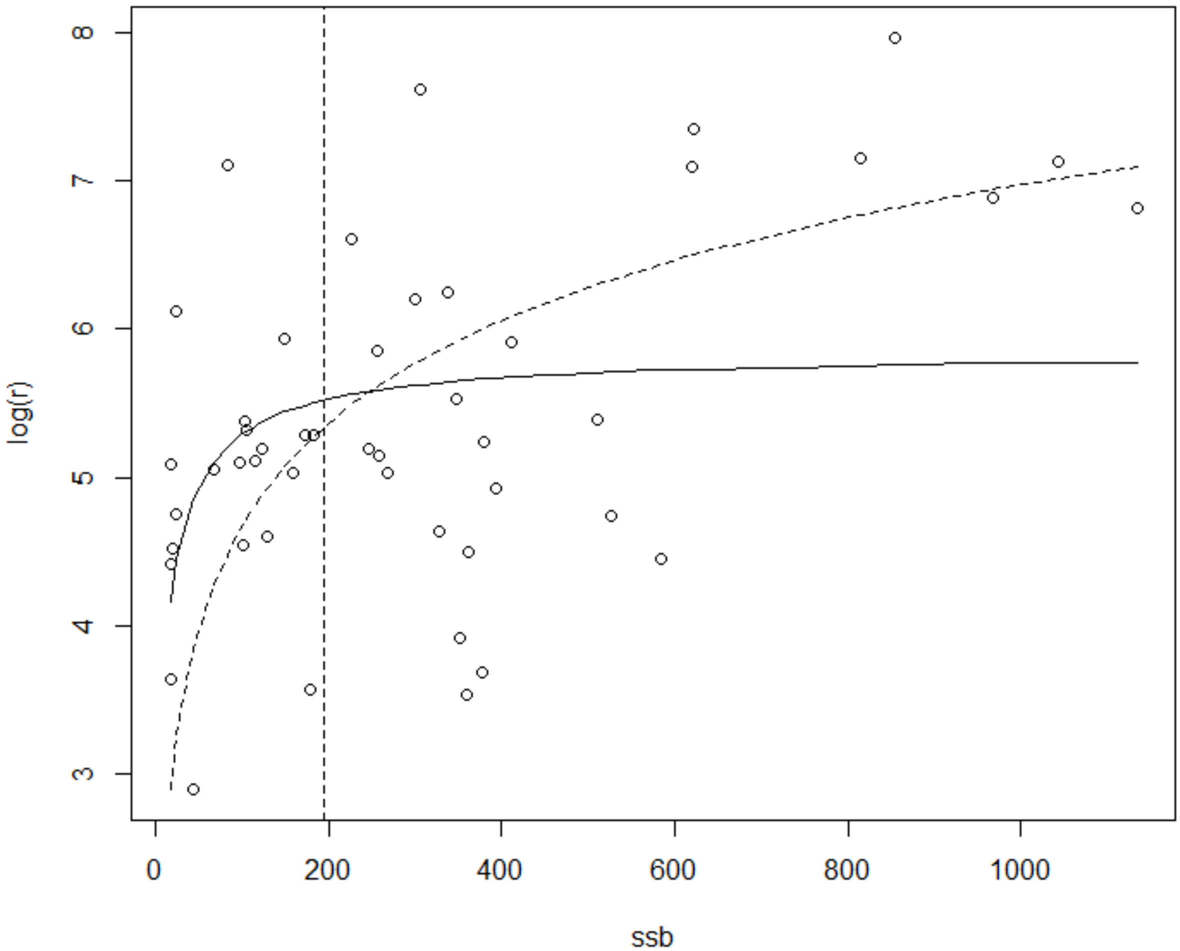

Figure 2. Semi log plot of recruitment (r) against spawning stock biomass (ssb). The solid line is a fitted Beverton Holt curve. The dashed vertical line is the estimate of SSB_{MSY} from the WG assessment and the curved dashed line is the replacement line corresponding to $F_{40\%}$. The replacement line intersects the Beverton Holt curve to the right of SSB_{MSY} and implies a larger equilibrium biomass at $F_{40\%}$.

Appendix 1. Bibliography

Background Papers

Berg, C.W., and A. Nielsen. 2016. Accounting for correlated observations in an age-based state-space stock assessment model. ICES Journal of Marine Science 73: 1788-1797.

Berrien, P. 1988. Atlantic mackerel, Scomber scombrus, total annual egg production and spawner biomass estimates for the Gulf of St. Lawrence and northeastern United States waters, 1987. NMFS Northeast Fisheries Science Center. Sandy Hook Laboratory Report No. 88-02. 18p.

Department of Fisheries and Oceans. 2014. Assessment of the Atlantic Mackerel stock for the Northwest Atlantic (Subareas 3 and 4) in 2013. Department of Fisheries and Oceans Canada. Science Advisory Report 2014/030.

Department of Fisheries and Oceans. 2017. Assessment of the Atlantic Mackerel stock for the Northwest Atlantic (Subareas 3 and 4) in 2016. Department of Fisheries and Oceans Canada. Science Advisory Report 2017/034.

Deroba, J. J., G. Shepherd, F. Grégoire, J. Nieland, and J. Link. 2010. Stock assessment of Atlantic Mackerel in the Northwest Atlantic – 2009. Fisheries and Oceans Canada Transboundary Resource Assessment Committee. Reference Document 2010-01. 64p.

Grégoire, F., M.-H. Gendron, J.-L. Beaulieu, and I. Lévesque. 2013. Results of the Atlantic mackerel (Scomber scombrus L.) egg surveys conducted in the southern Gulf of St. Lawrence from 2008 to 2011. Department of Fisheries and Oceans Canada. Science Advisory Secretariat. Research Document 2013/035. v + 57 p.

Kelly, C., M. Ortiz, and D. Robert. 2010. Transboundary Resources Assessment Committee (TRAC) Atlantic Mackerel benchmark and assessment. External review. Fisheries and Oceans Canada Transboundary Resource Assessment Committee. Reference Document 2010-03-12. 6p.

Legault, C. M., and V. R. Restrepo. 1998. A flexible forward age-structured assessment program. ICCAT Working Document SCRS/98/58. 15p.

Nielsen, A., and C. Berg. 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research 158: 96-101.

Northeast Fisheries Science Center. 2006. 42nd Northeast Regional Stock Assessment Workshop (42nd SAW) Stock Assessment Report. Part A: Silver Hake, Atlantic Mackerel, and Northern Shortfin Squid. Northeast Fisheries Science Center Reference Document 06-09a. 290p.

Northeast Fisheries Science Center. 2006. 42nd Northeast Regional Stock Assessment Workshop (42nd SAW) 42nd SAW Assessment Summary Report. Northeast Fisheries Science Center Reference Document 06-09. 70p.

Payne, A. I. L. 2005. Summary Report on the 42nd Northeast Regional Stock Assessment Workshop (SAW-42) Stock Assessment Review Committee Meeting. NMFS Northeast Fisheries Science Center. 91p.

Sette, O. E. 1943. Biology of the Atlantic Mackerel (Scomber scombrus) of North America. Part I: Early life history, including the growth, drift, and mortality of the egg and larval populations. Fishery Bulletin 50. 91p.

Sette, O. E. 1943. Biology of the Atlantic Mackerel (Scomber scombrus) of North America. Part II: Migrations and Habits. Fishery Bulletin 51. 110p.

Transboundary Resource Assessment Committee. 2010. Atlantic Mackerel in the Northwest Atlantic [NAFO Subareas 2 - 6]. Transboundary Resource Assessment Committee Status Report 2010/01. 12p.

Van Beveren, E., Castonguay, M., Doniol-Valcroze, T., and Duplisea, D. 2017. Results of an informal survey of Canadian Atlantic mackerel commercial, recreational and bait fishers. Department of Fisheries and Oceans Canada. Science Advisory Secretariat. Research Document 2017/029. v + 26 p.

Van Beveren, E., D. Duplisea, M. Castonguay, T. Doniol-Valcroze, S. Plourde, and N. Cadigan. 2017. How catch underreporting can bias stock assessment of and advice for northwest Atlantic Mackerel and a possible resolution using censored catch. Fisheries Research 194: 146-154.

Working Papers

Adams, C. F. 2017. Appendix 4: Spatial patterns in the spring NEFSC survey for Atlantic Mackerel. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 78p.

Axelson, L., W. K. Bright, L. Bright, G. DiDomenico, G. Goodwin, J. Hoey, J. Kaelin, J. Knight, M. Lapp, J. P. Manderson, G. McCallig, B. P. Mitchell, P. Moore, R. Mullen, G. O'Neill, P. Quinn, W. Reichle, J. Ruhle, and C. Sarro. 2017. Appendix 9: Fishing industry perspectives on the socioecological factors driving catchability and landings of Atlantic Mackerel in US waters. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 33p.

Carter, L., and D. Richardson. 2017. Appendix 2: Development of an egg index for Atlantic Mackerel (Scomber scombrus) on the northeast U.S. Continental Shelf. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 17p.

Deroba, J. J. 2017. Appendix 11: A State-Space Stock Assessment Model (SAM) for Northwest Atlantic Mackerel. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 30p.

Friedland, K., J. Manning, J. Manderson, and R. Morse. 2017. Appendix 7: Change in the spatial distribution of mackerel habitat during spring. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 8p.

Friedland, K., C. McManus, R. Morse, and M. Castonguay. 2017. Appendix 8: Physical conditions and lower trophic level ecology in the Atlantic Mackerel spawning areas in US and Canadian waters. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 18p.

Manderson, J. P., J. Kohut, J. Pessutti, D. Politikos, W. K Bright, P. Moore, M. Roffer, L. Nazarro, E. Curchister, and G. Didomenico. 2017. Appendix 5: Changes in the spatial structure of Atlantic Mackerel and thermal habitat during the spring NEFSC bottom trawl survey and a winter habitat model accounting for movement constraints. Part I. changes in spatial structure. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 32p.

Manderson, J., J. Pessutti, L. Nazarro, W. K. Bright, J. Kohut, D. Politikos, P. Moore, M. Roffer, E. Curchister, and G. Didomenico. 2017. Appendix 6: Winter habitat for juvenile and adult North West Atlantic Mackerel and its value for estimating availability to the spring NEFSC bottom trawl survey. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 18p.

Northeast Fisheries Science Center. 2017. Appendix 10: Sequence of ASAP model configurations. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 11p.

Northeast Fisheries Science Center. 2017. Appendix 12: Censored Catch Assessment Model (CCAM) figures. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 14p.

Northeast Fisheries Science Center. 2017. File = Run118.dat ASAP3 run on Monday, 30 Oct 2017 at 12:40:30. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 75p.

Secor, D., G. Redding, and M. Castonguay. 2017. Appendix 1: Contingent Mixing by Atlantic mackerel sampled in the Spring NEFSC Trawl Survey: inferences from otolith stable isotope analysis. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 16p.

Smith, B., and S. Gaichas. 2017. Appendix 3: Mackerel predation estimates from predators sampled in the NEFSC bottom trawl surveys. Stock Assessment Workshop 64. NMFS Northeast Fisheries Science Center. 10p.

WP#1 Stock assessment of Atlantic mackerel for 2017.Atlantic Mackerel Stock Assessment Working Group (AMWG) Report SAW/SARC 64 November 9, 2017.

Appendix 2. Statement of Work

Statement of Work

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

64th Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC)
Benchmark stock assessment for Atlantic mackerel

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

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

Scope
The Northeast Regional Stock Assessment Review Committee (SARC) 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 SARC peer review is the cornerstone of the Northeast Stock Assessment Workshop (SAW) process, which includes assessment development, and report preparation (which is done by SAW Working Groups or Atlantic States Marine Fisheries Commission (ASMFC) technical committees), assessment peer review (by the SARC), public

presentations, and document publication. This review determines whether or not the scientific assessments are adequate to serve as a basis for developing fishery management advice. Results provide the scientific basis for fisheries within the jurisdiction of NOAA's Greater Atlantic Regional Fisheries Office (GARFO).

The purpose of this meeting will be to provide an external peer review of a benchmark stock assessment for **Atlantic mackerel**. The requirements for the peer review follow. This Statement of Work (SOW) also includes Appendix 1: TORs for the stock assessment, which are the responsibility of the analysts; Appendix 2: a draft meeting agenda; Appendix 3: Individual Independent Review Report Requirements; and Appendix 4: SARC Summary Report Requirements.

Reviewer Requirements
NMFS requires three CIE reviewers under this contract to participate in the panel review. The SARC 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 SARC 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 SOW, OMB Guidelines, and the TORs below. All TORs must be addressed in each reviewer's report. No more than one of the reviewers selected for this review is permitted to have served on a SARC panel that reviewed this same species in the past. The reviewers shall have working knowledge and recent experience in the application of modern fishery stock assessment models. Expertise should include forward projecting statistical catch- at- age models. Reviewers should also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Reviewers should have experience in development of Biological Reference Points (BRPs) that includes an appreciation for the varying quality and quantity of data available to support estimation of BRPs. For mackerel, knowledge of migratory pelagics, spatial elements in a stock assessment, and data- limited assessment methods would be useful.

Tasks for Reviewers

- Review the background materials and reports prior to the review meeting
- 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 SOW and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.
- Each reviewer shall assist the SARC Chair with contributions to the SARC Summary Report
- Deliver individual Independent Review Reports to the Government according to the specified milestone dates

- This report should explain whether each stock assessment Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified below in the "Requirements for SARC 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 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 SARC Summary Report on specific stock assessment Terms of Reference or on additional questions raised during the meeting.

Requirements for SARC panel

- During the SARC meeting, the panel is to determine whether each stock assessment Term of Reference (TOR) of the SAW 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 SARC chair shall identify or facilitate agreement among the reviewers for each stock assessment TOR of the SAW.
- 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 SOW and Schedule of Milestones and Deliverables below.

Tasks for SARC chair and reviewers combined:

Review both the Assessment Report and the draft Assessment Summary Report. The draft Assessment Summary Report is reviewed and edited to assure that it is consistent with the outcome of the peer review, particularly statements about stock status recommendations and descriptions of assessment uncertainty.

The SARC Chair, with the assistance from the reviewers, will write the SARC Summary Report. Each reviewer and the chair will discuss whether they hold similar views on each stock assessment 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 SAW. For terms where a similar view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this SARC 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 the chair's opinion on each Term of Reference of the SAW, either as part of the group opinion, or as a separate minority opinion. The SARC Summary Report will not be submitted, reviewed, or approved by the Contractor.

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

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

Place of Performance
The place of performance shall be at the contractor's facilities, and at the Northeast Fisheries Science Center in Woods Hole, Massachusetts.

Period of Performance
The period of performance shall be from the time of award through January 26, 2018. Each reviewer's duties shall not exceed 14 days to complete all required tasks.

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

At time of award	Contractor sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
No later than November 14, 2017	NMFS Project Contact will provide reviewers the pre-review documents
Nov. 28-30, 2017	Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA
Nov. 30, 2017	SARC Chair and reviewers work at drafting reports during meeting at Woods Hole, MA, USA
Dec. 14, 2017	Contractor receives draft reports
Dec. 14, 2017	Draft of SARC Summary Report, reviewed by all reviewers, due to the SARC Chair *
Dec. 21, 2017	SARC Chair sends Final SARC Summary Report, approved by reviewers, to NMFS Project contact (i.e., SAW Chairman)
Jan. 4, 2018	Contractor submits final reports to the Government

* The SARC 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
All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $10,000.

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

NMFS Project Contact
Dr. James Weinberg, NEFSC SAW Chair
Northeast Fisheries Science Center

166 Water Street, Woods Hole, MA 02543
James.Weinberg@noaa.gov

Appendix 1. Stock Assessment Terms of Reference for SAW/SARC-64

The SARC Review Panel shall assess whether or not the SAW Working Group has reasonably and satisfactorily completed the following actions.

A. Atlantic mackerel (NAFO Subareas 3-6)

1. Spatial and ecosystem influences on stock dynamics:
    a. Evaluate possible spatial influences on the stock dynamics. Recommend any need to modify the current stock definition for future stock assessments.
    b. Describe data (e.g., oceanographic, habitat, or species interactions) that might pertain to Atlantic mackerel distribution and availability. If possible, integrate the results into the stock assessment (TOR- 4).

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. Evaluate fishery independent and fishery dependent indices being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age- length data, etc.). Characterize the uncertainty and any bias 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. Develop alternative approaches which might also be able to estimate population parameters. Include a comparison of new assessment results with those from previous assessment(s).

5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; 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. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

6. Make a recommended stock status determination (overfishing and overfished) based on new results developed for this peer review. Include qualitative written statements about the condition of the stock that will help to inform NMFS[a] about stock status.

7. Develop approaches and apply them to conduct stock projections.
    a. Provide numerical annual projections (3 years) and the statistical distribution (e.g., probability density function) of the catch at F_{MSY} or an F_{MSY} proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of

falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered
(e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions. Identify reasonable projection parameters (recruitment, weight- at- age, retrospective adjustments, etc.) to use when setting specifications.
c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent peer reviewed assessment and review panel reports. Identify new research recommendations.

[a]NMFS has final responsibility for making the stock status determination based on best available scientific information.

Clarification of Terms
used in the Stock Assessment Terms of Reference

Guidance to SAW WG about "Number of Models to include in the Assessment Report": In general, for any TOR in which one or more models are explored by the WG, 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 WG 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, 1-162009):

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 Stock Assessment Working Group:

Anyone participating in SAW 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)

64th Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC)
Benchmark stock assessment for A. Atlantic mackerel

Nov. 28-30, 2017

Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts
DRAFT AGENDA

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR

Tuesday, Nov. 28

10 – 10:30 AM
Welcome — **James Weinberg**, SAW Chair
Introduction — **Paul Rago,** SARC Chair
Agenda
Conduct of Meeting

10:30 – 12:30 PM Assessment Presentation (A. Mackerel)
Kiersten Curti **TBD**

12:30 – 1:30 PM Lunch

1:30 – 3:30 PM Assessment Presentation (A. Mackerel) **Kiersten Curti**
TBD

3:30 – 3:45 PM Break

3:45 – 5:45 PM SARC Discussion w/ Presenters (A. Mackerel)
Paul Rago , SARC Chair **TBD**

5:45 – 6 PM Public Comments

7 PM (**Social Gathering**)

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR

Wednesday, Nov. 29

9:00 – 10:45 Revisit with Presenters (A. Mackerel)

Paul Rago, SARC Chair **TBD**

10:45 - 11 Break

11 – 11:45 Revisit with Presenters (A. Mackerel)

Paul Rago , SARC Chair **TBD**

11:45 – Noon Public Comments

12 – 1:15 PM Lunch

1:15 – 4 Review/Edit Assessment Summary Report (A. Mackerel)

Paul Rago , SARC Chair **TBD**

4 – 4:15 PM Break

4:15 – 5:00 PM SARC Report writing

Thursday, Nov. 30

9:00 AM – 5:00 PM **SARC Report writing**

*All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public; however, during the Report Writing sessions on Nov. 29 and 30, we ask that the public refrain from engaging in discussion with the SARC.

Appendix 3. Individual Independent Peer Review Report Requirements

1. The independent peer review 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 SARC 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 SARC 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 Statement of Work
   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Appendix 4. SARC Summary Report Requirements

1. The main body of the report shall consist of an introduction prepared by the SARC 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 SARC. Following the introduction, for each assessment reviewed, the report should address whether or not each Term of Reference of the SAW Working Group was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully.

To make this determination, the SARC chair and reviewers should consider whether or not the work provides a scientifically credible basis for developing fishery management advice. If the reviewers and SARC 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 SAW, and relevant papers cited in the SARC Summary Report, along with a copy of the CIE Statement of Work.

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

Appendix 3. Panel Membership

John Boreman, SARC chair
Robin Cook, CIE
Joseph Powers, CIE
Kevin Stokes, CIE

NEFSC participants

Jim Weinber, SAW chair
Rus Brown, NEFSC, Population Dynamics Branch Chief
Kiersten Curti, Lead assessor and presenter
Gary Shepherd, Working Group chair

Rapporteurs

Mark Terceiro
Katherine Sosebee
Chris Legault
Toni Chute

In addition members of the public including fishing industry representatives contributed to the meeting.