SEDAR 37 South Atlantic and Gulf of Mexico Hogfish Assessment
Center for Independent Experts (CIE) Independent Peer Review Report

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Executive Summary

This is one of three independent reports that describes the findings and conclusions of a desk peer review for the SEDAR 37 South Atlantic and Gulf of Mexico Hogfish (*Lachnolaimus maximus*) 2013 Stock Assessment.

The data inputs were well founded and represent the best science available. The stock assessment is based on reliable and well-tested software, and the assessment methodology is fundamentally sound.

For the Eastern Gulf of Mexico (WFL) stock, the stock is not overfished and overfishing is not occurring. The stock assessment model fits the available data reasonably well, but diagnostics suggest results remain uncertain.

For the Florida Keys and southeast Florida (FLK/EFL) stock, the stock is overfished and overfishing is occurring. Of the three stock assessments, this one fits the data best and its results are probably most reliable.

For the Carolinas (GA-NC) stock, the stock status is not reliably determined and conflicts in the available information have not yet been adequately resolved. Specifically, the model does not fit the abundance index.

Uncertainty in the assessment has been generally underestimated, and as currently reported, will not be easily incorporated in scientific advice. Errors in the estimates of recreational catches are a particular problem. The assessment and treatment of this uncertainty could be better in the stock assessment and projections.

Background

This is one of three independent reports that describes the findings and conclusions of this review for the SEDAR 37 South Atlantic and Gulf of Mexico Hogfish (*Lachnolaimus maximus*) 2013 Stock Assessment in accordance with the Center for Independent Experts (CIE) statement of work (Appendix 2). The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise to conduct independent peer reviews of NMFS scientific projects without conflicts of interest. Each reviewer contracted by the CIE q1provides an independent peer review report to be approved by the CIE Steering Committee (www.ciereviews.org).

SEDAR 37 will be a compilation of the data, a benchmark assessment, and the CIE review. The CIE review in this case is a desk review with the objective of ensuring that the best possible assessment is provided through the SEDAR process. The outputs from the SEDAR 37 will provide guidance to the SEFSC to aid in their review and determination of best available science, and when determining if the assessment is useful for management. The hogfish stock is within the jurisdiction of the South Atlantic and Gulf of Mexico Fishery Management Councils, and the states of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and North Carolina.

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

The Center for Independent Experts (CIE) provided the SoW and ToRs. The NMFS Project Contact provided the link to the assessment and background documents on 30th June 2014, which were downloaded for the desk review. All available documents were read. The review

primarily covers the main assessment document, but the background material was used to check assessment decisions as well as provide the scientific context.

The review addressed each ToR as described in Appendix 2 Annex 2. The report is designed to be read independently, and therefore references to specific parts of the assessment report have been minimized.

This report fulfils the final term of reference for the SEDAR 37 review (8. Prepare a Peer Review Report summarizing the Reviewer's evaluation of the stock assessment and addressing each Term of Reference.), and therefore this ToR has no further reference in this report.

1 Evaluate the data used in the assessment, addressing the following:

a) Are data decisions made by the assessment panel sound and robust?

Hogfish has a short planktonic larval phase, nearshore settlement, and is predominantly found as adults on reef coral to a maximum depth of 65m. They tend to occupy home ranges and movements of adults are not thought to be very great.

Based on what is known of the life history and recent genetic research, the division of data into the three stock areas appears sound. Seyoum et al. (SEDAR37-WP-01) demonstrated three distinct stocks through analysis of population genetics: the eastern Gulf of Mexico (WFL), the Florida Keys and southeast Florida (FLK/EFL), and the Carolinas (GA-NC). These therefore make appropriate stock divisions, bearing in mind that this leaves some areas with limited data, and given the species occupies home-ranges, it may still be possible to cause local population depletions of adults even if the overall SSB remains high.

Qualitative information and some quantitative information on life history and biology of the species is good, and raises confidence that main structural assumptions for the model are sound. Assumptions regarding the low discard mortality seem reasonable, and the morphometric conversion models clearly fit the data well. Natural mortality was estimated through a range of methods and has been well-described. Decisions made on sex, growth, maturity and calculation of SSB are well-founded and well-explored.

The small number of age observations justify the decision to estimate growth separate to the assessment model (although age data were included for sensitivity runs). It is necessary to assume a constant growth model and this is most easily enforced by fitting this model to the available age and length data separately. The decision to use the WFL data, which covers the greatest range over ages and lengths, seems reasonable, although there is clearly a risk of bias, since separate stocks need not show the same growth rates. Nevertheless, for this assessment, this is not the most critical source of error.

Abundance indices are developed and reported on. Full reports on the indices are not provided, but information is sufficient to make appropriate choices in the validity of indices. Some are excluded and good reasons are provided for this. Most are retained, and are explored as part of the assessment, which is good practice.

For the WFL stock, the available abundances indices are fairly flat from the 1990s, but most show an increasing trend for 2005-2012. However, this final trend is not strongly supported by the fishery independent indices. The decisions to include these all indices except the REEF visual survey is well justified.

For the FLK/EFL stock, the hook and line commercial indices show a slight upward trend for 2000-2012, while the commercial spear and both recreational indices and fishery independent indices are flat over the same period. Decisions on which indices to include seem well reasoned overall.

For the GA/NC stock, the hook and line logbook index shows a downward trend for 2000-2012. The two trip ticket indices are highly variable and show no overall trend. The hook and line logbook data create the most reliable and consistent index and was used for this stock.

Where they are available, the fishery independent abundance indices provide valuable information on stock size. These indices include fish size information, which improves their accuracy. They are shorter time series than the fishery dependent data, but as they build in length, they should improve the assessments significantly.

In some cases, the reasoning on indices included reference to trends (e.g. "REEF visual index… was the only index that did not show the consistent pattern of an increase in abundance in the last year."). This should be avoided as it presupposes that other indices, which are possibly related, are correct. These are reasons to exclude or include indices in sensitivity runs, but criteria to use or not use an index should depend on other information (coverage, consistency etc.).

Catches form an important part of any assessment as they measure the relative impact of fishing on the stock. Catches have been estimated independently of the assessment model and are provided as estimates with a standard error. This is standard practice and done appropriately. However, where catches are poorly estimated, as is arguably the case for the recreational catch, errors may not be fully taken into account. An alternative approach to this is outlined as a recommendation and further comment is made in discussing the modeling.

The assessment report states that "Given the paucity of age information, use of stock-, gear-, and/or year-specific age-length information (e.g. age-length keys) would introduce substantial uncertainty, particularly if one was to attempt to estimate growth parameters within a model." However, the point of stock assessment is to obtain not only the best estimates of parameters of interest, but also to correctly assess the uncertainty. The tendency in this assessment has been to avoid uncertainty by making more assumptions than are probably warranted. There is some justification for this to ensure the model is aligned within reasonable bounds based on knowledge of the species and history of the fishery, but in this case some decisions over development of data sets and their analysis may have led to an underestimate of the uncertainty. Some recommendations have been made to deal with this.

Overall decisions that had to be made are justified and appear sound and robust, although some decisions may have led to underestimates of uncertainty. Perhaps the most significant problem for all these stock assessments is the poor estimates of catch data and the lack of length data.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Data uncertainties are acknowledged and reported. The report and supporting documents provide information on uncertainties and how they have been dealt with. Estimates of error, such as PSE or SE, are provided.

Commercial catch data (discards and landings) appear relatively well estimated. These estimates come from standard monitoring in commercial fisheries, and errors are within acceptable levels.

Recreational catch uncertainties are outside normal levels, albeit high errors are expected for recreational fisheries. The problem does not arise from discarding, which does not appear to increase uncertainty significantly in this fishery and has been well accounted for, but from the estimates of the landings. These total landings estimates rely on MFRSS/MRIP intercept data since the majority of landings are from private vessels. There is nothing fundamentally wrong with these data as far as I can see, apart from the very limited size of the sampling in each year. This leads to some very large changes in catch estimates from year to year. Given that recreational fishing effort exhibits much lower year to year variation, this suggests catchability changes dramatically for some of these gears, which seems unlikely. This problem is recognized in the text, but no adjustment has been made to the data, except in one extreme case, because no justification has been found for any change.

Considerable work has been put into developing abundance indices for these stocks. The standardization process was objective and should have improved the indices, reducing error. The standardization process and associated errors were reported and are within expected levels.

Although there are limited amounts of length data for many gears, this is not an unusual problem. Length and age data are often over-weighted in stock assessments because they are usually not random samples, but are selected based on availability and often samples are correlated. Information on potential bias in sampling was not provided. Length sampling errors are dealt with in the assessment by using effective sample size rather than nominal ones.

Age data are even more limited. These have been combined to produce a growth model which is incorporated into the assessment. While this does introduce limitations in modelling changes in growth dynamics over time, it is probably not the most significant source of error.

c) Are data applied properly within the assessment model?

The model structure and assumptions are appropriate for these data, except errors have not necessarily been well accounted for in the catch data. Most of the “data” are derived estimates. The model is not fitted, with the exception of the length compositions, to raw observations. This builds greater complexity into the model which may not be immediately apparent, and can make it harder to trace and correct structural errors.

The use of derived abundance indices is standard practice, and the assessment model should be able to account for index errors. The significant errors associated with catches are more difficult to account for as catches determine the exploitation level which the assessment is trying to detect in other information.

For the FLK/EFL and WFL stocks, catches may be sufficiently well estimated for the assessment approach. It is less clear that estimated catches are adequately estimated for the GA-NC stock, which contains some outliers. The Stock Synthesis software (SS3), using the hybrid-F fitting method, will be forced to fit catch estimates well. However, trying to estimate catches within an assessment generally leads to excessive smoothing, so it is unclear whether much improvement can be achieved within SS3. Alternatives are suggested as recommendations for the next assessment (ToR 7).

d) Are input data series reliable and sufficient to support the assessment approach and findings?

In general, the assessment makes good use of the limited data available. Considerable work has been put into developing data series suitable for assessment. Where weaknesses have been identified, these indicate that this process is perhaps unfinished rather the methods are incorrect.

All commercial landings appear reasonably accurate, with consistent data collection throughout the time series. The assumptions made, including the allocation of landings among stocks, were justified. While discards are reported and therefore may be uncertain, there is a good attempt to account for discard mortality and no reason to suspect discards are a significant problem for this assessment. Spearing has become the dominant gear.

Recreational harvest of hogfish forms a significant proportion of catches in all stocks and all have significant errors. These data are dependent on intercepts within the Marine Recreational Fishery Statistical Survey (MRFSS) and the Marine Recreational Information Program (MRIP) data collection systems. For the GA-NC stock for example, data were based on less than ten total intercepts per year across states for 1981-2012 except 1995. The small samples have resulted in high standard errors in catches. Within the assessment model, catches are not treated as a time series, and there is no conditioning between sequential catches. This can change the catch estimate observation errors to process errors within the assessment. Whether this is a problem depends on the relative size of the various errors.

The historical reconstruction of landings before 1981 could be important in helping to determine B_0 and hence appropriate reference points. The methodology applied and resulting time series of catches seem reasonable, albeit very different to the time series based on MRFFS/MRIP data. The catches are much smoother than the later series. The historical catches were not used except in sensitivity runs.

While the method to estimate discarding is reasonable, it probably exacerbates errors in the landings time series as it is based on broadly the same information. Discard rates and mortality are low, so the effect of this error is small.

Estimates of total effort were not used directly in the assessment model. Effort information was used in CPUE calculations and in raising the total catch from the recreational sampling data.

Use of affinity propagation clustering (APC) to identify species clusters and subsequently fitting a delta-lognormal GLM to standardize the CPUE seems a reasonable and relatively simple approach. The number and type of independent variables used in the standardization were limited, and are unlikely to account for all changes to catchability. The approach is, importantly, objective and should allow corrections for independent effects on catch rates. Nevertheless, any procedure selecting zero catch trips increases errors, and the diagnostics for the binomial part of the model are less secure than log-normal for the positive trips. There was some, but limited adjustment to the nominal indices.

Overall, the abundance indices were well developed using consistent methods. The standardization methodologies to deal with zero catch trips for the CPUE indices were objective and justified. Fishery independent surveys are useful, but for many of them the time series are too short to have much impact on this assessment. Nominal indices and indices based only on non-zero trips were not explored.

2 Evaluate the methods used to assess the stock, taking into account the available data.

a) Are methods scientifically sound and robust?

Stock Synthesis (SS3) is a well-known, robust platform for catch-at-age modelling. It is well tested, accurate and flexible. The methods applied by the model are scientifically sound and robust. The main problem with Stock Synthesis is the lack of flexibility in modelling data, where such models may benefit from non-standard approaches.

Information on life history, including growth and natural mortality, is adequate for stock assessment. Hogfish are monandric, protogynous hermaphrodites that form harems. This is not modelled explicitly, except in considering how to calculate SSB. I agree with the decision that SSB should be calculated as the sum of males and females together. Separate modelling of each sex's contribution to reproduction would require explicit modelling of the effect of fishing mortality on each sex and the effect of transition. The impact of disrupting harems through higher mortalities is a concern for this fishery as it is not taken explicitly into account.

Without explicit modelling of harems and resultant effects on reproductive success as a function of mortality rates with explicit sex-linked growth and reproductive success, it seems unlikely that separate sexes in the model would make any difference. In this context, the best approach is to consider the stock as effectively a single sex and calculate the SSB as the sum of all mature fish above a particular age/size. Information on the sex ratio in the catches would seem to be a pre-requisite for any improvement on this approach.

Given the model and data limitations, the method applied is robust. The assessment should produce good scientific advice where configured properly, subject to the limited data available. Improvements in the modelling are possible, but would probably need to be implemented outside Stock Synthesis.

b) Are assessment models configured properly and used consistent with standard practices?

In general, the assessment models have been configured properly and are used consistent with standard practice. However, the assessment is data-limited, and therefore the models are more susceptible to structural error, and these errors are more difficult to detect.

Given the lack of data, where possible simpler model configurations were chosen. Combining discards with catches and avoiding seasonality simplify the model with little likely loss in assessment accuracy. The numbers of parameters fitted were not excessive, although the "hybrid-F" fitting configuration for the model hides the fishing mortality parameter fits.

The variation in natural mortality with age used in this assessment is an approach consistent with similar assessments in the region. This should have only a small effect, but probably describes natural mortality more accurately.

The two sex model was not used except for sensitivity runs. Without more extensive biological sampling covering sex as well as length, weight and age, it will be difficult to fit a 2-sex model.

The Beverton and Holt stock-recruitment function is appropriate for this species. The Ricker function may fit the data better, but more evidence to support this function would be required from the life history research.

The historical catch reconstruction for hogfish was considered unreliable and not used in the base run. Because of the start of the model at 1986, initial fishing mortality rates were estimated for those fisheries that had measured catches during 1986 for both the WFL and FLK/EFL stocks. Although it is better to estimate the starting state for the model where historical catches are unreliable, this degrades the likely model accuracy and can lead to dramatic revisions in stock status should more accurate historical data become available.

The choices made in indices of abundance were justified and reasonable. The only potential issue is the exclusion of the index from the commercial logbook hook and line data for the FLK/EFL stock, which showed an increasing trend in contrast to the other indices. While a justification is given, there is always the chance that this is following abundance trends more accurately than the other indices, so this should be considered for a sensitivity run.

The basis for the choices made for the abundance indices selectivity functions and catches appear sound. I agree with the selectivity configurations based on length and decisions made with respect to whether they are domed or logistic shape. The basic decision is whether to use a domed-shaped selectivity or a logistic function. Domed selectivity is difficult to estimate well, is likely to change from year to year and generally leads to less precautionary results (e.g. higher F_{MSY}). Given the data limitations, length compositions appear reasonably well fitted in this model.

The model uses fixed errors for the landings data. This is appropriate where catches are well estimated, but may lead to underestimates of uncertainty in the assessment in this case.

The "hybrid F" fitting method in SS3 binds the fishing mortality estimates closely to the catch. This is reasonable where the catches are well estimated or exact. However, in this case the catches are themselves estimates with high error. The greater flexibility offered by estimating fishing mortality as separate parameters ("continuous F") may be a better theoretical option, although it was noted that when this alternative approach was used, similar results were obtained.

Methods to test the model and map out the uncertainty apply good practice, including random starts for parameters to show that the maximum likelihood results are effectively global, a parametric bootstrap to estimate observation error, a wide number of sensitivity analyses to estimate structure error, and retrospective analyses. Implementation of these methods has not accounted for all errors.

c) Are the methods appropriate for the available data?

The methods applied are not wholly suitable for data limited assessments. While SS3 has been adapted to cope with a wide range of types of data, like all modelling approaches, it is dependent on quality of data and appropriate interpretation. In this case, the way data are treated could be improved, although this might require moving the assessment out of the SS3 framework. There are significant advantages with continuing SS3, as once an acceptable configuration is developed, updates become straightforward. To achieve this, more robust catches need to be estimated, perhaps linked to methods used to develop the CPUE index.

For the parametric bootstrap procedure, SS3 creates a new data set with the same variance properties that were estimated when analyzing the original data. This suggests that in this case the catch uncertainty will be underestimated. The model fits the catches almost exactly and therefore the estimated error will be lower than the input errors. No account is taken of the true sampling errors in estimating catches. A better bootstrap could be based on simulating the MRFSS/MRIP data used for these estimates (Manly 2006).

The model fits the commercial and recreational catch estimates well. The exception to the fitted landings are the 1986 and 1995 recreational hook and line landings for the GA-NC stock, which appear to be estimated to be even higher than the observed values, which I suspect are already over-estimated.

The fits to the abundance indices are generally poor, and the assessments should seek to improve these fits if possible. For the WFL stock, although the assessment report points out that all indices increased in 2012, the model predicts a decrease. The fits to the FLK/EFL abundance indices, judged by eye, seem a little better than the WFL indices. The model does not fit the commercial hook and line GA-NC abundance index at all, showing almost completely opposite trends.

The length compositions show reasonable fits for WFL gears and surveys, suggesting that the selectivity functions are broadly consistent with the available information. Time varying selectivity could improve the WFL and FLK/EFL commercial spear, although sampling is too limited to justify this. For the GA-NC commercial hook and line, the length compositions are fitted relatively well, in contrast to the abundance index fit. There is a strong argument for a change in RVC Keys selectivity before and after 2000, coinciding with the catchability change. This essentially means the index should be split into two separate series. Given this, it may be sensible to drop the index to the start in 2000 or 2001, because splitting the series probably makes the early period uninformative.

3 Evaluate the assessment findings with respect to the following:

a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

For the Eastern Gulf of Mexico (WFL) and Florida Keys and Southeast Florida (FLK/EFL), the estimates of abundance are probably good enough to support status inferences. The model results are broadly consistent with all data sources. Improvements are possible that could improve accuracy. More and better data could lead to revisions of stock status, but in my opinion these would not be large unless historical catch data became available.

The WFL exhibits strong retrospective patterns, which suggest changes over time, which are not being accounted for. These problems stem from unrecorded changes in mortality (e.g. unrecorded catches or changing natural mortality) or changing catchability in the abundance indices. Retrospective patterns can also result from changes in the selectivity pattern. Some effort has been made in exploring the causes of these patterns, but this has so far been unsuccessful.

For the Carolinas (GA-NC), estimates are not reliable and the status of this stock remains uncertain. The reported results are not wholly consistent with input data. The results reported for this stock are not, at this stage, useful for scientific advice.

b) Is the stock overfished? What information helps you reach this conclusion?

Eastern Gulf of Mexico (WFL)

The WFL stock is not overfished. The available evidence suggests that the spawning stock biomass is greater than that which would achieve maximum sustainable yield (SSB >

MSSTMSY). Trends in the abundance indices, catches and sizes suggest the stock is stable and are compatible with this conclusion. This result should be treated with caution, but the retrospective bias suggests SSB may be underestimated.

Florida Keys and southeast Florida (FLK/EFL)

The stock is overfished. The estimate of stock size relative to reference points suggests that the current estimated SSB is lower than key benchmarks (SSB < MSSTMSY). The bootstraps which account for observation error, support this. In addition, some estimates of steepness and of the mean recruitment for the unexploited stock from the sensitivity runs suggest a lower productivity and therefore the stock may be even more depleted than the base run.

This interpretation of stock status is dependent on the estimates for the stock status at the start of the time series, since the decline in stock size has not been large over the assessment period. With the lack of historical catch time series, this is uncertain, although it is worth noting that the sensitivity extending the time series back to 1981 did not improve the perceived status of the stock. Nevertheless, the current level of depletion implies relatively large catches prior to 1986.

Carolinas (GA-NC)

In my opinion, the GA-NC stock status is not reliably estimated in this assessment. It is not possible to determine from the available information whether the stock is overfished or not. However, with a significant declining trend in the abundance index, there is a significant risk that the stock is below the maximum sustainable yield level.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

Eastern Gulf of Mexico (WFL)

The WFL stock is not undergoing overfishing. While the model results remain uncertain, the available evidence suggests that fishing mortality is less than that which would achieve maximum sustainable yield ($F < F_{MSY}$). Trends in the abundance indices, catches and sizes suggest the stock is stable and are compatible with this conclusion. Although this result should be treated with caution, the retrospective bias suggests fishing mortality may be overestimated. The F estimate is well below its benchmarks and below the lower 95% limit generated from the bootstrap.

Florida Keys and southeast Florida (FLK/EFL)

The stock is undergoing overfishing. The estimate of fishing mortality relative to reference points suggests the current estimated catch is too high. The bootstraps, which account for observation error, confirm this. In addition, some estimates of steepness and of the mean recruitment for the unexploited stock from the sensitivity runs, suggest lower productivity and a higher risk of overfishing.

Carolinas (GA-NC)

Fishing mortality is not reliably estimated in this assessment. The abundance index suggests that the stock may have been increasing or has been stable 2009-1012, although the lowest index value was in 2009. There has been a slightly increasing trend in the mean length of the commercial hook and line landings since 1990. Landings have fluctuated with apparent peaks in the mid-1990s and in recent years 2005-2012. These conflicting patterns could be consistent with shifting selectivity and changes in recruitment as well as the effects of depletion.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

Where the data are uninformative on steepness in the models, the prior is suitable for use not only in setting the value but also in projections. More precautionary steepness levels should also be considered in sensitivities, and could be chosen for more precautionary scientific advice. While the assessment considered the effect of sensitivities in estimates, this was not taken forward in the management advice.

For the Eastern Gulf of Mexico (WFL), the stock-recruitment relationship is flat and estimates of steepness are poorly determined from the data, but the values obtained remain reasonable and appropriate for the determination of reference points (benchmarks) and for the projections.

For the Florida Keys and southeast Florida (FLK/EFL), there is an apparent negative relationship between estimated spawning stock size and subsequent recruitment which makes the model informative on steepness. While there is considerable uncertainty in projecting individual recruitments, it is reasonable to use the steepness estimate from the model in this case. The final estimate (h=0.83) is not very different from the prior mode (h=0.84).

In the case of the Carolinas (GA-NC) stock, for the reasons given above, the stock recruitment is not useful for evaluation of productivity and future stock conditions.

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Eastern Gulf of Mexico (WFL)

The diagnostics for the fitted model suggest some inconsistencies between the model and data. There is a retrospective pattern, which suggests structural bias in the model and significant increases in uncertainty. However, the estimates are likely negatively biased and taking into account observation error within the model, the parameter estimates are still within key benchmarks (MSSTMSY, FMSY, F30%) with high probability. Therefore, the accuracy of estimates is acceptable for precautionary decision-making.

Florida Keys and southeast Florida (FLK/EFL)

The diagnostics suggest the fitted model is consistent with the data and therefore the reported results are reliable.

Carolinas (GA-NC)

The quantitative estimates of status are not reliable and evidence is conflicting. The abundance index suggests that the stock may have been increasing or has been stable during 2009-2012, while there has been a slightly increasing trend in the mean length of the commercial hook and line landings since 1990. Landings have fluctuated with apparent peaks in the mid-1990s and in recent years 2005-2012. The task of stock assessment is to balance or explain conflicting information to draw out a conclusion. This has not yet been achieved for this stock.

4 Evaluate the stock projections, rebuilding timeframes, and generation times, addressing the following:

a) Are the methods consistent with accepted practices and available data?

The methods used for projections are integral to SS3, and consistent with accepted practices and the available data.

b) Are the methods appropriate for the assessment model and outputs?

The SS3 assessment model incorporates the ability to make projections that are consistent with the fitted model. The performance of the different fishing mortality controls have been reported for the best fit and bootstrapped data sets. This approach is appropriate for the model and outputs.

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

For the Eastern Gulf of Mexico (WFL) stock, the retrospective pattern suggests that the performance of the projections in predicting outcomes may be poor. Although, they represent the best science available, the results should be treated with caution.

For the Florida Keys and southeast Florida (FLK/EFL), the projections are most likely reliable over a 5-10 year time frame. However, the lack of contrast in past stock conditions make the projections based on much lower or higher catches extrapolations rather than interpolations, and would therefore be much more sensitive to model errors.

For the Carolinas (GA-NC) stock, the projections are not useful and highly unlikely to accurately describe the response of the stock to changing catch levels.

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

All key uncertainties are acknowledged, and discussed. These stem from uncertainties in the model and data, and are primarily due to uncertain catch and possible changes in selectivity or catchability over time. Although the uncertainties on management decisions can be inferred from the information presented, it is not explicit. Specifically, uncertainties associated with the sensitivity analyses and bootstrap simulation are not reflected in projections.

The retrospective bias is also not accounted for in the projections. This is difficult to do, however, without carrying out a full management strategy evaluation. A better approach would be to identify possible causes of the retrospective bias, account for them in the sensitivity analyses and see how that might affect the determination of current and projected status.

The result is that the projections do not account for uncertainty and overestimate the accuracy of the predicted results.

5 Consider how uncertainties in the assessment, and their potential consequences, are addressed.

a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods

Parametric bootstraps can provide a good basis for assessing uncertainty, but the bootstrap simulations need to genuinely reflect the sampling process. In this case, this would be alternate catch time series, length compositions and abundance indices that could have been obtained from the sampling program. A parametric rather than non-parametric bootstrap is probably the best approach with small data sets, as in this case, but it is not clear that SS3's bootstrap implementation is entirely appropriate in this case. The SS3 bootstrap is based on the internal variance estimates, which are likely to have underestimated the true error.

Bootstrap simulated data could be generated for each data source, although this would require more work. Of the data used, it is likely the recreational catch data might benefit most from simulating the sampling program to generate alternate series. The delta-normal GLMs used to standardise the abundance indices could be used as the basis to provide alternative simulated abundance indices, whereas length compositions might be obtained from fitted densities (smoothed non-parametric bootstrap).

Sensitivity analysis is a good way to explore assumptions and structural uncertainty. A large number of sensitivity analyses were conducted, and some more are suggested for future assessments (ToR 7). However, while the effect of the sensitivity changes is reported, the results are not developed or taken forward in the management advice. A process is required to select one or two representative sensitivities as states of nature to include with the base case for further evaluation.

b) Ensure that the implications of uncertainty in technical conclusions are clearly stated.

Uncertainty is addressed in reporting data inputs, and for key outputs for the assessment, such as stock status, reference points. These are clearly stated in the technical conclusions.

The parametric bootstrap provides a robust way to assess observation error, but in this case it is not clear that all sampling errors are accounted for. Importantly, sampling errors associated with the recreational catch have not been fully addressed.

A large number of sensitivity analyses were conducted and described. Although extensive, these are not necessarily complete. Apart from indicating the range of results, no further decisions are made on which sensitivities might be used to represent structural uncertainty in the model.

Uncertainty in results were not carried forward into the management advice. As a result, it is difficult to see how the assessment of the uncertainty can be properly carried forward in scientific advice. Management guidance on acceptable risk and level of precaution would be useful in improving evaluations of possible management actions. This might be developed by reporting probabilities of falling above or below the different benchmarks in the projections under different levels of fishing mortality.

6 Consider the research recommendations provided and make any additional recommendations or prioritizations warranted.

a) Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.

The assessment document provides useful recommendations for further research, covering research on hogfish biology and improved monitoring data. Research on life history and growth has provided a good basis for the stock assessment modelling. While on-going research on hogfish biology will be useful, it is not a critical area for reducing uncertainty in the assessment at this stage. Improvements in monitoring data are more important.

Good stock assessments will not be possible without good estimates of catches and abundance indices. The assessment recommendations consist of improvements in biological sampling for lengths and age across all fisheries, and development of a fishery independent abundance index for the GA-NC stock.

While the assessment report recommendations are important, other areas of the assessment will also require improvement. The most valuable improvement would likely be better recreational catch data reporting. The proportional standard errors are very high for all estimated landings and it seems unlikely that catches will vary so significantly year by year as currently estimated. Some of these problems are historical, and recent years' catches appear more accurate. Dealing with past errors is an issue of improved robust estimation only, whereas ongoing improved sampling and estimation procedures could reduce errors in future. With recreational catches being so high in many Florida fisheries, improvement in monitoring recreational catches should provide benefits to a wide number of fishery assessments.

b) Provide recommendations on possible ways to improve the SEDAR process.

The SEDAR process would benefit from greater guidance on assessment output and greater focus on assessing uncertainty. It is recommended that the SEDAR process include:

- The stock assessment should identify a pair of sensitivities to bracket the uncertainty and bootstrap or MCMC simulations should be applied to these as well as the base case. These uncertainties should be included in the projections.
- Sensitivities should report changes in stock and fishing status, not only changes in parameter estimates. Parameter estimates may be correlated, so important indicators (e.g. F_{2012}/F_{MSY}, SSB_{2012}/SSB_{MSY}) may change very little.
- The assessment should report the breakdown of negative likelihood contributions for each of the main data components.
- It is useful to provide the input data and results in spreadsheet or text form if possible, so that additional graphs and tables can be made if necessary as part of the review. Although in most, but not all cases, tables are provided in the report and data can be extracted from these with some effort, it would be easier if original information was provided. Further diagnostic plots, such as observed vs expected values, residual plots and so on would have been useful and some of the presented graphs were unclear. Information provided in text or spreadsheets allows reviewers

to examine what they want while avoiding unnecessary work for the assessment team.

Terms of reference for the stock assessment and this review might be improved and better aligned. Specifically, the stock assessment ToRs should require that uncertainty is included in the projections, which is implied in the Review ToR 4.

The assessment should be given more guidance on practical management interventions so that the projection can be based on real options. In this case, it is also unclear how the fishing mortality targets used in the projections might be implemented where catches are so poorly monitored.

7 Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

It may be better to fit the model to the total recreational fishing effort (angler days) rather than the catch directly (e.g. Porch *et al.* 2006). The year-to-year variation in effort is much lower than the estimated catches and probably provides a better estimate of the variation in fishing mortality. An explicit likelihood linking the intercept samples and the total catch can be included in the stock assessment. This would account for the sampling error explicitly, and allow the model to smooth through the catches providing more accurate estimates. Currently, with no other information, the catch in the model is likely to follow the input estimate, while the implied catchability is not consistent with the abundance indices. If estimated within the model, the catches would be smoothed, but probably more accurate.

Including the catch estimation within the stock assessment is desirable, but may be too onerous as it would probably require developing a bespoke model. An alternative might be to link catch estimation to the development of abundance indices, which would limit the year to year variation in catch rates. Linear models could be used to build catch estimates conditional on observations across years consistent with the abundance indices implied catch rates rather than as independent samples.

Whereas parametric bootstraps provide an excellent tool for estimating uncertainty, the method used here does not account for much of the known uncertainty in input values. It would probably be better to simulate bootstrap datasets externally to SS3 where uncertainty in the dataset could be more accurately modelled. For example, the MRIP/MRFSS derived catch estimates could themselves be bootstrapped to generate alternative catch time series.

Identifying ways to remove the retrospective bias for the GA-NC and WFL stock assessments should help identify primary sources of structural error. Estimating time varying catchability is difficult within the model, but external adjustments to input data based on likely changes in catchability as well as adjusting catches (e.g. applying a smoothed catch time series) could at least identify possible causes for the bias as well as provide alternative sensitivities.

The purpose of sensitivity runs should not be so much to determine possible ranges for parameter estimates, but to try to incorporate uncertainty in key assumptions into management advice. The aim should be to identify a reasonable range from the sensitivities to capture this uncertainty and include the additional model configurations in projections.

Future additional sensitivities should be considered and include:

- Apply more changes on data component weights (lambdas) to explore how they affect the assessment outcome. Specifically for the GA-NC stock, weights to force fits

alternately to the abundance index, landings and length frequency data (use the "continuous Fs" option) should help elucidate problems in this model.

- Time varying selectivity could improve abundance indices, including the WFL and FLK/EFL commercial spear, and the GA-NC commercial hook and line. The RVC Keys index selectivity should be split into two separate series before and after 2000, or possibly drop the earlier period from the assessment.
- Nominal indices and indices based only on non-zero trips were not tried. It is not clear from the information presented how much influence the APC / binomial model has on the final index. It may be useful to consider the positives trips model alone (hogfish caught >= 1) as this could avoid bias in the trip selection procedure which is always very uncertain. If these alternative abundance indices give different indications of stock trends, they could form the basis for additional sensitivities.

Conclusions

The data preparation and stock assessment shows considerable work and progress in developing assessments for hogfish stocks in the US South Atlantic and Gulf of Mexico. For the WFL and FLK/EFL stocks, the assessment provides a good basis for determining stock status and developing management advice. The assessment of the GA-NC stock assessment requires more work.

The assessments suggest that the WFL stock is not overfished, whereas the FLK/EFL stock is overfished. The status of the GA-NC stock cannot yet be determined.

The stock assessments are data limited, and have significant problems, particularly with estimated catches. Catches are effectively assumed to be well estimated without bias in the stock assessment model used. An alternative model which estimates catches internally may provide a better solution in this case.

Uncertainty has been underestimated in the stock assessments and not fully taken into account in the management advice. Improvements in the assessment of uncertainty could not only improve the management advice, but also lead to better stock assessments.

As well as the assessment being data limited, there is a lack of contrast in data over the available period (1986-2012). Abundance indices, sizes and, most likely, catches have not changed much. This will limit the ability of the assessment to predict outcomes for management actions accurately.

References

Manly, B.F.J. (2006) Randomization, Bootstrap and Monte Carlo Methods in Biology, Third Edition. Texts in Statistical Science, Chapman & Hall/CRC.

Porch, C. E., Eklund, A., Scott, G. P. (2006) A catch-free stock assessment model with application to goliath grouper (*Epinephelus itajara*) off southern Florida. Fishery Bulletin 104:1

Appendix 1: Bibliography of materials provided for review

SEDAR 37 Southeastern U.S. Hogfish Assessment Report

Cooper, W., Collins, A., O'Hop, J., Addis, D. 2014. The 2013 Stock Assessment Report for Hogfish in the South Atlantic and Gulf of Mexico. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 Eighth Ave Southeast, St. Petersburg, Florida 33701-5020

Working Papers

SEDAR37-WP-01: Genetic population structure of hogfish (Labridae: *Lachnolaimus maximus*) in the southeastern United States

SEDAR37-WP-02: Commercial catch per unit effort of hogfish (*Lachnolaimus maximus*) from Florida Trip Ticket landings, 1994-2012

SEDAR37-WP-03: Recreational catch per unit effort of hogfish (*Lachnolaimus maximus*) in the Southeast US using MRFSS-MRIP intercept data, 1991-2012

SEDAR37-WP-04: Relative index of abundance from visual order-of-magnitude REEF surveys applied to Hogfish (*Lachnolaimus maximus*) in the Southeast US, 1994-2012

SEDAR37-WP-05: Fisheries-independent data for Hogfish (*Lachnolaimus maximus*) from reef-fish video surveys on the West Florida Shelf, 2005-2012

SEDAR37-WP-06: Fisheries-independent data for juvenile Hogfish (*Lachnolaimus maximus*) from the annual FWRI SEAMAP trawl survey, 2008-2012

SEDAR37-WP-07: Fisheries-independent data for juvenile Hogfish (*Lachnolaimus maximus*) from the annual baitfish survey, 2002-2012

SEDAR37-WP-08: Fisheries-independent data for juvenile Hogfish (*Lachnolaimus maximus*) from polyhaline seagrasses of the Florida Big Bend, 2008-2012

SEDAR37-WP-09: Fisheries-independent data for hogfish (*Lachnolaimus maximus*) from reef-fish visual surveys in the Florida Keys and Dry Tortugas, 1994-2012

SEDAR37-WP-10: Summary information for hogfish *Lachnolaimus maximus* seen on videos collected by the SouthEast Reef Fish Survey in 2010 ¿ 2012 between North Carolina and Florida

SEDAR37-WP-11: Standardization of commercial catch per unit effort of hogfish (*Lachnolaimus maximus*) from South Carolina Trip Ticket landings, 2004-2012

SEDAR37-WP-12: Analysis of Hogfish data from Coastal Fisheries Logbook Program (CFLP)

SEDAR37-WP-13: Standardization of commercial catch per unit effort of hogfish (*Lachnolaimus maximus*) from North Carolina Trip Ticket landings.

Research Papers

SEDAR37-RD01: Integrating life history, mating system, fishing effects, and habitat of hogfish, *Lachnolaimus maximus*, a harem spawning fish in the southeast U.S.

SEDAR37-RD02: Demographics by depth: spatially explicit life-history dynamics of a protogynous reef fish

SEDAR37-RD03: Sexual development and reproductive seasonality of hogfish (Labridae: *Lachnolaimus maximus*), an hermaphroditic reef fish

SEDAR37-RD04: Evidence of size-selective fishing mortality from an age an d growth study of hogfish (Labridae : *Lachnolaimus maximus*), a hermaphroditic reef fish

SEDAR37-RD05: Regional Variations of Hogfish (*Lachnolaimus maximus*) Life History: Consequences for Spawning Biomass and Egg Production Models

SEDAR37-RD06: Reproduction, habitat utilization, and movements of hogfish (*Lachnolaimus maximus*) in the Florida Keys, U.S.A.: comparisons from fished versus unfished habitats.

Appendix 2: Statement of Work for Dr. Paul Medley

External Independent Peer Review by the Center for Independent Experts

SEDAR 37: South Atlantic and Gulf of Mexico Hogfish Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 37 will be a compilation of data, a benchmark assessment of the stock, and CIE assessment review conducted for South Atlantic and Gulf of Mexico hogfish. The desk review provides an independent peer review of SEDAR stock assessments. The review is responsible for ensuring that the best possible assessment is provided through the SEDAR process and will provide guidance to the SEFSC to aid in their review and determination of best available science, and when determining if the assessment is useful for management. The stocks assessed through SEDAR 37 are within the jurisdiction of the South Atlantic and Gulf of Mexico Fishery Management Councils, and the states of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and North Carolina. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the statement of work (SoW) tasks and terms of reference (ToRs) specified herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall participate and conduct an independent peer review as a desk review; therefore travel will not be required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer contact information to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the

Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the assessment and other pertinent background documents for the peer review. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an impartial and independent peer review in accordance with the tasks and ToRs specified herein, and each ToRs must be addressed (Annex 2).
3) No later than June 30, 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Tentative Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

15 May 2014	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact

1 June 2014	NMFS Project Contact sends the stock assessment report and background documents to the CIE reviewers.
9-20 June 2014	Each reviewer shall conduct an independent desk peer review
30 June 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
13 July 2014	CIE submits CIE independent peer review reports to the COR
20 July 2014	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

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Key Personnel:

NMFS Project Contact:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

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

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2 – Terms of Reference

SEDAR 37: South Atlantic and Gulf of Mexico Hogfish Assessment Desk Review

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the assessment panel sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?
   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, rebuilding timeframes, and generation times, addressing the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and useful to support inferences of probable future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods

- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.
8. Prepare a Peer Review Report summarizing the Reviewer's evaluation of the stock assessment and addressing each Term of Reference.