Reviewer Report to the Center for Independent Experts on the Atlantic Red Drum Review Workshop (SEDAR 44) held August 25-27, 2015, in Charleston, South Carolina.

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Executive Summary

This document contains my independent reviewer report of review activities and findings for 44th Southeast Data, Assessment and Review (SEDAR 44), centered about the SEDAR 44 Review Workshop held in Charleston, South Carolina, August 25-27, 2015. SEDAR 44 was focused on an assessment of Atlantic red drum, which was further divided into two stocks, a northern stock and southern stock, consistent with recent assessments.

The SEDAR 44 Review Workshop was not a typical SEDAR review because the assessment models were not sufficiently developed for review for either the northern or southern stock. For this reason, the analytical team requested that the review panel provide guidance on developing working models rather than a review of completed work. As a result of this change in emphasis for the peer review meeting, and because working models were not available for either of the two stocks, not all terms of reference could be fully addressed at the meeting. Specifically, estimates of stock biomass, abundance, and exploitation rates for use in management could not be provided from this process at this time.

Overall, the Data Workshop Report and supporting working papers thoroughly documented the very large amount of information available for assessing Atlantic red drum. Data types included: life history information; commercial landings including discards and discard mortality; recreational fisheries harvests and releases; abundance indices based on both fishery- and fishery-independent surveys; length and age data for several fisheries and surveys; and results from tagging studies. In their current form, the assessments for these stocks are conditional on some constants about which there is some uncertainty, including the discard/release mortality rates, used to estimate a portion of the removals from the population; and tag reporting and loss rates, used when incorporating the tagging data into the model.

Stock Synthesis 3 was selected as a modelling framework for SEDAR 44, a decision that is sound given that SS3 already has methods to implement many of the desired changes to the models used in SEDAR 18. The models presented at the Review Workshop were very complex and detailed, and the primary recommendation made by the review panel was to greatly simplify the model structure in order to have the model working in order such that the model behavior and sensitivities could be understood, and then to build complexity into the model making small changes one at a time. During the Review Workshop, this approach worked well for the northern stock model, and although less progress was made with the southern stock model, the approach is anticipated to lead towards a working model.

In general, the model diagnostics, sensitivity analyses, and methods for characterizing uncertainty in parameter estimates appear appropriate for models at this stage in their development. At present, it is not known whether informative stock-recruitment relationships will result from the final models. In the absence of this relationship, the continued use of SPR-based reference points is recommended, although alternative proxies for F_{msy} that can be estimated from the stock-recruitment data that explicitly account for uncertainty in the relationship should also be explored.

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1.0. Background

This document contains my independent reviewer report of review activities and findings for 44th Southeast Data, Assessment and Review (SEDAR 44), centered about the SEDAR 44 Review Workshop held in Charleston, South Carolina, August 25-27, 2015. The focus of SEDAR 44 was an assessment of Atlantic red drum, a species that is fished both recreationally and commercially. As a species, red drum is found in the Atlantic Ocean from Massachusetts to Florida, and in the Gulf of Mexico from Florida to Tuxpan, Mexico, whereas Atlantic red drum refers to those fish found in Atlantic Ocean. Consistent with other recent assessments, Atlantic red drum were split into two stocks, a northern stock and a southern stock, for SEDAR 44.

Prior to the Review Workshop, the review panel (Appendix 3), were provided with a Statement of Work (Appendix 2), including the Terms of Reference (TORs) for the assessment and for the review panel. Assessment documents and background material (Appendix 1) were provided via a website during the three weeks before the meeting.

The SEDAR 44 Review Workshop was not a typical SEDAR review because the assessment team encountered difficulties developing the assessments models, and completed models were not available for review for either the northern or southern stock. For this reason, the assessment team requested that the review panel provide guidance on developing working models rather than a review of completed work. The review panel was informed of this request prior to the workshop, which was explicitly stated in the Assessment Report:

> The SS3 model results provided in this report are not intended to be evaluated in the current state for management use, but rather to provide the peer-review panel with background information on efforts to transition to the SS3 modeling framework. It is the hope of the SAS that the peer-review panel can provide alternative perspectives and expertise to modify, stabilize, and improve the SS3 models for management use following the peer-review workshop.

As a result of this change in emphasis for the peer review meeting, and because working models were not available for either of the two stocks, not all terms of reference could be addressed at the meeting. While the review panel did review the data inputs (TOR 1), the stock structure (TOR 2), and research recommendations (TOR 9); and did provide guidance on methods for evaluating uncertainty (TOR 5), reference points (TOR 8), and timing of the next benchmark assessment (TOR 10); the review panel spent the majority of their time addressing the requests for advice on model structure, inputs and setup (TOR 3) and sensitivity analyses to evaluate progress during model development (TOR 4), resulting in significant progress towards simplified working models for both stocks during the meeting. However, for these reasons, recommendations for the best estimates of stock biomass, abundance, and exploitation from the assessment for use in management (TOR 7) could not be provided from this meeting.

During the meeting there was a reasonably good consensus among the review panel on most of the main discussion points and findings of the panel as outlined in the Review Workshop Report, although discussion of model results did lead (appropriately) to different options about how to

proceed with further model development. This document contains a summary of those findings as well as my own views about these assessments.

2.0. Individual Reviewer Activities

Prior to the meeting I reviewed all the assessment and background documents provided for the workshop. The Data Workshop Report, workshop working papers and background material were provided to the review panel on August 10, 2015, and the Assessment Workshop Report was provided to the review panel on August 14th 2015, at which time the review panel was informed of the model issues and was asked if they had any suggestions for things that the assessment team could work on prior to the Review Workshop. I participated in a teleconference on August 19, 2015, during which the SEDAR process and model issues were discussed, and, as did the other review panel members, I provided my initial impressions and suggestions during the call. In the days prior to the workshop, the assessment team reran the model in an attempt to address some of concerns that had been raised. As a result of their efforts prior to the meeting, the Review Workshop was able to proceed with descriptions of both the initial modelling efforts as well as a first round of model changes.

I participated in the Review Workshop in Charleston, South Carolina, August 25-27, 2015. During the meeting, I actively participated as member of the review panel, and questioned and discussed several aspects of the data and models. The meeting was fairly informal with a lot of lively discussion during presentations, which worked particularly well given the changed emphasis towards developing a working model.

After the Review Workshop, I prepared this individual, independent report and assisted in writing the Review Workshop Report. As outlined in Appendix 2, this independent report is intended to summarize review activities during the panel review meeting, including providing a summary of findings, conclusions, and recommendations for each TOR. The following sections in this document contain my personal perspectives about this assessment and its results to date.

3.0. Summary of Findings in Accordance with the TOR's

1. Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:
    a. Presentation of data source variance (e.g., standard errors).
    b. Justification for inclusion or elimination of available data sources,
    c. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, aging accuracy, sample size),
    d. Calculation and/or standardization of abundance indices.
    e. Estimation of discards and size composition of discards.

The Data Workshop Report and supporting working papers thoroughly documented the very large amount of information available for assessing Atlantic red drum. Data types included: life history information such as: age-at-maturation, growth, length-weight conversion coefficients and natural mortality; commercial landings including discards and discard mortality; recreational

fisheries harvests and releases (including mortality rates of released fish); abundance indices based on both fishery- and fishery-independent surveys; length and age data for several fisheries and surveys; and results from tagging studies. In general, I think the data decisions from the Workshop report are sound and robust, although there remains some uncertainty about how best to incorporate the data into the model (discussed under TOR 3).

Life History Information

The assessment team provided a thorough description of the life cycle of red drum. In brief, juveniles settle in estuaries and then move into lower estuary areas where they remain until they are about three to five years old. Adults live in deeper coastal waters, moving back into the estuaries to spawn. Spawning occurs annually. Maximum age is 40 to 60 years, although there is very little data pertaining to the older animals in the population. Female age-at-50%-maturity was estimated to be 4.1 years for the northern stock, and 5.1 years for the southern stock.

The assessment team estimated age-specific natural mortality (M) externally to the model using Hoenig's method to derive a single value of M over the lifespan of the fish, and then re-scaling a Lorenzen relationship using this value such that the average natural mortality rate from age-1 through the maximum age was equal to the lifespan M. The assessment team chose to use a non-parametric growth model for this analysis, because growth in red drum does not appear well-approximated using a VonBertalanffy growth model, and as pointed out by the review panel, this created a discrepancy between the growth model used to estimate M and the growth component of the assessment model, where variants of a VonBertalanffy were used.

Although the use of Lorenzen relationships to derive age-specific estimates of M in stock assessments is relatively common, there are examples of species and populations for which natural mortality is higher for older/larger animals than for younger/smaller animals, such as Atlantic salmon, (e.g. Gibson et al. 2008) and Scotian Shelf Atlantic cod (Fu et al. 2001). For example, mortality rates may be higher for animals during reproduction due to increased energetic demands associated with this life history process. Because fishing mortality is thought to be relatively low for older animals, spawner biomass estimates would be expected to be very sensitive to assumptions about M for the older animals. Sensitivity analyses that include different functional forms for the age-mortality relationship could be considered in addition to higher and lower values.

During the Review Workshop, the assessment team presented a catch curve analysis for older age classes for the southern stock using the longline survey age composition data for this stock. This analysis provided an estimate of total mortality similar to the externally derived estimate of M used in the model for those older age classes. If fishing mortality is indeed very low for these older age-classes, it may be possible to estimate M, at least for these older age classes, within model.

The Data Workshop Report and background documents provided thorough descriptions of the available abundance indices, methods used for their calculation, their strengths and weaknesses, justification for their inclusion or exclusion as data inputs for the model and presentation of data source variance.

The assessment team used seven criteria when deciding whether to include the survey in the model. A survey was considered for rejection if it:

a) contained less than 5 consecutive years of red drum captures with consistent survey methodology,
b) contained low proportion non-zero samples,
c) exhibited unrealistic magnitude changes for unexplained reason,
d) for unexplained reason did not track strong year classes, if not a single age index,
e) for unexplained reason did not correlate with trends observed in nearby surveys,
f) covered a small geographic area relative to the spatial extent regional model(s),
g) was in some other way not representative of the regional stocks.

The review panel noted that there was an element of subjectivity associated with the selection criteria and noted that, although some level of data selection and filtering will be required for nearly any assessment, the philosophy of selecting indices in this manner was not completely consistent with that of integrated assessment approaches such as using SS3, where the model "evaluates" the index against all the other data and incorporates it accordingly. Of these criteria, I have the greatest concern with the use of correlations with nearby surveys as a selection criterion. If data are eliminated based on their inconsistency with other data, a source of uncertainty in the assessment is eliminated from the model.

In total, the assessment team considered a total of 23 indices for the northern stock, and 25 indices for the southern stock, retaining five abundance indices for the northern stock and eleven abundance indices for the southern stock. As pointed out by the assessment team, the majority of indices pertain only to the youngest ages, primarily ages 1-3. The paucity of information about the adult component of the population, particularly in earlier time periods, is a source of uncertainty in the assessment.

The assessment team provided measures of data source variance, in the form of standard errors and/or coefficients of variation, associated with the point estimates for the abundance indices. These were calculated from the data collected during the survey, and were generally considered appropriate measures of the uncertainty associated with the estimate. Less clear, however, is how to incorporate this information in the assessment model. Although they may be appropriate for the individual indices, in cases where spatial coverage of the index is limited, they may not be appropriate for weighting the likelihoods in the assessment model. This could be further explored as model development proceeds, particularly if weights can be assumed for some widespread surveys.

State-specific recreational harvests and releases were well described in the Data Workshop report for both stocks. The MRFSS and MRIP survey were used to provide estimates of the harvest and releases from 1981 to present, whereas CPUE data from the MRFSS were used to estimate harvests from 1950 to 1980. There is an increasing trend in catch-and-release fishing practices in this fishery, and hook-and-release mortality rate of 8% was assumed for released fish. With this increase, the total removals from the recreational fishery are becoming increasingly sensitive to the value for hook-and-release mortality used in its estimation. Overall, I believe the decisions made by the assessment team in calculating the recreational removals are reasonable, and agree

that there is greater uncertainty in the harvested component in the earlier time period. However, as noted in the Data Workshop Report, hook-and-release mortality estimates range from 2% to 15%, and assumptions about this rate determine the removals in the live release component of this fishery.

A thorough overview of the available commercial landings by state and gear type as available for the two stocks was provided by the assessment team. Data from 1950 to 2013 were used for the northern stock, with 90-95% of commercial harvest being reported from North Carolina. Although a few different gears have been used in varying proportions over time, there was limited biological sampling prior to 1989 upon which to model selectivity separately for each gear. The assessment team made the decision to model gillnet and beach seine landings as coming from a single combined fleet, and to consider all other gears as a separate fleet. The commercial fisheries from the southern stock were closed in the mid-1980's. Landings from 1950 to 1986 were used for this stock and, for modelling purposes, all commercial fisheries were grouped into a single commercial fishery due to the sparse amount of biological data available for estimating selectivity for differ gear types. I agree with the review panel perspective that, for both stocks, the selectivities of the various gears would be expected to differ, but that the decision to combine gears was practical given the limited age or length data available for the different gears.

Data about commercial discards are very limited, and are only available from North Carolina for the periods 2004 to 2006 and 2008 to 2013. With the knowledge that discarding did occur in the earlier years, the assessment team extrapolated to the entire time series using the ratio to the North Carolina gillnet landings. As such, discard rates in this fishery for the earlier years remain a source of uncertainty. Additionally, a discard mortality rate of 5% applied to the live discards from the commercial fishery. As was the case for the recreational releases, the assumed value determines the magnitude of the removals in this component of the fishery, and there is uncertainty associated with this value. For both the recreational and commercial fisheries, the estimated removals from the population associated with the discard/release components are a source of uncertainty in the assessment.

With the increasing trend in recreational catch-and-release fishing, in addition to the magnitude of the removals associated with this fishery component, the length-frequency of the fish released alive (the B2 component) is a source of uncertainty in the assessment (there is no data on this component of the catch). The assessment team made the decision to assume the length-frequency of the B2 component was the same as that of tagged fish that had been recaptured, measured, released alive and reported. This assumption would only be valid if the length-frequency of the tagged population was representative of the total population. This is unlikely given that small fish are more difficult to tag, fish within the slot limit may be more likely to be retained, and in some instances, anglers were specifically asked only to tag fish greater than a certain size. Additionally, as recreational anglers become more conservation minded, more fish within the slot limit are likely being released, which would create a non-stationarity in the selectivity of the recreational B2 fishery that would not be captured using regulatory changes alone to develop time steps. I agree with both the review panel and the assessment team that the B2 length-frequency is an important data gap, because assumptions made to address this gap ultimately determine the age-specific removals by this component of the fishery.

The assessment team provided thorough descriptions of the tagging data available for both the northern and southern stocks. Tagging began in the late 1970's for the southern stock and in the 1980's for the northern stock, with tagging occurring primarily in North and South Carolina. The assessment team filtered the tagging data for use in the assessment model, using criteria such as: availability of information such as the length at tagging and knowledge the recapture fleet; a sufficiently long time between release and recapture (7 days); and a sufficient sample size within each age/year/tag-type group (more than 300 tagged fish and recaptures observed over the first three years after tagging). It is not clear to me that the time period of 7 days between release and recapture to ensure that the capture probability is the same for tagged and untagged fish, an assumption that, if violated, would bias mortality rate estimates. Sensitivity analyses with respect to this decision are recommended for this reason.

In addition to tagging data selection, information about initial mortality associated with hook, tagging and release; tag loss rates and reporting rates are needed in order to use the data in the model. A hook and release mortality rate of 8% was assumed for all fish tagged by recreational anglers, although as discussed above, there is uncertainty associated with this value. Initial tag loss was fixed at zero in the tag recapture model, and as discussed below, the model results to date are sensitive to assumptions about the tag reporting rate and whether it is fixed or estimated in the model. I agree with the review panel comments that the issues of hook and release mortality, tag loss and reporting rate to be sources of uncertainty in the assessment and topics for further research (particularly reporting rate).

There was considerable discussion at the Review Workshop about the information that should be included in the Data Workshop Report. Analyses undertaken by the assessment team during the Review Workshop comparing indices were very informative in demonstrating the consistency of some of the indices as well as the ability to track cohorts within some of the data. For this reason, I strongly support the review panel recommendation that an important function of the data workshop should be to not only aggregate data, but also characterize the trends in the data and compare those trends between different data sources where possible. This additional information would be valuable when selecting a modelling approach.

2. Evaluate the definition of stock structure used in the assessment. Is the definition appropriate given the biology and management of red drum?

Consistent with SEDAR 18 and other assessments since 1996, SEDAR 44 carried forward the division of Atlantic red drum into two stocks: the northern stock, consisting of those fish occupying the waters of North Carolina and to the north, and the southern stock, defined as fish occupying the waters of South Carolina and to the south. The assessment team presented several lines of evidence in support of this decision, including a review of life history characteristics indicating differences in age-at-maturity, and growth between these two regions; genetics research indicating an isolation-by-distance pattern of genetic structuring with a break between these regions; and tagging data indicating that the majority of fish are recaptured in the waters of their state of release. Within each stock, there was some evidence of potential population structuring (during spawning), the most notable example being red drum in the areas around the Indian River lagoon/mosquito lagoon. Outside of the spawning season, run drum appear to be

mixed within the two stock units, and, to the extent that finer-scale population structure exists, much of the fishery occurs on populations that would be, to varying degrees, mixed.

Defining stock structure for assessments is often a pragmatic decision based on available information about population structure, but also the spatial scale for which data is collected (including commercial landings, which may include fish from mixed populations) and the scale at which management is implemented). Overall, I think the information provided for the review strongly supports the current use of two stocks as defined for this assessment as a practical decision.

In the longer term, research furthering the understanding of potential population structure within the stocks would be beneficial. Given the limited movement of red drum as evidenced by the tagging data, if localized depletion occurs, recovery could be slow, and the rate of recovery would depend in part on the degree to which a depleted component is isolated from other, less depleted populations. There are many indices available for Atlantic red drum providing the potential to monitor abundance on a small spatial scale. Even if the stock definitions used for assessment did not change, a better understanding of the population structure would be expected to aid the interpretation of these indices, particularly if indices from different areas diverge.

3. Evaluate the methods and models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, including but not limited to:
    a. Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of red drum?
    b. If multiple models were considered, evaluate the analysts' explanation of any differences in results.
    c. Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).

As noted in Section 1, because the assessment team encountered difficulties developing the assessments models, final base models were not available for review for either the northern or southern stock, and a significant portion of the Review Workshop was devoted to providing guidance on developing working models rather than a review of completed work intended to inform management decisions. Although significant progress was made towards working base models for both stocks during the workshop, the models are still very much works-in-progress. Preferred models and alternative models have not yet been developed.

Consistent with the perspectives presented in the Assessment Report and the Review Workshop Report, I believe the transition from the SCA modelling approach used in SEDAR 18, to the SS3 modelling framework used in SEDAR 44 was a sound decision. Although many of the recommendations from SEDAR 18 (e.g. integration of the tagging analysis into the assessment model) could be addressed within the SCA framework, methods to address these limitations have already been developed in SS3. The models as implemented by the assessment team, were very complex, including integrated analyses of the tagging data, a switch to length based selectivities,

more complex selectivity forms including time blocks, a long historical time period with very little data, and integrated growth and stock-recruitment models. Results from the models were not considered plausible by the assessment team, and the models had convergence issues which the assessment team demonstrated by jittering starting values. The primary recommendation made by the review panel was to greatly simplify the model structure in order to make certain that the model behavior and sensitivities could be understood, and then to build complexity ("realism", e.g. different selectivity for different gears or time periods) back into the model making small changes one at a time. During the Review Workshop, the approach of simplifying the model worked particularly well for the northern model, in that a working simplified model that was sufficient to develop at least a partial understanding of the model behavior. For example, using the simplified model, it was identified that estimating tag return rates in the model had the effect of, to some degree, decoupling the tagging data from the rest of the data which was one of the main issues contributing to the differences between the SS3 model and the continuity run.

The review panel provided several suggestions for continuing model development after the workshop. For the northern stock, working towards improvements in the model's ability to track cohort strength via exploration of the interplay between growth, selectivity and the age/length composition data was a primary recommendation. This could be achieved via exploration of: alternative methods of modelling growth (a non-parametric form via analyses external to the model, increased complexity by increasing the number of growth coefficients and/or changing the age range to which they apply); exploration of relative weightings for the length composition likelihoods; and exploration of age-based selectivity for the longline survey. Suggestions for the southern stock were less specific (due to less progress with the southern stock model at the meeting), and included an exploration of the effects removing the age bins from the model, as one step towards a simplified model. Overall, I think the suggestions made by the review panel are good ones.

With respect to the estimation of age-specific natural mortality, while I believe the methods are consistent with those often used in stock assessment models, as discussed under TOR 1, there are examples for which the Lorenzen relationship is not a good approximation. Because fishing mortality appears low for all but the youngest ages and given the longevity of red drum, natural mortality will be a key determinant of spawner biomass, the misspecification of which will lead to issues fitting a stock-recruitment relationship. However, if fishing mortality is quite low for the older ages, it should be reasonably approximated by total mortality and it might be possible to estimate it in the model, particularly if the selectivity pattern for the older ages in the longline survey is sufficiently constrained. When conducting sensitivity analyses for different values and functional forms for natural mortality, examination of resulting stock-recruitment relationship (biological plausibility) in each analysis may be informative in addition to examining overall model fits.

With respect to the choice of a stock-recruitment (SR) relationship, for the runs to date, the assessment team chose to model recruitment using annual recruitment deviates around a Beverton-Holt SR relationship with steepness set to 0.99. This formulation essentially estimates annual recruitment independently of spawner biomass, which I think is appropriate for models at this current developmental stage, and may also be appropriate for the completed model runs if

SR parameters cannot be reliably estimated within the model. In this instance, external analysis of the SR data could be useful towards an understanding of the underlying population dynamics and reference point estimation. Depending on a stock's status, estimation of one or the other (assuming a two parameter Beverton-Holt relationship) may be possible. If abundance is very low throughout the time series, then estimation of the slope at the origin may be possible, whereas if abundance is very high, the average recruitment might approximate unfished levels (particularly if the true steepness of the relationship is high). As models are further developed, runs with the unfished recruitment level set to near infinite values might help explore whether the slope of the origin of the relationship can be estimated, and also help evaluate whether the range of spawner abundances are on the ascending portion (where survival is, in essence, independent of spawner biomass) of the SR curve. Additional suggestions for estimating reference points from SR data in the absence of a well-determined SR relationship are provided under TOR 8.

Stepping back from the questions of model formulation, weighting and data selection, the red drum assessment differs from many assessments for marine fish species due to a reliance on assumed constants in addition to natural mortality rates. For example, removals by the B2 component of the recreational fishery are calculated using a discard mortality rate, the assumed value of which determines the magnitude of the removals. Similarly, as described above, explorations with the northern stock simplified model showed a high sensitivity to the assumed tag reporting rate. Assumptions about tag loss rates were not explored. Although the extent to which these assumptions will influence final model results is not presently clear, a large number of sensitivity runs to explore the implications of these assumptions, potentially producing quite different results, will likely be needed for the next iteration of this assessment.

4. Evaluate the diagnostic analyses performed, including but not limited to:
    a. Sensitivity analyses to determine model stability and potential consequences of major model assumptions
    b. Retrospective analysis

Sensitivity analyses and diagnostic plots played an important role in the model development that occurred during the Review Workshop. Sensitivity analyses were generally used to evaluate how the model responded to assumptions about various model parameters and datasets by fixing various model parameters and via various weighting schemes for components of the likelihood. Diagnostics plots to evaluate model fit included plots of the estimated and the observed values, residual plots, and profile likelihoods. These methods are appropriate for model development. The models are not currently developed to the point that a comprehensive set of sensitivity analyses to evaluate the robustness of conclusions to major assumptions can be recommended. Retrospective analyses were not reviewed at this workshop (their presentation would have been premature at this point in the models' development).

5. Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

There are several options available in ADMB for characterizing uncertainty in parameter estimates. The assessment team made extensive use of standard errors based on asymptotic

approximations and profile likelihoods when evaluating different model formulations and presenting model runs. Both are well-established methods, and although asymptotic approximations may be inappropriate if the distributional assumptions are not met, and profile likelihoods are conditional on all other model parameters being at their maximum likelihood estimate, their use by the assessment team is appropriate given the current developmental stage of these models. ADMB also includes Markov Chain Monte Carlo Methods to derive marginal probability densities for quantities of interest which more fully incorporate uncertainty in other model parameters. I agree with the review panel recommendation that MCMC methods be used to characterize uncertainty once base models are developed, but also suggest that using as model development proceeds, exploration of the parameter space via ADMB's MCMC capabilities can be a useful diagnostic tool once the models are further developed (as shown in SEDAR 18).

The uncertainty resulting from model specification, such as decisions about which data to include in the models, weighting decisions and the model formulation, often exceeds the estimation uncertainty associated with individual model runs. This source of uncertainty can be addressed via presentation of sensitivity runs (as above), although plausibility of the different scenarios is often subjective by necessity.

6. If a minority report has been filed, review minority opinion and any associated analyses. If possible, make recommendation on current or future use of alternative assessment approach presented in minority report.

The review panel was not provided with a minority opinion or any associated analyses for review.

7. Recommend best estimates of stock biomass, abundance, and exploitation from the assessment for use in management, if possible, or specify alternative estimation methods.

Neither of the models for the northern and southern Atlantic red drum stock was developed to the point where they could be used to provide estimates of stock biomass, abundance, and exploitation from the assessment for use in management. During the Review Workshop, the model for the northern stock progressed to the point that it was no longer as sensitive to starting values, and its sensitivity to issues like assumptions about the tag reporting rate had been identified. Analyses for the southern stock did not progress as far during the Review Workshop, but as the approach of simplifying the model and adding complexity is implemented, a workable model is anticipated. In my opinion, continued development of the SS3 models is the best path forward, rather than switching to alternative estimation methods.

8. Evaluate the choice of reference points and the methods used to estimate them. Recommend stock status determination from the assessment, or, if appropriate, specify alternative methods/measures.

As currently configured, the models being used for both the northern and southern stocks do not include an informative SR relationship. In the absence of this information about stock productivity, MSY-based reference points for fishing mortality and spawning biomass cannot be determined. As discussed above, as the models are further developed, further exploration of the

SR relationship is recommended, although it is not clear that there is sufficient contrast in the data to estimate the relationship.
Given the longevity of Atlantic red drum, and because the fisheries for Atlantic red drum primarily exploit very young animals, F-based reference points have the advantage that either over-fishing or the effects of management changes can be identified rapidly, whereas the effects of overfishing or reductions in fishing mortality may take a relatively long time period before their effects are noticeable relative to B-based estimates of stock status.

In the absence of a SR curve, the assessment team proposed the use of SPR-based reference points as proxies for F_{MSY}, a decision I support for the reasons above. I do not have any reason to believe that the recommended overfishing threshold of 30% and a target level of 40% of the unfished SPR are not reasonable for these stocks.

If a SR relationship cannot be estimated reliably within the model, it may be possible to either derive alternative reference points from the SR data, or to evaluate the SPR reference levels in other ways. For example, if a joint likelihood surface for the SR parameters is derived either using ADMB's MCMC capabilities or via analyses of the SR data external to the model, reference fishing mortality rates can be estimated using either the marginal probability density of the SR slope at the origin, or using decision theoretic methods. Using simulations of noisy SR data, Gibson and Myers (2004) found that a decision theoretic reference fishing mortality rate provided higher equilibrium yields (on average across populations) than did fishing at the MLE of F_{MSY}, while at the same time reducing the risk of over-exploitation (the reference F based on the marginal distribution was more conservative, producing lower yields but lowering further the risk of over exploiting the population). While the applicability of these methods to Atlantic red drum would need to be explored, they may be useful for evaluating the percentages of unfished SPR used to set the threshold and target reference fishing mortality rates for these populations, or as alternatives to the SPR approach.

In order for F-based reference points to be used, the models will need to be developed to a point where estimated age-specific fishing mortality rates are sufficient such that status can be evaluated against these reference values.

9. Review the research, data collection, and assessment methodology recommendations provided by the Technical Committee and make any additional recommendations warranted. Clearly prioritize the activities needed to inform and maintain the current assessment, and provide recommendations to improve the reliability of future assessments.

The review panel reviewed the research recommendations provided to the panel, with relatively good agreement among the review panel members. As such, many of the comments below mirror those in the Review Workshop Report. I've split the research recommendations into three categories. The first category includes recommendations with respect to modifications to the model in order to complete the development of base model for each stock using existing data; the second involves research that I believe should be implemented in the short-term, including focused studies that would be expected to improve the assessment on the time scale of a few years; and the third category includes longer term research that would be expected to lead to a

better understanding of Atlantic red drum and ultimately better assessments and management. With a few exceptions, my prioritization matches that of the assessment team. In the text below, research recommendations provided for review (Document RW01) have been re-ordered and are provided in italics.

Model development

With the modified objectives for the SEDAR 44 Review Workshop, most of the workshop was dedicated to developing recommendations/suggestions expected to lead to a working model for each stock. These recommendations are found throughout the report. I absolutely agree with the review panel recommendation that model development should begin with a relatively simple model, with complexity added only after the model is providing credible results and the assessment team understands how the model is performing. In the case of the model for the northern stock, the major simplifications including a shorter time period and a single set of selectivity parameters led to a model working well enough that model behavior could be better understood.

Based on the results of exploratory model runs for the northern stock, estimates of fishing mortality rates and stock size may hinge on assumptions made about the tag reporting rate. If so, I believe the review panel recommendation to review information about tag reporting rates, including evaluation of alternative estimation methods and information from other species, in order to justify assumptions about the rates used in the model is important.

In addition to this recommendation, if the tagging data provides the scale to the models via information about F, as seen for the northern stock during the RW, ensuring that the way these data are used in the model, specifically that the number of tags-at-large as estimated by the model, is being handled correctly and that the assumptions for mark-recapture analyses are being met, will be necessary in order that the scaling from these data is correct. Filtering the data to match the SS3 implementation may be one way this could be achieved.

Selectivities for the B2 component of the fishery are a significant source of uncertainty in the assessment. I agree with both the assessment team recommendation to:

> *Determine if existing and historic recreational data sources (e.g., tagging) can be used to evaluate better B2 selectivities,*

as well as the review panel recommendation that the recreational live release selectivity pattern should be bimodal, and could potentially be modelled using the non-parametric selectivity function with SS3.

Data explorations by the assessment team during the Review Workshop were very helpful in understanding the consistency of indices available for the stocks as well as the ability to track cohorts in the age data. While not specific to this assessment process, I think the review panel recommendation that additional time be spent (during the data workshop) evaluating available data sources prior to developing a model, is important.

Short term

The assessment team recommended several shorter term studies that focused on key information gaps for these stocks, which if addressed, would be expected to improve model performance:

> *Conduct experiments using logbooks to develop estimates of the B2 catch length composition in both the North and South regions.*

As discussed, the length composition of the B2 component of the fishery is an important source of uncertainty as implemented in this assessment. Studies to address this uncertainty should be a high priority.

> *Further study is needed to determine discard mortality estimates for the Atlantic coast, both for recreational and commercial gears. Additionally, discard estimates should examine the impact of slot-size limit management and explore regulatory discard impacts due to high-grading. Investigate covariates affecting discard mortality (e.g., depth, size, seasonality).*

Similarly, discard mortality rates enter the assessment model as constants and the overall removals resulting from discarding in both the commercial and recreational sectors are determined by these values. I agree that further information about discard mortality rates is a high priority.

> *Continued and expanded observer coverage for the NC and VA gill net fisheries (5-10% coverage).*

Given the magnitude of the discards in the gillnet fishery, I agree with the assessment team that this research is important for improving the assessment, particularly if the expanded coverage was carried out in a way that could lead to adjustment of older data, if needed.

> *Expand biostatistical sampling (ages and lengths) to better cover all statistical strata (gears/states - principally NC and VA) and collect more ages proportional to lengths, preferably otoliths. Conduct statistical analysis to determine appropriate sample sizes to adequately characterize the age-size composition of removals.*

I agree with the assessment team that improved age and length data covering all gears and states would be beneficial, but also agree with the review panel comments that sampling for the sake of increasing sample size can be counterproductive, and that sampling plans should be developed that fill identified data gaps and improve the model and/or management decisions while minimizing over sampling.

Long term

> *Continue cooperation between state ageing labs, such as the October 2008 red drum ageing workshop, to provide consistent age verification between labs.*

If aging methods are inconsistent, further work on this issue is warranted.

> *Expand observer coverage to include other gears of concern (i.e. haul seine, pound net, trawls).*

The assessment team suggested this recommendation be implemented in the short term, but given the magnitude of removals by these gears relative to other sectors in the fishery, I think it might be less of a priority.

> *Investigate alternative functions for retention to include recreational harvest and dead releases in the same fleets. Commercial discards should also be considered as a discard component of the landings fleet.*

Although this approach to modelling the fisheries might better approximate how fishing actually occurs, I agree with the review panel recommendation that this work receive lower priority, because it does not appear necessary to get a solid working model.

> *Allow for time varying reporting rate of tag recaptures in the assessment model. This would allow use of more recent tag-recapture data from NC and estimates of changes over time in both regions.*

As discussed above, short-term studies to better understand tag return rates are a high priority. However, I agree with the review panel concerns with this recommendation that SS3 might have a difficult time estimating time varying reporting rates given the other data. A better understanding of factors that influence reporting rates may be necessary before this recommendation could be implemented.

> *Consider a pilot Virginia adult survey and expanding current adult fishery independent survey coverage in Florida waters.*

I agree with the review panel comment that fishery independent sampling should be representative of the entire population, and that the adequacy of current sampling levels should be evaluated and expanded as necessary.

> *Investigate iterative re-weighting of data components to identify the appropriate weights given to each data component in the objective function.*

It is not clear to me how best to identify appropriate weights for each data component in the likelihood. Several of the data collections cover only part of each stock, and as such, the extent to which they are indicative of the entire stock, particularly relative to other data, is subjective. Additionally, data quality is known to vary (e.g. historical versus recent landings) and data borrowing is used to fill in gaps, which is also a subjective decision. In the short term, I think exploring the effects of various weighting schemes is important, as is reporting the effects in the assessment. If there are methods to identify appropriate weights in spite of these issues, then I support their use to the extent it improves the assessment.

Three research recommendations were provided that pertain to stock structure and mixing:

> *1. Continue genetic analyses (i.e. SC DNR analyses) to evaluate stock structure, and mixing and temporal changes in genetic composition of the red drum population.*
> *2. Conduct a tagging study using emerging technologies (i.e., acoustic tagging, satellite tagging, genetic tags) to evaluate stock mixing and identify movement of sub-adult fish transitioning to maturity.*
> *3. Otolith microchemistry analysis should be considered to look at state level differences between regions to support stock structure differentiation.*

With respect to these recommendations, as discussed under TOR 2, I agree with the review panel comments that the stock structure information provided during the RW was sufficient and informative. In the longer term, understanding the stock boundaries and mixing rates between these two stocks is important, but perhaps more so is investigating finer scale population structure, and if found, the extent to which putative sub-stocks contribute to the different sectors within the overall fishery. Sampling design considerations (e.g. ensuring sampling occurs when fish would be segregated into discrete sub-stocks) are important, as is interpreting information resulting from one of these methods in light of information provided from the other methods. I agree with the review panel recommendation that long term monitoring be conducted at modest levels of sampling using a combination of these three techniques.

Two research recommendations were provided that related to changing or variability in habitat quality and quantity:

> *1. Identify impacts of water quality, environmental, and ecosystem changes on red drum stock dynamics. Incorporate in the stock assessment models.*
> *2. Quantify habitat changes for future management planning*

It seems intuitive that species that depend on estuarine habitat are more likely to be affected by human-induced changes in water quality and habitat changes than species that reside entirely in offshore waters. Understanding how factors such as water quality, the timing of spawning (as determined by environmental factors), or changes in predator/prey abundance can be important for understanding how human activities other than fishing affect these stocks. Although this research may not directly contribute to the assessment in the very near term, an understanding of the factors influencing stock dynamics can be important in the longer term if conditions change.

Two research recommendations were presented that pertain to reproduction:

> *1. Determine batch fecundity estimates of red drum. Need to include age-specific spawning frequency and spawning season length for this indeterminate spawner.*
> *2. Update maturity schedules for Atlantic red drum from Florida to Virginia. Preferably, gonad histology samples should be collected from all sizes over time and archived.*

I support these research recommendations and longer term priorities, albeit with an emphasis on the maturity schedules to the extent that they are out of date. Although fecundity is also of interest, from an assessment perspective, the vast majority of assessments use spawner biomass

as a proxy of egg deposition. Basic life history information such as fecundity is important, particularly if it can be used to improve on the assumption that total egg deposition is proportional to spawner biomass. In addition to fecundity, egg quality and volume (an indicator of maternal investment) has been demonstrated to vary with age and spawning periodicity for other species (Reid and Chaput 2012).

10. Recommend timing of the next benchmark assessment and updates, if necessary, relative to the life history and current management of red drum.

This is a judgment call which is tricky in the absence of a completed assessment, because status is not known. A benchmark review should occur as soon as possible to review the results of a completed assessment. Given the current state of the models, a timeline of 6 months to a year might not be unreasonable, although there may be issues that arise during further work with the models that could change this timeline. This cannot be known at this point in time. The timing of the next benchmark will depend on the results of that process. For example, results from the model for the northern stock are currently very sensitive to decisions about the tag reporting rate and the conclusions about status may depend on these decisions. The timing of the next benchmark might then be as soon as data can be collected to resolve uncertainties about this parameter. Alternatively, if these sensitivities are resolved, a longer time period before the next framework may be appropriate. In my opinion, with an increasing proportion of the removals from the stocks coming from recreational fisheries, and with hook-and-release fishing practices becoming more prevalent, depending on status as well as specific management needs, the frequency of updates between benchmarks would be expected to decrease (maybe once every two to three years). Conversely, based on the analyses in this Review Workshop, there appears to be fairly high recruitment variability with a few strong year classes contributing significantly to the overall biomass. If this is indeed the case, then overexploitation of a single year class might be expected to have long-term population-level effects. A higher frequency of both benchmarks and updates should reduce the likelihood of this occurring.

11. Prepare a peer review panel terms of reference and advisory report summarizing the panel's evaluation of the stock assessment and addressing each peer review term of reference. Develop a list of tasks to be completed following the workshop. Complete and submit the report within 4 weeks of workshop conclusion.

This TOR is ongoing at the time of writing of this independent reviewer report. Writing tasks for the Peer Review Summary Report were assigned to the review panel members during the meeting, and a draft Review Workshop Summary Report and three rounds of review by the review panel have been completed. The review panel summary report appears on schedule for completion before the deadline.

4.0. Conclusions and Recommendations in Accordance with the TOR's

The statements below reflect my personal opinion about the major conclusions that I have drawn with respect to this assessment.

1. Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:
    a. Presentation of data source variance (e.g., standard errors).
    b. Justification for inclusion or elimination of available data sources,
    c. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, aging accuracy, sample size),
    d. Calculation and/or standardization of abundance indices.
    e. Estimation of discards and size composition of discards.

- Overall, the Data Workshop Report and supporting working papers thoroughly documented the very large amount of information available for assessing Atlantic red drum.
- Data types included: life history information; commercial landings including discards and discard mortality; recreational fisheries harvests and releases (including mortality rates of released fish); abundance indices based on both fishery- and fishery-independent surveys; length and age data for several fisheries and surveys; and results from tagging studies.
- Removals from the population associated with the discard/release components for both the recreational and commercial fisheries are a source of uncertainty in the assessment, particularly for the early time period.
- Recommendations include:
    - Exploration of alternative functional forms for age-specific natural mortality.
    - Re-consideration of the role of correlations with nearby indices as a selection criterion when choosing indices.
    - Reviewing the constants being used in the analyses (e.g. tag reporting rate, discard mortality, tag loss, etc.) to ensure sensitivity runs fully explore the range of values for these constants.
    - Ensure that the filtering criteria for the tagging data sufficient to meeting the assumptions required for mark-recapture analysis.

2. Evaluate the definition of stock structure used in the assessment. Is the definition appropriate given the biology and management of red drum?

- Although the potential for both finer-scale stock structure and for mixing between the two stocks exists, the decision to split Atlantic red drum into two stocks for this assessment appears practical and reasonable given the biology of red drum, current management, and the ways in which data are collected.
- Recommendations include:
    - Long-term research to further the understanding of potential population structure.
    - Using existing surveys to evaluate whether abundance trends at smaller spatial scales deviate from the trends for the entire stock.

3. Evaluate the methods and models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, including but not limited to:

a. Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of red drum?
b. If multiple models were considered, evaluate the analysts' explanation of any differences in results.
c. Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).

- Final models were not available for review at this workshop resulting in a change in emphasis from peer review of the assessment results to providing guidance on developing working models.
- The transition from the SCA modelling approach used in SEDAR 18 to the SS3 modelling framework used in SEDAR 44 is expected to lead to improved model development because SS3 already has methods to implement many of the desired changes to the models.
- The primary recommendation made by the review panel was to greatly simplify the model structure in order to have the model working in order such that the model behavior and sensitivities could be understood, and then to build complexity into the model making small changes one at a time. During Review Workshop, the approach of simplifying the model worked particularly well for the northern model, in that a working simplified model that was sufficient to develop at least a partial understanding of the model behavior.
- Suggestions for the southern stock included an exploration of the effects removing the age bins from the model, as one step towards a simplified model.
- This red drum assessment differs from many assessments for marine fish species due to a reliance on assumed constants in addition to natural mortality rates. Although the extent to which these assumptions will influence final model results it is not presently clear, a large number of sensitivity runs to explore the implications of these assumptions, will likely be needed for the next iteration of this assessment.

4. Evaluate the diagnostic analyses performed, including but not limited to:
    a. Sensitivity analyses to determine model stability and potential consequences of major model assumptions
    b. Retrospective analysis

- The sensitivity analyses used during the workshop were appropriate for evaluating how the model responded to assumptions about various model parameters and datasets by fixing model parameters and via various weighting schemes for components of the likelihood.
- Retrospective analyses were not reviewed at this workshop (their presentation would have been premature at this point in the models' development), but should be developed once a final base model is identified.

5. Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

- The methods for characterizing uncertainty in parameter estimates are well developed in ADMB.
- The current use of standard errors and profile likelihoods when evaluating different model formulations is appropriate given the current stage of the models.
- ADMB's MCMC capabilities can be a useful diagnostic tool once the models are further developed.
- The uncertainty resulting from model specification often exceeds the estimation uncertainty associated with individual model runs, and can be addressed via presentation of sensitivity runs, although evaluation of the plausibility of the scenarios is often subjective by necessity.

6. If a minority report has been filed, review minority opinion and any associated analyses. If possible, make recommendation on current or future use of alternative assessment approach presented in minority report.

- The review panel was not provided with a minority opinion or any associated analyses for review.

7. Recommend best estimates of stock biomass, abundance, and exploitation from the assessment for use in management, if possible, or specify alternative estimation methods.

- Neither of the models for the northern and southern Atlantic red drum stock was developed to the point where they could be used to provide estimates of stock biomass, abundance, and exploitation from the assessment for use in management.

8. Evaluate the choice of reference points and the methods used to estimate them. Recommend stock status determination from the assessment, or, if appropriate, specify alternative methods/measures.

- As currently configured, neither of the models being used for both the northern and southern stocks includes an informative SR relationship.
- In the absence of a SR curve, the use of SPR-based reference points as proxies for F_{MSY}, is appropriate, provided that models are developed to a point that fishing mortality rates can be reliably estimated.
- There are methods for deriving reference points from SR data, even when the SR relationship is uncertain, that should be explored.
- Recommendations:
    - After completion of the assessment models, explore estimation of reference fishing mortality rates based on marginal likelihoods and/or decision-theoretic

methods either in support of the percentage values being used for SPR-based reference points, or as alternatives to SPR-based reference points.

9. Review the research, data collection, and assessment methodology recommendations provided by the Technical Committee and make any additional recommendations warranted. Clearly prioritize the activities needed to inform and maintain the current assessment, and provide recommendations to improve the reliability of future assessments.

- In this report, research, data collection, and assessment methodology recommendations are divided into three categories: 1) those related to further development of the existing models, 2) focused studies that would be expected to improve the assessment on the time scale of a few years, and 3) longer term research that would be expected to lead to a better understanding of Atlantic red drum and ultimately better assessments and management.
- In the first category, continued use of the approach of starting with a simple model and adding complexity once the simpler model is understood is the top priority. To me, ensuring the tagging data analysis in SS3 is consistent with the data inputs and the assumptions of mark-recapture studies is also a high priority.
- In the second category, priorities include: research to better characterize the B2 length compositions, research to better quantify discards and discard mortality rates, and expansion of biostatistical sampling to improve age and length data collections.
- In the third category, priorities include: improvements to data collection, research to better understand stock structure, and research to understand environmental influences on red drum productivity.

10. Recommend timing of the next benchmark assessment and updates, if necessary, relative to the life history and current management of red drum.

- A peer review of this assessment is recommended once it is completed.
- The timing of the next benchmark will depend on the results of that process. For example, if results from this assessment are found to be sensitive model assumptions or constants used in the model, the timing of the next benchmark might then be as soon as data can be collected to resolve uncertainties about these assumptions.

11. Prepare a peer review panel terms of reference and advisory report summarizing the panel's evaluation of the stock assessment and addressing each peer review term of reference. Develop a list of tasks to be completed following the workshop. Complete and submit the report within 4 weeks of workshop conclusion.

- This TOR is ongoing at the time of writing of this independent reviewer report.

6.0. References

Fu, C., Mohn, R., and Fanning, L.P. 2001. Why the Atlantic cod (Gadus morhua) stock off eastern Nova Scotia has not recovered. Canadian Journal of Fisheries and Aquatic Sciences 58: 1613-1623.

Gibson, A.J.F., H.D. Bowlby, J.R. Bryan, and P.G. Amiro. 2008. Population viability analysis of Inner Bay of Fundy Atlantic Salmon with and without live gene banking. DFO Canadian Science Advisory Secretariat Research Document 2008/057.

Gibson, A.J.F., and R.A. Myers. 2004. Estimating reference fishing mortality rates from noisy spawner-recruit data. Canadian Journal of Fisheries and Aquatic Sciences 61:1771-1783.

Reid, J. E., and Chaput, G. 2012. Spawning history influence on fecundity, egg size, and egg survival of Atlantic salmon (Salmo salar) from the Miramichi River, New Brunswick, Canada. – ICES Journal of Marine Science, 69: 1678–1685.

7.0. Appendices

Appendix 1: Bibliography of Materials Provided for Review
Appendix 2: CIE Statement of Work
Appendix 3: Panel Membership

Appendix 1: Bibliography of Materials Provided for Review.

SEDAR 44 – Atlantic Red Drum Review Workshop Document List

Document #	Title	Authors
SEDAR44-DWReport	SEDAR 44 Atlantic Red Drum Data Workshop Report	
SEDAR44-AWReport	SEDAR 44 Atlantic Red Drum Assessment Workshop Report	
Documents Prepared for the Data Workshop		
SEDAR44-DW01	Adult Red Drum Genetic Diversity and Population Structure	Cushman, Jamison, and Darden 2014
SEDAR44-DW02	Red Drum Maturity Analysis	Arnott 2015 & South Carolina DNR
SEDAR44-DW03	Distance moved by red drum recaptured by recreational anglers	Arnott 2014
SEDAR44-DW04	Recreational Landings and Live Releases of Red drum (Sciaenops ocellatus) in the Southeast US using MRFSS-MRIP intercept data, 1981-2013.	Murphy 2014
SEDAR44-DW05	Sizes of tag recaptured red drum that were released alive by recreational anglers.	Arnott & Paramore 2015
SEDAR44-DW06	Estimating the age composition of the MRIP/MRFSS estimated landings and live-releases for red drum along the Atlantic coast, 1981-2013.	Murphy 2014
SEDAR44-DW07	Development of historical annual recreational landings of red drum from 1950 through 1980 for the Atlantic coast states from Florida through New Jersey.	Murphy 2015
SEDAR44-DW08	NC Biological Data Survey Descriptions and Background Information	Paramore 2014
SEDAR44-DW09	Fishery Independent Surveys of Sub-Adult Red Drum in South Carolina	Arnott 2014
SEDAR44-DW10	SCDNR adult red drum 1/3rd mile longline survey	Frazier and Shaw 2014
SEDAR44-DW11	Relative indices of abundance for Red drum (*Sciaenops ocellatus*) inhabiting estuarine waters along the Atlantic coast of Florida, 1997-2014.	Murphy 2014
SEDAR44-DW12	Relative indices of abundance for Red drum (*Sciaenops ocellatus*) inhabiting inland waters along the Atlantic coast based on 1991-2013	Murphy 2014

Appendix 1: Bibliography of Materials Provided for Review.

	angler catch rate data.	
Documents Prepared for the Review Workshop		
SEDAR44-RW01	Red Drum SEDAR 44 Stock Assessment Research Recommendations	Red Drum Technical Committee & Stock Assessment Sub-Committee
Final Assessment Reports		
SEDAR44-SAR1	Atlantic Red Drum Stock Assessment Report	To be prepared by SEDAR 44
Additional Supplementary Materials		
SEDAR44-RD01	SEDAR18-AW02: Nonparametric growth model for Atlantic red drum, and changes to natural mortality (M) estimates	Cadigan
SEDAR44-RD02	SEDAR 18 Atlantic Red Drum Review Workshop Report (excerpt from full Stock Assessment Report)	SEDAR 18 review panel
*The last assessment for Atlantic Red Drum was SEDAR 18. All SEDAR 18 documents (final assessment report, working papers, and reference documents) are available in a separate folder on the FTP site and on the SEDAR 18 web page (http://sedarweb.org/sedar-18). The two SEDAR 18 reference documents mentioned above were specifically suggested as supplementary materials for the SEDAR 44 Review Workshop.		

Appendix 2: CIE Statement of Work.

Statement of Work

External Independent Peer Review by the Center for Independent Experts

SEDAR 44 ASMFC Red Drum Assessment Review Workshop

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 Technical Representative (COTR), 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 44 will be a compilation of data, an assessment of the stock, and CIE assessment review conducted on ASMFC Red Drum. The Review Workshop provides an independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment panel. The review panel is ultimately responsible for ensuring that the best possible assessment is provided through the SEDAR process. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers should have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in **Charleston, South Carolina** during **August 25-27, 2015.**

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

Appendix 2: CIE Statement of Work.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, 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 background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE 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 CIE reviewers who are non-US citizens. For this reason, the CIE 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/

http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

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.

Panel Review Meeting: 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 cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Appendix 2: CIE Statement of Work.

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.

Other Tasks – Contribution to Summary Report: Each CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. Each CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

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) Participate during the panel review meeting in Charleston, South Carolina from August 25-27, 2015.
3) Conduct an independent peer review in accordance with the ToRs (Annex 2) in, Charleston, South Carolina, from August 25-27, 2015.
4) No later than **September 7, 2015** each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to *mshivlani@ntvifederal.com*, and Dr. David Sampson, CIE Regional Coordinator, via email to *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**.

Appendix 2: CIE Statement of Work.

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

August 10, 2015	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
August 10, 2015	NMFS Project Contact sends the CIE Reviewers the pre-review documents
August 25-27, 2015	Each reviewer participates and conducts an independent peer review during the panel review meeting
September 7, 2015	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
September 18, 2015	CIE submits CIE independent peer review reports to the COTR
September 21, 2015	The COTR 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 COTR within 10 working days after receipt of all required information of the decision on changes. The COTR 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 COTR 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 COTR (Allen Shimada, via Allen.shimada@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR 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.

Appendix 2: CIE Statement of Work.

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

Support Personnel:

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Appendix 2: CIE Statement of Work.

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.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The 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
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Appendix 2: CIE Statement of Work.

Annex 2: Tentative Terms of Reference for the Peer Review

SEDAR 44 ASMFC Red Drum Assessment Review Workshop

12. Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:
    f. Presentation of data source variance (e.g., standard errors).
    g. Justification for inclusion or elimination of available data sources,
    h. Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, aging accuracy, sample size),
    i. Calculation and/or standardization of abundance indices.
    j. Estimation of discards and size composition of discards.

13. Evaluate the definition of stock structure used in the assessment. Is the definition appropriate given the biology and management of red drum?

14. Evaluate the methods and models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, including but not limited to:
    a. Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of red drum?
    b. If multiple models were considered, evaluate the analysts' explanation of any differences in results.
    c. Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).

15. Evaluate the diagnostic analyses performed, including but not limited to:
    a. Sensitivity analyses to determine model stability and potential consequences of major model assumptions
    b. Retrospective analysis

16. Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

17. If a minority report has been filed, review minority opinion and any associated analyses. If possible, make recommendation on current or future use of alternative assessment approach presented in minority report.

18. Recommend best estimates of stock biomass, abundance, and exploitation from the assessment for use in management, if possible, or specify alternative estimation methods.

19. Evaluate the choice of reference points and the methods used to estimate them. Recommend stock status determination from the assessment, or, if appropriate, specify alternative methods/measures.

20. Review the research, data collection, and assessment methodology recommendations provided by the Technical Committee and make any additional recommendations warranted. Clearly prioritize the activities needed to inform and maintain the current assessment, and provide recommendations to improve the reliability of future assessments.

21. Recommend timing of the next benchmark assessment and updates, if necessary, relative to the life history and current management of red drum.

22. Prepare a peer review panel terms of reference and advisory report summarizing the panel's evaluation of the stock assessment and addressing each peer review term of reference. Develop a list of tasks to be completed following the workshop. Complete and submit the report within 4 weeks of workshop conclusion.

Appendix 2: CIE Statement of Work.

Annex 3: Tentative Agenda

SEDAR 44 ASMFC Atlantic Red Drum Review Workshop

Charleston, South Carolina, August 25-27, 2015

Tuesday

9:00 a.m.	**Convene**	
9:00 a.m. – 9:30 a.m	**Introductions and Opening Remarks** *- Agenda Review, TOR, Task Assignments*	**Coordinator**
9:30 a.m. – 12:00 a.m.	**Assessment Presentation**	**TBD**
12:00 a.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 3:30 p.m.	**Continue Presentations / Panel Discussion** **-** *Assessment Data & Methods* *- Identify additional analyses, sensitivities, corrections*	**Chair**
3:30 – 4:00	**Break**	
4:00 – 6:00	**Continue Discussion**	**Chair**

***Tuesday Goals*:** Initial presentations completed, sensitivity and base model discussion begun

Wednesday

8:30 a.m. – 12:00 a.m.	**Panel Discussion** **-** *Continue deliberations* *- Review additional analyses*	**Chair**
12:00 a.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 3:30 p.m.	**Panel Discussion** *- Continue deliberations* *- Review additional analyses*	**Chair**
3:30 p.m. – 4:00 p.m.	**Break**	
4:00 p.m. – 6:00 p.m.	**Panel Discussion/Panel Work Session** *- Recommendations and comments*	**Chair**

***Wednesday Goals*:** sensitivities and modifications identified, preferred models selected, projection approaches approved, Report drafts begun

Thursday

8:30 a.m. – 10:30 a.m.	**Panel Discussion** *- Final sensitivities reviewed.* *- Projections reviewed.*	**Chair** **Chair**
10:30 a.m. – 11:00 a.m.	**Break**	
11:00 a.m. – 1:00 p.m.	**Panel Discussion or Work Session** *- Review Reports*	**Chair**
1:00 p.m.	**ADJOURN**	

Thursday Goals: Complete assessment work and discussions, final results available. Draft Reports reviewed.

Appendix 3: Panel Membership

Review panel Membership

Jeff Brust	review panel Chair	ASMFC Appointee
Carmen Fernandez	Reviewer	CIE
Jaime Gibson	Reviewer	CIE
Sven Kupschus	Reviewer	CIE