Summary Report of the 48th Northeast Regional Stock Assessment Review Committee (SARC 48)

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1 Introduction

1.1 Background

The 48th SARC (Stock Assessment Review Committee) met in Woods Hole, Massachusetts, from Monday, June 1, through Thursday, June 4, 2009, to review three assessments: tilefish (*Lopholatilus chamaeleonticeps*), ocean quahog (*Arctica islandica*), and weakfish (*Cynoscion regalis*).

The review committee was composed of Dr. Patrick J. Sullivan (chair, NEFMC SSC and Cornell University) and three scientists affiliated with the Center for Independent Experts, Northern Taiga Ventures, Inc. (NTVI): Dr. Mike Bell, Dr. Jamie Gibson, and Sven Kupschus.

The SARC was assisted by the NEFSC SAW Chairman, Dr. James Weinberg, and his staff and Dr. Paul Rago, also from the NEFSC. The tilefish report was prepared by the Southern Demersal Working Group and was presented at the meeting by Dr. Paul Nitschke (NEFSC). The ocean quahog report was prepared by the Invertebrate Subcommittee and presented at the meeting by Dr. Larry Jacobson and Ms. Toni Chute (NEFSC). The weakfish report was prepared by the ASMFC Weakfish Technical Committee and presented at the meeting by Mr. Jeffrey Brust (NJDFW).

1.2 Review of Activities

About two weeks before the meeting, assessment documents and supporting materials were made available to the SARC via an ftp server. On the morning before the meeting, the assessment review committee met with Drs. Weinberg and Rago to discuss the meeting agenda, reporting requirements, and meeting logistics. During the SARC meeting, all documents were made available electronically and in print.

The meeting opened on Monday morning with a welcome and introductions by Jim Weinberg and Pat Sullivan. The tilefish assessment was presented that morning, after the introductions, followed by the ocean quahog assessment. On Tuesday morning the tilefish and ocean quahog assessments were discussed further, and on Tuesday afternoon the weakfish assessment was presented. Wednesday allowed for follow-up discussion on all three assessments and the committee asked further questions and then used the remaining time to derive a consensus on the content of the review. Thursday was spent developing the report.

1.3 SARC Process

The committee was able to arrive at a consensus on each of the three assessments. The specified terms of reference, in each case, appeared to be satisfied although several recommendations were made towards improving the assessments and the assessment advice. The reviews of each assessment are briefly summarized below with more details provided in the subsequent sections.

The tilefish assessment working group satisfactorily completed the TOR's for this assessment. Neither of the two models presented (a surplus production model and a statistical, age-and-length-structured model fit to the LPUE and length-frequency data) fit the data well nor were plausible parameter estimates derived. However, the working group thoroughly investigated both models, acknowledged issues with the models and provided practical management advice given the uncertainties identified in the analyses. There was a consensus within the review committee that the stock is not overfished and that overfishing is not occurring. The review committee also agreed with the working group that there is little evidence that the stock has rebuilt to B_{TARGET}.

The ocean quahog assessment working group also completed the TOR's for this assessment. The commercial landings and fishing effort are well characterized for this stock. Analyses were very thorough, at times using multiple independent methods to validate conclusions. As a whole, the stock is slowly being fished down to towards its B_{MSY} proxy reference point (1/2 of the virgin biomass). There was a consensus among the review committee that the stock is not overfished and that overfishing is not occurring. The unique biology of quahog (slow growth, low levels of recruitment and very long-lived) creates time lags that are outside the planning horizons for most managed activities and presents unique challenges for the assessment of this stock. These issues were handled well in the assessment.

The weakfish assessment working group did a considerable amount of work in meeting the TOR's for this assessment. Multiple analyses were presented to provide estimates of abundance, total mortality and fishing mortality, including an ADAPT VPA, an analysis of survey data as abundance indices, and a Steele-Henderson production model including predation effects. While there are technical issues with some of the modeling, taken as a whole the analyses indicate that abundance has declined markedly, total mortality is high, non-fishing mortality has recently increased and that the stock is currently in a depleted state.

2 Review of the Tilefish Assessment

Golden tilefish inhabit the outer continental shelf and upper continental slope of the western Atlantic from Nova Scotia to Venezuela. They are long-lived and slow growing, and are easily recognized by a large adipose flap on their head. They are harvested in southern New England and in the mid-Atlantic Bight primarily by long line, although some are taken by trawl or in a minimal recreational fishery. The Tilefish Fishery Management Plan was implemented in November 2001 with the intention of rebuilding the tilefish stock to B_{MSY}.

The panel agreed with the working group that the stock is not overfished and that overfishing is not occurring. The panel also agreed with the working group that while there is evidence that the stock is above $B_{THRESHOLD}$, there is no convincing evidence that the stock has rebuilt to B_{TARGET}.

Meeting the TOR for Tilefish

1. Characterize the commercial catch including landings, effort and discards. Characterize recreational landings. Evaluate utility of study fleet results as improved measures of CPUE.

The panel found that the working group addressed this TOR well. Commercial landings time series were presented spanning the period 1915 to 2008. Effort data were available from three sources (the Turner series, the weighout series and VTR series) spanning the period from 1973 to 2008. Landings are provided by size category. Recent observer data appear to indicate that the discarding is low. Recreational landings also appear to be low.

The panel approved of the results of the study fleet evaluation. The results showed that the current method of estimating effort (days absent - number of trips) does correlate well with effort measured in this study, but that other factors such as number of hooks and potentially location are possible explanatory variables that might improve the CPUE index in the future. Set-by-set geo-referencing is not currently available for analysis in the CPUE data. An industry representative suggested that the size of tilefish that were caught depended in part on where fishing takes place, an issue that could be addressed using the study fleet data if this program was continued in the future.

The working group also pointed out that the data could be improved if inconsistencies in the dealer, VTR and IVR reported landings, as well as inconsistencies in the market category designation among fishing ports, were addressed in the future. The panel agreed with the working group that the current data were sufficient for this assessment, but that addressing these inconsistencies could lead to improved future assessments.

2. Estimate fishing mortality and total stock biomass for the current year, and for previous years if possible, and characterize the uncertainty of those estimates. Incorporate results of new age and growth studies.

This TOR was met by the working group. Two models were used to evaluate fishing mortality and total stock biomass for the current year, a surplus production model (ASPIC) and a statistical, age-and-length-structured model fit to the LPUE and length-frequency data (SCALE). Results of new age and growth studies were incorporated into the SCALE model. These two models gave conflicting results, in part due to a rapid increase in the LPUE index, followed by a rapid decrease in recent years. The rapid rise and fall in the LPUE index, combined with the length frequency data, appeared to indicate the presence of one or two large cohorts moving through the fishable portion of the stock. As pointed out by the working group, neither model provided an ideal fit to the data: the ASPIC model was not able to track the changing LPUE very well, whereas the SCALE model did not provide plausible estimates of fishing mortality in the late 1990s (possibly due to a change in fishing practices, productivity or fishery selectivity). Uncertainty in the ASPIC model was evaluated by starting the model at different proportions of K, the carrying capacity, and by bootstrapping to obtain cumulative density functions for model parameter estimates for the preferred model run.

The panel agreed with the working group that ASPIC did a better job of characterizing the long-term productivity of the stock than did the SCALE model, and endorsed the working group position that the ASPIC model be used as the basis for this assessment. Notwithstanding this endorsement, both the panel and the working group acknowledged the resulting uncertainties in the estimation of current year's biomass and recent stock trends. While ASPIC showed a recent increase in abundance, the LPUE index shows a decline consistent with the passage of a strong cohort through the stock, which is consistent with the recent length-frequency data. ASPIC is not able to accurately track this type of dynamic, and as pointed out by the working group, may be overestimating biomass over the last few years. This leads to uncertainty about whether the stock has rebuilt (see below).

The panel was pleased with the development of the SCALE model and thought, if periodic large cohorts significantly contributed to total abundance, that an age-structured model has the potential to better estimate current year biomass than a surplus production model. The panel provided suggestions on model modifications that could potentially improve model performance, including the use of a dome-shaped selectivity curve, more fully specifying the likelihoods and the addition of residual plots to aid in model diagnostics. These and other suggestions are expanded upon in the individual reviewer reports. A key question is the extent to which changes in the length-frequency data are due to increased fishing (unlikely, given that the fishing mortality estimates provided by SCALE are implausibly high), productivity changes or changes in fishing practices. This question could be addressed, in part, through continued development of the study fleet project, hopefully leading to improved CPUE data in future years.

3. Update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and F_{MSY}). Comment on the scientific adequacy of existing and redefined BRPs.

This TOR was adequately met as the working group provided updated yield-per-recruit, spawner-biomass per-recruit (used as MSY proxies), and biomass-based MSY reference points. Estimates of Bmsy increased by 22% over the estimates presented in SAW 41. Although the working group did not comment explicitly on the scientific adequacy of the existing reference points, they did evaluate the uncertainty by providing bootstrap confidence intervals on the BRPs and by evaluating the sensitivity of BRP estimates to simulated data trajectories. The later were achieved by extending the data series used in the estimation process a few more years using assumed values and examining how sensitive the BRP estimates were to these assumed inputs. The analyses showed that the reference points appear to be quite sensitive to relatively small (projected) changes in LPUE.

The panel expressed a preference for the use of F_{MSY} proxies (e.g. $F_{40\%}$) over the biomass-based reference points for tilefish. The concept of B_{MSY} is based on the idea that a population can be maintained near an equilibrium size providing a long-term equilibrium yield. If intermittently-produced, large cohorts (year class effects) are a significant determinant of abundance (as indicated by the analyses presented by the working group), the stock would not be expected to remain at equilibrium. In this case, the fishing mortality based reference points would be expected to be better reference points than those based on equilibrium biomass levels.

4. Evaluate stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).

The panel determined that this TOR was adequately addressed by the working group. The panel agreed with the working group that given the nature of the data, it was not possible to determine with sufficient certainty whether the population had rebuilt to B_{TARGET}. Notwithstanding this uncertainty, the panel agreed with the working group that current biomass is likely above $B_{THRESHOLD}$.

In carrying forward the assessment results to the assessment summary, the working group placed greater emphasis on the ASPIC results than the SCALE model results due in part to the implausibly high fishing mortality rates obtained from the SCALE model during the 1990s. These high estimates appear to result as an artifact from a shift in the commercial length-frequency distribution to smaller sizes from the late 1970s to the 2000s. This shift could also result from changes in selectivity in the fishery. The panel agreed that giving more credence to the ASPIC model was appropriate, but also thought that ASPIC would not be able to track abundance well when abundance was changing as a result of 1 or 2 large cohorts moving through the stock. Additionally, given that the ASPIC model predicted LPUE is well above the observed LPUE in the last few years, the panel agreed with the working group that recent estimates of biomass are likely overestimates, even though the model may provide reasonable estimates of longer-term

productivity. Although the 2008 point biomass estimate from ASPIC is above B_{MSY}, the panel did not believe that the population had recovered because 1) of the previously mentioned over-estimation of recent LPUE, 2) a significant portion (roughly 40-45%) of the bootstrapped 2008 biomass estimates were below B_{MSY}, and 3) if one or two large cohorts are moving through the stock, abundance may continue to decline as they pass out of the stock. This position is consistent with the working group's view that increasing the status quo TAC = 905 mt to the updated MSY = 1868 mt would be risky considering the uncertainty in the assessment and stock status determination.

5. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).

- **a. -Provide numerical short-term projections (2-3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (alternate states of nature).**
- **b. -If possible, comment on the relative probability of the alternate states of nature and on which projections seem most realistic.**
- **c. -For a range of candidate ABCs, compute the probabilities of rebuilding the stock by November 1, 2011.**
- **d. -Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.**

The panel determined that this TOR was met by the working group. Deterministic projections based on both the ASPIC model and SCALE model results were provided as part of the assessment.

Although the panel did not have significant technical issues with the deterministic projections, they did not place a lot of faith in the projections given the uncertainty in the point estimates of 2008 biomass and the uncertainty in the future direction of the LPUE indices. Based on the SCALE model, projections were carried out assuming constant recruitment and two levels of fishing mortality (F = 0.13 and F=0.19). Both projections predicted population increase, although landings in these scenarios would be lower than the present TAC. The ASPIC model projections were highly variable depending on both the assumed future trend in LPUE and to small changes in the magnitude of the assumed future LPUE values. Given these sensitivities and the uncertainty in stock size, the panel agreed with the working group that the projections were useful for displaying the extent of the uncertainty in future stock size, but not for predicting future stock size.

The panel endorses the use of stochastic projections including uncertainty in both present stock size and productivity levels, as well as random variability in future productivity, but did not feel they were required in this assessment given the current uncertainties in deterministic projections.

The panel agreed with the working group that there are scenarios that would result in the stock being classified as "overfished". Under a projection scenario with decreasing CPUE assuming *status quo* landings, the working group concluded that the stock would be estimated to have lower resilience and productivity relative to the current assessment, resulting in a higher estimate of B_{MSY}. Under these conditions, the population would be considered overfished. These analyses, coupled with the influence of periodic large cohorts, the longevity of the species (longer-lived species typically have lower productivity rates) and the capacity of the fishery to capture immature fish, the panel believes the stock is vulnerable to becoming over-fished. This position supports that of the working group that immediate increases in TAC to the current MSY estimates would be risky.

6. Review, evaluate and report on the status of the research recommendations offered in recent SARC reviewed assessments. Identify new research recommendations, including recruitment estimation.

This term of reference was met. The working group evaluated and reported on progress made on research recommendations in recent SARC reviewed assessments, and proposed new research recommendations. The review panel largely endorses these recommendations. In particular, the panel believes that the continued development of the haul-based fishery-dependent LPUE index (the study fleet project) should lead to improved future assessments, particularly if developed in a way that assists in the interpretation of size-frequency changes (whether they are the result of changes in fishing practices or changes in productivity or survival). As recommended in the 2005 SARC 41 review, collection of data on spatial distribution and population size structure would also help address this question. Development of a fishery-based stratified random survey is one way this recommendation could be addressed.

Development of protocols to ensure consistency in dealer, VTR and IVR reports of landings, as well as ensuring consistency of market category designation among ports was recommended by the working group and was considered important by the panel.

The working group considered the development of a forward projecting, catch-length model to be complete (the SCALE model), but greater emphasis was placed on the ASPIC model results in this assessment. The panel encouraged the continued development of a statistical, length-based model based on the belief that a model incorporating some information on age-structure would be better able to track the year-to-year variability inherent in the tilefish data.

The panel also thought that continuing the age and growth study would be beneficial if and when samples from larger/older tilefish became available. These data would help to assess the reliance of the population on individual cohorts (if a wider length-frequency was eventually obtained) and could potentially help with the fit of the SCALE model (if a different growth model resulted from the addition of older animals).

3 Review of the Ocean Quahog Assessment

Ocean quahog are treated as a single stock in US waters from Virginia to Maine. The species occurs from 20-80 m depth in US waters and is almost entirely found in the EEZ. Ocean quahogs are long-lived (50-100 years commonly) and annual natural mortality is assumed to be around 2% (M = 0.02). Growth subsequent to recruitment is slow (0.51-0.77% per year in weight). Sexual maturity is variable, with the smallest mature male at 36 mm and 6 years but others still immature at 8-14 years. Significant recruitment events are regional and infrequent, but small ocean quahogs recorded in survey catches indicate that recruitment occurs at low levels during most years, particularly in northern areas.

The fishery occurs throughout this range except on Georges Bank because of potential toxicity associated with PSP. The fishery has been governed through quotas since 1979. Landings peaked at 22.5 thousand mt meats in 1992 and over recent years have varied between a low of 13.6 thousand mt in 2005 and 18.8 thousand mt in 2003. Provisional landings for 2008 were 15.5 thousand mt, which compares with a quota of 24.19 thousand mt for the EEZ. The fishery is subject to mandatory reporting of landings and effort (trip-level detail at ten-minute squares) available from logbooks. Based on logbook data, fishing effort has shifted from southern areas in the mid-Atlantic Bight to Delmarva and southern New Jersey, with increased effort recently in southern New England which now has the bulk of the landings. The geographical shift of the fishery corresponds with localized depletion in the southern parts of the fishery.

The fishery is managed by ITQ except in Maine waters where it is managed under a state quota. For stock assessments, a delay-difference model is used (KLAMZ), applied to both commercial and survey data. Data from the NEFSC clam survey, 1982-2008, which has been triennial over recent years, provide information on trends in biomass. Estimates of survey dredge efficiency, derived from depletion fishing experiments conducted in collaboration with industry, are used to calculate efficiency-corrected swept area biomass estimates for 1997-2008 surveys, providing information on the absolute scale of biomass. A simple cumulative catch ('VPA') model was also used to estimate biomass and fishing mortality for southern Virginia. Discards are assumed to be zero, based on logbook data, and incidental mortality from dredging assumed to be 5%. New biological reference points are $F_{45\%}$ applied to the exploited stock (i.e. excluding Georges Bank) and $B_{40\%}$ applied to the whole EEZ stock. According to these criteria, the stock is not currently overfished and overfishing is not occurring.

Meeting the TOR for Ocean Quahog

1. Characterize commercial catch including landings, effort, and discards.

The panel agreed that this TOR was completed satisfactorily.

There has been an ITQ fishery since 1980, with mandatory logbooks. There is good compliance with reporting requirements and the quality of landings and effort data is considered high. Landings from the fishery are exclusively commercial. There are no discards, but total removals are estimated using an assumed 5% incidental mortality caused by dredging operations.

Spatial patterns of landings, fishing effort and LPUE are well characterized, showing a northward movement of effort, from the Delmarva and New Jersey regions in the early years of the fishery to Long Island and Southern New England in more recent years as grounds to the south are serially depleted to below economic break-even levels. The most southerly grounds (South Virginia) are considered to be marginal to the main stock area, even at the start of the fishery.

Length-frequency data are available for the commercial data, showing some evidence of recent recruitment in the Long Island region.

2. Estimate fishing mortality, spawning stock biomass, and stock biomass for the current and previous years. Characterize uncertainty of the estimates.

The panel agreed that this TOR was completed satisfactorily, and that the final assessment results provide a scientifically credible basis for decisions about fishery management.

Fishery-independent survey data were an important source of information for the assessment. Twelve NEFSC clam surveys were conducted at approximately 1-3 year intervals since 1982. The panel commended the effort and care taken to determine effective tow distances based on sensor data collected during dredge hauls. Approaches to interpreting sensor data in terms of effective fishing performance were developed in conjunction with an experienced fishing industry engineer. The data highlight acknowledged issues in some surveys, related to pump performance, electrical cables, dredge angles, etc., but the resulting survey estimates are as reliable and validated as is possible given the methodology. Fully adjusted survey data for 1997-2008 were used to generate efficiency-corrected swept-area biomass (ESB) estimates, giving information in the assessment about the scale of biomass. Unadjusted survey estimates, comparable over the entire survey series, 1982-2008, were used to provide information on trend. In a pragmatic sense, this appears to be an effective use of survey data in the assessment, but the Invertebrate Subcommittee is urged to consider the statistical validity of using both adjusted and unadjusted data in the same assessment model.

The ESB estimates depend on correct estimation of the extent of suitable quahog habitat within each region. This is based on the proportion of successful survey tows – a database that accumulates over the surveys. There is potential for underestimation of ESB if a component of quahog habitat exists at 'untowable' locations, but this is unlikely to be a significant source of bias given the low proportions of tows classified as unsuitable within each region (< 10%).

An *ad hoc* 'data borrowing' strategy was used to fill missing strata in the survey data. The panel recognized that this is unlikely to have had a large influence on the survey estimates outside Georges Bank, but data borrowing has the potential to cause some underestimation of uncertainty in the survey estimates when carried forward into stochastic projections and confidence intervals around assessment outcomes. A model-based (GLM) approach would be more satisfactory, obviating the need for explicit gap filling and providing a statistically valid representation of uncertainty. The Invertebrate Subcommittee is urged to adopt a model-based approach in future.

Depletion fishing experiments were used to estimate survey dredge efficiency. The panel commended application of the patch depletion model as the best approach, at the same time noting that estimation of efficiency may depend on assumptions about tow width in relation to the effectiveness with which position is determined. Fifteen depletion experiments have been completed to 2008. The panel accepted use of the median as a robust representation of the central tendency in the set of efficiency estimates. The panel also noted that, given recognized effects of ground type on gear efficiency, there may be scope for stratifying the estimates by ground type in future.

KLAMZ, a delay-difference model, was used to integrate survey and commercial catch data into an overall assessment model framework. The panel agreed that KLAMZ is appropriate as a basis for both assessing status and future population projections. Few parameters are estimated, but the model appears to be sufficient to describe the stock dynamics and it is unlikely that further model complexity could be supported at present. The model does not use data on size composition of commercial or survey catches, but given slow growth and infrequent recruitment it is unlikely that the data would allow tracking of cohorts within the model. Recruitment is crudely (but adequately, given the available information) integrated as a step function for some regions. Likelihood profiles were used to identify 1993 as the change year in each case.

KLAMZ estimates depend on assumptions about natural mortality and catchability. Effects of natural mortality varying above and below the assumed value were considered, but catchability assumptions were not examined. It was assumed that the scaling factor between ESB and stock biomass should be close to unity. Given that the true scaling factor cannot exceed 1, this assumption is effectively precautionary (i.e. biomass would be under- rather than overestimated).

Overall biomass estimates are not sensitive to modeling approach. The sums of KLAMZ model estimates for each region are similar to overall estimates for regions combined, so the overall model is considered satisfactory for projections. The KLAMZ estimates are similar to 'VPA' (simple accounting) estimates for the exploited area. VPA is the only approach possible for Southern Virginia / North Carolina. Biomass estimates were computed for the total stock within the EEZ or for the exploited stock, being the stock in regions other than Georges Bank which is currently closed to fishing owing to concerns about PSP. The assessment does not 'see' quahogs below 50 mm SL owing to selectivity of the commercial and survey dredges. Estimates are given in terms of fishable biomass,

which requires much smaller raising factors for adjustment between survey and fishery selectivity. The panel endorses this approach, but urges that the Invertebrate Subcommittee take care to clearly define and make consistent use of the terms 'exploited', 'exploitable' and 'fishable' biomass, as to whether this refers to selectivity or areas open to the fishery.

Uncertainty around biomass and fishing mortality estimates was obtained by bootstrapping and through the use of the delta method. The panel believes that uncertainty was adequately characterized in the assessment, but recommends further exploration of MCMC approaches and bootstrapping of samples rather than error distributions.

3. Update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and F_{MSY}). Comment on the scientific adequacy of existing and redefined BRPs.

The panel agreed that this TOR was completed satisfactorily in the sense that operationally useful BRPs were produced for biomass and fishing mortality.

Given slow growth and population dynamics, recruitment to the commercially fishable ocean quahog stock in the EEZ is from individuals settled well before the start of the fishery, so that the assessment does not yet show a recruitment response to exploitation. For this reason, BRPs cannot be related to MSY, since a meaningful definition of sustainable fishing for ocean quahogs will not be possible until there is a much longer-term perspective on stock productivity. Such a perspective will not be possible for several decades, but even if available now it is unlikely that conventional MSY reference points would be applicable given slow dynamics and infrequent (decadal level) and spatially variable recruitment events.

An *ad hoc* approach to deriving BRPs was taken, based on pre-fishery biomass levels estimated for 1978. Reference points for fishing mortality were derived based on conventional approaches for long-lived animals (west coast rockfish). There was no strong scientific basis for choosing between $F_{40\%}$ and $F_{50\%}$ and the panel agreed with the Invertebrate Subcommittee that $F_{45\%}$ is a sensible compromise. BRPs based on spawner per recruit considerations are of doubtful applicability to a stock of unknown productivity, but the panel agreed with the pragmatic approach taken by the Invertebrate Subcommittee in deriving an operationally useful value.

The panel endorsed the approach of the Invertebrate Subcommittee in applying the fishing mortality reference point to the exploited portion of the stock only. Application at the whole stock level could theoretically result in extirpation of the stock in the exploited area whilst overall fishing mortality still remained within the reference point level. The panel also agreed that the biomass reference points should be applied to the whole stock, noting that similar approaches had been taken for scallops. There is an arbitrary element to the selection of $B_{THRESHOLD}$, there being no scientific basis for choosing $B_{40\%}$, except

that it is precautionarily above $B_{25\%}$. Given that there is little or no prospect of this threshold being crossed for the stock as a whole (or in the exploited regions) in the foreseeable future, the panel agreed that the approach was satisfactory on the basis of the available information.

4. Evaluate stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).

The panel considered that this TOR was completed satisfactorily and agreed with the conclusion of the Invertebrate Subcommittee that the ocean quahog stock within the EEZ is currently not overfished, nor is overfishing occurring. It should be noted that this conclusion is subject to the caveats given above (see TOR 3) about how meaningful the BRPs can be given stock dynamics and the currently available perspective on stock productivity. The pattern of serial depletion across the stock area calls into question the utility of BRPs applied at a large spatial scale. However, the panel accepts that the pattern of fishing is 'normal' for a sedentary stock of this nature, especially considering that the fishery started at the edge of the species' range.

5. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).

- **a. Provide numerical short-term projections (3-4 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (alternate states of nature).**
- **b. If possible, comment on the relative probability of the alternate states of nature and on which projections seem most realistic.**
- **c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.**

The panel agreed that this TOR was addressed to the extent possible given the available information on ocean quahog biology and dynamics.

Short-term deterministic and stochastic projections were performed based on KLAMZ model outputs. The panel agreed that this was an appropriate approach, consistent with the assessment methodology. Probabilities of exceeding BRPs were examined over an appropriate range of fishing scenarios. Alternate states of nature were considered by conducting projections using levels of natural mortality that were both higher and lower than the assumed value, but it was not possible to comment on the relative probabilities of these alternate states. The panel agreed with the Invertebrate Subcommittee's view that the ocean quahog stock in the EEZ is vulnerable to overfishing by virtue of its unproductive nature, but that this is unlikely to be an issue in the foreseeable future given the cap in the FMP and the small size of the fishing fleet.

6. Review, evaluate and report on the status of SARC/Working Group research recommendations listed in recent SARC reviewed assessments. Identify new research recommendations.

The panel agreed that this TOR was completed satisfactorily.

The Invertebrate Subcommittee reviewed progress against 17 research recommendations emanating from SARC 44. Ten of these were completed in full. One recommendation concerning 1989 surveys on Georges Bank was considered no longer relevant. The panel accepts this view. A recommendation concerning a model-based approach to filling survey data gaps was not addressed. As noted under TOR 2 (see above), the panel accepts that this is unlikely to have had a major effect on the assessment outcomes, but urges that this recommendation be carried forward into the future. The panel notes that the model-based approach has already been adopted for the surf clam survey. Improved estimates of biological parameters were not obtained. As already suggested by the Invertebrate Subcommittee, this recommendation should also be carried forward. A review of the assumed value of natural mortality ($M = 0.02$) was not attempted, although other possible values were considered in the assessment. The panel accepts that the current appreciation of stock status in relation to BRPs is robust to this assumed value. However, given that scale in the assessment outputs is influenced by the chosen value of M, the panel urges that the validity of this assumption be rigorously examined before the next assessment.

A length-structured stock-assessment, using survey and commercial length-frequency data was not attempted. The panel does not consider that this has been a significant limitation for the current assessment. Given that length-structured approaches depend on the ability to distinguish and follow year-classes, there may be limited scope to develop such assessment models for ocean quahogs. Whilst encouraging the exploration of length-structured approaches in the future, considering particularly the modeling of recruitment, the panel considers that this work is of relatively low priority.

A recommendation concerning survey and commercial dredge efficiency and selectivity estimates was completed in part. The panel recommends that commercial dredge selectivity for the fleet operating in the EEZ should be estimated and used in the next assessment rather than relying on estimates for dredges used in Iceland. Recommendations concerning future depletion studies were completed in most important respects. The panel agrees that it will be useful to consider the inclusion of dredge selectivity in the Patch model and that potential seasonal variation in dredge efficiency (owing to quahog burying behavior) should be examined.

The panel endorses the list of 22 recommendations for the future drawn up by the Invertebrate Subcommittee, and with their order of priority. These include the unaddressed and partly completed recommendations from SARC 44, noted above. The panel particularly emphasizes the importance of maintaining the continuity of the clam

survey time-series. Ongoing surveys at three-year intervals will be critical for future assessments and for providing the perspective on ocean quahog stock productivity that is necessary for defining sustainable exploitation into the future. *RV Delaware II* is due to be retired from service in the near future, but the groundwork for survey continuity has already been laid through use of *FV Endeavor* in the 2008 depletion experiments.

The panel has two recommendations to add to the list drawn up by the Invertebrate Subcommittee: (i) routine use of box cores during the clam surveys to determine the presence of small quahogs unavailable to the survey dredges – an important question in relation to recruitment processes; (ii) analysis and modeling of the spatial scale and dynamics of ocean quahog recruitment processes – this might include modeling of larval transport in relation to currents, larval duration and location of parent stocks.

4 Review of the Weakfish Assessment

There is a substantial history to the assessment of this stock. Previously used assessment methodologies have been troubled by significant deficiencies, which have not allowed effective management based on their results. As a consequence the technical committee was asked by way of the TORs to provide additional information and analyses, which were presented in the full report to the SARC panel. The work itself was well presented and addressed all the TORs adequately given the available data. However, the way in which the conclusions from the different pieces of work were put together in order to arrive at management recommendations was not always clear. Consequently, there were inconsistencies in the steps leading from the data to the assessment and then on to the projections. However, the management recommendations based on the sum of the work is not sensitive to these inconsistencies as the decline in the stock is very dramatic,. The decline is clearly based on a change in the natural mortality rate in recent years, and is likely further exacerbated by continued significant removals by the commercial and recreational fisheries.

The assessment methodology accepted by the panel was based on relative changes in abundance using an indexed-based approach, resulting in estimates of Z over the time series. To obtain absolute estimates of F the relative estimates were anchored to absolute values in the converged part of the VPA assessed by ADAPT over the period 82-85 when natural mortality estimates of M=0.25 were considered appropriate. Division of the observed catches by the index based abundance estimates then enables the estimation of a time series of natural mortality rates assuming accurate estimation of catches and survey abundances. Results indicate that M is now around 0.75, whilst fishing mortality has dropped to low levels around 0.07 weighted by numbers, although this is not comparable with F levels in the previous ADAPT assessment which represents an age-based average. SSB is estimated to be around 1,330 mt.

Projections for this stock present a very bleak picture, where even under a moratorium of fishing the stock is unlikely to recover rapidly to anywhere near what one could describe as safe biological conditions, although the longer-term outlook is highly dependent on the assumed rate of natural mortality. When natural mortality is high managers have limited options for increasing abundance. Having accepted that natural mortality is variable, the panel felt that equilibrium reference points, particularly those based on fishing mortality do not present a suitable management regime. We do however recognise the need for managers to have some measure of stock status so have tried to provide some basis for biomass reference points. Despite some dependence on model choice and some sensitivity to the exact estimate of natural mortality there is little doubt that the stock is depleted to levels well below any past or presently proposed reference point.

The main uncertainties in the assessment and advice include:

- The assessment assumes a variable natural mortality rate. Although strong supporting evidence of such an effect was provided, and a methodology for

determining the magnitude of the change in mortality, the resulting vector of mortalities is almost entirely dependent on the survey abundance index. The accepted methodology assumes the abundance indices are virtually exact so that bias and variance in the survey has now been subsumed in the mortality vector. Assuming there is still variability in the survey the exact magnitude of the change in mortality remains unknown.

- Discard mortality in the commercial data has been estimated on the basis of by-catch ratios, over the entire period of commercial catches, so that not only are the amounts of discards independent of year class strength, but also dependent on fluctuations in the abundance of other commercially exploited species. ADAPT VPA is likely to find it difficult to interpret year class signals and hence recruitment in the absence of better catch-at-age data at the younger ages.
- The projections for this stock indicate that the stock is unlikely to recover in the near future in the absence of fishing and for that purpose the projections are adequate. However the current assessment and other methods used for projections require further information than that usually used in a forecast if more precise estimates, such as an ABC, were to be required.

The panel considered the final assessment model as representing a valid basis for development of management advice despite the uncertainties, mainly because the state of the stock is so critical. However, future advice, particularly if M were to decline and the stock started to recover, would benefit from further research on these issues.

Meeting the TOR for Weakfish

1. Evaluate biases, precision, uncertainty, and sampling methodology of the commercial and recreational catch (including landings and discards) and effort.

This Term of Reference was completed successfully. The data collection schemes are adequate for estimating the quantity and size/age composition of all significant removals due to commercial and recreational fishing.

Discard estimates for the commercial fleet likely affect the ability of the model to track year class variation.

Some uncertainty exists regarding the release mortality from recreational discards.

2. Evaluate precision, geographical coverage, representation of stock structure, and relative accuracy of the fisheries independent and dependent indices of abundance. Review preliminary work on standardization of abundance indices.

The TOR was completed thoroughly and the panel agreed with the conclusions reached by the technical committee.

All evidence points to the fact that there is some significant structure at levels below that of the stock as currently defined, however the fishery and the fish operate at levels wider than the population structure so that it is not possible to draw representative assessment substructures at this point without further information on the spatial movements of both fish and fishers. The panel agrees with the technical committee that it is most appropriate to deal with the stock as a single unit at this point in time, accepting that mixing is unlikely to be complete in this stock.

The review of indices was substantial, expanding on work done for previous assessments. The results indicate that there are a number of indices that are consistent between each other and their spatial coverage indicates they should be representative of the dynamics of the stock. The panel agreed with both the choice of the indices taken forward into the assessment, as well as reasoning for the exclusion of others.

YOY indices indicated that reproduction was currently not strongly impaired in this stock, despite the very small stock size, but correlation with the older age disaggregated indices was poor in the most recent time period. The technical committee interpreted this as supporting evidence that the mortality of 1+ weakfish had changed in this period and the panel agreed that it is consistent with such a theory.

The final assessment as well as a number of the other assessment models investigated by the technical committee used normalized indices derived by subtracting the mean, dividing by the standard deviation and adding two. This is a common method in correlation analysis and here was employed to weight all indices equally irrespective of the scale of measurement at which they were collected. However, this could prove to be problematic, not because of the scale effect, which will merely alter the estimate of q in the assessment method, but because of the standardization to the scale of the variability, so that a linear decline in abundance by 10% is indistinguishable from linear decline in the abundance by 90%. Clearly the two are not the same if we are talking about the decline in a population.

A part of the assessment and projections was run using the transformed indices in the original assessment report. At the SARC meeting this part was rerun using an untransformed index and in this case it made very little difference and certainly had no impact on the management advice. Future assessments should ensure the use of either raw indices or means standardized indices.

3. Evaluate the ADAPT VPA catch at age modeling methods and the estimates of F, Z, spawning stock biomass, and total abundance of weakfish produced, along with the uncertainty and potential bias of those estimates. Review the severity of retrospective pattern.

ADAPT VPA estimates, including retrospectives were presented to the panel's satisfaction of the completion of the TOR. The panel agreed with the interpretation that the ADAPT VPA model was unsatisfactory for estimating recent trends in F and SSB because of the unrealistically high values of F in the recent period and the retrospective

bias indicated by the model. More detailed presentation and analysis of the diagnostics would have helped the panel considerably in identifying the sources of the conflict in the data, but these were not available during the review.

Using a different vector of M over the time period, derived from the accepted index based approach could not cure the retrospective bias in the ADAPT VPA model, not withstanding the fact that this would have introduced some circularity into the analysis, because the index was also used in the ADAPT VPA. At least part of the reason for this was that the Z's developed from the index model produced n-weighted mortalities, not compatible with the age-based mortalities used in the ADAPT VPA approach.

4. Evaluate the index-based methods and the estimates of F, ages 1+ stock biomass, surplus production, and time-varying natural mortality of weakfish produced, along with the uncertainty of those estimates. Determine whether these techniques could complement or substitute for age-based modeling for management advice.

The technical committee produced a large number of analyses to test for evidence of changes in natural mortality and / or production of the stock on the basis of predation, competition and environment. The quality of the analysis and the multitude of the approaches employed fully satisfied the requirements of this TOR. The production approaches all indicated a change in production in recent years and convinced the panel that a model allowing for some change in M was necessary to explain the observed stock trends compared to models varying in F only. Although, based on very different assumptions all the models indicated productivity had decreased in a very similar pattern over time.

No conclusion could be reached as to which of these models provided the most realistic interpretation of the stock development, but the panel agreed that this not particularly important to the single species management of the stock and decided to base its management advice on the index based approach as it dealt with time varying natural mortality without attributing causality which could lead to spurious future projections dependent on the covariates used in the assessment. This is in line with the views expressed by the technical committee.

The new methodology should be thought of as an interim measure only, as it does not currently allow for a number of important management diagnostics (reference points, F-at-age vectors, recruitment), and more importantly is increasingly susceptible to variability and bias due to changes in the stock dynamics and survey CPUE. In addition, any error in the catch matrix in the converged part of the VPA 82-85 will be compounded in all future assessments should the methodology be applied over longer time periods.

5. Evaluate testing of fishing and additional trophic and environmental covariates and modeling of hypotheses using biomass dynamic models featuring multiple indices blended into a single index with and without a Steele-Henderson (Type III) predator-prey extension. Evaluate biomass dynamic model estimates of F, ages 1+ stock biomass, surplus production, time-varying natural mortality, and biological

reference points along with uncertainty of those estimates. Advise on burden of proof necessary for acceptance of alternatives to constant M and whether these biomass dynamic techniques could complement or substitute for age-based modeling for management advice.

The TOR was completed to the satisfaction of the panel. Although the analysis was conducted in isolation the topics and conclusions and the TOR's themselves largely overlapped with TOR 4-7 so that the panel felt it necessary to treat these as a single TOR to avoid substantial repetition. The panel conclusions are given under TOR 4.

6. Evaluate AIC-based hypothesis testing of fishing and additional predation-competition effects using multi-index biomass dynamic models with and without prey-based, predator-based, or ratio dependent predator-prey extensions. Evaluate biomass dynamic model estimates of F, ages 1+ stock biomass, surplus production, time-varying natural mortality, and biological reference points along with uncertainty of those estimates. Advise on burden of proof necessary for acceptance of alternatives to constant M and whether these biomass dynamic techniques could complement or substitute for age-based modeling for management advice.

The TOR was completed to the satisfaction of the panel. Although the analysis was conducted in isolation the topics and conclusions and the TOR's themselves largely overlapped with TOR 4-7 so that the panel felt it necessary to treat these as a single TOR to avoid substantial repetition. The panel conclusions are given under TOR 4.

7. Review evidence for constant or recent systematic changes in natural mortality, productivity, and/or unreported removals.

The TOR was completed to the satisfaction of the panel. Although the analysis was conducted in isolation the topics and conclusions and the TOR's themselves largely overlapped with TOR 4-7 so that the panel felt it necessary to treat these as a single TOR to avoid substantial repetition. The panel conclusions are given under TOR 4.

8. Estimate biological reference points using equilibrium and non-equilibrium assumptions and evaluate stock status relative to these BRPs.

The technical committee provided a plethora of possible biomass and F reference points based on a variety of the analyses conducted for this assessment and as such satisfied the requirements of the TOR. However the panel in discussion and to a large part in agreement with the technical committee felt that equilibrium reference points as requested in the terms of reference were inappropriate for a stock under non equilibrium conditions with unknown trajectories of time-variant M.

F reference points are particularly meaningless in this scenario and the technical committee's suggestion of the use of Z_{MSY} was found to be lacking any sensible conceptual underpinning. However, the panel recognized that there was a need for managers to have some reference points in order to assess the degree of depletion in this

stock. An interim threshold and target biomass reference points should be considered as SSB 20% and SSB 50% under M=0.25. The rationale is that M=0.25 represents the lowest observed natural mortality and that population growth under such conditions rapidly rebuilds the stock buffering SSB sufficiently to allow the stock to pass through periods of more unfavorable conditions.

Recent levels of M seem to have stabilized around levels of 0.75, which should allow the calculation of new F reference points should this pattern be maintained. At this higher level productivity in the stock will be very low, and the risk to the stock would presumably be much more severe than that usually associated with a B_{MSY} level. This further underlines the difficulty in attempting to manage stocks by equilibrium reference points under time varying conditions.

9. Review stock projections and impacts on the stock under different assumptions of fishing and natural mortality.

The TOR could not be addressed adequately given the accepted assessment methodology chosen by the panel. Nevertheless, a number of projections were provided by the technical committee, which although not wholly satisfactory with regards to the precise estimates of stock and yield trends clearly showed that irrespective of the assumptions as to the cause of the change in mortality, the stock was unlikely to recover to levels where a significant yield could be sustainably removed in the near future, unless natural mortality reverted to the lower levels previously observed in the stock.

10. Make research recommendations for improving data collection and assessment.

The technical committee made good progress on most of the previous research recommendations. Much of this work concentrated on demonstration of time variant mortality, and a wide variety of suggestions why this might be occurring. Having produced some convincing evidence that there are few other explanations for the poor state of the stock and some plausible causes for the increase in mortality, the committee needs now to focus on obtaining more certain estimates of the mortality rate and assuming it continues to fluctuate, some means of predicting likely changes and consequential impacts on the stock. Much of the evidence about cause of the change in M was based on correlations, which can lead to spurious conclusions when the data contain substantial trends. The committee is encouraged to consider the use of time series approaches (e.g. differencing the data series, ARIMA models) when exploring the causes of the change.

One approach is to develop a maximum likelihood-based approach in an age-based assessment, able to take account of the uncertainty in recent M's compared to the magnitude of historic M's. In addition this would allow for a more comprehensive inclusion of the uncertainty of various data sources in the catch matrix, commercial vs recreational, retained vs discarded (avoiding the current problem of determining discard ratios for the whole time series), and contributions of different survey tuning information.

Further important information to any assessment can come from tagging information. This may give an independent estimate of total mortality, as well as provide important information regarding stock structure. The technical committee indicated that they have started to tag weakfish again.

The technical committee should continue to pursue the development of more flexible, forward projecting, statistical catch-at-age models. Even if this does not result in a satisfactory assessment methodology it will allow the technical committee to better understand the conflicts of the data.

5 Bibliography of SAW Materials

Working paper	Title	Authors
A-1	Assessment of Golden tilefish	Southern Demersal Working Group
Appendix 1	An overview of the tilefish data collected through the NEFSC Study Fleet Project	Palmer, Ball, Anderson, Conboy, Moser
Appendix 2	Evaluating shifts in size and age at maturity of Golden tilefish from the Mid-Atlantic Bight	Vidal
Appendix 3	Model Output	Nitschke
A-2	Golden tilefish Assessment Summary Report	Nitschke
A-3	Assessment of Golden tilefish (2005)	Southern Demersal Working Group
A-4	Golden tilefish Assessment Summary Report for 2005	
A-5	SARC 41 Chair's Report to the CIE (2005)	Jones
B-1	Stock Assessment for Ocean quahogs	Invertebrate Subcommittee
B-1a	Ocean quahog Appendix Report	Invertebrate Subcommittee
Appendix 1	Invertebrate Working Group	
Appendix 2	Ocean quahog resources in Maine waters	
Appendix 3	Clam dredge performanc	
Appendix 4	2008 Cooperative Industry Surfclam/Ocean quahog survey	
Appendix 5	Maps of clam survey catches 1980-2008	
Appendix 6	KLAMZ assessment model details	
Appendix 7	West Coast Harvest Policy	
Appendix 8	Updated shell length/meat weight	
B-2	Assessment Summary Report for Ocean quahogs	
B-3	SARC 44 Assessment Report (2005)	Invertebrate Subcommittee
B-4	2006 Ocean quahog Assessment Summary Report	
B-5	SARC 44 Summary Report for CIE (2006)	Jones
B-6	F35% Revisited 10 Years Later	Clark

Working paper	Title	Authors
C-1	Weakfish Stock Assessment Report	ASMFC Weakfish Technical Committee
C1a (App C1-C5) C-1	Weakfish Tech. Committees response to Data Poor Meeting comments	ASMFC Weakfish Technical Committee
Appendix C-2	Proportional Stock Density Indices for Weakfish	
Appendix C-3	SAS-based application of the Harvest Control Model to conduct Weakfish stock projections	
Appendix C-4	Index Standardization	
Appendix C-5	Preferred Run ADAPT Output	
C-2	Weakfish Assessment Summary Report	
C-3	2004 Assessment	
	2006 Assessment	
	Estimating Discards	
	Population Structure	
C-4	Report by the Peer Review Panel for the Northeast Data Poor Stocks Working Group	Miller

6 Statement of Work

(Subtask T007-05, v 22 December 2008)

External Independent Peer Review by the Center for Independent Experts

SARC 48: Tilefish, Ocean quahog, Weakfish Benchmark Stock Assessments

Meeting Date: June 1-4, 2009

Statement of Work (SOW) for CIE Panelists
(including a description of SARC Chairman's duties)

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract to provide external expertise through the Center for Independent Experts (CIE) to conduct impartial and independent peer reviews of NMFS scientific projects. This Statement of Work (SoW) described herein was established by the NMFS Contracting Officer's Technical Representative (COTR) and CIE based on the peer review requirements submitted by NMFS Project Contact. CIE reviewers are selected by the CIE Coordination Team and Steering Committee to conduct the peer review of NMFS science with project specific Terms of Reference (ToRs). Each CIE reviewer shall produce a CIE independent peer review report with specific format and content requirements (**Annex 1**). This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project.

Project Description: The Northeast Regional Stock Assessment Review Committee (SARC) meeting is a formal, multiple-day meeting of stock assessment experts who serve as a panel to peer-review tabled stock assessments and models. The SARC is the cornerstone of the Northeast Stock Assessment Workshop (SAW) process, which includes assessment development (SAW Working Groups or ASMFC technical committees), assessment peer review, public presentations, and document publication.

The SARC48 review panel will be composed of three appointed reviewers from the Center of Independent Experts (CIE), and an independent chair from the Science and Statistics Committee (SSC) of the New England or Mid-Atlantic Fishery Management Council. The panel will convene at the Woods Hole Laboratory of the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts during June 1-4, 2009 to review three assessments (tilefish (*Lopholatilus chamaeleonticeps*), ocean quahog (*Arctica islandica*), and weakfish (*Cynoscion regalis*)). In the days following the review of the assessment, the panel will write the SARC Summary Report and each CIE reviewer will write an individual independent review report. 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**. The summary report format is attached as **Annex 4.**

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein. CIE reviewers shall have working knowledge and recent experience in the application of modern fishery stock assessment models and Biological Reference Points. Expertise should include statistical catch-at-age and catch-at-length models, traditional VPA approaches, delay-difference models, and the implications of spatial harvesting patterns. Experience with comparative studies of these approaches is especially valuable. Reviewers should also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Experience with the biology and population dynamics of species on the agenda would be useful.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Woods Hole, Massachusetts during June 1-4, 2009.

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

The CIE's deliverables shall be provided according to the schedule of milestones listed below**.** The CIE reviewers, along with input and leadership from the SARC Chairman, will write the SARC Summary Report. In addition, each CIE reviewer will write an individual independent review report. These reports will provide peer-review information for a presentation to be made by NOAA Fisheries at meetings of the New England and Mid-Atlantic Fishery Management Councils. The SARC Summary Report shall be an accurate representation of the SARC panel viewpoint on how well each SAW Term of Reference was completed (please refer to Annex 2 for the SAW Terms of Reference).

The three CIE reviewers shall conduct an impartial and independent peer review in accordance with the Terms of Reference (ToR) herein. The three SARC CIE reviewers' duties shall occupy a maximum of 14 days per person (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; and several days following the open meeting to contribute to the SARC Summary Report and to produce the Independent CIE Reports).

Not covered by the CIE, the SARC chair's duties should occupy a maximum of 14 days (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; several days following the open meeting for SARC Summary Report preparation).

Charge to SARC panel

The panel is to determine and write down whether each Term of Reference of the SAW (see Annex 1) was or was not completed successfully during the SARC meeting. To

make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. Where possible, the chair shall identify or facilitate agreement among the reviewers for each Term of Reference of the SAW.

If the panel rejects any of the current Biological Reference Point (BRP) proxies for B_{MSY} and F_{MSY}, the panel should explain why those particular proxies are not suitable and the panel should recommend suitable alternatives. If such alternatives cannot be identified, then the panel should indicate that the existing BRPs are the best available at this time.

Roles and responsibilities

(1) Prior to the meeting
(SARC chair and CIE reviewers)
Review the reports produced by the Working Groups and read background reports.

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, and contact details) 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 information concerning other 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, 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/sponsor.html).

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will attempt to provide the CIE reviewers all necessary background information and reports for the peer review. This will be done by electronic mail or an

FTP site. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review.

(2) During the Open meeting

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToRs can not 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 in the contract SoW. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

(SARC chair)
Act as chairperson, where duties include control of the meeting, coordination of presentations and discussion, making sure all Terms of Reference of the SAW are reviewed, control of document flow, and facilitation of discussion. For the assessment, review both the Assessment Report and the Assessment Summary Report.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to discuss the stock assessment and to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

(SARC CIE reviewers)
For each stock assessment, participate as a peer reviewer in panel discussions on assessment validity, results, recommendations, and conclusions. From a reviewer's point of view, determine whether each Term of Reference of the SAW was completed successfully. Terms of Reference that are completed successfully are likely to serve as a basis for providing scientific advice to management. If a reviewer considers any existing Biological Reference Point proxy to be inappropriate, the reviewer should try to recommend an alternative, should one exist.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

(3) After the Open meeting

(SARC CIE reviewers)
Each CIE reviewer shall prepare an Independent CIE Report (see Annex 1). This report should explain whether each Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified above in the "Charge to SARC panel" statement.

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

During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the Independent CIE Report produced by each reviewer.

The Independent CIE Report can also be used to provide greater detail than the SARC Summary Report on specific Terms of Reference or on additional questions raised during the meeting.

(SARC chair)
The SARC chair shall prepare a document summarizing the background of the work to be conducted as part of the SARC process and summarizing whether the process was adequate to complete the Terms of Reference of the SAW. If appropriate, the chair will include suggestions on how to improve the process. This document will constitute the introduction to the SARC Summary Report.

(SARC chair and CIE reviewers)
The SARC Chair and CIE reviewers will prepare the SARC Summary Report. Each CIE reviewer and the chair will discuss whether they hold similar views on each Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar or a consensual view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this

report. The chair may express the chair's opinion on each Term of Reference of the SAW, either as part of the group opinion, or as a separate minority opinion.

The SARC Summary Report (please see Annex 3 for information on contents) should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, this report should state why that Term of Reference was or was not completed successfully. The Report should also include recommendations that might improve future assessments.

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

The contents of the draft SARC Summary Report will be approved by the CIE reviewers by the end of the SARC Summary Report development process. The SARC chair will complete all final editorial and formatting changes prior to approval of the contents of the draft SARC Summary Report by the CIE reviewers. The SARC chair will then submit the approved SARC Summary Report to the NEFSC contact (i.e., SAW Chairman).

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 will assist the Chair of the panel review meeting with contributions to the Summary Report. CIE reviewers are not required to reach a consensus, and should provide a brief summary of their 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 at the LOCATION and DATES as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Annex 2);
3) No later than REPORT SUBMISSION DATE, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent

Experts," and sent to Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to 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;

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

27 April 2009	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
18 May 2009	NMFS Project Contact will attempt to provide CIE Reviewers the pre-review documents by this date
1-4 June 2009	Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA
4 June 2009	SARC Chair and CIE reviewers work at drafting reports during meeting at Woods Hole, MA, USA
19 June 2009	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
22 June 2009	Draft of SARC Summary Report, reviewed by all CIE reviewers, due to the SARC Chair *
29 June 2009	SARC Chair sends Final SARC Summary Report, approved by CIE reviewers, to NEFSC contact (i.e., SAW Chairman)
2 July 2009	CIE submits CIE independent peer review reports to the COTR
9 July 2009	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

* The SARC Summary Report will not be submitted, reviewed, or approved by the CIE.

The SAW Chairman will assist the SARC chair prior to, during, and after the meeting in ensuring that documents are distributed in a timely fashion.

NEFSC staff and the SAW Chairman will make the final SARC Summary Report available to the public. Staff and the SAW Chairman will also be responsible for production and publication of the collective Working Group papers, which will serve as a SAW Assessment Report.

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule

are not adversely impacted. The SoW and ToRs cannot 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. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@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) each CIE report shall have the format and content in accordance with Annex 1, (2) each 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 notification of 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 approved CIE reports to the NMFS Project Contact and regional Center Director.

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7 Assessment Terms of Reference for SAW/SARC-48, June 1-4, 2009

7.1 *Tilefish*

1. Characterize the commercial catch including landings, effort and discards. Characterize recreational landings. Evaluate utility of study fleet results as improved measures of CPUE.

2. Estimate fishing mortality and total stock biomass for the current year, and for previous years if possible, and characterize the uncertainty of those estimates. Incorporate results of new age and growth studies.

3. Update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and F_{MSY}). Comment on the scientific adequacy of existing and redefined BRPs.

4. Evaluate stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).

5. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (2-3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (alternate states of nature).
    b. If possible, comment on the relative probability of the alternate states of nature and on which projections seem most realistic.
    c. For a range of candidate ABCs, compute the probabilities of rebuilding the stock by November 1, 2011.
    d. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.

6. Review, evaluate and report on the status of the research recommendations offered in recent SARC reviewed assessments. Identify new research recommendations, including recruitment estimation.

7.2 Ocean quahog

1. Characterize commercial catch including landings, effort, and discards.

2. Estimate fishing mortality, spawning stock biomass, and stock biomass for the current and previous years. Characterize uncertainty of the estimates.

3. Update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and F_{MSY}). Comment on the scientific adequacy of existing and redefined BRPs.

4. Evaluate stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).

5. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (3-4 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (alternate states of nature).
    b. If possible, comment on the relative probability of the alternate states of nature and on which projections seem most realistic.
    c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.

6. Review, evaluate and report on the status of SARC/Working Group research recommendations listed in recent SARC reviewed assessments. Identify new research recommendations.

7.3 Weakfish

(Final weakfish TORs approved by Weakfish Management Board 4-24-09)

1. Evaluate biases, precision, uncertainty, and sampling methodology of the commercial and recreational catch (including landings and discards) and effort.

2. Evaluate precision, geographical coverage, representation of stock structure, and relative accuracy of the fisheries independent and dependent indices of abundance. Review preliminary work on standardization of abundance indices.

3. Evaluate the ADAPT VPA catch at age modeling methods and the estimates of F, Z, spawning stock biomass, and total abundance of weakfish produced, along with the uncertainty and potential bias of those estimates. Review the severity of retrospective pattern.

4. Evaluate the index-based methods and the estimates of F, ages 1+ stock biomass, surplus production, and time-varying natural mortality of weakfish produced, along with the uncertainty of those estimates. Determine whether these techniques could complement or substitute for age-based modeling for management advice.

5. Evaluate testing of fishing and additional trophic and environmental covariates and modeling of hypotheses using biomass dynamic models featuring multiple indices blended into a single index with and without a Steele-Henderson (Type III) predator-prey extension. Evaluate biomass dynamic model estimates of F, ages 1+ stock biomass, surplus production, time-varying natural mortality, and biological reference points along with uncertainty of those estimates. Advise on burden of proof necessary for acceptance of alternatives to constant M and whether these biomass dynamic techniques could complement or substitute for age-based modeling for management advice.

6. Evaluate AIC-based hypothesis testing of fishing and additional predation-competition effects using multi-index biomass dynamic models with and without prey-based, predator-based, or ratio dependent predator-prey extensions. Evaluate biomass dynamic model estimates of F, ages 1+ stock biomass, surplus production, time-varying natural mortality, and biological reference points along with uncertainty of those estimates. Advise on burden of proof necessary for acceptance of alternatives to constant M and whether these biomass dynamic techniques could complement or substitute for age-based modeling for management advice.

7. Review evidence for constant or recent systematic changes in natural mortality, productivity, and/or unreported removals.

8. Estimate biological reference points using equilibrium and non-equilibrium assumptions and evaluate stock status relative to these BRPs.

9. Review stock projections and impacts on the stock under different assumptions of fishing and natural mortality.

10. Make research recommendations for improving data collection and assessment.