External Independent Peer Review

Center for Independent Experts

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

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Contents

Executive Summary

- This report is an independent peer review of benchmark assessments for tilefish, ocean quahog and weakfish, presented at the 48th SARC meeting.
- Terms of Reference (TOR) relating to the tilefish assessment were met in all important respects, although it was not possible to provide a single assessment model providing an unequivocal determination of stock biomass and fishing mortality. Commercial fishery data were adequately characterized, but results from a study fleet program indicate that improvements could be made to effort and CPUE measures. At present, there is a lack of fishery independent indices of abundance and recruitment, but there may be scope for the study fleet program to fill this gap in the future.
- A surplus production model (ASPIC) for tilefish provides a good description of long-term productivity, but does not account for short-term dynamics, specifically the passage of strong cohorts through the population. A length-based assessment (SCALE) offers advantages in terms of following cohorts, but provides some unrealistic estimates of fishing mortality. The ASPIC model was selected as the best basis for development of advice on fishery management, but with strong caveats about the overestimation of recent biomass levels. Biological reference points (BRPs) and projections were developed using ASPIC model results on the same basis.
- The assessment indicates that tilefish are neither overfished nor is overfishing occurring. Nevertheless, there are concerns that future stock levels depend strongly on incoming passage of recruits, for which there is currently little evidence. There is also concern about the lack of age diversity in the adult stock. It is concluded that it would be risky to increase the TAC from current *status quo* levels to the newly estimated MSY level.
- TORs were also met in all important respects for the ocean quahog assessment. Catch levels are very well characterized, and there is a survey time-series extending back nearly to the start of the fishery. A delay-difference model (KLAMZ) is applied to commercial and survey data. Unadjusted survey estimates are used to provide information on trend. Survey data for recent years, adjusted for effective tow lengths and converted to efficiency-corrected swept-area biomass (ESB) estimates, are used to provide information on the scale of biomass. Dredge efficiency estimates are derived from depletion experiments and application of the Patch depletion model.
- Recruitment events are infrequent for ocean quahog. Recruitment is included as a step function in KLAMZ model runs for some regions. Similar assessment outcomes are derived from alternative assessments based on simple catch accounting.
- Given the extreme longevity of ocean quahogs, infrequent recruitment, slow growth and generally slow population dynamics, the current assessment provides no perspective on stock productivity. It is likely that some decades will pass before any response to exploitation since the start of the fishery will be apparent in the fishable stock. Consequently, an *ad hoc* approach is taken to deriving operationally useful values for BRPs rather than relying on standard MSY-based approaches. The current perception is that the ocean quahog stock is not overfished and that overfishing is not occurring. This does not take into account the

spatial pattern of serial depletion to below commercial break-even levels in southern parts of the range.

- TORs were met to the extent possible in the weakfish assessment. Weakfish removals consist of harvest and discards from both commercial and recreational fisheries. These appear to be adequately characterized, although there are concerns about estimation of discards.
- An age-based assessment (ADAPT VPA) of the weakfish stock showed strong retrospective patterns which could not be resolved. Comprehensive analyses, including various types of surplus production models, with and without predator-prey extensions and environmental covariates, indicate that there has been a change in productivity of the weakfish stock. The most probable explanation is that natural mortality has increased. It is not possible to ascribe causality to this increase, but various plausible explanations (such as an increased predation pressure) were explored. Recruitment levels to the stock appear to be healthy, but survival to the adult stock is impaired.
- The final weakfish assessment was based on biomass and fishing indices derived from monitoring of the recreational fishery. It was possible to scale these indices to absolute terms by using the converged part of the ADAPT VPA model for early years.
- Equilibrium BRPs are not currently appropriate for the weakfish stock, but it was possible to derive threshold biomass levels. However, even under zero fishing mortality, there is little prospect of the weakfish stock recovering from current low levels until natural mortality returns to background levels.
- Recommendations are made for research to improve the understanding of the biology and dynamics of the assessed stocks and to improve future assessments.

Background

The Northeast Regional Stock Assessment Review Committee (SARC) meeting is a formal meeting of stock assessment experts serving as a panel to peer-review tabled stock assessments and models. This report is an independent peer review of benchmark stock assessments for tilefish, ocean quahog and weakfish presented at the SARC 48 meeting. The SARC panel consisted of a chairman and three reviewers appointed by the Center for Independent Experts (CIE). This report constitutes my own personal review of the assessments. It is designed to be read as a stand-alone document, but there are strong overlaps with the Summary Report of the SARC panel, to which I contributed. The report also contains the Statement of Work for the review (Appendix II), which includes Terms of Reference (TOR) for each assessment and a meeting agenda.

Description of Review Activities

Stock assessment reports and background working papers for SARC 48 (see Appendix I) were made available to the SARC Review Panel on the NEFSC website a month to ten days before the meeting. This allowed sufficient time for reviewers to become familiar with the overall context of the SARC process and with the material to be covered at the meeting. Terms of Reference and a draft agenda were also available before the meeting.

The SARC 48 meeting was held at the Northeast Fisheries Science Center (NEFSC) at Woods Hole, Massachusetts, starting at 10.00 am on Monday 1 June and finishing at 5.00 pm on Thursday 4 June 2009. Stock assessment presentations for tilefish and ocean quahog were made by the lead assessment scientists on Monday 1 June. Questions and comments from the SARC panel were taken during the presentations. The morning of Tuesday 2 June was taken up with follow-ups to the main presentations on tilefish and ocean quahog, with further discussion and presentation of responses to panel requests. Weakfish presentations were made on Tuesday afternoon and followed up on the morning of Wednesday 3 June. The remainder of Wednesday was taken up with drafting of the Assessment Summary Report for each stock. After dealing with some summary table revisions for ocean weakfish and ocean quahog, the SARC panel spent Thursday in drafting SARC summary report sections for each stock. This task was divided between the CIE reviewers: the tilefish summary was drafted by Jamie Gibson, the ocean quahog summary was drafted by Mike Bell and the weakfish summary was drafted by Sven Kupschus. The initial drafts were discussed, amended and agreed among the SARC panel before the close of the meeting. More advanced drafts were prepared by panel members during the two weeks following the meeting and edited into the overall SARC summary report by the SARC Chairman.

Drafting and discussion of the SARC summary report was undertaken in closed session, but all other parts of the meeting were open to other interested parties. Industry representatives, Management Council members and university scientists were present for some of the open sessions.

No consensus among SARC panel members was required or sought, but there was a broad level of agreement about the extent to which the TORs for each assessment were met. Panel members made their views clear during the open sessions, so that the teams responsible for each assessment were aware of the likely conclusions with respect to each TOR.

Summary of Findings

A. 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.*

This TOR was addressed in full.

It was possible to provide a long perspective on the commercial landings data, dating back to 1915. This demonstrates the episodic nature of the fishery for this species, although it was pointed out that the pattern is due in part to low levels of fishing during WWII and to a lack of data for the distant water fleet after the mid-1950s. Longline landings for the 1970s onwards, provided by size category, appear to be well characterized. Although there are some difficulties of interpretation owing to inconsistencies in the reporting of size categories, it does seem possible to track evidence of two strong recruitments through these categories. Recreational fishing is ignored in the current time-series, but landings are likely to be very low (<1% of the total). Discarding appeared to be variable in the pre-1970s trawl fishery. Based on observer data current discard rates appear to be low, but industry representatives indicate that true discard rates may be variable and higher in general.

Three sources of longline effort data were used to cover the period from the early 1970s onward. Effort is represented as days absent for the targeting fleet, from which one day per trip has been subtracted to represent steaming time. Trips targeting tilefish are identified by >74% tilefish in the landings, which appears to be reliable (using >90% would give the same results).

A study fleet evaluation indicated that port sampling gives a reliable indication of the length structure of landings. The days absent effort measure appears to be validated by the study fleet data, but fine-scale information from the electronic logbooks explains much more catch variability and may offer the possibility of improved effort and CPUE metrics for the future.

In conclusion, the commercial fishery data appear to be well characterized, but data from a study fleet indicate that there is scope for improvement in the future. Aside from improved CPUE indices, which provide the only perspectives on stock abundance (there being no fishery-independent data), improved data on discards and greater spatial resolution would be of greatest benefit to the assessment in the future. Continuation of the study fleet program is strongly recommended.

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 to the extent possible given available information and resources, but current stock biomass and fishing mortality were not unequivocally determined.

As in the previous assessment (SARC 41), inferences about stock biomass and fishing mortality were drawn principally from a surplus production model (ASPIC). Strengths of the assessment include:

- ASPIC appears adequate to capture the long-term dynamics and overall productivity of the tilefish stock. Every effort was made to ensure that the assessment was consistent with the approach taken at SARC 41, and that differences were not due to changes in the software.
- Perceptions about stock status at the start of the time-series appear more reliable than free estimates, and the final model used a starting biomass set at one half the carrying capacity. The assessment outcomes were robust to assumptions about starting conditions, different runs providing similar results after the evolution of the stock through the early years of the assessment.
- A statistical age-length model (SCALE) was also fit to the data, incorporating new information on growth and age. By forcing a focus on size structure, this provided an alternative perspective on stock status, giving some corroboration of recent recruitment patterns.

Weaknesses include:

- The ASPIC model does not take account of length-frequency data, and is unable to account for the passage of strong year-classes through the stock. This results in very poor fit to recent CPUE trends. ASPIC does not account for peaks in CPUE in 1997 and 2005. In contrast to the large decline in CPUE seen since 2005, ASPIC describes an increase in stock biomass. The assessment of current status is therefore overoptimistic. Long-term stock dynamics are captured in the sense that ASPIC provides a smooth curve through the CPUE trends, but this is not an adequate description of short-term dynamics.
- The SCALE model provides unrealistic results – estimated *F*s in the late 1990s are unrealistically high. Other concerns about the SCALE assessment are that no recruitment index is available and that the logistic model for selectivity may not be appropriate for the long-line fishery.

In conclusion, the assessment failed to provide an adequate single determination of stock status. Uncertainty in the assessments was effectively characterized as substantial. The current interpretation, based on a synthesis of results from both assessment approaches, is that the ASPIC model provides a useful perspective on average long-term productivity but does not account for the passage of a strong cohort through the stock, evidenced in CPUE data, size categories and the results of SCALE models. The future evolution of the stock depends strongly on the passage of further strong year-classes, and it is very important that the fishery be monitored for signs of incoming recruitments. At least at a qualitative level, and provided that (as emphasized by the Working Group) there are strong caveats to the literal interpretation of the final year stock status indicated in the ASPIC assessment, the overall assessment process provides some basis for the cautious evolution of fishery management advice.

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 completed in full.

Based on the ASPIC assessment, B_{MSY} was revised upwards and F_{MSY} was revised downwards from the previous (SARC 41) values. These values appear to be realistic with respect to long-term productivity, but it is questionable that this type of equilibrium framework is applicable to a stock dominated by irregular large recruitments (c.f. ocean quahog, below). ASPIC was the preferred basic for BRPs, since SCALE provided some implausibly high estimates of fishing mortality.

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

This TOR was completed, although it did not allow an unequivocal determination of relative stock status.

According to the ASPIC-based reference points, the current stock status is that it is not overfished and that overfishing is not occurring. Whilst all SARC panel members agreed with the Working Group in taking this view, it is also recognized that this perception of stock status must be strongly hedged by precautionary concerns. A lack of age-class diversity in the spawning stock means that, even though biomass may exceed threshold levels, this does not provide the same surety of stock safety as when biomass is composed of many year-classes. Clear evidence of incoming year-classes will be needed to provide even short-term surety. There appears to be a strong probability that current tilefish biomass is not above B_{MSY}, even though the point estimate for 2008 is above this level. The SARC panel agreed with the Working Group position that, given the uncertainty in the assessment of stock status, it would be unwise to increase the *status quo* TAC (905 mt) by a factor of two to the updated MSY level (1,868 mt). This also takes account of the assessment context, being that the ASPIC model is probably overoptimistic with respect to current stock status given the cohort signals emerging from CPUE. In all probability, the current stock has not rebuilt in the real sense of the word, both because the ASPIC assessment is overoptimistic and because of concerns about age structure within the stock.

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.*
    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.*

This TOR was met to the extent that the projections were performed. However, uncertainty about current stock status and the BRPs is so large that it is possible to say very little about the future of the stock.

Deterministic projections were performed based on both ASPIC and SCALE models. There were no technical issues with how the projections were performed, but the SARC panel agreed that the projections were not informative about likely future trends. The biggest uncertainty relates to the future trend in CPUE – this depends on whether significant recruitment events occur in the near future, about which little can be judged. Given that projections based on the ASPIC model are starting from a probable overestimate of current stock biomass, the projections provide no real guidance on the likely stock levels over the coming years. Stochastic projections, incorporating uncertainty in recruitment and stock size, would be unlikely to shed further light on future trends based on the current assessment models, but should be considered for future assessments.

The SARC panel agreed with the Working Group's view that the tilefish stock is vulnerable to being classified as 'overfished'. This perception hinges less on the current stock assessment than the facts that tilefish are a long-lived species with intermittent recruitment and that the fishery has the capacity to capture immature fish. Again, this supports the Working Group's view that it would be risky to increase TAC levels above the current *status quo*.

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 TOR was completed in full.

The Working Group reviewed progress against seven recommendations emanating from SARC 41 in 2005 and seven recommendations from a 1999 SSC review. Some of the 1999 recommendations were already addressed by SARC 41. Most of the remaining 1999 recommendations and most of the 2005 recommendations were addressed by SARC 48. Of the partially completed, or unaddressed recommendations, the only important one that should be carried forward concerns hook selectivity. A planned study was not undertaken because funding was rescinded.

The Working Group put forward five new research recommendations, which the SARC panel endorsed. The SARC panel particularly emphasized the importance of continuing the study fleet program to provide indices of abundance and recruitment. Several recommendations may be added to this list:

- Further development of length-based model beyond what has already been achieved using SCALE.
- Continue the age and growth study to include older ages / larger sizes.
- Undertake experimental studies to examine the behavioral basis for catchability and selectivity (this could subsume the recommendation on hook selectivity).
- Collate available information on tilefish reproductive biology and identify research gaps. The aim of this work would be to determine reproductive constraints to successful recruitment.
- Consider spatial processes within the tilefish stock, examining movements in relation to size / age / reproductive status and determining the spatial scale at which population processes occur.

More details of these recommendations are given below.

B. Ocean quahog

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

This TOR was completed in full.

A strength of the assessment is that there has been a system of mandatory logbooks since the start of the fishery in 1980, and compliance with this requirement by the relatively small fleet targeting ocean quahogs appears to be high. Consequently, the landings and effort data are considered to be of high quality. Given that there is no recreational fishery and that discards are effectively zero, there is relatively little uncertainty in the data on total fishery removals, and these are assumed to be known exactly for the analytical assessment (TOR 2). There are two sources of minor uncertainly, the first being the level of incidental mortality inflicted during fishing operations (quahogs killed but not landed). Based on a study by Murawski & Serchuk (1989), an incidental mortality of 5% is assumed. It might be questioned whether this component of mortality is likely to have remained stable for the last 20 years, or whether alterations in gear design or fishing practices may have changed the level of damage inflicted. The second possible uncertainty concerns bycatch of ocean quahogs by the surf clam fishery. Given that mixed landings of surf clams and ocean quahogs are not acceptable, it seems reasonable to suppose that mortality of ocean quahog inflicted by the surf clam fishery is negligible, but this assumption bears watching as surf clams move to deeper water in response to warming.

The commercial catch data are also well characterized in terms of spatial patterns and size composition. Landings, fishing effort and LPUE show strong spatial patterns, clearly demonstrating a northwards movement of the fishery as grounds to the south became serially depleted to below break-even levels. Length-frequency data show little evidence of year-classes within the exploited stock, but there is 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.*

This TOR was completed in full.

The ocean quahog assessment was based on a delay-difference model (KLAMZ) which integrates survey and commercial catch data into an overall assessment framework. As agreed during the review of the previous assessment (SARC 44), KLAMZ is appropriate as a basic for both assessment and projection. Strengths of the assessment include:

- Model simplicity – few parameters are estimated in the analytical assessment, which is both justified and necessary given the available information on stock dynamics. It seems unlikely that further model complexity could be supported on either statistical or biological grounds.
- Little uncertainty about removals quantities – as noted above, the assumption that catches are known exactly seems well justified.
- Good source of fishery-independent data – twelve NEFSC clam surveys, at 1-3 year intervals since 1982, which was shortly after the start of the fishery. This relatively long and spatially comprehensive series provides an excellent overview of temporal and spatial trends within the stock.
- Good fishery-independent information on absolute biomass levels in the stock – efficiency-corrected swept-area biomass (ESB) estimates from the survey series are used to provide information on the scale of biomass in the analytical assessment. The SARC panel praised the efforts taken by the assessment team to ensure that the distances of ground effectively fished during survey tows were accurately determined, this being a crucial component of ESB estimates. Interpretation of sensor data collected during survey dredge hauls has highlighted issues relating to pump performance, electrical cables, dredge angles, etc. in individual tows and in some surveys. In terms of critical examination, and response in preparing and interpreting data, the NEFSC clam surveys are at least equal to any other comparable survey, and it is a strength that this critical examination was done in conjunction with an experienced industry engineer.
- Availability of direct estimates of survey dredge efficiency – 15 depletion fishing experiments were completed to 2008. The database of available efficiency estimates is increasing with each new set of experiments, allowing improved characterization of average levels and uncertainty of survey dredge efficiency. The SARC panel accepted the use of the median estimate as a robust and stable measure of central tendency within the pool of available estimates.
- Use of the Patch model for depletion experiments – this appears to be the best available method of obtaining efficiency estimates. There may be scope for extending the method to include dredge selectivity in future.
- Assessment outcomes do not depend on the assessment method used – similar biomass estimates are obtained whether KLAMZ model outputs are used or whether a simple catch accounting ('VPA') method is used, lending confidence in the reliability of the estimates

- Assessments are undertaken on a region by region basis. Similar results are obtained, whether an overall assessment model is derived for the stock as a whole or the sum of regional assessments is considered. It is a strength that the assessment focus is applied on a regional basis, and a comfort that this provides consistent results with assessment at a stock level.
- The assessment was couched in terms of fishable biomass – this is the biomass unadjusted for dredge selectivity, obviating the need for large raising factors (for the more uncertainly determined biomasses of smaller size-classes) to estimate total biomass. This seems a sensible approach, but care is needed to define and make consistent use of the term 'fishable' (referring to dredge selectivity) as distinct from 'exploited' biomass (referring to the areas open to the fishery).

Weaknesses of the assessment include:

- *Ad hoc* treatment of survey data – a data 'borrowing' strategy was used to fill missing strata in the survey data. Unsampled spatial strata in a given year were filled by using data for the same stratum from previous and/or subsequent surveys. This approach is statistically unsatisfactory and unnecessary given the availability of model-based (GLM) approaches (already applied to the comparable surf clam survey data). A model-based approach would generate usable estimates of overall trends in the data (e.g. using the estimated year effects from a GLM), obviating the need for explicit gap filling. Moreover, a model-based approach would provide a valid representation of statistical uncertainty, whereas the current data borrowing strategy has the potential to under-represent the uncertainty in the survey estimates. This is potentially important, because the uncertainty is carried forward into stochastic projections and confidence intervals around assessment outcomes. It is accepted that the overall assessment outcomes are unlikely to have been strongly influenced by the data borrowing strategy, but it is important to ensure that the best possible methods, giving the most defensible estimates, are used in the future.
- Dependence on estimation of suitable ocean quahog habitat within each region – an important component of the ESB estimates. The extent of suitable ocean quahog habitat is currently estimated using the proportion of successful tows. Similar to the dredge efficiency estimates, this is a database that accumulates over successive surveys. There is potential for underestimation of ESB if a component of quahog exists as a mosaic within 'untowable' locations (similar to scallop grounds). Conversely, if there are repeat tows at adjacent locations in attempt to achieve tow success at a given location, this might result in the opposite bias. Given the low proportions (<10%) classified as unsuitable within each region, this is unlikely to have caused significant assessment biases, but it is suggested that the method of assessing unsuitable habitat be carefully considered for the future.
- Dependence of dredge efficiency on ground type – a single estimate of dredge efficiency is used, whereas it is likely that efficiency differs according to ground type. It was suggested that dredge efficiency during the 2008 depletion experiments might have been high because an underlying peat layer constrained the depth to which quahogs could bury in the sediment. There is potential for bias in the ESB estimates if the ground types covered by the depletion experiments are non-random, or if they are not representative of the proportionality of different ground types within each region. This may not be an issue if ground types are

relatively homogeneous across the overall stock area, such that variation in efficiency estimates is due to factors that are random with respect to the overall efficiency of fishing within each region. This is implicitly assumed by using a single population of efficiency estimates, with a single estimate of central tendency. It would be worth exploring the scope (and the need) for stratifying estimates by ground type in future.

- Unadjusted survey estimates are used to represent biomass trends – this is done in order to allow the full time-series of survey data to be used, irrespective of the availability of sensor data to correct for effective tow distance. This procedure seems a sensible way of avoiding discontinuities within the time-series, but it does raise the question of whether the assessment may be biased by the existence of apparent survey trends which are already known to be spurious given the adjustments. The answer to this question is probably that the assessments have not been biased, particularly in the light of the very simple view of stock dynamics necessary within the analytical model. However, it would useful to see some consideration of this issue at least on a qualitative level, whether or not it is possible to include the adjustments formally within the assessment model. This may become increasingly important in future as the time-series of adjusted estimates increases in length in relation to the time-series of unadjusted elements.

- Survey data are used twice in the assessments – first in the form of ESB estimates to provide information on biomass scale, and second in the form of unadjusted estimates to provide information on trend. I accept that, on a pragmatic basis, it may be the most effective use of information to use the same data twice, once adjusted and once unadjusted, to inform on different aspects of the assessment outcomes, but there may be statistical issues with such a procedure. It would be worth exploring this in a simulation context, which might also inform on statistically more efficient ways of dealing with the available information content.

- Recruitment is crudely integrated in the assessments. This is a weakness only in the sense that limited information is available to include recruitment patterns in the assessments – it is not a failing of the approach taken to assessment. Anything less crude is unlikely to be possible given the apparent infrequency of recruitment events in ocean quahogs and the lack of contrast in the length-frequency data. Length-frequency data are not included in the assessment, and would be unlikely to add much to the assessment given that slow growth and infrequent recruitment will preclude tracking of cohorts. Likelihood profiles were used to identify change years for modeling recruitment as a step function for some years. It is recommended that further consideration be given to the incorporation of recruitment in future assessment models, but it is also recognized that more sophisticated approaches may well not be possible or appropriate without further perspectives on ocean quahog productivity that only time can bring (but see recommendation below on surveying pre-recruit ocean quahogs).

In conclusion, the assessment constituted a very effective use of available information on levels and trends of abundance and biomass of ocean quahogs. There is scope for further improvement and refinement of methodology (as reflected in the recommendations below), but there is nothing to suggest that the current assessment is significantly biased or otherwise in error. In my opinion, the results of the assessment provide a scientifically credible basis for developing fishery management advice.

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 completed satisfactorily within the required framework.

The whole concept of BRPs for ocean quahogs is problematic, since no response to exploitation is yet apparent. Slow growth, infrequent (decadal level) and spatially variable recruitment, and overall slow population dynamics mean that there is, as yet, no perspective on stock productivity on the basis of which BRPs could be defined. A quahog expert (Eric Powell) present during the SARC sessions suggested that since the start of the fishery until the present time the fishery has depended upon quahog settlement up to the mid-1950s. This would mean that any recruitment response to fishery depletion of quahogs across the stock area would not be apparent for several decades. A meaningful definition of sustainable fishing of quahogs might have two aims: (i) to ensure sufficient remaining density of sexually mature quahogs on the ground to allow successful fertilization and sufficient production of larvae; and (ii) to optimize the trade-off between growth and natural mortality so as to make the best use (maximum harvest) of available quahog biomass. Nothing is known (to this reviewer) of the first aspect, but it is common to bivalve mollusks that supply of larvae is rarely a limiting issue for recruitment. The second point would point to managing the fishery on a yield per recruit basis, but this is to ignore the potential risks of depleting spawning stocks.

The Invertebrate Subcommittee took a pragmatic, *ad hoc*, view of BRPs for ocean quahogs. Reference points for fishing mortality were derived based on conventional approaches for long-lived animals (west coast rockfish). For reasons given above, spawner per recruit reference points are of doubtful applicability to a stock of unknown productivity, but the use of $F_{45\%}$ (a compromise between arguable alternatives $F_{40\%}$ and $F_{50\%}$) appears to provide an operationally useful value. The value is at least as defensible as any other F reference point, and it is worth pointing out that it has the virtue of being similar to M, which might be another candidate reference point value (and that, under different levels of natural mortality above and below the assumed value, $F_{45\%}$ continues to be close to the chosen value of M). The Invertebrate Subcommittee considered that the F reference point should be applied to the exploited portion of the stock only (i.e. excluding Georges Bank, which is currently closed because of PSP risks). This is sensible, given that application at the whole stock level could, in principle, allow fishing of the exploited stock to extinction, whilst still remaining within reference point levels.

The BRP for biomass was similarly pragmatic. Whilst there are no scientific grounds for choosing a particular threshold level for biomass, on precautionary grounds it is justifiable to choose $B_{40\%}$ as a value greater than $B_{25\%}$. Since there is virtually no prospect of this threshold being crossed, either for the stock as a whole (for which the BRP is proposed) or in the exploited regions, the suggested value is, in addition to being precautionary, a good pragmatic solution in the face of available information.

Whilst I am in full agreement with the conclusion that the TOR was addressed satisfactorily, and that operationally useful BRPs have been produced, I would offer one precautionary note: ocean quahogs are a sedentary stock, and very little appears to be known about the spatial scales over which population dynamic processes occur. If spawning and recruitment processes occur at spatial scales much smaller than that of the stock as a whole, BRPs defined at a large spatial scale may offer relatively little protection across much of the stock area, particularly given the pattern of serial depletion and northwards movement of the population. It is quite likely that stocks depleted to below commercial break-even levels are reproductively viable, but this should not be taken as a given. Fundamental research is needed into recruitment processes in ocean quahogs, yielding insights that are not available from analysis of current commercial and survey data.

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

This TOR was fully completed.

Given the assessment outcomes, and the BRPs derived under TOR 3, the conclusion of the Invertebrate Subcommittee that the ocean quahog stock within the EEZ is currently not overfished, nor is overfishing occurring, is fully justified. This is notwithstanding the caveats about how meaningful BRPs can be given our current knowledge of ocean quahog biology. It is worth stating again that the geographical pattern of serial depletion apparent in the landings, effort and LPUE data is of some concern given the definition of BRPs at a large spatial scale. Despite this concern, this pattern of fishing is probably normal, or at least inevitable, for a sedentary stock of this nature, and it is relevant that the fishery started at the edge of the species' range. Recommendations are given below for fundamental research into ocean quahog recruitment processes.

In conclusion, the Invertebrate Subcommittee's evaluation of stock status in relation to BRPs is as valid as is possible given the current state of knowledge.

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.*

As with the other TORs concerned with BRPs and assessment of stock status, this TOR was completed to the extent possible given the available information on ocean quahog biology and dynamics.

Given that KLAMZ was used as the main assessment model, it was entirely appropriate and consistent to use this as the basis for short-term deterministic and stochastic projections. In my opinion the projections were correctly done, and covered an appropriate and comprehensive range of scenarios. Alternate states of nature, being higher and lower levels of natural mortality than the assumed value, were considered, without it being possible to comment on the likelihood of these alternative states. The Invertebrate Subcommittee took the view that the ocean quahog stock within the EEZ is vulnerable to overfishing by virtue of its unproductive nature. I agree with this appraisal, noting also that overfishing is unlikely to be an issue in the near future given the cap in the FMP and the small size of the fishing fleet.

I conclude that the projections were satisfactorily performed, and that the projection outcomes are likely to be robust to possible uncertainties in the assessment.

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

This TOR was completed in full.

Progress was reported against all 17 research recommendations from SARC 44, when the previous ocean quahog assessment was presented. Ten of the recommendations were completed in full, with outcomes taken forward into the current assessment. With one exception, recommendations not addressed, or completed in part, were added to a list of new recommendations for the future drawn up by the Invertebrate Subcommittee. A recommendation concerning 1989 surveys on Georges Bank was considered no longer relevant. I agree with this assessment.

I agree also with the list of new recommendations and with their rough order of priority. I would highlight in particular:

- the application of a model-based (GLM) approach to addressing survey gaps (see above, and personal recommendations below);
- reconsideration of the assumed value of $M = 0.02$ – in terms of stock status relative to BRPs, the current assessment appears robust to assumptions about M, but given the scale dependence on M of the assessment outcomes, it is worth deriving the best possible value of M given the available information;
- estimation of commercial dredge efficiency and selectivity estimates – this was completed in part, but selectivity estimates in the current assessment depend on results for Icelandic dredges, whereas it would be preferable to have direct estimates for dredges operating in the EEZ;

- depletion studies – recommendations were completed in most important parts, but it will be useful to consider dredge selectivity within the Patch model and potential seasonal variations in dredge efficiency owing to quahog burying behavior.

To the recommendations can be added those given below in this review report. In particular, I would like to emphasize recommendations relating to quahog recruitment processes (modeling and box core sampling). Under this TOR it is also worth emphasizing that the future quality of the assessment, and the ability to provide effective advice for sustainable management of the ocean quahog stock, depends heavily on the continuity of the clam survey series. The current research vessel *RV Delaware II* is due to be retired from service in the near future, but the use of *FV Endeavor* in the 2008 depletion experiments has already laid the groundwork for continuation of the survey. Continuing the triennial frequency of clam surveys is vital to the future of ocean quahog assessments.

C. Weakfish

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

This TOR was completed in full.

Both commercial and recreational fisheries are important for weakfish. The commercial and recreational harvest and discard quantities were adequately characterized by the data collection schemes. Discard mortality was assumed to be 100% in the commercial fishery and 10% in the recreational fishery. There is some uncertainty about the latter figure. There are also issues with the use of a constant discard ratio assumed for commercial catches. 'Smudging' of the year-class structure likely hinders the estimation of year-class strength in the catch-at-age analyses. This may also force rejection of the fishery-independent indices which contain the most important information about recruitment.

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.*

This TOR was completed in full.

A comprehensive review of indices of abundance was undertaken. The panel agreed with the choice of indices taken forward into the assessment, and with the reasons for rejection of other indices. Indices for young fish indicated that reproduction is continuing to occur successfully in the weakfish stock. Low stock sizes appear to result from bottlenecks at a later life-history stage. As suggested by the Technical Committee, this pattern is consistent with an increase in mortality of 1+ weakfish.

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.*

This TOR was successfully completed.

Stock assessment using ADAPT VPA was attempted for weakfish. Severe retrospective patterns were apparent in the assessment outcomes, indicating unresolved conflicts in the data. Without detailed examination of model diagnostics (such as residual patterns) it was not possible to identify the sources of retrospective pattern. The panel agreed that the ADAPT VPA did not provide a satisfactory description of recent trends in fishing mortality and stock biomass, although the converged part of the VPA for earlier years of the assessment provides a good basis for further inference.

This last point was crucial for deriving an index-based assessment for weakfish. I do not agree, however, that the ADAPT VPA provided an adequate description of total mortality in the most recent years of the assessment, independent of the input value of M. Whether the Pope approximation is used, or the Baranov catch equation solved directly, the estimation of Z is inextricably tied up with the chosen value of M. Solution of the catch equation involves reconciling the catch quantity with the population required to produce it, *given* the value of M. Subtraction of (semi-)independent fishing mortality estimates from ADAPT VPA estimates of Z does not produce defensible estimates of M, even if the fishing and total mortality estimates were totally compatible.

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.*

In common with the approach taken in the SARC Summary Report, TOR 4 is considered together with TORs 5-7, all of which were directed towards finding evidence for and sources of changes in natural mortality. Analyses under these TORs were comprehensive and thorough, and I consider that, in combination, these TORs were completed in full.

A large number of analyses were undertaken by the Technical Committee, including several varieties of surplus production (biomass dynamic) models, with and without predator-prey extensions and inclusion of covariates. The results all point to a change in production in recent years, and that this is unlikely to be a result of fishery removals (including unreported ones). The SARC panel accepted that the most likely explanation is an increase in natural mortality. It is not possible to be certain of causality, although plausible hypotheses were examined (e.g. regarding striped bass predation).

An index-based approach was developed, based on indices derived from the recreational fishery. This allowed relative values for biomass and fishing mortality to be calculated, which could be scaled to absolute values under the assumption that the converged part of the ADAPT VPA model provides reliable estimates. The SARC panel accepted this index-based approach as an adequate basis for developing fishery management advice, although it is also recommended that every attempt is made to derive an effective analytical approach in future assessments.

The strengths of the assessment are that a variety of sophisticated analyses were undertaken in an attempt to understand the patterns in the data, and that assumptions and sources of variation were rigorously examined. The weaknesses are that the final analyses are (necessarily) somewhat *ad hoc*, and that causality has not conclusively been determined. This makes it difficult to make any predictions about future stock trajectories.

One aspect of the analyses deserves further comment. The panel expressed concern that abundance indices standardized to zero mean and unit standard deviation (Z-scores) lose any information they may contain about the scaling of trends. Some of the models used an abundance index produced by combining several sets of Z-scores. Further analysis during the meeting demonstrated that, in this case, conclusions about stock trends were not significantly biased by this data treatment. It was recommended that indices should be mean-standardized only. The issue is further explored below.

If index values x_i are proportional to population abundance N_i, then the two quantities are related by

$$x_i = qN_i$$

If the index is then converted to a Z-score x_i*, with the addition of a constant to make all values positive, by

$$x_i^* = \frac{x_i - \bar{x}}{\sigma_x} + k$$

then, by substitution of the second equation into the first, the relationship between the standardized index and the population abundance is

$$x_i^* = \frac{q}{\sigma_x} N_i - \frac{\bar{x}}{\sigma_x} + k \ .$$

This means that the standardized index is no longer proportional to population abundance unless the additive components of the expression sum to zero. Note that the subtracted term in this expression is 1/CV$_x$, which indicates that selection of k = 1/CV$_x$ should preserve the proportionality between the standardized index and population abundance. This does not, however, consider the contributions of sampling error, which may differ between indices indented to be combined into an overall score.

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.

This TOR was successfully completed. See text 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.*

This TOR was successfully completed. See text under TOR 4.

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

This TOR was successfully completed. See text under TOR 4.

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

This TOR was addressed to the extent possible given the available information and the condition of the stock.

The large number of analyses undertaken for this assessment gave rise to an even larger number of candidate BRPs. The panel agreed with the Technical Committee that equilibrium reference points are not appropriate given the probable trend of increasing natural mortality. If M was to stabilize at current levels (considered to be around 0.75) then it would be possible to define F_{MSY}, but there would be a very high risk to exploiting a stock at this low level of productivity.

Biomass reference points were proposed, based on $SSB_{20\%}$ and $SSB_{50\%}$. These appear to be sensible working values, although there is little prospect of their being achieved, even under zero fishing mortality, until M returns to previous low levels.

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

This TOR could not be addressed satisfactorily. Projections were precluded firstly by the absence of a quantitative framework appropriate to the index-based assessment outcomes, and secondly by the absence of an accepted causality for the changes in stock production. However, with or without projections, it is clear that recovery of the stock to levels that could support a fishery will not occur until natural mortality returns to background levels.

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

This TOR was completed in full.

The Technical Committee reviewed and updated the list of research recommendations emanating from the 2008 Weakfish FMP Review, added new recommendations and listed them in order of priority. The SARC panel mostly agreed with the recommendations and with their prioritization.

The SARC did not agree that Ecopath with Ecosim would be a useful model framework for considering species interactions involving weakfish. As currently defined, this framework is not able to deal with prey switches, such as are supposed for striped bass. The panel does agree, however, that it is a priority to understand mortality processes in weakfish, their causalities and how they have changed.

The panel endorses the use of tagging studies to elucidate spatial stock structure. As an additional objective, tagging studies may also be used to estimate natural mortality, although this is dependent on being able to tag and recover substantial numbers of fish.

The panel also endorses the consideration of alternative assessment models, and suggests that flexible statistical catch-at-age models may be useful. Progress in analytical assessments will depend heavily on identifying the causes of retrospective patterns and dealing with this through appropriate model structures and data formulations.

NMFS Review Process

The Statement of Work for CIE reviewers (Appendix II) asks for a critique of the NMFS review process, with suggestions for improvements of both process and products. From a reviewer's point-of-view the process worked extremely well during SARC 48. Strengths that should be emphasized include:

- availability of documentation well in advance of the review meeting;
- effective chairmanship of the review meeting, ensuring that discussions remained on-topic and included the views of all interested parties;
- effective guidance by the SAW chairman, ensuring that the required outcomes of the review were kept in mind;
- early availability during the meeting of presentation material and effective rapporteur reports;
- willingness of assessment scientists to undertake additional analyses when required;
- an atmosphere of scientific rigor coupled with a pragmatic, 'real world' approach to producing required outputs;
- precise terms of reference for the meeting and precisely defined requirements for reviewer outputs.

A number of these strengths are primarily indicative of a constructive attitude among meeting participants, but the existence of well-defined requirements and review structure created the necessary conditions for this to happen.

I cannot identify any real weaknesses to the process, although I could suggest more rigorous vetting of assessment TORs when they fall outside the standard requirements for fisheries management under the Magnusson-Stevens act. The repetitive nature of the weakfish TOR was not conducive to concise, effective presentation of the results of assessments and analyses nor to effective review of their outcomes.

In conclusion, the current review process has the right balance between defining the structure and requirements of the assessment and review and allowing the space for creative science, effective outcomes and constructive discussion. This balance should be carefully considered if changes to the review process are proposed in the future.

Recommendations

Tilefish

- It is strongly recommended that the tilefish study fleet program be continued for the future. This presents the possibility of improved metrics for effort and CPUE. Given that the study fleet monitoring is independent of the standard commercial sampling program, there is the possibility of developing a fishery independent (or at least, quasi-independent) index of abundance, which would greatly enhance the capability to produce reliable stock assessments in the future.
- Given the strongly localized nature of tilefish habitat, the assessment would benefit from improved spatial resolution in the data.
- Uncertainty about tilefish discarding practices may be important given the dependence of the fishery on incoming year-classes. Development of the study fleet program to provide reliable data on discards would enhance future assessments. Sampling of discards may also provide the basis for a recruitment index in the future.
- Further exploration of length-based modeling approaches should be undertaken for tilefish. Flexible model implementations that include selectivity models other than logistic (e.g. dome-shaped) should be considered. Other aspects of length-based modeling that could be explored include: age-based selectivity parameters; constraining the model using a stock-recruitment relationship; treating catch as known exactly, thus reducing the number of parameters to be estimated; examination of residual plots.
- It is recommended that there be experimental field studies of the behavioral basis for catchability and size-selectivity in tilefish. Longline capture requires a behavioral response to the gear which could be affected by inter- and intraspecific interactions, reproductive condition, environmental factors, etc. Any factor that affected burrow emergence behavior is likely to have repercussions for catchability. Reproductive condition and mate seeking behavior may be important in this respect. Fieldwork is likely to involve experimental fishing using longlines, coupled with other sampling techniques (e.g. fine-meshed trawls) to characterize the nature of the underlying population.
- Allied to the previous recommendation, an improved understanding of reproductive biology and behavior may aid the understanding of catchability and population processes. In particular, the spatial scales of reproductive processes may be important determinants of fertilization success (possibilities for sperm- or egg-limitation?) and of the viability of sub-stocks at particular locations.
- Also relevant to the above two recommendations, it is suggested that an improved understanding of spatial processes in tilefish populations would be helpful in determining the conditions for sustainable exploitation. Research gaps should be identified, and appropriate studies (e.g. tagging) be proposed.
- Tilefish age and growth studies should be continued, aiming in particular to improve coverage of older ages / larger sizes.

Ocean quahog

- Consideration should be given as to whether incidental and bycatch mortality levels in the ocean quahog fishery have remained stable. A 1989 study is the basis for the 5% assumed incidental mortality, but might it be possible that alterations in gear design or fishing practices might have changed the levels of incidental mortality? Similarly, given the possibility of greater spatial overlap between surf clam and ocean quahog stocks with warmer water conditions, it would be worth examining the incidence of mixed catch loads, whether these are landed or not.
- It will be important to develop a model-based approach to filling gaps in the ocean quahog survey data. A GLM approach will be useful not only to determine significant spatio-temporal patterns in the survey data, but also to generate measures of relative abundance (e.g. as year effects) and associated uncertainty estimates for use in the assessment and projections.
- It is suggested that the method for estimating the proportions of suitable ocean quahog habitat within a region be revisited. A statistical approach could be developed, based on modeling the probability of successful tows within stations and the probability of a station containing quahog habitat. Collection of acoustic ground discrimination data alongside survey tows might aid in the classification and measurement of suitable habitat.
- Consideration should be given to stratifying survey dredge efficiency estimates by ground type. Some ground-related differences in dredge efficiency are suspected, but it is not clear whether the population of dredge efficiency estimates is representative of the actual efficiency within each region. A first step in an analysis would be to model dredge efficiency estimates in terms of environmental variables (if available) for the locations at which they were measured. If significant amounts of variation can be accounted for in these models, the next step would be to generalize the efficiency estimates to all survey stations, based on the same environmental variables.
- It is recommended that the use of both adjusted and unadjusted survey data in the KLAMZ model for ocean quahogs be examined. Simulation modeling may reveal whether there is potential for biases to be introduced by use of unadjusted estimates and whether this is statistically the most efficient use of available information. This may become increasingly important as the time-series of adjusted survey estimates increases in length. It may be possible to deal with this in an analytical model by treating unadjustable and adjustable (and thus adjusted) estimates separately, with a proportionality constant to link the time series. External analyses may provide informative priors on this factor for use in the main assessment model.
- Investigations should continue into the best ways to include recruitment in the ocean quahog assessment models. It is recognized, however, that progress in these investigations is likely to be limited without additional perspectives on productivity within ocean quahog stocks.
- Fundamental research is needed into the spatial scales at which ocean quahog population dynamic processes occur. This applies particularly to recruitment. Given the apparent infrequency of recruitment events, does this mean that settlement is only occasionally successful, or is there a (density-dependent?) recruitment bottleneck at a later age? Box core sampling in the Maine fishery area revealed the presence of <5 mm ocean quahogs. Similar

box core sampling alongside the regular clam survey across the EEZ would reveal the presence or otherwise of pre-recruit ocean quahogs that are not 'visible' to normal dredge sampling. At a more theoretical level, modeling of larval transport in relation to oceanographic and climatic processes could be very revealing about what are the important sources and sinks for recruitment, and over what spatial scales they occur.

- The validity of the assumed value for natural mortality of ocean quahogs should continue to be reviewed. This is an important determinant of scale in the assessment outcomes.
- Efficiency and selectivity should be estimated for the dredges used in the EEZ, rather than relying on estimates for Icelandic dredges.
- The inclusion of dredge selectivity should be considered for the Patch depletion model.

Weakfish

- Further exploration of methods for estimating quantities and age-structure of commercial weakfish discards is needed.
- Comprehensive model diagnostics from age-based analyses should be examined to determine the data conflicts giving rise to retrospective patterns. It is suggested that forward-projecting statistical catch-at-age models should be investigated. It may be possible to deal with the causes of retrospective patterns through appropriate model formulations within flexible statistical frameworks.
- Standardized indices included in weakfish assessment models should be formulated to preserve the proportionality with stock abundance.
- Tagging studies are proposed to elucidate movement patterns in the weakfish stock. If possible, tagging studies should include as an additional objective the estimation of natural mortality (e.g. see Frusher & Hoenig, 2003). This would only be possible if sufficient numbers of fish could be tagged and recovered.

References

Frusher, S.D. & Hoenig, J.M., 2003. Recent developments in estimating fishing and natural mortality and tag reporting rate of lobsters using multi-year tagging models. *Fisheries Research*, **65**, 379-390.

Murawski, S.A. & Serchuk, F.M., 1989. Mechanized shellfish harvesting and its management: the offshore clam fishery of the eastern United States. pp. 479-506 in: Caddy, J.F. (ed.), *Marine Invertebrate Fisheries: Their Assessment and Management.* Wiley & Sons, Inc., New York.

APPENDIX I: Bibliography of materials provided for review

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	

Working paper	Title	Authors
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
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

APPENDIX II: CIE Statement of Work

Statement of Work for Dr. Michael Bell (ICIT/Heriot-Watt University)

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, 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.

Key Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

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NMFS Project Contact:

Dr. James Weinberg
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Dr. Nancy Thompson, NEFSC Science Director
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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Findings of whether they accept or reject the work that they reviewed, and an explanation of their decisions (strengths, weaknesses of the analyses, etc.) for each ToR, and Conclusions and Recommendations in accordance with the ToRs. For each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the Independent Review Report should state why that Term of Reference was or was not completed successfully. To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice.

a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a concise summary of whether they accept or reject the work that they reviewed, and to explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

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

c. Reviewers should elaborate on any points raised in the SARC 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 proceedings and findings of the meeting, 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 as separate appendices as follows:

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.

ANNEX 2:

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

(file: 4/27/09)

A. 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.

B. 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.

C. 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.

Appendix to the TORs:

Clarification of Terms
used in the SAW/8SARC Terms of Reference

(The text below is from DOC National Standard Guidelines, Federal Register, vol. 74, no. 11, January 16, 2009)

On "Acceptable Biological Catch":

Acceptable biological catch (ABC) is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of [overfishing limit] OFL and any other scientific uncertainty…" *(p. 3208) [In other words, OFL ≥ ABC.]*

ABC for overfished stocks. For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*

NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)

ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, [optimal yield] OY does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

On "Vulnerability":

"Vulnerability. A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Annex 3: Tentative Agenda

48th Northeast Regional Stock Assessment Workshop (SAW 48)
Stock Assessment Review Committee (SARC) Meeting

June 1-4, 2009

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

DRAFT AGENDA* **(version: 4-28-09)**

TOPIC	PRESENTER	SARC LEADER	RAPPORTEUR

Monday, 1 June

10:00 – 10:30 AM
Opening
Welcome — **James Weinberg**, SAW Chairman
Introduction — **Patrick Sullivan**, SARC Chairman
Agenda
Conduct of Meeting

10:30 - Noon	Tilefish Assessment Presentation (A)			
		TBD	**TBD**	**TBD**
Noon – 1:00 PM	Lunch			
1:00 – 2:30 PM	SARC Discussion of Tilefish (A)			
		Patrick Sullivan, SARC Chairman		
2:30 – 3:00 PM	Break			
3:00 - 5:00 PM	Ocean quahog Assessment Presentation (B)			
		Larry Jacobson	**TBD**	**TBD**
5:00 – 6:00 PM	SARC Discussion of Ocean quahog (B)			
		Patrick Sullivan, SARC Chairman		

Tuesday, 2 June

9:00 – 10:15 AM	Revisit Tilefish Assessment with Presenters (A)
10:15 – 10:30 AM	Break
10:30 - Noon	Revisit Ocean Quahog Assessment with Presenters (B)
Noon – 1:00 PM	Lunch
1:00 – 3:45 PM	Weakfish Assessment Presentation (C) **TBD** **TBD** **TBD**
3:45 – 4:00 PM	Break
4:00 – 5:30 PM	SARC Discussion of Weakfish (C) **Patrick Sullivan**, SARC Chairman

Wednesday, 3 June

9:00 – 10:15 AM	Revisit Weakfish Assessment with Presenters (C)
10:15 – 10:30 AM	Break
10:30 - Noon	Tilefish follow up + review Assessment Summary Report (A)
Noon – 1:00 PM	Lunch
1:00 – 3:00 PM	Ocean qua. follow up + review Assessment Summary Report (B)
3:00 – 3:15 PM	Break
3:15 – 5:15 PM	Weakfish follow up + review Assessment Summary Report (C)

Thursday, 4 June

9:00 – 10:15 AM	Final Revisits with presenters, if needed (A, B, C)
10:15 – 10:30 AM	Break
10:30 AM – 5 PM	SARC Report writing. (closed meeting)

*Times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public, except where noted.

ANNEX 4: Contents of SARC Summary Report

1. The main body of the report shall consist of an introduction prepared by the SARC chair that will include the background, a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully.

   To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice. Scientific criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. If the CIE reviewers and SARC chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

   The report may include recommendations on how to improve future assessments.

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

3. The report shall also include the bibliography of all materials provided during the SAW, and any papers cited in the SARC Summary Report, along with a copy of the CIE Statement of Work.

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

APPENDIX III: Review Panel

SARC Chair

Patrick Sullivan
Department of Natural Resources
Cornell University
Ithaca
New York

CIE Reviewers

Michael Bell
International Centre for Island Technology
Heriot-Watt University
Orkney
UK

Jamie Gibson
Department of Fisheries and Oceans
Dartmouth
Canada

Sven Kupschus
The Centre for Environment, Fisheries & Aquaculture Science
Lowestoft
UK