SAW/SARC 55 Working Group
(Gulf of Maine & Georges Bank Cod)
Modeling and Reference Points Meeting
Aquarium Building, S.H. Clark Conference Room, Woods Hole
29 October – 2 November 2012

Introduction

Benchmark assessments of the Gulf of Maine (GOM) and Georges Bank (GB) cod stocks are to be reviewed at the SAW/SARC 55 meeting of 3 – 7 December 2012. The Terms of Reference for this review are at http://www.nefsc.noaa.gov/saw/saw55/SAW-SARC-55-FINAL_TORs-2012-05-30-1.pdf. The last benchmark review of the Gulf of Maine cod assessment was conducted at the SARC 53 meeting of 29 Nov – 2 Dec 2011 while that of Georges Bank Cod was conducted at the GARM III meeting in August 2008. In preparation for the December review, the SAW/SARC 55 Working Group (WG) of the NMFS Northeast Fisheries Science Centre (NEFSC), Woods Hole, conducted a review of data issues during 27 – 31 August 2012, the report of which is at http://www.nefsc.noaa.gov/saw/. The WG is to discuss and formulate the assessment models and reference points for the GOM and GB cod during two meetings:

- Modeling issues: 15 – 19 October 2012
- Modeling and Reference point issues: 29 October – 2 November 2012

This document is the report of the Modeling and Reference Points meeting.

The task of the WG is to prepare a draft Assessment Report and Assessment Summary Report for each stock by 16 November 2012 at the latest. These reports are to address the SAW/SARC 55 TOR, taking into consideration the issues confronting each stock and will be peer reviewed at the December SARC 55.

Models and Reference Points Meetings

A number of issues confront the assessments of Gulf of Maine and Georges Bank cod, some of which are common to both. For GOM cod, these include but not exclusively:

- Implications for use of landings per unit effort (LPUE) and use of offshore NEFSC survey strata
- Fishing fleets to be included in the models
- Treatment of uncertainty in survey calibration coefficients
- Assumptions on flat vs. domed survey and fishery selectivity
- Pre – 1982 assessment data and implications for stock – recruitment relationship and reference points
- Implications for possible changes in natural mortality

For GB cod, a major issue is the source of the strong retrospective pattern observed in past assessments. This possibly implicates some of the following:

- Unreported catch
- Fishing fleets to be included in the models
- Treatment of uncertainty in survey calibration coefficients

- Assumptions on flat vs. domed survey and fishery selectivity
- Assumptions on the stock – recruitment relationship and implications for reference points
- Implications for possible changes in natural mortality

The draft Models and Reference Points meeting agenda is provided in Appendix 1. A number of changes were made to the agenda to meet contingences which arose during the meeting. Particularly, the start of the meeting was postponed to Tuesday morning due to Hurricane Sandy impacting the eastern seaboard of the US.

A list of background documents and working papers considered during the meeting are provided in Table 6. All papers and analyses conducted during WG meetings are preliminary and have no official status with the agency.

The participant list is provided in Table 7.

The reports by the rapporteurs (J. Blaylock, T. Chute, K. Curti, J. Nieland, M. Traver and S. Wigley) greatly assisted the drafting of this report and were much appreciated.

Gulf of Maine Cod

TOR 1: Estimation of Catch

Most of the work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was some discussion during the meeting relevant to this term of reference (TOR).

Uncertainty in the historical landings was discussed, noting that the cod discard estimates of the 1970s shrimp fishery, which predominantly caught age 0 – 2 fish, were based upon the 0.32 discard / kept ratio estimated for 1982 – 88. The WG noted that this was further rationale for the relatively high assumed coefficient of variation (CV) on the catch.

The WG revisited its decision to use the discard mortality estimates from the recent Discard Mortality workshop. It was noted that assuming 100% mortality of discards (as done by SAW 53) moderately improved model fits and reduced the retrospective pattern and was more consistent with tagging studies in which carefully handled cod can experience high (e.g. 50%) mortality within two days of being released. Notwithstanding this, the WG agreed to use the estimates from the Discard Mortality workshop for status determination and projections but to show the impact of the 100% discard mortality estimates on the 2012 spawning stock biomass (SSB) and fishing mortality (F) estimates without bringing these through to reference point and projection estimation.

TOR 2: Survey and Commercial Indices of Abundance

Work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was no further discussion during the meeting relevant to this term of reference (TOR).

TOR 3: Stock Structure

Work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was no further discussion during the meeting relevant to this term of reference (TOR).

TOR 4: Natural Mortality

At the previous WG meeting, it was reported that when natural mortality (M) profiling, using the ASAP model, was conducted on the GOM cod data set restricted to the historical time period, an M of between 0.1 and 0.2 was determined whereas profiling conducted on the more recent time period suggested a higher M (up to 0.6). These profiles were considered consistent with the tagging evidence for M being greater than 0.2 in the 2000s, representing a change in M over the longer term. These M profiles were updated (WP 43) using the three fishery selectivity blocks (1982 – 1988, 1989 – 2004 and 2005 – 2011) agreed to at the previous meeting. Whereas the updated profiles for 1982 – 2002 supported M in the order of 0.1 – 0.2, they no longer clearly supported increased M during 2003 – 2011, with the profile being relatively flat for estimates between 0.1 and 0.6. This change since the last meeting was likely due to the change in fishery selectivity block duration (by two years), highlighting the low discrimination power of the models to estimate M. Support for an M ramp, as formulated at the last meeting, rests primarily on its ability to reduce the retrospective pattern (although it is not as severe in this stock as it is in GB cod) as well as AIC from the SCAA model. The WG noted that the GMRI tagging analysis supported much higher M (0.6) than used in the M ramp model (0.4). Sensitivity runs of the ASAP and SCAA models were conducted using an M of 0.6 during the 2000s. Compared to the model using an M ramped up to 0.6, the fit with M ramped up to 0.4 improved fit by 14 – 35 log likelihood points, depending on the model.

These analyses indicated that while estimation of current spawning stock biomass (SSB) was generally comparable between models with different M options, the bigger issue is the impact of these options on reference point and thus stock status determination. The WG agreed to pursue two M options (M constant and M Change or ramp) as agreed to at the last meeting.

TOR 5: Estimation of Fishing Mortality, Recruitment and Stock Biomass

The WG considered analyses undertaken since the last meeting to resolve outstanding issues. As well, new analyses were considered which dealt with treatment of the retrospective pattern in the current year.

Start Year

The WG considered runs of both the ASAP and SCAA models which explored different starting years. In the case of the former (WP 43), three options (1932, 1963 and 1970) were considered while in the case of the latter (WP 42), six options (1934, 1963, 1964, 1965, 1967, 1970) were considered. Both models used model formulations as agreed to at the last meeting with a few modifications. The ASAP model employed a flat-top fishery selectivity estimated by temporal block, different assumed Fs during the pre-1982 period and internally estimated Beverton and Holt (BH) stock – recruitment relationships (with steepness either free or constrained to 0.84). The SCAA model employed a domed fishery selectivity with a common descending limb of the dome estimated across temporal blocks, and internally estimated Ricker and BH relationships, with steepness freely estimated. Each model series estimated similar 2011 SSB across the range of starting years, but the range of current SSB in the SCAA models (12.5 – 16.0 kt) was higher than that in the ASAP models (about 10.0 kt). The WG discussed the source(s) of this difference, these primarily being 1) fishery selectivity and 2) the impacts of the assumed (Ricker, BH or constant) stock-recruitment functions in 'shrinking' recent estimates of recruitment towards the means indicated by these respective relationships. Further analyses by the WG confirmed that the source of the difference was the stock – recruitment functions.

The WG discussed the merits of including the pre-1982 data in the assessment. It was argued that these data have considerable influence on reference points. Indeed, adding the pre-1982 and even 1970 information was necessary to provide the contrast to be able to fit stock –

recruitment functions. Particularly, it was noted that the poor year-classes estimated in the 1960s, which are associated with relatively high biomass, are based mainly upon age/size information in the 1970s NEFSC surveys. Arguments were made that lack of evidence of strong year classes at these biomasses should not be taken as evidence of absence. While Ricker fits are favoured over BH, the discrimination between the two is not great (two log likelihood points). As well, there were several cases where the steepness parameter (h) hit a boundary. It was also noted that a recent paper (Valpine and Hastings, 2002), through simulation work, indicated that Ricker functions are favoured when BH are true, although the relevance of these simulations was questioned because they were based on a relatively short time period. In response to these issues, it was contested that the models are fitting the data that are available and that these take account of the uncertainties. It was acknowledged that a random effects fitting of internally estimated stock – recruitment relationships may be more appropriate but this is beyond the capacity of current ASAP and SCAA formulations and is more appropriately a research recommendation.

It was noted that Ricker and BH models provide significantly different estimates of virgin biomass (K) with this ranging 70 – 260 kt depending on the model. It was argued that Alexander et al. (2009) estimates of landings of 60 – 80 kt during the 1860 - 1880s are inconsistent with the lower Ks produced by the Ricker relationship. On the other hand, these historical estimates are highly uncertain and there may have been broader changes to the ecosystem in the interim.

These alternate perspectives on the historical information content could not be resolved. It was agreed that two modeling options (long-term starting in 1932 and short-term starting in 1982) would be pursued to explore the consequences of these perspective for current status and reference points.

Biomass vs. Numbers Aggregate Indices

The ASAP model was run using both aggregate survey biomass and numbers. It was noted that the formulation used at the last meeting employed Rivard method – derived weights at age rather than those observed on the survey. When the latter were used, the model results using biomass and numbers were the same, with those using numbers being associated with marginally lower CVs. Given these findings, the WG agreed that further formulations use aggregate survey numbers.

Fishery Selectivities

As noted above, the ASAP and SCAA formulations used different fishery selectivity assumptions which could have been a reason for different estimated current year SSB. Runs of the ASAP formulations indicated that there no statistical basis to choose a dome over a flat-top and stock trends were the same. It was noted that during GARM III, the principle was adopted that a flat-top should be assumed unless there was evidence for a dome. Tagging analyses considered at that time indicated that flat-top relationships were to be expected. The WG discussed other processes which could explain a dome or a flat top (e.g. gear mix) but there were no specific explanations for a dome. In response, it was noted that the SCAA models favoured domes although over-parameterization could be an issue. The SCAA models were rerun with the flat-top selectivities from the ASAP models to see how this assumption is influencing the difference between the two formulations. These runs confirmed that use of a flat top fishery selectivity was not consequential to the difference and thus the WG agreed that further formulations would use flat top fishery selectivity relationships.

Retrospective Adjustment

The WG discussed criteria to judge when to adjust for a retrospective pattern. It was mentioned that there are no firm guidelines on when to (or not) adjust for a retrospective pattern. There was however WG agreement to always adjust for a consistent retrospective pattern and to do this on the numbers at age.

The ASAP model presented retrospective patterns based upon five year peels. It appeared that the retrospective pattern was transient with a one year peel showing no bias although there could be an issue with ages one – three. The WG discussed the utility of plotting Mohn`s rho against peel number and using the slope of the relationship to provide the correction factor to take account of a trend to the retrospective pattern. However, it was noted that the points are not independent; there is also a need to consider different weightings on the different years, with perhaps more weight given to the more recent time period.

The WG could not immediately agree on general criteria to adjust for the retrospective pattern, noting that this is a broader issue than GOM cod to address. It agreed that further formulations not adjust for the retrospective pattern given that the retrospective pattern is small, it may be reducing towards zero and that SAW 53 made no retrospective adjustment.

TOR 6: Reference Points

The WG considered reference points (RPs) associated with the ASAP and SCAA models. For the former, it was agreed that the data for 1982 – 2011 were not compelling regarding a relationship between stock and recruitment. Indeed, models for this time period did not admit adequate estimation of analytically derived estimates of B_{MSY} and associated RPs, so that a proxy approach was employed. The yield per recruit analysis for these proxies used long-term average maturity at age, M for 2003 – 2011 and average fishery selectivity 2005 – 2011. SAW 53 used $F_{40\%}$ as a proxy for F_{MSY}, which was in turn based on discussion during GARM III. An analysis of replacement lines under recent productivity (approximately last 10 years) indicated that for the M = 0.2 option, $F_{40\%}$ (0.18) was still appropriate. When the M was increased to 0.4, the replacement lines became steeper with $F_{40\%}$ rising to 0.44. It was noted that the F_{MSY} proxy for GB cod for the M = 0.4 model was set by the WG at $F_{50\%}$ based upon F_{med} considerations. Recognizing that this is a judgment call, the WG decided that the F_{MSY} proxy for the GOM cod higher M model should be based on $F_{50\%}$ (0.29), consistent with GB cod. While B_{MSY} proxies for $F_{40\%}$ for M = 0.2 were estimated, being in the order of 55kt, these need to be re-estimated using the $F_{50\%}$ for the M = 0.4 model.

A range of SCAA models indicated that analytical B_{MSY} based RPs could not be estimated if the models started in 1982, consistent with the ASAP findings. Both internally and externally estimated RPs gave similar results, with Ricker functions preferred, although as noted above, the discrimination is not great. When steepness was estimated, an upper bound on steepness was hit for the BH model in some cases. Overall, as information back in time from 1969 to 1963 was added to the models, the CVs on the RPs declined and the shape of the Ricker relationships changed. This raised discussion on the information content in the historical data, as reported under TOR 5.

TOR 7: Evaluation of Stock Status

The WG noted that during the Models and RPs WG meetings, many of the detailed differences between the ASAP and SCAA models had been resolved. The issues that remained were the information content in the pre-1982 data, which had implications for whether or not a Ricker or BH stock – recruitment relationship was favoured, and the choice of M. Four options were formulated by the WG:

- Long – term (1932 – present) with both M constant (M = 0.2 and with no retrospective adjustment) and M change (M ramping up to 0.4) options with Ricker function fit internally; the WG noted that a BH function should also be fit to confirm that it produced comparable results
- Short – term (1982 – present) with both M constant (M = 0.2 and with no retrospective adjustment) and M change (M ramping up to 0.4) options; note that the M = 0.2 option is most similar to the SAW 53 formulation; it was agreed that RPs associated with these options would be based upon the F_{MSY} proxies (see TOR 6).

The WG could not reach consensus on which model should be preferred but agreed that the 'newly proposed model' of TOR 7 should be that of each lead scientist. Notwithstanding this, it concurred that lack of consensus should not be interpreted as implying equal support for each option and developed pros and cons of the key features of each option which indicate their level of support (Table 1).

Table 1. Pros and Cons of key features of the GOM cod model options developed by the SAW 55 WG

<u>M Constant (base)</u>

Pros
- None identified (but see Cons to M Change)

Cons
- Presence of retrospective pattern

<u>M Change</u>
Pros
- Reduced retrospective pattern
- Objective function value lowest for M change (by 8-10 log-likelihood points compared to Base M 0.2, depending on the model)
- M is consistent with GMRI tagging data with 50% reporting rate (2003-2006); An M > 0.4 was suggested by Miller analysis (WP 31)
- There is evidence in 4X for increased M (tagging data and peer-reviewed assessment (model-driven))

Cons
- Diet composition data (from U.S. waters - Jason Link) do not support a ramp in M
- Flat M profiles (for 2003-2011 with M = 0.1 through 0.6); Likelihood profile based on the particular year where it was split
- Conditions in 4X may not apply to GOM (tagging data)
- Earlier tagging studies did not incorporate movement, but the later tagging studies did. Due to differing assumptions, the M's from these studies should not be compared
- No change in maturity-at-age, suggesting no change in mortality
- The meta-analysis (life history relationships) suggest M = 0.2 without a trend over time
- If reporting rate < 50% on high reward tags, then M would be less than 0.4

<u>Long-term (1932 – present)</u>
Pros

- Survey age data from 1970 provides information on recruitment strength in the late 1960s. Catch at length information is used from the 1963-1969 survey data
- The estimation process has explicitly taken into account agreed levels of catch uncertainty
- Alternative assumptions about commercial selectivities (pre-1982) make minimal differences to reference point estimates
- Sensitivity analyses (e.g. catch CVs) did not indicate qualitative differences in reference points
- There is a preference for Ricker over BH and moreover, for stronger domes than Ricker
- Ricker-derived SSBmsy estimate is reasonably precise (CV =~0.15); SSB_{2011} is more precise when the B-H model is used
- Evidence for cannibalism has been seen in some cod populations; but there has been no evidence found for post-larval cannibalism in cod populations in the GOM or Georges Bank.
- Estimates of SSBmsy are facilitated by using longer time series showing greater contrast
- Direct estimates avoid the use of proxies for SSBmsy

Cons

- The model selection rests on a time period (60s) where there is no age composition and fishery data are most uncertain
- There is no difference between the Ricker and BH models and the fits to data; Objective functions are identical.
- Spawning biomass and recruitment was the same from 1970 to present for both models; the 1960s information provided a basis for the spawner/recruitment relationships, however the models differ because there was no age composition data available in the 1960s
- The 1960s aggregate survey indices contain age zero fish which cannot be broken out, but biomass indices in which these numbers play a lesser role produce qualitatively similar results
- Simulation studies have indicated a propensity to fit S/R domes even when there is a flat top; however the results of simulation studies can depend heavily on the scenario simulated (e.g. length of time period considered).
- Ricker- based F_{MSY} is greater than F_{MAX}; however this is a property to be expected given any domed S/R relationship
- From the 1970s forward Fs and catches consistent with Ricker-based F_{MSY} caused SSB declines
- Ricker and BH show all or nearly all positive residuals during the time period of 1977-1987
- A number of issues were discussed during the SAW 55 Data meeting about the data pre-1982 (see meeting report)
- If there have been changes in productivity over time, the F_{MSY} estimate is a weighted average over the whole time series which may not reflect current conditions

<u>Short-term (1982 – present)</u>

Pros

- Very high data density; estimates of survey, commercial and recreational catch-at-age and discards as well as biological information such as maturity and L/W relationships are available
- Biomass and reference points are robust to a wide range of model assumptions and uncertainties

Cons

- Insufficient contrast to estimate S/R relationship, which necessitates use of an F_{MSY} proxy which in turn has uncertainties associated with the choice of the appropriate reference percent spawner per recruit.

TOR 8: Projections

The WG discussed how best to present the projections of the four options. It was agreed that candidate projections at 75% F_{MSY} would be conducted for 2013 – 2015 with catch set according to one option and the consequences of an alternate option (hypothesis of stock conditions) evaluated. The concept is illustrated in Table 2. The stock conditions and RPs of the rows of Table 2 would be those associated with the alternate 'true' hypotheses while the columns of Table 2 would be based upon catch set according to assumed stock conditions and RPs. Each cell of the table would evaluate overfishing and overfished status using the row specific RPs. The WG agreed that plots of catch, SSB and F in each cell would be for 2000 – 2015 to provide historical perspective for the projection period. Further discussion of the table format indicated that it may be better to separate the catch, SSB and F plots into separate rows. Also, it might be better to display hypotheses as columns and catch setting as rows. It was recognized that during the development of this analysis for the SARC 55 meeting, further refinements of the approach would occur.

Table 2. Risk analysis indicating consequences of setting catch during projection period (2013 – 2015) according to one option while an alternate hypothesis may be true; cells of table contain results of projection in which catch is set according to option indicated in column header and status evaluated using stock conditions indicated in row header

	Catch set according to:			
Hypothesis / Stock Conditions 'Truth'	**1932 – present M Constant**	**1932 – present M Change**	**1982 – present M Constant**	**1982 – present M Change**
1932 – present M Constant				
1932 – present M Change		Consequences for Catch, SSB and F status during 2000 – 2015 (plot for each)		
1982 – present M Constant				
1982 – present M Change				

To undertake these analyses, it was agreed that the leads of each ASAP and SCAA model would exchange catch series vectors for the projection period. The 2012 assumed catch will be provided by the NEFSC lead scientist. The results of these projections will be discussed on a teleconference on 13 November 2012.

A few issues were raised (WP 44) with the stock projections using the NEFSC's AGEPRO software. The first issue related to the assumption of the age one recruitment in year t+1, which is either based upon the geometric mean of an assessment's age one estimates during a specified time period or is estimated by the assessment. The second issue related to a difference between projected annual fishing mortalities and realized annual fishing mortalities under a multi-year rebuilding plan. In both cases, it was contested that the AGEPRO projection methodology likely resulted in under-stating variability and uncertainty in projected yield and stock conditions. This issue could not be fully resolved during the meeting. It was requested that the NEFSC examine these issues and report back to the author of WP 44, cced to the WG chair.

This discussion led to an important clarification of the GOM and GB cod stock projections. For both stocks, in the ASAP formulations, it was agreed that the 2012 age one recruitment estimates would be based upon the geometric mean of the 2000 – 2009 assessment model estimates.

TOR 9: Research Recommendations

The WG reviewed the status of previous research recommendations and proposed new ones to address issues raised during the three WG meetings, indicating priorities (High, Medium, Low) as it felt appropriate. Many of these recommendations were felt to be common to both GOM and GB cod. These are indicated as 'General' below.

GARM III

The Panel recommended that historical data be used to hindcast recruitments as far back in time as possible for use in the estimation of reference points and projections.

- Analyses to explore the use of the historical information were undertaken by the WG with the sensitivity of RPs examined.

SAW 53

Examine historical and contemporary estimates of cod catch in the lobster fishery. Preliminary discussions with Maine DMR suggest that the lobster bycatch may be relatively small proportional to other fishery removals.

- Y. Chen (UMaine) and C. Wilson (ME DMR) had been doing work on data collected to date. Work is still in progress and no information was available in time for SARC 55 (Y. Chen pers. comm.).
- Observer coverage of lobster vessels has been allocated for April 2012 – March 2013 to obtain info on bycatch
- The WG considered that this research recommendation needs to be carried forward

The SAW 53 data WG had recommended that consideration be given to inclusion of the inshore strata data when switching to the Bigelow survey time series. Sampling in these strata during both spring and fall surveys has been inconsistent or non-existent, dependent upon the stratum.

- The analysis presented to the WG indicated that inclusion of these inshore strata had minimal influence on the trends in both survey indices. It was thus recommended that these inshore strata be excluded from the SAW 55 analyses.

- When it is judged that the Bigelow time series is long enough to include as a separate series, reconsideration needs to be given to adding these strata back into the survey index

Further pursue the incorporation of the Maine/New Hampshire Inshore Trawl (MENH) Survey in future assessments. The unavailability of age information and short time series have precluded this survey from being used in past assessments. While age structures are currently collected from this survey, they have not been aged.

- While progress has been made on the implementation and analysis of the data collected since the start of this survey in 2000/2001, much still needs to be done. For instance, aging the collected cod otoliths was still considered as a priority.

The SARC 53 Data Working Group suggested exploration of the maturity information collected by the MENH survey to examine agreement with the NEFSC maturity ogives.

- DMR (S DMR pers comm ME S. Sherman ME pers. comm.) provided the maturity info for the MENH data. These data were presented at the SARC 55 data meeting.

Examine the reproductive information collected from the ME/NH survey for the early years (e.g., where Downeast Maine stations were sampled to evaluate whether any of the fish were mature and if it could possibly suggest the presence of a spawning aggregation.

- ME DMR (S. Sherman ME DMR pers. comm.) provided maps of cod ≥ 25 cm broken down in to two time blocks (2001- 2006, 2007-2011). Additionally, maturity data were examined in terms of proportion mature by region. These data were presented at the SARC 55 data meeting.

Examine the impacts of excluding the Commercial LPUE index from the assessment. The Commercial LPUE index exists for the year 1982 – 1993 and is no longer updated. Regulations implemented since 1994 (e.g., trip limits, area closures) limit the utility of a LPUE index that extends beyond these years. Initial modeling to explore this recommendation indicated no impact to the updated VPA and negligible impact to the ASAP base model if the Commercial LPUE index is excluded. The NDMBRPWG therefore decided to drop the Commercial LPUE index from this, and all future assessments of Gulf of Maine cod.

- This recommendation was included in TOR 2 of SAW 55. A number of surveys indicate that the Stellwagen Bank area appears to be a forage 'hot spot' for cod feeding on sand lance. As well, the VTR, observer and VMS information from the commercial fishery indicates that fishing effort since the mid-2000s has become concentrated in this area. As well, over the longer term, there have a number of regulatory changes (e.g. seasonal closures, trip limits, etc) which call into question the utility of commercial LPUE as an index of GOM cod biomass. Based on these concerns, the WG recommended that the commercial LPUE index not be used in the SAW 55 assessment model. This recommendation is consistent with the findings of the recent NEFSC-sponsored LPUE workshop. Given concerns comparable to those of the commercial fishery, the WG recommended that the recreational LPUE index also not be included in the GOM cod assessment model.

Stock definition should be re-assessed. The Panel (SAW 53) recommends that efforts be undertaken to reassess the stock definition for Gulf of Maine cod. Cod is a very population-rich species, and matching the scale of the assessment to the spatial scale of the population dynamics is important to achieve reliable, accurate assessments. Several lines of evidence support this recommendation: 1) The assessment under review presents compelling evidence of a change in the distribution of cod within the current stock area. The Panel was not able to determine whether this is solely a demographic response, but comments made during the SARC indicate that it may also relate to a reduction in the diversity of spawning times and locations; 2) There is compelling historical and contemporary evidence from natural history information and tagging studies of movements across stock boundaries that compromises the integrity of existing stock definitions, and 3) There is a wealth of historical and more recent genetic information of local stock structure and local adaption in cod and in fish populations general at finer spatial scales than previously admitted.

- As indicated under TOR 3, a separate process has been initiated to address this recommendation. The SAW 55 WG reported on the findings of a recent workshop on stock structure which was an element of this initiative

The level, schedule and variability of natural mortality should be evaluated. Currently, the level of fishing mortality, F, estimated in Gulf of Maine cod is substantially higher than the estimated rate of natural mortality, M. However, as managers begin to regulate harvests more effectively, F will decline and approach M. Under such circumstances the accuracy of the assumed M becomes more important. Accordingly, the Panel recommends that efforts be increased to evaluate size-specific, age-specific and inter-annual variation in M be expanded.

- This was considered and reported on under TOR 4 of SAW 55. The SAW 55 WG considered analyses which provide evidence for M greater (up to 0.6) than the currently assumed value of 0.2 during 2003 – 2006. These and other analyses were the basis of the WG's decision to consider an M change model option.

Study of the behavior of fishers in response to changes in the distribution of the stock and to changes in management. There was clear evidence presented in the assessment and at the SARC of changes in the distribution of cod within the stock area. The Panel recommends that research and analyses be conducted to: 1) understand and characterize changes in the distribution of the stock, 2) understand and characterize changes in the distribution of fishing effort and to evaluate the impacts of such changes on the pattern and biological characteristics of removals from the stock and 3) evaluate the potential for changes in the distribution of effort to be associated with changes in the distribution of vulnerability of different components of the stock to fishing mortality.

- As reported under TOR 2, a number of analyses were undertaken to describe GOM cod distributional changes, which particularly since 2006 appear to have been driven by prey (sand lance) spatial processes. The associated changes in commercial and recreational effort distribution, as well as regulatory changes over the longer term, imply that LPUE is no longer a representative index of abundance and led to the WG's decision to exclude these time series from the Base models.

SAW 55 WG

- The tagging analysis of Miller (WP 31) provided evidence of natural mortality greater than 0.4 during 2003 – 2006. Historical tagging data were reported to exist, but there was no comparable analysis to which this could be compared. It would be useful to reconsider historical tagging data using modern analytical methods similar to that in WP 31 to allow comparisons of the estimates of natural and fishing mortality (H)

- Estimates of discard mortality (i.e. post capture mortality), particularly in the recreational fishery, using electronic tags and acoustic arrays would allow confirmation of the currently used estimates (L)

- Studies to provide information on the natural mortality of cod and inferred temporal trends are needed. Specifically, predator population estimates (i.e. pinnepeds) specific to Gulf of Maine/Georges Bank and focused stomach collection and analyses of fish and other predators would assist in evaluating whether or not natural mortality may have changed (H)

- The WG noted that there may be advantages to inclusion of the tagging analysis formally within the stock assessment model. This would allow consideration of the factors affecting tagging estimates of F and M, including age/size based processes. This would be a longer-term project given the complexity of integrating the two analyses (H – General)

- The WG discussed at length the appropriate means to weight the proportions at age data within the ASAP model. The current error assumption (multinomial) assumes that the standardized variance on the proportions at age is constant. Analyses were presented to the WG that indicated that the variance on the proportions at age was not constant and that in order to properly account for this in the model fitting process, it was necessary to employ an age-dependent weighting, as the adjusted log-normal and sqrt(p) SCAA formulations do. While use of the multinomial would not produce biased estimates, it would likely result in the variance being over-estimated. Further, the AIC criterion would not be valid in model selection, although it was countered that the ASAP uses a penalized likelihood. This issue could not be fully resolved by the WG and further work is required to explore the appropriate weighting of the proportions at age data (M - General)

- The WG considered an approach that incorporated the Bigelow/Albatross calibration coefficients within the assessment model. This allowed re-estimation of the coefficients as data on year-classes was updated. While the effect in this assessment was small, the approach has merit and should be considered for incorporation into the ASAP software (M - General)

- The WG considered that exploration of a random errors approach to the internal fitting of stock – recruitment relationships had merit. This would require extensive software changes to ASAP code (M – General)

- The WG recommended that simulations (conditioned on data) of the internal estimation of stock - recruitment functions be used to explore potential bias in the fitting of these relationships (M – General)

Georges Bank Cod

TOR 1: Estimation of Catch

Work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was no further discussion during the meeting relevant to this term of reference (TOR).

TOR 2: Survey and Commercial Indices of Abundance

Work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was little discussion during the meeting relevant to this term of reference (TOR). However, there was a clarification requested when it was noted that a comparison of eastern Georges Bank NEFSC swept area biomass estimates from the 2001 TRAC assessment with those of the total Georges Bank indicated that the former was larger than the latter, which seemed counter-intuitive. Initial explorations could not resolve this issue with some issues identified (i.e. survey strata grouping, age-length key differences, NEFSC and DFO software differences). It was agreed that the NEFSC would interact with the appropriate DFO scientists after the WG meeting to resolve this issue.

TOR 3: Stock Structure

Work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was no further discussion during the meeting relevant to this term of reference (TOR).

TOR 4: Natural Mortality

Work for this term of reference was undertaken at the Data meeting of 27 – 31 August 2012. There was no further discussion during the meeting relevant to this term of reference (TOR).

TOR 5: Estimation of Fishing Mortality, Recruitment and Stock Biomass

The WG considered three GB cod model options, which had been agreed to at the previous WG meeting: M Constant (base with M = 0.2), M Change (M increasing to 0.4 in 2003 – 2011) and Catch Multiplier (recent catch increased by three times). The M Constant model exhibited a large retrospective pattern which the WG agreed needed to be adjusted for. Likelihood profiles of M were updated since the last meeting. The profile of M for 1978 – 2011 was relatively flat up until estimates of 0.5. Profiling of M during 1978 – 2002 indicated a preference for lower Ms (e.g. 0.2). On the other hand, profiling of M during 2003 – 2011 indicated a clear minimum between 0.3 and 0.4 with an improved retrospective pattern produced at M = 0.4. These analyses supported the M change model formulation with an M of 0.2 and 0.4 during 1978 – 1989 and 1990 – 2011 respectively and a ramped M in between.

Runs of the Catch Multiplier model confirmed that this also improved the retrospective pattern although the model total log likelihoods indicated that the M Change model was preferred.

The WG re-considered the evidence for a higher M in recent years. In contrast to the Base and Catch Multiplier models, which imply no stock productivity change, one is implied with a change in M. Thus, the consequences of these models for management are very different. It was noted that during the Data meeting, evidence of increased predation was not present in the foods habit data. Further, while the GMRI analysis (WP 31) suggested M greater than 0.2 during 2003 – 2005, it also indicated that M was lower in 4X than in 5Z. On the other hand, the condition of cod in 4X and on eastern GB has declined. The most recent TRAC assessment of

eastern GB cod considered an option in which the M on older cod has been 0.5 since 1994, based on model fit. Notwithstanding this, TRAC decided to choose RPs assuming that M was 0.2 on the basis that a change in M may be transitory. The WG also discussed the possibility of considering an option in which M would be assumed as 0.6 for the assessment time series although it was felt impractical to pursue in the time available.

Based on these discussions, the WG agreed to continue to pursue two M options (M constant at 0.2 and M Change increasing to 0.4) as well as the Catch Multiplier option.

The WG discussed how best to adjust for the retrospective pattern in the current year. It agreed that the adjustment should be applied and that it should be based on the numbers at age.

TOR 6: Reference Points

The WG considered RP analyses associated with each GB model option. The relationship between stock and recruitment during 1978 did not provide support for use of either a Ricker or BH function. Indeed, the relationship was relatively linear with infinite R_0 and SSB_0 implied. For this reason, the WG agreed that RPs for GB cod continue to be based upon B_{MSY} proxies. For these, the yield per recruit analyses used long-term maturity at age and the last five-year average of fishery selectivity and weights at age. Examination of the stock – recruitment data indicated that the 50 kt breakpoint, as used in the GARM III, was still appropriate.

The stock – recruitment replacement analysis for the M = 0.2 model indicated that 90% of the replacement lines were above $F_{40\%}$ (0.18) and thus that this F_{MSY} proxy was still appropriate. The WG concurred with this choice, noting that this is consistent with the existing RP. Stochastic projections at this F provided a B_{MSY} proxy of 186.6 kt.

A similar set of analysis for the Catch Multiplier option provided an $F_{40\%}$ of 0.18 and a B_{MSY} proxy of 166.2 kt. In this case, there was no evidence of a breakpoint in the stock – recruitment data and thus the stochastic projections sampled from the entire stock – recruit time series.

The situation with the M change model was different. The replacement line analysis indicated that fishing mortality would have to decrease to as low as $F_{80\%}$ (0.07) to ensure adequate replacement. This was due to the constraint imposed by Z. As M increases, F must decrease. The WG considered that this F_{MSY} proxy is likely too low and is inconsistent with commonly used ranges of percent spawner per recruit for RPs and estimates of $SSBmsy/SSB_0$ where these can be obtained for specific stocks or from meta-analyses. It noted that F_{MED} and F_{MEAN} for the 2001 – 2011 stock – recruit data were $F_{40\%}$ and $F_{50\%}$ respectively. The WG agreed to adopt the F50% (0.3) proxy based upon the need for a more conservative approach when M is assumed to be high. The stochastic projections at this F and with a 50 kt breakpoint provided a B_{MSY} proxy of 19.6 kt, considerably below the RPs of the other two models.

TOR 7: Evaluation of Stock Status

Current stock status according to the M Constant (base) and Catch Multiplier models were overfishing and overfished and neither overfishing nor overfished for the M Change model. Current SSB was similar in all models (if the unaccounted catch mortality is considered in the Catch Multiplier model). The difference in these models is the RPs.

As with GOM cod, the WG could not reach consensus on which of the three models should be preferred but agreed that the 'newly proposed model' of TOR 7 should be that of the lead scientist, which in this case in the M constant formulation. It noted that lack of consensus should not be interpreted as implying equal support for each option and developed pros and cons of the key features of each option which indicate their level of support (Table 3). The WG highlighted the importance of these for the SARC review.

Table 3. Pros and Cons of key features of the GB cod model options developed by the SAW 55 WG

<u>M Constant (base)</u>
Pros
- None identified (but see Cons to M Change)

Cons
- Presence of strong retrospective pattern

<u>M Change</u>
Pros
- Resolves retrospective bias
- Objective function value lowest for Ramp M (by 10 log-likelihood points compared to Base M 0.2)
- M is consistent with GMRI tagging data with 50% reporting rate (2003-2006); An M > 0.4 was suggested by Tim Miller's analysis
- There is evidence in 4X for increased M (tagging data and peer-reviewed assessment (model-driven))

Cons
- Diet composition data (from U.S. waters - Jason Link) do not support a ramp in M
- Flat M profiles (for 2004-2011 with M = 0.3 and 0.4); Likelihood profile based on the particular year where it was split
- Conditions in 4X may not apply to Georges Bank (tagging data)
- Earlier tagging studies did not incorporate movement, but the later tagging studies did. Due to differing assumptions, the M's from these studies should not be compared
- Maturity-at-age has increased over the last decade, suggesting a decreasing total mortality. Since F over this period has declined, this trend in maturity potentially suggests a constant M.
- The meta-analysis (life history relationships) suggest M = 0.2-0.3 without a trend over time

<u>Catch Multiplier</u>
Pros
- Resolves retrospective bias
- Unreported discards may have been substantial prior to 2010

Cons
- No evidence of substantial underreported landings
- Objective function value highest for Catch Multiplier (by 29 log-likelihood points compared to Base M 0.2)

TOR 8: Projections

The WG agreed that candidate projections at 75% F_{MSY} would be conducted for 2013 – 2015 with catch set according to one option and the consequences of an alternate option (hypothesis of stock conditions) evaluated, in a similar manner as for GOM cod (Table 4). The 2012 catch is to be determined by the lead scientist. The WG agreed that plots of catch, SSB and

F in each cell would be for 2000 – 2015 to provide historical perspective for the projection period. As with GOM cod, the display of the analyses was expected to change based on further exploration after the WG meeting.

The WG concurred that projected catches be multiplied by three as the mechanism of increased mortality, while unknown, may be due to post capture mortality.

Table 4. Risk analysis indicating consequences of setting catch during projection period (2013 – 2015) according to one option while an alternate hypothesis may be true; cells of table contain results of projection in which catch is set according to option indicated in column header and status evaluated using stock conditions indicated in row header

	Catch set according to:		
Hypothesis/ Stock Conditions 'Truth'	**M Constant (base)**	**M Change**	**Catch Multiplier**
M Constant (base)			
M Change		Consequences for Catch, SSB, F status During 2000 – 2015 (plot for each)	
Catch Multiplier			

TOR 9: Research Recommendations

As noted under GOM cod, the WG reviewed the status of previous research recommendations and proposed new ones to address issues raised during the three WG meetings, indicating priorities (High, Medium, Low) as it felt appropriate. Some of these recommendations were felt to be common to both GOM and GB cod and are indicated as 'General'. One of these is provided below. The rest are provided under TOR 9 of the GOM cod.

GARM III

The Panel recommended that historical data be used to hindcast recruitment estimates as far back in time as possible for use in the estimation of reference points and projections.

- Based upon the SAW 53 analysis on GOM cod, it was considered that taking the assessment back beyond the start of age data was not productive due to issues in the catch information

Continued exploration of retrospective pattern and methods to account for it are critical for this stock.

- Analyses to evaluate the impact of data and model formulations on status and RPs were conducted during SAW 55.

SAW 55 WG

- Canadian discard information is available for its scallop fishery since 1978 while only since 1997 for the groundfish (mostly longline) fishery. There is a lack of observer data for both the mobile and fixed gear fleets prior to 1997. The WG queried whether or not hindcasting of discards could be conducted for 1978 – 1996 in a similar fashion as done for the US fishery. A request was made to the Transboundary Resource Assessment Committee (TRAC) through the US TRAC co-chair (L. O'Brien) to have this analysis undertaken as part of the spring 2013 benchmark assessment of eastern Georges Bank cod. For the SAW 55, the Canadian discards were used as presented. DFO replied that it didn't consider that there is a need to do an analysis of hindcasting prior to 1996.

- On the premise that retrospective bias is likely due to unaccounted for mortality, i.e. unaccounted 'catch' (from natural mortality, fishing mortality, underestimated / unobservable discard mortality) the following is recommended to address the retrospective pattern
    - Conduct 'forensic accounting' analysis of 'missing catch' i.e. lost/unreported VTRs, lost/unreported dealer data, underestimated discards. This would include summarization of such work done to date (re: Wigley, Palmer). Request/require formal involvement of NMFS regional office to further progress on this issue.
    - Require near 100% observer coverage (for 3-5 years) of the fisheries that either target GB cod or have cod as bycatch to ascertain potential underestimation of GB cod discards.
    - Conduct designed discard mortality study of cod that pass through the trawl via trouser trawl experiment, including blood analysis to determine stress levels compared to control group. (H – general)

Preparations for SARC 55 Meeting of 3 – 7 December 2012

Report Drafting

Assessment Summary reports and more detailed Assessment reports are required to be drafted by the WG, for which the drafting assignments were agreed to. The sections of the Assessment Summary Report are as per each TOR. It was recognized that the format of the Assessment Report does not strictly follow the terms of reference and requires interpretation on the appropriate location of the text in the report. Compilation of each report for GOM and GB cod will be undertaken by Palmer and O'Brien respectively, with input from others as indicated below. The final drafts of each report for each stock will be reviewed by the WG chair.

The WG chair will use his discretion to identify background documents and place these on the SAW 55 server.

The WG will convene a teleconference on 13 November 2012 to review progress on report drafting. The WG chair will prepare an agenda for this meeting.

Table 5. Writing assignments for SAW 55 Assessment Summary and Assessment Reports of GOM and GB cod

TOR 1. Landings and discard

Text to be prepared by Palmer and O'Brien

TOR 2. Survey and fishery indices

Text to be prepared by Palmer and O'Brien

TOR 3. Stock structure

Text to be inserted from Data meeting

TOR 4. Natural mortality

Text to be prepared by Palmer and O'Brien with input from Miller

TOR 5. Estimates of fishing mortality, recruitment and stock biomass

For GOM cod, text on the ASAP and SCAA models to be prepared by Palmer and Butterworth. Sensitivity runs are to be included in appendices.

For GB cod, text on the ASAP models to be prepared by O'Brien.

TOR 6. Reference Points

For GOM cod, text on the RPs associated with the ASAP and SCAA model options to be prepared by Palmer and Butterworth.

For GB cod, text on the RPs associated with the ASAP model options to be prepared by O'Brien.

TOR 7. Stock Status

a) Existing Models

For both GOM and GB cod, the existing models are those of SAW 53 and GARM III respectively. Text on the models which were updated as part of the bridging analysis to be prepared by Palmer and O'Brien respectively.

b) Newly proposed Models

For each stock, a suite of models was developed (four for GOM cod and three for GB cod) to explore possible processes consistent with the evidence and / or explaining the retrospective pattern. These models will have been described under TOR 5. The 'newly proposed model' is the preference of the lead scientist of each stock. For GB cod, this is the M constant with a retrospective adjustment model. For GOM cod, these are 1) M constant and 1982 start year and 2) M ramp with 1932 start year. As noted above, the lack of WG consensus does not imply equal support for the alternative models. Each model has associated pros and cons which the WG prepared and which indicates the diversity of support for option.

For GB cod, text on the preferred model and the pros and cons of the options is to be prepared by O'Brien.

For GOM cod, text on the preferred models and the pros and cons of the options is to be prepared by O'Boyle with input from Palmer and Butterworth.

TOR 8. Projections

For each stock, risk analyses will be prepared which describes the consequences of projected catch under competing hypotheses. For GB cod, text on the consequences will be prepared by O'Brien. For GOM cod, text on the consequences will be prepared by O'Boyle with input from Palmer and Butterworth.

This TOR requires a description of each stock's vulnerability. The text for GOM and GB cod will be prepared by Palmer and O'Brien respectively.

TOR 9. Research Recommendations

Text to be prepared by Palmer and O'Brien

Presentations

The WG discussed the presentations for the SARC 55 peer review meeting. An overview of the WG process indicating the key decision points will be provided by the WG chair. The presentation on GB cod will be provided by O'Brien. For GOM cod, the data and ASAP models will be described by Palmer and the SCAA models by Butterworth. These presentations will include the historical performance of the respective models (as per TOR 5). This will be followed by a presentation of the WG chair on a comparison of the SSB, F and recruitment trends of the models, the pros and cons of these models, and risk analysis as per TOR 8.

References

Alexander, K. E., W. B. Leavenworth, J. Courname, A. B. Cooper, S. Claesson, S. Brennan, G. Smith, L. Rains, K. Magness, R. Dunn, T. K. Law, R. Gee, W. J. Bolster, and A. A. Rosenberg. 2009. Gulf of Maine cod in 1861: historical analysis of fishery logbooks, with ecosystem implications. Fish and Fisheries 10: 428-449.

Table 6. List of Working Papers and Background Documents considered at the SAW 55 Reference Points Meeting

WP #	Topic	TOR	Stock	Author	Title
42	Stock Status	7	GOM Cod	Butterworth, Rademeyer	Further Statistical Catch-at-Age Assessment Results together with Biological Reference Point estimates for Gulf of Maine cod, October 2012
43	Stock Status	7	GOM Cod	Palmer	ASAP Assessment Results with Reference Points for Gulf of Maine Cod
44	Projections	8	Both	Neis	Observations on AGEPRO projections
45	Stock estimation	5	GOM Cod	Rademeyer	Flat selectivity runs
46	Reference points	6	GOM Cod	Rademeyer	Ricker vs BH since 1934
47	Stock Status	7	GOM Cod	O'Brien	Georges Bank Cod reference points
48	Status Estimation	5	GOM Cod	Brooks	Historical runs and Ricker Stock - recruitment
Background	Reference Points	6	Both	Lee, Maunder, Piner, Methot	Can steepness be estimated in assessment models?
Background	Reference Points	6	Both	Valpine & Hastings	Fitting population models incorporating process and observation error
Background	Status Estimation	5	Both	CCSBT	Report of operating model and management procedure technical meeting
Background	Status Estimation	5	Both	Haltuch, Hicks & See	Status of petrale sole resource in 2010
Background	Status Estimation	5	Both	Anon	North Pacific minke whale RMP implementation
Background	Status Estimation	5	Both	Anon	2011 New Zealand Hoki assessment
Background	Status Estimation	5	Both	Rademeyer, Butteworth, Plaganyi	2008 assessment of south african hake
Background	Status Estimation	5	Both	Tuck	2010 assessment of australian scalefish and shark
Background	Status Estimation	5	Both	Wilderbuer, Nichol, Ianelli	2011 bering sea yellowfin sole assessment
Background	Reference Points	6	GOM Cod	Puvanendran, Laurel, Brown	Cannibalism in Atlantic Cod

Table 7. List of Participants of the SAW 55 Reference Points Meeting

Last Name	First Name	Affiliation	Email
Blaylock	Jessica	NEFSC	Jessica.blaylock@noaa.gov
Brooks	Liz	NEFSC	Liz.brooks@noaa.gov
Butterworth	Doug	UCT	doug.butterworth@uct.ac.za
Crawford	Jud	Pew Charitable Trust	jcrawford@pewtrusts.org
Curti	Kiersten	NEFSC	kiersten.curti@noaa.gov
Deroba	Jon	NEFSC	jonathan.deroba@noaa.gov
Giacalone	Vito	Northeast Seafood Coalition	summer-breeze@mindspring.com
Hart	Dvora	NEFSC	deborah.hart@noaa.gov
Hogan	Fiona	NEFMC	fiona.hogan@nefmc.org
Legault	Chris	NEFSC	chris.legault@noaa.gov
Miller	Tim	NEFSC	timothy.j.miller@noaa.gov
Nieland	Julie	NEFSC- Woods Hole	julie.nieland@noaa.gov
Nies	Tom	NEFMC	tnies@nefmc.org
Nitschke	Paul	NEFSC	paul.nitschke@noaa.gov
O'Boyle	Robert	Beta Scientific Consulting	betasci@eastlink.ca
O'Brien	Loretta	NEFSC	loretta.o'brien@noaa.gov
Odell	Jackie	Northeast Seafood Coalition	jackie_odell@yahoo.com
Palmer	Mike	NEFSC	Michael.Palmer@noaa.gov
Rago	Paul	NEFSC	Paul.Rago@noaa.gov
Raymond	Maggie	AFM	maggieraymond@comcast.net
Sosebee	Kathy	NEFSC	katherine.sosebee@noaa.gov
Traver	Michelle	NEFSC	michele.traver@noaa.gov
Wang	Yanjun	Fisheries and Oceans Canada	Yanjun.Wang@dfo-mpo.gc.ca
Weinberg	James	NEFSC	James.weinberg@noaa.gov
Wigley	Susan	NEFSC	Susan.wigley@noaa.gov
Wood	Tony	NEFSC	anthony.wood@noaa.gov

Appendix 1.

Draft Agenda*
55th Northeast Regional Stock Assessment Workshop (SAW 55)
Working Group Meeting on Reference Points
29 October – 2 November 2012
Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts

TIME/DATE	TOPIC
Monday, 29 October	
09:00 – 09:15	Introductory comments (WG Chair)
09:15 – 11:00	NEFSC model considerations of GOM Cod (Palmer)
11:00 – 12:00	Butterworth/Rademeyer model considerations of GOM Cod
12:00 – 13:00	Lunch
13:00 – 14:00	Butterworth/Rademeyer model considerations of GOM Cod (Butterworth)
14:00 – 17:00	NEFSC model considerations of Georges Bank Cod (O'Brien)
Tuesday, 30 October	
09:00 – 11:00	NEFSC reference points and projections of GOM Cod (Palmer)
11:00 – 12:00	Butterworth/Rademeyer reference points and projections of GOM Cod (Butterworth)
12:00 – 13:00	Lunch
13:00 – 14:00	Butterworth/Rademeyer reference points and projections of GOM Cod (Butterworth)
14:00 – 17:00	NEFSC reference points and projections of Georges Bank Cod (O'Brien)
Wednesday, 31 October	
09:00 – 12:00	Revisit of GOM Cod discussion
12:00 – 13:00	Lunch
13:00 – 17:00	Revisit of GB Cod discussion
Thursday, 1 November	
09:00 – 12:00	Reruns
12:00 – 13:00	Lunch
13:00 – 17:00	Reruns
Friday, 2 November	
09:00 – 12:00	Research recommendations
12:00 – 13:00	Lunch
13:00 – 17:00	Report considerations
17:00	Adjournment

* Times are approximate, and may be changed at discretion of WG chair; breaks will be held in morning and afternoon at discretion of chair; meeting is open to the public