
**Independent Peer Review Report on the 55th Stock Assessment
Workshop/Stock Assessment Review Committee (SAW/SARC):
Benchmark stock assessments for Georges Bank cod and Gulf of
Maine cod.**

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Prepared for

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1. Executive Summary

The 55th Stock Assessment Review Committee (SARC 55) meeting was held from 1pm on 3 December 2012 through 6.30 pm on 7 December 2012 at the Northeast Fisheries Science Centre, Wood's Hole, Massachusetts, USA. I was contracted by the Center for Independent Experts (CIE) to act as a member of the Review panel. The purpose of the meeting was to provide an external peer review of the benchmark stock assessments for Georges Bank cod and Gulf of Maine cod in accordance with the requirements for CIE reviewers contained in the Statement of Work (Appendix 2).

Review activities

A comprehensive set of assessment reports and supporting documentation was made available to the review panel via an *.ftp site in advance of the meeting. Prior to the review meeting I familiarized myself with the assessment reports and supporting documentation in order to gain a thorough understanding of the data and methods used, the results of the assessments and to identify any issues requiring clarification or explanation. The review was carried out in open session through a series of presentations on each stock. The review Panel questioned the presenters and other members of the assessment team on any points requiring elaboration and/or clarification and made several requests for additional analyses to be undertaken. The additional requests were all thoroughly addressed.

Main findings

Georges Bank cod

In general, the data used appeared adequate and appropriately assembled. The assessment was carried out using a statistical catch-at-age model (ASAP: Legault and Restrepo, 1999) which can more fully account for the uncertainties in the catch and surveys) and which was appropriate given the available data and information. Previous assessments were undertaken using VPA. While there were a number of unresolved issues especially the source of the retrospective pattern in fishing mortality (F) and spawning stock biomass (SSB) that would benefit from further investigation for future assessments, the model configuration which incorporated a correction to the observed retrospective pattern was preferred by the Review Panel.

Alternative model configurations incorporating an increase in the assumed natural mortality rate (M) over time also appeared to provide acceptable fits to the data, but were rejected on the grounds that the changes to the model specifications required (increase in M and timing of such an increase) were rather *ad hoc*. While there was evidence from tagging that in recent years, M may have been higher than the

assumed value of $M = 0.2$ used for the preferred assessment, the evidence was not strong and the resulting estimates were sensitive to the assumed high reward return rate of tagged fish. I acknowledge that acceptance of an assessment incorporating a post-assessment correction to account for the observed retrospective pattern is also *ad hoc*, it does at least have the advantage that the procedure is simple and transparent.

While I agree that the preferred assessment model represents the best representation of the state of the stock available at present, I have no means to judge whether the assumed value for M (constant at $M = 0.2$ on all ages and years) is likely to be representative of the true rate of natural mortality throughout the time period of the assessment. The observed retrospective pattern may arise through variety of other input assumptions which have not been investigated.

Given the uncertainty in the retrospective adjustment, downward trends in mean weight at age, and a potential recent increase in natural mortality (the key elements of the productivity processes), the projections may be optimistic.

Assessment results

The results of the accepted assessment for the Georges Bank cod are as follows:

Fishing mortality: From the preferred assessment, fishing mortality (F_{5-8}) in 2011 is estimated at 0.23 (90% posterior interval 0.15 – 0.34). For stock status determination, the 2011 F estimate was adjusted to 0.43 to account for the retrospective pattern

Spawning stock biomass: SSB in 2011 is estimated to be 22,217 mt (90% posterior interval 15,809 – 31,993 mt). For stock status determination, the 2011 SSB estimate is adjusted to 13,217 mt to account for the retrospective pattern.

Recruitment: The time series mean recruitment (age 1) was around 13.6 million fish. Strong year classes were produced in 1979, 1981, 1982, 1983, 1987, and 1991 with below average recruitment for the last two decades. Recruitment has not exceeded the long-term mean since the 1991 year class.

Biological reference points: A value for MSY could not be derived directly from the preferred ASAP assessment model. Hence a proxy for MSY ($F_{40\%}$ yield) was chosen as the overfishing threshold. The associated reference $F_{40\%}$ was estimated from a spawner-per-recruit analysis using 2007-2011 average SSB weights, catch weights, maturity and selectivity at age and is expressed as a fully recruited fishing mortality (ages 5+).

$$\begin{array}{ll} F_{MSY} = F_{40\%} = F_{threshold} & = 0.18 \\ SSB_{MSY} = B_{target} & = 186,535 \text{ mt.} \\ 1/2 SSB_{MSY} = B_{threshold} & = 93,268 \text{ mt} \\ MSY & = 30,622 \text{ mt.} \end{array}$$

Given that the source of the retrospective pattern remains unresolved it was not possible to estimate a value for $F_{rebuild}$.

Stock status: The Georges Bank cod stock is overfished and overfishing is occurring. Spawning stock biomass (SSB) in 2011 is estimated to be 13,217 mt, which is 7% of the estimate for SSB_{MSY} .

Projections: Short term projections (3-years) of catch and SSB were made under an assumption of $F = 0.75 \cdot F_{MSY}$ Proxy ($F = 0.14$). Future recruitment was estimated from a 2-stage cumulative density function (CDF) of 1978-2011 ASAP estimated age-1 fish associated with a SSB breakpoint of 50,000 mt.

Projections indicate that assuming a catch of 2,910 mt in 2012 will give rise to a median fishing mortality rate of $F=0.17$ in 2012 and median SSB in 2013 of 20,174 mt. Fishing at $F = 0.14$ in 2013, 2014 and 2015, is predicted to result in catches of 2594 mt, 2816 mt and 3265 mt respectively and SSB is predicted to be 21,415 mt in 2014 and 26,005 mt in 2015.

Gulf of Maine cod

As for Georges Bank cod, the data used for the assessment appeared adequate and appropriately assembled and there were no indications that any important sources of catch data that were not accounted for. The documentation of procedures and results to derive catches and catch at age for years for 1982 onwards was comprehensive. However, prior to 1982, the estimates of catches and catch at age are less certain.

Two of the models put forward by the working group were taken forward by the Panel. The essential differences were as follows: one model (denoted $M = 0.2$) assumed that natural mortality (M) was assumed to be 0.2 for all age groups and years; the second model (denoted M -ramp) was implemented with $M = 0.2$ on all age groups from 1982 to 1988, and $M = 0.4$ on all age groups between 2003 and 2011, with a linear ramp in M between 1989 and 2002. Compared to the previous assessment (NEFSC 2012), both assessments included updates to the recreational catch estimates, revised discard mortality estimates (varying by gear type and by recreational and commercial fishery) and minor modifications to the Massachusetts Department of Marine Fisheries (MADMF) spring survey.

The results from the two models differed particularly with regard to biomass reference points and in addition, some projections showed greater differences than those observed for Georges Bank cod. This was particularly true under differing assumptions about future natural mortality. In the time available it proved impossible to agree on which of the assumed natural mortality regimes is likely to be most representative of reality so a variety of scenarios were explored. Nevertheless, the different assumptions for natural mortality each lead to the same conclusions with respect to stock status although it proved impossible to determine incontrovertible numeric values for stock status.

Assessment results

The results of the two assessments carried forward for the Gulf of Maine cod are as follows:

Fishing mortality: The 2011 estimates of fishing mortality (F_{full}) are as follows|:

Model	$F_{full(2011)}$
M = 0.2	0.86 (90% posterior interval 0.53 – 1.05)
M-ramp	0.90 (90% posterior interval 0.57 – 1.09)

Both estimates are approximately 4.7-5.0 times higher than their respective MSY Proxies

Spawning stock biomass: The 2011 estimates of Spawning Stock Biomass (SSB) are as follows:

Model	$F_{full(2011)}$
M = 0.2	9,903 mt (90% posterior interval 7,644 – 13,503 mt)
M-ramp	10,221 mt (90% posterior interval 7,943 – 13,676 mt)

The estimates of spawning stock biomass (SSB) from both models have generally declined since a time series high of 22,036 (M = 0.2 model) or 21,531 mt (M-ramp model) in 1982. There were small increases in SSB in the early and late 2000s, but SSB has been declining since 2009 (Figure A3).

Recruitment: The time series mean recruitment (age 1) was around 7.2 million fish (M = 0.2 Model) or 10.2 million fish (M-ramp Model). Strong year classes were produced in 1981-1987. Subsequently, the recruitment estimates differ due to the different assumptions about natural mortality. Over the last five years recruitment estimates have declined to a low level in both assessments.

Biological reference points: A value for MSY could not be derived directly from either of the models carried forward. Hence a proxy for MSY ($F_{40\%}$ yield) was chosen as the overfishing threshold. The associated reference point $F_{40\%}$ was estimated from a spawner-per-recruit analysis using 2007-2011 average SSB weights, catch weights, maturity and selectivity at age and is expressed as a fully selected fishing mortality (F_{full}).

Reference points	Model	
	$M_{0.2}$	M_{Ramp}
F_{MSY}	0.18	0.18
SSB_{MSY} (mt)	54,743 (40,207 - 73,354)	80,200 (64,081 - 99,972)
MSY (mt)	9,399 (6,806 - 13,153)	13,786 (10,900 - 17,329)

Stock status: The Gulf of Maine Atlantic cod (*Gadus morhua*) stock is overfished and overfishing is occurring. Spawning stock biomass (SSB) in 2011 is estimated to be 9,903 mt or 10,221 mt which is 18% or 13% of the SSB_{MSY} proxy (54,473 mt or

80,200 mt) in the $M = 0.2$ or M-ramp models, respectively (Figure A2). The 2011 fully selected recruited fishing mortality is estimated to be 0.86 or 0.90 which is about 4 or 5 times the F_{MSY} proxy ($F = 0.18$ for both models).

Projections: Three sets of projections were presented and are shown in the table below: two sets of projections for the M-ramp assessment and a single projection for the $M = 0.2$ assessment. To bracket the range of natural mortality rates used in the M-ramp model, natural mortality was set to $M=0.2$ or $M = 0.4$ for the years 2013, 2014 and 2015.

Year	Input	ASAP, 1982 BASE			ASAP, 1982 M-RAMP					
		$M=0.2$			$M=0.2$			$M=0.4$		
		$F_{msy} = 0.18$, $BMSY = 54,743$ mt			$F_{msy} = 0.18$, $BMSY = 80,200$ mt			$F_{msy} = 0.18$, $BMSY = 80,200$ mt		
		Rebuild year at 75% $FMSY = 2022$			Rebuild year at 75% $FMSY = 2022$			NO REBUILD at 75% $FMSY$		
		Catch (mt)	SSB (mt)	F_{full}	Catch (mt)	SSB (mt)	F_{full}	Catch (mt)	SSB (mt)	F_{full}
2012	Assumed catch	3,767	8,995	0.46	3,767	8,196	0.52	3,767	7,711	0.58
2013	Projection	1,249	9,406	0.14	1,142	9,163	0.14	822	6,927	0.14
2014	Projection	1,503	12,143	0.14	1,563	13,916	0.14	935	8,875	0.14
2015	Projection	2,030	16,802	0.14	2,582	22,124	0.14	1,313	12,234	0.14

Projection results indicate that under the assumption of $M = 0.2$, rebuilding to SSB_{MSY} is expected to be achieved by 2022 for both the M-ramp and $M = 0.2$ models. Under the assumption that the future natural mortality rate is $M = 0.4$, the stock is not expected to rebuild to SSB_{MSY} and SSB is predicted to reach an asymptote at 27,000 mt.

Acknowledgement

I would like to acknowledge the tremendous efforts of all the scientific personnel in preparing the assessment reports. While the assessment teams were unable to agree on the most appropriate assessment, they have applied their knowledge and expertise to the best of their ability to try to arrive at the best assessments of the state of both Georges Bank and Gulf of Maine cod stocks. Despite the difficulties and tensions that inevitable arise through differing perceptions and preferences of assessment model formulations, all participants approached the review with a professional attitude and conducted themselves in an exemplary manner. While it is inevitable that during a review such as this, there will be aspects of the data and analysis that require additional clarification, elaboration or investigation, I was once again thoroughly impressed by the sheer volume and complexity of work undertaken by the analysts in preparing and documenting the data, analyses and findings for both stocks. Their patience and cooperation in the review process and their willingness to respond to requests on points of clarification and additional analyses to be undertaken was truly remarkable. Furthermore, the organization of the meeting by the Chair of the SARC was exemplary as was the welcome and hospitality extended by the staff of the population dynamics team in the NEFSC.

I would also like to thank the other members of the Panel for their assistance and support during the review. All three of them were a pleasure to work with.

Finally, I wish to thank Manoj Shivilani and Roberto Koeneke from the CIE for doing an excellent job in taking care of the logistical arrangements relating to my participation in this review.

2. Background

The purpose of the SARC 55 panel review meeting was to provide an external peer review of stock assessments for Georges Bank cod and Gulf of Maine cod. Atlantic cod, *Gadus morhua*, is a demersal gadoid species found on both sides of the North Atlantic. In U.S. waters, cod are assessed and managed as two stocks: Gulf of Maine, and Georges Bank and southward. Both stocks support important commercial and recreational fisheries. The last peer reviewed benchmark assessment of Gulf of Maine cod was in 2010 as part of SARC 53. The last peer reviewed assessment update of Georges Bank cod took place in 2012.

The SARC 55 review panel was composed of three independently appointed reviewers: Dr Noel Cadigan, (Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute of Memorial University, St. John's Newfoundland, Canada); Dr. John Casey (CEFAS, Lowestoft, Suffolk, United Kingdom); Dr. Steven Homes (Marine Scotland, Aberdeen, Scotland); and an independent chair from the Scientific and Statistical Committee (SSC) of the New England or MidAtlantic Fishery Management Council, Dr. Patrick J. Sullivan (Chair of the Committee, New England Fisheries Management Council's Scientific and Statistical Committee and Cornell University, Ithaca, New York, USA).

The results of the review provide the scientific basis for fishery management in the northeast region and the charge to the Panel was to determine whether the scientific assessments are adequate to serve as a basis for developing such fishery management advice.

3. Review Activities

Draft assessment documents, model input and output files, and extensive background material (previous assessments, previous SARC Panel reports, relevant research reports and publications etc.) were provided to the Panel in advance of the meeting on an FTP site, which served as an extremely convenient means to distribute the material for review. A file server was provided at the meeting room to provide common access to all presentation material and additional analyses that were conducted during the course of the Panel meeting. The Gulf of Maine cod assessment report was provided to the reviewers via the FTP site in accordance with the agreed timescale (Appendix 1) but the Georges Bank cod assessment report was only available some 5 days before the meeting. In practice this was not an issue and I was able to familiarize myself with the assessment reports and supporting documentation ahead of the review meeting.

The major part of the review (days 1-4) was carried out in open session through a series of presentations on each stock, each of which was structured to address the terms of reference given to the Stock Assessment Workshop (SAW). Questions on

points of clarification were raised by the Panel members and responded to by lead assessors. Discussions involved the Panel, lead assessors and audience participants. Rapporteurs provided detailed records of all questions and discussions held in open session. The stock assessment summary reports were drafted in open session on days 4 and 5, and for the latter part of day 5 the Panel met in closed session to begin drafting its consensus report. There was insufficient time to complete the consensus report by the close of the meeting. Panel members completed the consensus report by correspondence. The Panel's consensus report had not been finalized and agreed before the deadline for submission of this Independent Report to the CIE. Hence, while I would have preferred to incorporate the main conclusions and recommendations from the consensus report in this report, followed by additional comments of my own, this has not been done. The comments below therefore represent observations, conclusions and recommendations that I personally wish to draw attention to. It is likely that many, but not all of them will also appear in the Review Panel's consensus report.

Comments on the SARC the review process

In general the overall process worked very well. As for previous reviews that I have been involved with, the data and assessment documentation was extremely impressive and the logistical organization and preparations for the review by the SARC chair were once again excellent. The presentations and responses to Panel questions by the lead assessors (and others) were appropriately detailed and thorough.

However, compared to previous SARC review meetings that I have participated in, this one differed in one important aspect in that the Assessment Working Group could not reach consensus on a single assessment for each stock and the Review Panel was asked to review alternative assessments, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted. I personally felt that this was almost an impossible task given the circumstances and the time available at the review meeting. The panelists, although experienced in stock assessment methods and the provision of management advice, did not possess detailed expert knowledge of the fisheries and stocks concerned and there were multiple assessment model configurations to take into consideration. It was therefore rather a tall order to expect the Panel to make an informed choice between assessments when a large number of experts (approximately 50) with such knowledge, working for a much longer period of time could not take a decision on the most appropriate scientific approach. Nevertheless, the Panel was able to come to a decision on an appropriate scientific approach for the assessment of Georges Bank cod. However, it proved impossible to choose between two alternative assessment approaches for the cod stock in the Gulf of Maine and the results from two assessment models were carried forward.

Recognizing that the inability to agree on a single assessment for Gulf of Maine cod, is not ideal and is likely to make taking management decisions more problematic, it would be desirable, that for future assessments, only a single preferred model be put forward for independent review. I feel that the knowledge and expertise of the assessment team make them best placed to make informed judgments on the most

appropriate assessment model and model configuration since such factors should ideally be decided *a priori*.

As I have suggested in a previous report on the SARC process, I think it would be worth considering whether in the SARC summary report it would be worth documenting any additional requests to the SAW arising in the course of the SARC as is done in the STAR process. This would mean that any requests for additional work to be undertaken by the SAW during the SARC would be in writing and could be included in the SARC summary report. The rationale for the requests could also be documented and included together with the response to the request. Such an approach can prove to be extremely useful and provide a logical commentary on the discussions that took place.

It may also be worth considering the value and cost of the requirement for each CIE reviewer to provide an independent report in addition to contributing to the SARC summary report. I can see the value of three independent reviewers, but would have thought that in most cases a Panel report would suffice as a credible peer-review document. Even if the reviewers cannot reach consensus on all points, any disagreements could be documented in the Panel report. This would avoid repetition and would reduce the workload of the reviewers and the cost to the review process. An alternative consideration would be to ask reviewers to prepare a shorter report that would document only additional points or disagreements with what is presented in the Panel's consensus report.

4. Introduction to review of stock assessments

The following sections provide stock specific comments for each of the two cod stocks under review. They are structured so that I provide a commentary and response to each of the terms of reference provided to the SAW for each stock separately. Some of the points raised under each term of reference are repeated separately in each of the stock sections. This is deliberate and I have adopted this approach so that my comments relating to each stock can be read in isolation and stand alone.

5. Georges Bank cod

- 1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data and take into account the recommendations and subsequent work from the March 2012 MRIP workshop. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.*

As far as is possible to judge, the sources of data and the methodology adopted to produce input catch data for the assessment of Georges Bank cod were appropriate and acceptable. However, it is clear from the extensive documentation that the quality of catch information has improved with time. I note that the uncertainty in age-

compositions has been partially characterized, for USA commercial landings during 2003-2011 only.

While the WG acknowledged that there remains some uncertainty in the allocation of landings to Georges Bank and Gulf of Maine cod stock areas, I agree with the WG that such uncertainty is likely to be of little consequence for assessment purposes.

In summary, I consider that this term of reference was adequately addressed and that the data presented form a credible basis for the assessment approach used.

2. *Present the survey data and calibration information being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Consider model-based (e.g. GLM) as well as design-based analyses of the survey data in developing trends in relative abundance. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.*

Survey data were very well documented and I consider that the way the data were treated was appropriate and the data form a credible scientific basis for use in the assessment.

I note that the latest survey indices (Spring 2012 NEFSC survey) were the among the lowest on record, but were not used in the ASAP assessment model because of model design, although they were presented and considered in the review. The utility and applicability of backdating the spring survey indices at age to the start of the year to provide additional data point to the time series of survey indices at age may be worth investigating.

It would be helpful for future assessments if spatial plots of survey landings by year for the two stock areas combined (NEFSC Spring and Fall Surveys) could be plotted and presented in the assessment report. This would help to examine transboundary distributions of fish and provide information to aid the interpretation of stock structure, survey coverage of the stock, and the appropriate specification of stock strata for inclusion in the survey index. It would also be helpful if stock management boundaries were also identified on such plots. The assessment presentation on Georges bank cod included such plots but they were not presented in the assessment report.

I agree that the decision not to include commercial and recreational LPUE as indices of abundance to be used in the assessment and the working group clearly demonstrated why such time series are not indicative of trends in the stock as a whole. There may be useful information in such time series however and if properly evaluated, may prove to be useful for future assessments. The recreational LPUE series is a potential candidate as an early predictor of forthcoming recruitment to the commercial fishery.

Because the vessel conducting the NMFS surveys changed from SRV Albatross IV to SRV H.B. Bigelow, length-based catch rate calibrations between vessels were undertaken. As far as is possible to judge this was done appropriately but the

methods used probably should be subject to further scrutiny. Furthermore, given the high uncertainty in the conversion factors, it would seem appropriate to utilize methods that do not rely on conversion factors as soon as the length of the Bigelow time series permits.

Suggestions for future work regarding the use of survey data are given under Term of Reference 9 below.

3. Summarize the findings of recent workshops on stock structure of cod of the Northeastern US and Atlantic Canada.

I consider that the summary of the workshop findings was thorough and fully addressed the Terms of Reference.

In relation to a similar point in Term of Reference 2 above, it may prove useful to plot maps showing relative densities depicted as bubble plots by age group over time to give an overview of the spatial distribution by age-group. This would help inform on the changes in stock distribution over time and taking into account the spatial distribution of fishing effort that resulted in catches of cod, may help to interpret any perceived changes in the catchability at age or fishing mortality at age.

4. Investigate the evidence for natural mortality rates which are time- and/or age-specific. If appropriate, integrate these into the stock assessment (TOR 5).

I interpreted this term of reference to extend to a review of the appropriateness of the assessment model and the quality of the assessment and the credibility of the results as a basis for fishery management decisions.

This ToR was adequately addressed, but the evidence provided was not conclusive. This was a major topic of debate during the review and arguments based on tagging, life history information, and on total mortality from survey catch curve analysis were given for different natural mortality regimes over the years. While there was evidence from tagging that in recent years, M may have been higher than the assumed value of $M = 0.2$ used for the preferred assessment, the evidence was not strong and the resulting estimates were sensitive to the assumed high reward return rate of tagged fish. I acknowledge that choosing a value of $M = 0.2$ is rather *ad hoc*, but it does at least have the advantage that the procedure is simple and transparent. However, I have no means to judge whether the assumed value for M (constant at $M = 0.2$ on all ages and years) is likely to be representative of the true rate of natural mortality throughout the time period of the assessment.

The “true” values for natural mortality over time remained unresolved and future assessments are likely to benefit from further examination of potential changes in natural mortality over time.

5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Consider feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets, and whether to use domed or flat selectivity-at-age for the NEFSC surveys. Provide a summary of steps in the model building process. Include a

historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.

All of the above considerations were thoroughly addressed by the working group. I was unable to identify any omissions or errors. Of the assessment models investigated, the short and long-term results were reasonably comparable.

The results of the preferred assessment of Georges Bank cod were as follows:

Fishing mortality: From the preferred assessment, fishing mortality (F_{5-8}) in 2011 is estimated at 0.23 (90% posterior interval 0.15 – 0.34). For stock status determination, the 2011 F estimate was adjusted to 0.43 to account for the retrospective pattern

Spawning stock biomass: SSB in 2011 is estimated to be 22,217 mt (90% posterior interval 15,809 – 31,993 mt). For stock status determination, the 2011 SSB estimate is adjusted to 13,217 mt to account for the retrospective pattern.

Recruitment: The time series mean recruitment (age 1) was around 13.6 million fish. Strong year classes were produced in 1979, 1981, 1982, 1983, 1987, and 1991 with below average recruitment for the last two decades. Recruitment has not exceeded the long-term mean since the 1991 year class.

6. *State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY} , $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. Consider alternative parametric models of the stock recruitment relationship. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and any “new” (i.e., updated, redefined, or alternative) BRPs.*

This term of reference was successfully addressed and the choices and assumptions made appeared appropriate.

An MSY could not be derived directly from the ASAP assessment model, therefore an MSY proxy was chosen to determine reference points. Consistent with the previous assessment, and due to the absence of a suitable stock-recruit relationship, $F_{40\%}$ was chosen as the proxy for F_{MSY} (the overfishing threshold) and resulted in a value of fully selected fishing mortality of $F=0.18$. While $F_{40\%}$ may not necessarily be the best proxy to use, I agree that there is at present, no compelling reasons to abandon its use.

Stochastic projections at $F_{40\%}$ were used to determine new recommended biomass-related reference points (proxies for both SSB_{MSY} and MSY). The projection methodology used to determine SSB_{MSY} and MSY proxies was identical to those used for short-term projections. The proxy for SSB_{MSY} , the B_{TARGET} , is estimated at 186,535 mt, the median of the stochastic projections, with 10th and 90th percentiles spanning 155,398 mt – 220,756 mt. $B_{THRESHOLD}$ corresponding to half of SSB_{MSY} is 93,268 mt.

Age specific retrospective pattern adjustments to the abundance at age were used to start the projections. However, given that the source of the retrospective pattern observed in the preferred assessment is unresolved, F_{rebuild} could not be determined.

The proxy for MSY is 30,622 mt, with 10th and 90th percentiles spanning 25,450 – 36,302 mt. The median recruitment at SSB_{MSY} was estimated to be 23.3 million age 1 fish.

The BRPs for Georges Bank cod are summarized below:

$$\begin{aligned} F_{\text{MSY}} = F_{40\%} = F_{\text{threshold}} &= 0.18 \\ SSB_{\text{MSY}} = B_{\text{target}} &= 186,535 \text{ mt.} \\ 1/2 SSB_{\text{MSY}} = B_{\text{threshold}} &= 93,268 \text{ mt} \\ \text{MSY} &= 30,622 \text{ mt.} \end{aligned}$$

7. *Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.*
 - a. *When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.*
 - b. *Then use the newly proposed model and evaluate stock status with respect to “new” BRPs (from Cod TOR-6).*

This term of reference was satisfactorily addressed. In relation to the BRPs derived from the current assessment, the stock is currently overfished and overfishing is occurring.

Spawning stock biomass (SSB) in 2011 is estimated to be 13,217 mt, which is 7% of the SSB_{MSY} (186,535 mt). The 2011 fully recruited fishing mortality (ages 5+) is estimated to be 0.43 which is 240% of the F_{MSY} (0.18).

The biological reference points estimated in the last assessment (Groundfish Update, 2012) that had been used previously were $F_{\text{MSY}}=F_{40\%}=0.23$, $SSB_{\text{MSY}}=140,424$ mt, and $MSY=28,774$ mt.

7. *Evaluate stock status (overfished and overfishing) with respect to the “new” BRPs (from TOR 6), and with respect to the existing BRPs (from a previous accepted peer review) whose values have been updated.*

This Term of Reference was adequately addressed and I agree with the results of the preferred assessment.

Based on the previous reference points, the previous assessment indicated that the Georges Bank cod stock was overfished and overfishing was occurring.

Based on the reference points derived from the current preferred assessment, the new assessments indicate that the Georges Bank cod stock is still assessed to be overfished and overfishing is occurring.

It would be informative if future Terms of Reference to the SAW included an evaluation of the probability of being overfished or of overfishing taking place, rather than simply using a point estimate based on the model output.

8. *Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).*
 - a. *Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F , and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).*
 - b. *Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.*
 - c. *Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.*

This Term of Reference was adequately addressed. The methods used to undertake the projections were largely standard and appropriate and appear to have been carried out in the correct manner. I conclude that they form a scientifically credible basis for management decisions.

Short-term projections were provided using the same stochastic projection method used for the reference point calculations. Short term projections (3-years) of catch and SSB were made under an assumption of $F = 0.75 \cdot F_{MSY}$ Proxy ($F = 0.14$). Future recruitment was estimated from a 2-stage cumulative density function (CDF) of 1978-2011 ASAP estimated age-1 fish associated with a SSB breakpoint of 50,000 mt.

Projections indicate that assuming a catch of 2,910 mt in 2012 will give rise to a median fishing mortality rate of $F=0.17$ in 2012 and median SSB in 2013 of 20,174 mt. Fishing at $F= 0.14$ in 2013, 2014 and 2015, is predicted to result in catches of 2594 mt, 2816 mt and 3265 mt respectively and SSB is predicted to be 21,415 mt in 2014 and 26,005 mt in 2015.

A brief commentary on stock vulnerability was presented in the assessment document. The arguments presented are concise but cogent and conclude that productivity of the stock is low with two decades of poor recruitment and a truncated age structure. Furthermore, given the uncertainty in the magnitude of M and the

overfished state of the stock, at 7% of SSB_{MSY} the stock is vulnerable to an allowable biological catch (ABC) quota that is set too high.

9. *Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.*

The SAW has made good progress in addressing previous research recommendations and the proposed list of new recommendations presented in the assessment report is relevant.

I recommend that the following also be considered:

- It would be informative if increased inspection and analysis of survey data be conducted prior to inclusion of these data in future assessments. Examples of analyses that could be undertaken include:
 - Routine internal estimates of variance of annual survey estimates.
 - Inspection of relationships between age i and age $i+1$ within individual surveys to ensure cohorts are tracked – such analyses may help identify which ages to include in a plus group.
 - Inspection of correlations among different surveys to examine the information content of individual surveys.
- Given the high uncertainty in the conversion factors between the Albatross IV – Henry B. Bigelow survey series, it would be desirable to use methods that do not rely on these conversion factors as soon as the length of the Bigelow time series permits.
- It would be helpful for future assessments if spatial plots of survey landings by year for the two stock areas combined (NEFSC Spring and Fall Surveys) could be plotted and presented in the assessment report.

6. Gulf of Maine cod

1. *Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data and take into account the recommendations and subsequent work from the March 2012 MRIP workshop. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.*

As far as is possible to judge, the sources of data and the methodology adopted to produce input catch data for the assessment of Gulf of Maine cod were appropriate and acceptable. The results and procedures to estimate catch and their uncertainty was exceptionally well documented and very helpful. There were no concerns raised either by the analysts or by the members of the public attending the meeting that questioned the validity of the catch reports and no indications that important sources of catches were not accounted for.

I consider that this term of reference all elements of this TOR were thoroughly addressed and the data form a credible basis for the assessment approach used. However, it is clear that the quality of catch information has improved with time. The uncertainty has been adequately characterized.

Modern catch monitoring began in 1964 although landings statistics for area 5 (Gulf of Maine and part of Georges Bank stocks) exist back to 1893. However, the methods used to apportion landings to individual stock complex for the earlier time period are not well documented and the landings estimates from the earlier period are considered less reliable. Mis-allocation of catches in the recent period after 1994, are not considered to be significant and post 2006, the magnitude of misreporting error is estimated to be in the region of 2%. Prior to 1994, the panel assumed there is a greater potential for mis-allocation error of landings between the Gulf of Maine and Georges Bank stocks.

Uncertainty in biological sampling (length and age) of Gulf of Maine cod prior to 1982 was poor although there is sufficient information to estimate the age and composition of catches from 1982 onward. The uncertainty in the post 1982 length and age estimates was derived by a bootstrap procedure and was included in the stock assessment models.

Since 1999, due to restrictive trip limits during 1999-2004, commercial discards and recreational landings and discards have accounted for a much larger portion (25%-50%) of Gulf of Maine catches. Direct sampling of the commercial fishery for discards has been conducted by fisheries observers since 1989. Biological sampling during this period was considered to be good. The main reason for discarding was small size and this information was used when estimating the age composition of discards. Discards were hind casted prior to 1989.

The recreational fishery has accounted for 20%-30% of the catch during 1990-2011. For the current assessment, Marine Recreational Fisheries Statistical Survey

(MRFSS) data were re-estimated using revised methodologies consistent with the new Marine Recreational Information Program (MRIP) which has replaced the MRFSS program. The procedures used appear appropriate. Recreational discard mortality was taken to be 30% and, although the discard mortality rate is highly uncertain, it is unlikely to induce large assessment uncertainty because of the relatively small contribution of discards to total landings.

2. *Present the survey data and calibration information being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Consider model-based (e.g. GLM) as well as design-based analyses of the survey data in developing trends in relative abundance. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.*

The following comments apply to survey data used for both Georges bank and Gulf of Maine cod stocks and are repeated in each of the stock sections.

Survey data were very well documented and I consider that the way the data were treated was appropriate and the data form a credible scientific basis for use in the assessment.

I note that the latest survey indices (Spring 2012 NEFSC survey) were the among the lowest on record, but were not used in the ASAP assessment model because of model design, although they were presented and considered in the review. The utility and applicability of backdating the spring survey indices at age to the start of the year to provide additional data point to the time series of survey indices at age may be worth investigating.

It would be helpful for future assessments if spatial plots of survey landings by year for the two stock areas combined (NEFSC Spring and Fall Surveys) could be plotted and presented in the assessment report. This would help to examine transboundary distributions of fish and provide information to aid the interpretation of stock structure, survey coverage of the stock, and the appropriate specification of stock strata for inclusion in the survey index. It would also be helpful if stock management boundaries were also identified on such plots. The assessment presentation on Georges Bank cod included such plots but they were not presented in the assessment report.

I agree that the decision not to include Commercial and recreational LPUE as indices of abundance to be used in the assessment and the working group clearly demonstrated why such time series are not indicative of trends in the stock as a whole. There may be useful information in such time series however and if properly evaluated, may prove to be useful for future assessments. The recreational LPUE series is a potential candidate as an early predictor of forthcoming recruitment to the commercial fishery.

Because the vessel conducting the NMFS surveys changed from SRV Albatross IV to SRV H.B. Bigelow, length-based catch rate calibrations between vessels were undertaken, As far as is possible to judge this was undertaken appropriately but the

methods used probably should be subject to further scrutiny. Furthermore, given the high uncertainty in the conversion factors, it would seem appropriate to utilize methods that do not rely on conversion factors as soon as the length of the Bigelow time series permits.

Suggestions for future work regarding the use of survey data are given under Term of Reference 9 below.

3. Summarize the findings of recent workshops on stock structure of cod of the Northeastern US and Atlantic Canada.

I consider that the summary of the workshop findings was thorough and fully addressed the Terms of Reference.

In relation to a similar point in Term of Reference 2 above, it may prove useful to plot maps showing relative densities depicted as bubble plots by age group over time to give an overview of the spatial distribution by age-group. This would help inform on the changes in stock distribution over time and taking into account the spatial distribution of fishing effort that resulted in catches of cod, may help to interpret any perceived changes in the catchability at age or fishing mortality at age.

4. Investigate the evidence for natural mortality rates which are time- and/or age-specific. If appropriate, integrate these into the stock assessment (TOR 5).

I interpreted this term of reference to extend to a review of the appropriateness of the assessment model and the quality of the assessment and the credibility of the results as a basis for fishery management decisions.

This ToR was adequately addressed, but the evidence provided was not conclusive. This was a major topic of debate during the review and arguments based on tagging, life history information, and on total mortality from survey catch curve analysis were given for different natural mortality regimes over the years. While there was evidence from tagging that in recent years, M may have been higher than the assumed value of $M = 0.2$ used for the previous assessment, the evidence was not strong and the resulting estimates were sensitive to the assumed high reward return rate of tagged fish. An examination of the evidence for and against an appropriate value of natural mortality or whether natural mortality has changed over did not result in a decision on which natural mortality values or time varying scenarios were most appropriate for Gulf of Maine cod. Hence the “true” values for natural mortality over time remained unresolved and future assessments are likely to benefit from further examination of potential changes in natural mortality over time.

It was my perception that the discussions on the value for natural mortality or for a change in natural mortality primarily arose because of the ability to improve the retrospective pattern in F and SSB by increasing natural mortality in the model from $M = 0.2$ in 1989 to $M = 0.4$ in 2002 and fixing M at $M = 0.4$ from 2003 -2011. I consider that while such an approach may be appropriate to engineer a reduced retrospective pattern, the model-independent evidence for such an increase in M is not strong.

Like many assessments there is uncertainty in the values assumed for natural mortality for Georges Bank cod. In addition to the work already undertaken to investigate appropriate values for natural mortality, the following areas might be worth pursuing to examine their potential effects on natural mortality:

1. Evidence of environmental drivers
 - Changes in the diet of the cod that might lead to a change in condition or spawning potential.
 - Temperature preferences.
 - Mechanisms influencing juvenile mortality.
2. Re-examination of tagging data collected in earlier years.
3. What ages are tagging estimates of M indicative of?
5. *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Consider feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets, and whether to use domed or flat selectivity-at-age for the NEFSC surveys. Provide a summary of steps in the model building process. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.*

While this Term of Reference was extensively addressed through the examination of a variety of assessment model configurations, there remained a number of unresolved issues which prevented a decision on a single appropriate assessment to take forward as the basis for management advice. While several assessments were considered by the Panel, several were rejected, but the panel unanimously agreed that two alternative assessments were plausible candidates to assess stock status and provide management advice. Given the time available, the Panel was unable to identify, based on best available science, which of the two should move forward, so both are being considered.

The essential differences between the two assessment models were as follows: one model (denoted M = 0.2) assumed that natural mortality (M) was assumed to be 0.2 for all age groups and years; the second model (denoted M-ramp) was implemented with M = 0.2 on all age groups from 1982 to 1988, and M = 0.4 on all age groups between 2003 and 2011, with a linear ramp in M between 1989 and 2002.

Compared to the previous assessment (NEFSC 2012), both assessments included updates to the recreational catch estimates, revised discard mortality estimates (varying by gear type and by recreational and commercial fishery) and minor modifications to the Massachusetts Department of Marine Fisheries (MADMF) spring survey.

The results from the two models gave different results, particularly with regard to biomass reference points, and in addition, some projections showed greater differences than those observed for Georges Bank cod. This was particularly true under differing assumptions about future natural mortality. In the time available it

proved impossible to agree on which of the assumed natural mortality regimes is likely to be most representative of reality so a variety of scenarios were explored. Nevertheless, the different assumptions for natural mortality each lead to the same conclusions with respect to stock status although it proved impossible to determine incontrovertible numeric values for stock status.

Assessment results

The results of the two assessments carried forward for the Gulf of Maine cod are as follows:

Fishing mortality: The 2011 estimates of fishing mortality (F_{full}) are as follows|:

Model	$F_{full(2011)}$
M = 0.2	0.86 (90% posterior interval 0.53 – 1.05)
M-ramp	0.90 (90% posterior interval 0.57 – 1.09)

Both estimates are approximately 4.7-5.0 times higher than their respective MSY Proxies

Spawning stock biomass: The 2011 estimates of Spawning Stock Biomass (SSB) are as follows:

Model	$F_{full(2011)}$
M = 0.2	9,903 mt (90% posterior interval 7,644 – 13,503 mt)
M-ramp	10,221 mt (90% posterior interval 7,943 – 13,676 mt)

The estimates of spawning stock biomass (SSB) from both models have generally declined since a time series high of 22,036 (M = 0.2 model) or 21,531 mt (M-ramp model) in 1982. There were small increases in SSB in the early and late 2000s, but SSB has been declining since 2009.

Recruitment: The time series mean recruitment (age 1) was around 7.2 million fish (M = 0.2 Model) or 10.2 million fish (M-ramp Model). Strong year classes were produced in 1981-1987. Subsequently, the recruitment estimates differ due to the different assumptions about natural mortality. Over the last five years recruitment estimates have declined to a low level in both assessments.

With regard to the feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets and whether to use domed or flat selectivity-at-age for the NEFSC surveys, all of these issues were thoroughly addressed, although consensus was not reached in the working group on the most appropriate starting year. While I agree that in principle it is good practice to aim to include as long a time series as possible in the assessment, such an approach should take into account the quality of information available throughout the whole time series. It is my perception from the assessment report and presentations made during the review that data from 1982 to the present can be considered more reliable than data prior to that time.

The Working Group provided a detailed overview showing the connection between the previous ASAP assessment (NEFMC 2012) and the current

configuration. An historical retrospective analysis to allow a comparison with previous assessment results was provided and well documented. The performance of historical projections with respect to stock size, recruitment and fishing mortality were provided.

6. *State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY} , $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. Consider alternative parametric models of the stock recruitment relationship. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and any “new” (i.e., updated, redefined, or alternative) BRPs.*

This Term of Reference was successfully addressed and for each of the models carried forward by the Panel, the choices and assumptions made appeared appropriate.

Results from both the $M = 0.2$ and M-ramp models, indicate that the stock is overfished and overfishing is occurring.

A value for MSY could not be derived directly from either of the models carried forward. Hence a proxy for MSY ($F_{40\%}$ yield) was chosen as the overfishing threshold. The associated reference $F_{40\%}$ was estimated from a spawner-per-recruit analysis using 2007-2011 average SSB weights, catch weights, maturity and selectivity at age and is expressed as a fully selected fishing mortality (F_{full}). While $F_{40\%}$ may not necessarily be the best proxy to use, I agree that there is at present, no compelling reasons to abandon its use.

The Panel, in conjunction with Working Group members present, revised the M-ramp SSB_{MSY} reference points during the meeting. The other reference points presented by the Working Group were accepted by the Panel.

While recognizing that putting forward two alternative assessments is not ideal and complicates the question of making projections and identifying $F_{rebuild}$ and the rebuilding schedules, in this case it proved impossible to choose between either of the assessments. The reference points derived from each model are given in the table below.

Reference points	Model	
	$M_{0.2}$	M_{Ramp}
F_{MSY}	0.18	0.18
SSB_{MSY} (mt)	54,743 (40,207 - 73,354)	80,200 (64,081 - 99,972)
MSY (mt)	9,399 (6,806 - 13,153)	13,786 (10,900 - 17,329)

7. *Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model*

developed for this peer review. In both cases, evaluate whether the stock is rebuilt.

This term of reference was adequately addressed and I have no basis to choose which of the two assessment models carried forward is likely to be the best representation of the true state of nature.

Based on the previous reference points, the previous assessment indicated that the Gulf of Maine cod stock was overfished and overfishing was occurring.

Based on the reference points derived from the two new models, both new assessments indicate that the Gulf of Maine cod stock is still assessed to be overfished and overfishing is occurring

The results from both assessments indicate that the Gulf of Maine cod stock has experienced a long period of overfishing and cannot be considered to be rebuilt.

8. *Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).*
 - a. *Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).*
 - b. *Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.*
 - c. *Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.*

a. Short-term projections were provided using the same stochastic procedure used for the reference point calculations which accounts for uncertainties in terminal year abundance and variability in recruitment. However, only projection medians were provided. Annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass, were not provided.

Three sets of projections are presented in the table below: two sets of projections for the M-ramp assessment and a single projection for the M = 0.2 assessment. To bracket the range of natural mortality rates used in the M-ramp model, natural mortality was set to M = 0.2 or M = 0.4 for the years 2013, 2014 and 2315.

Year	Input	ASAP, 1982 BASE			ASAP, 1982 M-RAMP					
		M=0.2			M=0.2			M=0.4		
		Fmsy = 0.18, BMSY = 54,743 mt			Fmsy = 0.18, BMSY = 80,200 mt			Fmsy = 0.18, BMSY = 80,200 mt		
		Rebuild year at 75% FMSY = 2022			Rebuild year at 75% FMSY = 2022			NO REBUILD at 75% FMSY		
		Catch (mt)	SSB (mt)	F _{full}	Catch (mt)	SSB (mt)	F _{full}	Catch (mt)	SSB (mt)	F _{full}
2012	Assumed catch	3,767	8,995	0.46	3,767	8,196	0.52	3,767	7,711	0.58
2013	Projection	1,249	9,406	0.14	1,142	9,163	0.14	822	6,927	0.14
2014	Projection	1,503	12,143	0.14	1,563	13,916	0.14	935	8,875	0.14
2015	Projection	2,030	16,802	0.14	2,582	22,124	0.14	1,313	12,234	0.14

Projection results indicate that under the assumption of $M = 0.2$, rebuilding to SSB_{MSY} is expected to be achieved by 2022 for both the M-ramp and $M = 0.2$ models. Under the assumption that the future natural mortality rate is $M = 0.4$, the stock is not expected to rebuild to SSB_{MSY} and SSB is predicted to reach an asymptote at 27,000 mt.

b. Given that there was little evidence to determine which value for natural mortality of $M = 0.2$ or $M = 0.4$ was likely more plausible, it was not possible to favor one set of projections over the other. It seems reasonable to assume however, that in the short-term natural mortality is likely to remain at its current level, although that too is not precisely known. It also seems reasonable to assume that for long-term projections M should be assumed to be 0.2, because the longer-term historical evidence seems to indicate that $M = 0.2$ is more plausible.

c. A commentary on stock vulnerability was presented in the assessment document. The arguments presented are concise but cogent and conclude that the Gulf of Maine cod stock is currently undergoing processes that have not been incorporated into the analytical formulations. Nevertheless, they should be considered when setting the ABC. Of particular note is the fact that since the mid-1990s, as observed in the NEFSC bottom trawl surveys and consistent with the trends in the fishery, the distribution of cod has become increasingly concentrated in the western part of the Gulf, with a gradual loss of cod from the coastal and central Gulf. Furthermore, since the mid-2000s, the stock has become particularly concentrated in a small region of the western Gulf, an area which appears to be a forage 'hotspot' due to the presence of sand lance, a prey of cod. A concentration of the fishery on the areas where the remaining population is concentrated may result in the maintenance of fishery catch rates, make the stock more vulnerable to fishing and give the perception that the stock is in a healthier state than it really is.

9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations..

This Term of Reference was adequately addressed. The SAW has made good progress in addressing previous research recommendations and the proposed list of new recommendations presented in the assessment report is relevant.

A single recommendation carried forward from GARM III and was addressed in the WG report. Of the nine research recommendations brought forward from SARC 53, six were either partially or fully addressed.

The Working group addressed the GARM III research recommendation to use historical data to hind cast recruitments as far back in time as possible for use in the estimation of reference points and catch projections. However, without further investigation into the factors affecting recruitment, the value of such an exercise to inform on a stock recruit relationship is unclear. Many factors in addition to parental stock size can influence the recruitment that is produced, and these factors may change over time.

As a result of the current review, consideration should be given to addressing the following issues which are also likely to be recommended in the Review Panel's consensus report.

- Investigate temporal changes in the location and quality of preferred environment and habitats for cod and whether there are any potential implications for M (adult and juvenile) and spawning potential.
- Consider whether natural mortality can be reliably estimated by using telemetry tagging. This is likely to be possible if local populations with high fidelity can be recognized.
- Investigate whether the NEFSC and MADMF survey indices can be combined to provide comprehensive area coverage indices of abundance.
- As part of the model building exercise, consider summarizing the information about mortality rates and trends in stock size using a survey-only assessment model such as SURBA.
- It would be informative if increased inspection and analysis of survey data be conducted prior to inclusion of these data in future assessments. Examples of the analyses that could be undertaken include:
 - Routine internal estimates of variance of annual survey estimates.
 - Inspection of relationships between age i and age $i+1$ within individual surveys to ensure cohorts are tracked – such analyses may help identify which ages to include in a plus group.
 - Inspection of correlations among different surveys to examine information content of individual surveys.
- Given the high uncertainty in the conversion factors between the Albatross IV – Henry B. Bigelow survey series, it would be desirable to use methods that do not rely on these conversion factors as soon as the length of the Bigelow time series permits.

It would be helpful for future assessments if spatial plots of survey landings by year for the two stock areas combined (NEFSC Spring and Fall Surveys) could be plotted and presented in the assessment report.

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8. Appendix 2: CIE Statement of Work

55th Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC): Benchmark stock assessments for Georges Bank cod and Gulf of Maine cod

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

BACKGROUND

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

SCOPE

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 purpose of this panel review meeting will be to provide an external peer review of stock assessments for Georges Bank cod and Gulf of Maine cod. Atlantic cod, *Gadus morhua*, is a demersal gadoid species found on both sides of the North Atlantic. In U.S. waters, cod are assessed and managed as two stocks: Gulf of Maine, and Georges Bank and southward. Both stocks support important commercial and recreational fisheries. The last peer reviewed benchmark assessment of Gulf of Maine cod was in 2010 as part of SARC 53. The last peer reviewed assessment update of Georges Bank cod took place in 2012. The SARC 55 review panel will be composed of three independently appointed reviewers, and an independent chair from the Science and Statistical Committee (SSC) of the New England or MidAtlantic Fishery Management Council. The SARC panel will write the SARC Summary Report and each reviewer will write an individual independent review report. This review determines whether the scientific

assessments are adequate to serve as a basis for developing fishery management advice. Results provide the scientific basis for fishery management in the northeast region.

OBJECTIVES

The SARC review panel will be composed of three appointed reviewers from the Center of Independent Experts (CIE), and an independent chair from the SSC of the New England or MidAtlantic Fishery Management Council. The SARC panel will write the SARC Summary Report and each CIE reviewer will write an individual independent review report.

Duties of reviewers are explained below in the “**Requirements for CIE Reviewers**”, in the “**Charge to the SARC Panel**” and in the “**Statement of Tasks**”. The stock assessment Terms of Reference (ToRs) are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**. The SARC Summary Report format is described in **Annex 4**.

Requirements for the reviewers: Three reviewers shall conduct an impartial and independent peer review of the Georges Bank cod and Gulf of Maine cod stock assessments, and this review should be in accordance with this SoW and stock assessment ToRs herein. The reviewers shall have working knowledge and recent experience in the application of modern fishery stock assessment models. Expertise should include statistical catch-at-age, state-space and index methods. Reviewers should also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Reviewers should have experience in development of Biological Reference Points that includes an appreciation for the varying quality and quantity of data available to support estimation of Biological Reference Points. SARC 55 will address fishery stock assessments of Georges Bank cod and Gulf of Maine cod, therefore familiarity with forward projecting models and estimation used for North Atlantic stocks including cod stocks off North America and Europe is desirable.

PERIOD OF PERFORMANCE

The period of performance begins on the award date, and the contractor shall complete the tasks and deliverables as specified in this statement of work. Each reviewer’s duties shall not exceed a maximum of 16 days to complete all work tasks of the peer review described herein.

Not covered by the CIE, the SARC chair’s duties should not exceed a maximum of 16 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).

PLACE OF PERFORMANCE AND TRAVEL

Each reviewer shall conduct an independent peer review during the panel review meeting scheduled in Woods Hole, Massachusetts during December 3-7, 2012.

STATEMENT OF TASKS

Charge to SARC panel: During the SARC meeting, the panel is to determine and write down whether each stock assessment Term of Reference (ToR) of the SAW (see **Annex 2**) was or was not completed successfully. 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. **If alternative assessment models and model assumptions are presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted.** Where possible, the SARC chair shall identify or facilitate agreement among the reviewers for each stock assessment Term of Reference of the SAW.

If the panel rejects any of the current BRP or BRP proxies (for B_{MSY} and F_{MSY} and MSY), the panel should explain why those particular BRPs or 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 or BRP proxies are the best available at this time.

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

Tasks prior to the meeting: The contractor shall independently select qualified reviewers that do not have conflicts of interest to conduct an independent scientific peer review in accordance with the tasks and ToRs within the SoW. Upon completion of the independent reviewer selection by the contractor's technical team, the contractor shall provide the reviewer information (full name, title, affiliation, country, address, email, and FAX number) to the COR, who will forward this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The contractor shall be responsible for providing the SoW and stock assessment ToRs to each reviewer. The NMFS Project Contact will be responsible for providing the reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact will also be 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 COR prior to the commencement of the peer review.

Foreign National Security Clearance: The reviewers shall participate during a panel review meeting at a government facility, and the NMFS Project Contact will be responsible for obtaining the Foreign National Security Clearance approval for the reviewers who are non-US citizens. For this reason, the reviewers shall provide by FAX (not by email) the requested information (e.g., first and last name, contact information, gender, birth date, country of birth, country of citizenship, country of permanent residence, whether there is dual citizenship, passport number, country of passport) 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/>.

Pre-review Background Documents and Working Papers: Approximately two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at

an FTP site) to the SARC chair and CIE reviewers the necessary background information and reports (i.e., working papers) for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the COR on where to send documents. The reviewers are responsible only for the pre-review documents that are delivered to the contractor in accordance to the SoW scheduled deadlines specified herein. The reviewers shall read all documents deemed as necessary in preparation for the peer review.

Tasks during the panel review meeting: Each reviewer shall conduct the independent peer review in accordance with the SoW and stock assessment ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and contractor.** 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 stock assessment ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

(SARC chair)

Act as chairperson, where duties include control of the meeting, coordination of presentations and discussions, making sure all stock assessment Terms of Reference of the SAW are reviewed, control of document flow, and facilitation of discussion. For each assessment, review both the Assessment Report and the draft Assessment Summary Report. The draft Assessment Summary Report is reviewed to assure that it is consistent with the outcome of the peer review, particularly statements that address stock status and assessment uncertainty.

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. If alternative assessment models and model assumptions are presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted. From a reviewer's point of view, determine whether each stock assessment 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 or BRP proxy to be inappropriate, the reviewer should try to recommend an alternative, should one exist. Review both the Assessment Report and the draft Assessment Summary Report. The draft Assessment Summary Report is reviewed to assure that it is consistent with the outcome of the peer review, particularly statements that address stock status and assessment uncertainty.

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.

Tasks after the panel review meeting:

SARC CIE reviewers:

Each CIE reviewer shall prepare an Independent CIE Report (see **Annex 1**). This report should explain whether each stock assessment 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 alternative assessment models and model assumptions were presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted.

If any existing Biological Reference Points (BRP) or their 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 stock assessment 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 stock assessment 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 (see **Annex 4**).

SARC chair and CIE reviewers:

The SARC Chair, with the assistance from the CIE reviewers, will prepare the SARC Summary Report. Each CIE reviewer and the chair will discuss whether they hold similar views on each stock assessment 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 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 SARC 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 4** for information on contents) should address whether each stock assessment 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. If alternative assessment models and model assumptions were presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted. The Report should also include recommendations that might improve future assessments.

If any existing Biological Reference Points (BRP) or 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).

DELIVERY

Each reviewer shall complete an independent peer review report in accordance with the SoW. Each reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. Each reviewer shall complete the independent peer review addressing each stock assessment ToR listed in **Annex 2**.

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

- 1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
- 2) Participate during the panel review meeting at the Woods Hole, Massachusetts during December 3-7, 2012 (Tuesday through Saturday).
- 3) Conduct an independent peer review in accordance with this SoW and the assessment ToRs (listed in **Annex 2**).
- 4) No later than December 21, 2012, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shrivani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Die ddie@rsmas.miami.edu. Each

CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each assessment ToR in **Annex 2**.

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

October 12, 2012	Contractor sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
November 19, 2012	NMFS Project Contact will attempt to provide reviewers the pre-review documents
December 3-7, 2012	Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA
December 7, 2012	SARC Chair and CIE reviewers work at drafting reports during meeting at Woods Hole, MA, USA
December 21, 2012	Reviewers submit draft independent peer review reports to the contractor's technical team for independent review
December 21, 2012	Draft of SARC Summary Report, reviewed by all CIE reviewers, due to the SARC Chair *
December 28, 2012	SARC Chair sends Final SARC Summary Report, approved by CIE reviewers, to NEFSC contact (i.e., SAW Chairman)
January 3, 2013	Contractor submits independent peer review reports to the COR who reviews for compliance with the contract requirements
January 6, 2013	The COR distributes the final 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 approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on substitutions. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: The deliverables shall be the final peer review report from each reviewer that satisfies the requirements and terms of reference of this SoW. The contract shall be successfully completed upon the acceptance of the contract deliverables by the COR based on three performance standards:

- (1) each report shall be completed with the format and content in accordance with **Annex 1**,
- (2) each report shall address each stock assessment ToR listed in **Annex 2**,
- (3) each report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Upon the acceptance of each independent peer review report by the COR, the reports will be distributed to the NMFS Project Contact and pertinent NMFS science director, at which time the reports will be made publicly available through the government's website.

The contractor shall send the final reports in PDF format to the COR, designated to be William Michaels, via email William.Michaels@noaa.gov

Support Personnel:

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Key Personnel:

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Annex 1: Format and Contents of Independent Peer Review Report

1. The independent peer review 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 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 ToR of the SAW was completed successfully. For each ToR, the Independent Review Report should state why that ToR was or was not completed successfully. To make this determination, the SARC chair and reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice. If alternative assessment models and model assumptions were presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted.
 - a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and 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 independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not others read the SARC Summary Report. The independent report shall be an independent peer review of each ToR, and shall not simply repeat the contents of the summary report.
3. The reviewer report shall include the following appendices:
 - Appendix 1: Bibliography of materials provided for review
 - Appendix 2: A copy of this Statement of Work
 - Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: 55th SAW/SARC Stock Assessment Terms of Reference

A. Gulf of Maine cod stock

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data and take into account the recommendations and subsequent work from the March 2012 MRIP workshop. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.
2. Present the survey data and calibration information being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Consider model-based (e.g. GLM) as well as design-based analyses of the survey data in developing trends in relative abundance. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.
3. Summarize the findings of recent workshops on stock structure of cod of the Northeastern US and Atlantic Canada.
4. Investigate the evidence for natural mortality rates which are time- and/or age-specific. If appropriate, integrate these into the stock assessment (TOR 5).
5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Consider feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets, and whether to use domed or flat selectivity-at-age for the NEFSC surveys. Provide a summary of steps in the model building process. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.
6. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY} , $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. Consider alternative parametric models of the stock recruitment relationship. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and any “new” (i.e., updated, redefined, or alternative) BRPs.
7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.
 - a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

- b. Then use the newly proposed model and evaluate stock status with respect to “new” BRPs (from Cod TOR-6).
- 8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
 - a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F , and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
 - b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
 - c. Describe this stock’s vulnerability (see “Appendix to the SAW TORs”) to becoming overfished, and how this could affect the choice of ABC.
- 9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

B. Georges Bank cod stock

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data and take into account the recommendations and subsequent work from the March 2012 MRIP workshop. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.
2. Present the survey data and calibration information being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Consider model-based (e.g. GLM) as well as design-based analyses of the survey data in developing trends in relative abundance. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.
3. Summarize the findings of recent workshops on stock structure of cod of the Northeastern US and Atlantic Canada.
4. Investigate the evidence for natural mortality rates which are time- and/or age-specific. If appropriate, integrate these into the stock assessment (TOR 5).
5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Consider feasibility of survey catchability estimates, the starting year for the assessment, estimation of the stock recruitment curve, inclusion of multiple fleets, and whether to use domed or flat selectivity-at-age for the NEFSC surveys. Provide a summary of steps in the model building process. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.
6. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY} , $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. Consider alternative parametric models of the stock recruitment relationship. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and any “new” (i.e., updated, redefined, or alternative) BRPs.
7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.
 - a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
 - b. Then use the newly proposed model and evaluate stock status with respect to “new” BRPs (from Cod TOR-6).

8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
 - a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F , and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
 - b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
 - c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.
9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

Annex 2 (cont.):

Appendix to the Assessment TORs:

Explanation of “Acceptable Biological Catch” (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009):

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, $OFL \geq ABC$.*]

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)

Explanation of “Vulnerability” (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009):

“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)

Rules of Engagement among members of a SAW Assessment Working Group:

Anyone participating in SAW assessment working group meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting. Source code for NOAA Toolbox programs is available on request. These measures allow transparency and a fair evaluation of differences that emerge between models.

Annex 3: DRAFT Agenda (NOTE: Order of Topics in the final agenda is likely to change)

**55th Northeast Regional Stock Assessment Workshop (SAW 55)
Stock Assessment Review Committee (SARC) Meeting**

December 3-7, 2012

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

Draft AGENDA* (version: 3 Oct. 2012)

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR
<u>Monday, Dec. 3</u>			
1 – 1:30 PM			
Welcome	James Weinberg , SAW Chair		
Introduction	Patrick Sullivan , SARC Chair		
Agenda			
Conduct of Meeting			
1:30 – 3:30	Assessment Presentation (A. GOM cod) Mike Palmer	TBD	TBD
3:30 – 3:45	Break		
3:45 – 6	Assessment Presentation (A. GOM cod) Mike Palmer	TBD	TBD
<u>Tuesday, Dec. 4</u>			
9 – 10:45	SARC Discussion w/ presenters (A. GOM cod) Patrick Sullivan , SARC Chair		TBD
10:45 – 11	Break		
11 – 12:15	Assessment Presentation (B. GBK COD) Loretta O'Brien	TBD	TBD
12:15 – 1:30	Lunch		
1:30– 3:45	(cont.) Assessment Presentation (B. GBK COD) Loretta O'Brien	TBD	TBD
3:45 – 4	Break		
4 – 5:45	SARC Discussion w/ presenters (B. GBK COD)		

	Patrick Sullivan, SARC Chair	TBD
7	social event --location	TBD

Wednesday, Dec. 5

9 - 11	Revisit w/ presenters (A. GOM cod) Patrick Sullivan, SARC Chair	TBD
11 – 11:15	Break	
11:15 – 12:30	Revisit w/ presenters (B. GBK COD) Patrick Sullivan, SARC Chair	TBD
12:30 – 1:45	Lunch	
1:45 – 2:15	(cont.) Revisit w/ presenters (B. GBK COD) Patrick Sullivan, SARC Chair	TBD
2:15 -2:30	Break	
2:30 – 5:30	Review/edit Assessment Summary Report (A. GOM cod) Patrick Sullivan, SARC Chair	TBD

Thursday, Dec. 6

9 - 12	Review/edit Assessment Summary Report (B. GBK COD) Patrick Sullivan, SARC Chair	TBD
12 – 1:15	Lunch	
1:15 – 5	SARC Report writing. (closed meeting)	

Friday, Dec. 7

9:00 - 3 PM	(cont.) SARC Report writing. (closed meeting)
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*All 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 Working Group 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.

If alternative assessment models and model assumptions were presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted.

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

2.

If any existing Biological Reference Points (BRP) or BRP proxies are considered inappropriate, include recommendations and justification for alternatives. If such alternatives cannot be identified, then indicate that the existing BRPs or BRP proxies 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 assessment 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.

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

Chairman:

Dr. Patrick J. Sullivan,

Chair of the Committee, New England Fisheries Management Council's Scientific and Statistical Committee and Cornell University, Ithaca, New York, USA.

Review Panel members appointed by the CIE.

Dr. Noel G. Cadigan

Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute of Memorial University, St. John's Newfoundland, Canada.

Dr. John Casey

Cefas, Lowestoft, Suffolk, United Kingdom NR33 0HT

Dr. Steven Homes

Marine Scotland, Aberdeen, Scotland.