C.I.E. Review Report
of
SAW 33 SARC Meeting
Woods Hole, 25 June – 29 June, 2001

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Note
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33rd Northeast Regional Stock Assessment Workshop (SAW-33)
Stock Assessment Review Committee (SARC) Meeting
Woods Hole, 25 June – 29 June, 2001
CIE Review Report

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1. Executive summary
   a) Impetus and goals for the review
      The SARC Meeting reviewed the stock assessments for the Gulf of Maine cod, the white hake and redfish stocks and the use of production models in estimating reference points consistent with the provisions of the SFA. The outcomes of this SARC meeting are to be reported in two documents, the SARC Consensus Summary of Assessments and the draft Advisory Report on Stock Status. This CIE Review Report discusses the assessments, the adequacy of the review and its resultant findings, and examines opportunities for improving future assessments.
   b) Main conclusions and recommendations
      i. The assessments indicate that the Gulf of Maine cod and redfish stocks are depleted and that exploitation should be constrained to allow recovery.
      ii. The quality of the input data for white hake hampered the assessment for this stock. However, the current exploitation of the older fish appeared excessive and the current biomass of these fish appeared inadequate, thus exploitation of white hake should be constrained to allow the stock to rebuild.
      iii. The programs for sampling commercial landings at ports and sea sampling of commercial catches (including discards) require review and enhancement to ensure that samples are both adequate and representative. Catches are likely to decline further if the recommendations of the SARC are implemented, and the sampling regimes will need to be robust with respect to reduced catches.
      iv. For white hake, an improved sea sampling program is required to obtain more precise estimates of the species composition of the landings and thus to accurately estimate the landings of that species.
      v. A recommendation should be forwarded to the Fishery Management Council that critical reference points should be expressed in a form that is both model and data independent, thus avoiding specification of absolute values, which of necessity are both model and data dependent. Thus, these critical reference points might be expressed as specific values of the ratios of the estimated biomass to the estimated B_{MSY} and

of the estimated fishing mortality to the estimated F_{MSY}. All estimates would then be derived using the same model and data, but the structure of the model would not be specified.

vi. Fishers should be encouraged to improve the quality of the Vessel Trip Report data, and scientists should assess whether those data are consistent with stock assessments derived from fishery-independent data.

vii. Alternative models, that are more robust to the white hake data than the VPA, should be developed to assess the white hake fishery and to reflect the uncertainty associated with misidentification of the species composition of the younger fish.

viii. Further investigation should be undertaken of the impact on the assessments of imprecision in estimates of the age composition of the annual catches, noting that sampling in recent years appears to have been inadequate.

ix. Improved methods to communicate the uncertainty of alternative assumptions and of parameter estimates should be investigated. In particular, methods that may be used to determine the appropriate management advice given this uncertainty should be identified. Consideration should be given to the presentation of advice in the context of probability of outcome and risk.

x. It would be useful for the stock assessments to receive external peer review and feedback, with sufficient time for re-assessment (to incorporate advice arising from the external peer review) and internal peer review, before background documents (that address all terms of reference) are presented to the SARC.

c) Interpretation of the findings with respect to conclusions and management advice

Gulf of Maine cod

Although the biomass of the stock has increased over recent years, due to the relatively strong 1998 year class, it is still very depressed, with the estimated biomass lying well below B_{msy}. The current level of exploitation is high at around 48% per annum, and the estimated fishing mortality is well above F_{msy}.

White hake

The abundance indices for fish with lengths greater than 60 cm indicated that, by 1999, the biomass of these fish had been reduced considerably from the levels observed in the 1970s. The level of exploitation in the 1980s and 1990s had increased considerably from the levels seen in the 1970s. Indices of total biomass had also been reduced to very low levels.

Redfish

By the 1980s, the estimated biomass of the Acadian redfish stock had been reduced to very low levels compared with the estimated initial biomass. However, exploitation in the 1990s was considerably lower than that estimated for the three preceding decades, and the biomass in 2001 was approximately 33% of the biomass at MSY while the current level of F was around 5% of F_{msy}. It must be noted that the current age structure of the stock is biased towards the younger age classes. As redfish are long-lived and slow growing, rebuilding the stock to the required level and age structure is likely to be a slow process.

2. Introduction

a) Background

The SARC last reviewed Gulf of Maine cod in 1998 (SAW 27), white hake in 1998 (SAW 28), and redfish in 1992 (SAW 15). The stocks of each of these three demersal species had declined, and for each, the goal of fishery managers had been to reduce fishing mortality, thus allowing the stock to re-build. The new assessment was required to review the current state of each stock and the current level of fishing mortality, and to determine appropriate recommendations for future management.

When setting the initial critical reference points for management, $F_{Threshold}$ and $B_{Threshold}$, values from surplus production models had been chosen. Recognizing that these reference points were model dependent, the Methods Working Group had explored the use, limitations, and associated uncertainties of such reference points derived from surplus production models, and ways to estimate approximately equivalent reference points using more complex models.

The Assessment Group and the Methods Working Group had met prior to the SARC Meeting, to determine the advice that would be presented to the SARC. Details of these earlier meetings are given in the table, below.

ASSESSMENT GROUP	**CHAIR**	**SPECIES**	**MEETING DATE AND PLACE**
SAW Northern Demersal Subcommittee	Ralph Mayo	GOM cod redfish white hake	May 14 -18 - NEFSC, Woods Hole, MA
Methods Working Group	Paul Rago		• April 23 - NEFSC, Woods Hole, MA • May 3 - NEFSC, Woods Hole, MA • May 11 - NEFSC, Woods Hole, MA • May 22-24 - NEFSC, Woods Hole, MA • June 1 - NEFSC, Woods Hole, MA

b) Terms of reference

Prior to the review meeting, the SARC was advised that

"The species/stocks to be addressed during SAW-33 are:

Gulf of Maine Cod
Redfish
White Hake

Draft Terms of reference for these stocks are as follows:

(A) Gulf of Maine Cod

** Update the status of the Gulf of Maine cod stock, providing, to the extent practicable, estimates of fishing mortality and stock size. Characterize uncertainty in estimates.*

** Provide updated estimates of biological reference points (biomass and fishing mortality targets/thresholds), or appropriate proxies, based on available population data.*

** Provide projections of biomass in 2002 and 2003 and catch in 2002 under various fishing mortality rate options.*

(B) White Hake:

** Update the status of the white hake stock, providing, to the extent practicable, estimates of fishing mortality and stock size. Characterize uncertainty in estimates.*

** Provide updated estimates of biological reference points (biomass and fishing mortality targets/thresholds), or appropriate proxies, based on available population data.*

** Provide projections of biomass in 2002 and 2003 and catch in 2002 under various fishing mortality rate options.*

(C) Redfish:

** Update the status of the redfish stock, providing, to the extent practicable, estimates of fishing mortality and stock size. Characterize uncertainty in estimates.*

** Provide updated estimates of biological reference points (biomass and fishing mortality targets/thresholds), or appropriate proxies, based on available population data.*

** Provide updated indices of relative abundance and biomass, based on appropriate research vessel survey series.*

(D) Production Modeling:

** Evaluate the use of production models in providing estimates of biomass and yield targets and thresholds consistent with the provisions of the SFA.*

** Provide guidance on the use and limitations of production model results for establishing management goals.*

** Evaluate various types of production models (age/stage structured, non-equilibrium, etc.) and provide guidance on the use of model types in differing circumstances of data availability, exploitation history and length of time series.*

** Compare estimates of MSY, Fmsy and Bmsy from production models with those based on catch-at-age model results as a basis for understanding biases, stability and precision of such estimated parameters.*

** Provide updated estimates of biological reference points (biomass and fishing mortality targets/thresholds), or appropriate proxies, based on available population data.*

** Provide projections of biomass in 2000 and 2001 and catch in 2000 under various fishing mortality rate options*".

c) Panel membership (as identified in documents circulated prior to the SARC meeting)

SAW-33 SARC Chairman
Patrick J. Sullivan, CIE (Cornell University)
Experts from the NEFSC
Jon Brodziak
Steve Cadrin
Michael Fogarty
Josef Idoine
Bill Overholtz
NMFS Northeast Regional Office
John Witzig
New England Regional Fishery Management Council
Andrew Applegate
Atlantic States Marine Fisheries Commission
Jim Armstrong, NC Division of Marine Fisheries
Kevin Kelly, Maine Department of Marine Resources
Other laboratories, research institutions, and academia
Norman Hall, CIE (Murdoch University)
Bob Mohn, BIO - DFO, Halifax
Donald Power, DFO, St. Johns
Michael Prager (NOAA/NMFS/SEFSC)
Peter A. Shelton, DFO, St. Johns
Carl Bouchard, NEFMC Industry Representative
Maggie Raymond, NEFMC Industry Representative

d) Date and place
The Stock Assessment Review Committee (SARC) Meeting for the 33rd Northeast Regional Stock Assessment Workshop (SAW-33) was held in the Aquarium Conference Room, NEFSC Woods Hole Laboratory, Woods Hole, Massachusetts, from 25 - 29 June 2001.

e) Acknowledgements
The meeting was organized and coordinated by Dr Terry Smith, SAW Chairman, and Pie Smith, SAW Coordinator. The staff of the NEFSC, and in particular, Ralph May, Paul Rago, Katherine Sosebee, played an essential role in presenting details of the assessments and undertaking further analyses, in acting as rapporteurs, and in preparing the drafts of the reports produced by the SARC. Without this support, the meeting would not have been successful.

3. Summary of available information
A summary of the various data sets, that were available for use in the assessment of the three stocks, is provided in the table below.

Data	**Gulf of Maine cod**	**Redfish**	**White hake**
Annual commercial landings	From 1960 to 2000	From 1934 to 2000	• From 1964 to 2000 • Quality affected by species misidentification (with red hake)
Discards from commercial catches	• Estimated for 1989-2000 from NEFSC Sea Sample data • Inadequate sample data for recent years • Estimated for 1999-2000 from VTR data • Estimated for 1999-2000 from economic model using 1996-97 VTR data	Not available	From 1989 to 2000
Recreational landings	• From Marine Recreational Fishery Statistics Surveys for 1979-2000 • From Party/Charter Vessel VTR data for 1995-2000	Not available	Insignificant (<0.1 mt per year)
Discards from recreational catches	• From Marine Recreational Fishery Statistics Surveys for 1979-2000 • Assumed to have no discard mortality	No information	Insignificant

Length composition of commercial landings	• Available from commercial port sampling for 1982 to 2000 • Sampling of market categories has been poor and unrepresentative in recent years, particularly for large cod in 2000	• Landings sampled from 1969 to 2000 • Sampling of market categories has been poor since 1994	• Landed headed and gutted • Regression from dorsal-caudal fin length to total length used • Poor samples in 1989 and 1995 • Poor samples of unclassified market category in recent years
Length composition of commercial discards	• Prior to 1998, discarded cod were mainly small fish below the legal minimum size • Size distribution of discarded cod likely to have been affected by trip limits in 1999-2000 • Assumed that size composition of discards in 1999-2000 was same as that of commercial landings	No information	• Inadequate sampling of sink gill nets • Poor samples in 1997 to 1999
Length composition of recreational landings	• Sampled from Marine Recreational Fishery Statistics Surveys for 1981-2000 • Low sampling intensity	No information	Insignificant
Length composition of recreational discards	• Not available • Intercept sampling is unlikely to be representative of discarded catch	No information	Insignificant
Age composition of commercial landings	• From 1982 to 2000 • Sampling of market categories has been poor and unrepresentative in recent years, particularly for large cod in 2000	• Data available for 1969 to 1985 • Age samples collected in 1970-71 and 1973-1991 • Aging ceased after 1985	• From 1985 to 2000 • Landed headed and gutted • Otolith samples not available from market samples. • Age-length keys from research samples were used.
Age composition of commercial discards	Assumed that size composition of discards in 1999-2000 was the same as that of commercial	No information	• From 1989 to 2000 • Inadequate

	landings		sampling of sink gill nets • Poor samples in 1997 to 1999. Age-length keys from research samples were used.
Age composition of recreational landings	Used age-length keys from commercial landings plus age samples from NEFSC surveys for cod < 40 cm.	No information	Insignificant
Age composition of recreational discards	Not available.	No information	Insignificant
Commercial landings per unit of effort (LPUE)	• Calculated for 1965 to 1996 • Efficiency of fishing effort affected by management decisions (*e.g.*, closures) from 1997	• From 1942 to 1989 • Based on directed trips (50% redfish) • Decline in catches precludes calculation from 1989	• Not calculated • Efficiency of fishing effort affected by management decisions (*e.g.*, closures)
Commercial fishing effort	For 1965 to 1996	For 1942 to 1989	Not calculated
Survey indices of abundance and biomass	• NEFSC autumn survey from 1963 • NEFSC spring survey from 1968 • NEFSC data adjusted for vessel and door effects • MA Division of Marine Fisheries inshore spring survey from 1978 • MA Division of Marine Fisheries inshore autumn survey from 1978	• NEFSC autumn survey from 1963 • NEFSC spring survey from 1968	• NEFSC autumn survey from 1963, but gear problem in 1982 • NEFSC spring survey from 1968 • No vessel, door or gear effects for NEFSC data • MA spring survey from 1978 • MA autumn survey from 1978 • ASMFC summer shrimp survey from 1986 to 2000 • During the SARC meeting, an index of the abundance of fish > 60 cm was calculated from the NEFSC autumn survey
Survey indices of abundance and biomass at length	Not presented	• NEFSC autumn survey from 1963 • NEFSC spring	Not presented

		survey from 1968 • NEFSC shrimp surveys from 1985 to 1999	
Survey indices of abundance and biomass at age	• NEFSC autumn survey from 1963 • NEFSC spring survey from 1968 • NEFSC data adjusted for vessel and door effects • MA Division of Marine Fisheries inshore spring survey from 1978 • MA Division of Marine Fisheries inshore autumn survey from 1978	• NEFSC autumn survey from 1975 to 2000 • NEFSC spring survey from 1975 to 1990	• NEFSC autumn survey from 1982 • NEFSC spring survey from 1982 • ASMFC summer shrimp survey for 1989-90 and 1995-2000
Concentration indices	For NEFSC autumn survey data from 1963 to 2000	Not available	Not available
Natural mortality	M = 0.2 year^{-1}	• M = 0.05 year^{-1} • Assumption based on maximum age	• M=0.2 year^{-1} • Assumption based on maximum age
Proportion mature at age	Available	Available	Available
Day/night comparison of survey indices	Not available	NEFSC data examined for 1992-2000	Not available
Inshore-offshore comparison of survey indices	For NEFSC autumn survey data from 1963	For NEFSC autumn survey data from 1963	Not available
Index of exploitation	Not available	Calculated from ratio of NEFSC biomass index to total commercial landings for 1963 to 2000	• Not available before SARC meeting. • During the meeting, for fish > 60 cm, the ratio of the survey biomass index to catch was calculated
VPA	Available	Analyses available from earlier assessments till 1986	Available
Age-structured dynamics model	Not available	Fitted using catch data from 1934 to 2000	Not available
Yield and spawning stock	Available	Available	Not available before SARC meeting

biomass per recruit			
Biomass dynamics model	Available	Available	Not available
Short term projections	Not available before meeting, but assessed at the SARC meeting	Not available before SARC meeting	Not available before SARC meeting
Long term projections	Not available before meeting, but assessed at the SARC meeting	Not available before SARC meeting	Not available before SARC meeting

4. Review of information used in the assessment
   A considerable body of scientific literature exists for the stocks that were assessed. While I have commented on the specific information (or lack thereof) that was explicitly presented in the background documents, information reported in these other studies was certainly used in the assessments. The background documents present a summary of the scientific basis for the assessments, however it is recognized that the assessments will have drawn on the full set of knowledge available for each species.

Gulf of Maine cod

a) Stock structure
   The issue of stock identity was not discussed explicitly in the materials provided, other than to identify the stock as those Atlantic cod, *Gadus morhua*, in NAFO Division 5Y. Cod catches from the Gulf of Maine stock are identified using information on the location of capture, however Canadian landings that had previously been reported as Gulf of Maine cod are now considered by Canadian scientists to be misreported catches from the Scotian shelf stock. The Gulf of Maine stock is considered to extend along the Maine coast from Massachusetts Bay to the Bay of Fundy. The SAW assessment report noted that the Gulf of Maine cod are distinguished from those on Georges Bank by a slower rate of growth and later age of sexual maturity.
b) Life history data
   No details of the distribution of adult fish at the time of spawning, the season of spawning, or the distribution of settling and juvenile fish, were provided (Background Document A1).
   Natural mortality
   The instantaneous rate of natural mortality, *M*, was assumed to be 0.20 year^{-1}. This assumption was supported by citation of the studies by Paloheimo and Koeler (1968), Pinhorn (1975), and Minet (1978). No estimates were provided of the 95% confidence limits for *M*.
   Sex ratio
   Males and females are assumed to be in equal proportions at each age (Background Document A1, Appendix 3, page 7).
   Age at maturity
   A table of the percentage of females that are mature at each age was provided in the listing of the VPA results (Background Document A1, Appendix 3, page 6). The table indicates that the percentage maturity at age has changed over time, and the data suggests that reviews have occurred irregularly in or

prior to 1982, in 1985, 1990 and 1994. Recently, the age at 50% maturity appears to have been about 2.2 years, while approximately 95% of the female cod are mature by about 3.3 years. No details of the reproductive studies were provided in the background documents presented to the SARC.

Fecundity

No estimates of fecundity appear to be available. It appears from the VPA listing (Background Document A1, Appendix 3, pages 5-7) that spawning stock biomass is calculated as a proxy for fecundity. This appears to be estimated as the product of the January 1 biomass estimate and the female percentage mature at age, noting that males and females are assumed to be in equal proportions at age.

Growth

Details of studies that validated the methods used to age cod were not identified (Background Document A1). While parameters of growth curves were not provided, details of the mean length at age from samples of the commercial and recreational catches were provided (Background Document A1, Tables A9b, A10b, and A13b). Both data sets provide biased estimates of the mean length at age within the stock due to partial recruitment and hence non-random sampling of the stock by fishers.

c) Catch data

The total quantity of fish removed from the stock as a result of fishing, that should be considered when assessing the stock, must include both landings and those discards that die following release. The "catch" is estimated as the combined total of the commercial and recreational landings of cod and the fraction of the discards of cod from each fishing sector that will die as a result of their capture and subsequent discard. Thus, projected "catches" include the estimated quantities of cod that are killed through discard, and projected landings must allow for the portion of the catch that is discarded.

Estimates of total commercial landings of Gulf of Maine cod are available from 1960. The data from 1960 to 1993 were based on reports of landings supplied voluntarily by processors and dealers, supported by data on fishing effort and location obtained through interviews of fishers by port agents for a subset of trips. From 1994, the data were collected from mandatory vessel trip reports (VTRs) supplied by dealers. Despite problems associated with stock identity for some earlier data, these data were considered to be both accurate and complete.

Fishers provide the details of the locations from which catches have been taken. Accordingly, the fishers determine the quality of the data that are supplied. Prior to 1994, such data were obtained for a subset of trips by interviews of fishing captains conducted by port agents. It was noted (Background Document A1) that Canadian landings between 1977 and 1990, which were reported as Gulf of Maine catches, were believed to be misreported catches from the Scotian Shelf stock. The mandatory logbook reports that had been submitted since 1994 required that details of catch locale be specified. Limited validation of the accuracy of the reported locations from which the catches had been taken was possible. Results of studies of fish concentration and of the shift in distribution of cod from offshore to inshore waters suggest that details of fishing location may become increasingly important to the stock assessments for the fishery.

The fish captured during fishing operations may be retained and ultimately landed or may be discarded. For commercial fishers, discards have resulted from poor fish quality, minimum size regulations and trip limits, where the latter may also have led to "high-grading". For recreational fishers, fish discards result from minimum size regulations. Those discarded fish that fail to survive capture and discard are removed from the stock. It has been assumed that all cod discarded by commercial fishers will die, and that all cod discarded by recreational fishers will survive. No justification was provided to support this assumption (Background Document A1), however it was discussed briefly at the SARC meeting and related both to the depth of fishing and methods of capture of the two fishing sectors.

While statistics are readily available for landed catch, statistics on discards rely on fishers' estimates of the quantities of discarded catches, often imprecise as the individual fish are not retained on board but are released immediately, thereby requiring the fisher to estimate the cumulative total of the individual fish that have been discarded. Three methods of estimating discarded catches were explored.

- Estimates of commercial discards are recorded in NEFSC sea sampling data for each quarter, for otter trawl, shrimp trawl and sink gillnet till 1993 and for otter trawl and sink gillnet from 1994. Inadequate sea sampling data for 1999 and 2000, and a temporal resolution in 1999 that failed to match the changes in trip limits that were introduced, resulted in estimates that were considered imprecise and possibly biased. While the discards for earlier years were considered adequate, lack of size and age composition data for these discarded catches prevented their inclusion in the VPA. As these earlier discards resulted from minimum length regulations and from concerns regarding quality of the product, their age and size composition would differ from that of the landed commercial catch.
- Estimates of discarded catches were also determined from vessel trip reports supplied by fishers. While the practice in earlier years is unclear, it appears that in 1999 the software used to enter details of trip reports into the database applied a zero as the default entry for discarded catch rather than a null. As a consequence, the resulting estimates of discards derived from the VTR records may be biased.
- A third estimate of the discarded commercial catches for 1999 and 2000 was determined by Dr Eric Thunberg, by determining the economic consequences of the application of the 1999 and 2000 trip limits if these had been applied to the observed VTR data for 1996 and

1997, thereby estimating the discard to kept ratios that were likely to result from the introduction of the trip limits. These discard to kept ratios were then applied to the landed commercial catches for 1999 and 2000, to estimate the discarded catch that might have occurred.

While estimates of discarded catches for 1999 and 2000 of broadly similar magnitudes were produced by these three methods, the SARC concluded that accurate estimates were unavailable. The SARC proposed a set of alternative values, based on the estimates, to be tested in the assessment procedure, thereby exploring the uncertainty associated with the inaccurate estimates of discards from commercial catches for these two years.

Details of recreational catches and discards of cod have been estimated from the annual Marine Recreational Fishery Statistics Survey. Estimates were available of the retained and discarded catches since 1981.

d) Abundance indices

To avoid high coefficients of variation for the estimates of terminal year stock size, older age classes were combined to form a ‘plus’ group.

The indices of abundance that were used in the VPA are listed below.

Indices of abundance at age	**Related numbers at age**
The mean number per tow from autumn NEFSC stratified trawl surveys (adjusted for vessel and door changes), for ages 2 to 6	The numbers in ages 3 to 7, respectively, in the stock at January 1 in the year following the survey (*i.e.*, lagged by 1 year and 1 age class)
The mean number per tow from spring NEFSC stratified trawl surveys (adjusted for vessel and door changes), for ages 2 to 6	The numbers in the corresponding ages in the stock at January 1 in the year of the survey
The mean number per tow from the spring Massachusetts Division of Marine Fisheries inshore bottom trawl surveys, for ages 2 to 4	The numbers in the corresponding ages in the stock at January 1 in the year of the survey
The mean number per tow from the autumn Massachusetts Division of Marine Fisheries inshore bottom trawl surveys, for ages 1 to 3	The numbers in ages 2 to 4, respectively, in the stock at January 1 in the year following the survey (*i.e.*, lagged by 1 year and 1 age class)
The estimates of LPUE at age derived from commercial landings per unit effort data (from 1982 to 1993), for ages 2 to 6	The numbers in the corresponding ages present in the stock at mid-year

e) Length/age composition

Port sampling was undertaken to provide information on the length and age composition of the commercial landings. Sampling was intended to be stratified by market category and quarter, but sampling in recent years failed to provide adequate coverage of all quarters of the year or of the larger categories of cod landed. The age samples for each market category in each quarter were intended to provide a quarterly age-length key, from which, in combination with the length composition data and the landings for that market category within the quarter, the numbers at age in the landings for each quarter might be derived.

Limited sampling had been undertaken to obtain details of the length composition of the recreational landings of cod. The length compositions were converted to age composition estimates using age-length keys derived from a combination of the commercial landings and of the cod less than 40 cm in length taken in NEFSC bottom trawl surveys.

f) Effort

A time series of estimates of standardized commercial fishing effort, corresponding to a selected "effort sub-fleet", was presented for the period from 1982 to 1993. The introduction of trip limits and rolling closures had impacted on the effort measure, as landings per unit of fishing effort were no longer consistent with those of earlier years. Accordingly, no estimates of fishing effort had been calculated for recent years.

g) Other

Estimates of the concentration of fishing effort on cod had been developed using the Lorenz curve. These concentration indices were consistent with the view that, overall, there had been a contraction of the stock to the inner, western regions of the Gulf of Maine. This change in distribution had implications for catchability in the fishery and was likely to have produced the apparent inconsistency between the survey results and the fishers' perception of the state of the stock. However, the concentration indices also suggested a possible cyclic pattern of increase and decrease (Background Document A1, Figure A11).

White hake

a) Stock structure

All white hake from NAFO sub-areas 5 and 6 were treated as a single stock. The scientific basis for this decision was not presented (Background Document B1), but the approach was consistent with earlier assessments. Discrimination between white hake, *Urophycis tenuis*, and red hake, *Urophycis chuss*, requires examination of the gill rakers from whole fish. Commercial catches from the shallower bays and estuaries often contain a mixture of the two species, but the true catch of white hake cannot be determined as fish are headed at sea. Older white hake tend to be found in deeper water than red hake, however, and the location of capture could be used to identify the catches of white hake.

b) Life history data

No details of the distribution of adult fish at the time of spawning, the season of spawning, or the distribution of settling and juvenile fish, were provided (Background Document B1).

Natural mortality

The instantaneous rate of natural mortality, *M*, was assumed to be 0.20 $year^{-1}$. It was noted that the maximum age, T_{max}, observed in NEFSC samples was 15 years (Background Document B1). Using an assumed maximum age of 20 years, an estimate of total mortality of Z=0.2 year^{-1} was derived from the relationship between total mortality, Z, and T_{max} derived by Hoenig (1983). However, it should be noted that Hoenig subsequently modified the relationship to allow for the effect of sample size. The additional assumption that fishing mortality was negligible, F=0, is neither discussed nor justified (Background Document B1). No estimates were provided of the 95% confidence limits for M.

Sex ratio

Males and females were assumed to be in equal proportions at each age (Background Document B1, Appendix A, page A6).

Age at maturity

A table of the percentage of females that are mature at each age is provided in the listing of the VPA results (Background Document B1, Appendix A, page A5). From this table, the age at 50% maturity appears to be about 2.6 years, while approximately 95% of the female fish are mature by about 4.2 years. No details of the reproductive studies were provided (Background Document B1).

Fecundity

No estimates of fecundity appear to be available. It appears from the VPA listing (Background Document B1, Appendix A) that spawning stock biomass was calculated as a proxy for fecundity. This appears to have been estimated as the product of the January 1 biomass estimate and the female percentage mature at age, noting that males and females were assumed to be in equal proportions at age.

Growth

No details of studies that validated the methods used to age white hake were provided (Background Document B1). While parameters of growth curves were not provided, details of the mean length at age from samples of the commercial landings and otter trawl discards were provided, together with estimates of the mean length at age for the total catch (Background Document B1, Tables B10, B12, and B13). These data sets provide biased estimates of the mean length at age of the stock due to partial recruitment and hence non-random sampling of the stock by fishers.

c) Catch data

Details of commercial landings of "white hake" between 1964 to 2000 from Canada and the U.S.A. were presented (Background Document B1). The US landings were reported by gear type, with the catch in 2000 being taken predominantly by otter trawl (61%) and sink gill net (35%). The recreational catch was negligible. Discarded catches by gear type were estimated from data collected in the Domestic Sea Sampling Program (Background Document B1). Estimates of total catch (landings plus discards) are uncertain due to possible species misidentification in commercial and sea sampling data and limited discard data. To overcome the deficiency associated with species misidentification, catches of fish greater than 60 cm total length (*i.e.*, fish of about 4 years or older) were calculated.

d) Abundance indices

The NEFSC autumn and spring stratified bottom trawl surveys provided the principal time series that were used as indices of abundance for the assessment. Other series used were the spring and autumn surveys undertaken by Massachusetts, and the ASMFC summer shrimp survey.

To overcome the deficiencies of the assessment associated with species misidentification, the NEFSC indices of abundance were also calculated for white hake larger than 60 cm total length.

e) Length/age composition

As commercial landings were comprised of headed and gutted fish, port samples provided measures of dorsal fin to caudal fin lengths, from which total lengths and length compositions were derived. Port samples were stratified by market category, but categories were pooled when sampling intensity was poor. The length composition of the commercial landings was determined from the landings within each market category. The age composition of the commercial catch was then estimated using age-length keys derived from NEFSC survey data, combined with data collected from sea sampling trips. Where data were inadequate, pooled keys were applied.

Insufficient data were available to estimate the length composition of discards for sink gill nets. For otter trawls, the length compositions of the discards were determined from the Domestic Sea Sampling Program. These length compositions were combined with the age-length keys to provide estimates of the age composition of the discards from the otter trawls.

The age compositions of the commercial landings and the otter trawl discards were combined to provide the age composition data used within the VPA.

f) Effort

Commercial landings per unit of effort were not calculated, as recent management regulations were considered likely to have affected the effectiveness of fishing effort. Hence, fishing effort was not estimated.

Redfish

a) Stock structure

No details of stock structure were provided (Background Document C1). However, the assumption was made that the redfish caught in the Gulf of Maine-Georges Bank region are a single stock of Acadian redfish, *Sebastes fasciatus*. These are distinguished from their close congener, the deepwater redfish, *Sebastes mentella*, by anal fin ray counts, parietal spine counts, and by the number of vertebrae (http://www.redfish.de/biology/anatomy-ident.html, July 16, 2001).

b) Life history data

No details of the distribution of adult fish at the time of spawning, the season of spawning, or the distribution of settling and juvenile fish were provided (Background Document C1).

Natural mortality

The instantaneous rate of natural mortality, M, was assumed to be 0.05 year^{-1} (Background Document C1). This estimate was based on the fact that redfish are relatively long-lived and slow growing. Growth studies reported by Mayo *et al*. (1990), as cited in Background Document C1, recorded maximum ages of 50-60 years. No estimates were provided of the 95% confidence limits for M, however the sensitivity of the Age Structured Dynamics Model to values of M ranging from 0.02 to 0.1 year^{-1} was explored in the assessment (Background Document C1, Figure C34).

Sex ratio

No details of the sex ratio were provided (Background Document C1).

Age at maturity

The median age at maturity has been estimated by Mayo *et al*. (1990) and O'Brien *et al*. (1993) to be 5.5 years (as cited in Background Document C1). The relationship between maturation and length was assessed, and suggested a slight trend towards decreasing size at maturity (C1, page 8). The estimated L50s for males ranged from 20.2 to 21.3 cm, and those for females varied from 20.3 cm to 22.6 cm.

Fecundity

No estimates of fecundity appear to be available. It appears from the assessment (Background Document C1) that spawning stock biomass is calculated as a proxy for fecundity.

Growth

While not described in detail, a study by Mayo *et al*. (1981) was cited (Background Document C1), in which the progression of modal lengths and otolith edge formation were used to validate growth rates for deepwater redfish up to age 7. However, no details of the validation of the methods used to age the Acadian redfish were provided (Background Document C1). While parameters of growth curves were not provided, Mayo *et al*. (1990) were cited (Background Document C1) as reporting that the lengths of the fish for which maximum ages of 50 to 60 years were recorded ranged from 45 to 50 cm. The age-structured fishery model developed to describe the Acadian redfish used the mean weights at age as determined from fishery sampling between 1969 and 1985. Growth curves were reported as differing between sexes (Background Document C1, page 3), and thus mean weights were determined using the estimated numbers and landed weights at age calculated for each sex.

c) Catch data

Commercial landings of redfish from the Gulf of Maine-Georges Bank region have been recorded since 1934. The time series of catches removed from the fishery was assumed to be equivalent to the time series of recorded commercial landings. No recreational catches or discards were included.

d) Abundance indices

Commercial landings per unit effort (LPUE) for 1942 to 1989 had been calculated, using the method described by Mayo *et al*. (1979), as cited in Background Document C1, using directed trips (50% redfish), and standardized for vessel tonnage class. The greatly reduced abundance of redfish from 1990 precluded the use of directed trips and calculation of this abundance index for more recent years.

The NEFSC bottom trawl surveys conducted in autumn (since 1963) and spring (since 1968) provided additional indices of abundance and biomass.

e) Length/age composition
Commercial landings had been sampled since 1969. While sampling intensity was sufficient to allow determination of length compositions from 1969 to 1993 and age compositions from 1969 to 1985, subsequent samples proved insufficient to provide estimates of the length or age compositions (Background Document C1). Calculations to estimate the numbers at age and the mean weight at age had been carried out separately for each sex, due to the differences in the growths of the males and females; the resulting estimates had then been combined.

Length compositions had been determined from the 1968 to 2000 spring, 1963 to 2000 summer and 1985 to 1999 shrimp trawl surveys conducted by NEFSC. Otolith samples drawn from the NEFSC survey catches had been used to determine age compositions for the 1975 to 1990 spring surveys, and for the 1975 to 2000 autumn surveys.

f) Effort
Estimated effort was calculated for the period from 1942 to 1989 by dividing the recorded commercial landings by the standardized commercial LPUE.

Methods

a) Overview and graphical and diagnostic measures
It was noted that, while considerable data existed for many of the fisheries assessed by the NEFSC, information content was often limited through lack of contrast and the assessments were complicated by use of multiple gears and lack of information on total removals. Fishing mortality was usually age dependent, yet the resulting estimates of fishing mortality at age were required to be converted to a single measure for comparison with the reference point. The diagnostic plots proposed by the Methods Working Group (Background Document D1) offered insight into the adequacy of surplus production models when fitted to the available data. Caution was urged when applying surplus production modeling techniques to smoothed data. It was also noted that biomass weighted estimates of fishing mortality are sensitive to the transient effects of variable annual recruitment. The Working Group identified that it was "*unlikely that a single model or approach will* [be] *sufficient to capture the underlying dynamics and biological reference points*" for different species, different fisheries, and data sets of varying quality.

b) External surplus production models
By fitting the surplus production models to the best estimates of annual biomass available from other stock assessment models, the resulting surplus production model reflects the full set of data and the assumptions used within

those other models (Background Document D2). These externally estimated surplus production models provide a mapping between the more complex models, such as VPA, and the traditional surplus production modeling approach.

c) Tools for estimating surplus production and F_{MSY} in any stock assessment model
Estimates of MSY and F_{MSY} may be calculated directly (internally) in the more complex stock assessment models (Background Document D3). The Working Group recommended that both internal and external methods should be applied routinely when undertaking stock assessment analyses.

d) Bayesian surplus production models
Use of a Bayesian surplus production model was explored (Background Document D4), and the results were found to offer greater insight into the results from traditional modeling approaches. The assumption of density-dependent catchability was likely to result in imprecise estimates of parameters for the data set analyzed. Similarly, it was unlikely that the estimate of an initial population biomass would differ from the estimate of carrying capacity for this data set. The Working Group suggested that, by including process error, the model would provide a more realistic representation of the uncertainty of estimated quantities.

e) Sensitivity of MSY reference points to recruitment decisions
Estimates of MSY and B_{MSY} were found to be very sensitive to the assumptions made regarding the recruitment model (Background Document D5). However, F_{MSY} was found to be less sensitive to the recruitment assumption.

5. Review of the assessment results
Gulf of Maine cod
a) Methods
The primary method of assessment was Virtual Population Analysis (VPA), using the ADAPT calibration method (Background Document A1). Results of a biomass dynamics model (ASPIC) were also provided (Background Document A1). After considering the alternative estimates of commercial discards, the SARC specified a set of alternative estimates of discarded commercial catches to be explored using the VPA. The results of these runs were considered and the SARC decided to apply discards of 2500 mt and 1000 mt in 1999 and 2000, respectively, as the baseline run for further assessment (Background Document A2). The sensitivity of MSY reference point estimates to different assumptions regarding the form of the stock-recruitment relationship was examined (Background Document A3). The decision was taken to use a Beverton and Holt relationship fitted to VPA estimates of spawning stock biomass from 1982 to 1999 and the estimates of subsequent recruitment. This age-structured production model, based on the Beverton

and Holt stock-recruitment relationship and appropriate estimates of partial recruitment, was then used to determine estimates of B_{msy} and F_{msy} (Background Document A4) that would be consistent with the projections that were being undertaken using the VPA (Background Documents A4 and A5).

b) Abundance
The estimated biomass of cod, for ages 1++ years, appears to have increased slightly from the very low values estimated for 1997 to 1999. The estimated spawning biomass has also shown a slight increase. Much of these increases may be attributed to the relatively strong 1998 year class. The stock is still very depressed, with the estimated biomass lying well below B_{msy}.

c) Fishing mortality
The estimated fishing mortality remains very high, and is well above the level of F_{msy}. While the estimated level of fishing mortality has been reduced from the levels estimated for 1994 to 1996, the current level of exploitation is high at around 48% per annum.

d) Uncertainty
Details of discarded catch are poorly reported and recorded, leading to considerable uncertainty regarding their magnitude, and the mortality and the age composition associated with the discards from each fishing sector. Uncertainty is associated with the age compositions of both the commercial and recreational catches, and with the indices of abundance at age. With the decline in catches, both sampling intensity and representativeness of samples have become less adequate. Uncertainty regarding the future recruitment stream also affects the projections of catch and spawning stock biomass.

e) Projections
While projections were not available prior to the SARC review, further analyses were undertaken during the meeting. The projections required assumptions regarding the current state of the stock, the annual levels of fishing mortality to be applied, and future levels of annual recruitment. It was assumed that the status quo fishing mortality would apply in 2001 (thus determining the short term projection for 2002), but that fishing mortality would then be set at a specified level for subsequent years. A Beverton and Holt stock-recruitment relationship was fitted to the VPA estimates of the 1982-99 year classes, and the resulting relationship was used in generating the long-term projections. With fishing mortality set to $F_{0.1}$, and with the future recruitment stream determined from the Beverton and Holt stock recruitment relationship, the projections suggest that the spawning stock is likely to recover to the level corresponding with MSY within ten years.

White hake

a) Methods
The white hake stock was assessed using a VPA. However, following examination of the results, the review panel concluded that the quality of the data for the younger age classes precluded the use of the VPA for assessment of this stock. To avoid the problems associated with species misidentification, estimates were obtained of the portions of the catches that were of fish larger

than 60 cm (*i.e.*, fish of about 4 years or older), and of the indices of abundance associated with these larger fish. A biomass dynamics (ASPIC) model was fitted to the catch and abundance data for fish with lengths greater than 60 cm (Background Document B2).

b) Abundance
The abundance indices for fish with lengths greater than 60 cm indicated that, by 1999, the biomass of these fish had been reduced considerably from the levels observed in the 1970s. Indices of total biomass had also been reduced to very low levels.

c) Fishing mortality
The ratios of the abundance indices to the catches for fish with lengths greater than 60 cm indicate that the level of exploitation in the 1980s and 1990s had increased considerably from the levels seen in the 1970s.

d) Uncertainty
Considerable uncertainty exists in the estimates of the total catch and of the age composition of the commercial catch due to the difficulties associated with species identification. Examination of the results from the VPA suggest that this model is sensitive to the quality of the input data for the white hake, and accordingly the SARC was unwilling to accept the analysis. The identification of fish greater than 60 cm in length as white hake (*i.e.*, fish of about 4 years or older) was considered relatively reliable. However, the average age at which white hake reach maturity is about 2.6 years, and considerable quantities of small white hake (and misidentified red hake) are caught. The restriction of the assessment to these larger fish ignores the impact of fishing mortality on the smaller white hake, and on the resultant estimates of biomass and of the biomass weighted fishing mortality.

e) Projections
No projections were undertaken, due to the inadequacy of existing models given the quality of the input data.

Redfish

a) Methods
Ratios of the NEFSC autumn survey indices to the commercial landings were calculated to provide estimates of annual exploitation. An age-structured dynamic model (ASDM), using forward projection, was fitted to catch-at-age and abundance-at-age data to represent the fishery from 1934 to 2000 (Background Documents C1 and C2). Yield and spawning stock biomass per recruit were then calculated using partial recruitments determined from the selectivities-at-age estimated by the ASDM. A non-age-structured biomass dynamics model (ASPIC) was also fitted using the NEFSC autumn survey indices.

b) Abundance
By the 1980s, the estimated biomass of the Acadian redfish stock had been reduced to very low levels compared with the estimated initial biomass (Background Document C1, Figures C29 and C34). Subsequently, with recruitment of the 1992 year class, biomass had recovered slightly. The

ASDM produced higher absolute estimates of biomass than the ASPIC model (Background Document C1, Figure C42). The ASDM estimates of biomass for the early portion of the time series were considered rather unreliable and reflected the transient behavior of the model associated with the estimates of the initial state of the stock. While the ASPIC estimates of biomass are possibly biased, the ratio of the current biomass estimate to the estimated biomass at MSY is considered reliable. The ASPIC results suggest that the biomass in 2001 was approximately 33% of the biomass at MSY (Background Document C1, Figure C43).

c) Fishing mortality
The estimates of annual exploitation provided by the ratios of the survey indices of abundance to the landings indicate that exploitation in the 1990s is considerably lower than that estimated for the three preceding decades. While the ASDM produced unreliable estimates of fishing mortality in the 1940s, the estimates for later years from 1963 to 2000 were considered more reliable (Background Document C1, Figure C31). The estimated fishing mortality in the 1990s was considerably lower than in the period from 1963 to 1990. The ASPIC produced similar results. Again, although the absolute level of fishing mortality may be biased, the ratio of the current estimate of fishing mortality to the fishing mortality associated with MSY is considered relatively reliable. The ASPIC results indicated that the current level of F was around 5% of F_{msy}.

d) Uncertainty
- Much of the information related to the virgin stock of redfish is not contained within the data available to current researchers, as catch-at-age and abundance-at-age indices are not available for the early years of the fishery.
- Information on discards has not been incorporated in the assessment.
- Samples of the commercial catch since 1985 are insufficient for estimation of the age compositions of the annual catches.
- Estimates of indices of abundance are imprecise.
- Estimates of length composition and age compositions are imprecise.
- Samples may not be representative of the population, or portion of the population within the stratum.

e) Projections
The ASPIC model has been used to produce estimates of the projected biomass that might result in the absence of fishing mortality and if relatively strong recruitment persisted. Under such conditions, the stock may rebuild to B_{msy} by 2010. However, it must be noted that the current age structure of the stock is biased towards the younger age classes. As redfish are long-lived and slow growing, rebuilding the stock to the required level and age structure is likely to be a slow process.

Methods
The SARC noted that the discussions regarding methodology of stock assessment were among the most interesting sessions at the review meeting, and provided valuable insight into the uncertainty of model output related to the selection of the

model and its associated assumptions. Further exploration of alternative methods and of new approaches was encouraged, as such development offered the opportunity of improving future stock assessments.

6. Review of scientific advice
   The stock assessments for Gulf of Maine cod and redfish were soundly based although their precision and accuracy were dependent on the quality of the input data. The inadequacies of the input data and resultant failure of the VPA to adequately represent the white hake stock were recognized. Input data were subjected to critical review. After fitting appropriate models, diagnostic analyses were undertaken and examined to determine any failure of those models to adequately represent the data. The sensitivity of the redfish and GOM cod models to alternative assumptions was explored. Alternative model structures such as surplus production and per recruit models were then applied. The limitations of the models and of the resulting estimates of biomass and fishing mortality were recognized. The process of reporting, review within the stock assessment working group and subsequent review by the SARC encourages the development of sound assessments.

7. Recommendations
   a) Data collection and analyses
      - The design of the sea sampling programs required to obtain estimates of the length and age composition of the discarded commercial catches, with appropriate precision, should be reviewed. The enhanced sampling program should be implemented as soon as possible.
      - For white hake, an improved sea sampling program is required to obtain precise estimates of the species composition of the landings and thus to accurately estimate the landings of that species.
      - The sampling regime intended to produce estimates of the length and age compositions of the commercial landings appears to have been designed when stocks and catches were larger, and when management controls were not affecting the resulting length and age composition. With reduced catches, it appears that the sampling design may need to be reviewed to ensure that, under current regulations and with the current state of the fishery, samples are adequate to produce estimates of the age composition that will be of sufficient precision for the intended stock assessment methods. The enhanced sampling regime should be introduced as soon as possible.
      - Apparently, there is concern among fishers that the data, which they record, fails to reflect the survey data used in stock assessments. Further, there is concern among scientists that the data recorded in VTRs may be inaccurate. Attempts should be made to improve the quality of the VTR data, and to use these data in assessments. They offer opportunity to improve the quality of those data that otherwise are available only through an extensive sea sampling program. Greater acceptance of stock assessment results and management controls are likely if fishers recognize

that their data are non-random samples, yet are consistent with the estimates produced by the fishery models.

b) Assessment methods
- The uncertainty associated with the age composition of the catches should be considered when modeling the fisheries. The assumption appears to be made in the VPA that the age composition of the catch is accurate. With the reduced quality of sampling over recent years, further investigation of this assumption may be warranted.
- Alternative models, that are more robust to the white hake data than the VPA, should be developed to assess the white hake fishery and to reflect the uncertainty associated with misidentification of the species composition of the younger fish.
- The uncertainty associated with different model assumptions should be assessed through fitting alternative models. Use of age-structured dynamic models that use forward projection can add another perspective to the outcomes derived from the VPA models. Similarly, the use of simpler biomass dynamics may provide valuable insight that augments the results from more complex models. Further exploration of modeling, such as that reported to the SARC by the Methods Working Group, is encouraged as such models provide improved understanding of the uncertainties associated with model structure or with input data.
- In examining the alternative VPAs associated with the use of different abundance indices, or using different age classes, the selection of the most appropriate model appears to have been based on the resulting precision of the parameter estimates. However, it should be noted that the outcomes of the alternative VPAs reflect the uncertainty associated with model structure and input data. Rather than selecting the "best" of these models, consideration should be given to the uncertainty associated with the outcomes from the alternative models. Certainly, further research may be required to reconcile the differences between the alternative models. However, until the inconsistencies are resolved, the advice to managers should reflect the uncertainty associated with the alternative model structures.

c) Other
- The current specification of the critical biological reference points for management in terms of the absolute estimates of B_{MSY} and F_{MSY}, as derived from surplus production models, appeared to be a constraint on the stock assessments that were undertaken. Such absolute values are both model and data dependent. It is reasonable to compare estimates of the current biomass and fishing mortality derived from the same model and using the same data with the absolute estimates of B_{MSY} and F_{MSY}. However, estimates derived from alternative models using extended or different data sets are unlikely to be directly comparable with the reference points. Accordingly, it is preferable to specify the critical reference points as ratios of those estimates of B_{MSY} and F_{MSY} derived using the same

model and same data set. Such a specification is then both model and data independent.

- The methods used to communicate the impact on the management advice resulting from the uncertainties associated with different aspects of the assessment might be improved. The current approach investigates and reports the sensitivity of model outputs (and confidence limits) under different assumptions or using different model structures. The “best” representation of the fishery then appears to be selected subjectively, and the resulting point estimates from this are used to provide the management advice that is presented to fishery managers. While the management advice for the three fisheries that were assessed is likely to be relatively robust to the uncertainties that are present in the alternative assessments, an objective method of communicating and of integrating these uncertainties to derive the advice that is offered to fishery managers should be developed. Consideration might also be given to presenting the advice in terms of probability and risk.
- While considerable attention was given to exploring the sensitivity of model outputs to alternative assumptions and to fitting alternative models, little attention was given to assessing whether the management controls, that had been implemented, had produced the intended effect and that the fishery had responded according to predictions. Assessments of the social and economic impact of alternative management controls on fishers should also be considered.
- It is recognized that a considerable body of scientific literature exists for each stock. However, when preparing background documents for future assessments, it would be useful to provide a brief summary of the biology, life history and distribution of the species, thereby providing a context to assist the SARC in evaluating the details of the assessment. The table that was provided in the background document for the Gulf of Maine cod, listing the past management actions likely to have affected the input data for the assessment, was useful. In preparing the background documents for future assessments, consideration should be given to supplying a similar timeline of the management actions that may have affected the stock or the input data used in the assessment.
- The explicit processes of assessment and both internal and external review that are implemented through the SAW are commendable, and the quality of the assessments undertaken reflects the very considerable experience and expertise of the fisheries scientists involved.

  It is important, however, that the assessments that are undertaken and reported by the Assessment Group to the SARC for review should address all the terms of reference. Where decisions must be made on the adequacy of alternative approaches, or new approaches must be instigated, it is appropriate that these should be determined by the Assessment Group and that any necessary model development or exploration should be undertaken prior to consideration by the SARC. The SARC would then confine itself to the responsibilities of review and critique, further exploration of uncertainty, provision of recommendations for further research or management and advising on the adequacy of the assessments undertaken.

A problem that has been identified with the existing SAW process is that the Assessment Group may require, and would welcome, feedback from external peer review prior to finalizing the assessments undertaken, addressing all the terms of reference, and then preparing the background reports for the SARC. Such external peer review should be independent of the SARC. Without such peer review, there is a tendency to leave some aspects of the assessment incomplete, waiting on advice from the SARC before addressing some aspects of the terms of reference.

While the additional loop in the assessment process would extend the time required for the SAW, the quality of the advice would improve and the projections from the assessments could be adjusted to allow for the increased lead time between commencement of the assessment and resultant implementation of management actions. For the scientists undertaking the assessment, the slightly extended process would allow a more rigorous and careful assessment than is currently possible.

8. Implications
   - Existing data provide little of the contrast required to improve the estimates of the pristine biomass or of the maximum sustainable biomass. However, while the demersal stocks are rebuilding, the opportunity exists to collect appropriate data that might provide valuable information on the population dynamics of these fisheries. Without improvement of the sampling regime, this opportunity might be lost.
   - There is little doubt that the Gulf of Maine cod and redfish stocks are depleted and that exploitation should be constrained to allow recovery. The quality of the data available for the white hake was inadequate to allow an assessment based on the full range of exploited age classes. However, based on an assessment of the data for white hake larger than 60 cm, the current level of fishing mortality on these fish was inappropriate and their current biomass was too low. Accordingly, it was concluded that exploitation of white hake should also be constrained to allow the stock to rebuild.

9. References

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10. Appendices

10.1. Bibliography of materials

An electronic copy of the bibliography of all materials was to be forwarded to the SARC following the meeting. However, this copy is not yet available, and the following list has been prepared from the papers that were received. The SAW Coordinator advised that copies of all documents had been forwarded to the C.I.E.

A1. Assessment of the Gulf of Maine cod stock.
A2. GoM cod – Re-runs and projections.
A3. Sensitivity of MSY reference point estimates to recruitment decisions for Gulf of Maine cod.
A4. GoM cod – Revised age-based MSY based on 1982-1999 stock-recruit curve and more projections for Model 3.
A5. GoM cod – Even more projections for Model 5.
A6. GoM cod – Are the model results consistent with observed data?
B1. Stock assessment for white hake in the Gulf of Maine – Georges Bank region, 2001.
B2. White hake – surplus production model output for fish with lengths of 60 cm or greater.
C1. Biological characteristics, population dynamics, and current status of redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine – Georges Bank region.
C2. An update of the age-structured model for redfish.
D1. Methods Subcommittee overview with graphical and diagnostic measures for the evaluation of surplus production models.
D2. External surplus production models for striped bass, summer flounder, redfish, white hake, and Gulf of Maine cod.
D3. Tools for estimating surplus production and F_{MSY} in any stock assessment model.
D4. Bayesian Surplus production models for Gulf of Maine-Georges Bank redfish.
D5. Sensitivity of MSY reference points to recruitment decisions for Georges Bank yellowtail flounder.
D6. Methods Subcommittee presentation (6/26/01).
D7. Methods Subcommittee presentation (6/27/01).

Draft advisory reports and consensus summary comments were also prepared at, or subsequent to, the SARC Meeting.

10.2. Statement of work

STATEMENT OF TASK

Consulting Agreement between the University of Miami and Dr. Norman Hall

June 15, 2001

General

The Stock Assessment Review Committee (SARC) is a formal, one-week long meeting of a group of stock assessment experts who serve as a peer-review panel for several tabled stock assessments. It is part of the overall Northeast Stock Assessment Workshop (SAW) process that also includes peer assessment development (SAW Working Groups), public presentations, and document publication within a cycle that lasts six months. The panel consists of some 12-15 assessment scientists which include 4 scientists from the NEFSC; a scientist from the Northeast Regional office, staff from the NEFMC, MAFMC, and ASMFC with additional panelists from state fisheries agencies, academia (US and Canada), and other federal research institutions (US and Canada).

Designee will serve as panelist on the 33rd Stock Assessment Review Committee panel. The panel will convene at the NEFSC in Woods Hole the week of 25 June (25-29 June, 2001) and review assessments for Gulf of Maine cod, white hake and redfish. The panel will also review a report from the SAW Methods Working group on the role of stock production modeling in determining and evaluating biological reference points.

Specific

(1) Prior to the meeting: become familiar with the working papers produced by the SAW Working Groups (total number not final; there will be at least one per stock);

(2) During the meeting: participate, as a peer, in panel discussions on assessment validity, results, recommendations, and conclusions. Participate in the formulation of the draft SARC Advisory Report;

(3) Review the final Draft Advisory Report and Consensus Summary Report.

(4) No later than July 30, 2001, submit a written report of findings, analysis, and conclusions. The report should be addressed to the "UM Independent System for Peer Reviews, " and sent to David Die, UM/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149 (or via email to ddie@rsmas.miami.edu).

A Workshop Participant's duties will occupy a total of 7-10 workdays; a day or two prior to the meeting for document review; the week long meeting; and a day or two following the meeting to ensure that the final documents are consistent with the SARC'S recommendations and advice.

No consensus opinion between two CIE reviewers will be accepted.

Contact persons: Dr. Terrence P. Smith, NEFSC, Woods Hole, SAW Chairman, 508-495-2230
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Signed______________________________ Date_______________