Report by the Peer Review Panel for the Northeast Data Poor Stocks Working Group

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Table of Contents

List of Abbreviations

AIM	An Index Method
ASMFC	Atlantic States Marine Fisheries Commission
ASAP	Age structured assessment program
BRP	Biological reference points
B_{MSY}	Biomass at maximum sustainable yield
DCAC	Depletion corrected average catch model
DPSWG	Data Poor Stocks Working Group
F	The instantaneous rate of fishing mortality, usually expressed as a per year rate
F_{MSY}	Fishing mortality rate at maximum sustainable yield
GOM	Gulf of Maine
K	The growth coefficient for a species, derived from the from the von Bertalanffy growth equation: $$L_t = L_\infty \cdot (1 - e^{k \cdot t})$$ where t is age (years) and L are lengths at specific ages
L_∞	The theoretical maximum length for a species, derived from the von Bertalanffy growth equation
M	The instantaneous rate of natural mortality, usually expressed as a per year rate
MAFMC	Mid-Atlantic Fishery Management Council
MER	Maximum excess recruitment
MSP	Maximum spawning potential
MSY	Maximum sustainable yield
mt	metric tonnes (1000 kg)
NE	New England
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fishery Science Center
NJDEP	New Jersey Department of Environmental Protection
RV	Research Vessel
SARC	Stock Assessment Review Committee
SAW	Stock Assessment Workshop
SCALE	Statistical catch at length model
SSC	Scientific and Statistical Committee
FSV	Fishery Survey Vessel
TC	Technical Committee
VPA	Virtual population analysis
VTR	Vessel trip reports

1. Background

The meeting of the Review Panel of the Northeast Data Poor Stocks Working Group (DPSWG) was held at the National Marine Fisheries Service's Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA from December 8-12, 2008. The Review Panel had two core objectives:

> (1) Review assessments on five stocks or stock complexes deemed to be "data poor." For the purposes of this review, the stocks considered either lacked empirical data, or were stocks for which there was limited contrast or information in the available data. The stocks considered by the Review Panel were the skate complex, deep sea red crab (*Chaeceon quinquedens*), Atlantic wolffish (*Anarhichas lupus*), scup (*Stenotomus chrysops*), and black seabass (*Centropristis striata*).
>
> and
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> (2) Provide feedback to the Atlantic States Marine Fisheries Commission on status and progress made toward completion of a stock assessment for weakfish (*Cynoscion regalis*) by the Commission's technical committee.

The specific terms of reference for the Review Panel are provided in Section 2 of this report.

The Review Panel (hereafter termed the Panel) was chaired by Dr. Thomas Miller (University of Maryland Center for Environmental Science Chesapeake Biological Laboratory). Also serving on the Panel were Dr. Robert Muller (Florida Fish and Wildlife Commission), Mr. Robert O'Boyle (Beta Scientific Consulting Inc) and Dr. Andrew Rosenberg (Department of Natural Resources, University of New Hampshire). The Panel was assisted by Drs. Jim Weinberg (SAW Chair, NEFSC, NOAA/NMFS), Paul Rago (Chief - Population Dynamics Branch, NEFSC, NOAA/NMFS), and Fred Serchuk (Senior Science Advisor, NEFSC, NOAA/NMFS). Dr. Paul Rago was Chair of the DPSWG. Additionally, representatives of the New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC) were included in Panel discussions. The meeting was open to the public and was attended by scientists from NEFSC, industry representatives, and observers from the Marine Stewardship Council.

The Panel was provided access to working papers concerning each stock prior to the meeting (Appendix I). The level of detail in the working papers varied, reflecting the level of data available for each stock. Additional working papers were made available to the Panel at the meeting. During presentations to the Panel and throughout subsequent discussion rapporteurs provided notes which were used to develop parts of the report.

The meeting began at 12:30 on Monday December 8th with introductions and opening remarks. Presentations and discussions continued on each of the subsequent five days. Presentations were made to the Panel for each data poor stock and for weakfish. Questions of the presenters were entertained from both Panel members and the general public. However, only Panel members voted in development of the final recommendations. All Panel recommendations represent the unanimous opinion of the Panel. The Panel adjourned at 3:00 pm on Friday December 12th.

The skate complex was the first data poor stock considered. Presentations were made to the Panel by Kathy Sosebee (NEFSC), Liz Brooks (NEFSC) and Andy Applegate (NEFMC). Based on these presentations, the Panel requested additional information and clarification of certain points. The Panel discussed its recommendations for the skate complex on the morning of Wednesday December 10th, and finalized its recommendations on Friday December 12th.

The assessment of red crab was presented late on the afternoon of Monday December 8th, with Panel discussions on the following day. Toni Chute (NEFSC) and Paul Rago (NEFSC) presented the results of the assessment to the Panel. The Panel finalized its recommendations on Friday December 12th.

Atlantic wolffish was the third data poor stock considered. Presentations were made to the review Panel on Tuesday December 9th by Charles Keith (NEFSC) and Paul Nitshcke (NEFSC). Panel discussions immediately followed the presentation, and the Panel finalized its recommendations on the final day of the meeting.

The results of the assessment for scup were presented by Mark Terceiro (NEFSC) on Wednesday December 10th. The Panel held preliminary discussions regarding the status of scup on Thursday, and finalized its recommendations on Friday December 12th.

The last data poor stock presented to the Panel was black sea bass. The presentation was made by Gary Shepherd (NEFSC) on Wednesday December 10th. The Panel requested additional analyses and clarification of conclusions presented that were presented to the Panel on Thursday December 11th. Following this discussion, further clarification was sought, and the final recommendations were developed on Friday December 12th.

The ASMFC weakfish Technical Committee (TC) chair (Jeff Brust, NJ DEP) presented an update of the assessment for weakfish to the Panel on the afternoon of Thursday December 11th and the morning of Friday December 12th. The Panel, council representatives and NEFSC scientists questioned the TC chair and discussed the assessment for almost four hours. While this was not sufficient time for a detailed peer review of the assessment, the Panel felt it was sufficient to assess its overall quality and to identify points of concern that the ASMFC should be aware of as the their weakfish TC continues to revise and finalizes its work.

This report is structured in four sections. This overview and process description represents the first section. Section 2 presents the Panel's conclusions regarding each of the data poor stocks. This section is organized by stock, and the material for each stock is presented in the same order. For each stock, we identify why the stock is considered data poor, review the general approach taken by each assessment, provide recommendations for biological reference points (BRPs), and comment on scientific uncertainties that should be considered by the relevant Scientific and Statistical Committees (SSCs). For each stock, the Panel identified three categories of uncertainty for consideration by the SSC: overall, observation, and process. Within each category, the review Panel identified specific areas which they recommend the SSC consider when recommending buffers between limit reference points and allowable biological catches. The material for each species in Section 2 closes with a list of prioritized research recommendations that integrate both the recommendations developed in the working papers and those that arose from the Panel's discussions. Section 3 of the Panel report presents comments on the weakfish assessment. The structure of this section differs from Section 2 as the terms of reference for weakfish differed from those for the other species. The final section, Section 4, presents literature cited in the report.

2. Data Poor Stocks

The Panel was charged with four specific terms of reference to guide its work on the data poor stocks. The terms of reference were

a). Recommend BRPs and measurable BRP and maximum sustainable yield (MSY) proxies for the following data poor stocks: Black sea bass; Deep-sea red crab; Scup; Skates; Atlantic wolffish.

b). Provide advice about scientific uncertainty and risk for SSCs to consider when they develop fishing level recommendations for these stocks.

c). Consider developing BRPs for species groups for situations where the catch or landings can not be identified to species. Work on this objective will depend on, and needs to be consistent with, final guidance on implementing the Reauthorized Magnuson-Stevens Act, whenever that guidance becomes available.

d). Comment on what can be done to improve the information, proxies or assessments for each species.

We note that the third term of reference relates specifically to the skate complex and does not apply to the other species considered. The Panel recommendations are presented for skates, red crab, Atlantic wolffish, scup and black seabass in the next section.

2.1 Skate Complex

2.1.1 Background

The skate complex in the northwest Atlantic coastal shelf ecosystem comprises seven species: little skate (*Leucoraja erinacea*), winter skate (*L. ocellata*), barndoor skate (*Dipturus laevis),* thorny skate (*Amblyraja radiata*), smooth skate (*Malacoraja senta*), clearnose skate (*Raja eglanteria*), and rosette skate (*L. garmani*).

The skates are considered a data poor stock complex for several reasons. First, there is substantial uncertainty in total catch. In part, this is because skates were originally a discard in the groundfish trawl fisheries for cod, haddock and flounder and records for discards for individual species and indeed for all skates are poor. As a targeted fishery for skates developed to supply the European and niche domestic markets, the overall quality of catch and landings data improved, but still there was no economic or regulatory requirement to identify landings to species. Thus, even when available, landings data with regard to individual skate species are uncertain. Further complicating the catch record is the fact that juvenile skates can be difficult to distinguish to species, often requiring genetic tools for definitive identification (Alvarado Bremer et al. 2005). In addition to uncertainties regarding catch levels, a lack of detailed knowledge of skate population dynamics and life histories also limit assessment approaches. For example aging is uncertain in some species (Sulikowski et al. 2003, Sulikowski et al. 2005a, Frisk and Miller 2006). Reproductive biology is also poorly described (Sulikowski et al. 2002, Sulikowski et al. 2005b, Sulikowski et al. 2005c, Sulikowski et al. 2006, Frisk and Miller 2009). The potential dynamics of skate populations have not been investigated in detail (Frisk et al. 2002, Frisk et al. 2004, Gedamke et al. 2009). Together the lack of empirical data, the resolution of the data that are available and the lack of understanding of skate dynamics all contribute to the status of this complex as "data poor."

Two working papers were presented to the Panel (DPSWG 2008b: Working Paper 1: Skates and Brooks et al. 2008: Working Paper 2: Skates). The first working paper (DPSWG 2008b; Working Paper 1: Skates) provided updates on the empirical estimates of catch and discards as well as survey indices. Considerable effort had been invested by the DPSWG in developing a variety of approaches to estimating catch, discards and the resultant landings for each species. Survey estimates were updated for all species. The second working paper (Brooks et al. 2008) discussed methods to examine overfished and overfishing reference point definitions for the complex. This approach was based on defining the stock size that achieves maximum excess recruitment (Goodyear 1980) from empirically derived stock-recruitment functions.

After considerable discussion over the merits of alternative approaches, the Panel recommended that survey-based approaches be continued as the definition for BRPs for this stock complex. Three concerns contributed to the Panel's recommendation not to change the foundation of the BRP definition, even though they recognized that progress toward model-based BRPs and single species based assessments has been made and continued efforts should be encouraged. The first concern related to the quality of the species-specific catch data. In general, historical skate catches are imprecisely known because of the combining of individual species in the historical record into a single category for both landings and discards. Overcoming this challenge requires developing an algorithm to disaggregate these data. Four such methods were presented to the Panel. However, there was insufficient time at the meeting for the Panel to explore the strengths and weakness of each in order for the Panel to provide a recommendation for which approach should be adopted. The second concern related to the quality of the survey data. The survey data did not appear to display the expected pattern for each species, (e.g., relationship between replacement ratio and relative fishing mortality and stock biomass and recruitment deviated from expected patterns). A third, more practical, concern was that even were the overfishing reference points to be accepted by the Panel, there is no methodology available to determine the status of individual species against the model-based reference points. Thus, until a more detailed assessment approach is developed for the individual skate species, the review Panel recommended that survey-based BRP definitions be maintained for management.

2.1.2 Recommend BRP, and measurable BRP and MSY proxies:

The Panel agreed with the DPSWG's recommendation that model-based reference points were not yet a reliable foundation for setting BRPs for management.

The Panel recommended maintaining index-based reference points developed at SARC 30 (Northeast Fisheries Science Center 2000). The B_{MSY} proxies are defined based on the 75th percentile of the survey time series, expressed in biomass.tow^{-1}. $B_{threshold}$ values are half B_{MSY}.

The Panel rejected the proposed SSB-based index reference points owing to uncertainty in reproductive dynamics, specifically the maturity ogives and fecundity levels, of each of the skate species.

Additionally, the Panel recommended using the most recent survey data in estimating the BRPs for all species except barndoor skate. The Panel felt that failure to update the survey time period used for the reference points was tantamount to claiming that the most recent data are of less value than the older data. For barndoor, the review Panel agreed to maintain the current definition based on the 1963-1966 period. Accordingly the definitions of the BRPs for each species in the complex are:

Species	*Survey*	*Survey time period*	*Biomass threshold (kg.tow^{-1})*	*Biomass target (kg.tow^{-1})*	*Status*
Winter skate	*Autumn*	*1967-2007*	*2.80*	*5.60*	*Not overfished/ No overfishing*
Little skate	*Spring*	*1982-2008*	*3.51*	*7.03*	*Not overfished/ No overfishing*
Barndoor	*Autumn*	*1963-1966*	*0.81*	*1.62*	*Not overfished/ No overfishing*
Thorny	*Autumn*	*1963-2007*	*2.06*	*4.12*	*Overfished/ Overfishing*
Smooth	*Autumn*	*1963-2007*	*0.14*	*0.29*	*Not overfished/*

					No overfishing
Clearnose	*Autumn*	*1963-2007*	*0.38*	*0.77*	*Not overfished/ No overfishing*
Rosette	*Autumn*	*1963-2007*	*0.024*	*0.048*	*Not overfished/ No overfishing*

The Panel also recommended maintaining existing overfishing BRP definitions, based on annual percentage declines of the three year average of the NEFSC trawl survey used for the biomass reference points. However, the review Panel noted that this is not an acceptable long term solution to establishing overfishing BRPs for the skate complex. As the life history and population dynamics of individual skate species within the complex become better known, model-based overfishing BRPs are to be preferred.

2.1.3 Advice about scientific uncertainties for consideration by SSC

2.1.3.1 Overall Uncertainty

a) While a desired long-term goal, undertaking assessment of individual stocks within the skate complex is not feasible currently. Two key challenges must be overcome before such analyses can be successfully completed. First, the catch data (landings and discard) must be disaggregating by species, which in turn requires accurate species identification and sampling data. Second, stock-specific assessments require knowledge on stock structure, growth, movement and distribution, and mortality at a minimum. Much of this information is lacking for species in the skate complex. Thus if currently attempted stock-specific assessments require use of a number of assumptions, all of which may combine to produce less, rather than more, accurate stock – specific assessments
b) Thus, in the current situation of skate information, aggregate data across all skate species may provide some information on the dynamics of the complex

2.1.3.2 Observation Uncertainty

Biology

a) Considerable uncertainty remains in the rate of natural mortality (M) and some other life history traits (e.g., L_∞, k, fecundity, and maturity) for all skate species within the complex. This lack of data limits the development of model-based BRPs.
b) Fisheries management generally assumes a unit stock. However, stock structure and patterns of exchange among putative skate stock areas is uncertain. Recent evidence suggests that there may well be stock structure within the northwest Atlantic coastal shelf ecosystem for individual skate species (Frisk et al. 2008). The potential for spatial stock structure will have to be considered if single species reference points and models are developed.

Survey

c) There is insufficient sampling effort for some species in some areas such that abundances and vital rates estimated from samples may be imprecise or biased. For example, clearnose skate makes extensive use of nearshore and estuarine habitats that are not currently sampled. As a result a substantial fraction of this population would not be included in abundance trends or in estimates of growth derived from samples collected during the NEFSC surveys.

d) The change of the NEFSC research vessels from the Research Vessel (RV) Albatross to Fishery Survey Vessel (FSV) Bigelow has implications for the interpretation of survey catchability for all species. Given that skate BRPs are based on survey indices, this may introduce additional uncertainty in future stock status determinations. The Panel recognized this weakness in recommending the maintenance of index-based reference points, but saw no credible alternative at this time. It is hoped that model-based approaches for individual species will be developed in the future. Such model-based approaches have the added advantage that they will be able to account for any potential differences in survey catchabilities between the two research vessels once sufficient data from the FSV Bigelow surveys become available.

e) Concerns over pattern of selectivity to survey gear may bias estimates of recruitment and spawning stock.

Fishery

f) Species identification in the catch is not as accurate as desired. This affects the quality of the allocation of both landings and discard estimates to each species. Much of the concern relates to historical data, and it is likely that little can be done to improve their reliability.

g) Size composition information has improved since previous assessments but additional effort in this area would still benefit future assessments.

h) Several approaches to estimating historical discards were brought forward for the Panel's consideration. All methods presented were discussed, but need to be further evaluated in future work. The Panel did not have sufficient time to conduct an in depth review of these different approaches. It is recommended that this be a term of reference at a future SAW/SARC at which the skate complex is considered.

i) Hindcasts of discard data have unknown reliability. The uncertainty in these data relates both to the species allocation issue, and to the lack of reliable catch records for both the domestic and foreign fleets, particularly prior to 1989. While historical fisheries had targeted hauls, it is also clear that a substantial fraction of the landings were likely by catch in non-targeted fishing. The extent to which this by catch was landed or discarded depended on market conditions.

2.1.3.3 Process Uncertainty

a) The population dynamics (e.g., recruitment dynamics and compensatory processes) of skates are poorly understood generally. Development of credible single species models for the skate complex will require a substantial improvement in the level of current understanding (Frisk et al. 2001, 2002, Frisk et al. 2004, Gedamke et al. 2007, Gedamke et al. 2009, Frisk et al. Submitted)

b) Model fits to An Index Method (AIM) model developed by the DPSWG did not demonstrate dynamics expected in the catch and survey data (e.g. lack of relationship between replacement ratios and relative fishing mortality). This gives rise to concerns over the reliability of catch information and potentially of survey indices as well.

c) The Maximum Excess Recruitment (MER) analysis presented by Brooks et al (2008 Working Paper 2: Skates) utilized stock-recruitment data derived from NEFSC surveys to develop estimates of expected equilibrium abundance of several species of skates in the complex. However, these models provided unrealistic results for clearnose skate, and in thorny and winter skate evidence of stock biomasses considerably in excess of that believed to be characteristic of equilibrium. These findings suggest model misspecification or concerns over the reliability of the input data that currently limit the application of these estimates to management.

2.1.4 BRPs for species groups:

The Panel recognized the benefit of developing single species assessments for several species in the complex. However, the Panel also recognized that determination of the reliability of the single species models when developed could be facilitated by comparison of the single species BRPs back to BRPs developed by aggregate models of the complex as a whole. Therefore, the Panel recommended that aggregate production models for skates continue to be developed on a regional basis. Regional production models could be used to explore broader patterns in productivity. This analysis would be facilitated by consideration of the appropriate skate species groupings to use in the modelling. For instance, clearnose and rosette skate are nearshore and deepwater skate species respectively and might confound model explorations of the dynamics of the other skate species.

2.1.5 Research Recommendations:

In addition to the research recommendations identified in the working papers (DPSWG 200b Working Paper 1: Skates, Brooks et al. 2008 Working Paper 2: Skates), the Panel recommends the following prioritized research recommendations be addressed to reduce uncertainty in BRPs:

a) Continued development of species-specific statistical catch models for species for which data are sufficient, for example winter and little skate, is to be encouraged.
b) Age and growth estimates for all species should be improved, particularly with respect to rosette skate for which such estimates are almost completely lacking.
c) Fecundity studies and improvements to estimates of maturity ogives are needed for all species.
d) Continued development of catch estimates by species is needed. This will involve reconsideration of the approach to allocating catch by species from aggregate landings records. One potential approach that may be useful is the application of generalized linear models to discard data to identify significant covariates of discarding.
d) Improved methods for identification of skates in the field should be encouraged, particularly of juvenile-sized skates in research surveys.
e) Discard mortality estimates are needed for all skate species in the complex.
f) Exploration of stock structure of all seven species using genetic and traditional tagging data would be beneficial.
g) Exploration of Productivity – Susceptibility Analysis (Smith et al. 2007) of species in the skate complex to identify those species that are likely most sensitive to fishing may be beneficial.

h) Inter-model comparison of single species models with aggregate models should be conducted to better understand the dynamics of the skate complex.
i) Examination of spatial patterns in survey data to better understand the abundance trends in these time series would be helpful.

2.2 Deep Sea Red Crab

2.2.1 Background

Deep sea red crab (*Chaceon quinquidens*) is distributed broadly along the shelf break in waters from 200-1800 m from Emerald Bank on the Scotian Shelf southward to the mid-Atlantic Bight. Red crab also occurs in the Gulf of Mexico. However, genetic evidence suggests that these two stocks are distinct and separate(Weinberg et al. 2003). Red crab supports a fishery in the northwest Atlantic involving five licensed vessels.

The stock was surveyed in 1974 prior to the development of the fishery (Wigley et al. 1975). This effort relied on a targeted survey involving both trawl gear and a camera sledge that collected data on relative abundance and size and sex composition. No other surveys were conducted until the Wigley et al work was "repeated" in 2003-2005 (Wahle et al. 2008). Although catch records are available for the intervening period, there are no fishery-independent data charting the course of the red crab population during the intervening period. In addition to the lack of fishery-independent data, there is also little known about the biology and ecology of this species. It is believed that red crabs segregate by size and sex, but this segregation is not complete and the degree to which the fishery exploits such segregation is unclear. Quantitative estimates of life history traits are almost wholly lacking. Little is known about the growth dynamics including the intermolt period and the growth per molt of individual crabs or about the reproductive biology of this species. It is presumed that females have a functional terminal molt (Chang et al. 1993). The fecundity of individual females and the number of broods per female per mating has not been described. Similarly, little is known about the potential for sperm limitation – effectively too few males to effectively inseminate the available females – a process relatively common in decapod crustaceans (Jivoff 2003). These data limitations and gaps in our understanding the biology of this species combine to make this a "data poor" stock.

The Panel was presented with information on the survey abundance, size structure and catches for this species (Chute et al. 2008 Working Paper 1: Red crab). Additionally the results of a depletion corrected average catch model (DCAC - Alec MacCall, NMFS/SWFSC/FED, pers. comm.) and a two boundary estimation model were presented. The Panel accepted the use of a DCAC model as a foundation for estimating MSY.

2.2.2 Recommend BRP, and measurable BRP and MSY proxies:

The Panel agreed with the DPSWG (Chute et al. 2008 Working Paper 1: Red crab) that the MSY level developed in the original Fishery Management Plan (FMP) is no longer reliable as a foundation for setting BRPs. This determination was made on the assumptions that reductions in the size structure of landings that have been observed indicate that previous higher landings were not at a sustainable MSY levels as had been previously assumed.

The Panel concluded that estimates of MSY in the male only fishery of 1700-1900 mt represent the best available scientific information, based on the congruence of average landings and results from the DCAC model. The Panel noted that the current overfishing threshold is exceeded when male landings are greater than the estimated MSY. The Panel had no foundation to recommend changes to this standard.

The Panel was not able to recommend a B_{MSY} proxy (and thus an overfished BRP) for this stock. Concern was expressed by the Panel over the impacts of size changes in the harvest on the reliability of a simple biomass-based proxy. The Panel suggests that size and sex ratio based reference points may be of utility in the future. But the Panel cautions that application of such approaches would require more frequent surveys of the resource. The Panel recognized that their decision will result in a default to the existing overfished definition. This value is higher than other values presented in the working paper (Chute et al. 2008 Working Paper 1: Red crab), and thus represents a precautionary approach.

The Panel recommended that future analyses should seek to develop F reference points based on sex ratio and size ratio considerations. However, the Panel recognized that such reference points require an unbiased estimate of the sex and size distribution in the population. The Panel expressed concern over the potential for changes in the spatial distribution of the resource or of the fishery to impact such estimates of BRPs. As noted previously, if such an approach is adopted, additional scientifically-designed surveys will need to be implemented. The Panel believed that it would be possible to conduct such surveys cooperatively with industry.

Overall, the Panel noted the substantial uncertainty in all BRP estimates. Further, it noted that the BRPs recommended relate to the current area being fished and/or to the current extent of the survey. Changes in the current area being fished would require reconsideration of the BRPs.

2.2.3 Advice about scientific uncertainties for consideration by SSC;

2.2.3.1 Overall Uncertainty

No specific concerns were identified in this category by the Panel.

2.2.3.2 Observation Uncertainty

Biology

a) Fundamental aspects of red crab life history are almost wholly unknown. Of particular importance is the lack of information on the following:
   i) crab age and maximum age,
   ii) growth per molt, intermolt period and status of terminal molt, and
   iii) reproductive biology including maturity, sperm storage, brood production, and sperm quality and mate competition.

b) The distribution of population is believed to change seasonally, and in relation to crab size and sex. These changes will alter the availability of crabs to the surveys and to the fishery, and will therefore likely impact BRPs and stock status determination.

Survey

c) The stock has been assessed only on two occasions – in1974 (believed to be representative of virgin conditions), and in 2003-2005 after 30 yrs of fishing. There is no fishery-independent information on population status during the intervening period. Thus our knowledge on the pattern of abundance, size structure and sex ratio in the population between these two time periods depends entirely on fishery-dependent data sources. This introduces substantial uncertainty into our knowledge of stock dynamics.

d) There is some concern regarding the comparability of the sampling methods between the two surveys. It has been suggested that the earlier surveys may have underestimated abundance due to assumptions regarding the area imaged by the sledge-mounted camera. This would affect the statistical expansion of crab counts to area-specific estimates of abundance.

e) The distribution of fishery effort over time was poorly described. It was also not clear how fishing effort might have changed with respect to the distribution of population. A key assumption made in all of the analyses brought forward by the DPSWG for this population was that the harvest pattern was a sample from a stationary population. This extent to which this assumption is met is unknown, and introduces considerable uncertainty into the BRPs

2.2.3.3 Process Uncertainty

a) The influence of variation in the relative abundance of males: females, and in the size ratio of males: females on reproductive potential are unknown.

b) Shifts in size structure of male catch may have important consequence on productivity as a result of the potential for sperm limitation in decapod crustaceans.

c) Shifts in distribution of fishery may alter availability patterns. Current information on the distribution of fishing effort does not permit determination of whether such shifts have occurred.

d) The quality of vessel trip reports (VTR) discard information has not been validated, although the female size structure has not changed substantially suggesting discard mortality may not be a significant factor.

e) It is unclear how shifts in size distribution of landings affect estimates of BRPs derived from the DCAC model. Although the data were standardized to a common size structure, differences in the size structure of the catch may still introduce considerable uncertainty in the performance of the DCAC model.

2.2.4 BRPs for species groups:

Not relevant for this species.

2.2.5 Research Recommendations:

In addition to the research recommendations identified in the working papers, the review team recommends the following prioritized research recommendations be addressed to reduce uncertainty in BRPs:

a) Additional fishery-independent surveys should be considered, with continued industry support and involvement. These cooperative surveys might include standardized trap-based sampling or camera-based surveys. The Panel noted that the industry is already supporting a sizeable tagging program.

b) Additional information on relative sizes of mating pairs and its consequences on reproductive potential, particularly with regard to the potential for sperm limitation, would allow for the inclusion of additional size-based BRPs.
i) Simulation modelling could be used to explore the response of the population sex ratio to different exploitation patterns to determine whether sex ratios may serve as a tool to inform management on current catch rates. The Panel noted that such an approach would only work if knowledge of the population wide sex ratio was being monitored appropriately.
c) Studies of brood production, incubation period, and pattern of sperm storage would be helpful.
d) Studies to refine growth (intermolt period and growth per molt) and longevity would improve understanding of stock dynamics.
e) Assessment of whether females, in particular, exhibit a terminal molt would help development of growth models.
f) Information on movement and behavior of crabs within their range would be of utility.
g) Better understanding of abundance-habitat relationships may permit more efficient allocation of effort in future surveys, whether conducted by the NEFSC or collaboratively with the industry.
h) Economic factors in crab and other fisheries may alter distribution and interpretation of fishing effort for this fishery, emphasizing the need for fishery-independent observations.

2.3. *Atlantic Wolffish*

2.3.1 Background

Atlantic wolffish (*Anarhichas lupus,* hereafter wolffish) is distributed on both sides of the Atlantic basin. In the New England / Gulf of Maine region, wolffish is toward the southern limit of its distribution and thus might be expected to be particularly sensitive to environmental variability. Tagging studies in Canadian waters indicate that individual fish exhibit low levels of vagility, suggesting the potential for considerable population structure within this domain (Templeman 1984).

Wolffish is a demersal fish that typically selects regions of high habitat complexity which provide refuges and spawning habitats (Rountree 2002). This affinity for rocky habitats means that the species is likely not well surveyed by the trawl gear used in the NEFSC surveys. Accordingly, survey indices and population abundances may not be proportionally related, although there is no clear evidence supporting this contention.

Estimates of life history parameters for wolffish have high levels of uncertainty. Maximum sizes are not well described. The reproductive schedule of wolffish within the NE / GOM region is also poorly described, although detailed studies exist for other regions (Templeman 1986, Falk-Petersen and Hansen 1991, Pavlov and Novikov 1993, Gunnarsson et al. 2006). The impact of this lack of regional data relates specifically to the presumed time lag between the first appearance of eggs in female wolffish and their subsequent development to mature eggs.

Three main issues combine to make wolffish a “data poor” species, including concerns over which geographical regions to include in developing and assessing population status relative to BRPs, over the reliability of survey data as indices of population abundance and over life history parameters for the species within the northwestern Atlantic Ocean.

The Panel was presented with analyses of catch, landings and survey indices for wolfish from the coastal ocean of Massachusetts, New Hampshire and Maine (DPSWG 2008a Working Paper 1: Atlantic wolfish). The DPSWG excluded data from survey catches of wolffish on the northeast edge of Georges Bank. This decision to exclude survey data in this region was made because of the challenge of obtaining and partitioning Canadian catch data. While the Panel supported this decision, they also noted that the decision is equivalent to assuming limited exchange between the coastal and Georges Bank stocks. The extent of such exchange has not been quantified.

The Panel was presented with the results of a statistical catch at length (SCALE) model for the coastal wolffish stock (DPSWG 200a Working Paper 1: Atlantic wolffish). The Panel accepted the SCALE model as the foundation for determination of biological reference points and stock status. This model allowed an appropriate synthesis of the limited data available on the wolffish stock.

2.3.2 Recommend BRP, and measurable BRP and MSY proxies:

Given current information, the Panel concluded that an $F_{40\%}$ MSP proxy for the overfishing F_{MSY} reference point was a reasonable and justifiable approach. The Panel further concluded that the levels of uncertainty in the maturity schedule for wolffish and the selectivity patterns of the fisheries for this species suggest values of the F_{MSY} proxy less than F= 0.35 yr^{-1} are most probable and represent a precautionary approach. However, the Panel concluded that determination of the 2007 status with regard to this overfishing definition is uncertain. Imprecision over the maturity schedule and the pattern of selectivity in the fishery prevented determination of whether or not overfishing was occurring. Plausible models gave differing conclusions regarding this determination.

Application of SCALE model suggests that estimates of SSB_{MSY} are likely 800-1000 mt, implying that the current population is 31-45% of SSB_{MSY}. Therefore, the Panel concluded that the stock is currently overfished.

The Panel concluded that MSY is likely in the range 138-150 mt. However, given the potential for extremely low recruitments indicated in recent survey catches, future catches may have to be lower than MSY until the pattern of incoming recruitment is more precisely known.

2.3.3 Advice about scientific uncertainties for consideration by SSC

2.3.3.1 Overall Uncertainty

There were no recommendations pertinent to this category made by the Panel.

2.3.3.1 Observation Uncertainty

Biology

a) There is considerable uncertainty in several life history traits critical to the evaluation of BRPs and stock status, including M, maximum age, the maturity schedule and fecundity. Current estimates of maturity patterns used in the model have not been adequately developed for the northwest Atlantic coastal shelf ecosystem and for the Gulf of Maine region in particular.

b) There appear to be two areas of concentration of wolffish abundance within US territorial waters: on Georges Bank and in coastal waters of Massachusetts, New Hampshire and Maine north of Cape Cod. The consequences of the distributional patterns to population connectivity and dynamics are unclear. This uncertainty impacts decisions regarding which survey strata and catch statistics to include in models and may impact BRP and stock status determination.

Survey

c) There is uncertainty over the degree to which the survey provides a reliable index of the population. These concerns arise because:

- i) given presumed patterns of habitat use, availability of fish to survey gear may not be proportionally related to abundance,

ii) given that wolffish are at the southern limit of their range, they may exhibit particularly wide changes in distribution, and
iii) given concerns over availability and distribution, zero catches in surveys are difficult to interpret.

Fishery

d) Unknown catches from foreign fleets (particularly prior to 1977) cannot be incorporated in current statistics.
e) The extent of unreported catches is unclear. Unreported catches may result from limited or no observer coverage in these fisheries and potentially from by-catch in other fisheries, e.g., lobster.

2.3.3.3 Process Uncertainty

a) There is little evidence of any truncation in the population size frequency over time. This observation is anomalous given the level of the fishery assumed. The mismatch between the lack of change in the size distribution and fishing activity may suggest that fishing may not be solely responsible for observed changes in abundance. Changes in the availability of preferred habitat should be considered as one viable alternative hypothesis.
b) Survey catchabilities for pre-recruits and recruited sizes estimated by the SCALE model seem unreasonably high. This may be a reflection of the survey not adequately sampling wolffish abundance in rocky habitats.
c) BRPs calculated by the SCALE model appear sensitive to assumptions regarding the maturity ogive and fishery selectivity, both of which have high degrees of uncertainty.
d) The interpretation of zero-catches in survey data will influence conclusions regarding future stock status. The Panel believed that stock projections would be unreliable and should not be undertaken.

2.3.4 BRPs for species groups

Not relevant for this species.

2.3.5 Research Recommendations:

The Panel prioritized the research recommendations developed by the working group to reduce uncertainty in BRPs:

a) Exploration of the relationship between survey catch per tow and habitat complexity and environmental signals should continue. These studies will aid understanding of the relationship between survey estimates and population abundance.
b) Age and growth studies for wolffish in the NE/GOM region should be conducted to refine estimates of L_∞.
c) Maturity ogive data are currently based on simple presence of eggs in females, and do not account for functional maturity which requires presence of larger eggs. The Panel considered the current approach inadequate. Regional maturity ogives should be developed.
d) The Panel recommended that a fixed gear survey be considered to assess abundance in non trawlable habitats.

e) Tagging studies should be conducted to explore and quantify the vagility of wolffish to help improve understanding of population structure and connectivity.

2.4 Scup

2.4.1. Background

Scup (*Stenotomus chrysops*) is a schooling, semi demersal fish. It is a member of the Sparidae (Porgy) family. Scup is distributed widely along the Atlantic coast of North America from Newfoundland, Canada to the Gulf of Mexico, although it is rare north of the Gulf of Maine and south of Cape Hatteras, NC. Within this range, scup make extensive migrations moving northwards and inshore in the spring to spawn, and southwards and offshore during non breeding months. The life history of scup is fairly well described. Growth models are believed to be reliable. Maturity and fecundity schedules are similarly reliable.

Scup is caught in sizeable numbers in the NEFSC surveys during both spring and autumn. However, comparison of the age structure in the commercial catch and in the survey suggests that the survey does not provide a reliable index of stock abundance. In part as a result of the mismatch of size and age structure in the survey data and in the commercial catch, attempts at completing stock assessments have heretofore met with little success because individual elements of the assessment rarely completed each other to produce an acceptable overall picture of the stock dynamics. Together these observations have categorized scup as a "data poor" species.

The Panel was presented with the results of the application of an AIM model and a statistical catch at age model, termed an age structured assessment program (ASAP), to scup (Terceiro 2008 Working Paper 1: Scup). The Panel accepted the ASAP model as a foundation for determining BRPs and stock status. Further, the Panel noted the particular thoroughness with which the assessment was conducted and presented. However, in accepting the results of the ASAP model, the Panel was aware that its acceptance of the ASAP model leads to markedly different conclusions regarding the status of the stock compared to existing BRPs. The Panel felt that the revised conclusions of stock status were amply justified.

The Panel recommends that given the success of the presented assessment scup should no longer be considered part of the "data poor" suite.

2.4.2 Recommend BRP, and measurable BRP and MSY proxies:

Previous biomass reference points were based on a 3-yr (NMFS Spring survey 1977-1979) index standard. This approach indicated that in 2007 the stock was overfished. The Panel recommended abandoning this approach in favor of revised BRPs based on the statistical catch at age model, ASAP, which integrates information from multiple sources more fully than the existing approach.

Previous overfishing reference points were based on a yield per recruit analysis. No direct estimate of fishing mortality, F, was available and so a relative F (estimated as the reported landings divided by a survey index) was used to determine exploitation status. Using this BRP, the stock was considered not to be experiencing overfishing in 2007. The Panel recommended abandoning this approach, in part because it felt that the relative F index is questionable given the high levels of uncertainty associated with estimates of discards.

The Panel recommends adopting exploitation reference points based on $F_{40\%}$ as F_{MSY} proxy as a more precautionary approach owing to uncertainties over whether recent high recruitments will be maintained in the future. The recommend reference points from the ASAP model are:

BRP	$F_{40\%MSP}$	SSB(t)	MSY(t)
	0.177	92,044	16,161

The 2007 SSB (119,343 tonnes) was 130 % of the new overfished BRP proxy while the 2007 fishing mortality (0.054) was 31% of the new overfishing BRP proxy. Thus, the Panel agrees with the DPSWG's conclusion that the scup stock is not overfished and that overfishing is not occurring (Terceiro 2008 Working Paper 1: Scup).

However, the Panel also recommends that rapid increases in quota to meet the revised MSY would be unwarranted given uncertainties in recent recruitments. A more gradual increase in quotas is a preferred approach reflective of the uncertainty in the model estimates and stock status.

2.4.3 Advice about scientific uncertainties for consideration by SSC

2.4.3.1 Overall Uncertainty

There were no recommendations pertinent to this category made by the Panel.

2.4.3.2 Observation Uncertainty

Biology

a) The maximum age of scup remains uncertain. The uncertainty in this parameter introduces uncertainties in estimates of BRPs which rely on this parameter. The current age structure of this stock is continuing to expand, which may indicate the need to revise upward estimates of maximum age to values older than assumed in the current assessment.

Survey

b) High interannual variability in survey indices, perhaps due to changes in availability, affects the interpretation of survey time series.

Fishery

c) Commercial fishery discards are about 30% of catch and historical sampling of discard is the least precisely estimated component of the catch input, thereby introducing uncertainty into estimates of the biological characteristics of the catch.

2.4.3.3 Process Uncertainty

a) Surveys indices used in the ASAP model are only available for fish of ages 0-2. Thus, the interpretation of the dynamics of older age groups relies on the catch information from the fishery and on assumptions regarding M. Thus, the results of the model with respect to fully recruited ages are driven by the fishery data.
b) The current model assumes that commercial fishery discard mortality rate is 100%, however, the true level of discarding mortality is uncertain, thereby introducing uncertainty into BRP estimates.
c) Likelihood profiling of the natural mortality indicated a lower M than was used in the accepted model provided better overall model fits. This is counter-intuitive given the maximum observed age of scup of 14 years. There is thus uncertainty on the natural mortality rate.
d) The weightings used on the different likelihood components in the model have considerable flexibility. Altering these weighting changes the degree of fit in different elements of the model. Notwithstanding this, the Panel considered that the final model configuration that was acceptable for determination of BRPs and stock status.

2.4.4 BRPs for species groups:

Not relevant for this species.

2.4.5 Research Recommendations:

The Panel combined recommendations from the working paper and from its own discussions and developed the following prioritized research recommendations be addressed to reduce uncertainty in BRPs. Because of the progress made on the assessment of this species, the Panel felt comfortable in identifying short term and longer term research objectives.

Short term analytical tasks

a) Development of indicators of potential changes in stock status that could provide signs to fisheries management of potential reductions of stock productivity would be helpful. These could be based upon in-season spatial and temporal observations from the fishery (e.g., changes in spawning areas, size groups of scup observed by season and area). While these indicators might not be incorporated into the assessment model, they may provide warning signs that would initiate more in-depth analysis of the assessment-related information.
b) A management strategy evaluation of alternative approaches to setting quotas would be helpful.

Longer term data and analyses needs

a) Current research trawl surveys are likely adequate to index the abundance of scup at ages 0 to 2. However, the implementation of new standardized research surveys that focus on accurately indexing the abundance of older scup (ages 3 and older) would likely improve the accuracy of the stock assessment.

b) Continuation of at least the current levels of at-sea and port sampling of the commercial and recreational fisheries in which scup are landed and discarded is critical to adequately characterize the quantity, length and age composition of the fishery catches.
c) Further quantification of the biases in the catch and discards, including estimates of non-compliance, would help confirm the weightings used in the model. Additional studies would be required to address this issue.
d) The commercial discard mortality rate was assumed to be 100% in this assessment. Experimental work to better characterize the discard mortality rate of scup captured by different commercial gear types should be conducted to more accurately quantify the magnitude of scup discard mortality.

2.5 Black Sea Bass

2.5.1 Background

Black sea bass (*Centropristis striata*, hereafter sea bass) is a temperate bass (family Serranidae) that is distributed from the Gulf of Maine to the Gulf of Mexico. For management purposes, the fish north of the Cape Hatteras are considered a single management unit. Black sea bass is a protogynous (female first) hermaphroditic species. Transition from female to male occurs between ages 2-5 years. Following transition from female to male, sea bass can follow one of two behavioral pathways; either becoming a dominant male, characterized by a larger size and a bright blue nuccal hump during spawning season, or a subordinate male which have few distinguishing features. The consequences of protogyny to management have been considered by several authors (Armsworth 2001, Alonzo and Mangel 2005, Heppell et al. 2006). Alonzo et al (2008) noted that the effect of male depletion by a fishery on spawning potential based reference points is highly variable and, in part reflective of this finding, Brooks et al. (2008) recommended that reference points be based on the spawning stock biomass of the two sexes combined. The uncertainty introduced into the management arena of the protogynous life history might alone justify the status of this species as a data poor stock.

Black sea bass is a reef associated species. Tagging studies have indicated the potential for site fidelity, despite the existing of large spawning migrations(Moser and Shepherd 2009). The association with reef habitats and site fidelity combine to suggest that the NEFSC trawl surveys are likely not optimal gear to assess abundance of this species. This further justifies why this species is considered a data poor stock.

Previously, attempts have been made to assess this species with both index-based approaches and with age-structured virtual population analyses. Age-structured models have been rejected by previous peer review panels. Accordingly, current BRPs are based on an index-based approach. For this assessment, approaches based on an index method (AIM) that had been developed for the 2004 assessment , and on a statistical catch at length (SCALE) model were presented (Shepherd 2008 Working Paper 1: Black sea bass). The Panel recommended accepting a SCALE model for establishing BRPs and stock status. The Panel was fully aware that the decision to recommend a change in the assessment methodology for this species also causes a change in the current stock status for management purposes.

2.5.2 Recommend BRP, and measurable BRP and MSY proxies:

Previous biomass reference points were based on the 3-yr average (NMFS Spring survey 1977-1979) index standard. This approach indicated that in 2007 the stock was overfished. The Panel recommended abandoning this approach in favor of revised BRPs based on a statistical catch at length (SCALE) model which integrates information from multiple sources more fully than the existing approach.

A number of different model configurations were presented to the Panel. These models were filtered based on the assumption that the MSY is close to the long term (1968-1997) average catch of 3,100mt. The accepted model had a value of M=0.4 based on the congruence of estimates from tagging studies and from meta-analyses of mortality rates in other fishes (Hewitt and Hoenig 2005).

The Panel recommended an F_{MSY} proxy of $F_{40\%}$, currently estimated to be F=0.419, and a related SSB_{MSY} proxy of 12,537 mt. SCALE model output estimated that the F for 2007 was 0.48, indicating that the stock was experiencing overfishing. The 2007 SSB was estimated to 11,478 mt. Using Bmsy/2 as the overfished definition, the stock was not overfished in 2007. Further the 2007 SSB estimate indicated that the stock was at 92% of its target level. An MSY value of 3,903 mt was accepted.

However, the Panel notes that there remains considerable uncertainty with respect to stock status. The lack of fit between model estimates and the recent survey information is an important source of uncertainty. For example, the SCALE model was not able to produce the recent high peak in the adult winter index, nor did it fully track the recent trends in recruitment (Shepherd 2008 Working Paper 1: Black sea bass). Thus, while accepting the model for assessment purposes and the reference points, the Panel recommends that, management should proceed with caution until the implications of recent rapid change from high to low index values observed in the survey, but not in model estimates of time series, are more adequately understood. The review Panel recommends the SSC recognize and allow for the sizeable uncertainty in stock status when establishing catch limits.

2.5.3 Advice about scientific uncertainties for consideration by SSC

2.5.3.1 Overall Uncertainty

There were no recommendations pertinent to this category.

2.5.3.2. Observation Uncertainty

Biology

a) Tagging study data indicate that an M=0.2, the rate used in the previous assessment, is not appropriate for this stock. Application of Hewitt and Hoenig’s (2005) model for a maximum age of sea bass of approximately 10 would suggest M ~ 0.4. However, while M is likely above 0.2 and possibly closer to 0.4, the true value of M remains poorly described.

b) The Panel considered that the hypothesized logistic function for M was not supported by evidence presented from other protogynous species, or from the tagging data itself. The Panel felt that this strong assumption over the shape of the M function with age, while providing an adequate fit to the data, needed further corroboration before it is used in modelling sea bass populations.

c) Current modelling approaches assume a single unit stock of sea bass. Yet tagging studies suggest the potential for stock structure, with putative northern and southern components, despite large scale onshore-offshore migrations. The possible presence of stock structure introduces uncertainty into estimates of vital rates and vulnerability to fisheries in this species.

Survey

c) The degree to which the spring survey is a reliable index of abundance is unclear. However, the Panel felt that the congruence of survey size structure and the commercial catch data, particular with regard to maximum sizes, lent support to the use of the survey as a stock monitoring index. The Panel also noted that the change to the FSV Bigelow may present challenges for a use of the spring survey index in assessment and BRPs. This is an additional motivation for moving from an index-based to model-based assessment.

Fishery

d) There is a high degree of uncertainty in the magnitude and size composition of the commercial discards.
e) Discards can be a sizeable fraction of the total catch. The estimate of 50% commercial discard mortality is uncertain. The sensitivity of model-based BRPs to this assumption is unclear, and accordingly introduces uncertainty into BRPs.

2.5.3.3 Process Uncertainty

a) The protogynous life history pattern of sea bass complicates management options with regard to size limits and their influence on sex ratios and reproductive potential.
b) There is limited understanding of the relationship between the life history pattern of this species and the resultant pattern in size and/or age dependence of M.
c) The SCALE models presented to the Panel exhibited limited capacity to resolve optimal parameter estimates, with different model configurations providing similar fits to the data. It was thus necessary to constrain model selection through use of information external to the model. For this reason, the Panel used estimates of fishing mortality from tagging data and assumed long term (1968-1997) catch similar to MSY to filter the range of model configurations. Accordingly, the reliability of the final model configuration is uncertain.
d) The sensitivity of the SCALE model results to alternative data input weightings was not explored in the assessment. Thus, there remains a high degree of uncertainty over the uniqueness of estimates used in the development of BRPs.

2.5.4 BRPs for species groups

Not relevant for this species.

2.5.5 Research Recommendations

In addition to the research recommendations identified in the working papers, the review team recommends the following be addressed to reduce uncertainty in BRPs:

a) On-going ageing studies should be continued to provide a foundation for an age-based assessment.
b) A pot survey for black sea bass should be considered.

c) At-sea samples need to be taken to improve understanding of the timing of sex change over years in order to study the potential influence of population size on sex switching. This may have implications of overfishing BRPs.
d) Ageing validation studies should be undertaken to examine implications of sex change as well as temperature and salinity changes associated with movement onshore and offshore on ageing reliability.
e) Meta-analysis of patterns of natural mortality in protogynous fishes should be undertaken.
f) Exploration of management approaches used on species with protogynous life histories would be helpful.
g) Research is needed to understand the implication of removals of large males on population dynamics. These could be field studies or large scale mesocosm experiments. This could involve collaboration with industry and recreational sectors.
h) Efforts to quantify discard mortality are needed.
i) Exploration of model behavior, including retrospective analysis, is required.
j) Non-compliance may be an alternate explanation for high assumed rates of natural mortality. It would be useful to estimate whether or not there are sufficient amounts of non-reported catch to account of the assumed high rates of M.
k) The sensitivity of the SCALE model results to alternative data weightings should be explored.

3. Weakfish

3.1 Background

The stock assessment for weakfish (*Cynoscion regalis*) that is being conducted by the Atlantic States Marine Fisheries Commission's technical committee (ASMFC - TC) was presented to the Panel by Mr. Jeff Brust, chair of the ASMFC weakfish TC on the afternoon of Thursday December 11th. The discussion on this first afternoon focused on the application of an age-structured virtual population analysis to the weakfish stock. The remainder of the presentation, which focused on biomass dynamic models of weakfish that include covariates, was given on Friday morning.

In preparation for the meeting, the review Panel was provided with access to a range of working papers (ASMFC Weakfish TC 2008a, b, c, Uphoff 2008) that outlined the approach taken in several key aspects of the assessment.

The Panel did not have time to provide a full and careful consideration of all elements of the assessment including the quality of all data inputs and the appropriateness of the inferences drawn. Thus, the comments that follow should not be considered as representing a detailed peer-review of the weakfish assessment. However, the Panel considered that it had adequate time to provide some general overview comments which we hope will be of help to the ASMFC in providing guidance to the weakfish TC as it seeks to complete its assessment. Discussions between Panel members and the TC chair were open and cordial.

3.2. Virtual Population Analysis

At their core stock assessments examine the consequences of observations under a suite of assumptions to explain the dynamics of the stock. Thus, it is critical that the assessment team be confident of the observations entering the assessment model. Errors and uncertainties in the observations on which the assessment is based can lead to spurious patterns in the inferred dynamics that may not be reflective of the true underlying dynamics.

The Panel expressed serious concerns over the reliability of input data used in the weakfish Virtual Population Analysis (VPA). The Panel concluded that until apparent inconsistencies in the input data are more fully explored, the TC's conclusion that the lack of fit of the VPA to the observations is due solely to an increasing natural mortality (M) rate is premature. The Panel recognizes that increasing M could be a possibility. This has been observed in other stocks at low population sizes (e.g. northwest Atlantic Cod) where predator – prey dynamics can maintain prey at low levels of abundance. However, before concluding that M is increasing, it is essential that the TC fully address the data input issues. The Panel does not consider that the VPA results are indicative of a pattern of increasing M to the exclusion of other plausible explanations.

The concerns noted by the Panel centred on the following issues:

a) Reliability of catch information: While the Panel did not have sufficient time to examine the catch records in detail, there was some suggestion from the presentation that catches in some fisheries may have been underestimated substantially. For example, the TC chair and the Panel discussed uncertainties in the NC landings, particularly with regard to allocation to different gear types. It is important that not only the total catch is known, but that it is allocated accurately to the different sectors given the different biological catch characteristics in those sectors.
b) Expansion of discard estimates based on catch per haul of targeted species on observed vessels to total discard for the fleet is likely biased: Related to the concerns expressed over the reliability of the catch data, similar concerns were expressed over the reliability of the discard data. The Panel suggested alternative approaches to the TC chair that might ameliorate these concerns.
c) Reliability of catch at age information: The catch and discard tonnage are partitioned in the catch at age matrix. The key assumption of the VPA is that the catch at age is known with no or negligible error. For weakfish, catch at age is not fully described and estimates from one region and one sector have to be applied to other regions and sectors to provide a full catch at age matrix. The Panel concluded that the catch at matrix is of unknown precision.
d) Spatial and temporal coverage of the indices: Although the VPA could have used more than 40 separate indices, many were found to be inappropriate by the TC for several valid reasons. However, the fishery-independent indices that were selected did not cover the entire population area, but rather were restricted to limited spatial areas within the overall weakfish stock area. Such indices may not reflective of the entire population. If such indices are used, the implicit assumption is that each index represents a constant proportion of the overall population across the entire time series. When this assumption is not met, the overall results of the assessment are likely not reliable. While the TC spent considerable effort selecting those indices whose aggregate trends were comparable, the Panel remained concerned that these indices may have been coherent because they contained little information, rather than because they are reliable indices of population abundance.
e) MRFSS CPUE index: The use of a MRFSS index is not inherently inappropriate and the assessment team appeared to be aware of potential issues in the use of such indices. However, the Panel noted particular concerns given that the MRFSS index was one of the few that exhibited any clear signal or contrast. When such indices dominate the input data set, these concerns become magnified. The Panel was appreciative of the efforts by the TC that have been made since the previous assessment to improve the index but still had concerns over the reliability of this index. For example, the index could have declined because anglers switched the rigging of tackle used to favour striped bass. The MRFSS weakfish CPUE would be expected to decline for this reason alone, particularly as all private and party boat trips were used as the index of effort. The Panel could not suggest a better estimator of effort for use in the calculations given the time available. The Panel remained concerned over the reliability of this fishery-dependent index, particularly given its pivotal role in the VPA.
f) Coherence of fishery-independent indices: The Panel was troubled by the apparent coherence of the aggregate fishery independent indices used as input to the model

compared to the different trajectories estimated as output by the VPA when different groupings of these indices were used as inputs. The Panel considered that the differences between the coherence of the input time series and the model outputs may reflect differences in the age-specific catchabilities and thus abundances monitored by these surveys. The Panel felt that detailed exploration of this apparent discrepancy should be conducted.

g) Weights at age: The Panel noted substantial discrepancies in the weights at age in the catch at age (e.g., age-4 weakfish in one year were heavier than age-5 fish in the subsequent year). These discrepancies could be a consequence of estimation of the catch at age for one fleet using catch at age data from a different fleet.

Overall the review Panel believed that the conclusion that a time varying M was the principal explanation for the pattern of low biomass and high F's observed in the MRFSS tuned VPA was unwarranted. The review Panel felt that other alternative explanations, even assuming inputs were correct, including missing catch, changing catchabilities and inappropriateness of information in the input surveys should be fully explored before the results of the VPA can be used as a spring board to suggest the need to explain an increasing pattern in M. The Panel noted that many of these concerns had been raised by the previous peer review team and have yet to be adequately addressed. Given the nature of the concerns regarding the catch at age, the assessment team should consider a statistical catch at age approach rather than VPA.

3.3. Biomass dynamic modelling

The Panel was very interested in the results of the biomass dynamic models that were presented during the meeting. The Panel felt that they were an interesting exploration of potential ecological mechanisms acting on weakfish. However, if such models are to form the foundation for management there needs to be compelling and direct empirical evidence for the mechanisms being hypothesized. In general, the Panel considered that such evidence was lacking. The Panel was further concerned that the implications of the results for management (e.g., if surplus production in weakfish is truly negative currently, then no viable weakfish fishery is possible) had not been fully considered by the TC.

The Panel again noted the central role of the MRFSS index in determining the results of the biomass dynamic modelling. When an index with a strong, almost exponentially declining pattern is used to drive a model, any variable that shows an opposite trend will appear as a strong covariate in model fits – particularly given the latitude in parameters implied by the assumption of the form of a type III functional response. However, such correlations obviously do not imply causation. Under such circumstances, the Panel noted that documentation of weakfish consumption by striped bass needs to be more fully documented to provide the causation strongly implied by the assumptions of the models presented to the Panel. The TC needs to consider the pattern of spatial and temporal overlap of the two species and the influence of this dynamic on the levels of consumption required. Such consideration appeared lacking from the material presented to the Panel.

The assumption of a type III functional response appears arbitrary. There are several valid alternatives that have been used in other predator-prey models – ranging from type I and II, to foraging arena concepts (Walters and Juanes 1993, Walters and Martell 2004). Each of the different functional responses would have extremely different consequences for the dynamics of weakfish inferred by such models. It was not apparent from the material presented that an adequate exploration of this aspect of the biomass dynamic models with covariates had been undertaken.

The Panel noted that when a resource is in a depleted condition, such as in the case of weakfish, a number of factors can be responsible for maintaining the stock in the depressed state. Examples in the literature of “predator pits” preventing recovery in predator - prey models have been reported (Bundy and Fanning 2005). There is a continuing debate in Atlantic Canada on the role of grey seals maintaining Atlantic cod at their low level of abundance (Chouinard et al. 2005, Trzcinski et al. 2006). However, the mechanisms maintaining the prey species at low levels of abundance and the mechanism that caused the reduced abundance in the first place are not necessarily the same thing. Thus, for weakfish, predation may be maintaining the population at low levels, without having contributed to the original decline of the stock.

The Panel felt that the attempts of the TC to develop a minimum realistic model (MRM) for weakfish trophic interactions, as recommended by Plagányi (2007), were laudable. However, the Panel also felt that the biomass dynamic models were not yet at the stage to provide a reliable basis for the determination of weakfish stock status.

The Panel did not have sufficient time to provide responses to a number of specific questions raised by the TC themselves (ASMFC Weakfish TC 2008a). However, the Panel noted that it has provided guidance on several questions. Most importantly, perhaps for the management of weakfish, the Panel feels that the VPA is not yet sufficiently developed or its results sufficiently explored to support the conclusion of an increasing pattern in M. While the Panel appreciated the spirit of the exploration of ecological mechanisms to explain a pattern of increasing M, these analyses are not of sufficient reliability, given concerns over the MRFSS index and the lack of empirical evidence for the hypothesized predator-prey interaction involving striped bass and weakfish, to be a current assessment tool of the weakfish resource.

4. Literature Cited

Alonzo, S. H., T. Ish, M. Key, A. D. MacCall, and M. Mangel. 2008. The importance of incorporating protogynous sex change into stock assessments. Bulletin of Marine Science **83**:163-179.

Alonzo, S. H., and M. Mangel. 2005. Sex-change rules, stock dynamics, and the performance of spawning-per-recruit measures in protogynous stocks. Fishery Bulletin **103**:229-245.

Alvarado Bremer, J. R. A., M. G. Frisk, T. J. Miller, J. Turner, J. Vinas, and K. Kwil. 2005. Genetic identification of cryptic juveniles of little skate and winter skate. Journal of Fish Biology **66**:1177-1182.

Armsworth, P. R. 2001. Effects of fishing on a protogynous hermaphrodite. Canadian Journal of Fisheries and Aquatic Sciences **58**:568-578.

Brooks, E. N., K. W. Shertzer, T. Gedamke, and D. S. Vaughan. 2008. Stock assessment of protogynous fish: evaluating measures of spawning biomass used to estimate biological reference points. Fishery Bulletin **106**:12-23.

Bundy, A., and L. P. Fanning. 2005. Can Atlantic cod (*Gadus morhua*) recover? Exploring trophic explanations for the non-recovery of the cod stock on the eastern Scotian Shelf, Canada. Canadian Journal of Fisheries and Aquatic Sciences **62**:1474-1489.

Chang, E. S., M. J. Bruce, and S. L. Tamone. 1993. Regulation of Crustacean Molting - a Multi-Hormonal System. American Zoologist **33**:324-329.

Chouinard, G. A., D. P. Swain, M. O. Hammill, and G. A. Poirier. 2005. Covariation between grey seal (*Halichoerus grypus*) abundance and natural mortality of cod (*Gadus morhua*) in the southern Gulf of St. Lawrence. Canadian Journal of Fisheries and Aquatic Sciences **62**:1991-2000.

Falk-Petersen, I.-B., and T. K. Hansen. 1991. Reproductive biology of wolffish *Anarhichas lupus* from North Norwegian waters. International Council for the Exploration of the Sea **CM 1991, G14**:18.

Frisk, M. G., S. J. D. Martell, K. Sosebee, and T. J. Miller. Submitted. Exploring the population dynamics of winter skate in the Georges Bank region using a length-based statistical catch-at-age model. Canadian Journal of Fisheries and Aquatic Sciences.

Frisk, M. G., and T. J. Miller. 2006. Age, growth, and latitudinal patterns of two Rajidae species in the northwestern Atlantic: little skate (*Leucoraja erinacea*) and winter skate (*Leucoraja ocellata*). Canadian Journal of Fisheries and Aquatic Sciences **63**:1078-1091.

Frisk, M. G., and T. J. Miller. 2009. Maturation, of little skate, *Leucoraja erinacea*, and winter skate, *L. ocellata* in the western Atlantic from Cape Hatteras to Georges Bank. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Sciences **1**:000-000.

Frisk, M. G., T. J. Miller, and N. K. Dulvy. 2004. Life histories and vulnerability to exploitation of elasmobranches: Inferences from elasticity, perturbation and phylogenetic analyses. Journal of Northwest Atlantic Fishery Science **35**:27-45.

Frisk, M. G., T. J. Miller, and M. J. Fogarty. 2001. Estimation and analysis of biological parameters in elasmobranch fishes: a comparative life history study. Canadian Journal of Fisheries and Aquatic Science **58**:969-981.

Frisk, M. G., T. J. Miller, and M. J. Fogarty. 2002. The population dynamics of little skate *Leucoraja erinacea*, winter skate *Leucoraja ocellata*, and barndoor skate *Dipturus laevis*:

predicting exploitation limits using matrix analyses. ICES Journal of Marine Science **59**:576-586.
Frisk, M. G., T. J. Miller, S. J. D. Martell, and K. Sosebee. 2008. New hypothesis helps explain elasmobranch "outburst" on Georges Bank in the 1980s. Ecological Applications **18**:234-245.
Gedamke, T., J. M. Hoenig, W. D. DuPaul, and J. A. Musik. 2009. Stock-recruitment dynamics and the maximum population growth rate of barndoor skate on Georges Bank. North American Journal of Fisheries Management **XX**.
Gedamke, T., J. M. Hoenig, J. A. Musick, W. D. DuPaul, and S. H. Gruber. 2007. Using demographic models to determine intrinsic rate of increase and sustainable fishing for elasmobranchs: Pitfalls, advances, and applications. North American Journal of Fisheries Management **27**:605-618.
Goodyear, C. P. 1980. Compensation in fish populations. Pages 253-280 *in* C. H. Hocutt and J. R. Stauffer, editors. Biological Monitoring of Fish. Lexington Books, Lexington, MA.
Gunnarsson, A., E. Hjörleifsson, K. Thörarinsson, and G. Marteinsdóttir. 2006. Growth, maturity and fecundity of wolffish *Anarhichas lupus* L. in Icelandic waters. Journal of Fish Biology **68**:1158-1176.
Heppell, S. S., S. A. Heppell, F. C. Coleman, and C. C. Koenig. 2006. Models to compare management options for a protogynous fish. Ecological Applications **16**:238-249.
Hewitt, D. A., and J. M. Hoenig. 2005. Comparison of two approaches for estimating natural mortality based on longevity. Fishery Bulletin **103**:433-437.
Jivoff, P. 2003. A review of male mating success in the blue crab, *Callinectes sapidus*, in reference to the potential for fisheries-induced sperm limitation. Bulletin of Marine Science **72**:273-286.
Moser, J., and G. R. Shepherd. 2009. Seasonal distribution and movement of black sea bass (*Centropristis striata*) in the Northwest Atlantic as determined from a mark-recapture experiment. Journal of Northwest Atlantic Fisheries Science **In Press**.
Northeast Fisheries Science Center. 2000. Report of the 30th Northeast Regional Stock Assessment Workshop (30th SAW) Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref Doc 00-03, NOAA/NMFS/NEFSC, Woods Hole, MA.
Pavlov, D. A., and G. G. Novikov. 1993. Life history and peculiarities of common wolffish (*Anarhichas lupus*) in the White Sea. ICES Journal of Marine Science **50**:271-277.
Plagányi, É. E. 2007. Models for an ecosystem approach to fisheries. FAO Technical Paper 477, Food and Agriculture Organisation of the United Nations, Rome.
Rountree, R. A. 2002. Wolffishes. Family Anarchichadidae. Pages 486-496 *in* B. B. Collette and G. Klein-MacPhee, editors. Bigelow and Schroeder's Fishes of the Gulf of Maine.3rd Edition. Smithsonian Institution Press, Washington, DC.
Smith, A. D. M., E. J. Fulton, A. J. Hobday, D. C. Smith, and P. Shoulder. 2007. Scientific tools to support the practical implementation of ecosystem-based fisheries management. ICES Journal of Marine Science **64**:633-639.
Sulikowski, J. A., J. Kneebone, S. Elzey, J. Jurek, P. D. Danley, W. H. Howell, and P. C. W. Tsang. 2005a. Age and growth estimates of the thorny skate (*Amblyraja radiata*) in the western Gulf of Maine. Fishery Bulletin **103**:161-168.

Sulikowski, J. A., J. Kneebone, S. Elzey, J. Jurek, P. D. Danley, W. H. Howell, and P. C. W. Tsang. 2005b. The reproductive cycle of the thorny skate (*Amblyraja radiata*) in the western Gulf of Maine. Fishery Bulletin **103**:536-543.

Sulikowski, J. A., J. Kneebone, S. Elzey, J. Jurek, W. H. Howell, and P. C. W. Tsang. 2006. Using the composite variables of reproductive morphology, histology and steroid hormones to determine age and size at sexual maturity for the thorny skate *Amblyraja radiata* in the western Gulf of Maine. Journal of Fish Biology **69**:1449-1465.

Sulikowski, J. A., M. D. Morin, S. H. Suk, and W. H. Howell. 2003. Age and growth estimates of the winter skate (*Leucoraja ocellata*) in the western Gulf of Maine. Fishery Bulletin **101**:405-413.

Sulikowski, J. A., P. C. Tsang, and W. H. Howell. 2002. Morphological, histological and steroidal examination of the reproductive cycle in the winter skate, *Leucoraja ocellata*. Integrative and Comparative Biology **42**:1321-1321.

Sulikowski, J. A., P. C. W. Tsang, and W. H. Howell. 2005c. Age and size at sexual maturity for the winter skate, *Leucoraja ocellata*, in the western Gulf of Maine based on morphological, histological and steroid hormone analyses. Environmental Biology of Fishes **72**:429-441.

Templeman, W. 1984. Migration of wolffishes, *Anarhichas sp.*, from tagging in the Newfoundland area. Journal of the Northwest Atlantic Fishery Science **5**:93-97.

Templeman, W. 1986. Some biological aspects of Atlantic wolffish (*Anarhichas lupus*) in the Northwest Atlantic. Journal of the Northwest Atlantic Fishery Science **7**:57-65.

Trzcinski, M. K., R. Mohn, and W. D. Bowen. 2006. Continued decline of an Atlantic cod population: How important is gray seal predation? Ecological Applications **16**:2276-2292.

Wahle, R. A., C. E. Bergeron, A. S. Chute, L. D. Jacobson, and Y. Chen. 2008. The Northwest Atlantic deep-sea red crab (*Chaceon quinquedens*) population before and after the onset of harvesting. ICES Journal of Marine Science **65**:862-872.

Walters, C. J., and F. Juanes. 1993. Recruitment limitation as a consequence of natural selection for use of restricted feeding habitats and predation risk-taking by juvenile fishes. Canadian Journal of Fisheries and Aquatic Sciences **50**:2058-2070.

Walters, C. J., and S. J. D. Martell. 2004. Fisheries Ecology and Management. Princeton University Press, Princeton, NJ.

Weinberg, J. R., T. G. Dahlgren, N. Trowbridge, and K. M. Halanych. 2003. Genetic differences within and between species of deep-sea crabs (*Chaceon*) from the North Atlantic Ocean. Biological Bulletin **204**:318-326.

Wigley, R. L., R. B. Theroux, and H. E. Murray. 1975. Deep-sea Red Crab, *Geryon quinquedens,* survey off northeastern United-States. Marine Fisheries Review **37**:1-21.

Appendix I :List of working papers provided to the Panel

Atlantic wolffish

DPSWG 2008a. Atlantic wolffish. Working Paper 1: Atlantic wolffish. NMFS/NEFSC. Woods Hole, MA. 86p

Black Sea Bass

Shepherd, G. 2008. Black sea bass. Working Paper 1: Black sea bass. NMFS/NEFSC. Woods Hole, MA. 54p

Deep Sea Red Crab

Chute, A, L. Jacobsen and P. Rago. 2008. Deep sea red crab. Working Paper 1: Red crab. NMFS/NEFSC. Woods Hole, MA. 59p

Scup

Terceiro, M. 2008. Scup: Text, tables and figures. Working Paper 1: Scup. NMFS/NEFSC. Woods Hole, MA. 132p

Skates

Brooks, E., T. Gedamke, K. Sosebee. 2008. Methodology to determine overfished and overfishing reference points for skates. Working Paper 2: Skates. NMFS/NEFSC. Woods Hole, MA. 21p

DPSWG 2008b. Examination of potential biological reference points for the northeast region skate complex. Working Paper 1: Skates. NMFS/NEFSC. Woods Hole, MA. 99p

Weakfish

ASMFC Weakfish TC. 2008c. Memorandum to DPSWG Review Panel Members. Working Paper 1: Weakfish. Atlantic States Marine Fisheries Commission, Washington DC 1p

ASMFC Weakfish TC. 2008b. Weakfish stock assessment report. Draft. Atlantic States Marine Fisheries Commission, Washington DC. 47 p

Uphoff, J. 2008. Biomass dynamic models and external factor hypothesis testing. Working Paper 2: Weakfish. Atlantic States Marine Fisheries Commission, Washington DC. 3p

ASMFC Weakfish TC. 2008c. Weakfish predation models summary. Draft. Working Paper 3: Weakfish. Atlantic States Marine Fisheries Commission, Washington DC 1p