# SEDAR

## Southeast Data, Assessment, and Review

---

# SEDAR 23

# South Atlantic and Gulf of Mexico

# Goliath Grouper

## SECTION V: Review Workshop Report

**January 2011**

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

**Table of Contents**

1. INTRODUCTION ..... 2
1.1 WORKSHOP TIME AND PLACE ..... 2
1.2 TERMS OF REFERENCE ..... 2
1.3 LIST OF PARTICIPANTS ..... 3
1.4 LIST OF REVIEW WORKSHOP WORKING PAPERS AND DOCUMENTS ..... 4
2. REVIEW PANEL REPORT ..... 4

# 1. INTRODUCTION

## *1.1 WORKSHOP TIME AND PLACE*

The SEDAR 23 Review Workshop was held November 15-17, 2010 in Key West, Florida.

## *1.2 TERMS OF REFERENCE*

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks and provide estimated values for management benchmarks, and declarations of stock status.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.
8. Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops.

9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.
10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Summary Report within 3 weeks of workshop conclusion.

The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.**

## *1.3 LIST OF PARTICIPANTS*

***Workshop Panel***

Luiz Barbieri, Chair ..... SAFMC and GMFMC SSC/FWC FWRI
Shannon Cass-Calay ..... GMFMC SSC
Barbara Dorf ..... GMFMC SSC
Jamie Gibson..... CIE Reviewer
John Hoenig .....SAFMC SSC
Sven Kupschus ..... CIE Reviewer
Kevin Stokes ..... CIE Reviewer

***Analytic Representation***

Joe O'Hop .....FWC FWRI
Joseph Munyandorero .....FWC FWRI

***Council Representation***

Ben Hartig .....SAFMC
Kay Williams .....GMFMC

***Official Observers***

Ben Fairey ..... GMFMC AP

***Other Observers***

Angela Collins ..... FWRI
Bill Causey ..... NOS

Don DeMaria .....
Sarah Frias-Torres..... Ocean Research & Conservation Association
Doug Gregory .....FL SeaGrant
Manoj Shivlani..... CIE/RAMAS
Bill Teehan..... FWC

***Staff***
Karen Burns .....GMFMC Staff
Patrick Gilles.....NMFS Miami
Rachael Lindsay..... SEDAR
Julie Neer ..... SEDAR

### *1.4 LIST OF REVIEW WORKSHOP WORKING PAPERS AND DOCUMENTS*

| **Documents Prepared for the Review Workshop** | | |
|---|---|---|
| SEDAR23-RW-01 | Application of Stock Reduction Analysis to goliath grouper (*Epinephelus itajara*) off southeastern U.S.A, 1918 – 2009 | Joseph Munyandorero |
| SEDAR23-RW-02 | Working paper for the review panel | Sarah Frias-Torres |

## 2. REVIEW PANEL REPORT

1. SEDAR 23 Review Panel Summary Report

The stock assessment of goliath grouper presented by the SEDAR 23 Assessment Workshop (AW) provided the Review Panel with thorough descriptions of the data available for assessing goliath grouper, information about the life history of this species, as well as outputs and results from the catch-free model developed for this stock by Porch et al. (2006). The panel felt the proposed base model parameterization as presented was inappropriate to provide information on goliath grouper stock status or benchmarks as it does not reflect appropriate stock dynamics. Further, the panel felt that the output of the model is unlikely to represent real changes in the F trajectories because some model assumptions were thought to be heavily influencing the model output, and the recruitment pattern did not appear realistic with respect to expected patterns of recruitment for a long-lived species. A stochastic stock reduction analysis (SSRA) was also presented for exploratory purposes. In principle, with appropriate attention to better quantifying removals and to sensitivity testing the SSRA could be used in the future to provide more relevant information for management purposes. The Review Panel briefly considered the SSRA but could not review it to draw conclusions as it had not already been considered by the AW. In any case, results from the SSRA would critically depend on credible inputs on removals, which are difficult to derive given some uncertainties in the historical commercial landings and recreational catch. These uncertainties were well described by the data workshop (DW). The catch-free model did not require such an input.

2. Terms of Reference:

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

The Review Panel comments, concerns, and recommendations on the adequacy, appropriateness, and application of the data used in the SEDAR 23 assessment is listed below in itemized format.

<u>Stock structure</u>: Genetic data were used by the data working group to examine stock structure. The panel feels it is safe to say that stocks don't extend to other countries. However, within the United States the resolution of the data is not fine enough to determine spatial structure of stocks. Tagging data demonstrate site fidelity but also long distance movements (~175 km). A single stock within US waters was assumed for the assessment for convenience. This may be reasonable but there are some potential problems with this approach. Management actions may need to be made on a finer spatial scale to prevent localized depletion but the data and models used do not allow for this. Interpretation of indices with varying spatial coverage may be complicated by fish movement patterns which are poorly understood.

The Review Panel thought it might be helpful to evaluate the indices of abundance at a finer temporal and spatial scales. This may shed some light on stock structure and is important for assessing how the indices can be incorporated in an assessment model (see discussion under Indices).

<u>Indices</u>: Multiple indices were developed covering both juvenile and adult life stages. Standard, credible statistical modelling was thoroughly used. Nevertheless, there are some

issues of note. The panel felt it needed more information on the indices, specifically more background on their nature and construction, the conclusions of the DW on the quality of the data, as well as technical details including maps and diagnostics (residuals). The SEDAR criteria for standardizing indices should be followed (the panel did not find this information in the DW report). The panel accepted the indices at face value as other issues already suggested likely rejection of the catch-free assessment model. However, if the assessment had been viewed more positively the panel would have needed to consider the indices in greater detail to advise on their utility. Specific comments and recommendations are presented below.

- ENP creel survey**:** This is the index with the longest time series and the only index spanning the implementation of the moratorium. It covers fish ranging in size from 200mm to 1000mm (predominantly ages 2-8). It only covers part of the juvenile geographic range (though when it was started it was believed to cover the core of the distribution; since the moratorium the distribution has expanded). It is a fishery index based on intercept interviews and there is uncertainty about fishery changes through time. In recent years the index has shown a strong increase but the index declined significantly in 2008 and 2009.

- REEF**:** Positive aspects of the reef survey are that it is not fishery based and it has broad spatial coverage. The panel had concerns over the logarithmic nature of the index (observations are binned in intervals of unequal size) and noted that DW panels for several other SEDAR assessments have rejected REEF for this reason. The panel did not discuss this at length but rather accepted the index at face value. The panel believed the index (both SE and SW subsets) showed increases in stock size over time though the rates of increase is not likely plausible in terms of the assessment. It might be possible to handle the binning using a Poisson model to get an index of abundance but in the extreme, if all observations are in the largest bin then one could not detect even large changes. Simulation might be used to investigate how to use these data—but this would need to be in the context of an assessment model (and may therefore not be useful at this time).

  The panel noted that the SW and SE REEF indices show different behavior. There is a problem with including indices in a model without an explanation or description of the mechanisms giving rise to the discrepancies. A possible explanation is a range expansion or redistribution of fish, or it may be indicative of differing demographics in the two areas. In either case, it needs to be determined how to weight the two indices. (See comments on 'Stock Structure' above.)

- MRFFS**:** This index is important but there are three issues. First, the index is highly variable. Second, there may have been changes in recreational targeting and reporting. Third, this is a proportion positive index for private boats only. It may have been more appropriate to consider trips only in areas where goliath grouper are likely targeted. As a proportion positive index the steep increase may be appropriately structured. However, the panel had concern about how the assessment model treats the index (with errors treated as log-normal instead of binomial).

- DeMaria**:** This index is critical to the assessment because it drives the little bits of variability being estimated by the model (all else is fixed by assumption and the

DeMaria index is the only information presented in that time period). The very rapid declining of this index drives the estimated decline prior to the moratorium. The index represents observations on 4 artificial reefs, in the same general area which is difficult to access. Thus, it could be indicative of a local depletion, potentially after depletion in other areas had occurred. Such a sharp decline during a period of relatively constant catches (adjusted) or slow fall off (non-adjusted) suggests need for care in interpretation. The assessment model output suggests a trebling of F in the period of the DeMaria decline despite constant catch and (presumably) effort. Although this index is potentially important—because it includes information on older fish and is the only information for that time period, the review panel questioned whether it was indicative of the abundance decline of the entire stock and whether the resulting F estimates were realistic.

Reproduction**:** Although the panel believed the reproductive parameters used in the model were based on the best available information, they questioned their sufficiency because they came from early studies or from proxy species. Specifically, age-at-maturity, and spawning frequency are needed for deriving SPR. The panel notes that information suggests an earlier age-at-maturity for males than females which seems to contradict the assumption of protogyny (as observed in other members of the family). Spawning frequency is not known. Thus, there is a need to determine the basic reproductive characteristics of the species.

Natural Mortality**:** The panel notes that there was a lot of effort devoted to modelling age-specific M, a parameter that does influence the current stock status and estimated recovery times. Note that if a different assessment model is adopted the value of natural mortality rate may be very important so there is value in trying to improve the estimation of M.

The panel notes that the value of $T_{MAX}$ (longevity) is what determines the natural mortality rate in the Hoenig model and an underestimate of $T_{MAX}$ results in an overestimate of natural mortality. The maximum recorded age (37 years) may be low because the older fish were fished down and there has only been 20 years since the fishery was closed. Therefore, it was appropriate for the assessment to consider higher values of longevity. It would be appropriate to consider the suite of alternative estimators of natural mortality based on life history correlates. This was apparently done, but the results do not appear in the DW report.

The panel had some concerns about the adjustment of the natural mortality rate, based on Lorenzen's model, to obtain age-specific natural mortality. The panel felt that Hoenig's method describes natural mortality of most of the exploited phase of the life history and there is no reason to contradict this model; Lorenzen's model can be used to adjust Hoenig's M upward for younger ages. In the goliath grouper assessment, mortality rates for all ages were apparently modified so that the overall mortality rate matched Hoenig's M. This methodology should be justified. It was also noted that adjusting Hoenig's M by the Lorenzen method has not been tested and there are some species for which this is likely inappropriate because natural mortality may be lower for at least some younger ages.

Growth: The panel felt the data used were the best available and most appropriate to use. However, it was also noted that this is a primary aspect of the catch-free assessment model and errors in the growth estimates and in the estimates of variability in growth has impacts on the estimated recruitment. If this model were to be used in the future it would be important to look at improving the estimates of growth.

Selectivity: Two methods were used to estimate selectivity. The Panel considered one of the methods inappropriate because it does not take account of cohort sizes. The other method uses a value of F to adjust for unequal cohort sizes but, as this is a parameter that needs to be estimated the Panel felt this procedure leads to some circular reasoning. (See section on selectivity under TOR # 2).

Removals: Information on removals is not needed for the catch-free model but it could still be useful diagnostically. For the alternative model presented, Stock Reduction Analysis (SRA), information on removals is of key importance. The Panel agreed with the AW that there are major concerns about the removal data, including uncertainties in the treatment of questionable records from one dealer and the smoothing of the data. If a model is used that requires removal data then there is a critical need to find the best method for reconstruction of the time series of landings as well as exploration of a variety of scenarios encompassing plausible landings values. In particular, the data should be considered both with and without the adjustments. For recreational removals, the MRFSS figures by number suggest there could be very high catches—possibly equal or greater than historical commercial landings. There is a need to explore methods of constructing historical series.

Discards: The Panel discussed whether discards should be modelled as constant catch versus constant exploitation rate. This issue should be further explored in the next assessment and a clear justification of the decision included in the stock assessment report.

2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

The Review Panel were presented with an assessment of the stock dynamics of goliath grouper using the catch-free method developed by Porch et al. (2006), which had previously been used to assess the stock. The AW presented a model run employed the settings previously adopted by SEDAR 6 to assess the stock updated with current data (a continuity run); as well as a proposed base run, which differed in the indices used, dropping the fisher interview index, adding the MRFSS and the REEF SW index, and with a different prior as to the effectiveness of the moratorium. In addition, the constant natural mortality at age used in the continuity run was replaced by age dependent natural mortality (see TOR #1 above), and selectivities were reassessed. Full MCMC runs were presented to assess model uncertainty for both runs and the uncertainty in some key parameters such as the maximum age and the effectiveness of the moratorium were explored for the proposed base run.

Both runs indicated that there had been a sharp decline in SSB since 1950 reaching a low around 1990, the time at which the moratorium was established for this stock. Both runs also indicated that a reduction in F and an increase in SSB associated with the moratorium. SSB since that time is estimated to have reached higher relative levels in 2009 in the continuity run than in the proposed base run (1.4 x B50%SPR instead of 1 x B50%SPR). Fishing mortality is estimated to have risen slowly from 1950 to 1980 after which it increased, and subsequently decreased five-fold to 1989 when it dropped away to residual levels associated with the effectiveness of the moratorium, although this pattern may have been largely influenced by some model assumptions (see below).

The choice of the catch-free model is logical given the types of available data as the catch is unknown since the implementation of the moratorium and highly uncertain prior to that. In addition, the available age data is too sparse to develop an explicit age-based assessment to estimate cohort strength. However, its appropriateness to management as currently implemented by the Council is questionable given that it is essentially a method that only provides estimates of relative fishing mortality and abundance. To obtain relative levels of abundance the model is scaled, in this case by assuming the biomass at the beginning of the time series equaled the unexploited equilibrium biomass, an assumption unlikely to be appropriate given the historical landings record of goliath grouper. The model does not provide estimates of the value of the unexploited equilibrium biomass. Because the model does not provide estimates of the actual abundance or biomass, the assessment is unable to provide information on catch limits and hence stock status projections other than under a zero catch scenario.

The review panel examined the proposed base model run and voiced the following concerns:

Moratorium Effectiveness: fishing mortality although nominally estimated within the assessment is essentially fixed or at least highly constrained. At the end of the time series (post moratorium) F is largely governed by the choice of the prior on moratorium effectiveness as the parameters would otherwise be highly correlated to recent recruitment levels. Additional runs performed at the request of the panel using alternative priors suggest that the most parsimonious solution points to an unrealistic 100% effectiveness of the moratorium, mainly because the recent rate of SSB increase suggested by the indices is greater than that deemed realistic by the implemented stock-recruitment relationship.

Historic levels of F: relative changes in F during 1950-1978 are guided by the proxy index of historical fishing pressure based on the US census indicating a mildly exponential increase in F over the period where no index information exists. Available landings data for that period, although not used in the assessment, appears to be inconsistent with this assumption.

Selectivities: in the following period, F is less constrained and spikes dramatically with a five-fold increase in 5 years. Fluctuations of this magnitude are considered to be unlikely over such a short time frame and are not anecdotally supported. Industry representatives at the meeting indicated that this was a serial depletion over a longer time period under a spatially expanding fishery, rather than a short-term high intensity depletion. Even in this period, the model F is still effectively constrained externally by the methodology of determining selectivities, which require a priory estimate of total mortality to develop age length-keys—which the Panel considered a circular argument.

In other words, the model is being supplied with a predetermined F trajectory, such that the output from the model closely reflects these input parameters. The Panel felt that at least in some instances these constraints seemed to be unnecessary in the sense that the model converged—suggesting that there is sufficient information to determine the required parameters in the absence of such constraints.

The model diagnostics in the form of the residual patterns on the indices generally suggest temporally autocorrelated residual patterns, particularly for those indices providing information in recent years. All indices indicate strong increases in biomass from 1990 to 2008 (where available), so that the serial autocorrelation in opposing directions suggests that the implied rate of increase is different for different indices.

Prior to 1990 only two indices are effective in guiding the assessment. The residual pattern suggest that most of the information of the decline of the stock in the early period is driven by the ENP index modified by the DeMaria index altering the rate of the decline to a more recent and much sharper decline. Nevertheless, the low point of the series is entirely independent of the inclusion of the index and hence is most likely driven by the overly sharp increase in the indices in conjunction with the fixed mortality rates. The sharp rate of decline seems unrealistic and may be associated with the small spatial scale over which the DeMaria index is derived.

Residual patterns suggest relatively little influence of individual tuning series (robust to the inputs) implying consistency of the information. However, the residuals suggest a failure of the model to represent realistic stock dynamics possibly due to the strong constraints in the model regarding F.

Given these caveats the panel felt the proposed base model parameterization as presented here is inappropriate in providing information on stock status or benchmarks as it does not reflect appropriate stock dynamics. The output of the model is unlikely to represent real changes in the F trajectory as described above. Furthermore, the panel questioned whether the recruitment estimates are realistic with respect to expected recruitment relationship for a long-lived species. In order to fit the rapid, recent increases in some abundance indices, the model produced estimates of the maximum reproductive rate that were high relative to the prior (considered to be reasonable) used for this parameter in the model, as well as a series of positive recruitment deviates in recent years, potentially implying that the stock-recruitment dynamics were not well characterized by the model. These dynamics would largely determine the reference levels against which relative status is evaluated.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

The assessment runs presented by the AW utilize a catch-free model with limited data input and a wide range of assumptions and constraints. By definition, the model used can only provide estimates of relative abundance, biomass and exploitation (and related benchmarks)—there is no information provided to the model to allow scaling to absolute values.

At SEDAR 6 the catch-free model was adopted to provide relative estimates and to provide guidance on the possible recovery time of goliath grouper. At SEDAR 23 the same model was employed but the context has changed with a management need for information to guide possible OFL/ABC setting. The catch-free model cannot provide this information as it does not use data on removals to scale necessary estimates and because it cannot take account of possible future exploitation patterns.

At the SEDAR 23 RW a stochastic stock reduction analysis (SSRA) was also presented for exploratory purposes. In principle, with appropriate attention to better quantifying removals and to sensitivity testing the SSRA could be used to provide more relevant information for management purposes. The Review Panel briefly considered the SSRA but could not review it to draw conclusions as it had not already been considered by the AW. In any case, results from the SSRA would critically depend on credible inputs on removals, which are presently considered uncertain by the DW as the catch-free model did not require such an input (see TOR #1).

4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks and provide estimated values for management benchmarks, and declarations of stock status.

In principle, use of the catch-free model to estimate F and SSB relative to SPR-based benchmarks is appropriate given the uncertainty in the landings data, but is limited in its capacity to provide catch advice. The AW did assess status relative to population benchmarks for continuity and proposed runs of the catch-free model (Fig 3.3.8 of the AW Report). Interpretation of the estimated ratios is, however, problematic for reasons outlined in ToR #2.

The review workshop (RW) did not discuss the use of the $F_{50\%SPR}$ proxy as a $B_{MSY}$-related reference point (as opposed to alternative %SPR values or for the species generally given uncertain life-history). However, even if the F and SSB ratios were accepted at face value, estimation of current (and projected) status is highly dependent on the assumed level of natural mortality (see Fig 3.3.8 of the AW Report) and the assumed level of moratorium efficacy. This latter point was not investigated by the AW but limited runs during the RW demonstrated the dependency.

The issue of sensitivity to natural mortality is significant. At an assumed $T_{max}$ of 37 years, the point estimate of $F_{2009}/F_{50\%SPR}$ is 0.821. As $T_{max}$ increases, the point estimate exceeds 1 at $T_{max}$ = 50 years and rises linearly to greater than 1.5 at $T_{max}$ = 80 years. The ratio of $SSB_{2009}/SSB_{F50\%SPR}$ declines exponentially from over 0.9 to less than 0.3 over the same range of $T_{max}$. As noted in ToR 1, the exploration of sensitivity to $T_{max}$ in the range 37 (maximum observed age) to 80 years was deemed appropriate (based on comparison of other grouper species).

It is not possible, therefore, for the RW to recommend appropriate benchmarks or to provide estimates. Nevertheless, some qualitative statements can be made about abundance, biomass and exploitation, and stock status, based solely on data. Whilst interpretation of indices is not straightforward (see ToR 1), all indices suggest that abundance and biomass have increased since 1990 when the moratorium was implemented. The extent of that increase is difficult to gauge given the nature of the indices which all suggest faster rates of increase, and in some cases variability, than seem plausible given the biology of the species. There are also clear indications from indices representative of younger fish that recent recruitment may be less than in the preceding years. It is difficult to interpret the degree of previous stock decline as the perceived status in 1990 is strongly driven by the way the assessment must interpret the limited DeMaria index information (see ToR 1 and ToR 2).

5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

Notwithstanding the issues with the underlying assessment model, the panel agreed that the methods used by the AW to project future population status were adequate. Projections of the relative levels of spawning stock biomass were made based upon the state of the population

and the relative fishing mortality rate in the final year of the assessment (2009). Uncertainty in the projections was assessed using MCMC simulations for the projection time period. This method ensures that the uncertainty in the current stock biomass and current fishing mortality, including covariance in the estimated model parameters, is carried forward throughout the projections. However, as stated in the assessment report, the projection methods did not include other sources of potential variability, such as implementation uncertainty, episodic sources of mortality (e.g. cold kills, red tide mortalities, etc.) or good and bad recruitment years. Uncertainty in the projections is not fully quantified as a result. While these other factors could theoretically be incorporated into the projection model via Monte Carlo simulation within the MCMC runs , given that the underlying sampling distributions for these other sources of variability are not known, the panel considered the methods as implemented were appropriate for this assessment.

Although the methods used to project future population status were implemented correctly, due to the underlying issues in the assessment model, estimates of future stock condition cannot be made at this time.

6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The Review Panel believed that the methods used to characterize uncertainty in the estimated parameters were appropriate for this assessment and that the methods were correctly applied.

The AW used two methods within ADMB to characterize uncertainty: the calculation of asymptotic standard errors and covariances for parameter estimates, as well as the use of Bayesian Markov Chain Monte Carlo (MCMC) methods implemented with this software. The use of two methods allowed the uncertainty of the resulting estimates to be evaluated. Of these methods, MCMC has two advantages: it produces estimates of the marginal posterior probability distributions that constrain the resulting confidence intervals to be within the parameter bounds and that parameter covariance is preserved during the simulations. The AW used cumulative probability distributions, based on the MCMC runs, to evaluate the probability that management benchmarks had been met or exceeded, an approach the panel considered to be appropriate for carrying forward the uncertainty in an individual model run. The methods used by the AW to select an appropriate burn-in period and an appropriate level of thinning of the MCMC chain to reduce autocorrelation were considered appropriate.

In addition to assessing the uncertainty in the model output, the AW used informative priors on some input parameters (e.g. the maximum lifetime reproductive rate and the effectiveness of the fishery closure) to input uncertainty in these values into the model. Although this approach can strongly influence model output, its influence can be less than fixing the parameter at a constant value, an approach at times used when data are not sufficient to provide a parameter estimate.

The AW also evaluated the effects of assumed parameter values on the model output. As an example, they thoroughly evaluated the influence of the maximum age of goliath grouper by repeating the analysis using several assumed values, clearly illustrating how uncertainty in

this life history characteristic influenced the model output. The panel agreed with the AW that maximum age was a key source of uncertainty in the assessment. At the review meeting, the assessment team also evaluated the effect of the prior on the effectiveness of the fishery closure by using a less informative prior for this parameter, thereby demonstrating that the model would converge with less information being provided to the model about the value for this parameter. Additionally, the assessment team carried out a retrospective analysis and ran the assessment model using subsets of the survey indices to characterize the sensitivity of the model output to both recent data and the influence of the individual surveys.

Overall, the methods used by the AW to characterize uncertainty aided the Panel in its evaluation of the assessment. Although the methods used to characterize the uncertainty in the estimated parameters were considered appropriate, due to the underlying issues in the assessment model (parameter estimates from the model were not accepted), measures of the uncertainty for the estimated parameters cannot be provided at this time.

7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.

The Review Panel ensured that the stock assessment results were clearly and accurately presented in the SEDAR 23 Summary Report and that the results were consistent with the Review Panel recommendations.

8. Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops.

The Review Panel had no specific comments about the SEDAR process in regard to the review of the goliath grouper stock assessment. However, issues of relevance to the overall SEDAR process were discussed. The international members of the panel noted that a short summary of US management regulations and benchmarks would have provided a useful reminder of the legislative and management framework in which the panel is expected to operate.

9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.

Although results were unsatisfactory for this stock assessment, they did serve to clarify additional research necessary for future assessment efforts. The next benchmark assessment cannot be successfully completed without data from the research recommended by the Data, Assessment, and Review Panels.

Stock Definition:

- Goliath grouper should be genetically sampled from as many areas in the South Atlantic and Gulf of Mexico as possible to allow for a more thorough examination of the current single stock definition.
- Examination of spawning aggregations over the entire distribution range should include seasonality, sex ratios, and individual fidelity.

Long-term monitoring:

- Basic reproductive data are lacking throughout the species distribution, including: size and age at maturity for each sex, sexual sequence with size and age for each sex, and fecundity.
- As described in the above research recommendations by the Life History Working Group, research on age structure, and locations of suitable juvenile and adult habitat, discard and discard mortality rates should be accomplished throughout the species distribution

Economic impact:

- Because of the relatively small size of a potentially reopened consumptive fishery for goliath grouper, a socio-economic evaluation of the relative benefits of consumptive versus non-consumptive uses would be beneficial. There may be greater long-term economic benefit to development of sustainable non-consumptive eco-tourism venues than would be possible from a consumptive fishery.

10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Summary Report within 3 weeks of workshop conclusion.

This report constitutes the Review Panel's summary evaluation of the stock assessment and discussion of the Terms of Reference. The Review Panel will complete edits to its report and submit to SEDAR for inclusion in the full set of documents associated with SEDAR 23.

## 3.2. References

Porch, C.E., Eklund, A.M., and Scott, G.P. 2006. A catch-free stock assessment model with application to goliath grouper (*Epinephelus itajara*) off southern Florida. Fishery Bulletin 104: 89-101.