CIE Independent Peer Review Report

on

SEDAR 30

Caribbean blue tang and queen triggerfish assessment review

Prepared by

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I. Executive Summary

Queen triggerfish (*Balistes vetula*) and blue tang (*Acanthurus coeruleus*) are reef dwelling and widely distributed in the Atlantic Ocean. They are common in the Caribbean Sea and support two important fisheries in the Puerto Rico and U.S. Virgin Islands. Commercial landing data of the U.S. Caribbean queen triggerfish and blue tang were included in snapper/grouper landings in the 1970s -1990s and then in species groups in the 2000s, and species-specific landing data were only available in recent years. Limited life history parameters such as von Bertalanffy growth parameters are available. Length-composition data are also available for all locations except for the Puerto Rico blue tang. No fishery-independent and fishery-dependent abundance index data were available for the assessment. Because limited data are available for their stock assessment, they are considered data-poor fisheries and a formal stock assessment model is not applicable to these two fish stocks.

An estimator, which uses length-frequency data and requires no assumption of equilibrium population, was used in the assessment for estimating total mortality rate. The natural mortality was estimated from various methods. The fishing mortality was then estimated as the difference between the total and natural mortality rates. No biological reference points such as F_{MSY} and B_{MSY} were estimated. The natural mortality was used as a proxy of F_{MSY}. The estimated fishing mortality was compared with the natural mortality to determine if the fishery was in the status of "overfishing". Because no biomass could be estimated, it is impossible to determine if the queen triggerfish and blue tang stocks were "overfished" and no stock projection under different management strategies could be done. A comprehensive sensitivity analysis was conducted to evaluate impacts of uncertainty associated with the key life history parameters. The stock assessment suggests that the choice of growth parameters and estimators of natural mortality influenced the determination of status of the U.S. Caribbean queen triggerfish and blue tang. For certain combinations of growth parameters and natural mortality estimators, the fisheries could be defined as experiencing "overfishing", but for the other combinations, the fisheries were considered not in the status of "overfishing". Although large uncertainty existed in the status of the fisheries, it appears that these two fish stocks were *less likely* to be in the status of "overfishing". *Overall, I conclude this assessment is the best the AW panel could do given the restriction of data availability; however I cannot conclude that the assessment is "sound" and "robust" as the assessment quality and results are affected greatly by large uncertainty in the data quality and estimators of natural mortality.*

I have made the following recommendations for improving the assessment: (1) the expert and background knowledge on species of similar life history patterns be used to exclude biologically unrealistic values of K, L_∞, natural mortality, and total mortality; (2) uncertainty associated with K, L_∞, natural mortality, total mortality, and subsequently fishing mortality be quantified using a Monte Carlo simulation; (3) a program be developed to interview fishermen to collect the information on temporal and spatial variability of the fishing grounds, target species and sizes, and fishing efforts; (4) the information on the species composition of current landings be used to decompose the historical landings of species group into the species-specific landings; (5) a fishery-independent survey program be developed for the queen triggerfish, blue tang and other reef-dependent species sharing similar habitat to collect samples for estimating basic life history parameters and for driving reliable abundance indices; (6) a simulation study be conducted to evaluate the performance of the length-based estimator and identify factors that are critical in influencing the performance of the estimator; (7) a yield-per-recruit analysis be conducted with the incorporation of uncertainty in life history parameters to estimate biological reference points such as F_{max} and $F_{0.1}$; and (8) a spawning stock biomass-per-recruit analysis be done with the incorporation of uncertainty associated with life history parameters to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

II. Background

Queen triggerfish (*Balistes vetula*) is a reef dwelling triggerfish mainly distributed in the Atlantic Ocean. In the West Atlantic, they are distributed from Canada to southern Brazil and are common in the US Caribbean. They are reef-dependent and typically occur at coral and rocky reefs in shallow waters. However, they sometimes also can be found in relatively deep water (up to 275 m) and in areas with sand or seagrass. Adult queen triggerfish are opportunistic feeders. The species is subject to diurnal movement and tends to be either solitary or aggregate in small groups (Randall 1968; Aiken 1975). The maximum length was observed at 572 mm fork length in the U.S. Virgin Islands (Randall 1968). The oldest age recorded in the U.S. Caribbean was 7 years old (Manooch and Drennon 1987).

Blue tang (*Acanthurus coeruleus*), also known as the Atlantic blue tang surgeonfish or the Atlantic blue tang, is a surgeonfish in the Atlantic Ocean. Blue tang is common in the Caribbean Sea and Gulf of Mexico. They inhabit shallow-water, coral reefs and rocky habitat (Carpenter 2002). Adult blue tang are herbivorous, feeding on various benthic algae (Carpenter 2002). The maximum length was observed at 457 mm total length in St. Thomas (Olsen 2011), and the oldest age was found to be 20 years of age (Mutz 2006). Growth parameters estimated in different studies tend to differ greatly as a result of differences in sampling locations, sample sizes, and ranges of age/size composition of sampled fish (Choat and Robertson 2002; Mutz 2006).

Both the fisheries are data-poor with a limited amount of information/data available to the stock assessment. The historical landing data were aggregated by snapper/grouper earlier in the 1970s -1990s, by species groups in the 2000s, and were only separated by species in recent years (after 2011). The recreational data tend to have few trips of positive catch. No reliable fishing effort and no fishery-independent data were available. Size composition data of commercial catch derived from relatively large sample sizes were available for all locations except for the blue tang stock in Puerto Rico (SEDAR30 2013).

Size composition data were used in the stock assessment for estimating the total mortality rate using a length-based estimator developed by Gedamke and Hoenig (2006). This method improves the traditional Beverton-Holt mortality estimator (Beverton and Holt 1957) with no requirement for the assumption of an equilibrium population. The natural mortality was estimated from various methods (Pauly 1980; Hoenig 1983; Jensen 1996). The fishing mortality was then estimated as the difference between the total and natural mortality rates. Because this is data-poor fishery, no biological reference points such as F_{MSY} and B_{MSY} were estimated. The natural mortality was used as a proxy of F_{MSY} (King 1995). Thus, the estimated fishing mortality was compared with the natural mortality to determine if the fishery was in the status of "overfishing". Because no biomass could be estimated, it is impossible to determine if the queen triggerfish and blue tang stocks are "overfished" and no stock projection can be done to evaluate impacts of various management strategies on the stocks. A comprehensive sensitivity analysis was conducted to evaluate impacts of uncertainty associated with the estimates of key life history parameters. The stock assessment suggests that the choice of growth parameters and estimators of natural mortality influenced the determination of status of the U.S. Caribbean queen triggerfish and blue tang. For certain combinations of growth parameters and natural mortality estimators, the fisheries could be defined as experiencing “overfishing”, but for the other combinations, the fisheries were considered not in the status of “overfishing” (SEDAR30 2013).

III. Description of the Individual Reviewer’s Role in the Review Activities

As the SoW states that “*Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs*”, my role as a CIE independent reviewer is to conduct an impartial and independent peer review of SEDAR 30 “Caribbean blue tang and queen triggerfish assessment” with respect to the pre-defined Terms of Reference.

This is a desk review. Thus, I have no opportunity for face-to-face discussion and questioning. I read the “SEDAR30-SAR1: Final Stock Assessment Report for Caribbean Blue Tang” and “SEDAR30-SAR2: Final Stock Assessment Report for Caribbean Queen Triggerfish” and all other background documents that were sent to me (see the list in the Appendix I). I also read references relevant to the topics covered in the reports and the SoW. I addressed each topic covered in the ToRs, evaluated the strengths and weaknesses of what was done in this assessment, and provided recommendations to improve future assessment. Based on these evaluations and analyses, I made research recommendations for future assessment of Caribbean blue tang and queen triggerfish.

IV: Summary of Findings

IV-1. Queen triggerfish

The following summary of my findings is provided with respect to a set of pre-defined TORs for the U.S. Caribbean queen triggerfish.

IV-1-1. Evaluate the data used in the assessment, addressing the following:

Data available to the assessment include commercial landings, recreational intercept data and length frequency data estimated separately for St. Thomas/St. John, St. Croix, and Puerto Rico.

For Puerto Rico, the commercial landing data of queen triggerfish by gear and fishing center were estimated from self-reported fisher logbooks/sale receipts for the time period from 1983 to 2011. Because the report was incomplete, the total landings were adjusted (SEDAR30, 2013). The number of trips with reported queen triggerfish landings was also estimated by gear and year.

For St.Thomas and St. John, although logbook reporting started in 1974, landings were reported by gear and by either snapper/grouper or other finfish prior to 1997. Landings were reported by species group and gear from 1997 to 1999, all commercial landings were reported by species group from 2000 to 2010, and the landing data have been reported by species since 2011. For the years included in this assessment, queen triggerfish-specific landing data are not available prior to 2011, and landing data are only available for the triggerfish species group.

For St. Croix, similar to St. Thomas and St. John, landing data were only available for the triggerfish species group, not for queen triggerfish. Commercial landing data were only available from 1998 to 2011.

Marine Recreational Fisheries Sampling Survey (MRFSS) collects data from Puerto Rico, but not the US Virgin Islands. The sampling design consists of two complementary components, an angler-site intercept survey for estimating catch and length frequency data and a fishing effort telephone survey to estimate fishing effort. However, the positive intercepted trips (i.e., presence of queen triggerfish) were less than 1% in almost all the years. Only 60 queen triggerfish were measured from 2000-2011.

The VBGF parameters were estimated in two studies, but K differs greatly (Manooch and Drennon 1987; de Albuquerque et al. 2011). The maximum age in the sample is 7 (Manooch and Drennon 1987) and 14 years of age (de Albuquerque et al. 2011), and the growth curves in neither study reached the asymptotic lengths. The VBGF parameters estimated in Manooch and Drennon (1987) were used because the samples were taken in Puerto Rico and the US Virgin Islands.

Length frequency data were estimated from samples taken in pot and trap fisheries in Puerto Rico, St. Thomas and St. John, and St. Croix. However, the temporal changes in length frequency data might be influenced by changes in market demand for large sizes of queen triggerfish and/or possible expansion of the fishery into new areas.

IV-1-1-a. Are data decisions made by the Assessment Workshop sound and robust?

The AW panel decided to use the von Bertalanffy growth parameters estimated in Manooch and Drennon (1987) because the samples were taken in Puerto Rico and the US Virgin Islands. The AW panel also decided to use length-frequency data estimated in the pot and trap fisheries for estimating the total mortality using a length-based mortality estimator. The AW decided not to use the intercepted catch, effort, and length data from MRFSS because of the low proportion of positive trips and sample sizes of length data.

Based on the data available, these decisions are the best the AW panel could make. However, based on the information available I do not have evidence to conclude if the data decisions are "sound and robust".

IV-1-1-b. Are data uncertainties acknowledged, reported, and within normal or expected levels?

The AW panel did acknowledge potential issues which might influence the quality of the data. The MRFSS data were excluded because of small sample sizes, and good discussions were made on potential causes resulting in large shifts in length compositions over time. However, I do not see distributional quantification of uncertainty associated with the estimates of the von Bertalanffy growth parameters. I think the estimation of these parameters should come with estimates of uncertainty (e.g., bootstrap-estimated confidence intervals). Given there are only 7 age groups available in Manooch and Drennon (1987), the uncertainty associated with the estimated L_∞ and K could be large. It is also unclear if the variation in size within an age group was considered and if the fitting of the VBGF was weighted by the sample sizes of the different age groups.

IV-1-1-c.Are data applied properly within the assessment model?

This is a data-poor fishery, and there is no enough information for a formal stock assessment. Given the data available, I consider the data are properly applied in the estimation of total, natural and fishing mortality rates in the assessment.

However, I believe the sensitivity analysis could be better designed and justified if the uncertainty associated with K and L_∞ could be better quantified and if expert and background knowledge could be used to exclude biologically unrealistic combinations of values for the growth parameters and natural mortality.

IV-1-1-d.Are input data series reliable and sufficient to support the assessment approach and findings?

Estimation of the length-frequency data might be influenced by temporal variability in the shifted preference of market demand for large queen triggerfish, which might change the selectivity of the fishery over the time. Thus, the temporal variability in length composition might not reflect changes in fish mortality; rather reflect changes in selectivity. Although potential changes in the total mortality could be incorporated in Gedamke and Hoenig (2006), I did not see how possible changes in selectivity could be incorporated. This may yield biases in the assessment results.

IV-1-2. Evaluate the methods used to assess the stock, taking into account the available data.

Given the limitation of data availability, the Beverton-Holt length-based mortality estimator (Beverton and Holt 1957) is a good option for the assessment of this fishery. However, as the AW panel explicitly described in the assessment report, this method, explicitly and implicitly, requires six assumptions: (1) growth is constant over time and space; (2) there is no variability in growth among individuals; (3) there is constant and continuous recruitment over time; (4) the mortality rate is the same for fish older than the age at recruitment; (5) the mortality rate is constant over time and space; and (6) the population is in equilibrium. Apparently none of these assumptions can be satisfied in the U.S. Caribbean queen triggerfish fishery. Instead of using this traditional approach, the AW panel used a modified Beverton-Holt length-based mortality estimator which requires no assumption of an equilibrium population. However, the other assumptions are still required. There were a number of years when mortality rate changes were identified using the Akaike Information Criterion (AIC) as the model selection measure. A systematic sensitivity analysis was done to evaluate impacts of uncertainty in the growth parameters on the estimation of fish mortality rates.

IV-1-2-a. Are methods scientifically sound and robust?

Given the limitation of data availability, this approach may be the best choice the AW panel can have for the assessment of the U.S. Caribbean queen triggerfish. However, based on what has been reported in the AW report, I cannot conclude that this is scientifically sound and robust because it is difficult to evaluate whether this approach can capture the real fishing mortality rate without knowing the true value. A simulation study, similar to the one in

Gedamke and Hoenig (2006) but based on the queen triggerfish data, should be conducted to evaluate the performance and robustness of this mortality estimator for the queen triggerfish with respect to different assumptions associated with the fishery.

IV-1-2-b. Are assessment models configured properly and used consistent with standard practices?

Given what is available, I believe that the configuration of the assessment models is consistent with standard practices. However, the uncertainty in growth parameters was not estimated and the sensitivity analysis could be better designed if the uncertainty associated with K and L_∞ was explicitly estimated. The values of K and L_∞ are usually strongly and negatively correlated, and such negative correlations should be considered in the sensitivity analysis. The sensitivity analysis should focus on one parameter (either K or L_∞) with the value of the other parameter drawn from a joint probability distribution with a defined covariance structure for K and L_∞. A bootstrap approach can be used to define the joint probability distribution of K and L_∞.

The AW panel considered different approaches for estimating natural mortality, and recommended that the M estimated using the Pauly's equation (Pauly 1980) be used because the growth parameters were also used in the estimation. I agree with the AW panel and believe this perhaps is the most robust approach to reduce potential biases in the estimated fishing mortality rate (because F = Z-M). However, I think a more appropriate approach for estimating M may be the use of a subset of fish species with similar habitat and life history characteristics (e.g., reef-associated species) to modify Pauly's equation to make the estimation of M more consistent with the life history and habitat characteristics of the Caribbean queen triggerfish.

The use of M as a proxy for F_{MSY} is a common practice for a data-poor fishery (King 1995). This *ad hoc* limit reference point appears to be the best choice given the available data.

I*V-1-2-c. Are the methods appropriate for the available data?*

Overall, I believe that the method is appropriate for the available data. However, I believe a simulation study should be conducted to evaluate the performance of the method.

IV-1-3. Evaluate the assessment findings with respect to the following:

I*V-1-3-a. Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?*

Because of data limitations, neither abundance nor biomass was estimated. Fishing mortality was derived from the difference between the total mortality estimated from length-composition data and natural mortality estimated from Pauly's model (Pauly 1980). Uncertainty associated with the fishing mortality was evaluated by considering possible ranges of the total mortality estimated using different growth parameters and natural mortality estimated using different estimators.

I believe that the lack of abundance/biomass estimates is consistent with the limitation of data availability. Large uncertainty associated with fishing mortality estimates is consistent with possible issues related to the estimates of life history parameters used in estimating the total and natural mortality rates.

IV-1-3-b. Is the stock overfished? What information helps you reach this conclusion?

The stock biomass/abundance and biomass-based limit reference points cannot be estimated reliably in this assessment based on the data available. The AW panel concluded that this assessment did not have enough information to determine if the stock was overfished. Given the available data, I agree with the AW panel.

IV-1-3-c. Is the stock undergoing overfishing? What information helps you reach this conclusion?

Puerto Rico

Large uncertainty is associated with the estimation of fishing mortality as a result of the varying choices of estimators for estimating natural mortality and different growth parameters used in estimating the total mortality. However, for most scenarios tested, the estimated fishing mortality tended to be much lower than natural mortality, suggesting that the queen triggerfish experienced low fishing mortality. If the natural mortality is used as a limit reference point in determining if the fishery is in the status of overfishing, we may conclude that the Puerto Rico queen triggerfish fishery is not in the status of overfishing. The analysis of length composition data from the pot and trap fishery shows that fishing mortality has a declining trend in the late 1990s; however large uncertainty as a result of lack of understanding of possible temporal changes in selectivity and fishing grounds complicates the interpretation of this result.

St. Thomas and St. John

The results of comparing fishing mortality and natural mortality depend on the choices of (1) growth parameters used in the estimation of the total mortality; (2) estimators of natural mortality; and (3) maximum age (i.e., 7 in Manooch and Drennon (1987) or 14 in de Albuquerque et al. 2011). Given such large uncertainty and lack of strong evidence to justify the use of one set of life history parameters over the other, it is difficult to conclude if the fishery is in the status of overfishing.

St. Croix

The results of comparing fishing mortality and natural mortality depend on the choice of growth parameters, which determine the estimates of the total mortality. For the set of life history parameters resulting in a high level for the total mortality estimate, the fishing mortality is higher than natural mortality, suggesting that fishing mortality may be too high. However, for the set of life history parameters resulting in a low level for the total mortality estimate, the estimated fishing mortality is lower than natural mortality, suggesting that the fishing mortality is not too high. We do not have strong evidence favoring one set of the life history parameters over the other, and hence it is difficult to decide if the fishery is in the status of overfishing.

IV-1-3-d. Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

No stock-recruitment relationship can be developed based on the available data.

IV-1-3-e. Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Like many data-poor fisheries, natural mortality was used as a proxy for F_{MSY} in the assessment (King 1995). This effectively treats natural mortality as a limit biological reference point to determine if the fishery is in the status of overfishing. The AW panel explored and evaluated different methods in quantifying the natural mortality and found large uncertainty associated with the natural mortality estimates. Given the information available, I believe that yield-per-recruit (and maybe egg-per-recruit) analysis can be conducted, which can produce estimates of F0.1 and Fmax. The AW panel did mention that they did not do per-recruit analysis because of concerns on the quality of life history parameters. However, given the same life history parameters used in estimating the total fishing mortality and natural mortality (for some methods), I do not see the logic here for not doing a per-recruit analysis. I think the uncertainty associated with life history parameters can be readily incorporated in a per-recruit analysis using a Monte Carlo approach (e.g., Chen and Wilson 2002; Chang et al. 2009).

IV-1-4. Evaluate the stock projections, addressing the following:

No formal stock projection was done in the assessment because of data limitations.

IV-1-4-a. Are the methods consistent with accepted practices and available data?

Stock projections were not done in the assessment because of lack of the information on the dynamics of the fish population.

IV-1-4-b. Are the methods appropriate for the assessment model and outputs?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-1-4-c. Are the results informative and robust, and useful to support inferences of probable future conditions?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-1-4-d. Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-1-5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The AW panel outlined several sources of uncertainty in the assessment. The uncertainty associated with the quality and quantity of fisheries data (e.g., commercial and recreational catch and size composition data, fishing efforts, and sample sizes) is well discussed to determine which data sets should be used in the assessment. Large variabilities on growth parameters among different studies were identified and their impacts on the estimation of total mortality and fishing mortality were evaluated in a sensitivity analysis. Uncertainty resulting from choices of estimators for natural mortality also was discussed.

Although the AW panel discussed the uncertainty of different sources rather thoroughly and developed sensitivity analyses to evaluate impacts of the uncertainty on the estimation of the total, natural and fishing mortality rates, I believe the uncertainty should be incorporated in the assessment in a more systematic way. I suggest using a Monte Carlo simulation approach to systematically incorporate the uncertainty in life history parameters into the estimation of the fishing mortality rate. For each parameter, a distribution (uniform, multinomial, normal, or log-normal) can be defined based on the type of the data and possible ranges of the values. For each run, the value of a given parameter can be randomly drawn from such a distribution. The correlations between L_∞ and K should be considered and their values should be drawn from a joint distribution of these two values. One hundred or more runs of Monte Carlo simulation can yield a distribution for the total, natural and fishing mortality rates. Such an approach can better capture and quantify the uncertainty, which can be used directly in comparing probability distributions of natural mortality and fishing mortality to determine the likelihood of overfishing. Before this can be done, however, the range of the growth parameters and natural mortality should be narrowed down based on the expert knowledge and background information on fish species of similar life history and habitat needs.

IV-1- 6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

The AW panel recommends improving the quality of life history parameter estimates; developing a fishery-independent monitoring program; continuing the efforts to improve the collection of species-specific catch and effort data; and modifying the length-based total mortality estimator to account for potential changes in selectivity. I consider these research areas are important for reducing the uncertainty and improving the quality of the assessment. The AW panel probably needs to prioritize the research recommendations and separate the short-term research plan from the long-term plan.

Given the problems associated with the data, an important research goal should be to improve the data quality and quantity. Short-term and long-term plans should be developed to achieve the goal. Short term research priority may include (1) improvement of life history data estimates and the quantification of their uncertainty in the form of probably distributions; (2) identification of major fishing areas and their spatio-temporal variability via conducting interviews with fishermen involved in the fishery; and (3) identification of potential approaches that can be used to estimate species-specific landing data (e.g., based on species composition of landings that become available in recent years). The long-term research plan should include the development of a fishery-independent monitoring program and continued improvement of the sampling protocol for the collection of fishery-dependent data (catch and effort).

Given the data limitations, I believe another research priority that should be addressed soon is to evaluate the performance of the length-based estimator (Gedamke and Hoenig 2006) for the total mortality. Based on the information available and with some assumptions, a queen triggerfish fishery can be simulated, following the approach used in Gedamke and Hoenig (2006). A simulation study can be conducted with this simulated fishery to evaluate the performance of this length-based estimator for estimating the total mortality. Different scenarios can be developed to identify key factors that may have significant impacts on the performance of the estimator. This can guide the future model development and data collection.

IV-1-7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

I recommend the following key areas for the improvement when scheduling the next assessment:

- Growth parameters K and L_∞ should be estimated with uncertainty. A bootstrap approach can be used with the von Bertalanffy growth model to quantify the joint probability distribution of K and L_∞, which can be used for quantifying probability distributions for the total, natural and fishing mortality rates;

- More basic biological studies need to be conducted to improve our understanding of key life history processes and estimate key life history parameters such as growth parameters, length/age at maturity, fecundity, and their spatial variability;

- An interviewing-fishermen program should be done to identify major fishing grounds and main size classes of landed catch, and possible changes over time;

- Use the proportion of queen triggerfish in the total catch of all triggerfish species estimated in recent years to estimate the queen triggerfish catch in the past (assuming that the proportion is the same over time);

- A simulation study needs to be conducted to evaluate the performance of the length-based estimator of the total mortality rate and identify assumptions/parameters that can influence greatly the performance of the estimator, which will help us understand the quality of the estimates of the total mortality;

- Uncertainty associated with the natural mortality rate should be quantified in the form of a probability distribution, which can be done with a Monte Carlo simulation approach;

- The Pauly natural mortality estimator was derived from many species with very different life history and habitat needs (Pauly 1983), and a subset of fish species that have life history and habitat needs similar to the focal species may yield a more appropriate natural mortality estimator;

- A yield-per-recruit analysis with the consideration of uncertainty associated with life history parameters (e.g., Chen 1996; Chang et al. 2009) can be done to estimate theoretical biological reference points such as F_{max} and $F_{0.1}$; and

- A spawning stock biomass-per-recruit analysis with the incorporation of uncertainty associated with life history parameters can also be done to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

IV-2. Blue tang

The following summary of my findings is provided with respect to the set of pre-defined TORs for blue tang.

IV-2-1. Evaluate the data used in the assessment, addressing the following:

Data available to the assessment included commercial landings, recreational intercept data and length-frequency data estimated separately for St. Thomas/St. John, St. Croix, and Puerto Rico. Life history data obtained from published studies were also used in the assessment.

For Puerto Rico, the commercial landing data of blue tang were included in the reported catch of the species group surgeonfishes by gear and fishing center, and the proportion of blue tang within the surgeonfishes species group was unknown. Hence, no separate landing data are available for blue tang. The landing data were reported by gear and fishing center and estimated from self-reported fisher logbooks/sale receipts for the time period from 1983 to 2011. Because the report was incomplete, the total landings were adjusted (Caribbean Fisheries Data Evaluation Final Report, 2009). Length composition data were derived from small sample sizes.

For St.Thomas and St. John, although logbook reporting started in 1974, landings were reported by gear and by either snapper/grouper or other finfish prior to 1997. Some landings were reported by species group and gear from 1997 to 1999, and all reported commercial landings was reported by species group from 2000 to 2010, and the landing data have been reported by species since 2011. For the years included in this assessment, landing data were provided as surgeonfishes with all the species combined, and blue tang-specific landing data are not available.

For St. Croix, similar to St. Thomas and St. John, landing data were only available for surgeonfishes, and no blue tang-specific landing data were available. Commercial landing data were only available from 1998 to 2011.

Marine Recreational Fisheries Sampling Survey (MRFSS) collects data from Puerto Rico, but not the US Virgin Islands. The sampling design consists of two complementary components, an angler-site intercept survey for estimating catch and length frequency data and a fishing effort telephone survey to estimate fishing effort. However, the positive intercepted trips (i.e., presence of blue tang) are too small. The AW panel concluded that this data set was not useful for the blue tang assessment.

The VBGF parameters were estimated for different locations in the U.S. Caribbean in two studies (Choat and Robertson 2002; Mutz 2006). Large differences were found in the estimates between the studies. A sensitivity analysis was done to evaluate the range of possible values for K and L_∞.

Length frequency data were estimated from samples taken in the NMFS Trip Interview program for the pot and trap fisheries in Puerto Rico, St. Thomas and St. John, and St. Croix. The number of blue tang measured in Puerto Rico was small compared to St. Thomas/St John or St. Croix.

IV-2-1-a. Are data decisions made by the Assessment Workshop sound and robust?

The AW panel concluded that the sample sizes for the length-frequency data in the pot and trap fisheries in the US Virgin Islands were sufficient for length-based mortality estimation. The growth parameters used in the initial analysis were from Mutz (2006). A sensitivity analysis was conducted to evaluate alternative values and their impacts on the estimation of the total fish mortality. The AW panel decided not to use the intercepted catch, effort, and length data from MRFSS because of the low proportion of positive trips and sample sizes of length data.

The AW panel considered that the sample size for estimating length-composition data was not sufficient in Puerto Rico, and derived length-composition data were not appropriate for length-based mortality estimator.

Based on the data available and limited choices the AW panel had, these decisions were the best one could make. However, because there is no scientific evidence showing the results are robust regarding these decisions, I cannot conclude that the data decisions are "sound and robust".

IV-2-1-b. Are data uncertainties acknowledged, reported, and within normal or expected levels?

The AW did acknowledge potential issues which might influence the quality and quantity of the data. The MRFSS data were excluded because of small sample sizes, and good discussions were made on potential causes resulting in changes in length compositions over time. However, I do not see quantification of uncertainty associated with the estimates of von Bertalanffy growth parameters (although the differences in the parameters estimated in different studies were shown). I think the estimation of these parameters should come with estimates of uncertainty, which could be derived using an approach such as a bootstrap method.

IV-2-1-c.Are data applied properly within the assessment model?

This is a data-poor fishery, and there is not enough information for a formal stock assessment. Given the data available and limitation of stock assessment model choices, I consider the data are properly applied in the estimation of the fish mortality in this stock assessment.

However, I believe the sensitivity analysis could be better designed and justified if the uncertainty associated with K and L_∞ could be estimated and quantified. The values of K and L_∞ in the sensitivity analysis should be drawn from their joint distribution (Chen 1996; Chang et al. 2009) rather than varied independently. The correlation between K and L_∞ and standard errors associated with L and L_∞ can be estimated in the Nonlinear Least Squares or their joint probability distribution could be derived using the bootstrap approach.

IV-2-1-d.Are input data series reliable and sufficient to support the assessment approach and findings?

Estimation of the length-frequency data may be influenced by spatio-temporal variability in fishing selectivity. Thus, the temporal variability in length composition may not reflect changes in fish mortality; but rather reflect changes in selectivity and fishing locations. Although potential changes in the total mortality rate can be incorporated in Gedamke and Hoenig (2006), I do not see how changes in selectivity can be incorporated. This may yield biases in the assessment.

IV-2-2. Evaluate the methods used to assess the stock, taking into account the available data.

Given the limitations of data availability, the Beverton-Holt length-based mortality estimator (Beverton and Holt 1957) is a good option for the assessment of this fishery. However, as the AW panel explicitly described in the assessment report, this method, explicitly and implicitly, has six assumptions: (1) growth is constant over time and space; (2) there is no variability in growth among individuals; (3) there is constant and continuous recruitment over time; (4) the mortality rate is the same for fish older than the age at recruitment; (5) the mortality rate is constant over time and space; and (6) the population is in equilibrium. Apparently none of these assumptions can be satisfied in the US Caribbean queen triggerfish fishery. Instead of using this traditional approach, the AW panel used a modified length-based mortality estimator. This method does not need to make the equilibrium assumption, but still needs the other five assumptions. The number of years when mortality rate changes was estimated using the Akaike Information Criterion (AIC) as the performance measure. A systematic sensitivity analysis was done to evaluate impacts of uncertainty in growth parameters on the estimation of fish mortality rates.

IV-2-2-a. Are methods scientifically sound and robust?

Given the limitation of data availability, this approach may be the best the AW panel can have for the assessment of the US Caribbean blue tang. However, based on what has been reported in the AW report, I cannot conclude that this is scientifically sound and robust because there is no evidence showing that this approach can capture the real rate of fishing mortality. A simulation study, similar to the one in Gedamke and Hoenig (2006) but based on the blue tang data, should be conducted to evaluate the performance and robustness of this mortality estimator for blue tang with respect to different assumptions associated with the fishery.

IV-2-2-b. Are assessment models configured properly and used consistent with standard practices?

Given what is available, I believe that the configuration of the assessment models is consistent with standard practices to estimate mortality rates and to evaluate impacts of uncertainty in growth parameters on the mortality estimation. However, the uncertainty in the growth parameters was not estimated and the sensitivity analysis could be better designed. The values of K and L_∞ are usually strongly and negatively correlated, and such negative correlations should be considered in the sensitivity analysis. The sensitivity analysis should focus one parameter (either K or L_∞) with the value of the other parameter drawn from a joint probability distribution with defined correlations of K and L_∞. Alternatively, a bootstrap approach can be used to estimate a joint distribution of K and L_∞, which can be used to quantify the uncertainty associated with the estimates of the total and natural mortality rates.

The AW panel considered different approaches for estimating natural mortality, and recommended that the M estimated from Pauly equation (Pauly 1980) be used because the growth parameters were also used in the estimation. I agree with the AW panel and believe this perhaps is the most robust approach to reduce potential biases in estimating fishing mortality (because F = Z-M). However, I think a more appropriate approach for estimating M may be the use of a subset of fish species with similar habitat and life history (e.g., reef-associated species) to modify the Pauly equation, which can make the estimation of M more consistent with the life history and habitat of the Caribbean blue tang. Biologically unrealistic estimates of natural mortality, judged based on life history theory and knowledge on species of similar life history and habitat need, should be excluded from further consideration in the estimation of fishing mortality.

The use of M as a proxy for F_{MSY} is a common practice for a data-poor fishery (King 1995). This *ad hoc* limit reference point appears to be the best choice given the available data.

IV-2-2-c. Are the methods appropriate for the available data?

Overall, I believe the method is appropriate for the available data. However, I believe a simulation study should be conducted to evaluate the performance of the method.

IV-2-3. Evaluate the assessment findings with respect to the following:

IV-2-3-a. Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

Because of data limitations, neither abundance nor biomass was estimated. Fishing mortality was derived from the difference between the total mortality rate estimated from length-composition data and natural mortality rate estimated from Pauly's model (Pauly 1980). Uncertainty associated with the fishing mortality rate was evaluated by evaluating possible ranges of the total mortality rate estimated using different growth parameters and natural mortality estimated using different estimators.

I consider the lack of abundance/biomass estimates is consistent with the limitations of data availability. Large uncertainty associated with the fishing mortality estimates is consistent with possible issues related to the estimates of life history parameters used in the estimation of the total and natural mortality rates.

The AW panel did not estimate the total mortality rate for the Puerto Rico blue tang from the length-frequency data because they believed that the sample size was too small. I agree with the AW panel and consider this is consistent with the data available.

IV-2-3-b. Is the stock overfished? What information helps you reach this conclusion?

The stock biomass/abundance and biomass-based limit reference points cannot be estimated reliably in this assessment based on the data available. The AW panel concluded that this assessment did not have enough information to determine if the stock is overfished. Given the available data, I agree with the AW panel.

IV-2-3-c. Is the stock undergoing overfishing? What information helps you reach this conclusion?

Puerto Rico

No length-based analysis was done because the AW panel concluded that the sample size used to derive the length-composition data was too small. Thus, there were no estimates of the total, natural and fishing mortality rates for the Puerto Rico blue tang.

St. Thomas and St. John

The results of comparing the fishing mortality and natural mortality rates depend on the choices of (1) growth parameters used in the estimation of the total mortality; and (2) estimators of natural mortality. The AP panel suggested that Pauly's natural mortality estimator be used because both K and L_∞ were used, which is consistent with what is used in estimating the total mortality. Based on this approach, the fishing mortality rate, estimated as the difference between the total mortality rate estimated from the length-based estimator (Gedamke and Hoenig 2006) and natural mortality rate estimated using Pauly's equation (Pauly 1980), was much smaller than the natural mortality rate, which is commonly used as limit reference point to determining if a data-poor fishery is in the status of overfishing. This suggests that the fishery was not in the status of overfishing. However, if natural mortality was estimated from age-based data, the results would depend on the choice of growth parameters in estimating the total mortality. For the most scenarios tested in the sensitivity analysis, it appears that the fishing mortality rate was lower than the natural mortality rate, suggesting that the St. Thomas and St. John blue tang were likely not in the status of overfishing. However, given such large uncertainty and the lack of strong evidence to justify the use of one set of life history parameters over the other, it is difficult to yield a conclusive result regarding the status of the fishery.

St. Croix

Like the assessment for the St. Thomas and St. John blue tang, the results of comparing fishing mortality and natural mortality depend on the choice of growth parameters, which determine the estimates of the total and natural mortality rates. For the set of life history parameters resulting in a high level for the total mortality rate, the fishing mortality rate is higher than the natural mortality rate, suggesting that fishing mortality may be too high. However, for the set of life history parameters resulting in a low level for the total mortality rate, the estimated fishing mortality was lower than natural mortality, suggesting that the fishing mortality was not too high. We do not have strong evidence favoring one set of the life history parameters over the other, and hence it is difficult to decide if the fishery is in the status of overfishing.

IV-2-3-d. Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

No stock-recruitment relationship can be developed based on the available data.

IV-2-3-e. Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Like many data-poor fisheries, natural mortality is used as a proxy for F_{MSY} in the assessment (King 1995). This effectively treats the natural mortality rate as a limit biological reference point to determine if the fishery is in the status of overfishing. The AW panel explored and evaluated different methods for quantifying the natural mortality rate and found large uncertainty associated with the natural mortality rate estimates. Given the information available, I believe that a yield-per-recruit (and maybe egg-per-recruit) analysis can be conducted, which can yield estimates for $F_{0.1}$ and F_{max}. The AW panel did mention that they did not do a per-recruit analysis because of concerns on the quality of life history parameters. However, given the same life history parameters used in estimating the total fishing mortality and natural mortality (for some methods), I do not see the logic for not doing a per-recruit analysis. I think the uncertainty associated with the life history parameters can be readily incorporated in a per-recruit analysis using a Monte Carlo approach (e.g., Chen and Wilson 2002; Chang et al. 2009).

IV-2-4. Evaluate the stock projections, addressing the following:

No formal stock projection was done in the assessment because of data limitations.

IV-2-4-a. Are the methods consistent with accepted practices and available data?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-4-b. Are the methods appropriate for the assessment model and outputs?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-4-c. Are the results informative and robust, and useful to support inferences of probable future conditions?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-4-d. Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The AW panel outlined several sources of uncertainty in the assessment. The uncertainty associated with the quality and quantity of fisheries data (e.g., commercial and recreational catch and size composition data, fishing efforts, and sample sizes) is well discussed to determine which data set should be used in the assessment. Large variability in growth parameters among different studies was identified and their impact on the estimation of the total mortality rate and fishing mortality rate were evaluated in a sensitivity analysis. Uncertainty resulting from choices of estimators for the natural mortality rate also was discussed.

Although the AW panel discussed the uncertainty of different sources rather thoroughly and developed sensitivity analyses to evaluate impacts of the uncertainty on the estimation of the total, natural and fishing mortality rates, I believe the uncertainty should be incorporated in the assessment in a more systematic way. I suggest using a Monte Carlo simulation approach to systematically incorporate the uncertainty in life history parameters into the estimation of the fishing mortality rate. For each parameter, a distribution (uniform, multinomial, normal, or log-normal) can be defined based on the type of the data and possible ranges of the values. For each run, the value of a given parameter can be randomly drawn from such a distribution. The correlations between L_∞ and K should be considered and their values should be drawn from a joint distribution of these two values. One hundred or more runs of Monte Carlo simulation can yield a distribution for the total, natural and fishing mortality rates. Such an approach can better capture and quantify the uncertainty, which can be used directly in comparing probability distributions of the natural mortality rate and fishing mortality rate to determine the likelihood of overfishing. Before this can be done, however, the range of the growth parameters and natural mortality rate should be narrowed down based on expert knowledge and background information on fish species of similar life history and habitat needs.

IV-2- 6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

The AW panel recommended improving the quality of life history parameter estimates; developing a fishery-independent monitoring program; continuing efforts to improve the collection of species-specific catch and effort data; and modifying the length-based total mortality rate estimator to account for potential changes in selectivity. I consider these research areas are important for reducing the uncertainty and improving the quality of the assessment. The AW panel probably needs to prioritize the research recommendations and separate the short-term research plan from the long-term plan.

Given the problems associated with the data, an important goal should be to improve the data quality and quantity. Short-term and long-term plans should be developed to achieve the goal. The short term research priority may include (1) improving life history data estimates and the quantification of their uncertainty in the form of probably distributions; (2) identifying major fishing areas and how the fishing areas vary with time via conducting interviews with fishermen involved in the fishery; and (3) identifying potential approaches that can be used to estimate species-specific landing data (e.g., based on species composition of landings that become available in recent years). The long-term research plan should include the development of fishery-independent monitoring program and continue improving the sampling protocol in the collection of fishery-dependent data (catch and effort).

Given the data limitations, I believe another research priority is to evaluate the performance of the length-based estimator (Gedamke and Hoenig 2006) for the total mortality. Based on the information available and with some assumptions, a queen triggerfish fishery can be simulated, following the approach used in Gedamke and Hoenig (2006). A simulation can be conducted with this simulated fishery to evaluate the performance of this length-based estimator in estimating the total mortality rate. Different scenarios can be developed to identify key factors that may have significant impacts on the performance of the estimator. This can guide the future model development and data collection.

IV-2-7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

I recommend the following key areas for the improvement when scheduling the next assessment:

- Growth parameters K and L_∞ should be estimated with uncertainty. A bootstrap approach can be used with the von Bertalanffy growth model to quantify the joint probability distribution of K and L_∞, which can be used for quantifying probability distributions for the total, natural and fishing mortality rates;

- More basic biological studies need to be conducted to improve our understanding of key life history processes and estimate key life history parameters such as growth parameters, length/age at maturity, fecundity, and their spatial variability;

- An interviewing-fishermen program should be done to identify major fishing grounds and main size classes of landed catch, and possible changes over time;

- Use the proportion of blue tang in the total catch of all surgeonfish species estimated in recent years to estimate the queen triggerfish catch in the past (assuming that the proportion is the same over time);

- A simulation study needs to be conducted to evaluate the performance of the length-based estimator of the total mortality rte and identify assumptions/parameters that can influence greatly the performance of the estimator, which will help us understand the quality of the estimates of the total mortality rate;

- Uncertainty associated with the natural mortality rate should be quantified in the form of a probability distribution, which can be done with a Monte Carlo simulation approach;

- The Pauly natural mortality rate estimator was derived from many species with very different life history and habitat needs (Pauly 1980), and a subset of fish species that have life history and habitat needs similar to the focal species may yield a more appropriate natural mortality rate estimator;

- A yield-per-recruit analysis with the consideration of uncertainty associated with life history parameters (e.g., Chen 1996; Chang et al. 2009) can be done to estimate theoretical biological reference points such as F_{max} and $F_{0.1}$; and

- A spawning stock biomass-per-recruit analysis with the incorporation of uncertainty associated with life history parameters can also be done to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

V. Conclusions and Recommendations

Given the data limitations, the assessment appears to be well-planned and structured. Uncertainties in the quality and quantity of data, fisheries (e.g., selectivity) and life history parameters (e.g., von Bertalanffy growth parameters and natural mortality rate), and model structure (different estimators used to estimate the total and natural mortality rates) were carefully evaluated. I would like to commend the efforts of the AW panel in addressing data quality and quantity issues, identifying and evaluating implicit and explicit assumptions associated with methods and data, designing and conducting a rather systematic sensitivity analysis, exploring alternative model configurations and parameterization. However, based on the information I have reviewed, I cannot conclude that this assessment is scientifically sound, and adequately addresses needs for management advice. This mainly results from the data limitations.

I do have concerns for both the Caribbean queen triggerfish and blue tang that I hope the AW panel could address to improve the assessment of the Caribbean queen triggerfish and blue tang. I made the following general comments and specific recommendations.

General comments

The Caribbean queen triggerfish and blue tang are typical data-poor fisheries with no fishery-independent data and limited fishery-dependent data of questionable quality. Their life history processes are not well understood and key life history parameters are not well quantified. The low quality and quantity of the information available makes it extremely difficult to assess the status of the Caribbean queen triggerfish and blue tang stocks. The top priority should be to develop a fishery-independent monitoring program for the reef-dependent species such as queen triggerfish and blue tang in the U.S. Caribbean. Such a program can yield a reliable abundance index and provide samples for basic biological studies to estimate key life history parameters such as von Bertalanffy growth parameters, fecundity, and length/age at maturity and their spatial variability, not only for the Caribbean queen triggerfish and blue tang; but also for other reef-dependent fish species inhabiting the same area.

The quality and quantity of fishery-dependent data should also be improved. This can be done by developing a port or sea sampling program or further improve current reporting system by including the information on spatial locations of catch and conducting some cross-validation studies of fishermen's reported data. The report of species-specific landings in recent years is certainly a good way to improve the data quality and quantity, making the landing data useful in the species-specific stock assessment. The information may be useful to decompose the historical landings of species group into species-specific landings. A program should be developed to interview fishermen on their historical and current fishing areas and the changes in their attitude towards the targeted species and size composition in the fishery (Ames 2004). I believe such an interview program is cost effective to collect some valuable historical information regarding fishing grounds and fishermen's preferences for species and size. Such information will be valuable to improve the quality of the historical data and improve the understanding of possible temporal changes in fishing effort distribution and selectivity.

Given the data limitations, the choice of stock assessment models is rather limited for the U.S. Caribbean queen triggerfish and blue tang stock assessment. Instead of using a traditional Beverton-Holt method to estimate the total mortality from length-composition data, the AW panel listed six assumptions explicitly and explicitly associated with the method and decided to use the method by Gedamke and Hoenig (2006) which does not require the assumption of an equilibrium population. Given the available data, this may be the best approach available. However, this approach also requires some assumptions in temporal variability in selectivity. Although Gedamke and Hoenig (2006) conducted a simulation study to evaluate the performance of the estimator, their simulation was based on a single species with different biology and fishing intensity. I suggest that the AW panel uses the Caribbean queen triggerfish and blue tang data to design a similar simulation study. The AW panel can design a few scenarios to evaluate the performance of the estimator in retrieving the "true" built in the simulation study and identify key factors that may greatly influence the performance of the estimator for the U.S. Caribbean queen triggerfish and blue tang fisheries.

A rather comprehensive sensitivity analysis was conducted to evaluate possible impacts of uncertainty associated with the growth parameters for the estimation of the total mortality rate in the assessment of the queen triggerfish and blue tang. Although I appreciate the AW panel's efforts, I believe a better structured Monte Carlo simulation approach may be better in quantifying the uncertainty associated with the estimation of the total mortality rate and natural mortality rate. The AW panel can use the sensitivity analysis to identify the most plausible parameterization of the Gedamke-Hoenig model (Gedamke and Hoenig 2006) and then conduct a Monte Carlo simulation approach with parameters K and L_∞ randomly drawn from their joint distribution which can be derived from bootstrapped nonlinear least squares in fitting the von Bertalanffy growth model to length-at-age data. similar approach can be used for estimating the natural mortality rate.

I also believe expert and background knowledge about the queen triggerfish and blue tang should be used to reduce the magnitude of the uncertainty on the growth parameters and natural mortality rate. Some values for M, K, and L_∞ appear to be not biologically realistic for a fish species with a life history process similar to the queen triggerfish and blue tang, and should be excluded in the assessment. Maybe a literature search for fish species of similar life history and habitat should be done to derive a range of values that are biologically realistic for the key life history parameters.

The AW panel did not do a yield-per-recruit analysis and SSB-per-recruit (or egg-per-recruit) analysis because of uncertainty associated with the growth parameters and natural mortality rate. However, these values were used in the estimation of the total mortality rate and natural mortality rate. This is a rather inconsistent argument. I would like to suggest that at least a yield-per-recruit analysis can be done to estimate F_{MAX} and $F_{0.1}$ for possible reference points. The fact that both growth parameters and natural mortality rate are used in a yield-per-recruit analysis and estimation of the current fishing mortality rate using the approach described in the assessment may reduce the impact of uncertainty associated with the growth parameters and natural mortality rate on the determination of the fishery status.

Specific recommendations

Although I have provided comments and recommendations under each TOR, I would like to re-iterate the following recommendations.

- I recommend that expert and background knowledge/information on species of similar life history patterns and habitat needs be used to exclude biologically unrealistic values of K, L_∞, natural mortality rate, and total mortality rate;

- I recommend that uncertainty associated with K, L_∞, natural mortality rate, total mortality rate, and subsequently fishing mortality rate be quantified using a Monte Carlo simulation;

- I suggest that a program be developed for interviewing fishermen to have a better understanding of temporal and spatial variability of the fishing ground, target fish species and size (i.e. selectivity), and fishing efforts;

- I recommend that information on the fish species composition of current landings be used to decompose the historical landings of species group into the species-specific landings;

- I recommend that a fishery-independent survey program be developed for the U.S. Caribbean queen triggerfish, blue tang and other reef-dependent species sharing similar habitat to collect samples for estimating basic life history parameters and for driving reliable abundance indices;

- I recommend that a simulation study be conducted to evaluate the performance of the length-based estimator of the total mortality rate and identify assumptions/parameters that can influence greatly the performance of the estimator;

- I suggest that a yield-per-recruit analysis be conducted with the incorporation of uncertainty associated with life history parameters to estimate theoretical biological reference points such as F_{max} and $F_{0.1}$; and

- I recommend that a spawning stock biomass-per-recruit analysis be done with the incorporation of uncertainty associated with life history parameters to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

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Appendix 1: Bibliography of materials provided for review for SEDAR 30 Caribbean Blue Tang and Queen Triggerfish

Documents Prepared for the Assessment Workshop

- Bryan, M. 2012. Summary of recreational catch and effort for blue tang and queen triggerfish caught in Puerto Rico since 2000. SEDAR30-AW-01.

- Bryan, M. 2012. Evaluation of the available length-frequency information in the US Caribbean Trip Interview Program (TIP) data. SEDAR30-AW-02

- Rios, A. B. 2012. A review of the life history characteristics of blue tang and queen triggerfish. SEDAR30-AW-03

- McCarthy, K. J. 2012. Commercial fishery landings of queen triggerfish and blue tang in the United States Caribbean, 1983-201. SEDAR30-AW-04

Final Stock Assessment Reports

- SEDAR30-SAR1: Blue Tang Assessment Report

- SEDAR30-SAR2: Queen Triggerfish Assessment Report

Reference Documents

- SEDAR30-RD01: A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean

- SEDAR30-RD02: A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of U.S. Caribbean (Saint Croix)

Appendix 2: A copy of the CIE Statement of Work

Attachment A: Statement of Work for Dr. Yong Chen

External Independent Peer Review by the Center for Independent Experts

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

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

Project Description SEDAR 30 will be a compilation of data, an assessment of the stock, and an assessment review conducted for Caribbean blue tang and queen triggerfish. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 30 are within the jurisdiction of the Caribbean Fisheries Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the tasks and ToRs described in the SoW herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct the desk review during 4-7 February 2013, therefore no travel will be required.

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

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, who forwards this information to the NMFS Project

Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other information pertinent to the desk review arrangements. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

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

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

2) During February 4-7, 2013 as specified herein, conduct an independent desk peer review in accordance with the ToRs (**Annex 2**).

3) No later than February 21, 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

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

14 January 2013	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
18 January 2013	NMFS Project Contact sends the stock assessment report and background documents to the CIE reviewers.
4-13 February 2013	Each reviewer conducts an independent desk peer review
19 February 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
7 March 2013	CIE submits CIE independent peer review reports to the COR
14 March 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

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Key Personnel:

NMFS Project Contact:

Julie Neer, SEDAR Coordinator
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North Charleston, SC 29405
julie.neer@safmc.net Phone: 843-571-4366

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed. The CIE independent report shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the Assessment Workshop sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?
   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and useful to support inferences of probable future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.