Center for Independent Experts (CIE) Independent Peer Review Report

on

Stock Assessment of the Main Hawaiian Islands

Deep7 Bottomfish Complex Through 2010

Prepared by

Yong Chen

Professor of Fisheries Population Dynamics
School of Marine Sciences
University of Maine
Orono, ME 04469

Contents

I. Executive Summary

The Deep7 bottomfish complex in the Main Hawaii Islands (MHI) fishing zone consists of seven species and supports a traditional deepwater handline fishery in Hawaii. An assessment in 2005 suggested that the MHI bottomfish were not overfished, but overfishing occurred in 2004 with fishing mortality being 24% higher than the overfishing threshold. Subsequently, relevant management regulations were developed to reduce fishing mortality. This stock assessment was updated in 2008 with use of revised CPUE data and Bayesian methods. A review was conducted in 2009 to evaluate the 2008 assessment update. The reviewers made recommendations on: (1) improvement of quality and quantity of input data including both catch/CPUE data and priors; (2) modification of stock assessment models and statistical methods; and (3) improved stock assessment report and supporting documents.

The current stock assessment update was conducted to address the concerns raised in the 2009 review. The major components/tasks and modifications in this assessment include: (1) focusing on the Deep7 bottomfish species considered to have similar life histories; (2) substantially reducing the mean value of priors for the intrinsic growth rate; (3) developing various scenarios to account for unreported catch; (4) developing various scenarios to account for uncertainty in CPUE estimation; (5) considering three scenarios for temporal changes in fishing power; (6) conducting CPUE standardizations and relevant sensitivity analyses; (7) reparameterizing the production model; (8) developing informative priors for key model parameters; (9) evaluating stock assessment results and uncertainty under various configurations of model, data, and priors in modeling the stock dynamics; (10) conducting a short-term risk analysis for different levels of exploitation; (11) conducting sensitivity analyses to evaluate the impacts on stock assessment due to uncertainty associated with various data and parameters; and (12) developing a decision tree analysis to evaluate the performance of different levels of TAC under uncertainty.

As a CIE reviewer, I evaluated this current stock assessment report with respect to a set of pre-defined Terms of Reference. *I conclude that overall this assessment update is scientifically sound and adequately addresses most concerns raised in the 2009 review report.* In particular, I would like to commend the efforts of Dr. Brodziak and his co-workers to address uncertainty regarding data quality and quantity in the assessment. However, I also believe some important questions (mostly new and not identified in the 2009 review report) have not received enough attention or have not been addressed in this assessment. These issues include: a general lack of understanding of the surplus production model's performance in quantifying the Deep7 stock complex; no evaluation of impacts of priors on the assessment and relative contributions between the priors and data; no analysis of possible retrospective errors; and failure to explicitly define target, threshold and limit reference points for stock biomass and fishing mortality.

Accordingly, I recommend that future research be done in the following areas: (1) conducting an extensive simulation study to evaluate the performance of surplus production model in modeling dynamics of the Deep7 stock complex consisting of species with relatively long life spans; (2) evaluating impacts of priors on the assessment and relative contribution of the priors and data to the assessment; (3) conducting a retrospective analysis to evaluate possible retrospective errors; (4) attempting to develop a fishery-independent monitoring program or an index fishery program with standard fishing methods to yield a more reliable abundance index and to compare with standardized commercial CPUE; (5) improving documentation of various scenarios and quantification of differences in the assessment results among these different scenarios; (6) explicitly evaluating and defining target, threshold and limit references and corresponding harvest control rules; and (7) attempting to conduct stock assessments for individual species using age/size structured population models.

II. Background

The Hawaii bottomfish complex, inhabiting waters of the Hawaiian Archipelago, comprises of several species of snappers and jacks, plus a grouper. The complex historically supported deepwater handline fisheries in three fishing zones, the Main Hawaiian Islands (MHI) zone, the Mau zone, and the Hoomalu zone. However, fishing currently takes place only in the MHI zone with fishing activity prohibited in the other two zones. The Deep7 bottomfish complex includes seven species that are the main targets of this fishery and that have been the focus of fishery management measures since 2005 (Brodziak et al. 2008).

A stock assessment was conducted for the Hawaiian bottomfish complex in 2005 by fitting a surplus production model to fishery data through calendar year 2004 using a nonlinear least squares estimator (Moffitt et al. 2006). The assessment suggests that the MHI bottomfish were not overfished, but that overfishing occurred in 2004 when fishing mortality was 24% higher than the overfishing threshold. Subsequently, relevant management regulations were developed to reduce fishing mortality. This stock assessment was updated in 2008 by fitting the same surplus production model to fishery data through calendar year 2007 using Bayesian methods (Brodziak et al. 2008). In the update stock assessment, catch and effort information was audited to include only those of single day trip in the estimation of CPUE and Bayesian method replaced least squares method to better quantify uncertainty in key population parameters. The stock assessment was done separately for the three Hawaiian fishing zones: the Main Hawaiian Islands zone, the Mau zone, and the Hoomalu zone. Uninformative priors were assumed for all the production model parameters except for intrinsic growth rate for which an informative prior was assumed (Brodziak et al. 2008). The use of revised CPUE data and Bayesian methods was considered an improvement over the 2005 stock assessment.

A review was conducted in 2009 to evaluate the 2008 assessment update. The reviewers suggested that the surplus production model is adequate for assessment of the Hawaiian bottomfish complex but made various recommendations on: (1) improvement of quality and quantity of input data, including both catch/CPUE data and priors; (2) modification of stock assessment models and statistical methods; and (3) preparation of stock assessment reports and supporting documents.

The current stock assessment update was conducted to address the concerns raised in the review. The baseline model structure was similar to the model used in the 2008 update. The assessment focused on the Deep7 bottomfish species that were considered to have similar life history processes. Many scenarios were developed in the current assessment to incorporate uncertainties in assessment data, model assumptions, and statistical methods. The major modifications done in this assessment include: (1) focusing on the Deep7 bottomfish species perceived to have similar life histories; (2) substantially reducing the mean value of priors for the intrinsic growth rate; (3) using fishing year (July 1 – June 30), instead of calendar year; (4) considering four scenarios in estimating catch statistics to account for unreported catch; (5) considering three scenarios in assuming temporal changes in fishing power; (6) considering various scenarios to account for uncertainty in estimating nominal CPUE; (7) conducting CPUE standardization and relevant sensitivity analyses; (8) re-parameterizing the surplus production model; (9) developing various scenarios of priors for key model parameters; (10)

conducting convergence diagnostics; (11) evaluating the performance of various configurations of model, data, and priors in modeling the stock dynamics; (12) conducting a short term risk analysis of different levels of TAC; (13) conducting sensitivity analysis to evaluate the impacts on stock assessment due to uncertainty associated with various data and parameters; and (14) developing a decision tree analysis to evaluate the performance of different TACs under uncertainty.

As a CIE reviewer, I am charged to evaluate this current stock assessment update with respect to the Terms of Reference including whether this stock assessment adequately addresses the comments raised in the 2009 review report (Stokes 2009).

This report includes an executive summary (Section I), background introduction (Section II), description of my role in the review activities (Section III), my comments on each item listed in the Terms of Reference (ToRs, Section IV), summary of my comments and recommendations (Section V), and references (Section VI). The final part of this report (Section VII) includes a collection of appendices including the Statement of Work (SoW).

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

As stated in the SoW, this review is "to conduct a follow-up peer review to determine if the recommendations have been adequately addressed and adequacy of the revised assessment for management purposes". My role as a CIE independent reviewer is to "conduct an impartial and independent peer review" of the stock assessment of the Hawaiian Deep7 bottomfish complex through 2010, 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 "Stock Assessment of the Main Hawaiian Islands Deep7 Bottomfish Complex Through 2010" by Brodziak et al. (2011), "Report of the Western Pacific Stock Assessment Review 1 Hawaii Deep Slope Bottomfish" by Stokes (2009) and all other background documents that were sent to me (see the list in the Appendix II). I also read references relevant to the topics covered in the reports and the SoW. Based on these readings, I address each topic covered in the ToRs, evaluate the strengths and weaknesses of what was done in this assessment update, and provide recommendations to improve future assessment. Based on these evaluations and analyses, I identify future research priorities for the assessment of the Deep7 bottomfish stock complex.

IV. Summary of Findings

My detailed comments on each item of the ToRs are provided under their respective subtitles from the ToRs (see below).

IV-1. Determine if recommendations from the June 2009 WPSAR/CIE review have been adequately addressed within the assessment update.

I conclude that recommendations from the June 2009 WPSAR/CIE review with respect to data quality and quantity have been adequately addressed and that recommendations on stock assessment models and documentation have been partially addressed in this stock assessment update.

Recommendations made in the 2009 WPSAR/CIE review (Stokes 2009) can be summarized as follows:

(1) Improving data quality and quantity: adjusting unaccounted catch data, developing more representative CPUE data by identifying fishing trips targeting the Deep7 species , considering various sources of uncertainty in the CPUE standardization (e.g., temporal changes in fishing efficiency and models used to standardize the CPUE) and deriving more biologically realistic informative priors for some key parameters based on meta-analysis.

(2) Improving population dynamic models and statistics: considering the hierarchical Bayesian approach (Jiao et al. 2009), incorporating uncertainty in input data in CPUE standardization and assessment modeling, and conducting separate assessments for those species most susceptible to overfishing.

(3) Improving documentation of stock assessment data preparation, model parameterization, and result reporting: standardizing the format and providing more details on the derivation of key fisheries statistics.

The current stock assessment update has explicitly addressed the issues related to data quality and quantity, and recommendations on models and documentation have been partially addressed. In particular, I believe the documentation can be further improved by streamlining the scenarios tested in this assessment update and by better quantifying differences in the assessment results among different scenarios.

More specifically, this assessment update has adequately addressed the following issues related to the input data for the surplus production model used in assessing the Deep7 bottomfish complex:

- Assessed the Deep7 bottomfish species as a single stock complex to develop population benchmarks and management parameters;

- Conducted a comprehensive evaluation of MHI catch and effort data and relevant qualitative information in collaboration with HDAR and fishermen;

- Developed a criterion to filter catch and effort data to yield improved nominal CPUEs for CPUE standardization;

- Developed plausible scenarios for alternative CPUE indices to account for potential uncertainty associated with CPUE;

- Reconstructed non-commercial catch histories and estimated non-reported catch;

- Conducted a meta-analysis of fish life history data to develop informative priors on population intrinsic growth rate *r* and carrying capacity *K*.

This assessment update has adequately addressed the following model issues:

- Explored alternative models for the CPUE standardization;

- Evaluated the performance of different CPUE standardization model configurations; and

- Evaluated the performance of a hierarchical Bayesian approach applied to the surplus production model.

However, this assessment has not addressed the following recommendations on modeling:

"• A Bayesian assessment model for the two species (onaga and ehu) most likely being overfished and another assessment model for the remainder of the deep slope bottomfish.
• A Bayesian assessment model for the deep 7 bottomfish and another model to the remainder of the deep slope bottomfish and compare the TAC estimated in comparison to using a ratio of the TAC for the deep slope bottomfish.
• A separate Bayesian assessment model of the fast and slower growing snappers.
• As a potential independent measure of stocks status, undertake length frequency sampling and use past data to calculate SPR or an SPR proxy by species. " (Stokes 2009)

Although the documentation of data and models has been improved in this assessment update, I believe there is room for further improvement. In particular, I recommend a table summarizing all the scenarios considered in this study and a second table summarizing all the priors and their specific values. I also suggest better quantification of the differences in assessment results among different scenarios. I elaborated on these recommendations in my comments on TOR 6.

IV-2. Review the assessment methods used: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data.

The general approach applied in this study is reasonable and perhaps the best one can do, given data limitation. However, I conclude that an extensive simulation study is needed to evaluate whether surplus production model is adequate and appropriate for the Deep7 stock complex.

This assessment follows an assessment for the MHI bottomfish complex conducted in 2005 with data through 2004 (Moffitt et al. 2006) and its 2008 update with data through 2007 (Brodziak et al. 2009). Although some substantial efforts were made in revising catch and CPUE data and defining priors, the assessment method used is similar to that used in the past. A surplus production model was used to quantify dynamics of the Deep7 bottomfish complex. The model incorporates a shape parameter and is re-parameterized by scaling stock biomass with carrying capacity *K*. The model fit to the catch and standardized CPUE data was implemented using a Bayesian approach with distributional assumptions on process and observational errors. Priors for the model parameters were assigned based on the modelers' understanding of the biology of the Deep7 bottomfish complex. MSY-based biological reference points were estimated and short-term risk analysis was done with respect to different harvest levels for different scenarios of uncertainty in catch and CPUE.

Overall, I believe this is a rather appropriate approach, given the data available to the assessment. In particular, I would like to commend Dr. Brodziak and his co-workers' efforts to incorporate different sources of uncertainty into the assessment and their openness to the discussion of issues in the assessment that may have given rise to data limitation. Having said so, I do believe the assessment approach leaves room for improvement.

The 2009 review panel concluded that they have "every confidence in the surplus production model used as a way of providing management advice… " (Stokes 2009). Although I agree that the surplus production model might be an obvious candidate given the limited data, I am not convinced that this type of model is suitable for the Deep7 bottomfish complex. An implicit assumption associated with a surplus production model is that population size/age structure does not significantly affect population dynamics. This might be a reasonable assumption for fish with short life span and/or relatively simple age/size structure, but certainly not the case for the Deep7 complex. This complex includes species with long life spans, the most abundant species possesses a life span of 40 years. Addition of a shape parameter to the model may remedy this problem a bit, but performance of this model in quantifying the dynamics of the Deep7 complex is still unknown. I believe a computer simulation study is needed to evaluate if the surplus production model is adequate to quantify the dynamics of the Deep7 bottomfish complex. The simulation study should include the development of a size/age-structured operating model able to generate input data (i.e., catch and CPUE data) for the surplus production model. I provide more details about this research priority in Section IV-6.

IV-3. Evaluate the implementation of the assessment model: configuration, assumptions, and input data and parameters (fishery life history); more specifically determine if data are properly used, if choice of input parameters seem reasonable, if models are appropriately specified and configured, assumptions are reasonably satisfied, and primary sources of uncertainty accounted for.

Overall I believe the implementation of this assessment model is scientifically sound.

Brodziak et al. (2011) modified the surplus production model by adding a shape parameter to better capture the dynamics of the Deep7 complex and re-parameterizing the model to improve the parameter estimation. They also made every effort to audit their database to improve the quality and quantity of catch and CPUE data. Extra analyses were done to justify the setting of priors for some key model parameters. Assumptions regarding process and observational errors in modeling are reasonable and commonly used in assessments of similar nature. Fish life history parameters, although not used explicitly in the model, are used to justify prior probability distributions of some key parameters. Choices of alternative scenarios in the assessment were justified based on the information available and perhaps covered the most likely ranges of uncertainty associated with the CPUE and catch data. I conclude that, overall, this assessment is scientifically sound. My specific comments are described below.

<u>*Is use of the data proper?*</u>

Given all the limitations and uncertainty, I conclude that the data were used properly in general. I do have some issues which are described below.

The standardized CPUE data were derived from catch generated by fishing efforts targeting the Deep7 bottomfish species. The data were filtered from the database based on a criterion developed in this study. The criterion used to select a cutoff fraction value was the maximum total bottomfish catch weight and sale value (page 10, Brodziak et al. 2011). This resulted in trips comprising only 17% of bottomfish catch being included in the CPUE standardization. This is quite different from the number used in the past. Although I commend the efforts to develop a relatively objective criterion to filter catch resulting from targeted efforts, I am curious whether this low percentage of data really represent all the efforts targeting the Deep7 complex species. This selection may overlook inefficient/inexperience fishermen who also target the Deep7 species. Depending on temporal variability in the efforts of such fishermen, this might result in biases in CPUE standardization. I suggest evaluating the potential impacts of using this criterion to filter catch/effort data by comparing its assessment results against those derived from the one used in the 2008 assessment update.

Different scenarios were developed regarding uncertainty associated with temporal changes in catchability. The nominal CPUE data were then adjusted accordingly prior to the CPUE standardization. I commend this effort because temporal change in catchability is critical in stock assessment. However, I am not sure if pre-adjusting CPUE is a good approach. Such an approach may be subjective in determining temporal trend in catchability. If there is strong evidence pointing to the existence of temporal trends in catchability, a more objective approach is to build a function into the observational model and to estimate function parameters in modeling. The format of the function should depend on how catchability is understood to change with time.

A problem in the assessment of this stock complex is the lack of a fishery-independent abundance index. Future research priorities should include developing a fishery-independent monitoring program to generate a time series of a reliable abundance index which can be used to cross-check with the fishery CPUE. In the event a fishery-independent monitoring program cannot be developed, an index fishery sampling program employing standard gear and method and carried out by volunteer fishermen may be a good choice for yielding a cost-effective, reliable and consistent abundance index.

Is choice of input parameters reasonable?

I think this item is not well defined in the ToR. So, I consider the following two possibilities.

(1) Assuming that this refers to defining priors for model parameters (because most model parameters are estimated, rather than inputted, but priors are inputted).

Overall I believe the priors defined are plausible and cover parameter uncertainty reasonably well. However, I have concerns as to the impacts of prior specifications on the stock assessment results that were not evaluated in this assessment update. The two most important parameters *r* (intrinsic growth rate) and *K* (carrying capacity) were both given informative priors. These priors were derived based on past stock assessments and some recent analyses of the life history of key species in the Deep7 complex. Priors for r differ greatly from those used in the 2008 stock update. I am curious how the stock assessment results would differ if priors for r and K were the same as those used in 2008. Such a comparison may provide some insights about the impacts of priors on stock assessment, and would partially address my concerns. I commend all the efforts by Dr. Brodziak and his co-workers in attempting to justify their choices of priors, but do believe that it is necessary to evaluate the impacts of priors for key parameters (e.g., *r* and *K*) on stock assessment (Chen et al. 2008a).

It is also unclear to me if there are upper and lower boundaries for informative priors to avoid biologically unrealistic values drawn from prior distributions. A summary table of all the priors with their upper and lower boundaries and their distributional specifications may be helpful.

Parameters *r* and *K* are often strongly and negatively correlated (Hilborn and Walters 1992). Such a correlation can be estimated based on previous assessments (e.g., evaluating correlations between posterior distributions of *r* and *K*). I suggest that such a correlation be considered in developing priors for *r* and *K* so that priors of these two parameters can be drawn from an *r*-*K* joint prior probability distribution. In any case, I believe it is necessary to evaluate correlations between posterior distributions of *r* and *K*.

I suggest plotting priors and posterior distributions together to show the relative importance of data and priors in determining the dynamics of the Deep7 bottomfsh complex. A small difference between the two distributions for key parameters like *r* and *K* may suggest that priors play a more important role than the data, while a large difference may suggest that the data used are more important. The former suggests that the data are less informative and calls for attention because priors are more or less subjectively defined.

(2) Assuming that this refers to choice of model parameterization.

If this is what this specific ToR refers to, I think Dr. Brodziak and his co-authors made an excellent choice.

They re-parameterized a typical surplus production model to improve the parameter estimation, added a shape parameter to make the surplus production calculation biologically more reasonable to this stock complex, and included both process and observational errors in modeling.

Are models appropriately specified and configured?

Given the data available to this study, the models developed for standardizing CPUE and quantifying Deep7 stock complex dynamics are well specified and configured. However, the model specification and configuration can be further improved with the inclusion of some environmental variables (e.g., depth, distance to fishing ports, and bottom type) in the GLM for CPUE standardization. There is also room for improvement in documenting the model specification and configuration. I also suggest incorporating a time-varied catchability in the surplus production observational model to account for temporal trends in catchability.

Three model configurations were considered for standardizing CPUE: (1) no change in bottomfish fishing power; (2) decadal increase in fishing power during 1949-2010; and (3) substantial increase in fishing power since the 1950s at an annual rate of 1.2%. All these configurations used the observed Deep7 single-trip handline data re-audited in this assessment. Both spatial and temporal factors were considered in the CPUE standardization. Akaike's information criterion (AIC) was used to select the most suitable model specification. The updated assessment evaluated the impacts on CPUE standardization attendant to different temporal scales (monthly or quarterly) and different areas, but only with respect to the first CPUE model scenario. Similarly, alternative CPUE model specifications were tested, but again only with regard to the first model scenario. The alternative specifications tested included a delta-GLM model, a quasi-likelihood Poisson-GLM model, or simply having all the data, including the years 1958-1960. Given the subjective nature of defining temporal changes in fishing power, I suggest that nominal CPUE values not be adjusted prior to the CPUE standardization. Instead possible temporal trends in catchability should be considered in surplus production modeling. I also suggest evaluating the possibility of including some environmental variables in the CPUE standardization if these variables can potentially influence fishing power (it seems that some environmental information, such as bottom temperature, distance to fishing port, and bottom type, can be derived and included in the CPUE standardization if fishing locations are known).

The constant PI (π) value was wrongly defined in WINBUGS coding, although I believe this should not change the AIC ranking among different GLM configurations. WINBUGS usually requires the initial values for all the parameters, and the results may be sensitive to those initials. However, I could not find the relevant source codes in WINBUGS.

The documentation of various models leaves room for improvement. I suggest including a table listing all parameters, along with their explanations and prior distributions, and with upper and lower boundaries defined for these priors. I also suggest streamlining all the scenarios evaluated in the assessment by means of a summary table that would include each scenario along with variables that were analyzed for their uncertainty. *The current piece-by-piece descriptions of scenarios are confusing and hard to evaluate while also considering adequate combinations of uncertainties from different sources.*

Are assumptions reasonably satisfied?

I believe that the statistical assumptions were well dealt with in CPUE standardization modeling and surplus production modeling.

However, I believe some residual plots are necessary to evaluate distributional assumptions in CPUE standardization modeling. I also think it is necessary to evaluate whether size/age structure is important in regulating Deep7 bottomfish stock complex dynamics, as one of the most important assumptions implied in surplus production models is that age/size structure will not influence the dynamics. I understand this may not be possible in this study, but it should be considered as a top priority for future research.

Residual plots were nicely done in surplus production modeling to evaluate whether there is a temporal trend. I suggest adding a Q-Q plot to evaluate the distribution of residuals and the possible existence of outliers. I did not see residual plots and Q-Q plots for CPUE standardization modeling, and suggest that it is necessary to evaluate residual distributions for this modeling.

Are primary sources of uncertainty accounted for?

I would like to commend the efforts made to consider various sources of uncertainty in this assessment.

These include uncertainty associated with data quality and quantity (catch and CPUE), process and observational errors, and model parameter priors. Information of different sources was used to justify the scenario choices and probability distributions considered in the assessment. The only source of uncertainty seemingly not considered or even mentioned in the assessment was uncertainty in the models used to quantify stock dynamics. I believe the assessment should at least state the potential problems with using surplus production models to quantify the Deep7 bottomfish stock complex dynamics.

Another potential source of uncertainty that was not evaluated in the assessment stems from how MCMC was run. A thinning interval of 4 runs might not be enough for a population model in this assessment with a relatively low burning-in run. I suggest evaluating possible impacts of different thinning intervals (e.g., 50, 100 or 200) on posterior distributions.

Although it is not commonly done for a surplus production model, I recommend that a retrospective analysis be done to evaluate if there exist retrospective errors in the assessment. This should be done at least for the base case scenario. Given uncertainty in the temporal trend in catchability, such an analysis may be very important (Mohn 1999, Chen et al. 2008b).

IV-4. Comment on the scientific soundness of the estimated population benchmarks and management parameters (e.g. MSY, Fmsy, Bmsy, MSST, and MFMT) and their potential efficacy in addressing the management goals stated in the relevant FMP or other documents provided to the review panel.

I think the estimation of management biological reference points and their associated uncertainties is scientifically sound. However, I believe the report did not clearly define the target, threshold, and limit reference points and no harvest control rule was defined for the Deep7 bottomfish stock complex.

I could not find an explicit description of target, threshold and limit reference points for either stock biomass or fishing mortality. I suggest that a harvest control rule plot be included in the report to explicitly describe what target and limit (and threshold) reference points are and how these estimated management parameters are used in determining the status of the fishery and stock complex and developing harvest strategies.

Based on my reading of the report I consider this fishery as being managed with MSY-based reference points. Although MSY is stated as biological objective in the management of many fisheries in the USA, the use of MSY in this fishery should be cautious. This is because the stock complex consists of 7 species with different life history processes and some of these species may be more susceptible to overfishing than others. Thus I suggest considering a fishing mortality rate $f_{0.1}$, equivalent to $F_{0.1}$ (as opposed to F_{max}) derived from yield-per-recruit analysis (Chen and Montgomery 1999), instead of F_{MSY}. Similar to the definition of $F_{0.1}$ (i.e., fishing mortality at which the slope of the yield-per-recruit curve is 10% of its maximum slope), $f_{0.1}$ can be defined and estimated from a surplus production model as

$$0.1\frac{\partial C(F)}{\partial F}\Big|_{F=f_{0.1}} = \frac{\partial C(F)}{\partial F}\Big|_{F=0}$$

where $C(F)$ is catch as a function of fishing mortality F that can be derived from surplus production model with the population being in the equilibrium status (in the same way that F_{MSY} is estimated as $\frac{\partial C(F)}{\partial F}\Big|_{F=F_{MSY}} = 0$; Chen and Montgomery 1999). Corresponding stock biomass can also be estimated. Such reference points may be more appropriate as management targets for the Deep7 bottomfish complex.

No harvest control rule was explicitly defined. No target, threshold or limit biological reference points were explicitly defined for either fishing mortality or stock biomass.

IV-5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status.

Overall I believe that the approach developed for the short-term (2 years) projection of how the Deep7 bottomfish stock complex may respond to different levels of exploitation is sound. However, if relatively long-term projection (e.g., 10, 20 years) is needed, the approach needs to be modified. A harvest control rule needs to be developed and implementation errors need to be considered in the projection.

The short-tem projection was made under different scenarios considered in the assessment. No implementation errors were considered. Risk analysis was done under uncertainty to evaluate the potential risks of overfishing the complex and of the complex itself becoming overfished within the next 1-2 years. However, I found the use of target, threshold or limit reference points in this assessment to be confusing and often not explicit. Estimated stock biomass and fishing mortality were compared with B_{MSY} and F_{MSY}, respectively (e.g., Fig. 20, Brodziak et al. 2011), but 70% F_{MSY} was also mentioned in the assessment report. It was not clear to me how "overfishing" and "overfished stock" were defined in this assessment. I did find limited information in other documents I was given (e.g., Brodziak et al. 2009), but I was not sure if similar rules were used in this assessment. I suggest a clear and explicit definition be included in the stock assessment report.

No long-term projection was done in this assessment.

IV-6. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices. Include guidance on single species models, and whether this is possible given the current nature of this multispecies fishery, and difficulties in partitioning fishing effort between species.

My biggest concern with this stock assessment is a general lack of consideration of the performance of the surplus production model in quantifying dynamics of the Deep7 bottomfish stock complex. Given implicit model assumptions about the role of size/age structure and relatively long life span of the most abundant species (up to 40 years), use of surplus production models should be questioned. I suggest taking the following steps to evaluate the performance of the surplus production model:

(1) Develop size/age-structured population dynamic models (with exponential survival equation, catch equation and von Bertalanffy growth model; Ricker 1975) for each species, parameterize these models with known (or assumed) life history and fishery

parameters, and use these models as operating models to simulate the dynamics of the Deep7 bottomfish stock complex;

(2) Use the historical fisheries statistics to simulate a fishery using the operating model developed in step (1);

(3) Generate "observed" CPUE and landing data in the simulated fishery with the consideration of different scenarios with respect to process errors in population dynamics and observational errors in catch and effort;

(4) Fit the surplus production model developed in this study to the CPUE and landing data "observed" in the simulated fishery to estimate the dynamics of the simulated Deep7 bottomfish stock complex;

(5) Compare the stock dynamics estimated in Step (4) with the built-in stock dynamics in Steps (1) and (2) to determine the performance of the surplus production model.

The above procedures can also be modified to evaluate the performance of different statistical estimators and to identify key factors (e.g., uncertainty associated with certain data) that may significantly influence the quality of stock assessment. This may lead to efforts to improve quality of key information.

Lack of a fishery-independent survey program also concerns me. Large uncertainty associated with commercial CPUE makes the stock abundance index less reliable. This stock assessment yielded largely similar conclusions about the status of the fishery and the stock under different assumptions regarding uncertainty in the CPUE and catch data. I suspect the following two reasons contributing to such consistent conclusions in the face of large uncertainty in CPUE and catch data: (1) fishery and stock status were indeed healthy; and/or (2) consistent priors given to key model parameters for different scenarios. Clearly this does not mean uncertainty in the data will not be a problem in the future when stock status changes. I recommend the development of a fishery-independent monitoring program to yield a reliable stock abundance index. If this is logistically or financially impossible, I suggest developing an index sampling program with volunteer fishermen fishing in a standard way with good spatial and temporal coverage to develop an abundance index. In either case, these newly derived abundance indices can be compared with those from the commercial fishery.

I also have concerns about seeming lack of consideration of the impacts of priors on the stock assessment. The two most important parameters were assumed to have informative priors, which might lead to underestimation of uncertainty associated with the stock assessment. More studies are needed to evaluate the robustness of the conclusions of this assessment with respect to priors. Relative importance of the priors and observed data (i.e., catch and standardized CPUE) should also be carefully evaluated in the assessment.

Given likely existence of a temporal trend in fishing efficiency, a retrospective analysis is necessary to evaluate possible retrospective error.

An explicit harvest control rule should be developed with target, threshold, and limit references explicitly defined for both stock biomass and fishing mortality. An extensive simulation study may be needed to evaluate the performance of different harvest control rules/biological reference points in achieving the management objectives of this fishery. The operating model developed for testing the performance of the surplus model can also be used in such a simulation study.

Even though the assessment report suggests that differences in life history are small among the Deep7 bottomfish species, I found such differences were not that small at all with very different life spans, growth, and natural mortality distinguishing these species (Table 2, Brodziak et al. 2011). It seems to me that a single species based stock assessment is the way to go. Given the data available, I believe an age-structured stock assessment model can be developed and used for some species of the Deep7 bottomfish complex. Given the overlapping habitats of these species and the passive gears used in the fishery, differences in catch among these species may reflect differences in their "exploitable" abundances. Ratios of catches of different species aggregated over some space and time may be used to partition fishing efforts in estimating CPUE. This approach can also be evaluated if a fishery-independent monitoring program or an index fishery sampling program can be developed.

V. Conclusions and Recommendations

Overall I believe this assessment update is scientifically sound and adequately addresses most concerns raised in the 2009 review report. In particular, I would like to commend the efforts of Dr. Brodziak and his co-workers to address uncertainty in data quality and quantity in the assessment. However, I believe some important questions (mostly new and not identified in the 2009 review report) have not received enough attention or have not been addressed in this assessment.

In summary, I believe the assessment can be further improved by addressing the following issues:

- Improving documentation of scenarios, priors and quantification of differences in the assessment results among different scenarios;
- Carefully checking WINBUGS codes to avoid errors (constant π is wrongly defined) and including the initial values assigned for all the parameters in WINBUGS source codes so that the sensitivity of stock assessment results can be evaluated regarding to those initial values;
- Evaluating implicit biological assumptions (i.e., roles of size/age structure in regulating population dynamics) associated with the surplus production model with respect to the Deep7 bottomfish life history;
- Evaluating uncertainty in defining priors, considering the impacts of this uncertainty on the assessment, and evaluating the relative importance of priors and data in estimating posterior distributions by comparing prior and posterior distributions for each model parameter;

- Evaluating different thinning intervals in MCMC to determine whether the current thinning interval of 4 runs is sufficient;

- Attempting to incorporate temporal trends in catchability in the observational model so that parameters describing these trends can be estimated through modeling, rather than decided subjectively;

- Fitting the model to the base case data configuration compiled in the 2008 assessment update and comparing the results with those derived for the base case selected in this assessment to quantify differences resulting from changes made in this assessment;

- Explicitly defining target, threshold and limit reference points for stock biomass and fishing mortality;

- Conducting a retrospective analysis to evaluate whether retrospective errors exist in the assessment;

I recommend that future research priorities be focused on the following areas:

- Developing an age/size structured operating model to simulate dynamics of Deep7 stock complex and evaluate the performance of the surplus production model in quantifying these simulated dynamics;

- Developing and evaluating explicit harvest control rules and relevant target, threshold and limit reference points for long-term projection and management of the Deep7 bottomfish complex;

- Developing a fishery-independent monitoring program or an index fishery program to yield a more reliable abundance index and to cross-check standardized CPUE data from the commercial fishery;

- Developing an age/size structured stock assessment framework for individual species.

VI. References

Brodziak, J. R. Moffitt, and G. DiNardo. 2009. Hawaiian Bottomfish Assessment Update for 2008. Pacific Islands Fisheries Science Center Administrative Report H-09-02.

Brodziak, J., D. Courtney, L. Wagatsuma, J. O'Malley, H. H. Lee, W. Walsh, A. Andrews, R. Humphreys, and G. DiNardo. 2011. Stock Assessment of the Main Hawaiian Islands Deep7 Bottomfish Complex Through 2010. Pacific Islands Fisheries Science Center National Marine Fisheries Service, 2570 Dole Street, Honolulu, Hawaii 96822-2396

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Hilborn R.,Walters C., 1992, Quantitative fisheries stock assessment: choice, dynamics and uncertainty. New York, Chapman and Hall.

Jiao, Y., C. Hayes, and E. Cortes. 2009. Hierarchical Bayesian approach for population dynamics modeling of fish complexes without species-specific data. ICES J. Mar. Sci. 66:367-377.

Moffitt, R., D. Kobyashi, and G. DiNardo. 2006. Status of the Hawaiian bottomfish stocks, 2004. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Ser., NOAA, Honolulu, HI 96822-2326. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-06-01, 45 p.

Mohn R., 1999, The retrospective problem in sequential population analysis: An investigation using cod fishery and simulated data. ICES J. Mar. Sci. 56, 473–488.

Ricker, W. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd Canada Bull., 191.

Stokes, K. 2009. Report on the Western Pacific stock assessment review 1 Hawaii deep slope bottomfish. Center for Independent Experts, stokes.net.nz Ltd., Wellington 6035, New Zealand, 27 p.

Appendix I: Statement of Work for Dr. Yong Chen

External Independent Peer Review by the Center for Independent Experts

Hawaii Deepslope Bottomfish

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract to provide external expertise through the Center for Independent Experts (CIE) to conduct impartial and independent peer reviews of NMFS scientific projects. This Statement of Work (SoW) described herein was established by the NMFS Contracting Officer's Technical Representative (COTR) and CIE based on the peer review requirements submitted by NMFS Project Contact. CIE reviewers are selected by the CIE Coordination Team and Steering Committee to conduct the peer review of NMFS science with project specific Terms of Reference (ToRs). Each CIE reviewer shall produce a CIE independent peer review report with specific format and content requirements (**Annex 1**). This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project.

Project Description: A peer review of the Hawaiian multispecies deepslope bottomfish resource is required using the CIE process. The scientific information and assessment for Hawaiian deepslope bottomfish was peer reviewed in June 2009 providing recommendations to increase the accuracy of the assessment. The objective of this review is to conduct a follow-up peer review to determine if the recommendations have been adequacy addressed and adequacy of the revised assessment for management purposes. The assessment has a large potential impact on a valuable fishery important to commercial and recreational fishers in Hawaii and fish consumers in the state. It forms the basis of bottomfish management decisions by the Western Pacific Regional Fishery Management Council (WPFMC), NMFS, and the State of Hawaii. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs 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. The CIE reviewers shall have the expertise, background, and experience to complete an independent peer review in accordance with the SoW and ToRs herein. CIE reviewer expertise shall include fish stock assessment, mathematical modeling, and statistical computing.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: The 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 COTR, 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 pertinent information. Any changes to the SoW or ToRs must be made through the COTR 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 reviewers in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

This list of pre-review documents may be updated up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, each CIE reviewer is responsible only for the pre-review documents that are delivered to the reviewers in accordance to the SoW scheduled deadlines specified herein.

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 can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR 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) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than 28 January 2011, 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 Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.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.

4 January 2011	CIE sends each reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
7 January 2011	NMFS Project Contact sends the CIE Reviewers the pre-review background documents
13 January 2011	Project contact provides the CIE reviewers with the report to be peer reviewed
14-28 January 2011	Each reviewer conducts an independent peer review as a desk review
28 January 2011	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
11 February 2011	CIE submits CIE independent peer review reports to the COTR
Feb. 15 2011	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

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

Applicable Performance Standards: The contract is successfully completed when the COTR 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 have 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 report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

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

Key Personnel:

William Michaels, Program Manager, COTR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

NMFS Project Contact:

Gerard DiNardo
Pacific Islands Fisheries Science Center
2570 Dole Street
Honolulu, HI 96822-2396
Robert.Moffitt@noaa.gov
808-983-5397

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.

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

Hawaii Deepslope Bottomfish

1. Determine if recommendations from the June 2009 WPSAR/CIE review have been adequately addressed within the assessment update. .

2. Review the assessment methods used: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data.

3. Evaluate the implementation of the assessment model: configuration, assumptions, and input data and parameters (fishery life history); more specifically determine if data are properly used, if choice of input parameters seem reasonable, if models are appropriately specified and configured, assumptions are reasonably satisfied, and primary sources of uncertainty accounted for.

4. Comment on the scientific soundness of the estimated population benchmarks and management parameters (e.g. MSY, Fmsy, Bmsy, MSST, and MFMT) and their potential efficacy in addressing the management goals stated in the relevant FMP or other documents provided to the review panel.

5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status.

6. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices. Include guidance on single species models, and whether this is possible given the current nature of this multispecies fishery, and difficulties in partitioning fishing effort between species.

Appendix II. List of documents received

Brodziak, J. R. Moffitt, and G. DiNardo. 2009. Hawaiian Bottomfish Assessment Update for 2008. Pacific Islands Fisheries Science Center Administrative Report H-09-02.

Courtney, D. 2011. Review of unreported to reported catch ratios for bottomfish resources in the Main Hawaiian Islands. PIFSC Internal Report, PIFSC, 2570 Dole Street, Honolulu, HI 96822, 10 p.

Lamson, M. R., McNaughton, B., and C. J. Severance. 2007. Analysis and expansion of the 2005 Hawaii state/Western Pacific Regional Fishery Council Bottomfish Fishermen Survey. Submitted to the Western Pacific Regional Fishery Management Council on 29 May 2007.

Martell, S. J., Korman, J., Darcy, M. Christensen, L. B., and D. Zeller. 2006. Status and trends of the Hawaiian bottomfish stocks: 1948-2006. Report to NOAA NMFS Pacific Islands Fisheries Science Center. University of British Columbia Fisheries Centre, Vancouver, p. 55.

Moffitt, R., D. Kobyashi, and G. DiNardo. 2006. Status of the Hawaiian bottomfish stocks, 2004. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Ser., NOAA, Honolulu, HI 96822-2326. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-06-01, 45 p.

Moffitt, R., G. DiNardo, J. Brodziak, K. Kawamoto, M. Quach, M. Pan, K. Brookins, C. Tam, and M. Mitsuyatsu. 2009. CPUE standardization workshop proceedings August 4-6, 2008. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Ser., NOAA, Honolulu, HI 96822-2326. Pacific Islands Fish. Sci. Cent. Internal Rep.

Piner, K., and H-. H. Lee. 2011. Estimation of bottomfish CPUE using the delta method and HDAR logbooks 1948-2010. PIFSC Internal Report, PIFSC, 2570 Dole Street, Honolulu, HI 96822, 8 p.

Ralston, S., S. Cox, M. Labelle, and C. Mees. 2004. Final Panel Report on Bottomfish Stock Assessment Workshop. January 13-16, 2004, Western Pacific Fishery Management Council 11643 Bishop Street, Suite 1400, Honolulu, Hawaii 96813

Stillman, R. 2009. Report on the Western Pacific stock assessment review 1 Hawaii deep slope bottomfish. WPSAR Review Panel.