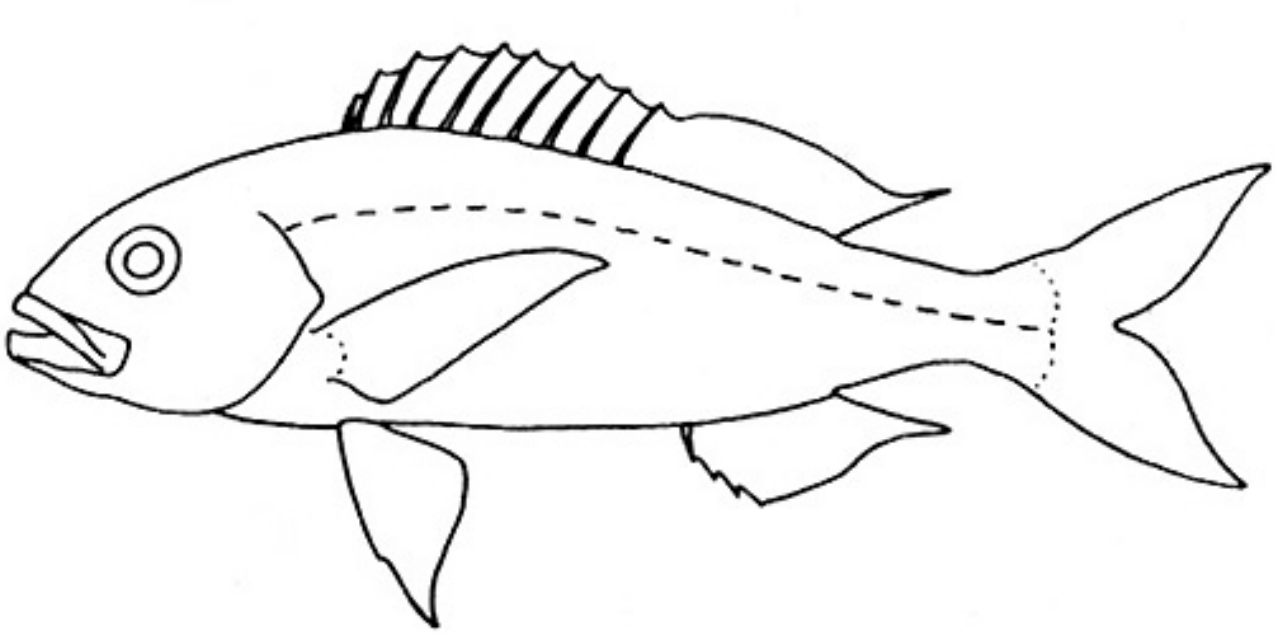
Independent Peer Review Report on the review of Developing Integrated Assessments for Data Poor Stocks

By

Robin Cook



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Contents

Executive Summary

i. A review of the new catch-MSY model was conducted at the Western Pacific Regional Fishery Management Council from 13-16 October 2015. Review materials included a description of a new age based model that utilizes biomass and length data, and a preliminary R package to implement the model. The review was conducted in a positive manner with excellent co-operation from all contributors during the meeting. Preliminary results of the review were presented on the last day of the meeting.

ii. At the current stage of development, it is premature to assess whether the model is reliable and adequate for management purposes, but the theoretical basis is sound and in principle the approach is appropriate for the species and fisheries concerned. A significant advantage of the proposed model is that it can potentially make use of a wider range of data than the biomass and aggregate catch data alone.

iii. The move from a purely biomass-based population dynamics model to an age based model introduces greater realism but with added complexity. A key issue, therefore, is whether the advantages of increased realism outweigh the uncertainty associated with additional model parameters, and this as well as other key model assumptions needs to be tested with a clearly designed plan using both simulated and real data.

iv. In its present form the model treats the observed catch as exact. Even where catch data are precise they are likely to reflect process error which will be translated directly into errors in the model estimates of fishing mortality. The problem may be less severe in determining plausible MSY ranges, but it could be significant in assessing current stock status. Overall, it is important to try to evaluate the importance of the assumption of exact catches in determining both MSY and current stock status.

v. The survey biomass data based on underwater observers appear to be well executed with a number of quality control protocols. There are limitations in the survey method due to depth and area coverage that may lead to bias. Every effort should be made to maintain and improve these surveys.

vi. The life history data enter the model as constants which determine the slope of the replacement line and hence biomass equilibrium points such as B_{msy}. There is a program of research to quantify these life history characteristics, but as yet not all species or areas are covered. Though such values may be derived from life history invariants it will mean that there is a great deal of uncertainty in the estimated MSY values that is not captured by the model. It is also very unclear how stocks that comprise mixed species can be configured for the model.

vii. The model requires the specification of fishery selectivity, and currently this is determined externally. Such selectivity may have an important influence on the estimates of MSY. The robustness of the model to errors in this assumption needs to be tested.

viii. As well as technical documentation of the software, it would be highly desirable to prepare a user manual for practitioners that explains how to configure the model and choose appropriate priors and input values. Informative diagnostics for the model output should be developed.

Background

1. In June 2014, an "Augmented Catch-MSY model" (Sabater & Kleiber, 2014) based on the Martell & Froese (2012) model was reviewed for application to data-poor coral reef fish stocks throughout the Pacific Islands Region, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. The model was considered suitable for further development with a specific recommendation to include a formal statistical treatment of survey data. Following the review, a modified integrated assessment model has been developed, focusing on developing extensions for the Catch-MSY method, by incorporating data other than catch time series that directly inform total mortality rates (e.g. changes in mean size), relative and absolute abundance estimates, and other life history information.

2. The new model has not previously been applied for management purposes in the Pacific Islands Region, so there is a need to conduct an independent peer review of the analyses to improve the scientific basis for management.

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

3. Review materials were received on the 5th October. These included the principal material for review, Martell (2015) and four supporting papers (Martell & Froese, 2012; Martell et al., 2008; Kimura & Taggart 1982; Sabater & Kleiber, 2014). In addition, a link to the R package hosted on Github was received to allow installation of the package. All papers were reviewed before the meeting, but it was not possible to install the R catchMSY package on a Windows platform at this juncture.

4. The review meeting commenced on the 13th October with presentations on the catch data (Lowe), underwater surveys (Williams), life history data (Humphreys), and the fisheries (Sabater). Following these presentations, the new model was presented (Martell) and discussed. In addition, revisions were made to the R package which permitted installation on Windows platforms. However, a number of technical issues prevented full use of the package and it was not possible for the reviewers to test-run the software.

5. Discussion with the model and software author continued on the 14-15th October when illustrative runs were performed by Steven Martell using the Lutjanid complex as an example to show how different configurations of the model could be run making various assumptions about priors and the inclusion/exclusion of survey biomass data. The model as extant at the beginning of the review only allowed the inclusion of catch and biomass data. During discussion additions were made to the software to permit the inclusion of length composition data, but while illustrations of this change were run, the work was still in progress at the end of the meeting.

6. On the final day of the meeting (16th October), the CIE reviewers presented their preliminary findings to Steven Martell, Beth Lumsden, Marlowe Sabater and Christofer Boggs.

Summary of Findings

7. The terms of reference for the review appear to have been developed on the assumption that by the time of the review meeting, the catch-MSY software would be fairly complete and that a number of full stock assessments would have been conducted. In practice, the R package was still incomplete and very little direct application to assessments had been done. As a result, it is difficult to respond usefully to terms of reference 3 and 4, and comments relating to ToRs 1 and 2 are restricted to discussion of the model itself and its relationship to the data. Additional comments are added after discussion of ToRs 1-4 which deal with issues of relevance in the review but not referenced in the ToRs.

ToR 1. Review the assessment methods used: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data considering that the data itself have been accepted for management purposes.

8. At the current stage of development, it is premature to assess whether the model is reliable and adequate, but the theoretical basis is sound and in principle the approach is appropriate for the species and fisheries concerned. While the basic catch-MSY model (Martell & Froese, 2012) has been tested by Rosenberg et al. (2014) and found to perform well relative to other data poor methods, the new model is sufficiently different that it requires its own suite of tests to ensure that it achieves the desired performance. At the time of the review, the state of development of the software meant that the results of such testing are not yet available.

9. The assessment model is described in Martell (2015) and responds positively to a number of comments made at the review in June 2014 of the Augmented Catch MSY model developed by Sabater and Kleiber (2014). Although the model draws on ideas of the latter, it differs fundamentally in two key respects. Firstly, the underlying population model is age based unlike the earlier version that was entirely framed in terms of aggregate biomass. Secondly, the parameterization of the model is in terms of MSY and F_{msy} as opposed to r and K in the original Schaefer version. Thus, whereas the Schaefer model required priors on the ranges of r and K, the new version requires priors on MSY and F_{msy}. These are important new innovations that require careful thought in the implementation of the model.

10. The change from a purely biomass-based population dynamics model to an age based model introduces greater realism but with added complexity. A key issue, therefore, is whether the advantages of increased realism outweigh the uncertainty associated with additional model parameters and this needs to be tested. Much of the available data (catch and biomass indices) contain little, if any, information on age structure which means that some model parameters have to be specified externally before fitting to data. By necessity, the underlying population model is deterministic and does not, for example, capture recruitment deviations or changes in fishing selection patterns. These are strong assumptions that need to be tested to ensure they are adequate for the estimation of essential management metrics.

11. A significant advantage of the proposed model is that it can potentially make use of a wider range of data than the biomass and aggregate catch data alone. In particular, at least some of the catch and biomass indices have associated length compositions and

these can be included in the likelihood function. Length composition data may be able to resolve some selectivity parameters and provide some information on changes to fishing mortality rate; however, the useful information they contain will be heavily dependent on the precision of the data and the extent to which annual pulses of recruitment influence the mean length of fish in the population. If age data from otolith reading are available, the model could also be adapted to fit to these and is potentially a significant route to improving the performance of the model.

12. At present the model is configured to accommodate a single fishery and an associated homogenous stock. This means the growth, maturity, natural mortality and selectivity parameters are unique vectors tailored to these assumptions. These too are strong assumptions that need to be tested to show they are adequate for purpose. Some of the data (both catch and biomass) are for species groups or families, and are fished by a variety of different gears, which inevitably raises the question as to how biological data (growth, etc.) and selectivity data can be appropriately specified. Although in principle it would be straight forward to modify the model to include multiple species and gears, it is highly unlikely that the available data could support such increased model complexity.

13. The model in Martell (2015) considers fishery selectivity (or vulnerability) to be asymptotic (equation 5) which is a conventional assumption for trawl fisheries. However, many of the gears used in the reef fisheries are likely to be much more selective. Spears, hand nets, gill nets, lines, etc., are more likely to have dome shaped selectivity and it will be a challenge to appropriately specify fishery selectivity for the model where these gears predominate.

14. The population dynamics model is closed by forecasting annual recruitment from an orthodox stock recruitment function such as Beverton-Holt or Ricker. Conventionally, these functions are defined by two parameters that describe the rate of increase of recruitment and the discounting effect of density dependence as the biomass increases. Typically, many assessment models estimate these parameters (or equivalents such as steepness and unexploited biomass) directly within the model. The new catch-MSY model takes a different approach where the stock recruitment parameters are derived directly from MSY and F_{msy}; thus, making these two values the model parameters to be estimated as opposed to derived quantities calculated from the stock-recruitment function. The advantage of this approach lies mainly in the way the model is set up to identify boundaries for plausible values of MSY reference points when only catch data exist, or the biomass and other data are insufficient to estimate them. It means that the end user is required to specify prior ranges on MSY and F_{msy} rather than the parameters of the stock recruitment function (or r and K in the case of the Schaefer model). It is arguably more intuitive to specify these MSY ranges than steepness and unexploited biomass. However, a consequence of this approach is that the stock-recruitment parameters are conditioned on the assumptions of gear selectivity, and points to the need to ensure that model assumptions about selectivity are fit for purpose.

15. In its present form, the model treats the observed catch as exact. In Hawaii where detailed catch records exist, this may be a reasonable assumption, but in the Territories where catches are estimated from surveys the values are likely to be subject to considerable observation error. Even where catch data are precisely

estimated they are likely to reflect process error caused, for example, by fluctuations in recruitment. Such errors will be translated directly into errors in the model estimates of fishing mortality and this problem is likely to be exacerbated by the fact that the modelled population is deterministic which means that both observation and process error will be incorporated into estimates of fishing mortality. The problem may be less severe in determining plausible MSY ranges, but it could be significant in assessing current stock status. Overall, it is important to try to evaluate the importance of the assumption of exact catches in determining both MSY and current stock status.

ToR 2. Evaluate the implementation of the assessment methods: determine if data in its current form are properly used, if choice of input parameters seems reasonable, if models are appropriately specified and configured, assumptions are reasonable and reasonably satisfied, and primary sources of uncertainty accounted for.

16. One might loosely classify the data into three components: (a) the catch which may have associated length compositions, (b) estimates of biomass from surveys with associated length compositions, and (c) life history data that are treated as constants. For both (a) and (b), these data may reflect groups of species or families rather than individual stocks. The model is able to make use of all these data sources and hence represents an improvement over the original catch-MSY method. The statistical treatment of some of the data (biomass indices and length data) is an improvement over the Sabater and Kleiber approach that was prone to subjective judgement.

17. Each of these data groups present different challenges to the analysis. Comment has already been made above about the catch data with respect to the assumption of precision. With regard to (b) the model uses the data in a likelihood framework so that any information it contains should refine the ranges of MSY and F_{msy} emerging from the analysis. Only through application will it be possible to determine if these data do indeed improve the estimates, but the formal statistical framework provides a sound basis for making this judgement.

18. The survey biomass data based on underwater observers appear to be well executed with a number of quality control protocols. There are limitations in the survey method due to depth and area coverage that may lead to bias. Scaling up the samples to total biomass is always prone to bias, and there may be an argument for treating the data as a relative abundance index to avoid potential inconsistency with the scale of the catches.

19. The life history data (c) enter the model as constants, and effectively determine the slope of the replacement line (Sissenwine and Shepherd, 1987) for any given value of fishing mortality. Hence, they are important in determining biomass equilibrium points such as B_{msy} and unexploited biomass. There is a program of research to quantify these life history characteristics, but as yet not all species or areas are covered. It is suggested in Martell (2015) that in the absence of observations, values may be derived from life history invariants (Jensen, 1996). While this is undoubtedly a sensible and pragmatic approach it will mean that there is a great deal of uncertainty in the replacement line that is not captured in the model. It is also very unclear, as commented earlier, how stocks that comprise mixed species can be configured for the model.

20. At the time of the review it was proposed that the length frequency (or weight frequency) data would be included in the model likelihood in the form of mean length. Changes in mean length may reflect changes in fishing mortality (e.g. Nadon *et al.* 2015). During the review meeting, it was suggested that the full length frequency could be included. This potentially could contribute more information and perhaps help in the estimation of selectivity, information that is lacking in the mean length data alone. It remains a matter of experimentation to determine which approach is preferable. In practice, the model is based on age, and the modelled lengths have to be recreated assuming a distribution around the growth curve. It is a moot point as to whether these modelled distributions are adequate predictors of the true length distribution, or whether the observed length distributions adequately reflect reality. If not, then recourse to the use of mean length may be a more robust approach, albeit with associated loss of information on selectivity. There are many assessment models that are based entirely on length, and these are better able to exploit good quality length information (e.g. Sullivan et al. 1990). There may be some merit in exploring such methods if the length data are considered to be of appropriate quality.

ToR 3. Comment on the scientific soundness of the estimated population benchmarks and management parameters (e.g. stock status estimates, MSY-based reference points or their proxies) and their potential efficacy in addressing the management goals stated in the relevant FEP or other documents provided to the review panel.

21. At the time of the review the method had not been applied to a full assessment of the stocks in question, so it is not possible to comment on the soundness of the estimated population benchmarks. Illustrative runs were performed on Lutjanid data that showed the inclusion of biomass data reduced the range of plausible biomass trajectories. The analyses also showed that the estimates of MSY were sensitive to the priors, but whether this is a stock specific problem or a more general property is impossible to gauge.

ToR 4. Determine whether the results (such as MSY proxies, stock status) in their current form from the assessment methods can be used for management purposes without further analyses or changes considering that the data itself have been accepted for management purposes.

22. At the time of the review there were no results available for management purposes. It is difficult to judge purely on the basis of the model description in Martell (2015) whether results from the model will be adequate for management purposes. To do so would require applying the model to real data and reviewing diagnostics not only from model fitting, but also a fairly detailed analysis that looked at sensitivity to the key model assumptions and the chosen priors.

Additional Comments

23. No assessment model is without its weaknesses and the catch-MSY model is no exception. The discussion above identifies some of the more obvious potential weaknesses, but the question is not about discarding the approach because of this, but to determine the extent to which these weaknesses qualify confidence in the results or can be mitigated by further model development. Unfortunately, at the time of the review it was not possible to address this question other than on the basis of purely theoretical merit. However appropriate the model structure and assumptions are, it is

always essential to trial the model with real data to reveal areas of strength and weakness and adapt the model accordingly. There is a pressing need for such a step in the model under review.

24. In the earlier development of the catch-MSY approach by Sabater & Kleiber, the stock population dynamics were described purely in biomass but the biomass data were included in the model in an *ad hoc* manner. The model could almost certainly be improved upon by treating the biomass data in a formal statistical approach as is done in the model under the current review. However, the new model has a very different underlying population dynamics model that is more data demanding so there is an important question about whether the increased realism of the new model out-performs a simpler, purely biomass-based model especially since the available data offer very little information on age structure. A comparison is necessary to show that the new model represents an improvement over the surplus production model.

25. The R package is being developed for use by practitioners who will not be expert in the mathematical or statistical basis of the model. To avoid inappropriate choice of input values (e.g. selectivity, growth, etc.) and mishandling of data it is important that effective guidance is provided that identifies which assumptions are in need of particular care and where appropriate sensitivity analysis should be performed. It is also important that output diagnostics are provided that enable practitioners to sensibly interpret the results.

26. At the time of the review, the R package implemented the core catch-MSY model with biomass data. Work was still in progress as to how to handle length data. There is a danger of proceeding with further model development before confronting it with real data, and hence failing to gain a good understanding of its limitations and where resources are best invested to improve the model. It would be desirable at this stage to focus on completing the R package with the current state of the model and test it with real data before further elaboration.

ToR 5. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices. Comment on alternative data sources and modeling.

27. At present priority should be given to completing the R package with the current state of the model and testing it with simulated and real data. Tests need to show that the age structured model performs better than a Schaefer model when used on comparable data sets.

28. Model diagnostics need to be developed that assist end users to understand model performance. An important issue is the extent to which bounds are required to obtain meaningful maximum likelihood estimates of F_{msy} and MSY. In principle, if the data contain good information on these quantities it should not be necessary to place bounds on their values. In practice, given the data available, bounds are almost certain to be required and a diagnostic which gives some assessment of the degree to which the results are informed by the data would be useful.

29. Even the most sophisticated age structured models with good data have difficulty estimating the parameters of the stock recruitment relationship because process error can be very large. Often a long time series of data is required to have any prospect of adequate parameter estimates. For the stocks involved at this review, none of the data is age structured and fishery independent data are limited to the most recent period. It is highly unlikely, therefore, that MSY reference points can adequately be determined from a parameterized stock recruitment function unless significant prior information is provided. This risks influencing the result unduly with priors that are more informative than can be justified. One way of mitigating this would be to make a less restrictive assumption about recruitment and rely on MSY proxies based on SPR. For example, modelling recruitment as being drawn from a lognormal distribution with a stationary mean may be more helpful in accommodating process error even though the linkage to spawning stock biomass is lost. Thus, it would not be possible to calculate a true MSY, but it would be possible to estimate unexploited biomass assuming average recruitment and hence derive MSY proxies. Some investigation of alternative ways of deriving MSY reference points that avoided trying to estimate the stock recruitment function would be desirable.

30. As discussed in paragraph 15, the model treats the catch as known exactly. It would be desirable to investigate ways of relaxing this assumption so that errors have a smaller influence on the estimates of fishing mortality. For example, if fishing mortality was modelled as a random walk, $F_{t+1}=F_t\exp(e_t)$, $e_t \sim N(0,\sigma)$, the catch could be treated as a random variable to be included in the likelihood. It might be necessary to specify σ, but this could be based upon experience of how much the fishery changes from year to year.

31. The current model specification assumes all the fish in the stock have the same life history characteristics and clearly this will be violated by those "stocks" that comprise multiple species. Research into ways of combining species by similarity of life history characteristics rather than species relatedness may be useful in satisfying the model assumptions.

32. It is likely that model performance could be greatly enhanced if age structured data were available. The presentation of the life history program (Humphreys) indicated that otoliths could be collected and read with some accuracy for the purposes of estimating growth parameters. Thus, it may be worthwhile investigating whether a limited collection of age data for the higher priority species is worthwhile. Initially, this could be done using simulated age data to see if there is any advantage in including such information in the model.

Conclusions and Recommendations

33. The new catch-MSY model is a major development of the original Schaefer based model described by Martell and Froese (2012) by adopting an age based population dynamics model and treating the data in a formal statistical framework. The model is more flexible in including a variety of different data and, arguably, is parameterized in a more natural way for management reference points. A fundamental question, however, is whether the increased complexity of the age-structure model introduces greater uncertainty in the estimated values than a simple biomass dynamic model.

This question needs to be addressed in a comprehensive testing program that also examines the robustness of model assumptions.

34. The free availability of the R package on Github is welcome and should be applauded.

35. Although at an advanced stage, at the time of the review the R package to implement the model was still incomplete. There are a number of ways in which the model might be developed depending on the type and availability of data. Further model development should only be undertaken when the current software is fully completed and tested. It should then be applied to a number of candidate stocks (say, in the region of 5) that encompass the range of challenges likely to be experienced in stock assessment of reef fishes. The results of these assessments should then be used to identify the most promising avenues for further development of the model and software.

36. As well as technical documentation of the software, it would be highly desirable to prepare a user manual that explains for practitioners how to configure the model and choose appropriate priors and input values.

37. For the reasons above, the method is not yet ready for the provision of management advice, but this should not prevent the development of the model and software which both show promise.

38. The value of the new method is heavily dependent on data from the underwater biomass surveys, the quality of the catch data and the accuracy of life history data. Every effort should be made to ensure the continuity and quality of these data. Access to age data should also be investigated to enhance the performance of the model.

NMFS review process

39. The review was conducted in a positive manner with very helpful presentations by the model author, staff of the Pacific Islands Fisheries Science Center and Western Pacific Regional Fishery Management Council. Good meeting facilities were provided and the reviewers received excellent co-operation from all contributors during the meeting.

40. The timing of the meeting in relation to the state of development of the software to implement the model meant that less progress could be made on a number of the Terms of Reference. While, hopefully, the review has proved useful, perhaps greater value might have been achieved if a wider range of test results had been available.

41. Given the very long journey time to the meeting and the time zone change (11 hours) it would have been beneficial to all if budget rules allowed earlier arrival in Hawaii before the meeting so that reviewers could adjust and perform at full mental capacity at the review meeting itself.

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Appendix 1: Bibliography of materials provided for review

Literature

Sabater, M. and Kleiber, P. 2014. Augmented catch-MSY approach to fishery management in coral-associated fisheries. S.A. Bortone (Ed.), Interrelationships between Corals and fisheries, CRC Press, Boca Raton, FL (2014), pp. 199–218 321 pgs.

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Sun Bak Hospital 2014. Western Pacific Regional Creel Survey Data Historical Summary and Analyses: 1982-2012.

M. Kimberly Lowe. Summary of Creel Survey Data Raw vs Expanded Data and Data Quality.

Presentations

M. Kimberly Lowe. Hawaii Commercial Fishery-Dependent Data: Overview
Robert Humphreys. Life history information
Steve Martell. CIE Review of An Integrated Catch-MSY Model for Data Poor Stocks
Marlowe Sabater. Coral Reef Fisheries in the Western Pacific Region
Ivor Williams. Reef Fish Visual Survey Program;Data Gathering Overview

Spreadsheets

Robert Humphreys: Life history parameters for select coral reef species

Appendix 2: CIE Statement of Work

Statement of Work

External Independent Peer Review by the Center for Independent Experts

Developing Integrated Assessments for Data Poor Stocks

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 Technical Representative (COTR), 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:

A large number of fish and invertebrate species listed in fisheries management plans have insufficient data to conduct routine stock assessments and determine stock status to inform managers' selection of Annual Catch Limits (ACLs). The current practice for setting ACLs for many data-poor species is based solely on: (a) the historical catch information, or (b) use of ratios such as change in mean size or spawning potential ratio (SPR) to infer depletion, or (c) comparative studies on local density in heavily depleted versus near pristine habitats using underwater visual census.

Nearly all of the assessment methods for data-poor stocks rely solely on catch data, or one source of data for directly estimating population density. A modified integrated assessment model has been developed, focusing on developing extensions for the Catch-MSY method, or stock reduction analysis proposed by Martell and Froese (2012) and Taggart and Kimura (1982) and modified by Sabater & Kleiber (2014), by incorporating data other than catch times series that directly inform total mortality rates (e.g. changes in mean size), relative and absolute abundance estimates, and other life history information. This modified model is being applied to data-poor coral reef fish stocks throughout the Pacific Islands Region, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. However these scientific analyses have not previously been applied for management

purposes in the Pacific Islands Region, so there is a need to conduct an independent peer review of the analyses to improve the scientific basis for management.

The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of: General fisheries stock assessment methods, specifically numerical methods for constructing posterior distributions (e.g. Monte Carlo methods), and data-poor approaches to conducting stock assessments.

Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Honolulu, HI during October 13-16, 2015.

Statement of Tasks: Each CIE reviewers 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, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

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 the following documents (and others to be provided) in preparation for the peer review.

Document describing the newly-extended Catch-MSY method which incorporates data other than catch times series.

M. Sabater, P. Kleiber. 2014. Augmented catch-MSY approach to fishery management in coral-associated fisheries. S.A. Bortone (Ed.), Interrelationships between Corals and Fisheries, CRC Press, Boca Raton, FL (2014), pp. 199–218 321 pgs

Martell S, Froese R. 2013. A simple method for estimating MSY from catch and resilience. Fish. Fish. 14: 504-514.

Kimura, D. and Tagart, J. 1982. Stock reduction analysis, another solution to the catch equations. Canadian Journal of Fisheries and Aquatic Sciences, 39, 1467–1472.

Panel Review Meeting: 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 cannot 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.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility 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) Participate during the panel review meeting at the *Honolulu, HI* during *October 13-16, 2015*, and conduct an independent peer review in accordance with the ToRs (**Annex 2**).

3) No later than November 7, 2015, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlani@ntvifederal.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.

September 7, 2015	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
September 28, 2015	NMFS Project Contact sends the CIE Reviewers the pre-review documents
October 13-16, 2015	Each reviewer participates and conducts an independent peer review during the panel review meeting
November 7, 2015	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
November 16, 2015	CIE submits CIE independent peer review reports to the COTR
November 23, 2015	The COTR 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 COTR within 10 working days after receipt of all required information of the decision on changes. The COTR 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 COTR 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 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 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 COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

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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 following Annex 2 Terms of Reference.

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.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   d. 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
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

Developing Integrated Assessments for Data-Poor Stocks

1. Review the assessment methods used: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data considering that the data itself have been accepted for management purposes.

2. Evaluate the implementation of the assessment methods: determine if data in its current form are properly used, if choice of input parameters seems reasonable, if models are appropriately specified and configured, assumptions are reasonable and reasonably satisfied, and primary sources of uncertainty accounted for.

3. Comment on the scientific soundness of the estimated population benchmarks and management parameters (e.g. stock status estimates, MSY-based reference points or their proxies) and their potential efficacy in addressing the management goals stated in the relevant FEP or other documents provided to the review panel.

4. Determine whether the results (such as MSY proxies, stock status) in their current form from the assessment methods can be used for management purposes without further analyses or changes considering that the data itself have been accepted for management purposes.

5. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices. Comment on alternative data sources and modeling.

Annex 3: Tentative Agenda

Review of Modified Integrated Assessments (based on Catch-MSY model) for Data-Poor Stocks

Honolulu, HI
October 13-16, 2015
8:30 AM – 5:00 PM

Tuesday October 13

1. Introduction
2. Background information - Objectives and Terms of Reference
3. Coral reef fisheries in the Pacific Islands Region
    - Operation (presented by PIFSC)
    - Management (Council and PIRO)
4. Data
    - State of Hawaii commercial system
    - Coral Reef Ecosystem Division surveys
    - Biological data
    - Other data
5. Discussion

Wednesday October 14

6. Review of modified integrated Catch-MSY stock assessment
7. Discussion

Thursday October 15

8. Continue Assessment Review (1/2 day)
9. Discussion
10. Panel discussions (Closed)

Friday October 16

11. Panel Discussions (1/2 day)
12. Present Results (afternoon)
13. Adjourn

Appendix 3: Panel Membership

Robin Cook, CIE, UK
Jose D'Oliveira, CIE, UK
John Neilson, CIE, Canada