Developing Integrated Assessments for Data-Poor Stocks
In the Western Pacific

Center for Independent Experts (CIE) Independent Peer Review Report prepared by:

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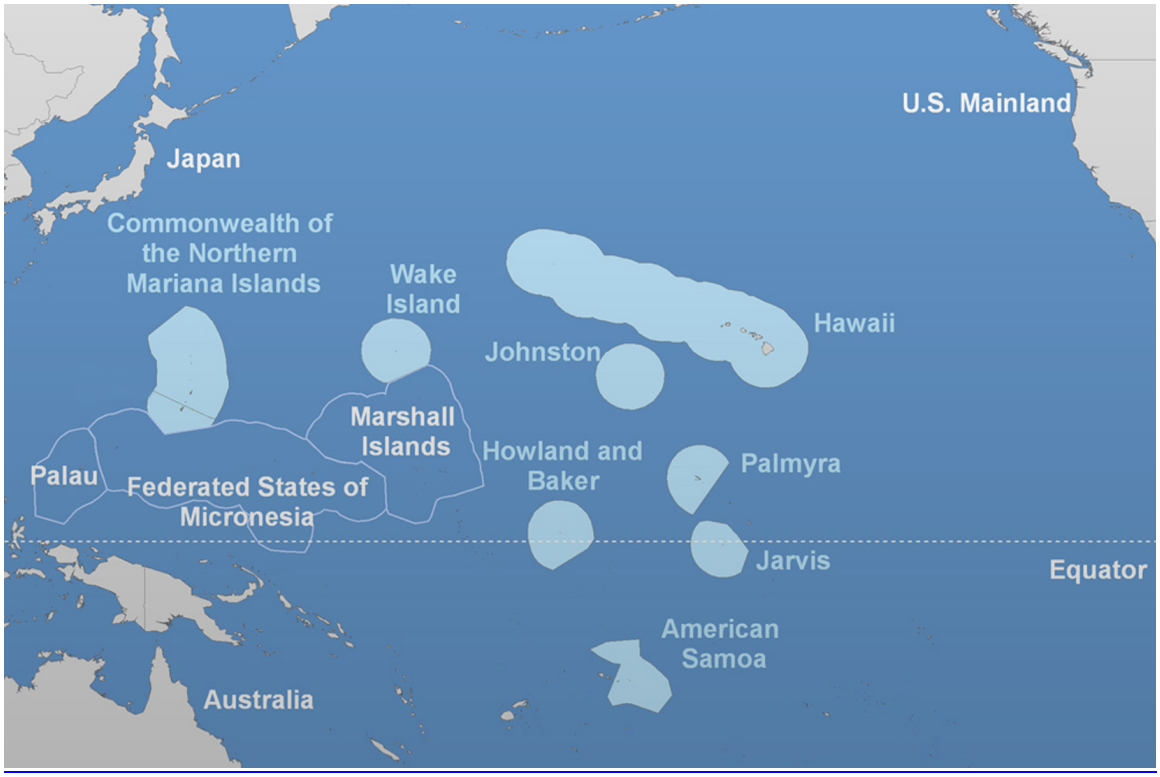

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[1].The Western Pacific Region, showing the geographic extent of stocks that could be considered "data-poor". Graphic supplied courtesy of Bob Humphries, NMFS.

Executive Summary

A Center for Independent Experts (CIE) review of a new method for conducting stock assessments of data-poor coral reef species was conducted in Honolulu, HI Oct. 12-16, 2015. The CIE Panel members were Dr. Robin Cook, Dr. Jose de Oliviera, and myself. The main focus of the review was the so-called Integrated Catch-MSY method described in Martell (2015), which is a new stock assessment approach and associated R software developed to meet the special circumstances of the coral reef fisheries in the Western Pacific Region.

The Panel was presented with five Terms of Reference to structure its review. The first Term of Reference required the Panel members to 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. I concluded that the Integrated Catch-MSY was potentially useful, theoretically correct, and appropriate for the data that are available in the Region. There are some important caveats, however. It is critical to note that the results obtained from the use of the Integrated Catch-MSY method are dependent on the quality of the catch data. For certain taxonomic groupings for which management advice is needed, it was clear from the review that the catch data are imprecise, and likely biased. Analysts using the new method need to be careful to understand the limitations of the catch data, possibly through sensitivity analyses, and qualify management advice accordingly. I also noted that the R software for the use of the model was still under development, both from the inclusion of important model components and from de-bugging. Addressing the absence of thorough software testing is a critical next step towards the evolution of the method as a standard assessment tool, and is discussed in the Research Recommendations.

Under the second Term of Reference, the Panel was asked to evaluate the implementation of the assessment methods: determine if data in its current form are properly used, if choice of input parameters was reasonable, if models were appropriately specified and configured, assumptions were reasonable and reasonably satisfied, and primary sources of uncertainty accounted for. I concluded that the Integrated Catch-MSY method has

flexibility to include more survey and life history information than the original Catch-MSY and Biomass Augmented Catch-MSY approaches. In providing such flexibility, the model development is consistent with the current research direction identified by other researchers for data-poor methods (Thorson et al. 2015). However, much of the life history information required for input into the Integrated Catch-MSY method such as the von Bertalanffy growth parameters, and size at maturity data are not currently available for the species of interest in the Western Pacific. However, the availability of fisheries-independent survey abundance information along with size composition data in the Region is particularly noteworthy and important. Data from this source is of obvious value for documenting changes in abundance, either relative or absolute. The data obtained from the surveys appeared to be of high quality, and represent an important asset for stock assessment purposes.

The third Term of Reference required Panelists to evaluate the scientific soundness of the estimated population benchmarks and management parameters (e.g. stock status estimates, MSY-based reference points or their proxies). I was unable to comment on this Term of Reference, as the necessary model testing has not yet been done. I reached a similar conclusion for the fourth Term of Reference, that asked the Panelists to determine if the results (such as MSY proxies, stock status) in their current form can be used for management purposes. I concluded that the current model results cannot be used for management purposes until more model development and testing is completed.

The final Term of Reference asked the Panel to make recommendations for future research directions. I responded with a number of recommendations, structured into "immediate" and "longer term" categories. Within the immediate group of recommendations, I noted the need for more testing using simulated data. This is probably the most important part of the testing process. There is also a need to conduct sensitivity analyses, including evaluating misspecifications of catch, selectivity, and recruitment. As was done in Martell and Froese (2012), comparing results from the new method to "full" stock assessments would be very helpful, particularly for tropical fish stock assessments. I considered that it was very important to include standard diagnostic output for assessing goodness of fit (residual plots over time, q-q plots, and the like).

I recommend including biomass dynamics capabilities within the package. It would be highly desirable to contrast results of the biomass dynamics approach of Sabater and Kleiber (2014) with the results from the Integrated Catch-MSY model. It would also be desirable to develop a User's Manual that guides users wishing to use the Integrated Catch-MSY approach. Finally, once the testing and model validation is completed, it would be advised to archive a supported version of the software. This version should be the standard version used by stock assessment scientists.

Under "longer-term" research recommendations, I recommend continuing to investigate alternative groupings of species with similar life histories rather than by families. There was evidence presented during the review meeting that grouping at the family level may be inappropriate in some instances, given substantial variation in the productive capacity of individual species within the family. I also note that obtaining the full suite of life history traits will be an expensive and time-consuming activity. Therefore, it would be potentially useful to conduct sensitivity analyses of the various life history inputs to assess how influential such values are on the estimates required for management. The results of the analyses could be used to prioritize research activities.

As a comment on the review process, I noted that the Terms of Reference for this review appeared much like CIE stock assessment reviews I have seen in the past. In a sense, given that the review focused on a project that was still ongoing and there was not an immediate need to produce management advice, the Terms of Reference were inappropriate and could have been better written to help guide the reviewers.

A. Background

Description of the Reviewer's Role

The author was contacted by the Center for Independent Experts (CIE) on Sept. 4, 2015 to conduct the following tasks (see also Appendix 2, the Statement of Work):

1) Review background documentation provided by the CIE in advance of the review meeting. A list of the background documentation is provided in Appendix One.

2) Participate in a review meeting in Honolulu, HI October 13-16, 2015.

3) Submit a final report following the prescribed format by November 7, 2015.

Prior to this review, the author has had no involvement with the development of assessment approach contained in Martell (2015).

Review Activities

As part of the CIE Panel, I was provided with background information from Pacific Island Fisheries Center Staff on the first day of the review (October 13th, 2015). Dr. Kimberley Lowe (PIFSC) provided a useful overview of the available fisheries data in the region, which could perhaps be described as a complex mosaic of information involving various data collection systems operated by different authorities. For me, there were several important messages with regard to inputs for stock assessment. The first, and possibly most important, point is that data quality and completeness has varied over time. The catch data are undoubtedly imprecise and probably biased. For example, we were told that since the introduction of Annual Catch Limits (ACLs) in about 2000, there has been a positive incentive to report catches that did not exist prior to the introduction of ACLs. The recreational fishery catch is poorly documented, and is a major concern.

At my request, Dr. Lowe provided a further reference on fisheries creel survey data, which documents an important source of catch data in the region (Hospital 2014).

Dr. Bob Humphries provided an overview of the life history research being conducted within the PIFSC. Given that the model of Martell (2015) requires input of this type (von Bertalanffy growth parameters, size at maturity, length-weight conversions), it was important to understand the availability of this type of input data. For life history data for the management jurisdiction (Hawaii, Samoa, and the Marianas), most of the available life history info is for Acanthuridae (surgeonfish) and Scaridae (parrotfish) (R. Humphries, pers. Comm.). Further complicating matters was the observation that regional differences in life history parameters have been observed within the Region. At my request, Dr. Humphries produced an overview table that illustrates both the extent of the available data and the regional variations in life history parameters (Table 1). Dr. Humphries also cautioned that some of the current taxonomic groupings used to provide management advice contain species that exhibit different life history traits and productivities.

Dr. Ivor Williams of the Coral Reef Ecology Division (PIFSC) gave an informative presentation on the available fishery independent survey data that are being gathered in the Region. I was impressed by this program, which appears to provide useful and precise abundance estimates (both relative and absolute) as well as size information. While the estimates of abundance for the various regions are not available on an annual basis, the relatively new program has great promise and is definitely one of the most significant assets for the stock assessment program.

Dr. Matt Dunlap of the WPFMC gave an overview of the management process used to establish annual catch limits (ACLs). Of note is that there are 74 Coral Reef Management Units defined at present, placing a significant burden on fisheries managers, as well as need for management advice.

Dr. Marlowe Sabater also of the WPFMC gave an overview of the fisheries of the region. There is a striking diversity of species caught and gear employed in these fisheries. Stock

assessment efforts will need to exercise care to construct representative length frequencies for the catch. A further feature of the coral reef fisheries is that the characteristics of the fisheries vary on a regional basis (main species caught, gear employed). Dr. Sabater noted that the economic value of the coral reef fisheries is small compared with some of the other fisheries such as the pelagics, but they are of considerable cultural significance.

Our review on October 14 included a presentation from Dr. Steve Martell on his assessment method, and a Panel discussion on the method. The work of the Panel on October 15th focused on the use of the software, and the review concluded with the presentation of preliminary findings on October 16th. My reactions to both the method and the software are provided in the next section of this report.

B. Summary of Conclusions Referring to the Terms of Reference.

I concluded that the development and evolution of assessment tools for coral reef fisheries in the Western Pacific was consistent with the guidance and philosophy of other researchers working in the field. For example, see the text taken from the Introduction to Fisheries Research, Vol. 111 (2015) a special issue addressing the theme of Data-poor Methods for fish stock assessment:

"We therefore emphasize the importance of developing assessment methods that use multiple types of data, of varying quality, to accommodate the particular circumstances of a given stock. Given that data-poor assessment methods are still being developed, we advocate that researchers continue to expand the types of data that can be incorporated within their models."

In the Western Pacific region, models have evolved from catch-only methods that use surplus production approaches (Martell and Froese 2012), to inclusion of biomass estimates (Sabater and Kleiber 2014), and now to an age-structured approach that allows inclusion of both size composition and abundance data (Martell 2015) in a more statistically robust framework.

My summary points with regard to the Terms of Reference are given below (the Terms of Reference are given in italics):

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.

The CIE Review Panel considered the model referred to as the Integrated Catch-MSY model (Martell 2015). The new model appears appropriate, and makes better use of available data than the original Catch-MSY model (Martell and Froese 2012), and the Sabater and Kleiber (2014) Biomass-augmented Catch–MSY model. The latest model avoids the need to estimate highly confounded terms such as r and K in the original Martell and Froese (2012) formulation, is open source, and runs quickly, at least on the laptop used to demonstrate the software (MacBook Pro). Implementation on Windows-based machines did not seem as advanced, which could pose a problem given that many assessment scientists use such platforms.

However, there is an absence of testing that makes it difficult to determine if the assessment model produces reliable results. This is a key deficiency that must be addressed (see recommendations later). In addition, there are certain key assumptions and user-specified inputs that should require further evaluation, possibly through sensitivity analyses. The model is dependent on reliable catch information, without which, unreliable management advice may follow.

It also should be noted that while the model has considerable promise, it is not yet ready for routine use by stock assessment scientists, and appears to be very much reliant on guidance from the author of the software to get results.

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.

From information provided by NMFS staff, I understand that the available input data, particularly catch, are very heterogeneous in quantity and quality within the Region. For example, the records of catch for some species assemblages including pelagics, goatfishes and mullets are considered reasonably complete. However, species with a large recreational component such as parrotfish targeted by the spear-fishery are more problematic (K. Lowe, pers. Comm.). It was also noted that the quantity of dead discards is not known and could be significant for certain fisheries. Recognition of input data quality in the modeling work will therefore be very important. Having a flexible tool that allows different approaches respecting the quality of information that is available will be helpful for the analyst.

As noted, the Integrated Catch - MSY model has flexibility to include more survey and life history information than the original Catch-MSY and Biomass Augmented Catch-MSY approaches. However, much of the life history information such as the von Bertalanffy growth parameters, and size at maturity data are not currently available for the species of interest in the Western Pacific. Available data for Regional fish stocks appear to be largely limited to surgeonfish and parrotfish (see Table 1, supplied courtesy of R. Humphries). Obtaining the full suite of life history information required for the various species assemblages will be a major undertaking that will demand considerable resources over many years.

The availability of fisheries-independent survey abundance information along with size composition data in the Region is particularly noteworthy and important. Data from this source is of obvious value for documenting changes in abundance, either relative or absolute. The data obtained from the surveys appear to be of high quality, and represent a real asset for stock assessment purposes. Inclusion of biomass data in the trials undertaken by Dr. Martell at the request of the Panel resulted in more precise biomass trends, an expected result. Carruthers et al. (2014) have also noted the high value of additional information regarding stock depletion and current abundance when only catch

data are available. The surveys will therefore be an important component of the stock assessment program for these species complexes, and should continue to be supported.

As noted by another member of the CIE panel, it appears as though there are some age determinations available for certain species. It would be helpful to document such data and consider including the information in the modeling work. I believe such data could be particularly informative, as some of the growth curves asymptote quite quickly, and in the absence of age information, a considerable fraction of the population may be assigned a plus group in the age structured model.

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.

I was unable to comment on this Term of Reference, as the necessary model testing has not yet been done. However, at the request of the Panel, Dr. Martell did compare the estimates of MSY obtained when the biomass data were used as single point estimates (as done in the Sabater and Kleiber model) compared with the approach where trends in biomass estimates are evaluated assuming log-normal error distributions. This work was completed for the Lutjanid species complex in American Samoa. It was potentially important to note that the estimates of MSY differed considerably between the two approaches, with the earlier version returning an estimate of about 54,000 lbs, whereas the newer Integrated Catch-MSY model estimates MSY as about 15,000 lbs. While exact agreement is not expected, a difference of this magnitude needs to be reconciled.

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.

The answer for Term of Reference 3 above applies here as well. The current model results cannot be used for management purposes until more model development and testing is completed.

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.

Immediate Priorities

- More testing of the Integrated Catch-MSY method using simulated data. This is probably the most important part of the testing process, and it is acknowledged that it is not trivial to construct a realistic set of simulated data, but it needs to be done nonetheless. Examples in the literature of simulation testing of related methods include Carruthers et al. (2011) who tested the performance of two methods that use catch data only.

- Continue to work towards obtaining complete and unbiased estimates of total catch, including dead discards, recognizing that the method of Martell (2015) and other data-poor methods such as Depletion-based Stock Reduction Analyses are critically dependent on accurate total catch data (Berkson et al. 2011).

- Sensitivity analyses including evaluating misspecifications of catch, selectivity, life history trait, and recruitment.

- As was done in Martell and Froese (2012), comparing results from the new method to "full" stock assessments would be very helpful, particularly for tropical fish stock assessments. It is acknowledged that the results of such comparisons are sometimes ambivalent (which model is really more reliable?), but seeing that contrasting methods return similar results is at least comforting.

- Include standard diagnostic output for assessing goodness of fit (residual plots over time, q-q plots, and the like).

- Include biomass dynamics capabilities within the package. It would be highly desirable to contrast results of the biomass dynamics approach of Sabater and Kleiber (2014) with the results from the Integrated Catch-MSY model. In this manner, some of the trade-offs between the potentially greater complexity and realism of the age-structured model and the simplicity of the biomass dynamics approach could be investigated.

- Develop a User's Manual that guides users wishing to use the Integrated Catch-MSY approach. It would be desirable to not only provide technical direction in building the models and using the code, but also to offer guidance in dealing with common issues such as derivation of representative length-composition data where multiple gear types exist.

- Develop a tested, archived and supported version of the software. This version should be the standard version used by stock assessment scientists.

Longer Term Priorities

- Continue investigating alternative groupings of species with similar life histories rather than by families. This is important, given the variation in life history traits (and productive capacity) known to exist within families (see Table 1 for examples).

- Given that obtaining the full suite of life history traits will be an expensive and time-consuming activity, it would be potentially useful to conduct sensitivity analyses of the various life history inputs to assess how influential such values are on the estimates required for management. The results of the analyses could be used to prioritize research activities.

C. Conclusions

To reiterate, the current method of Martell (2015), while promising and seemingly built from a sound theoretical basis, requires more testing and documentation before it can be considered to be a front-line stock assessment tool. As emphasized throughout the review by all members of the Panel and observers, the results from the analyses are heavily dependent on the quality of the catch data. Analysts will have to be very careful in documenting changes in reporting systems and management measures that may result in biases in the catch data, and make choices on how to conduct the analyses in an informed manner. Without such careful background work, there is a real possibility of obtaining seriously erroneous results with negative impacts on the reliability of management advice.

Given the number of potential management units in the region, the incomplete fishery monitoring systems and understanding of life history parameters, the demands for input data for the Integrated MSY-catch model may be difficult or impossible to meet for certain stocks. In such instances, use of the Integrated MSY-catch method will not be possible, and alternative methods that are less demanding of quantitative inputs will be necessary, such as those suggested by Johannes (1998).

As a comment on the review process, I noted that the Terms of Reference for this review appeared much like CIE stock assessment reviews I have seen in the past. In a sense, given that the current review focused on a project that was still ongoing and there was not an immediate need to produce management advice, the Terms of Reference were inappropriate and could have been better written to help guide the reviewers.

While the purpose of this review is to provide constructive criticism, I think it is important to recognize and acknowledge the work of the WCPFC and PIFSC in developing tools for coral reef fisheries throughout a vast oceanic region (see figure on Title Page). These organizations have become world leaders in dealing with this complex problem. The underwater surveys look particularly promising, and I look forward to seeing the data from the surveys used in stock assessments in the future.

Many thanks to Dr. Steve Martell for his hard work during the review. I would also like to thank the staff of the PIFSC and the WPRFMC for hosting the review and responding so quickly and thoroughly to the questions that were raised during the review.

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Table 1. Life history parameters for selected coral reef fish species (courtesy of R. Humphries, PIFSC).

SPECIES	FAMILY	LOCATION	L(inf)-Females	k - Females	t(0) - Females	L(inf)-Males	k - Males	t(0) - Males	L(inf)-Pooled	k - Pooled	t(0) - Pooled	Age(50) Female (years)	Age(50) Male (years)	L(50) Female (cm)	L(50) Male (cm)	L(50) Sex Reversal (cm)	Age(50) Sex Reversal (years)	Data Source
Naso literatus	Acanthuridae	Guam							20.4	0.93	-0.30	N/A	2.4	14.5	17.8	N/A	N/A	Taylor & Choat 2014)
Naso literatus	Acanthuridae	Pohnpei							21.2	1.38	-0.20	2.2	2.0			N/A	N/A	Taylor & Choat 2014)
Naso unicornis	Acanthuridae	Hawaii	48.2	0.40	-0.23	47.6	0.45	-0.08				~3.1	~2.1	35.5	30.1	N/A	N/A	(DeMartini 2015; unpubl. data; be advised that the 3-parameter von Bertalanffy growth curve is likely under-parameterized)
Naso unicornis	Acanthuridae	Guam							49.3	0.22	-0.48	4.0	3.2	29.2	27.1	N/A	N/A	Taylor & Choat 2014)
Naso unicornis	Acanthuridae	Pohnpei							47.1	0.36	-0.14	2.9	2.2	31.2	26.9	N/A	N/A	Taylor & Choat 2014)
Calotomus carolinus	Scaridae	Hawaii								N/A		~1		24.3	N/A	36.9	~3+	(DeMartini 2015; k & Age(50) Female data unpubl.; L(50) Female & L(50) Sex Reversal data in press)
Chlorurus spilurus	Scaridae	Hawaii								0.46		~1.5		17.2	N/A	27.3	~4	(DeMartini 2015; k & Age(50) Female data unpubl.; L(50) Female & L(50) Sex Reversal data in press)
Scarus psittacus	Scaridae	Hawaii								0.53		~1		13.9	N/A	22.6	~2+	(DeMartini 2015; k & Age(50) Female data unpubl.; L(50) Female & L(50) Sex Reversal data in press)
Chlorurus perspicillatus	Scaridae	Hawaii								0.3		~3		34.5	N/A	46.4	~8	(DeMartini 2015; k & Age(50) Female data unpubl.; L(50) Female & L(50) Sex Reversal data in press)
Scarus rubroviolaceus	Scaridae	Hawaii								0.44		~3		35.0	N/A	47.3	~5	(DeMartini 2015; k & Age(50) Female data unpubl.; L(50) Female & L(50) Sex Reversal data in press)
Calotomus carolinus	Scaridae	Guam							26.3	0.91	-0.065	1.14		16.8				Taylor et al. 2014)
Cetoscarus bicolor	Scaridae	Pohnpei							40.2	0.59	-0.065	3.05		32.3				Taylor et al. 2014)
Chlorurus frontalis	Scaridae	Guam							37.2	0.71	-0.058	1.55		24.0				Taylor et al. 2014)
Chlorurus microrhinus	Scaridae	Guam							45.7	0.34	-0.097	3.70		30.8				Taylor et al. 2014)
Chlorurus spilurus	Scaridae	Guam							21.8	0.95	-0.075	1.30		14.4				Taylor et al. 2014)
Hipposcarus longiceps	Scaridae	Pohnpei							36.6	0.76	-0.055	3.12		31.7				Taylor et al. 2014)
Scarus altipinnis	Scaridae	Guam							33.9	0.66	-0.069	2.89		25.1				Taylor et al. 2014)
Scarus forsteni	Scaridae	Guam							28.1	0.88	-0.062	1.79		21.6				Taylor et al. 2014)
Scarus ghobban	Scaridae	Pohnpei							31.0	1.41	-0.035	N/A		N/A				Taylor et al. 2014)
Scarus psittacus	Scaridae	Guam							20.7	0.91	-0.083	1.36		10.3				Taylor et al. 2014)
Scarus rubroviolaceus	Scaridae	Guam							37.6	0.66	-0.062	1.91		27.1				Taylor et al. 2014)
Scarus schlegeli	Scaridae	Guam							25.2	1.03	-0.600	1.99		N/A				Taylor et al. 2014)

Appendix 1: Bibliography of materials provided for review

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Appendix 2

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