Center for Independent Experts (CIE) Independent Peer Review Report

Methodology for Sampling and Estimating Bycatch of the Hawaii Deep-Set Longline Fishery

August 24-28, 2015

Honolulu, Hawaii

Report to:

The Center for Independent Experts

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Contents

Executive Summary

Methodology for sampling and estimating bycatch of the Hawaii Deep-Set Longline Fishery was reviewed. This document reports the main findings of the methodology and recommendations for future research.

Sampling design for observer assignment in the Hawaii DSLL fishery encounters atypical situations due to many constraints. Clearly, it is challenging to design a statistically rigorous sampling plan when the size of sampling frame is undetermined, and the number of observers and their availability also fluctuate. The two-stage SYSPLUS sample is a novel and highly adaptive approach that can effectively accommodate uncontrollable constraints. The estimation comprises a large number of species, many of which are often rarely observed. The amount of work and its complexity are well recognized.

The review found that the main concerns reside in estimating bycatch, although the current methods for estimating total bycatch and intervals do not appear to have fundamental problems. The simple design-based estimators can be calculated quickly, which is an advantage and can meet the time requirement for a large number of bycatch species. However, several individual approaches seem overcomplicated. For example, the procedure for estimating inclusion probability, approximating CIs based on the finite population central limit theorem, and nonparametric bootstrap sampling, can use simple and straightforward techniques that are easier to understand and execute. This report made several specific recommendations for future research:

(1) The large number of bycatch species should be divided into two or three groups according to their observed frequency. Different group of species should use alternative estimation technique(s). Clear criteria for categorization may be developed by examining historical data and results.

(2) Post-stratification should be explored to determine optimal strategy that may minimize bias and variance. The large volume of observer data accumulated over the past decade should be used to signify less subjective selections of strata, clusters, or groups in the sample design.

(3) Developing model-based approaches should become a research priority in the future. Bayesian hierarchical models that include additional covariates are considered to be highly competent. Depending on the resource, Bayesian models can be applied to selected priority species, not necessary for all species. Simultaneously analysing data from all years and treating year and subregion as covariates allow borrowing strength from each other and facilitate the domain estimates.

(4) For data-rich species, the method based on the finite population central limit theorem and the bootstrap method may be sufficient. Simplified techniques suggested in the "summary of findings" should be considered.

Background

The Hawaii deep-set longline (DSLL) fishery incidentally catches over a hundred bycatch species, including marine mammals, seabirds, sea turtles, elasmobranchs, and many teleosts. A sampling design has been used to collect bycatch data over the past decade, and bycatch estimates are computed based on the sampling data. This document reports on the review of the sampling design and the methods used to estimate bycatch.

Two weeks before the review meeting, I received three documents from the NMFS Project Contact:

1. Sampling the Hawaii deep-set longline fishery and point estimators of bycatch;

2. Interval estimation of annual bycatch in the Hawaii deep-set longline fishery;

3. Domain estimators for the total number of cetacean bycatch events resulting in a dead or serious injury classification.

These documents indicate that the review involves five components: (1) sampling design; (2) point estimation of total bycatch for each species; (3) uncertainty evaluation; (4) estimation of the total number of bycatch events classified as “dead or seriously injured (DSI)” among the total bycatch for each marine mammal species; and (5) estimation of DSI within sub-geographical areas. These five components nicely match up with the Terms of Reference (ToR) that I received during the panel review meeting in Honolulu.

The CIE invited three independent reviewers, including myself, who all attended the review meeting. Background information regarding the Hawaii longline fishery and observer program was presented during the meeting. The project team provided detailed explanations about the methodology. Extensive discussions were exchanged between the team and the review panel. This review report results from the discussions as well as my own assessment.

Description of Reviewer's Role and Review Activities

I read the three background documents and made many notes before travelling to the review meeting. The panel meeting was held at the University of Hawaii, in Honolulu, Hawaii, from August 24 to 28, 2015. The activities during the review meeting are briefly described as follows.

Monday, August 24, 2015

Chris Boggs, NMFS Pacific Islands Fisheries Science Center, gave an introduction and provided background information about the Hawaii Longline Fishery. We learnt that the deep-set longline fishery targeted primarily tunas. Interestingly, the catch in the Hawaii-based longline fishery only comprised a small fraction of the total tuna catch in the western and central Pacific Ocean. The majority of bycatch took place in other fisheries and were not well estimated. C. Boggs also described the Terms of Reference and expectation of the outcomes from the review.

Joe Arceneaux, NMFS PIRO Observer Program, presented the "Hawaii Longline Observer Program". The program targeted 20% observer coverage each year for the deep-set longline fleet. The observer coverage rate originated from a court order rather than as determined by statistical criteria.

Marti McCracken, NMFS Pacific Islands Fisheries Science Center, then gave a detailed presentation on sampling design. Extensive discussions, questions and answers between the presenter and the panel took place during the presentation. Some additional materials, including examples of sample data in spreadsheets, were provided to the review panel.

Tuesday, August 25, 2015

The second day focused on the presentation and review of the second and the third components, the point estimators and interval estimators. Again, there were extensive discussions, questions and answers between the presenter and the review panel. Graphic examples were provided for some species.

Wednesday, August 26, 2015

The presentation and review of interval estimators continued. This was followed by presentation on estimators of DSI, and finally the estimators of subpopulation in each specific geographic areas. Some examples in spreadsheets were provided to the panel. As over the previous two days, the discussions, questions and answers lasted a full day.

Thursday, August 27, 2015

The day was set for panel discussion and writing. The panel digested relevant information gathered over the past three days and discussed the pros and cons of the methodology used for the Hawaii deep-set longline fishery bycatch.

Friday, August 28, 2015

Individual panel members presented the key findings to the NMFS Project team. Recommendations for future work were also briefly discussed. The panel had the last opportunity to ask questions and clarify some issues in the documents and in the presentations over the last several days.

Overall, the review meeting was well organized and ran smoothly. The project scientist was very helpful in clarifying questions during the meeting. The project team was also very open-minded for suggestions and recommendations. Evidently, the sampling design encompasses complex situations and the estimations involve a large number of species often with very few records. The amount of work and its complexity are quite impressive.

Summary of Findings

The main findings of the methodology that stemmed from the review are presented in this section. Some of these points have been discussed in the review meeting, while a few additional comments arose from further reading the documents after the meeting. Each of the ToRs is addressed as follows.

1. Review the sampling design used to select trips for observer placement and determine if it is a preferred design for estimating bycatch considering constraints and reporting requirements.

The key objective of the project under review is to estimate the total annual bycatch for each species in a relatively short time on a yearly basis. Reliable bycatch data can only come from observers and not from fishery logbooks. Statistical estimation is needed to expand the recorded bycatch by observers to the entire fleet and fishing trips. This is a complex and challenging situation because: (1) the total number of fishing trips and their distribution over time are unknown at the beginning of the year when the sampling design is required; (2) the total number of observers and their availability are unknown at the beginning of the year; (3) the sampling rate is predetermined at about 20% which is desirably to be maintained throughout the year; and (4) more than a hundred species have been caught in the fishery, and many are rare species.

With these constraints, the current two-stage probability sample design is adequate and desirable. This sampling design uses the list of notifications as sampling frame. A systematic sample is taken from the sampling frame at a sample rate less than the target (20%), which leaves a small fraction (about 5%) for the additional samples required to achieve the targeted coverage level. The remaining small fraction of samples is selected after all upcoming notifications drawn by the systematic sample have been assigned an observer and more observers are still available. This two-stage, so-called, systematic-plus (SYSPLUS) design is highly adaptive and can accommodate constrains mentioned above. Furthermore, this SYSPLUS design can be modified to allow more than one systematic sampling when the percent coverage needs to be adjusted during the year due to change in observer availability.

Except for its advantages, I have a few comments about the design.

(1) In a sampling design, sample size is typically determined by several things, including the acceptable margin of error, confidence level, and standard deviation (Lohr, 2010; Thompson, 1992). By contrast, here the level of observer coverage is predetermined at 20%. Although it is impossible to derive one optimal sample size for many species, it would be informative to give a summary table showing the precision of the estimators for all species and see whether the fixed sampling rate at 20% could yield acceptable precision for most or key species.

(2) The number of strata, blocks, and groups are set at design stage. Some sensitivity analyses of historical data could be carried out to see whether these numbers are efficient. Will, for instance, post-stratification be a better option to reduce bias and variance?

(3) Document #1 Section 3 "Approximating Inclusion Probabilities" focuses on the design stage and appears to be overcomplicated. Instead of using notification number and estimating inclusion probability, bycatch estimation should use realized trips by the end of the year and emphasize observer data that have been collected over the whole year. Putting emphasis on the bycatch data at hand would make the estimation process simpler and easier to understand than computing and adjusting inclusion probabilities (see below).

(4) Finally, it is suggested that a table with clear definitions of technical terms be provided (e.g., stratum, cluster, group, block, days sample, etc.).

2. Evaluate the point estimators and determine if they are good estimators given the sample design, observed frequency distribution of bycatch events, and constraints.

The methodology uses two point estimators: the Horvitz-Thompson estimator (HTE) and the generalized ratio estimator (GRE). Further, the GRE uses three alternative fishing efforts, ntrip, nsets, and nhooks. Hence, there are a total of four different estimators for the species-specific total bycatch. These simple estimators can be calculated quickly, which is an advantage and can meet the time requirement for a large number of bycatch species.

(1) Horvitz-Thompson estimator

The HTE first expands the sample sum of the observed bycatch by an inclusion probability π to derive a subtotal bycatch, and then adds all subtotals to obtain the total annual bycatch for each species by the entire fishery. The observed bycatch, inclusion probability, and the subtotal bycatch are group- and stratum-specific so that the potential variation in bycatch rate over time can be accounted for. For rare species, stratification into groups and strata is undesirable; thus, the observed bycatch can be summed together and a single inclusion probability is used to estimate the total bycatch.

As suggested in ToR 1, instead of estimating inclusion probability at the design stage, a simple estimator from textbooks (Lohr, 2010; Thompson, 1992) can be used to estimate total bycatch τ:

$$\hat{\tau} = \sum_{h=1}^{H} \frac{N_h}{n_h} \sum_{i \in S_h} y_{hi} \qquad \text{(A)}$$

Note that here N_h is the total realized trips in stratum h rather than the number of notifications, n_h is the realized sampled trips in the same stratum h which includes both systematic and plus samples. This equation assumes that the systematic sample plus any additional "plus sample" are SRS within the stratum. This assumption may be slightly violated but shouldn't cause major problems. If "group" is another necessary level, adding this level makes this alternative formulation identical to equation 4.1 in document #1.

(2) Generalized ratio estimator

The GRE is a simple model-based estimator that uses fishing effort as a predictor. This model-based method is the same as HTE when ntrip is used as the predictor because HTE is also based on ntrip. It is recommended that for each species only one of the three types of fishing effort (ntrip, nsets, and nhooks) be used as the predictor. The optimal type of fishing effort should be determined by comparing the historical performance.

Both the HTE and GRE are classic estimators in sampling technique. Hence, they are generally good estimators given the sample design.

(3) Categorizing species based on observation frequency

As there are four estimators and all can be applied to either stratified samples or non-stratified samples, the question is which specific method is applied to which group of species. This is unclear from the documents.

In the review meeting, we learnt that species were roughly classified into three groups: (1) common, with more than 20 observations each year; (2) rare, with annual observations between 10 and 20; and (3) very rare, with annual observations less than 10. This is a reasonable starting point to determine a suitable estimator for a specific species according to the amount of available data. This categorisation can be formalized by examining historical data and analyses to detect the best breaking points based on the rate of observations (i.e. number of records / number of trips) and the best method for each category of species. Examining the historical analyses can help establishing a clear rule for future analyses. As there are several alternative estimators, choosing which one to use for which species and which result to be included in the report could be subjective and time-consuming. Therefore, a decision rule can simplify the process and ensure consistency across years and species.

(4) Model-based approach

The number of bycatch is essentially determined by two factors: the available abundance at a particular location and time, and longline gear catchability. Estimating bycatch is similar to CPUE standardisation for target species where statistic models are built to link catch rate to various covariates that may affect these two factors (Campbell, 2015; Maunder and Punt, 2004). As discussed above, the GRE can be considered as a simple model-based estimator. Moreover in document #2, a Poisson model is used to derive confidence interval. A question is then which approach, the design-based or model-based inference, should be preferred. It is worth to compare the two approaches by using previous years' data. Alternative post-stratification (e.g. based on seasons, areas, catch of target species, etc.) should be explored to determine whether bias and variance can be reduced. An overall best strategy, when found, can be adopted in future analysis. For the model-based approach, in addition to the three types of fishing effort, other covariates (e.g. season, area, catch of target species, fishing depth (inferred from longline configuration), etc.) should also be investigated and, if significant, should be included in the model. The model-based approach, particularly under a Bayesian framework, is widely used to estimate rare events. The existing work on rare bycatch species can be extended in this direction.

3. Evaluate the interval estimators and determine if they are good estimators given the sample design, observed frequency distribution of bycatch events, and constraints.

Four alternative methods for interval estimation have been used in the DSLL bycatch estimation project: (1) the design-based approach based on the finite population central limit theorem; (2) nonparametric bootstrapping; (3) model-based method; and (4) a Bayesian approach. All these methods are commonly used in practice and are suitable for bycatch interval estimation. Similar to the point estimators, the major recommendation is to establish a clear rule on which method(s) to be applied to which species and what result(s) to be included in the report. The rule should be based on the previous years' analytical outcomes as a function of the number of bycatch records and their distributions.

I also made following additional comments on specific methods for interval estimation.

(1) Approximate CIs based on the finite population central limit theorem

In the first method based on the finite population central limit theorem, three alternative estimators are currently used for $v(\tau_{\pi})$ (eqn 2.1, 2.2, and 2.3 in document #2). Assuming a SRS within a group, a more straightforward method from textbooks may be used for each species:

$$\hat{v}(\hat{\tau}) = \sum_{h}^{H} \left(1 - \frac{n_h}{N_h}\right) N_h^{\,2} \frac{s_h^{\,2}}{n_h} \qquad \text{(B)}$$

where $s_h^{\,2} = \sum_{i \in S_h} \frac{(y_{hi} - \bar{y}_h)^2}{n_h - 1}$.

The stratum (or group in our case) *h* contains SYSPLUS samples and their corresponding total annual trips in the whole fishery. y_{hi} is the number of observed bycatch in stratum *h*, trip *i*. This method is consistent with equation (A) for point estimator.

(2) Nonparametric bootstrap sampling approximate CI

The bootstrap process appears to be very complicated (it takes more than five pages to describe) and difficult to understand. A simplified process is suggested as follows:

(i) Duplicate each sample trip *i* in each stratum (or group) by weight w_h. This will result in a pseudo-population where the total number of expanded trips equals the total number of realized trips U_{yr} (including sampled and unsampled trips) while preserving the temporal structure of the sampled and unsampled trips.

(ii) Draw SRSWR from this pseudo-population U_{yr} times. Repeat R = 10,000 as done in the existing method and simply calculate the point estimator and interval estimates.

(3) Model-based interval estimates

As discussed in ToR 2, a model-based method is preferred for estimating bycatch. Here, a Poisson model is used to derive confidence interval. To be consistent, it is suggested that the model should be used for both point estimation and interval estimation. The current method (page 9, document #2) involves two random processes: a Poisson process and then a binomial process. The number of bycatch in each trip is random so it is correct to assume a random process (Poisson or other distributions). However, because the number of trips, both sampled and unsampled, is known without error, it appears that the binomial process is unnecessary and should be eliminated.

Moreover, a common assumption is that the number of bycatch per trip, rather than the total bycatch from all trips, follows a Poisson distribution, i.e., $y_{i \in S_{yr}} \sim Poisson(\lambda)$. The expected catch per trip is assumed to be the same for both sampled and unsampled trips. Consequently, $\hat{\tau}_{U_{yr}} = \lambda \sum_{i \in U_{yr}} trip_i$, from which both point and interval estimators can be obtained.

(4) Bayesian interval estimates

Bayesian method has been used for rarely observed bycatch species in the Hawaii DSLL fishery. Three models are presented in document #2 and in the review meeting: A Poisson model, a conditional binomial model, and a Poisson-SYSPLUS model. The Poisson model assumes a common bycatch rate per unit of effort (e.g. trip). The conditional binomial model was applied to cases when no bycatch was observed. The Poisson-SYSPLUS model assumes bycatch rate varies over time. This method is newly developed and it appears that choosing reasonable priors is challenging.

The theory behind the Bayesian approach is standard and acceptable. The three models do not appear to have major problems. However, using multiple divergent models and ignoring plus sample or treating them differently can make things complicated. The choice of priors can also be debatable.

(5) Hierarchical Bayesian modelling–potential for future analysis

Conceivably, paragraphs (3) and (4) above can be combined and extended to a general hierarchical Bayesian modelling framework. Instead of estimating the total bycatch, interval, and each year separately, the Bayesian hierarchical model allows analysing data in all years together so the information can be shared across years and strength borrowed from each other. This can be particularly effective for rare species.

For a species that has sufficient number of observation each year, a Poisson model may be used. However, we noticed that many species have no bycatch in most trips while a large number of bycatch may occur in a single trip. Therefore, models other than Poisson, such as the negative binomial (NB) or zero-inflated negative binomial model (ZNB) could be more appropriate and the exploration of these models is encouraged.

4. Evaluate estimators of total bycatch events resulting in a death or serious injury (DSI) classification and determine if they are good estimators given the sample design, observed frequency distribution of injury classifications (non-serious or DSI), and constraints.

Estimation of total bycatch events resulting in DSI is pertinent to rare species, particularly marine mammals. Two methods have been used:

(1) Simply expanding the observed DSI events to all trips that have an observer aboard, which is similar to estimating τ in documents #1.

(2) First computing the probability that a bycatch event results in a DSI using 2002-2010 data and then applying this probability to the estimated total bycatch.

Both approaches have advantages and disadvantages as discussed in document #3 and in the meeting. Furthermore, a new method using a Bayesian model has been proposed for future use. There is no major issue with these estimators. As estimates of each species' total bycatch need to be produced in a quick manner on a yearly basis, simple methods such as these are proper estimators.

However, for rare bycatch events, more reliable and precise results can be achieved by advanced methods. Specifically, the new proposed Bayesian model could be enhanced to a hierarchical structure as explained above. Categorised bycatch in previous years should be included in the model to inform and support limited observations in the current year. Classification of injury involves error and is a random process. A Dirichlet distribution for the classification probability and a multinomial distribution for the categories are reasonable choices. Under the hierarchical formulation, hyper-priors can be uninformative, avoiding some subjective decisions for the prior.

5. Evaluate the subpopulation estimators being applied to estimate bycatch within a political geographical boundary and determine if they are good estimators given the sample design, reporting requirements under the MMPA, and constraints.

The design-based HTE and GRE described in document #1 are used for subpopulation estimators within each geographical areas. Again, these are traditional approaches and there is nothing wrong to use them. The main concern is that the observed bycatch events are already rare for many species in the whole DSLL fishery. Breaking rare events down to multiple areas further reduces frequency of these events at the domain level. Therefore, model-based approaches that treat area as a covariate and employ additional auxiliary variables (such as season, catch of target species, hook depth, etc.) could be preferred. Likewise, a hierarchical Bayesian model could be valuable where a year is treated as a covariate and data from early years can be included to strengthen the estimates in the current year.

6. Suggest future research priorities to improve methods for estimating bycatch with increased efficiency given the current data structure. Suggest future research priorities for improving the sampling design for the purposes of estimating bycatch, with efficient use of sampling resources as a consideration.

While addressing each ToRs above, I have made suggestions relevant to that ToR. In this section, I summarize main points as follows.

(1) The DSLL fishery incidentally catches over a hundred bycatch species. The observed frequency of these species varies substantially from nil to hundreds of individuals. Accordingly, methods for estimating total bycatch and its intervals should be tailored to each group of species based on the frequency of observations. A clear rule with multiple criteria is needed to categorize species and suitable method(s) for each category. Historical data and analytical results can be used for this purpose.

(2) For design-based estimators, alternative post-stratification (e.g. based on season, area, catch of target species, gear configuration, etc.) should be explored to see if bias and variance can be reduced.

(3) The development of model-based approaches is encouraged, particularly under the Bayesian hierarchical modelling framework. In addition to fishing effort, other covariates should be investigated and included in the model, e.g., season, area, catch of target species, hook depth, and other variables that are recorded in the logbooks or can be easily obtained from other sources (such as sea surface temperature). Models other than the Poisson distribution, e.g. NB or ZNB, may be preferred for rarely observed and over-dispersed bycatch. Hierarchical Bayesian models are typically recommended for data-poor situation, which is exactly the case of rare bycatch. Furthermore, treating subregion as a covariate can facilitate the computation in the domain estimators (document #3).

(4) If the method based on the finite population central limit theorem and the bootstrap method continue to be used for interval estimation, simplified versions may be considered. Assuming SRS within each stratum/group, the total bycatch and its variance can be derived using common equations in the textbooks. Nonparametric bootstrapping can be done in two to three steps.

(5) The sampling design (SYSPLUS) in general appears to be an ideal strategy for the DSLL fishery given the range of constraints. The observer program has collected a large amount of data in the past over 10 years. It would be beneficial to examine these historical data to inform:

(i) Whether the fixed 20% sampling rate could yield acceptable precision for most species;

(ii) Whether the number of block, strata, or group used in the sample design is an optimal choice.

Conclusions and Recommendations

1. Designing a sound sampling plan for the Hawaii deep-set longline fishery is complicated and challenging due to operational and technical constrains, including unknowing number of fishing trips and their distribution at the time of designing sampling, varying number of observers and their availability, and a large number of bycatch species with markedly different bycatch rates.
2. The two-stage SYSPLUS design is statistically defensible and highly adaptive, although some sensitivity analyses are helpful for determining the optimal number of strata, clusters, and groups.
3. There is nothing seriously wrong with the point estimator and interval estimates. However, the methods can be (and should be) simplified, streamlined, and improved.
4. It is recommended that model-based approaches, particularly the Bayesian hierarchical models, be a major priority for future research. This approach can be applied to a selected subgroup of priority species when the resource is limited.
5. Other recommendations pertinent to the methodology for sampling and estimating bycatch in the DSLL fishery are provided in the previous section (ToR 6).
6. The NMFS CIE peer review process is perhaps the best practice in the world to insure science quality. NMFS has many outstanding scientists. It would be beneficial to have an NMFS internal discussion and review before a CIE review is requested.

References

Campbell, R. a. 2015. Constructing stock abundance indices from catch and effort data: Some nuts and bolts. Fisheries Research, 161: 109–130. Elsevier B.V. http://linkinghub.elsevier.com/retrieve/pii/S0165783614002185 (Accessed 4 September 2014).

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Maunder, M. N., and Punt, A. E. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research, 70: 141–159. http://linkinghub.elsevier.com/retrieve/pii/S0165783604001638 (Accessed 16 July 2014).

Thompson, S. K. 1992. Sampling. Wiley. New York.

Appendix 1: Bibliography of materials provided for review

Documents provided two weeks prior to the review meeting:

1. McCracken, M.L. 2015. Sampling the Hawaii deep-set longline fishery and point estimators of bycatch. Pacific Islands Fisheries Science Center. 17p.
2. McCracken, M.L. 2015. Interval estimation of annual bycatch in the Hawaii deep-set longline fishery. Pacific Islands Fisheries Science Center. 18p.
3. McCracken, M.L. 2015. Domain estimators for the total number of cetacean bycatch events resulting in a dead or serious injury classification. Pacific Islands Fisheries Science Center. 11p.

Materials provided during the review meeting:

4. Longline logbook protected species marine mammals and turtles.
5. NMFS Western Pacific Longline Fishing Log.
6. Regulation Summary: Hawaii Pelagic Longline Fishing.
7. Hawaii Longline Observer Program Field Manual, version LM.14.04.
8. Sample notification logs m08d23y15.xlsx.
9. Multiple figures as examples for bycatch frequency.
10. Examples of marine mammal bycatch in spreadsheets.

Appendix 2: A copy of the CIE Statement of Work

Statement of Work

External Independent Peer Review by the Center for Independent Experts

Methodology for Sampling and Estimating Bycatch of the Hawaii Deep-Set Longline Fishery

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:

Quantifying bycatch in the Hawaii deep-set longline fishery is required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA), Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), and Migratory Bird Treaty Act (MBTA) and their implementing regulations. As over a hundred species, some of them listed as endangered or threatened, have been recorded as being caught in the Hawaii deep-set longline fishery, reliable bycatch estimates need to be computed in a relatively quick manner on a yearly basis. Since mid-year 2002, a unique complex sampling design has been used to select deep-set longline trips for observer placement. While aboard a selected longline trip, NMFS trained observers collect information on bycatch and ancillary variables for each longline fishing operation. Based on the sampling design, bycatch estimates are computed for all marine mammals, protected species, sharks, and fish that have been observed at least once in the fishery or are of special interest. What estimators are used depends on the observed frequency distribution of bycatch events for the species of interest. Interval estimators have been developed for commonly, seldom, and very rarely bycaught species. Methods for estimating bycatch within political geographical areas within the fishing grounds and the total number of marine mammal bycatch events resulting in a death or serious injury (DSI) have also been developed as the MMPA requires estimates of DSI within and outside the Economic Exclusive Zones (EEZ) of the United States.

These annual bycatch estimates of sea turtles, seabirds, and marine mammals are used to monitor takes within the deep-set longline fishery. These estimates have a large potential impact on endangered species and the valuable longline commercial fishery in Hawaii. Additionally, bycatch estimates of all species are provided for inclusion in the National Bycatch Report, seabird and sea turtle estimates are submitted annually to the IATTC (Inter-American Tropical Tuna Commission) per Resolution C-11-02 and C-04-05, and marine mammal, seabird, and sea turtle estimates are provided for inclusion in the annual WCPFC (Western and Central Pacific Fisheries Commission) National report. The methods to be reviewed have not undergone independent peer review and there is a need to evaluate the methods 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. Reviewers shall have working knowledge and recent experience in the application of statistical inference for finite populations. Reviewers should be statisticians with comprehensive knowledge of both theoretical and applied sampling design and analysis. Furthermore, reviewers should have some knowledge of analyzing rare events, bootstrap techniques for finite population sampling, and frequentist and Bayesian inference for finite populations. Experience in statistics related to natural resources is beneficial.

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 August 24-28, 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 all documents in preparation for the peer review.

Documents will describe:

- The stratified systematic-plus design and approximation of inclusion probabilities.
- Point estimators of total bycatch.
- Interval estimators of total bycatch, including estimators for very rarely bycaught species.
- Estimators for subpopulation totals, specifically estimators of bycatch within geographical areas of the fishing grounds.
- Estimators of total number of marine mammal bycatch events resulting in a classification of dead or serious injury (DSI).

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 can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** 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 reviewers understand 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 in Honolulu, HI, from August 24-28, 2015.
3) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) No later than September 14, 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 mshivlani@ntvifederal.net, and Dr. David Die, CIE Regional Coordinator, via email. 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.

July 20, 2015	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
August 10, 2015	NMFS Project Contact sends the CIE Reviewers the pre-review documents
August 24-28, 2015	Each reviewer participates and conducts an independent peer review during the panel review meeting
September 14, 2015	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
October 2, 2015	CIE submits CIE independent peer review reports to the COTR
October 5, 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. Each CIE independent peer review 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

Methodology for Sampling and Estimating Bycatch

of the Hawaii Deep-Set Longline Fishery

1. Review the sampling design used to select trips for observer placement and determine if it is a preferred design for estimating bycatch considering constraints and reporting requirements.
2. Evaluate the point estimators and determine if they are good estimators given the sample design, observed frequency distribution of bycatch events, and constraints.
3. Evaluate the interval estimators and determine if they are good estimators given the sample design, observed frequency distribution of bycatch events, and constraints.
4. Evaluate estimators of total bycatch events resulting in a death or serious injury (DSI) classification and determine if they are good estimators given the sample design, observed frequency distribution of injury classifications (non-serious or DSI), and constraints.
5. Evaluate the subpopulation estimators being applied to estimate bycatch within a political geographical boundary and determine if they are good estimators given the sample design, reporting requirements under the MMPA, and constraints.
6. Suggest future research priorities to improve methods for estimating bycatch with increased efficiency given the current data structure. Suggest future research priorities for improving the sampling design for the purposes of estimating bycatch, with efficient use of sampling resources as a consideration.

Annex 3: Tentative Agenda

Methodology for Sampling and Estimating Bycatch

of the Hawaii Deep-Set Longline Fishery

24-27 August: Honolulu Service Center, NOAA Fisheries Pier 38, Honolulu Harbor, 1139 N. Nimitz Hwy, Suite 220, Honolulu, HI 96817

28 August: NOAA Daniel K Inouye Regional Center, 1845 Wasp Boulevard, Building 176, Conference Room 2545, Honolulu, HI 96818

8:30am-5:00pm, 24-28 August 2015

Monday, August 24

1. Introduction
2. Background information - Objectives and Terms of Reference
3. Observer Program and Longline Fishery
   - Observer program (presented by Pacific Islands Observer Program)
   - Deep-Set Longline Fishery
4. Review of Sampling Design
5. Review of Approximation of Inclusion Probabilities

Tuesday, August 25

6. Review of Point Estimators of Bycatch
7. Review of Interval Estimators

Wednesday, August 26

8. Review of Estimators of DSI (marine mammals)
9. Review of Estimators of Subpopulation Totals. ,

Thursday, August 27

10. Panel discussions (Closed)

Friday, August 28

11. Panel discussions
12. Adjourn

Appendix 3: Panel Membership

Mary C. Christman, USA

Yan Jiao, USA

Shijie Zhou, Australia

Other participants:

Joe Arceneaux, NMFS PIRO Observer Program

Chris Boggs, NMFS Pacific Islands Fisheries Science Center

Asuka Ishizaki, Western Pacific Fishery Management Council

Jarad Makiau, NMFS PIRO Observer Program

Marti McCracken, NMFS Pacific Islands Fisheries Science Center

Ben Richards, NMFS Pacific Islands Fisheries Science Center