Report for Review of

Cumulative Discard Methodology

November 2016, Gloucester, Massachusetts

Report to:
The Centre for Independent Experts

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December 2016

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Executive Summary

Cumulative Discard Methodology (CDM) for fisheries in the Greater Atlantic Region was reviewed. This review report describes the main findings of the methodology and its application in four fisheries: the Atlantic Sea Scallop Fishery, the Longfin Squid Fishery, the Atlantic Herring and Atlantic Mackerel Fisheries, and the Northeast United States Groundfish Fishery. The report also makes several recommendations for future research.

The design-based CDM has several advantages: it uses simple equations to derive discard estimate and its variance; it ensures consistency when the same methodology is applied to all fisheries; the method is coded in an R package "discaRd", which facilitates the analytical process; and the ratio estimator allows using auxiliary information.

The Terms of Reference (ToR) emphasize the application of CDM and alternative stratification schemes. For ToR 1, the studies show that the variability in discard ratios exist across strata and fisheries, which is summarized and clearly presented by various figures and tables in all the working papers (WP). Because the same methodology and same R package are used for the four fisheries, the presentations are similar across the working papers, making them easy to follow and compare. Alternative stratifications to improve precision are explored, where some factors such as area and gear are well examined, but other factors such as season and volume of catch have not been investigated in some fisheries.

Seeking optimal stratification schemes has been the main objective in the current project, as specified in ToR 2. Alternative stratification by area, gear, season, total landings, and vessel size have been explored, but not all combinations have been investigated in every fishery. The studies indicate that optimal applications of the current CDM depend on the species and stratification variables considered. Because the true amount of total discards is unknown, identifying optimal stratification can be difficult. Ideally, the comparison of alternative stratifications should use known discard data generated by computer simulations based on observed historical trips. With simulated data, both bias and precision can be compared across all stratification schemes.

To address ToR 3 about the precision and consistency of the discard estimates, the CDM typically uses multiple line graphs to show estimated discards over time. The presentation clearly demonstrates the precision and consistency of the estimates. The figures also indicate two potential concerns about the methodology: high precision in the beginning of the year and smaller cumulative discards in later time steps than in earlier time steps.

The CDM uses data from past years to estimate discards in the current year. There are two alternative approaches: a 5-trip transition rate and a moving window method. ToR 4 requests examining these methods to improve predicting the in-season estimation of discards. Using data from past years by applying a fixed ratio and a fixed length of time is uncommon in traditional sampling theory. Both methods assume that discard ratio in the past year is applicable to the current year. The application of these two methods has a significant impact on the pattern of the discard estimates. When the true discards are unknown, the scale of bias resulting from these methods cannot be quantified. Examining historical data across years could reveal the reliability of using data from past years. If borrowing information from past years is necessary (i.e., when the proportion of the observed trips is very small) more formal and defendable methods (e.g., Bayesian) should be considered.

Using archived data to simulate in-season behavior and find a preferred method is an excellent suggestion, which is specified in ToR 5. Formal simulation (not bootstrapping) should be undertaken in the future.

This review also provides several additional comments about the CDM. (1) By definition, the amount of cumulative discards cannot decline over time, but the decline has been observed in many cases in the working papers, indicating the "cumulative discard rate" method may have to be modified. (2) Using the kept catch of all species as a denominator in the ratio estimator may not be appropriate for all species because the assumption of a correlation (i.e., in their spatial-temporal distribution and catchability) between the discarded species and other species can be easily violated. (3) Using a transition rate is uncommon in the traditional sampling design. A Bayesian approach deserves consideration in the cases of low sampling rate. (4) Non-parametric bootstrapping cannot solve the problem of low sample size, but tends to underestimate uncertainty. A parametric bootstrapping based on a prior distribution from data in earlier years may yield a more realistic variability. (5) Finally, a model-based approach is a logical alternative to the current design-based approach.

Background

A cumulative discard methodology (CDM) is used by the Greater Atlantic Regional Fisheries Office to estimate discards for in-season management adjustments and for computing total catches (landings plus discards) to monitor compliance with Annual Catch Limits. The CDM is based on the Standardized Bycatch Reporting Methodology developed by scientists at the Northeast Fisheries Science Centre. This designed based CDM has been coded as an R package by the scientists at the Greater Atlantic Regional Fisheries Office to facilitate its application and consistency across multiple fisheries in the region. This review covers four major fisheries: the Atlantic Sea Scallop Fishery, the Longfin Squid Fishery, the Atlantic Herring and Atlantic Mackerel Fisheries, and the Northeast United States Groundfish Fishery. Because the same methodology is used for all these four fisheries, this review report evaluates the application of CDM in general.

Ten days before the review meeting, I received five draft working papers (WP) from Dr. M. Lanning, Chief of the Monitoring and Analysis Section at the Greater Atlantic Region office:

1. Methods for examining in-season behavior of the cumulative discard estimation in the Greater Atlantic Region;
2. Cumulative discard methodology review for catch cap monitoring in the Atlantic sea scallop (*Placopecten magellanicus*);
3. Cumulative discard methodology review for butterfish (*Peprilus triacanthus*) discards in the longfin squid (*Doryteuthis* (Amerigo) *pealeii*) fishery;
4. Cumulative discard methodology review for catch cap monitoring in the Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) fisheries;
5. Cumulative discard methodology review for groundfish discards in the Northeast United States groundfish fishery.

The final versions of these documents were received two days before the review meeting. My review is based on the final versions, if there are any discrepancies between two versions.

The CIE invited two independent reviewers. The peer review meeting was open to the public and dozens of people attended the meeting. Background information regarding the CDM and individual fisheries was presented during the meeting. 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 in the Review Activities

I read the background materials and draft documents prior to the review meeting. The Regional Office set up a website designated for this review (https://www.greateratlantic.fisheries.noaa.gov/aps/discard/review/index.html). I also had a look at the 2010 Peer Review Document from this website. The peer review meeting was held at the Greater Atlantic Regional Fisheries Office, Gloucester, Massachusetts from November 7 to 9. The daily agenda and activities are briefly described as follows.

Monday, November 7, 2016

Dr. M. Lanning, Chief of the Monitoring and Analysis Section, gave an introduction about the review and agenda. He explained the discard review project, its scope and structure, and the Terms of Reference (ToR).

Following the introduction, Dr. D. Linden gave a presentation on "Method for examining in-season behaviour of the cumulative discard estimation". This method is used by all fisheries in the region to estimate cumulative discards. We learnt that the sampling design, including assignment of observers to each trip, was carried out by scientists at Woods Hole Science Center and the discard sampling was only one of the multiple objectives in the observer program.

An R package called "discaRd" has been developed by the team to assist discard estimation. Dr. B. Galuardi demonstrated the program by using Windowpane flounder bycatch in the Atlantic Sea Scallop Fishery as an example.

The review panel and other participants requested a range of clarifications. Questions and discussions were exchanged between the panel and the team.

Tuesday, November 8, 2016

Discard estimations for individual fisheries were presented and discussed on the second day. Presentations include: (1) "Cumulative Discard Methodology in the Atlantic Sea Scallop Fishery" by B. Galuardi; (2) "Cumulative discard methodology review for butterfish discards in the longfin squid fishery" by J. Hermsen; (3) "Cumulative Discard Methodology Review for Haddock and River Herring/Shad Catch Caps in the Atlantic Herring and Mackerel Fisheries" by B McAfee; and (4) "Cumulative Discard Methodology Review for Groundfish" by D. Caless.

These presentations were very informative and helpful for understanding the methodology, aspects of each fishery, and various stratification strategies. Some key questions were discussed, such as observer bias, seasonality, observer coverage, and important factors affecting discard variability.

Wednesday, November 9, 2016

While it was still open to the public, this day was arranged for discussion between the review panel and the team. We overviewed relevant information gathered in the past two days and discussed pros and cons of the cumulative discard methodology used for the fisheries in the Greater Atlantic Region. I raised several key issues (see Additional Comments below) and recommended some alternative approaches.

I was impressed by the great effort from the Greater Atlantic Regional Fisheries Office. As a result, the review meeting was well organized and successful. The project team were very helpful in clarifying questions during the meeting. They were also very open-minded for suggestions and recommendations. With limited data and many uncontrollable variables, estimating fisheries discards is obviously challenging.

Summary of Findings

The Terms of Reference ask five key questions and multiple sub-questions. Each of the ToRs is addressed as follows. Some of these points were discussed in the review meeting, while additional observations arose from my further reading the documents after the meeting.

1. For each fishery subject to in-season discard monitoring utilizing the cumulative discard method, summarize the variability in discard rate by measurable strata: fishery, gear, area, season, volume of catch, etc.

The working papers include extensive results, from the observer coverage rate to the estimated discard ratio, and from the estimated amount of discards to the probability and date of exceeding catch cap. The variability in discard ratio, typically expressed as coefficient of variation, is summarized and clearly presented by various figures and tables. In particular, I like the summary tables for butterfish discards in the Longfin Squid Fishery where clear table captions and column descriptions are provided. This working paper (WP #3) also includes strata-specific discard ratios. As the discard ratio is a key parameter, it should have been presented in a table for all fisheries. Because the same methodology and the same R package are used for the four fisheries, it would be helpful to adopt a similar presentation format for all working papers, which will make it easy for readers to follow and compare. There are some variations, for example, using different types of graphs. Since daily or weekly observer data are available, it would be very helpful to present such temporal variability as shown in the paper for the Longfin Squid Fishery (WP #3).

One of the key objectives in developing this CDM is to explore alternative stratification to improve precision. As expected, variability in discard ratio exists across strata and fisheries, which have been summarized in the working papers (not repeated here). Among several possible factors, some are well examined (e.g., area and gear). Note that year is an essential factor as discard cap is set annually. However, not all measurable factors (e.g. season and volume of catch) have been formally stratified and evaluated in all fisheries. It is well known that many fish species exhibit temporal patterns in their abundance, distribution, and vulnerability, which will affect their catch. For fisheries where temporal stratification has not been formally explored (e.g. groundfish), it is worth doing so in the future.

There appears to be some inconsistency in terminology. For example, simulation and bootstrapping are used in different working papers. Strictly speaking, the CDM only involves bootstrapping in all four fisheries.

2. Identify more optimal applications of the current cumulative method for in-season estimation of discards in comparison to existing cumulative discard methodology and stratification schemes. Alternatives identified will include

   a. Existing cumulative discard methodology and stratification scheme as a baseline

   b. Pooling data across current stratifications to increase information and precision. As an example, pooling across sectors and gears.

   c. Including seasonality as a stratification

   d. Allocate/restrict sampling requirements to those strata which in aggregate constitute a target fraction of total stock-specific discards. (i.e, excluding or minimizing sampling for strata with negligible discard totals).

Seeking optimal stratification schemes is the main objective in the current project. Alternative stratification by area, gear, season, total landings, and vessel size have been investigated but not by all combinations in all four fisheries (e.g., volume of catch in scallop fishery and temporal stratification in groundfish fishery). The working papers use the coefficient of variation as a primary criterion for comparison. Given the fact that the true amount of discards is unknown, the method for comparing and evaluating alternative stratification schemes is adequate for these fisheries.

Optimal applications of the current CDM depend on the species and stratification variables considered. This is expected. As discarded species differ in their biology and the characteristics of the targeting fishery, no single best strategy can be identified and applied to all species and all fisheries. The groundfish fishery (WP #5) provides a good example for ToR 2b where combining sectors and broad stock areas reduces the CV for some stocks but increases the CV for other stocks. Similarly, including seasonality as a stratification variable (ToR 2c) is important for estimating butterfish discards, while it results in varying outcomes in the Atlantic herring and mackerel fisheries (WP #4), and shows little difference for yellowtail and windowpane (WP #2). Results from these studies imply an important message: a best and unique stratification strategy for each discarded species should be identified by analysing historical data pertinent to that species.

From reading the working papers and discussing with the team, I realise that ToR 2d has not been specifically investigated. However, it is conceivable that if the total discards in a stratum are known to be negligible, excluding this stratum will have little impact on the total estimate. Note that this is not about excluding observed zero discard trips.

Ideally, statistical simulations should be carried out to identify optimal application of the current CDM. In the simulations, a computer program generates known discards for all trips and then random samples are taken according to pre-designed sampling schemes. Any difference among alternative stratifications can be demonstrated by a comparison between the estimated discards (and its variance) and the true values.

3. Methods identified in TOR 2 will be compared using the following metrics
   a. Precision of the discard estimates for a given level of observer coverage
   b. Consistency of discard estimates calculated over the course of the fishing year.
   c. Precision and consistency of the CV discard metric for a given level of observer coverage
   d. Sensitivity to missing or erroneous data.

Given that the ultimate objective is to estimate the cumulative discards over time on a yearly basis, this ToR is essential. The precision of the discard estimates for given levels of observer coverage (ToR 3a) is provided in some working papers (i.e. WP #3). For butterfish discards, the actual observer coverage appears to be acceptable on a yearly basis, as it yields a CV smaller than the target (CV=0.3) in some years but larger in other years. However, at the trimester strata level the precision tends to be too low (CV > 0.3) in most cases. I would like to suggest that similar information be included in other species/fisheries.

Consistency of discard estimates over the course of the fishing year (ToR 3b) is typically illustrated by line graphs plotting estimated discards over fishing day in all working papers. The figures include several lines: current estimate (without bootstrapping), median, and 50% and 90% percentiles from bootstrapping. The visual presentation clearly delivers its information: the percentile lines indicate precision and the shapes of the lines reveal consistency of the estimates over time. In addition, summary tables are provided in some working papers to compare precision between alternative stratification schemes.

Although the metrics and presentations for precision and consistency are adequate and clear, there are two potential issues associated with the statistical method used to derive these curves: a declining precision (increasing percentiles) over time and frequently smaller cumulative discards than the estimates in earlier time steps (see discussion below).

A figure plotting CV over observer coverage is used in all the working papers (ToR 3c). It is understandable that precision of the discard estimates and the observer coverage needed to meet the target precision may vary between species and fisheries. In addition to the figures, a summary table that includes the CV and required coverage to achieve 30% CV will be very helpful (as presented in WP #3 for butterfish). Again, historical data can provide a general guideline for the level of observer coverage in each fishery that can be adopted for sampling design in future years.

Although ToR 3d has not been formally investigated, it is expected that missing data (such as unobserved trips) will introduce additional uncertainty whereas erroneous data will bias the estimate.

4. Examine methods for including data from past years to improve predicting the in-season estimation of discards.

The first step in the CDM is to obtain a discard ratio by deriving observed discards by total kept pounds of all species in the same strata. Two approaches are used for incorporating data from past years into the current year: a 5-trip transition rate and a moving window method. Both methods are based on strong assumptions. The 5-trip method assumes that last year's discard ratio contributes 0.7/n to the current year's ratio when $0 < n < 5$. The moving window method assumes that the discard ratio at the current time step is the same as the overall discard ratio in the past selected period (e.g., 365 days).

These two methods appear to be innovative but uncommon in traditional sampling theory. The application to these fisheries shows a significant impact on the pattern of discard estimates throughout the fishing year, at least in some fisheries. There are visible variations between the two methods, particularly in the earlier part of the year. Because the true discards are unknown, comparing these two methods based on estimated values cannot reveal which one performs better. However, the data from past year in the moving window approach with a spread of 365 days tends to have a greater impact on the estimate of the current discard ratio than the 5-trip approach. If the assumptions are valid, using information from past years could reduce variance (although this is not necessarily the case if the data in previous years are very uncertain). On the other hand, if the assumptions are violated, the estimated discard ratios and the resulting discard estimates will be biased. Examining historical data across years may reveal how including data from past years affects reliability in calculating discards in the current year.

Since the sampling program requires certain accuracy (i.e. 30% CV) and homogeneous observer coverage over time, using data from past years may not be necessary for all species and in all strata. The traditional sampling method that uses only data within the sampling frame should be preferred in some circumstances. In the case when borrowing information from previous years is necessary (e.g., very few observed trips within a stratum), more formal and defendable methods, such as Bayesian inference, should be adopted. For example, the discard ratios in the same period in previous years can be used as a prior and updated with new discard ratio when it becomes available. Ideally, simulation based on historical observed data should be carried out to examine the impact of including data from past years.

5. Use archived data to simulate in-season behavior (with various time steps and discarding patterns) and recommend a preferred method for each fishery with consideration of the following:

   a. Feasibility, particularly the implications of stratum size and within-year pattern of precision.

   b. The probability and timing of premature closure (i.e. false positive).

   c. The probability and magnitude of exceeding a cap (i.e. e. false negative).

Because the majority of the fishing trips are not observed, using historical observed trips to explore in-season behaviour is very valuable. This type of exercise has not been fully undertaken in the current working papers. The term "simulation" in the working papers appears to denote "bootstrapping". Bootstrapping allows estimation of accuracy of sample estimates, but not the bias and accuracy in regards to the true population. A true simulation involves using known data and a model (e.g., stratification scheme in this case) to see how the system works. One possible approach is to generate a large number of known discards based on the statistical properties of observed discards in one selected past year. Various stratification schemes are then applied to this known population and random samples are taken. Different estimators can be used to examine stratum size, accuracy of the discard estimates, and alternative transition rates. The probability and timing of premature closure, as well as the probability and magnitude of exceeding a cap can also be investigated. This type of simulation should be undertaken to identify a preferred sampling design for each fishery.

Additional comments

Considering the title of "Cumulative Discard Methodology Review", I would like to provide additional comments about the methodology. Most of these comments were discussed with the project team in the review meeting.

1. Cumulative discard

The word "cumulative" refers to increasing or growing by accumulation or successive additions. It appears to be straightforward to derive cumulative discards over time by successively adding estimated discards in each time step. By definition, cumulative discards in time step t+1 must be greater than or equal to the cumulative discards in time step t, i.e., $cD_{t+1} \geq cD_t$. Most plots of D ~ Fishing Day in the working papers show that some parts of the curves violate this rule, indicating a potential issue in the methodology. The CDM uses a "cumulative" discard ratio that is updated at each time step using all observed trips from the beginning of the year to the current time step (also data from last year if the transition rate is used). This treatment of the data makes the calculated discard ratio smooth over time and possibly results in a lower cumulative discard ratio at later stages. If the daily (or weekly) discard ratio is constant over time, using the cumulative discard ratio is fine. However, when the daily discard ratio exhibits a seasonal pattern (e.g., butterfish discards in the Longfin Squid Fishery), this method could result in $cD_t > cD_{t+1}$, as seen in many figures.

The decline in estimated cumulative discards can be explained as follows.

Using a simple example of one stratum and the notations used in the working papers, let d = observed discards, k = observed kept all species, K = total kept species, D = estimated total discards, r = discard ratio, cr = cumulative discard ratio, cK = cumulative total kept species, cD = cumulative total discards, and subscript t = time step. At time step 1 and 2,

$cD_1 = D_1 = K_1 * r_1$

$cD_2 = cK_2 * cr_2 = (K_1+K_2) * (d_1+d_2)/(k_1+k_2)$

Let $cr_2 = a\, cr_1$. The condition to ensure $cD_2 \geq cD_1$ is $a(K_1 + K_2) \geq K_1$, or $K_2 \geq K_1(1-a)/a$. This inequality can be altered by three values: K_1, K_2, and a.

Here is a simple numerical example showing that using current CDM the estimated cumulative discards at time step 2 can be smaller than cumulative discards at time step 1. Let $k_1 = 100$, $k_2 = 5$, $d_1 = 50$, $d_2 = 1$, $K_1 = 1000$, $K_2 = 10$. Then we have: $r_1 = cr_1 = d_1/k_1 = 0.5$, $r_2 = d_2/k_2 = 0.2$, $cr_2 = (d_1 + d_2)/(k_1+k_2) = 0.4857$, $cK_1 = K_1 = 1000$, $cK_2 = K_1 + K_2 = 1010$, $cD_1 = cr_1 * cK_1 = 500$, $cD_2 = cr_2 * cK_2 = 490.57$, i.e., $cD_2 < cD_1$.

The CDM is basically a form of stratified random sampling. Temporal stratification is necessary for many species because of their seasonal population dynamics, seasonal fishing activities, and possibly varying observer coverage over time. Even if the sampling design has no temporal stratification, the method has already used a daily or weekly time step in estimating the in-season cumulative discards. Therefore, the basic stratified sampling equations in the sampling textbook (also described in WP #1) should be tested and, if better, be used to derive cumulative discards.

2. Ratio estimator

The ratio estimator is commonly used in sampling where auxiliary information can improve the estimation. In fisheries, fishing effort is typically used as auxiliary data to produce catch per unit effort (CPUE) or discard per unit effort (DPUE). DPUE is a ratio estimator where the denominator is fishing effort such as number of hauls, trips, or fishing-days. The discard ratio in the CDM uses the total kept catch of all species as the denominator to produce a "discard per unit of all catch". This ratio assumes a constant relationship in the catch between the discarded species and all other species, implying a correlation in their spatial and temporal distribution and gear catchability. This assumption can be easily violated for many species, resulting in biased estimates. The commonly used DPUE should be considered or at least tested for some species.

3. Transition rate

It is uncommon to use data from previous years in a traditional sampling design. For stratified random sampling with a target precision, the number of observed trips in each stratum must be sufficient to produce predefined precision for the estimates in that stratum. The CDM described in WP #1 adheres to this principle and derives the number of trips required to achieve 30% CV in each strata. With a properly designed sampling scheme, the variance of the estimated discards does not change dramatically over time and using past years' data is not always required. If borrowing information from previous years is necessary, a Bayesian approach is ideal for incorporating data from the past year as a prior distribution.

4. Sampling error and bootstrapping

Estimating discards involves sampling error at two stages. The first sampling error occurs on the vessel when the observer takes a subsample of fish. The current CDM does not take this sampling error into account. The second sampling error results from less than 100% observer coverage. This sampling error is the focus of the CDM. The method derives the discard ratio using combined data from the beginning of the year to current time. The observed trips available for bootstrapping increases over time. When the number of observed trips is low, quantifying variance will be problematic (more likely to be underestimated). For example, if there is only one observed trip, the bootstrapping will take the same value repeatedly, resulting in a perfect estimate with zero variance. This is probably one of the reasons that uncertainty is small at the beginning of the year but the percentile lines widen quickly over time in the D~Fishing Day figures. When the sample size is small, a parametric bootstrapping based on the variance derived from past years may be more appropriate. Again, it is worth testing the sampling design that includes temporal stratification and treats each strata as independent for bootstrapping (as well as discard estimation). By the way, the standard bootstrapping approach is to obtain random samples with replacement.

5. Model-based approach

The amount of discards is essentially determined by the amount of bycatch. Bycatch in turn is largely determined by three factors: the availability of the species at the fishing location and time, gear catchability, and fishing effort. A model-based approach can be used to estimate discards, where the statistical model links observed discards to various covariates that may affect fish availability and catchability. It is worth comparing a designed-based approach and a model-based one using historical data. A hierarchical Bayesian modelling framework is particularly useful when the observer coverage is low. Instead of modelling discards each year and analysing data in each strata separately, the Bayesian hierarchical model allows analysing data in all years and strata together so the information can be shared across strata and the data strength can be borrowed from each other. Alternative forms of post-stratification (e.g. based on season, area, gear, catch of target species, etc.) can be explored to determine whether bias and variance can be reduced. Possible co-variates such as environmental variables can be easily included in the model. Their significance can be simply be tested, and insignificant variables excluded.

Conclusions and Recommendations

1. The variability in discard ratio exists across strata and fisheries, which is typically expressed as coefficient of variation and summarized by various figures and tables.
2. Optimal applications of the CDM depend on the species and stratification variables considered. The working papers use the coefficient of variation as a primary criterion for comparing alternative stratification schemes. Given the fact that the true amount of discards is unknown, the method for comparing and evaluating different schemes is adequate for these fisheries.
3. The precision and consistency of the discard estimates and their variability are presented by figures, and the metrics are adequate and clear. However, there are two potential issues with the method *per se*: a lack of consistency in precision over time and possible inconsistency in the “cumulative” discard estimation (i.e., $cD_t > cD_{t+1}$). Further investigation into these inconsistencies is needed.
4. Data from past years are incorporated into the current year through a “transition rate”. This transition rate, whether based on a 5-trip method or a moving window method, assumes a similar discard ratio between the past year and the current time step. The assumption may not hold for all cases, resulting biased estimation. If borrowing information from last year is necessary (which is not the case for an appropriately designed stratified random sampling), a formal Bayesian approach should be used.

5. Using archived data to simulate in-season behaviour is particularly valuable. Such an analysis should be formally pursued in the future.
6. It is recommended that model-based approaches, particularly the Bayesian hierarchical models, should be investigated and be used in the future if they found to be superior to the design-based method.
7. Other recommendations pertinent to the CDM include the type of ratio estimator, use of transition rate, bootstrapping for low sample size, and model-based approach.
8. Other NMFS offices have also conducted similar discard studies. It would be beneficial if scientists within NMFS communicate and coordinate similar studies before a CIE review is requested. The products (i.e., the working papers) can be further improved by adopting a standard format, including figures, tables, and terminology across all working papers.

Appendix 1: Bibliography of materials provided for review

WP #1. Daniel W. Linden, Benjamin Galuardi, and Brant M. McAfee. 2016. Methods for examining in-season behavior of the cumulative discard estimation in the Greater Atlantic Region. 14p.

WP #2. Benjamin Galuardi. 2016. Cumulative discard methodology review for catch cap monitoring in the Atlantic sea scallop (*Placopecten magellanicus*). 46p.

WP #3. Jerome M. Hermsen. 2016. Cumulative discard methodology review for butterfish (*Peprilus triacanthus*) discards in the longfin squid (*Doryteuthis* (Amerigo) *pealeii*) fishery. 47p.

WP #4. Brant M. McAfee. 2016. Cumulative discard methodology review for catch cap monitoring in the Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) fisheries. 39p.

WP #5. Daniel E. Caless. 2016. Cumulative discard methodology review for groundfish discards in the Northeast United States groundfish fishery. 25p.

Appendix 2: The CIE Statement of Work

Statement of Work
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review
Review of Cumulative Discard Methodology

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).

Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The Greater Atlantic Regional Fisheries Office (GARFO) requests a review of the Cumulative Discard Methodology currently used to monitor fishery discards throughout the year. Cumulative discard estimates are used for in-season management adjustments and for computing annual catches to monitor compliance with Annual Catch Limits.

Requirements

NMFS requires three reviewers to conduct an impartial and independent peer review in accordance with the SOW, OMB Guidelines, and the TORs below. Reviewers shall have working knowledge and recent experience in:

- Advanced statistical sampling theory and survey design.
- Application of real time-estimation methods for decision-making and imputation.
- Risk analysis as applied to natural resource management
- Basic understanding of fishery monitoring.

Tasks for Reviewers

- Review background materials and reports prior to the review meeting
- Attend and participate in the panel review meeting

o The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers

o The reviewers shall conduct an independent peer review in accordance with the requirements specified in this SOW, OMB guidelines, and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus

o Each reviewer may assist the Chair of the meeting with contributions to the summary report, if required by the TORs

• Deliver their reports to the Government according to the specified milestone dates

Foreign National Security Clearance

When 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 reviewers who are non-US citizens. For this reason, the 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.htmland . The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be at the contractor's facilities and at the in-person review meeting in Gloucester, MA.

Period of Performance

The period of performance shall be from the time of award through December 31, 2016. Each reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

No later than September 22, 2016	Contractor selects and confirms reviewers
No later than October 25, 2016	Contractor provides the pre-review documents to reviewers.
November 7 –9, 2016	Panel review meeting and independent peer review in Gloucester, MA
November 23, 2016	Contractor receives draft reports
December 7, 2016	Contractor submits final reports to the Government

* The Summary Report will not be submitted, reviewed, or approved by the CIE.

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards:

(1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each TOR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $15,000.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

Principal Review Meeting Contact(s):

Dr. J. Michael Lanning
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55 Great Republic Drive, Gloucester, MA 01930-2276
J.Michael.Lanning@noaa.gov (Phone: 978-281-9308) (FAX: 978-281-9333)

Hannah Goodale, Assistant Regional Administrator
Greater Atlantic Regional Fisheries Office
55 Great Republic Drive, Gloucester, MA 01930
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Terms of Reference for the Peer Review

Review of Cumulative Discard Methodology

1. For each fishery subject to in-season discard monitoring utilizing the cumulative discard method, summarize the variability in discard ratio by measurable strata: fishery, gear, area, season, volume of catch, etc.

2. Identify more optimal applications of the current cumulative method for in-season estimation of discards in comparison to existing cumulative discard methodology and stratification schemes. Alternatives identified will include:

a. Existing cumulative discard methodology and stratification scheme as a baseline

b. Pooling data across current stratifications to increase information and precision. As an example, pooling across sectors and gears.

c. Including seasonality as a stratification

d. Allocate/restrict sampling requirements to those strata which in aggregate constitute a target fraction of total stock-specific discards. (i.e, excluding or minimizing sampling for strata with negligible discard totals)

3. Methods identified in TOR 2 will be compared using the following metrics:

a. Precision of the discard estimates for a given level of observer coverage

b. Consistency of discard estimates calculated over the course of the fishing year.

c. Precision and consistency of the CV discard metric for a given level of observer coverage

d. Sensitivity to missing or erroneous data.

4. Examine methods for including data from past years to improve predicting the in-season estimation of discards.

5. Use archived data to simulate in-season behavior (with various time steps and discarding patterns) and recommend a preferred method for each fishery with consideration of the following:

a. Feasibility, particularly the implications of stratum size and within-year pattern of precision.

b. The probability and timing of premature closure (i.e. false positive).

c. The probability and magnitude of exceeding a cap (i.e. e. false negative).

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Draft AGENDA

Cumulative Discard Methodology Review
GARFO
November 7 – 9, 2016

• Welcome and Meeting Expectations

• Review of the cumulative discard method

• Discussion of pros and cons of the cumulative discard method current implementation

• Review of the modeling techniques to simulate in-season behavior with archived data

• By fishery utilizing the cumulative discard method:

  o Summary of the variability of the in-season discard estimation

  o Discussion of alternative applications of the cumulative method

  o Comparison of proposed alternate applications results

• Meeting Summary and Deliverables

Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether or not the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles 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 must describe in their own words the review activities completed during the panel review meeting, including 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, but especially where there were divergent views.

c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.

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

e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

Appendix 1: Bibliography of materials provided for review

Appendix 2: A copy of this Statement of Work

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

Appendix 3: Panel Membership

Dr. Robin Cook, University of Strathclyde, Glasgow, Scotland

Dr. Shijie Zhou, CSIRO Oceans & Atmosphere, Australia