

**Summary Report of the Review of Sea Scallop Survey Methodologies and
Their Integration for Stock Assessment and Fishery Management**

**Meeting to Review Sea Scallop Survey Methodologies and
Their Integration for Stock Assessment and Fishery Management**

17-19 March 2015

**Waypoint Event Center at the Marriott Fairfield Inn and Suites, New Bedford,
MA**

Prepared by the Review Team

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1. Introduction

According to the National Oceanic and Atmospheric Administration (NOAA) FishWatch (http://www.fishwatch.gov/seafood_profiles/species/scallop/species_pages/atlantic_sea_scallop.htm), this sea scallop fishery is now not only one of the most valuable fisheries in the USA, but also the most valuable wild scallop fishery in the world thanks to the collaborative work of scallop fishermen, scientists, fishery managers, and environmentalists.

In the 1990s, the U.S. fishery for Atlantic sea scallops in the northeastern U.S. was not sustainable. According to the web site above, *"in 1994, managers closed three large areas on Georges Bank to any gear that could be used to target groundfish or scallops to allow both groundfish and scallop populations to recover. They also altered other fisheries regulations, gradually increasing the minimum dredge ring size from 3 inches to 4 inches, allowing small scallops to escape and grow to larger sizes before being caught. They put limits on crew size and days that each vessel could fish to reduce fishing pressure on scallops. Managers implemented a sort of crop rotation for the scallop fishery – they defined management areas around concentrations of sea scallops on Georges Bank and off the Mid-Atlantic states that are closed to enable young scallops to grow undisturbed and reproduce, and then reopened when ready to harvest. This crop rotation combined with other key management measures allowed the scallop population to increase ten-fold since its low point in 1993. Adaptive, science-based fisheries management has maintained the sea scallop resource at sustainable levels since 2001."*

The project description in the statement of work for this review states: *"On April 20, 2012, the New England Fishery Management Council voted to task its Science and Statistical Committee (SSC) "to 1) review the sea scallop HabCam survey technology and methods to determine if the HabCam is appropriate at this time for performing annual sea scallop surveys; 2) review how HabCam results will be integrated into sea scallop assessments for determining biomass and fishing mortality, and determine the impacts of reduced survey coverage from current dredge and SMAST video surveys."* Further discussions broadened the scope of this task to examine all of the primary survey methods for assessing sea scallop abundance. *Methods include scallop dredge surveys conducted on research vessels, scallop dredge surveys conducted on commercial vessels, the drop camera survey implemented by SMAST, and the HabCam system developed by WHOI and NEFSC. **The objectives of this broadened scope are to assess the strong and weak points of each sampling approach, and identify the complementary facets of each survey methodology and opportunities for each method as part of the scallop survey sampling program going forward"** (emphasis added).*

1.1 Background

The Panel to Review Sea Scallop Survey Methodologies and Their Integration for Stock Assessment and Fishery Management met at the Waypoint Event Center at the Marriott Fairfield Inn and Suites, New Bedford, MA 17-19 March 2015 to review material prepared by four independent scientific teams conducting surveys on Sea Scallops (Arnie's Fisheries, North East Fisheries Science Center (NEFSC), School of Marine Science and Technology (SMAST), and Virginia Institute of Marine Science (VIMS). The review panel was composed of four scientists appointed by the Center for Independent Experts: Noel Cadigan, Martin Cryer, Jon Helge Vølstad, Brent Wise and J.-J. Maguire who chaired the review panel as a member of the New England Fisheries Management Council Scientific and Statistical Committee.

The review panel was assisted by the NEFSC Stock Assessment Workshop (SAW) Chairman, Dr. James Weinberg, Dr. Paul Rago, Acting Chief of the NEFSC Resource Evaluation and Assessment Division and Deirdre Boelke from the New England Fisheries Management Council. Presentations were made by Paul Rago, Dvora Hart, Dave Rudders, Kevin Stokesbury, Scott Gallagher, Richard Taylor, Burton Shank, Jui-Han Chang and Deirdre Boelke. Toni Chute and Larry Jacobson from the NEFSC acted as rapporteurs. In addition to the review panel, a total of 49 people attended the sea scallop survey methodologies review meeting. The meeting was also available to participants via webinar.

1.2 Review of Activities and Peer Review Process

Before the meeting, material to be reviewed was made available to the review panel via a server on the NEFSC website according to the schedule included in the Statement of Work. The meeting opened on the morning of Tuesday March 17, with welcoming remarks by Bill Karp, NEFSC Science and Research Director and Jon Mitchell, Mayor of New Bedford. Participants and audience members introduced themselves. The remainder of March 17 was devoted to presentations by each of the four scientific teams. Several of the presentations on day 1 used all their allotted time with little left for questions and discussions. However, on the following days, more time was allowed for questions and discussions.

The review panel and the scientific teams worked in a collegial atmosphere during the meeting.

The review panel agreed on bullet points to be included in the report in the afternoon of Thursday, March 19. Scientific teams and the public were allowed in the room, but microphones were turned off.

The Chair compiled and edited the draft Summary Report, which was distributed to the Panel for final review before being submitted to the NEFSC. Additionally, each of the CIE Panelists drafted and submitted an independent reviewer's report to the Center for Independent Experts.

The review process was effective in structuring a critical review of the work and in identifying areas of concern and needs for future research. The first day of the meeting was heavy with presentations leaving little time for questions and discussions. Day 2 and 3 were more balanced.

Review of individual Terms of References

In reviewing individual ToRs, according to the Statement of Work, the review panel "will review field and analytical procedures used by each survey in estimating sea scallop abundance and biomass and collecting biological data that contribute to resource assessment and management of sea scallops and other species. Describe the strengths, weaknesses and the opportunities for improvement in the surveys, including their methods and estimators, as an overall program that serves as a basis for abundance and biomass estimates used in annual area-based scallop fishery management procedures and triennial benchmark stock assessments. Finally, describe opportunities for using each survey in monitoring and managing resources other than sea scallops".

1. Review the statistical design and data collection procedures for each survey system

a. Dredge surveys conducted on research vessels

- b. Dredge surveys conducted on commercial vessels**
- c. SMAST video drop camera system**
- d. HabCam camera and sensor sled**

This term of reference was addressed satisfactorily by all presentations.

The review panel was provided with substantial information on the statistical design and data collection procedures (i.e. manuals), and quality control procedures, for each survey system. The review panel greatly appreciated the efforts of the survey scientists for their excellent documentation provided before the review meeting, and their presentations and willingness to respond to questions during the meeting.

The review panel concludes that all the survey approaches discussed during the meeting have strengths and weaknesses: the dredge surveys on research vessels provide a long time series of biomass estimates, they have been conducted since 1960, covered a more consistent area since 1975, and have used a stratified random statistical sampling design since 1977, albeit with reduced coverage in recent years. The survey has been conducted on different vessels, mostly on NOAA R/V Albatross IV and the University of Delaware R/V Hugh Sharp, but this is not seen as a weakness - comparative fishing experiments using various vessels have shown no vessel effect as the dredge gear behavior is robust to what vessel is used.

The VIMS dredge surveys on commercial vessels have provided detailed information in areas closed to fishing to evaluate when these could be re-opened and how much could be harvested in individual areas. The SMAST video drop camera system originally focused on estimating biomass in closed areas, but coverage expanded progressively. This is a cooperative survey with the fishing industry, using non-invasive gear, adaptable to management changes and providing abundance estimates quickly at the end of the survey. There are in fact two HabCam surveys, one with HabCam V4 conducted on the NOAA research vessel Sharp and one with HabCam V2 conducted by Arnie's fisheries. The results of the two dredge surveys and those of the video drop camera and HABCAM surveys have been used in the assessment.

The NEFSC dredge survey has a statistical stratified random sampling design, the VIMS dredge survey and the SMAST drop camera surveys have statistical uniform systematic designs. The HABCAM V2 survey has generally followed a systematic transect sampling design with high intensity sampling along closely spaced transects. Work is continuing on finalizing a statistical sampling design that would be set before the beginning of a survey with the HABCAM V4. All the statistical survey designs considered by the Panel could be used to provide unbiased estimates of mean abundance in the surveyed areas. It is difficult to produce a design-unbiased estimator of the variance of the abundance estimate using uniform systematic designs, while this is reasonably straight-forward with the stratified random sampling design.

The overall sampling intensity of the SMAST drop camera and VIMS dredge surveys are very good for the areas they survey, but the VIMS dredge survey does not cover the entire range of the stock. The uniform systematic sampling design of the SMAST drop camera and VIMS dredge surveys are inefficient for estimating abundance because the sampling intensity is the same in areas of low and high scallop abundance. More precise estimates require more sampling in areas of high abundance. The review panel notes that these surveys pursue multiple objectives: e.g. distribution of abundance and size classes, habitat classification, by-catch, monitoring other species. These additional considerations may justify the systematic sampling designs, but optimal survey design would depend on the primary

purpose of the survey and compromises are usually necessary if multiple objectives are to be addressed.

The HabCam V4 surveys provide very detailed information along transects but the typical distance between transects seems wide. At times and places this survey has provided much greater sampling coverage but it was not clear if this was a regular part of its design. Typically, the HabCam V2 surveys have been high intensity with short distances between transects, but for small parts of the total stock area.

The area of the NEFSC dredge survey has reduced over time (figure 1 below). The recent sample sizes and coverage for this survey introduces some risk that the survey biomass estimates may be less reliable (less precision and potential bias). The stratification and quasi-optimal allocation for the dredge survey seems useful overall but insufficient detail about the specific sampling plans or any analysis of its potential efficiency compared to stratified simple random sampling were available for the review panel to reach more definitive conclusions. The objective is to achieve a comprehensive survey of the entire area. The NEFSC survey has the flexibility to take into account the surveys conducted under the RSA programs and redistribute effort to help achieve a coverage as comprehensive as possible. This flexibility is possible because the gear types have been cross calibrated.

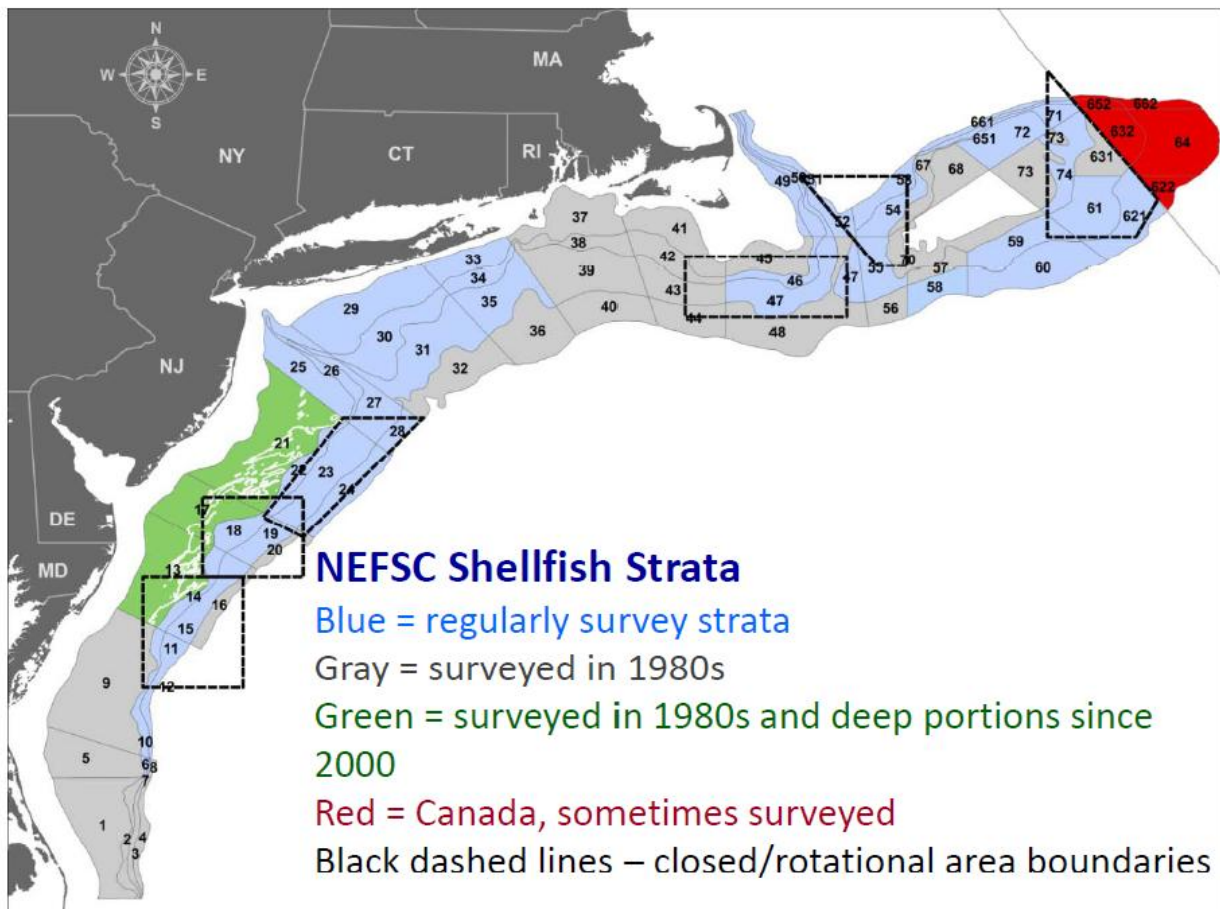


Figure 1: Areas sampled during the NEFSC dredge survey. From slide 9 in file NEFSCDredgeTOR1-4_final-Tue.pdf

The review panel considers that surveys with greater spatial coverage tend to reduce bias and provide more accurate estimates of stock size, especially for populations whose spatial distribution can vary substantially from year to year or on longer time horizons. As indicated above, the allocation of samples in the survey area should ideally ensure coverage of the entire spatial range of the stock, with more intense sampling (aka higher inclusion probabilities) in areas of high scallop abundance to increase the precision of the overall biomass estimate. Spatial management measures may require more detail sampling in rotational areas to achieve optimal use of the resource.

Each individual survey brings useful information to the assessment of the scallop resource and the management of its fisheries.

2. For each survey, evaluate measurement error of observations including shell height measurement, detection of scallops, determination of live vs. dead scallops, selectivity of gear, and influence of confounding factors (e.g., light, turbidity, sea state, tide etc.)

All presentations addressed this term of reference satisfactorily.

The review panel concludes that the dredge surveys provide more accurate measurements of shell height compared to the optical surveys (both dropped and towed cameras). It is critical to have reliable estimates of length compositions for the length-based assessment model. The actual collection of physical samples with dredges is necessary to estimate the spatio-temporal variation in shell height to meat weight relationship, critical to the stock assessment, and other measurements that require physical and laboratory examination of specimens.

The review panel concludes that the optical surveys provide almost complete detection of exploitable scallops and better detection of recruitment compared to dredge surveys; however recruitment information is still only qualitative. The optical surveys have been used to estimate the efficiency of dredge surveys: 40% on sand and 24% on gravel, i.e. the dredge catches 40% of what the optical systems saw on sand and 24% of what the optical systems saw on gravel. This clearly demonstrated that dredges do not capture all available scallops. The review panel expects that these are average values and that they are likely to vary depending on environmental, physical and substrate conditions (e.g. currents, slope, roughness of the bottom, other bottom types, etc.).

The SMAST drop camera edge-effect correction method inflates the sampled area by including a buffer around the actual quadrat of width equal to half the average length of the observed scallops. This approach will underestimate the abundance of small scallops because small scallops on the outer part of the buffer zone will not be visible in the quadrat and thus the effective sampled area will be overestimated. Conversely, very large scallops that are partly visible in the quadrat may extend beyond the buffer zone and thus the effective sampled area will be underestimated (leading to overestimates of the abundance of large scallops). This bias is particularly important for exploitable biomass estimation because meatweight scales with a power of 3 or more on length. It is better to correct for edge effects for individual scallops and methods of doing this that could be applied to existing data were offered by the panel.

In practice there also appears to be some differential detectability of scallops near the borders and especially corners of the SMAST photos and this probably leads to some negative bias. A method of assessing and correcting for such bias that could be applied to existing data was offered by the panel.

The review panel expects that optical surveys would produce less reliable estimates of the proportion of dead scallops (false alive or dead) but the magnitude of this was not quantified.

There are many confounding factors (i.e. optical distortion, attenuation, etc) for optical surveys and many of these have been addressed in the SMAST drop camera and the HabCam surveys. The review panel considers that the HABCAM 4 imaging processing procedures are more advanced and encourages further research in this area.

3. Review the biological sampling aspects of the surveys, including sub-sampling procedures and the ability to sample all size classes. For each survey, evaluate the utility of data to detect incoming recruitment, assess the potential ability to assess fine scale ecology (e.g., Allee effect, predator-prey interactions, disturbance from fishing gear, etc.).

All presentations addressed this term of reference satisfactorily.

Both towed and dropped cameras provide potential information on predator-prey interactions. The review panel thinks it possible that finfish avoidance is potentially more of a problem for the towed camera than for the drop camera because it is likely to be detected earlier by finfish than the drop camera would. However, the towed camera, given sufficient transects, provides a much larger along-transects sample size (i.e. images) that could be used to evaluate predator-prey distributions at a variety of spatial scales.

The review panel appreciates the complexity and magnitude of work involved in processing the large amount of data collected with the HabCam V4 system. The review panel encourages further development of automatic image processing capabilities. The review panel concludes that HabCam V4 with side scan sonar system is the only sampling procedure reviewed that could be used to detect the physical impacts of fishing gear and use this to study the effects of fishing at a very fine scale.

The physical capture of scallops using a dredge or other techniques is necessary to collect other biological information such as disease prevalence (e.g. grey meat) which provides important information about potential future natural mortality, which can greatly affect the efficacy of management plans, growth rates and potential yield.

While the optical surveys have higher delectability of scallops < 20 mm than the dredge surveys, and therefore provide better information on recruitment, they provide less accurate information on the exploitable (i.e. 40mm+) size composition because the optical sampling and analytical procedures introduce statistical noise. This leads to distributions of size (shell heights) being widened (very small and very large scallops can be "invented" by the optical systems) and cohorts being "smeared" together (the example shown was a trimodal length frequency distribution that appeared unimodal using an optical system). However, there is some potential for dredges to have a dome-shaped selection pattern which would lead to underestimating the proportion of very large scallops in dredge length frequency distributions. This requires further investigation (studies are currently going on).

Subsampling for meat weights is currently done by selecting 5 meats per NEFSC dredge survey station. A statistical sampling design should be developed and applied.

The review panel recommends that the total number of baskets and fraction sampled be recorded on dredge surveys, and that the between basket variation in scallop counts (for subsamples) be recorded. This could provide useful information on this source of variation.

All reliable (after screening for poor images) images from the drop camera survey are sampled. Subsampling of images in the HABCAM surveys seemed reasonable but the within transect variation can be large and alternative sampling strategies may be required for other species or for areas where scallop densities are low.

4. Review methods for using survey data to estimate abundance indices. Evaluate accuracy (measures of bias) of indices as estimates of absolute abundance.

All presentations addressed this term of reference satisfactorily.

The VIMS dredge survey is post-stratified into 9 sub-areas and standard design-based methods are used to estimate abundance and biomass within sub-areas and to aggregate estimates for all areas. The survey uses both a commercial and a survey dredge, and the efficiency of both gears has been previously estimated and corrections applied to estimate abundance and biomass. The panel did not review the estimates of efficiency in detail but the methodology and estimates seemed appropriate. However, potential biases in the efficiency estimates (over time or space) will affect the accuracy of the survey biomass estimated. The review panel agrees with the VIMS scientist that the variance estimation has issues related to 1) the systematic sampling design, 2) unaccounted measurement error, 3) efficiency corrections. The VIMS scientist indicated the survey design will change to attempt to address some of these issues. The review panel understood that the objectives of the VIMS survey could also change.

The abundance and biomass estimation methodology for the SMAST drop-camera survey seemed appropriate, subject to the probable positive bias associated with the method of correcting for edge effects and the probable negative bias associated with detectability of <100% towards the edges and corners of each photograph. This survey, like the VIMS dredge survey, uses a statistical uniform systematic design, the variance estimation for this survey also has bias issues related to 1) the systematic sampling design, 2) unaccounted measurement error, 3) uncertainty due to edge corrections. The uniform allocation of stations is reasonable for multiple objectives, including the detection of new recruitment of scallops, but is likely to be inefficient for the estimation of abundance of exploitable biomass since substantial sampling effort is allocated to areas with minimal or zero abundance of scallops above 40 mm.

For both HABCAM V2 and V4, three model-based methods (ordinary kriging, GAM/GAMM with kriging) and a design-based method (stratified mean) were tested through simulations. A model based approach involving a hurdle-GAM for large scale trend plus kriging on residuals was used for several (~14) large areas. This was a complicated model that the review panel did not fully investigate but it was selected by the analyst as the best method giving low bias in the simulation studies and the lowest root mean square error. However the review panel noted that there was no single method that consistently achieved this criteria across all simulations (see next paragraph). The review panel concludes that the geostatistical modelling approach seems reasonable but that biomass variance estimates are likely under-estimated because degrees of freedom were not adjusted for and model uncertainty is an unaccounted source of variation in the biomass and abundance estimates. The review panel encourages further research to improve these procedures.

Model-based methods should be used with care. The review panel notes that in a few cases the model estimated the highest abundance in areas with no samples and it is not clear why this occurred. This could be seriously misleading if the modeled biomass estimates were used uncritically in a spatial management procedure.

5. Evaluate any proposed methods for integrating and using surveys outside of a stock assessment model for management purposes.

All presentations addressed this term of reference satisfactorily.

Analyses of surveys have been integrated in a few ways. One is to do a combined analysis of survey observations, internally adjusting for differences in catchability where appropriate. This has been done for VIMS+NEFSC dredge surveys. The review panel considers this appropriate because the same dredge gear is used in both surveys; however, these two surveys are not at the same time and the populations being surveyed could be different due to growth and mortality processes.

Another approach is to integrate/combine survey biomass estimates. However, the issue of timing of surveys also applies here. Two methods have been used to combine estimates from SMAST, HABCAM V2+4, and combined (VIMS+NEFSC) dredge surveys: straight average and inverse variance weighting. Combining surveys is only appropriate if the survey biomass estimates are for the same area. Raw averaging of surveys does not account for the different precision of the estimates. However, inverse variance weighting is reliable only if there are reliable estimates of variance which is uncertain for at least the surveys with uniform systematic designs (SMAST drop camera and VIMS dredge) where variance is expected to be overestimated.

One presentation introduced an analysis attempting to combine observations from all surveys in a single model using a co-kriging model. This is work in progress, but the review panel notes that, strictly speaking, co-kriging attempts to improve the estimation by using co-variates. In this case, different surveys are used as co-variates.

Demonstrations were provided to illustrate that the data could be used for other management purposes (e.g. early detection of recruitment, unusual mortality events, avoiding bycatch). The review panel concludes that complementary survey methods provide enhanced capabilities to achieve such objectives, particularly, since no survey method has provided complete coverage of the entire stock area on a regular basis.

6. Comment on potential contribution of each survey to assessments for non-scallop species and use of data apart from assessment purposes such as characterizing species habitat, understanding sea scallop ecology, and ecosystem studies.

All presentations addressed this term of reference satisfactorily.

All surveys have the potential to contribute to assessments for non-scallop species and use data apart from assessment purposes (e.g. characterizing species habitat, understanding sea scallop ecology, and ecosystem studies). In many cases the information from the various surveys is complementary or additive. The optical methods have provided additional information on species habitat, sea scallop ecology, and ecosystem studies. All of the surveys were demonstrated to provide information on changes in abundance of other species.

The review panel considers that the HABCAM V4 survey technology has the greatest potential in providing information on bottom habitat, gear impacts, species interactions, and spatial structure on a continuously-variable variety of scales.

The VIMS and NEFSC dredge surveys have recorded detailed information on fewer species than the optical surveys and integrate spatially over hundreds of metres which limits their contribution to ecosystem studies.

Broad scale coverage is particularly useful when contributing information to ecosystem studies including changes to community composition over time. The review panel encourages further research in these areas.

7. Comment on the current and/or any proposals for optimal frequency and combination of survey methods.

This term of reference was addressed satisfactorily.

While no specific proposals for optimal frequency of surveys were evaluated, the review panel agrees that annual surveys are required to support the management process with fishery specification adjusted every year in addition to spatial management procedures. Yearly surveys also make it possible to detect and protect recruitment events, and avoid under- and over-harvesting of stock components.

To some extent the VIMS dredge survey, NEFSC dredge survey, and the HabCam V2 and V4 surveys are integrated because they cooperate to address survey gaps and standardize dredge catch rates. The review panel recommends that survey efforts should be further integrated to provide a standard monitoring survey of the entire stock distribution; however, the optical and dredge surveys are complementary and both should be maintained and integrated. The continuity of time-series should be also be maintained to the fullest extent possible.

The review panel recommends that all available information be used to devise an optimal and integrated statistical survey design (involving the use of complementary survey methods) and estimation procedure for stock size, spatial distribution, and other primary objectives. This may require simulation studies.

8. Identify future research and areas of collaboration among investigators and institutions.

This term of reference was addressed satisfactorily.

To devise an optimal and integrated statistical survey design and estimation procedure for stock size, spatial distribution, and other primary objectives, the review panel recommends that all available information from all surveys be thoroughly analyzed, including an evaluation of the efficiency of using shorter tow durations.

Further understanding the correlation between dredge tow catches and HabCam observations, and using model-assisted regression estimators (dredge catch versus HabCam "catch") may be a simple and intuitive approach to combine and improve estimation of stock size while maintaining the continuity of the NEFSC dredge time series. If high correlation between HabCam scallop counts (for sampling units of similar lengths as the dredge tows) is

confirmed, then the HabCam counts from the total cruise track could be used as covariates to improve the abundance/biomass estimates based on the dredge counts.

In a survey design with increased dredge coverage, the review panel found no compelling advantage in using both dredge and HABCAM sampling gears on the same vessel. However, statistically-designed dredge sampling that includes a portion of samples that overlap with the HabCam track is still required. The designer of HabCam felt that the best usage of this technology is continuous sampling and the review panel agreed with this. A joint integrated survey using two vessels (one for HABCAM and one for dredge) could result in a better survey with improved coverage.

Appendix 1: Bibliography and Presentations

Dredge-NEFSC

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Dredge-VIMS

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- Appendix 7: Rudders, D.B., DuPaul, W.D., Hudson, J., Bergeron, J. 2014. An Assessment of Sea Scallop Abundance and Distribution in the Mid-Atlantic Bight. Presented August 26-27, 2014. 30 slides.
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TOR 3: Biological Sampling Aspects of the Surveys. 13p.

TOR 4: Methods for Using Survey Data to Estimate Abundance Indices. 20p.

TOR 5: CoKriging As a Method for Combining Resource Surveys, Decreasing Uncertainty, and Mitigating Bias. 13p.

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Statement of Work

Review of Sea Scallop Survey Methodologies and Their Integration for Stock Assessment and Fishery Management

Statement of Work (SOW) for CIE Panelists (including a description of Chair's duties)

BACKGROUND

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 Representative (COR), 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 independently 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.

SCOPE

Project Description: On April 20, 2012, the New England Fishery Management Council voted to task its Science and Statistical Committee (SSC) "to 1) review the sea scallop HabCam survey technology and methods to determine if the HabCam is appropriate at this time for performing annual sea scallop surveys; 2) review how HabCam results will be integrated into sea scallop assessments for determining biomass and fishing mortality, and determine the impacts of reduced survey coverage from current dredge and SMAST video surveys." Further discussions broadened the scope of this task to examine all of the primary survey methods for assessing sea scallop abundance. Methods include scallop dredge surveys conducted on research vessels, scallop dredge surveys conducted on commercial vessels, the drop camera survey implemented by SMAST, and the HabCam system developed by WHOI and NEFSC. The objectives of this broadened scope are to assess the strong and weak points of each sampling approach, and identify the complementary facets of each survey methodology and opportunities for each method as part of the scallop survey sampling program going forward.

The purpose of this meeting will be to provide an external peer review of survey methodologies currently being used which provide data for sea scallop stock assessments and related fishery management models.

OBJECTIVES

The review panel will be composed of three appointed reviewers from the Center of Independent Experts (CIE), and an independent chair from the SSC of the New England or Mid-Atlantic Fishery Management Council. The panel will write the Panel Summary Report and each CIE reviewer will write an individual independent review report.

Duties of reviewers are explained below in the “**Requirements for the Reviewers**”, in the “**Charge to the Review Panel**” and in the “**Statement of Tasks**”. The Terms of Reference (ToRs) are attached in **Annex 2**. The draft agenda of the panel review meeting is attached in **Annex 3**.

Requirements for the reviewers: Three reviewers shall conduct an impartial and independent peer review of **sea scallop** survey methodology, and this review should be in accordance with this SoW and ToRs herein. Collectively, the reviewers shall have advanced knowledge, recent experience and:

1. Expertise in use of optical imaging in estimating abundance in marine biological surveys
2. Expertise in statistical design and estimation of surveys for stock assessments including stratified random, systematic and transect surveys.
3. Expertise with model-based estimation of abundance using geostatistical tools.
4. Expertise in the use of dredge surveys for sessile benthic organisms.

Knowledge of sessile invertebrates and spatial management would be desirable.

PERIOD OF PERFORMANCE

The contractor shall complete the tasks and deliverables as specified in the schedule of milestones within this statement of work. Each reviewer’s duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Not covered by the CIE, the Chair’s duties should not exceed a maximum of 10 days (i.e., several days prior to the meeting for document review; the peer review meeting; several days following the meeting for Panel Summary Report preparation).

PLACE OF PERFORMANCE AND TRAVEL

Each reviewer shall conduct an independent peer review during the panel review meeting scheduled in or near New Bedford, Massachusetts during March 17-19, 2015.

STATEMENT OF TASKS

Charge to the Review Panel:

The panel will review field and analytical procedures used by each survey in estimating sea scallop abundance and biomass and collecting biological data that contribute to resource assessment and management of sea scallops and other species. Describe the strengths, weaknesses and the opportunities for improvement in the surveys, including their methods and estimators, as an overall program that serves as a basis for abundance and biomass estimates used in annual area-based scallop fishery management procedures and triennial

benchmark stock assessments. Finally, describe opportunities for using each survey in monitoring and managing resources other than sea scallops.

Each reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Tasks prior to the meeting: The contractor shall independently select qualified reviewers, without conflicts of interest, to conduct an independent scientific peer review of reports and presentations prepared by NEFSC and other groups in accordance with the tasks and ToRs within the SoW. Upon completion of the independent reviewer selection by the contractor's technical team, the contractor shall provide the reviewer information (full name, title, affiliation, country, address, email, FAX number, and CV suitable for public distribution) to the COR, who will forward this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The contractor shall be responsible for providing the SoW and ToRs to each reviewer. The NMFS Project Contact will be responsible for providing the reviewers with the background documents, reports for review, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact will also be 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 COR prior to the commencement of the peer review.

Foreign National Security Clearance: The reviewers shall participate during a panel review meeting possibly at a government facility, and the NMFS Project Contact is therefore responsible for obtaining the Foreign National Security Clearance approval (if the meeting is held on federal property) for the reviewers who are non-US citizens. For this reason, the reviewers shall provide by FAX (or by email if necessary) the requested information (e.g., 1.name [first, middle, and last], 2.contact information, 3.gender, 4.country of birth, 5.country of citizenship, 6.country of permanent residence, 7.whether there is dual citizenship, 8.country of current residence, 9.birth date [mo, day, year], 10.passport number, 11.country of passport) 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/>.

Pre-review Background Documents and Working Papers: Approximately two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the Chair and CIE reviewers the necessary background information and reports (i.e., working papers) for the peer review. Should documents need to be mailed, the NMFS Project Contact will consult with the COR on where to send documents. The reviewers are responsible only for the pre-review documents that are delivered to the contractor in accordance to the SoW scheduled deadlines specified herein. The reviewers shall read all documents deemed as necessary in preparation for the peer review.

Tasks during the panel review meeting: Each reviewer shall conduct the independent peer review of documents and presentations in accordance with the SoW ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and contractor.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS

Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

(Chair)

Act as chairperson, where duties include control of the meeting, coordination of presentations and discussions, ensuring all Terms of Reference are reviewed, controlling document flow, and facilitating discussion.

During the question and answer periods, provide appropriate feedback to the scientists on the sufficiency of their analyses and presentations. It is permissible to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced in the time allotted.

(CIE reviewers)

Participate as peer reviewer in panel discussions on validity, results, recommendations, and conclusions. From a reviewer's point of view, determine whether each Term of Reference was completed successfully. During the question and answer periods, provide appropriate feedback to the scientists on the sufficiency of their survey methods and related analyses. It is permissible to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced in the time allotted.

Tasks after the panel review meeting:

CIE reviewers:

Each CIE reviewer shall prepare an Independent CIE Report (see **Annex 1**). This report should comment, for each TOR as appropriate, on the strengths and weaknesses of the surveys, both individually and as a group going forward. The report should follow the guidance provided in the "Charge to the Review Panel" statement.

During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the Independent CIE Report produced by each reviewer.

The Independent CIE Report can also be used to provide greater detail than the Panel Summary Report.

Chair:

The Chair shall prepare a document summarizing the background of the work to be conducted as part of the review process and summarizing whether the process was adequate to complete review of the Terms of Reference. If appropriate, the chair will include suggestions on how to improve the process. This document will constitute the introduction to the Panel Summary Report (see **Annex 4**).

Chair and CIE reviewers:

The Chair, with the assistance from the CIE reviewers, will prepare the Panel Summary Report. Each CIE reviewer and the chair will discuss whether they hold

similar views on each ToR and whether their opinions can be summarized into a single conclusion for all or only for some of the ToRs. For ToRs where a similar view can be reached, the Panel Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given ToR, the Panel Summary Report will note that there is no agreement and will specify - in a summary manner - what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this Panel Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this report. The chair may express the chair's opinion on each Term of Reference, either as part of the group opinion, or as a separate minority opinion.

The Panel Summary Report (please see **Annex 4** for information on contents) should address each of the ToRs, keeping in mind criteria in the "Charge to the Review Panel".

The contents of the draft Panel Summary Report will be approved by the CIE reviewers by the end of the Panel Summary Report development process. The chair will complete all final editorial and formatting changes prior to approval of the contents of the draft Summary Report by the CIE reviewers. The Chair will then submit the approved Summary Report to the NEFSC contact.

DELIVERY

Each reviewer shall complete an independent peer review report in accordance with the SoW including required format and content as described in **Annex 1**. Each reviewer shall complete the independent peer review addressing each ToR listed in **Annex 2**.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

- 1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
- 2) Participate during the panel review meeting at the Woods Hole, Massachusetts scheduled during the tentative dates of March 17-19, 2015.
- 3) Conduct an independent peer review in accordance with this SoW and the ToRs (listed in **Annex 2**).
- 4) No later than April 3, 2015, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each assessment ToR in **Annex 2**.

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

February 6, 2015	Contractor sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
March 2, 2015	NMFS Project Contact will attempt to provide reviewers the pre-review documents
March 17-19, 2015	Each reviewer participates and conducts an independent peer review during the panel review meeting in New Bedford, MA. Chair and CIE reviewers work at drafting reports during meeting
April 3, 2015	Reviewers submit draft independent peer review reports to the contractor's technical team for independent review
April 3, 2015	Draft of Panel Summary Report*, reviewed by all CIE reviewers, due to the Chair
April 10, 2015	Chair sends Final Panel Summary Report, approved by CIE reviewers, to NEFSC contact
April 17, 2015	Contractor submits individual peer review reports to the COR who reviews for compliance with the contract requirements
April 22, 2015	The COR distributes the final individual reports to the NMFS Project Contact and regional Center Director

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

The NEFSC Project Contact will assist the chair prior to, during, and after the meeting in ensuring that documents are distributed in a timely fashion.

NEFSC staff and the Chair will make the final Panel Summary Report available to the public.

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on substitutions. The COR 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 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: The deliverables shall be the final peer review report from each reviewer that satisfies the requirements and terms of reference of this SoW. The contract shall be successfully completed upon the acceptance of the contract deliverables by the COR based on three performance standards:

- (1) each report shall be completed with the format and content in accordance with **Annex 1**,
- (2) each report shall address each ToR listed in **Annex 2**,
- (3) each report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Upon the acceptance of each independent peer review report by the COR, the reports will be distributed to the NMFS Project Contact and pertinent NMFS science director, at which time the reports will be made publicly available through the government's website.

The contractor shall send the final reports in PDF format to the COR, designated to be William Michaels, via email William.Michaels@noaa.gov

Support Personnel:

William Michaels, Program Manager, COR
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Key Personnel:

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Annex 1: Format and Contents of Independent Individual Peer Review Report

1. The independent peer review report shall be prefaced with an Executive Summary providing a concise summary of the strengths and weaknesses of the reviewed sea scallop surveys, both individually and when used in combination.
2. The main body of the report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Key findings on work reviewed, and an explanation of their conclusions and recommendations (strengths, weaknesses of the analyses, etc.) for each ToR.
 - a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of strengths and weaknesses of the analyses and recommendations for the future.
 - 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 should elaborate on any points raised in the Panel Summary Report that they feel 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 individual independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not others read the Panel Summary Report. The independent report shall be an independent peer review of each ToR, and shall not simply repeat the contents of the Panel Summary Report.
3. The reviewer 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.

Annex 2: Terms of Reference

(These ToRs are to be carried out by the scientists involved with scallop survey methods and analyses. The Peer Review Panel will then address the strengths and weaknesses of the various survey approaches and survey methodologies, with a focus on these ToRs.)

1. Review the statistical design and data collection procedures for each survey system
 - a. Dredge surveys conducted on research vessels
 - b. Dredge surveys conducted on commercial vessels
 - c. SMAST video drop camera system
 - d. HabCam camera and sensor sled
2. For each survey, evaluate measurement error of observations including shell height measurement, detection of scallops, determination of live vs. dead scallops, selectivity of gear, and influence of confounding factors (e.g., light, turbidity, sea state, tide etc.)
3. Review the biological sampling aspects of the surveys, including sub-sampling procedures and the ability to sample all size classes. For each survey, evaluate the utility of data to detect incoming recruitment, assess the potential ability to assess fine scale ecology (e.g., Allee effect, predator-prey interactions, disturbance from fishing gear, etc.).
4. Review methods for using survey data to estimate abundance indices. Evaluate accuracy (measures of bias) of indices as estimates of absolute abundance.
5. Evaluate any proposed methods for integrating and using surveys outside of a stock assessment model for management purposes.
6. Comment on potential contribution of each survey to assessments for non-scallop species and use of data apart from assessment purposes such as characterizing species habitat, understanding sea scallop ecology, and ecosystem studies.
7. Comment on the current and/or any proposals for optimal frequency and combination of survey methods.
8. Identify future research and areas of collaboration among investigators and institutions.

Appendix to Annex 2:

In their presentations and reports for the peer review, analysts (as opposed to the peer reviewers) will cover a broad range of topics, such as:

1. Summaries of historical scallop survey indices, and their components (e.g., frequency, spatial extent, data collected), from the NEFSC sea scallop survey, the SMAST video survey, relevant VIMS cooperative industry surveys, and HabCam surveys from WHOI and Arnie's Fisheries. For each of these surveys, additional topics include survey design, objectives, methods, and any relevant changes over time.

2. Summaries of current approaches for using abundance indices in stock assessment and management models. (Stock assessment models describe the dynamics of populations over time and estimate total stock size and mortality rates. Management models are used to evaluate the short-term effects of alternative harvesting scenarios at varying degrees of spatial resolution.)
3. Summaries of procedures for data acquisition, post processing, archiving, availability to outside investigators, publication of derived products in primary literature, and use for stock assessments.

Rules of Engagement among analysts on Working Groups preparing for peer reviews:

Anyone participating in working group meetings that will be running or presenting results from a design or model based estimator is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed description in advance of the meeting. These measures allow transparency and a fair evaluation of differences that emerge among design and model based estimates of abundance.

Annex 3: Draft Agenda
Sea scallops Survey methods review

March 17-19, 2015

(Location: Likely to be near New Bedford, Mass.)

DRAFT AGENDA* (version: October 17, 2014)

TOPIC	PRESENTER(S)	RAPPORTEUR
<u>Tuesday, March 17</u>		
9 – 9:30 AM Welcome Introduction Agenda Conduct of Meeting	Chair	TBD
9:30 – 10:30 AM	Presentation #1 TBD	TBD
12:30 – 1:30 PM	Lunch	
1:30 – 3:30 PM	Presentation #2 TBD	TBD
3:30 – 3:45 PM	Break	
3:45 – 5:45 PM	Presentation #3 Chair	TBD
5:45 – 6 PM	Public Comments	

TOPIC
RAPPORTEUR

PRESENTER(S)

Wednesday, March 18

9 – 10:45 AM	Presentation #4		
		TBD	TBD
10:45 – 11 AM	Break		
11 – 12:30 PM	Presentation #5		
		TBD	TBD
12:30 – 1:45 PM	Lunch		
1:45 – 3:15 PM	Presentation #6		
3:15 – 3:30 PM	Public Comments	TBD	TBD
3:30 -3:45 PM	Break		
3:45 – 6 PM	Presentation #7		
		TBD	TBD
7 PM	(Social Gathering)		

Thursday, March 19

8:30 – 10:15	Review of Key Findings		
		Chair	TBD
10:15 – 10:30	Break		
10:30 – 12:30	Review/edit Panel Summary Report		
		Chair	TBD
12:30 – 1:45 PM	Lunch		
1:45 – 2:15 PM	Review/edit Panel Summary Report (cont.)		
		Chair	TBD
2:15 – 2:30 PM	Break		
2:30 – 5 PM	Review/edit Panel Summary Report		
		Chair	TBD

*All times are approximate, and may be changed at the discretion of the Chair. The meeting is open to the public.

**The NMFS Project contact will provide the final agenda about four weeks before meeting.
Reviewers must attend the entire meeting.**

Annex 4: Contents of Review Panel Summary Report

1. The main body of the report shall consist of an introduction prepared by the Chair that will include the background, a review of activities and comments on the appropriateness of the process in reaching the goals of the Review. Following the introduction, for each ToR the report should address the issues described earlier in the “Charge to the Review Panel” within the “Statement of Tasks”.
2. To make its determinations, the Chair and CIE reviewers should consider whether the survey methods provide a scientifically credible basis for estimating sea scallop abundance. Scientific criteria to consider include: whether the methodologies and estimators are adequate and used properly, and are leading to conclusions that are correct/reasonable. If the CIE reviewers and chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.
3. The report shall also include the bibliography of all materials provided during the review, and relevant papers cited in the Summary Report, along with a copy of the CIE Statement of Work.
4. The report shall also include as a separate appendix the Terms of Reference (Annex 2), including any changes to the ToRs or specific topics/issues directly requiring Panel advice.

Appendix 3: List of Participants

<u>Participants</u>	<u>Affiliation</u>	<u>Contact Information</u>
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