CIE Independent Peer Review Report

Eastern Bering Sea Crab and Groundfish Bottom Trawl Surveys

Prepared by

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I. Executive Summary

The CIE review for the Eastern Bering Sea (EBS) crab and groundfish bottom trawl surveys, held in Seattle, WA from April 10-12, 2012, is aimed to evaluate survey design and sampling protocol for yielding consistent and reliable abundance index and biological information for the assessment of crab and groundfish species in the survey area and make recommendations for possible improvement. This review is the first CIE review for this survey program. The Alaska Fisheries Science Center (AFSC) provided all the necessary logistic support, documentation, data, and background information I requested. The scientists involved in the process were open to suggestions and provided additional information upon request. The whole process was very open and constructive and all the materials were sent to me in a timely manner. As a CIE reviewer, I am charged to evaluate the EBS crab and groundfish bottom trawl surveys with respect to the Terms of Reference.

I would like to commend the continuing effort of the AFSC scientists for improving the survey. I was impressed by the breadth of expertise and experience, the amount of effort spent to standardize sampling protocol and data collection process, the openness of discussion for considering alternative approaches/suggestions, and the constructive dialogue between the CIE reviewers and other participants throughout the review.

Overall I believe that the EBS crab and groundfish bottom trawl surveys provide consistent time series of abundance indices and relevant biological information on many key crab and finfish populations, which are critical to the assessment of these populations. The survey design and sampling protocol are scientifically sound and robust, and adequately address assessment and management needs. However, I believe that some important questions still need to be addressed and there is still room for improvement.

I have made the following recommendations: (1) Experiments be conducted to evaluate if it is feasible to reduce the tow duration from 30 minutes to 15-20 minutes; (2) impacts of any change/modification of sampling gear and protocol on survey catchability be carefully evaluated and necessary corrections/adjustments be done for the whole time series to ensure the consistency and comparability of data before and after the change/modification; (3) the historical data be used for a Monte Carlo simulation study to evaluate and identify an optimal (cost-effective) subsampling size for measuring size composition at each sampling station for each species; (4) data collected from the hotspots and two high density areas be analyzed for evaluating their effectiveness in achieving the goal of setting these sampling stations in the first place and an adaptive survey design be developed to deal with patchy distributions of key crab and finfish species; (5) experiments to improve understanding of impacts of different variables on survey catchability be designed and conducted in a systematic way; (6) variance of abundance index be estimated based on systematic design or a bootstrap type of approach, which mimics how sampling stations are surveyed in a systematic design, be developed for estimating variance; (7) I support the research effort of complementing the bottom trawl surveys with the acoustic surveys to improve our understanding of fish vertical distribution and its impacts on survey catchability; (8) for a given species, in-depth analysis of historical data be conducted to quantify spatial variability among the strata and determine if such variability is consistent over time, which can help evaluate if the current allocation of sampling effort among the strata is effective

in improving the precision of abundance index estimates and if it is necessary to adjust sampling effort among the strata; (9) an official policy and/or protocol be developed for data distributions and utilizations to ensure proper interpretation of the data; (10) survey abundance index be standardized using a general linear model (GLM) and/or general additive model (GAM) including variables that are considered to be important in influencing survey catchability (e.g., boat, temperature, bottom type, location, depth etc.); (11) a habitat suitability modeling approach be used to quantify the relationship between fish/crab abundance and environmental variables, which can then be used to identify suitable habitats for the fish/crab, based on the environmental variables (e.g., substrates and ocean observatory or model data); and (12) an extensive computer simulation study be done based on the data collected in the past to evaluate the performance of the current survey design in capturing temporal and spatial variability for some key species.

II. Background

The eastern Bering Sea (EBS) crab and groundfish bottom trawl survey provides information critical to more than 25 groundfish and crab stock assessments conducted by the Alaska Fisheries Science Center (AFSC), the State of Alaska, and the International Pacific Halibut Commission. The annual survey started in 1971 in the EBS and was extended to cover the EBS shelf in 1975 to collect baseline data for evaluating possible impacts of proposed offshore oil exploration on fisheries resources. The survey intensity was reduced between 1976 and1979, but essentially repeated the stations identified in the 1975 survey after 1979. Some major target crab species of great commercial importance include Tanner crab (*Chionoecetes bairdi*), snow crab (*C. opilio*), blue king crab (*Paralithodes platypus*), red king crab (*P. camtschaticus*), and hair crab (*Erimacrus isenbeckii*) (Chilton et al. 2009). Some target groundfish species include walleye pollock (*Theragra chalcogramma*), yellowfin sole (*Limanda aspera*), and Pacific cod (*Gadus macrocephalus*) (Thompson et al. 2010, Ianelli et al. 2011; Wilderbuer et al. 2011).

Prior to 1982, survey gears were not standardized. After 1982, surveys became consistent in sampling gear and protocol. The EBS survey program covers Bristol Bay and a majority of the Bering Sea continental shelf and follows systematic design with a fixed sampling station at the center of each grid square (20 x 20 nautical miles; Lauth 2010). There is no random start station. The survey program includes two geographic strata: NW (arctic area) and SE (sub-arctic area); and three depth strata: inner shelf < 50 m, mid-shelf between 50 and 200 m, and outer shelf > 200 m. Highly patchy distribution of blue king crab calls for a further division of high-dependent and standard density sampling strata, resulting in 12 strata in total. Such a stratification design considers differences in oceanographic conditions, which is critical to stock structure. There are 376 survey stations, with a target tow duration of 30 minutes at a speed of 3 knots. The survey begins in the northeast section of Bristol Bay and progresses from east to west to respond to movements by yellowfin sole and other species that tend to move eastward during the survey. The survey has been conducted by two charter fishing boats. The balance of spatial coverage by the two boats is considered in determining the sampling route. Because of the large area it needs to cover, the survey usually lasts for two months, typically from June to July.

The sampling process follows national and regional protocols (Stauffer 2004). Possible differences in gear between the two survey boats were minimized. Subsamples have been taken from these surveys for size measurement and age determination. The nominal survey abundance index is standardized with the swept area. The mean and standard deviation of survey abundance index were estimated under the assumption that the survey followed stratified random design. Various experiments have been conducted to evaluate factors that may influence survey catchability (e.g., Lauth et al. 1998, Somerton et al. 2002, Kotwicki et al. 2006, Weinberg and Kotwicki 2008). Fish vertical distribution has also been studied to evaluate their availability to survey trawl (e.g., Nichol et al. 2007, von Szalay et al. 2007, Somerton et al. 2011).

Although extensive research efforts have been focused on the standardization of survey protocol to reduce temporal variability in survey catchability, it is important to note that the survey takes about two months to complete and survey abundance has not been standardized to remove the possible impact of temporally-variant vessels, temperature and other environmental variables, and equipment on survey catchability. Abundance index standardizations are usually not necessary for a fishery-independent survey program. However, for the EBS surveys, there are too many factors varying over time and within a survey season, which calls for thorough studies to evaluate their impacts on survey abundance.

Although all AFSC bottom trawl surveys, as well as those conducted by other NMFS science centers, were examined closely during the development of the NOAA Bottom Trawl Protocols in 2004 (Stauffer 2004), the AFSC surveys have never been formally reviewed by a CIE panel. The AFSC has conducted considerable research on factors affecting trawl performance and catchability and their impacts on resulting survey estimates of distribution and abundance. However, in recent years the trawl and survey performance and results of this multi-species survey have come under scrutiny by industry, particularly with respect to Bering Sea red king crab, snow crab, and Pacific cod. Considering the importance of the data produced by the EBS bottom trawl surveys, a CIE review in 2012 is timely and beneficial.

As a CIE reviewer, I am charged to evaluate the EBS crab and groundfish bottom trawl surveys with respect to the Terms of Reference. This report includes an executive summary (Section I), a background introduction (Section II), a description of my role in the review activities (Section III), my comments on each item listed in the Terms of Reference (ToRs, Section IV), a summary of my comments and recommendations (Section V), and references (Section VI). The final part of this report (Section VII) includes a collection of appendices including the Statement of Work (SoW).

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

My role as a CIE independent reviewer is to conduct an impartial and independent peer review of the EBS crab and groundfish bottom trawl survey with respect to the pre-defined Terms of Reference.

Two weeks prior to the review in the AFSC in Seattle, I received the EBS crab and groundfish bottom trawl survey reports and relevant documents (see Appendix I for the list of documents received). I read all the documents I received prior to the review. I also collected and read references relevant to the topics covered in the reports and the SoW prior to my trip to the ASFC.

The CIE review was held from April 10 to 12, 2012 in the AFSC in Seattle, WA (see Appendix II for the schedule). The review was chaired by Dr. David Somerton and attended by the AFSC scientists who are involved in the EBS bottom trawl survey, two stock assessment scientists who used the data for stock assessment, and industrial representatives, in addition to the three CIE reviewers (see the List of Participants in Appendix III).

A series of presentations were given during the review to provide the CIE reviewers with background information on the evolution of the EBS bottom trawl survey program (see the list of presentations in Appendix I). I was actively involved in the discussion during the presentation by (1) questioning and asking for clarification on monitoring/sampling program design, data collection operation, statistical analysis, and interpretations; (2) making observations of the process; and (3) making comments and suggestions for alternative approaches and more analyses. I interacted with the relevant scientists who presented the talks and asked for further clarifications and references during the review. I also discussed relevant issues with the fellow CIE reviewers.

IV. Summary of Findings

My detailed comments on each item of the ToRs are provided under their respective subtitles from the ToRs (see below).

IV-1. *Evaluate the data collection operations and sampling design of the survey in term of their adequacy for producing consistent and precise estimates of relative abundance for the various fishes and invertebrates of concern.*

Great effort has been devoted to the standardization of survey operational and data collection protocols to yield temporally consistent and precise estimates of abundance index for the important crab and finfish species. I believe that the abundance indices derived in the survey are adequate in quantifying temporal variability of stock sizes for the key crab and finfish species. However, there is room for further improvement.

Ideally, a fishery-independent survey program should not have a temporal trend in selectivity, catchability, vulnerability, and availability (but these four processes are often combined and are referred to as selectivity and/or catchability in this report). This allows catch derived from such a survey to be used as an unbiased abundance index to monitor changes in stock biomass over time. The EBS survey follows a systematic design. However, unlike a common systematic design, its start sampling station is not selected randomly, although the start time varies from year to year. The survey duration is long and usually lasts for 2 months. Survey catches are standardized by swept area. Thus, any systematic change over the time, which may influence area swept and selectivity/catchability for the species in the survey area, can introduce systematic biases in derived abundance index.

The EBS bottom trawl survey program has experienced some substantial changes and modifications since its inception including changes in survey vessels, trawling gears, sampling protocol, and monitoring devices for gear performance and towing speed. These changes have been made in an effort to standardize fishing operation and sampling protocol of the survey. For example, length of towing cable was standardized by depth in 1989; standard setting and retrieval procedures were implemented in 1993; standard wire marking was instituted in 1997; real-time monitoring of vessel speed started in 2001, and national sampling protocols were published in 2004. These continuous changes/modifications have improved temporal consistency of catchability/selectivity and accuracy and precision in measuring effective areas swept by the sampling gears. However, for some changes/modifications, limited experiments were done to compare before and after the changes, which might result in inconsistency in developing abundance indices for some species. It is important to note that the most important issue here is temporal consistency, which makes the derived abundance indices comparable over time for a given species. Any significant change in fishing operation and sampling protocol without a good understanding of its impacts on factors influencing catchability/selectivity may introduce biases in abundance index. Thus, although I would like to commend great effort for continuing to improve data collection and sampling protocol, large changes to the current protocol should be avoided. If such changes have to be made, a well deigned experiment and analysis should be conducted to adjust the abundance index for the whole time series, including both before and after the change, to ensure temporal consistency.

The survey follows a systematic design without a random start station. Although this seems to be an issue, start time varies from year to year because of logistic reasons and weather, which may act as a random start.

Two high density sampling areas are defined around St. Matthew Island and the Pribilof Islands, mainly targeting for blue king crab. The addition of these two areas may complicate population estimation, and an analysis of historical data with and without inclusion of these two areas of data may help evaluate and understand effects of adding these two areas. These two areas may need to be considered as separate strata. Blue king crabs prefer rocky habitats which are not suitable for trawling. Thus, setting two high density sampling areas does not achieve the goal of sampling blue king crab. Crab pots/traps may be more appropriate if the target species is blue king crab.

Resampling was conducted at the end of survey mainly for red king crab in Bristol Bay in eight cold years (i.e., 1999-2000, 2006-2011) to account for temperature-dependent movement by spawning female red king crab. Analyses show clear differences in the condition of females captured at the beginning and end of the survey. Although it may be necessary to resample the Bristol Bay in a cold year to account for the temperature-dependent movement, this may complicate the analysis. Unusually low temperature may also affect the movement and distribution of other species. For a systematic design with fixed station, it may be more appropriate to determine the start time based on temperature (or equivalent indicators such as ice coverage). An in-depth analysis of historical data might reveal some patterns of suitable temperature (or ice coverage) at which the survey can start.

A sampling site with 100 or more king crab or tanner crab was considered as a crab hotspot. A crab hotspot was sampled 5 nm in four cardinal directions to reduce variance and effect of single large tow. This was done 7 times in 8 years, but was discontinued in 2011 because of potential issues of affecting mean estimates of crab abundance. An adaptive survey, which includes rules of more intensive sampling in an area with high abundance, may be a more effective way to improve the population estimation of patchily distributed crab and fish species.

The survey has been conducted using charter fishing boats, rather than NOAA survey boats. This has been considered as one of the key factors for the success of this survey program. The charter boats are preferred because of collaboration between the AFSC scientists and industry members, fishermen's work experience, and efficiency. I strongly support this approach as long as differences in fishing power between the charter boats are kept minimal.

IV-2. *Evaluate the analytical methodology.*

The analytical methodology has not been thoroughly developed. This may result from the fact that most effort has been allocated to the improvement of field survey and sampling protocols. More effort is needed for developing methods to quantify uncertainty associated with abundance indices and for conducting more in-depth analyses of data collected in the past to evaluate the performance of current survey design and sampling protocols.

Although the survey design is a stratified system design, the analysis was done as if the survey follows stratified random survey design. This may create some issues for estimating variances. For a given stratum *h* in a systematic design, sampling variance of mean $v(\bar{X})$ can be estimated using the following equation:

$$v(\bar{X}_h) = \frac{1-f}{n}\sum_{i=1}^{n-1}\frac{(x_i - x_{i+1})^2}{2(n-1)}$$

where *f* is finite population correction term $f = \frac{n}{N}$ (N is the population size and n is sample size, and *f* can be set as 0 because of small sample size here), x_i is catch at station i, and x_{i+1} is catch at the next surveyed station. This method can be used to estimate sampling variance of mean for each stratum. The overall standard error can then be estimated as $\sqrt{\sum_{h=1}^{H} W_h^2 v(\bar{X}_h)}$, where W_h is the proportion of area for stratum *h* over the total survey area. Alternatively, I believe a computation-intensive method can also be developed to mimic the sampling design for estimating variance (e.g., Smith 1990, 1997).

Some species can only be found in a small proportion of tows in the survey. Methods such as delta estimator may need to be used. Geometric means may also be more appropriate for the species with a few large tows, which may skew the estimation of arithmetic means (Hutchings 1996).

Survey catchability/selectivity may change over the time because of changes in fish availability to the survey, long survey durations, large areas covered by survey programs, systematic survey design (for BS), and large variations in environmental variables over the survey area and duration. It may be necessary to standardize the survey abundance index to remove the temporal trend in selectivity/catchability/availability. The temporal trend in selectivity/catchability/availability identified in the standardization can also be compared with the temporal trend derived in stock assessment models (e.g., SS3) to identify possible differences.

I suggest conducting an analysis of historical data for some key fish species to evaluate the performance of the sampling design (i.e., allocation of sampling efforts among sampling strata). For a given species, I suggest doing the Neyman allocation of sample sizes among strata according to the following equation:

$$n_h = n \frac{W_h S_h}{\sum_{h=1}^{H} W_h S_h}$$

where n is the total sample size, S_h is variance of samples for stratum h, and n_h is sample size for stratum h. The newly estimated sample size for each stratum can then be compared with the current allocation of sampling stations. This can be done for some key species to evaluate if current allocation of sampling efforts needs to be adjusted.

To evaluate the effects of stratifications, I suggest evaluating design effect (d^2) for the historical data which can be calculated as

$$d^2 = \frac{v(\bar{X})}{v_{SRS}(\bar{X})}$$

where $v_{SRS}(\bar{X})$ is sampling variance of mean for simple sampling without stratification (i.e., assuming there is no stratum in the calculation) and $v(\bar{X})$ is sampling variance of mean for designed survey (i.e., current design). Again, this can be done for each year and for each species.

IV-3. Evaluate the procedures used for data quality control and archiving

The procedures used for data quality control and archiving are adequate.

I would like to commend the effort by the AFSC staff for developing and implementing relevant procedures for data quality control and archiving. This is reflected by good documentations and independently developed scripts to retrieve and summarize the data for cross validations.

The EBS bottom trawl survey program provides the most comprehensive set of the data for monitoring the dynamics of many fish species in the EBS. The data have been used by groups/individuals who are interested in the EBS ecosystem. Because of a lack of background in understanding potential issues related to this data set, the data may be mis-interpreted. Currently there is no formal policy/protocol for distributing data to other groups/individuals. I recommend that a formal policy/protocol be developed for distributing data to make sure that the data are used and interpreted properly.

V-4. Evaluate the research approaches to evaluate gear performance and estimate survey catchability.

The research approaches that have been used and proposed are appropriate for evaluating gear performance and estimating survey catchability.

Trawl capture process can be divided into different components, and experiments can be conducted to evaluate each component and subsequently gear performance and survey catchability. Various experiments have been conducted or will be conducted in the near future for evaluating impacts of different gear settings on survey catchabilty. Most experiments are, however, focused on side herding effects and fish/crab escaping from bottom lines, although more recent studies also evaluate impacts of fish vertical distributions on survey catchability. More studies (e.g., tagging, acoustic survey to identify vertical distribution, and comparing catch from varying headlines) are needed to improve our understanding of survey catchability. Although the interpretation of the results may rely on some assumptions, such experiments can improve our understanding of how gear formations, fish behavior and environmental variables (e.g., depth and bottom type) may influence sampling efficiency and survey catchability. In general, I support developing and conducting various experiments to evaluate factors influencing survey catchability. However, I believe that relevant constraints/assumptions associated with the experiments should be made explicit and the results need to be interpreted and applied carefully. For example, in the Pacific cod stock assessment, the trawl-survey catchability coefficient for recent years was constrained so that the average product of q and S over the 60-81 cm size range equals the point estimate in Nichol et al. (2007). However, the study by Nichol et al. (2007) was effectively based on 11 fish mainly from the Gulf of Alaska, and the estimate is associated with a large variation. This creates large uncertainty associated with the current approach.

Both depth and bottom type are important factors in influencing survey catchability. The possible range of depth and bottom type for survey stations should be considered in an experiment for estimating survey catchability. Because the sampling stations are fixed, bottom type for each station can be identified and mapped, which can be used for improving estimates of survey catchability.

For walleye pollock and Pacific cod, I support the research effort to complement the bottom trawl survey with the acoustic survey to improve our understanding of impacts of fish vertical distribution on the estimation of survey catchability.

IV-5. Evaluate the collection of ancillary biological and environmental data in support of an ecosystem approach to fisheries management.

The procedure of collecting ancillary biological and environmental data is outlined. However, limited analyses have been done for the data collected in the past to demonstrate the use of the data in support of an ecosystem approach to fisheries management. I also did not see evidence of conducting any analysis to evaluate the adequacy of the data collected for quantifying ecosystem dynamics.

Information on some key environmental variables (e.g., depth and temperature) has been collected in the survey. However, collection of other variables such as bottom type, which may play a key role in defining habitats of some fish and crab species and influencing survey catchability, tends to be limited. Stomach samples were not taken in a systematic way, and no stratification was considered. Given possible large spatial variability in food availability for many species, large spatial variability of prey compositions can be expected. Without following the survey design, the spatial coverage of stomach content samples is not consistent with that of the survey. If the data were used in estimating prey consumption and/or prey composition for a fish population, the results would be biased.

IV-6. Evaluate whether the survey data could be collected more cost effectively.

The survey data could be collected more cost effectively.

The target towing duration is 30 minutes in the EBS bottom trawl survey. Considering the large quantity of catch in each tow (i.e., about 2 mt/tow on average), this may be too long. The large quantity of catch also complicates subsampling fish for their biological information (e.g., size/age composition, stomach content analysis, and maturation). I recommend that the tow duration be reduced to 15 - 20 minutes. Tow duration may affect species and size composition of catch because of patchiness of invertebrate species' distribution and differences in swimming ability among different size/species of fish (Somerton et al. 2002). Thus, it is necessary to evaluate impacts of tow duration on species and size composition. I suggest selecting some stations randomly by strata (e.g., 33% or 50% stations in a stratum) for 15 or 20 minute tows. The results can be compared with 30 minute tows in the same year and with the historical data which were collected in 30-minute tows to evaluate possible impacts of reducing the tow duration from 30 minutes to 15 or 20 minutes.

A large number of fish/crabs are measured at each sampling station to estimate size composition. This large sample size does not necessarily increase effective sample sizes used to weigh size composition data in stock assessment. I suggest using the historical data to conduct a Monte Carlo simulation study to evaluate and identify an optimal (cost-effective) sampling size for measuring size composition at each sampling station for each species (e.g., Andrew and Chen 1997, Muffett et al.2011).

It has been proposed that the survey be conducted every two years. This will result in a lack of abundance index and size/age composition data for some years. Although a simulation study may help evaluate potential impacts of having only one year of data every two years and some studies may indicate the impacts are small, I believe that the survey should be conducted annually because of its importance to the assessment of so many important fisheries stocks.

IV-7. Provide recommendations for further improvements

There are a lot of discussions about needs of research for further improvements among participants. The participating AFSC scientists also presented their research plan to further improve the survey design and understand factors that may influence the quality of the data collected in the survey. My detailed recommendations are presented in the next section of this report.

V. Conclusions and Recommendations

I would like to commend the effort of all the participants in the CIE review for a very constructive and informative discussion on the EBS crab and groundfish bottom trawl surveys. I was impressed by the breadth of expertise and experience of the participants, the amount of effort spent to improve the survey design and data collection protocol, the openness of discussion for considering alternative approaches/suggestions, and the constructive dialogs between the CIE reviewers and other participants throughout the review. I observed on many occasions constructive interactions and dialogs between scientists and the representatives of the industry in the review. All materials were sent to me in a timely manner and almost all my requests for extra information were addressed promptly.

Overall I believe that the EBS crab and groundfish bottom trawl surveys provide a comprehensive and consistent time series of abundance indices and relevant biological information on many key crab and finfish populations, which are critical to the stock assessment of these populations. The survey design and sampling protocol appear to be scientifically sound and robust, and adequately addresses management needs. However, I believe there is still room for improving the current design and more in-depth analyses can be done. I have made the following recommendations.

- I recommend that an experiment be conducted to evaluate if it is feasible to reduce the tow duration from 30 minutes to 15-20 minutes. I suggest that stations be selected randomly within each stratum (e.g., 33% or 50% stations in a stratum) for 15 or 20 minutes tow. The results are compared with those for the 30 minutes tow in the same year and with the historical data to evaluate possible impacts of reducing the tow duration from 30 minutes to 15 or 20 minutes on the estimation of species composition and size composition.

- Various modifications have been made to gear configurations and operational procedures since the inception of this survey program in the hope that the effective sampling effort can be measured more accurately and sampling efficiency can be standardized. I support all the standardization effort of sampling procedures and gear configurations. I recommend that impacts of any change/modification on survey catchability should be carefully evaluated and necessary corrections/adjustments should be done for the whole time series to ensure the consistency and comparability of data before and after a change/modification.

- A large number of fish/crabs are measured at each sampling station to estimate size composition. This large sample size does not necessarily increase the precision of fish size compositions estimates. I suggest using the historical data to conduct a Monte Carlo simulation study to evaluate and identify an optimal (cost-effective) sampling size for measuring size composition at each sampling station for each species.

- I suggest analyzing the historical data collected from the survey stations in the hotspots and high density areas to evaluate their effectiveness in achieving the goal of setting these sampling stations in the first place. I believe incorporation of an adaptive survey design may be more effective.

- I support to continue conducting more experiments to improve understanding of impacts of different variables on survey catchability. I suggest that such experiments should be designed and conducted in a systematic way.

- Variances associated with mean estimates should be estimated in a way that is consistent with the survey design. I recommend that variance of abundance index within a stratum be estimated based on systematic design. Alternatively, I suggest developing a bootstrap type of approach, which mimics how sampling stations are surveyed in a systematic design, to estimating variance.

- I support the research effort of complementing the bottom trawl surveys with the acoustic surveys to improve our understanding of fish vertical distribution and its impacts on survey catchability.

- For a given species, in-depth analysis of historical data should be conducted to quantify spatial variability among the strata and determine if such variability is consistent over time. The results of such an analysis can help evaluate if the current allocation of sampling effort among the strata is effective in improving the precision of abundance index estimates and if it is necessary to adjust sampling effort among the strata.

- I recommend developing an official policy/protocol for data distributions and utilizations to ensure proper interpretation of the data.

- I suggest standardizing survey abundance index using a general linear model (GLM) and/or general additive model (GAM) including variables that are considered to be important in influencing survey catchability (e.g., boat, temperature, bottom type, location, depth, etc.).

- Because the survey follows a systematic design and lasts for 2 months in a season when many species are experiencing migrations, uncertainty associated with the abundance index derived from the survey may also include biases (i.e., not all errors are random from year to year), it is necessary to standardize survey abundance index to improve data quality BEFORE the data are used in the stock assessment model. Trying to resolve all uncertainties, especially biased errors, within stock assessment models (e.g., SS3) may complicate parameter estimation, resulting in difficulty in the model convergence.

- Effective sample size has been determined rather arbitrarily for size composition in the stock assessment. For example, annual effective sample sizes of 100, 200, and 300 were used for snow crab, walleye pollock, and Pacific cod, respectively, in their stock assessment. The choice of effective sample size can have large impacts on the stock assessment. I suggest more studies be done to re-scale actual sample sizes to effective sample sizes used in the stock assessment. Such re-scaling should reflect temporal differences in data quality among years (rather than current practice of using the same number for all the years).

- A habitat suitability modeling approach (e.g., Chang et al. 2010) can be used to quantify the relationship between fish/crab abundance and environmental variables. The developed model can then be used to identify suitable habitats for the fish/crab, based on the environmental variables (e.g., substrates and ocean observatory or model data). This can lead to the development of potential habitat maps in the EBS for the fish/crab species. For a given species, the map can be used to evaluate whether survey sampling stations cover all the effective habitats. Such an approach can also be used to project possible changes in fish/crab spatial distribution if key habitat variables (e.g., temperature) change. The estimated spatial distribution from such a study can help evaluate and improve survey designs.

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Weinberg, K. L., and D. A. Somerton. 2006. Variation in trawl geometry due to unequal warp length. Fish. Bull., U.S., 104:21-34.

Weinberg, K., and S. Kotwicki. 2008. Factors influencing net width and sea floor contact of a survey bottom trawl. Fish. Res. 93:265-279.

VII-1. Appendix 1: Bibliography of materials provided for review

(1) **<u>Documents received prior to the review</u>**
NOAA-Fisheries Advanced Sampling Technology Working Group (ASTWG) FY05 Annual Report

- Chilton, E. A., C. E. Armistead, and R. J. Foy. 2009. The 2009 Eastern Bering Sea Continental Shelf Bottom Trawl Survey: Results for Commercial Crab Species. NOAA Technical Memorandum NMFS-AFSC-201, Alaska Fisheries Science Center.

- The Plan Team for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands. 2011. Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions Crab SAFE, North Pacific Fishery Management Council, Anchorage, AK 99501.

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- Groundfish Assessment Program literature on trawl catchability, survey standardization, acoustics and survey data analysis.

- Lauth, R. R. 2010. Results of the 2009 Eastern Bering Sea Continental Shelf Bottom Trawl Survey of Groundfish and Invertebrate Resources. NOAA Technical Memorandum NMFS-AFSC-204. National Marine Fisheries Service, Alaska Fisheries Science Center.

- Somerton, David, Ken Weinberg, Scott Goodman. 2012. Snow crab selectivity by the NMFS trawl survey Groundfish Assessment Program, RACE Division, Alaska Fisheries Science Center, NOAA, Seattle, Wa.

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- Wilderbuer, Thomas K., Daniel G. Nichol and James Ianelli. 2011. Assessment of the Yellowfin sole stock in the Bering Sea and Aleutian Islands. NPFMC Bering Sea and Aleutian Islands SAFE. Alaska Fisheries Science Center, NOAA, Seattle, Wa.

(2) **<u>Documents received during the review</u>**

- Sigler, M.F., M. Renner, S.L. Danielson, L.B. Eisner, R.R. Lauth, K.J. Kuletz, E.A. Logerwell, and G.L. Hunt Jr. 2011. Fluxes, fins, and feathers: Relationships among the Bering, Chukchi, and Beaufort Seas in a time of climate change. Oceanography 24(3):250–265, http://dx.doi.org/10.5670/oceanog.2011.77.

- Stabeno, P. J., E. Farley, N. Kachel, S. Moore, C. Mordy, J. M. Napp, J. E. Overland, A. I. Pinchuk, M. F. Sigler. A comparison of the physics of the northern and southern shelves of the eastern Bering Sea and some implications for the ecosystem. Deep-Sea Research II.

- Weinberg, K., and S. Kotwicki. 2008. Factors influencing net width and sea floor contact of a survey bottom trawl. Fish. Res. 93:265-279.

- Wilderbuer, T. K., R. F. Kappenman & D. R. Gunderson (1998): Analysis of Fishing Power Correction Factor Estimates from a Trawl Comparison Experiment, North American Journal of Fisheries Management, 18:1, 11-18.

- Kinderl, T. H. and James D. Schumacher. 1981. Circulation Over the Continental Shelf of the Southeastern Bering Sea. Physical Oceanography: 53-75.

- Kinderl, T. H. and James D. Schumacher. 1981. Hydrographic Structure Over the Continental Shelf of the Southeastern Bering Sea. Physical Oceanography:31-52.

- Munro, P. T. 1998. A decision rule based on the mean square error for correcting relative fishing power differences in trawl survey data. Fish. Bull., U. S. 96:538-546.

- Kotwicki, S., M. H. Martin, and E. A. Laman. 2011. Improving area swept estimates from bottom trawl surveys. Fish. Res. 110:198-206.

(3) <u>Presentations at the review</u>

- Crab Data Analysis: Eastern Bering Sea Bottom Trawl Survey by Robert Foy (Alaska Fisheries Science Center)

- Eastern Bering Sea shelf bottom trawl survey of groundfish and crab resources by Bob Lauth and Robert Foy (Alaska Fisheries Science Center)

- Analytical methods: groundfish general by Bob Lauth (Alaska Fisheries Science Center)

- Data QA/QC Databases by Bob Lauth (Alaska Fisheries Science Center)
- Improving pollock biomass estimates using acoustic data by Stan Kotwicki (Alaska Fisheries Science Center)

- Trawl survey standardization by Ken Weinberg (Alaska Fisheries Science Center)
- CIE Review of the Bering Sea Shelf Bottom Trawl Survey by David Somerton (Alaska Fisheries Science Center)
- Experimental estimation of q by David Somerton (Alaska Fisheries Science Center)

VII-2. Appendix 2: Statement of Work for Dr. Yong Chen

Attachment A: Statement of Work for Dr. Yong Chen

External Independent Peer Review by the Center for Independent Experts

Eastern Bering Sea Crab and Groundfish Bottom Trawl Surveys

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The Alaska Fisheries Science Center (AFSC) requests a Center of Independent Experts (CIE) review of the eastern Bering Sea crab and groundfish bottom trawl surveys. The data from this survey are used in more than 25 stock assessments conducted by the AFSC as well as the State of Alaska and the International Pacific Halibut Commission. Although all AFSC bottom trawl surveys, as well as those conduct by other NMFS science centers, were examined closely during the development of the NOAA Bottom Trawl Protocols in 2004, the AFSC surveys have never been formally reviewed by a CIE panel. The AFSC has conducted considerable research on factors affecting trawl performance and catchability and their impacts on resulting survey estimates of distribution and abundance. However, in recent years the trawl and survey performance and results of this multi-species survey have come under scrutiny by industry, particularly with respect to Bering Sea red king crab, snow crab, and Pacific cod. Considering the importance of the data produced by the Bering Sea bottom trawl surveys, a CIE review in 2012 would be timely and beneficial. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of stock assessment, including population dynamics, survey design and methodology, and statistical analysis. It is not expected that each of the three reviewers have all of these specialized areas of expertise, rather that at least one of the three reviewers should be knowledgeable in each of these areas. Reviewers should also have experience conducting stock assessments for fisheries management. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Seattle, Washington tentatively during April 10-12, 2012.

Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

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

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Each CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. Each CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

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 in the panel review meeting in Seattle, Washington during April 10-12, 2012.
3) In Seattle, Washington during April 10-12, 2012 as specified herein, conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) No later than April 26, 2012, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to David Die ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

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

March 6, 2012	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
March 27, 2012	NMFS Project Contact sends the CIE Reviewers the pre-review documents
April 10-12, 2012	Each reviewer participates and conducts an independent peer review during the panel review meeting

April 26, 2012	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
May 10, 2012	CIE submits CIE independent peer review reports to the COTR
May 17, 2012	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) each CIE report shall be completed with the format and content in accordance with **Annex 1**,
(2) each CIE report shall address each ToR as specified in **Annex 2**,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COTR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
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Key Personnel:

David Somerton, NMFS Project Contact
NMFS Alaska Fisheries Science Center
7600 Sand Point Way NE., Seattle, WA 98115-6349
david.somerton@noaa.gov Phone: 206-526-4116

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

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

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

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

   c. Reviewers should elaborate on any points raised in the 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 CIE independent 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 CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Tentative Terms of Reference for the Peer Review

Eastern Bering Sea Crab and Groundfish Bottom Trawl Surveys

1. *Evaluate the data collection operations and sampling design of the survey in term of their adequacy for producing consistent and precise estimates of relative abundance for the various fishes and invertebrates of concern.*
2. *Evaluate the analytical methodology.*
3. *Evaluate the procedures used for data quality control and archiving.*
4. *Evaluate the research approaches to evaluate gear performance and estimate survey catchability.*
5. *Evaluate the collection of ancillary biological and environmental data in support of an ecosystem approach to fisheries management.*
6. *Evaluate whether the survey data could be collected more cost effectively.*
7. *Provide recommendations for further improvements*

Note – CIE reviewers typically address scientific subjects, hence ToRs usually do not involve CIE reviewers with regulatory and management issues unless this expertise is specifically requested in the SoW.

Annex 3: Tentative Agenda

CIE Review of the Eastern Bering Sea Crab and Groundfish Bottom Trawl Surveys
Alaska Fisheries Science Center
7600 Sand Point Way NE, Seattle, WA 98115
Building 4; Room 2076 (April 10-12, 2012)

Review panel chair: David Somerton, david.somerton@noaa.gov

Survey group leaders: Robert Lauth, bob.lauth@noaa.gov (groundfish) and Robert Foy, robert.foy@noaa.gov (crab)

Security and check-in: Ron Erickson, ron.erickson@noaa.gov
Sessions will run from 9 a.m. to 5 p.m. each day, with time for lunch and morning and afternoon breaks.
Discussion will be open to everyone, with priority given to the panel, presenters, and survey group leaders.

Tuesday, April 10th

0900 Welcome and Introductions. The EBS environment and commercial fisheries (*Somerton*)

0930 The EBS survey (*Lauth & Foy*)

History of the EBS survey, current sampling design including the use of charter vessels. Description of the trawl pre- and post- 1982. Wheelhouse activities and catch processing procedures – i.e. how we do a tow. Area swept estimation – how we do it and why.

10:30 break

11:00 The EBS survey (continued**;** *Lauth & Foy*)

11:30 Database, data editing and QA (*Vijgen*)

12:00 Lunch

13:00 Survey standardization (*Weinberg*)

14:00 Tour of net shed

1530 Analytic methodologies used for the estimation of relative abundance (*Lauth & Foy*)
Area swept estimation: new approaches. Biomass and variance calculation.
The fishing power correction. Post hoc sampling for crab – hot spots and retows.

Wednesday, April 11th

0900 Q research - demersal fish and crabs (*Somerton*)

Snow crab selectivity. Escapement and herding of flatfish. Vertical availability of Pcod. Light and vertical distribution

10:15 Break

10:30 Use of acoustics on the EBS survey (*Kotwicki*)
AVO project (collect acoustics for others). Acoustic and bottom trawl blind zones (combining acoustic and bottom trawl survey for pollock). Using acoustics to estimate Pollock between stations to improve biomass estimate.

12:00 Lunch

1300 Presentations on the survey estimates and uncertainty relative to model assumptions and structure: introduction (*Somerton*)

13:15 Snow crab (*Turnock*)

13:45 Pollock (Ianelli)

14:15 Break

14:30 Discussion between CIE committee and survey scientists

Thursday, April 12th

0900 -1200 Presentations on the survey estimates and uncertainty relative to model assumptions and structure (continued)

noon -1300 Lunch

1300 -1700 Discussion and wrap-up

Appendix VII-3. Panel Membership

Dr. David Somerton, Review Panel Chair (AFSC)
Dr. Normal Hall, CIE Reviewer
Dr. Jon Helge Voelstad, CIE Reviewer
Dr. Yong Chen, CIE Reviewer

Dr. Robert Lauth, Groundfish survey group leader (AFSC)
Dr. Robert Foy, Crab survey group leader (AFSC)