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Bristol Bay Red King Crab Stock Assessment Review

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Executive Summary

The Center of Independent Experts (CIE) requested a review of the population dynamics and harvest strategy models for the Bristol Bay red king crab (*Paralithodes camtschaticus*) assessment. The review was also to examine the potential utility of conducting a dedicated crab survey for eastern Bering Sea stocks including Bristol Bay red king crab (BBRKC). The current NMFS survey is a multispecies survey that has issues with respect to survey timing relative to mating, molting and egg extrusion, survey boundaries and movement, and catchability.

Two CIE reviewers conducted the peer review. Two weeks before the peer review, NMFS made available at an FTP site all necessary background information and reports for the peer review. The CIE reviewers participated in a panel review meeting in Seattle, Washington, from 29 June to 3 July, 2009 to conduct a peer review with the authors of the red king crab assessment. The reviewers met with scientists involved in the RKC fishery including those from the Alaska Fisheries Science Center and the Alaska Department of Fish and Game. The scientists presented the key aspects of their research on the first two days. Copies of the presentations were provided to the reviewers. The CIE panel and other scientists present asked questions on issues of the stock assessment and related research that was presented. All presenters answered questions and expanded on some aspects of the stock assessment and research. The panel sought additional analyses from the authors of the stock assessment report and additional information on bycatch estimates in late 1970s and early 1980s, which was also presented.

The review addressed the following Terms of References:

1. A statement of the strengths and weaknesses of the Bristol Bay red king crab stock assessment and stock projection models;
2. Recommendations for alternative model configurations or formulations;
3. Recommendations of alternative model assumptions and estimators.
4. A review of the results of the Bering Sea Fisheries Research Foundation (BSFRF) Bristol Bay red king crab supplemental survey and its potential contribution to the stock assessment.
5. A review of the cost and benefit of diverting research from studies that would reduce uncertainty in key parameters used in the assessment to conduct a dedicated crab survey.
6. Suggested research priorities to improve the stock assessment.

The key strengths of the BBRKC stock assessment include: (a) a multi-species NMFS research trawl survey conducted since the 1968; (b) resurveys of the NMFS surveys undertaken in some recent years to obtain an improved estimate of mature female crab abundance which are required when water temperature is cold and there is a delayed mating period into early June; (c) a BSFRF dedicated RKC survey has been undertaken in 2005, 2007 and 2008; (d) observer bycatch data of the RKC fishery since 1990 and groundfish trawl bycatch estimates of the RKC fishery since 1976; (e) catch length frequencies by sex; (f) catch and effort estimates; (g) research studies relevant for stock assessment, e.g. growth, selectivity, mortality, stock recruitment, environmental factors affecting recruitment; (h) food web assessment; (i) a length-based stock assessment model has been used to integrate the above information; and (j) decision rule framework that has overfishing and overfished definitions.

Some weaknesses of the BBRKC stock assessment include: (a) use of different natural mortality rates for males and females for different time periods provides a better fit to the data but it is not clear what the biological processes may be to justify this assumption; (b) the complex state/federal decision rule framework in the stock assessment process and the step function being used in the Alaskan state decision framework for setting quotas may make it difficult if the biological estimates are close to the threshold levels given there is some uncertainty with estimates; (c) the stock assessment process does not utilize the fishing effort and catch rate (CPUE) information for the trap fishery; (d) potential underestimate of the Tanner and RKC fisheries bycatch of RKCs that may affect the estimate of natural mortality; (e) the occurrence of the hotspots of abundance of RKCs from the annual trawl survey on the boundary of the trawl area near the coast could result in a significant underestimate of the biomass if there is a high abundance in the non-surveyed areas along the coast; and (f) a useful addition to the stock assessment document would be a description of the life cycle that provides an understanding of the key biological processes taking place over time and space.

Recommendations for alternative model configurations and assumptions are: (a) the move to crab rationalization has resulted in improved economic data collection that can be used to set harvest rate targets for improved profitability of the fishery; (b) average recruitment during 1968-2008, 1985-2008, 1995-2008 were considered in setting overfishing limits - the choice of $B_{35\%}$ should take into account the stock-recruitment relationship so that the level of mature biomass is sufficiently high that if good environmental conditions occur then good recruitments will occur; (c) the assessment of the mature male biomass (MMB) contributing to the mating each year should take into account the decline in molting probability with size which means that the larger males may be contributing proportionally more to mating than smaller males that are molting most years; (d) alternative hypotheses for cause of mortality in the early 1980s should be explored e.g. an additional mortality at different time periods, bycatch in the RKC and/or tanner crab fisheries. Information on size structure should be taken into account to obtain improved estimates of bycatch when observer data was not available as well the effectiveness of the escape gaps and bycatch mortality rates at different levels of catch rate; and (e) sensitivity analysis of trawl survey catchability estimates.

The RKC BSFRF survey is a directed survey using a smaller mesh and a smaller vessel than the NMFS survey. The BSFRF survey has enabled the multi-purpose NMFS survey to be ground truthed and most abundance estimates were similar, though the BSFRF survey may provide a better estimate of smaller crabs. The BSFRF survey sampling approach with short trawl durations results in improved precision of abundance estimates. This survey also provided for an improved inshore sampling regime, but there is still a sampling gap in the inshore area near abundance hotspots as parts of this inshore area may be unsuitable of trawling. The inshore habitat may need to be surveyed first to determine areas suitable for trawling before a RKC survey is planned and this should possibly be a focus for any future BSFRF survey. The sampling approach for high abundance samples ('hotspots') also needs review and one approach be to undertake additional samples near the hotspots area every year as they typically occur in the same area each year.

If the BSFRF survey is to be undertaken on a regular basis then it probably should be undertaken in late June or early July to ensure migration/mating is complete. This avoids the need for resurveys of the NMFS survey that are required when water temperature is cold and there is a delayed mating period into early June which results in an underestimate of mature females. Consideration should be given to see whether any adjustment for mature female abundance can be undertaken for survey abundance undertaken when temperature was cold at the time of the survey (or the ratio of eyed to uneyed eggs was high) and no resurveying was undertaken. An adjustment should be possible based on the water temperature at the time of survey. The timing of previous surveys should be examined to check whether adjustments to the mature female abundance needs to be undertaken in the model for years when the survey was early.

In general there does not appear to be any significant benefit associated from undertaking a dedicated RKC survey that effectively repeats the multi-species NMFS survey. If the timing of the NMFS cannot be changed to accommodate the timing of the mating and migration, then there appears to be some value in undertaking a dedicated RKC resurvey. Consideration should be given to whether the resurvey can be undertaken as a 5-10 min survey to minimize costs.

Some suggested research priorities to improve the stock assessment include:

1. Catch rate (CPUE) assessment of logbook and monitoring data using generalized linear modeling (GLM) taking into account factors such as year, month, location, fishing boat, soak time, fishing power, environmental conditions which provide estimates of standardized annual abundance.
2. Fishing effort can also be analyzed to: (a) undertake an assessment of effective fishing effort that can be used to compare with fishing mortality estimates from the modeling; and (b) compare the spatial distribution of effort since the introduction of the crab rationalization (individual quotas) to assess whether fishers have changed their fishing practices by fishing closer to port to save costs.
3. A depletion analysis of blocks that are heavily fished during a season such that there is a significant decline in catch rate due to the effects of fishing could provide some valuable insights into fishery dynamics.
4. Assessment of nominal and effective fishing effort required to take the TAC is needed to evaluate the relationship between fishing effort and catch which is required for the assessment of catch and effort that targets maximum economic yield.

5. The introduction of crab rationalization has seen the annual collection of economic data on the cost of fishing and revenues. The economic data can be combined with the catch-effort relationship for an assessment of the MEY.
6. A number of closed areas are in place for different fishing methods. Consideration should be given to whether any research monitoring of these closed areas (with appropriate control areas) should be undertaken to assess the effects of the fishing and other biological parameters.
7. A number of studies have examined different factors that may be associated with the declining abundance of crabs in the early 1980s. However when there is such a large magnitude of change that has affected the recruit and adult abundance as well as the spatial distribution of abundance, it is likely that a combination of factors have contributed to the change. A research project should be considered to review and update these studies and consider the combined effects of these factors on the stock. A conceptual model can be developed to examine the relationship between the factors identified as affecting the RKC stocks including:
    a. environmental factors such as Aleutian low may affect recruitment – this factor has decadal variation as well as an annual variation;
    b. the same or other environmental variables may have also affected groundfish abundance which may have resulted in increased predation on RKC;
    c. increased groundfish trawling may have resulted in increased RKC bycatch;
    d. increased groundfish fishing was concentrated in the southern part of RKC stock where there was a high abundance of mature multiparous females due to an ontogenic migration south;
    e. changes in the spatial distribution of RKC occurred during late 1970s and early 1980s with the centre of abundance moving to the northeast and this coincided with a decrease in the area of the cold pool summer near-bottom temperatures in early 1980s;
    f. the change in distribution may have been affected by the changes to the migration pattern due to the environmental effects; and
    g. the decline in the spawning abundance, particularly in the south may have affected the larval dynamics and negatively affected the recruitment.
8. An experimental approach should be considered to assess the effects of fishing on the southern grounds by closing a research area to trawling to determine whether the crab stocks build up there. The two competing hypotheses on decline of the king crab stocks since the 1980's, i.e. regime shift and the effects of increased crab fishing and increased bycatch, may both be contributing to the decline in recruitment. Many stocks quite often collapse when there is the combined effect of poor environmental conditions at a time when the breeding stock is reduced.
9. While research and management changes on escape gaps have been undertaken, there is still considerable retention of undersize crabs, many of which may die as a result of being captured. This makes it imperative to undertake further research (if necessary) to choose the number and size of the escape gaps that maximizes the escape of undersize male and female crabs even if it means that some of the smaller legal-size males are allowed to escape. Additional research on the handling practices should also be undertaken to assess if there are ways to improve them and hence increase survival of discards.

Background

The Center of Independent Experts (CIE) requested a review of the population dynamics and harvest strategy models for the Bristol Bay red king crab (*Paralithodes camtschaticus*) assessment. While a red king crab stock assessment model was developed in 1995 for use in TAC setting, the model has recently been revised for use in setting overfishing levels and determining reference points. An independent review of this revised model was needed to evaluate its suitability in defining overfishing definitions and reference points. The CIE requested a review of the use of Bering Sea trawl survey data in the assessment, the stock assessment model structure, assumptions, life history data, and harvest control rule. New overfishing definitions for Bering Sea crab stocks require the use of the red king crab stock assessment model to estimate reference points and the status of the stock relative to those reference points. Uncertainty exists in several key parameters including the survey selectivity and catchability, molting probabilities, natural mortality, discard mortality and age.

The CIE also requested a review of the potential utility of conducting a dedicated crab survey for eastern Bering Sea stocks including Bristol Bay red king crab (BBRKC). The current survey is a multispecies survey that has issues with respect to survey timing relative to mating, molting and egg extrusion, survey boundaries and movement, and catchability. The CIE review was asked to comment on the costs and benefits of a crab specific survey relative to other research needed to improve the red king crab stock assessment.

Two CIE reviewers conducted the peer review in accordance with the Terms of Reference (ToRs) in Annex 2 of the Appendix. Two weeks before the peer review, the NMFS made available at an FTP site all necessary background information and reports for the peer review. The CIE reviewers participated in a panel review meeting in Seattle, Washington from 29 June to 3 July 2009 to conduct a peer review of the stock assessment with the authors of the red king crab assessment. The reviewers met with scientists involved in the RKC fishery including those from the Alaska Fisheries Science Center and the Alaska Department of Fish and Game. The meeting was chaired by Dr Anne Hollowed. The scientists presented the key aspects of their research on the first two days according to the agenda in Annex 3 of the Appendix. Copies of the presentations were provided to the reviewers. Throughout the presentations the CIE panel and other scientists present asked questions on issues of the stock assessment and related research that was presented. All presenters answered questions and expanded on some aspects of the stock assessment and research. On the third and fourth day the CIE panel met to determine the key issues in the stock assessment modeling that would require some additional comment. The reviewers sought additional analyses from the authors of the stock assessment report and additional information on bycatch estimates in late 1970s and early 1980s (from Turnock and Rugolo) which was later presented. The reviewers then prepared to write their individual reports.

The report generated by reviewers addressed the following TORs:

1. A statement of the strengths and weaknesses of the Bristol Bay red king crab stock assessment and stock projection models;
2. Recommendations for alternative model configurations or formulations;
3. Recommendations of alternative model assumptions and estimators.
4. A review of the results of the BSFRF Bristol Bay red king crab supplemental survey and its potential contribution to the stock assessment.
5. A review of the cost and benefit of diverting research from studies that would reduce uncertainty in key parameters used in the assessment to conduct a dedicated crab survey.
6. Suggested research priorities to improve the stock assessment.

Summary of Findings

The findings of the review have been presented based according to the terms of reference set of the panel:

1. *A statement of the strengths and weaknesses of the Bristol Bay red king crab stock assessment and stock projection models.*

The strength of the BBRKC stock assessment include:

- A multi-species NMFS research trawl survey has been conducted since the 1968 that provides reliable estimates of abundance which are consistent with fishery catch data.
- Resurveys of the NMFS surveys are sometimes undertaken to obtain an improved estimate of mature female crab abundance. These resurveys have been undertaken in 1999, 2000 and 2006-2008 and appear to be required when water temperature is cold and there is a delayed mating period into early June which affects the migration back into the deepwater area (Dew 2008).
- More recently a Bering Sea Fisheries Research Foundation (BSFRF) dedicated RKC survey has been undertaken in 2005, 2007 and 2008 which have provided a cross check to the multi-purpose NMFS survey.
- Observer bycatch data of the RKC fishery since 1990 and estimates of bycatch before 1990 have been made.
- Groundfish trawl bycatch estimates of the RKC fishery since 1976.
- Catch length frequencies, sex and other biological data.
- Catch estimates from the pot RKC fishery and from other foreign fleets in the 1960s and 1970s
- A number of research studies over the years, e.g. growth, selectivity, mortality, stock recruitment, environmental factors affecting recruitment, that have provided valuable information for the stock assessment.
- A length-based stock assessment model has been used to integrate the above information. It was based on the period since 1968 when survey data was available.
- A number of recent improvements have been made in the stock assessment modeling which are summarized in the Executive Summary of the stock

assessment document (Zheng and Siddeek 2009) including (a) all bycatch mortality; (b) extended time series back to 1968; (c) changes in size of maturity over the years; (d) improved catchability estimates based on experimental data; (e) changes weighting factors being based on CVs;

- Decision rule framework that has overfishing and overfished definitions
- Consideration of other research including environmental effects on spatial distribution, predation, and food webs.

Some weaknesses of the BBRKC stock assessment include:

- The use of different natural mortality rates for different periods appears to be justified to explain the declines in abundance in the early 1980s which may be linked to regime shifts, predation, bycatch or effects of trawling. The changes in the mortality rates for males and females for different time periods provides a better fit to the data but it is not clear what the biological processes may be to justify this assumption.
- The model has been developed for the whole stock which hides some interesting spatial dynamics that is occurring in the fishery such as (a) differential rates of migration between inshore and offshore; and (b) changes in the spatial distribution of the spawning stock that may have affected the recruitment abundance and distribution.
- The complex state/federal decision rule framework is a weakness in the stock assessment process. The step function being used in the Alaskan state decision framework for setting quotas (Fig.1 of Zheng and Siddeek 2009) may make it difficult if the biological estimates are close to the threshold levels given there is some uncertainty associated with these estimates. A slope function between the harvest rate and biomass may provide a better representation for the decision rule.
- The stock assessment process does not utilize the fishing effort and catch rate (CPUE) information for the pot fishery. This may be a valuable data set that may enhance the stock assessment process. Further comments on this analysis are provided below.
- Potential underestimate of the Tanner and RKC fisheries bycatch of RKCs that may affect the estimate of natural mortality. Consideration should be given to the effect that: (a) rate of retention for undersize in traps may be greater during periods of high catch rate as escape gaps may not function as well; and (b) higher bycatch mortality rate may be associated with handling in periods of high catch rate.
- One of the hotspots of abundance of RKCs from the annual trawl survey regularly occurs on the boundary of the trawl area near the coast. This could result in a significant underestimate of the biomass if there is a high abundance in the non-surveyed areas along the coast.
- A useful addition to the stock assessment document would be a description of the life cycle that provides an understanding of the key biological processes taking place over time and space. This should include time and place of primiparous and multiparous mating, hatching, larval period and movement, settlement period and location, growth, time and size at maturity, time to legal size, molt frequency and

timing, migration patterns of males and females. Some of this information is directly relevant to the stock assessment and other information may be supplementary to the stock assessment process. Development of a spatial-temporal conceptual model of the life history of RKC and the fisheries affecting it would be useful.

2. *Recommendations for alternative model configurations or formulations;*

3. *Recommendations of alternative model assumptions and estimators.*

Issues associated with TOR 2 and 3 are dealt with together as follows:

- The move to crab rationalization has resulted in improved economic data collection. This provides an opportunity to set harvest rate targets that take into account cost of fishing and revenues and provide management options for improved profitability of the fishery such as maximum economic yield (MEY). The threshold levels can be maintained at the current maximum sustainable yield (MSY) but a new target level for harvest rate and biomass could be developed based on MEY.
- Average recruitment during 1968-2008, 1985-2008, 1995-2008 were considered in setting overfishing limits. The stock assessment document outlines a number of reasons for selecting 1995-2008 (Zheng and Siddeek 2009) which appear to be reasonable. Another consideration in determining the choice of $B_{35\%}$ is the stock-recruitment relationship of the stock assessment document (Fig. 35 of Zheng and Siddeek 2009). The cause of the reduction in the red king crab stocks since the 1980s is critical in determining what should be the target B_{msy} level. If the reduction is due to a regime shift then basing the B_{msy} on the lower levels of mature biomass since the 1980s is appropriate. There is evidence of the negative effect of the increase in trawling since 1980, particularly in the most productive south spawning grounds. If it is not possible to restrict trawling from the more productive RKC spawning areas then basing the B_{msy} on the lower levels of mature biomass since the 1980s is appropriate as the breeding stock may not return to the levels of the 1970s. However it is important that the level of mature biomass be sufficiently high that if good environmental conditions occur then good recruitments are able to occur. The sustained level of poor recruitment in 1985 to 1994, were often associated with low biomass (Fig. 35 Zheng and Siddeek 2009) and target biomass at this level should be avoided. The biomass level in the range of 60-80 million lbs of mature male biomass (MMB) appears sufficient to achieve good recruitment if the environmental conditions are satisfactory. The other option for MMB_{msy} of about 140 million lbs appears overly conservative from a stock recruitment perspective.
- The assessment of the MMB contributing to the mating each year should also be undertaken. Dew and McConnaughey (2005) indicate that about 50% of the MMB contribute to the mating each year i.e. recently molted males are incapable of mating. However the relationship of male molting probability and size indicates that there is a decline in molting probability with size (Fig. 22 Zheng

and Siddeek 2009). This means that the larger males may be contributing proportionally more to mating than smaller males that are molting most years. As the male size distribution can vary between years then an estimate of the 'effective' MMB should be made. If the larger males are proportionally more important in mating females then this may have implications for level of harvesting being allowed. The monitoring of the proportion of mature females with empty clutches and the level of clutch fullness provides an indication of whether there are sufficient males for mating the mature females.

- Alternative hypotheses for the cause of mortality in the early 1980s should be explored e.g. an unknown mortality, bycatch in the RKC and/or tanner crab fisheries. The stock assessment model currently assumes an additional mortality applied to males and female at different time periods. Preliminary estimates of possible bycatch in late 1970s and early 1980s were presented (Turnock and Rugolo) based on some bycatch monitoring in 1982 by Griffin et al. (1983) and applying these data to earlier years. However it was suggested that some assumptions about bycatch to legal catch from 1982 may not be applicable to earlier years as the size structure would have changed. Information on size structure is available from the earlier period and this could be used to obtain improved estimates of bycatch during this period when observer data was not available. Another issue to consider in making these estimates is the variation in total numbers of crabs per pot lift between years as this can affect the effectiveness of the escape gaps. A higher retention rate of undersize would be expected if there was a higher overall abundance of crabs per pot as access to escape gaps is reduced. This hypothesis may be examined for years when bycatch estimates are available. Also the handling mortality of undersize and female bycatch crabs being returned is likely to be higher in years when crabs per pot lift are higher. Fishers will take more time to physically sort and measure the undersize when there are a large number of crabs to be sorted. This increases the time the bycatch crabs spend onboard the vessels exposed to the elements and hence an increased level of mortality may occur. The air temperature has been identified as one of the key factors affecting mortality of bycatch. Currently a constant pot handling mortality rate of 0.2 is assumed and a sensitivity analysis is required.
- Trawl survey catchabilities were estimated in the LBA model but based on a trawl experiment (Weinberg et al. 2004). A sensitivity analysis of these estimates would be worthwhile. Separate estimates were made for 3 periods, 1970-1972, 1973-1981 and 1982-2008 and for males and females (Fig. 21a Zheng and Siddeek 2009). For the two latter periods the estimates of males and females were similar however for the 1970-1972 period the female catchability was much less that for males for sizes greater than 115 mm and the basis for this is not clear.

4. *A review of the results of the BSFRF Bristol Bay red king crab supplemental survey and its potential contribution to the stock assessment.*

The RKC BSFRF survey is a directed survey using a smaller mesh and a smaller vessel. The following observations are made about the survey that was conducted in 2005, 2007 and 2008:

- The BSFRF survey has enabled the multi-purpose NMFS survey to be ground truthed with a targeted RKC survey. Most abundance estimates were similar, however the BSFRF survey may provide a better estimate of smaller crabs due to its smaller mesh that may provide an improved estimate of recruitment to the model. The sampling survey approach with short trawl durations results in improved precision of abundance estimates.
- This survey also provided for an improved inshore sampling regime but there is still a sampling gap in the inshore area as parts of this inshore area may be unsuitable of trawling. This gap is important as this survey confirms the regular existence of an abundance hotspot on the inshore boundary of sampling. It appears that the inshore habitat may need to be surveyed first to determine areas suitable for trawling before a RKC survey is planned.
- If the BSFRF survey is to be undertaken on a regular basis then it probably should be done late in June or early July to ensure migration/mating is complete. This avoids the need for resurveys of the NMFS survey.

5. *A review of the cost and benefit of diverting research from studies that would reduce uncertainty in key parameters used in the assessment to conduct a dedicated crab survey.*

There are two dedicated crab surveys that are complementary to the longstanding multi-species NMFS survey that can be discussed under this TOR. They are the resurvey of the NMFS survey that is sometimes undertaken to obtain an improved estimate of mature female crab abundance and the BSFRF surveys that has been used to verify the abundances being achieved under the NMFS survey. The following observations are made about these surveys (see also comments under TOR 4):

- These resurveys of the multi-species NMFS surveys appear to be required when water temperature is cold and there is a delayed mating period into early June which results in an underestimate of mature females. As the resurveys are focused on crabs then an alternative cost-effective survey strategy may be to use 5-10 min trawls as these have proved effective in the BSFRF survey.
- When resurveys are undertaken then both surveys are used to assess male abundance in the stock assessment model as there does not appear to be a major difference in male abundance between the surveys. However in some years (e.g. 2008) the percent of old shell males appears to increase in the second survey which may be expected if the old shell males are returning from a mating migration. Using both surveys for the estimate of male abundance in the model is a reasonable approach as it utilizes all the survey data. The use of resurvey data

only for female abundance in the modeling is also reasonable as these provide a better representation of the mature female abundance. However consideration should be given to see whether any adjustment can be undertaken for earlier survey abundance undertaken when temperature was cold at the time of the survey (or the ratio of eyed to uneyed eggs was high) and no resurveying was undertaken. An adjustment may be possible based on the water temperature data at the time of survey.

- Dew (2008) also indicated that the timing of survey may affect estimates of mature females. The timing of previous surveys should be examined to check whether adjustments to the mature female abundance need to be undertaken in the model for years when the survey was early,
- The sampling approach required to treat high abundance samples ('hotspots') was discussed. One approach would be to undertake the additional samples near the hotspot so the area of the hotspot is better defined and use a geostatistic approach to estimate the abundance and variance. As the hotspots encountered are typically in the same area when they do occur (about every couple of years), consideration should be given to undertaking multiple samples in these hotspots which is effectively a stratification involving the potential hotspot areas.
- Concern was also raised about whether the samples with zero crabs should be resampled. This is usually unnecessary as it is unlikely that the resample of zero sample will result in a revised abundance estimate that makes a significant change to the overall abundance in the way that a resample of a hotspot abundance can make a difference.

In general there does not appear to be any significant benefit associated from undertaking a dedicated RKC survey that effectively repeats the result in the multi-species NMFS survey. If the timing of the NMFS cannot be changed to accommodate the timing of the mating and migration then there appears to be some value in undertaking a dedicated RKC resurvey. Consideration should be given to whether this can be undertaken as a 5-10 min survey to minimize costs. As discussed above there would be value in exploring the potential of a survey of the currently unsurveyed inshore areas, particularly those areas adjacent to the hotspot abundance areas.

6. *Suggested research priorities to improve the stock assessment.*

Some suggested research priorities to improve the stock assessment include:

1. Catch rate (CPUE) assessment of logbook and monitoring data using generalized linear modeling (GLM) taking into account factors affecting catch rates such as year, month, location of fishing, fishing boat, soak time, fishing power effects, environmental conditions, etc. and providing estimates standardized annual abundance. These analyses may also be used to provide a comparison between the CPUE from the fishery and the abundance in the survey data using a different fishing method (see 1991, Fig. 3 Zheng and Siddeek 2009). A comparison of the spatial distribution of catch and catch rate compared to the survey spatial distribution could also be informative.

2. Fishing effort data can also be analyzed to: (a) undertake an assessment of effective fishing effort that can be used to compare with fishing mortality estimates from the modeling; and (b) compare the spatial distribution of effort since the introduction of the crab rationalization (individual quotas) to assess whether fishers have changed their fishing practices by, for example, fishing closer to port to save costs.
3. A depletion analysis of some blocks that are heavily fished during a season such that there is a significant decline in catch rate due to the effects of fishing could provide some valuable insights into fishery dynamics. A comparison of the daily retained male CPUE in a block (or groups of blocks) and the cumulative legal catch removed from that block(s) over the period that the fishery operates enables an estimate of the residual legal biomass at the end of fishing, the catchability of potting for male crabs and the exploitation rate.
4. An assessment of nominal and effective fishing effort required to take the TAC is required to evaluate the relationship between the level of fishing effort and catch which is required as part of the assessment of catch and effort that targets MEY.
5. The introduction of crab rationalization has seen the annual collection of economic data on the cost of fishing and revenues. The economic data can be combined with the catch-effort relationship for a preliminary assessment of the MEY.
6. A number of closed areas are in place for different fishing methods. Consideration should be given whether any research monitoring of these closed areas (with appropriate control areas) should be undertaken to assess the effects of the fishing and other biological parameters.
7. A number of studies have examined different factors that may be associated with the declining abundance of crabs in the early 1980s (e.g. Dew and McConnaughey 2005, Loher and Armstrong 2005, Zheng and Kruse 2006) and some are referred to in the stock assessment document under ecological considerations. However when there is such a large change in abundance that has affected the recruit and adult abundance as well as the spatial distribution of abundance, it is likely that a combination of events have contributed to the change. A research project should be considered to review and update these studies with additional years of data and consider the combined effects of these factors on the stocks. The factors identified to be affecting the RKC stocks include:

   - environmental factors such as Aleutian low may affect recruitment – this factor has decadal variation as well as an annual variation (Zheng and Kruse 2006);
   - the same or other environmental variables may have also affected groundfish abundance (Zheng and Kruse 2006) which may have resulted in increased predation on RKC;
   - increased groundfish trawling may have resulted in increased RKC bycatch (Dew and McConnaughey 2005);

- increased groundfish fishing was concentrated in the southern part of RKC stock where there was a high abundance of mature multiparous females due to an ontogenic migration south (Dew and McConnaughey 2005);
- changes in the spatial distribution of RKC occurred during late 1970s and early 1980s with the centre of abundance moving to the northeast and this coincided with a decrease in the area of the cold pool summer near-bottom temperatures in early 1980s (Loher and Armstrong 2005);
- the change in distribution may have been affected by the changes to the migration pattern due to the environmental effects;
- the decline in the spawning abundance in the southern area in particular may have affected the larval dynamics which may have negatively affected the recruitment (Loher and Armstrong 2005, Zheng and Kruse 2008).

A starting point for this assessment of factors affecting the RKC stocks may be the development of a conceptual model (see Fig. 1).

8. An experimental approach should be considered to assess the effects of fishing on these productive southern grounds by closing an appropriately-sized research area to trawling to determine whether the crab stocks build up in that area. The two competing hypotheses on decline of the king crab stocks since the 1980's, i.e. regime shift and the effects of increased targeted crab fishing and increased bycatch from trawling, may both be contributing to the decline in recruitment. Many stocks quite often collapse when there is the combined effect of poor environmental conditions at a time when the breeding stock is reduced due to changes in fishing practices.
9. While considerable research on escape gaps and subsequent changes have been undertaken on escape gaps, it appears that there is still considerable retention of undersize crabs, many of which may die as a result of being captured. This makes it imperative to undertake further research (if necessary) to choose the number and size of the escape gaps that maximizes the escape of undersize male and female crabs even if it means that some of the smaller legal-size males are allowed to escape. Additional research on the handling practices should also be undertaken to assess if there are ways to improve them and hence increase survival of discards.

References

Dew, C.B. (2008). Red king crab mating success, sex ratio, spatial distribution, and abundance estimates as artifacts of survey timing in Bristol Bay, Alaska. North American Journal of Fisheries Management 28: 1618-1637.

Dew, C.B. and McConnaughey, R (2005). Did trawling on the brood stock contribute to the collapse of the Alaska's king crab? Ecological applications 15: 919-941.

Griffin, K.L., M.F. Eaton, and R.S. Otto (1983). An observer program to gaterh in-season and post-season on-the-grounds red king crab catch data in southeastern Bering Sea. North Pacific Fishery Mangement Council, 39 pp.

Loher, T. and D.A. Armstrong (2005). Historical changes in the abundance and distribution of ovigerous red king crabs (*Paralithodes camtschaticus*) in Bristol Bay (Alaska), and potential relationship with bottom temperature. Fisheries Oceanography 14: 292-306.

North Pacific Fishery Management Council (NPFMC). 2007. Environmental assessment for proposed amendment 24 to the fishery management plan for Bering Sea and Aleutian Islands king and Tanner crabs to revise overfishing definitions.

The BSAI king and Tanner crab FMP Amendment 24.

Weinberg, K.L., R.S. Otto and D.A. Somerton (2004). Capture probability of a survey trawl for red king crab (*Paralithodes camtschaticus*). Fish. Bull. 102:740-749.

Zheng, J. 2005. A review of natural mortality estimation for crab stocks: data-limited for every stock? Pages 595-612. IN G. H. Kruse, V. F. Gallucci, E.E. Hay, R. I. Perry, R. M. Peterman, T. C. Shirley, P. D. Spencer, B. Wilson, and D. Woodby (eds.). Fisheries Assessment and Management in Data Limited Situations. Alaska Sea Grant College Program, AK-SG-05-02, Fairbanks, AK.

Zheng, J. and G. H. Kruse. 2000. Recruitment patterns of Alaskan crabs and relationships to decadal shifts in climate and physical oceanography. ICES J. Mar. Sci. 57:438-451.

Zheng, J. and G. H. Kruse. 2002a. Retrospective length-based analysis of Bristol Bay red king crabs: model evaluation and management implications. Pages 475-494. IN A. J. Paul, E. G. Dawe, R. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, and D. Woodby (eds.). Crabs in Cold Water Regions: Biology, Management, and Economics. University of Alaska Sea Grant, AK-SG-02-01, Fairbanks.

Zheng, J. and G. H. Kruse. 2002b. Assessment and management of crab stocks under uncertainty of massive die-offs and rapid changes in survey catchability. Pages 367-384. IN A. J. Paul, E. G. Dawe, R. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, and D. Woodby (eds.). Crabs in Cold Water Regions: Biology, Management, and Economics. University of Alaska Sea Grant, AK-SG-02-01, Fairbanks.

Zheng, J. and G. H. Kruse. 2006. Recruitment variation of eastern Bering Sea crabs: climate forcing or top-down effects? Prog. Oceanography 68: 184-204.

Zheng, J., M.S.M Siddeek. 2008. Bristol Bay Red King Crab Stock Assessment in Fall 2008. In the Stock Assessment Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W. 4th Ave. #306, Anchorage, AK.

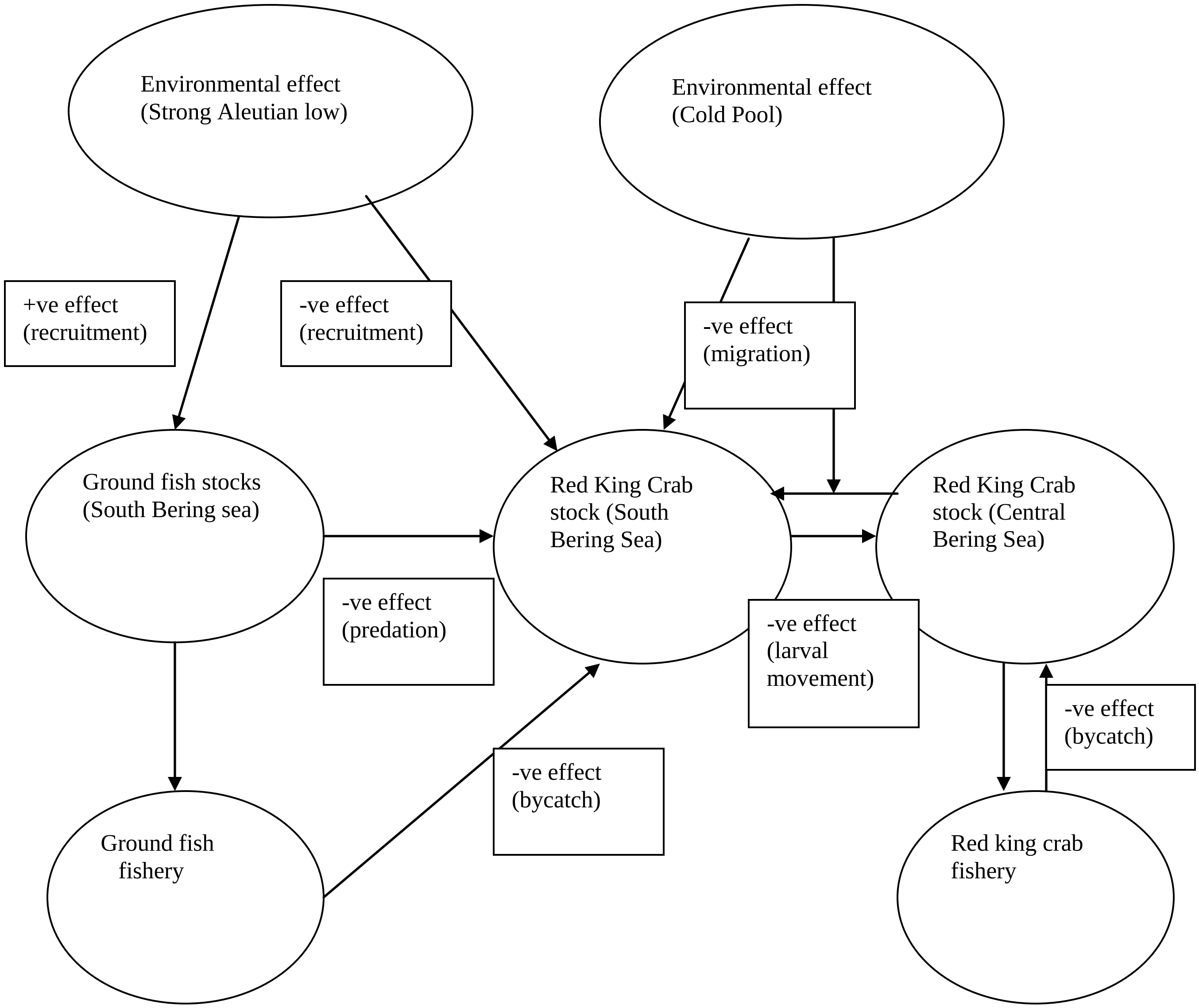

Fig. 1. Example of possible relationships between environmental effects, ground fish stocks and fishery, red king crab stocks and fishery.

Appendix 1: Statement of Work

Statement of Work for Dr. Nick Caputi

External Independent Peer Review by the Center for Independent Experts

Bristol Bay Red King Crab Stock Assessment

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract to provide external expertise through the Center for Independent Experts (CIE) to conduct impartial and independent peer reviews of NMFS scientific projects. This Statement of Work (SoW) described herein was established by the NMFS Contracting Officer's Technical Representative (COTR) and CIE based on the peer review requirements submitted by NMFS Project Contact. CIE reviewers are selected by the CIE Coordination Team and Steering Committee to conduct the peer review of NMFS science with project specific Terms of Reference (ToRs). Each CIE reviewer shall produce a CIE independent peer review report with specific format and content requirements (**Annex 1**). This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project.

Project Description: The CIE requests a review of the population dynamics and harvest strategy models for the Bristol Bay red king crab (*Paralithodes camtschaticus*) assessment. While a red king crab stock assessment model was developed in 1995 for use in TAC setting, the model has recently been revised for use in setting overfishing levels and determining reference points. An independent review of this revised model is needed to evaluate it's suitability in defining overfishing definitions and reference points. The red king crab assessment is a high profile assessment and with the adoption of revisions to the overfishing definitions it is critical that it provides the best available science on the status of this resource. The CIE requests a review of the use of Bering Sea trawl survey data in the assessment, the stock assessment model structure, assumptions, life history data, and harvest control rule. New overfishing definitions for Bering Sea crab stocks require the use of the red king crab stock assessment model to estimate reference points and the status of the stock relative to those reference points. Uncertainty exists in several key parameters including the survey selectivity and catchability, molting probabilities, natural mortality, discard mortality and age. This review will help in the decision process as to which alternative model is most appropriate, given the current state of knowledge of Bristol Bay red king crab.

The CIE also requests a review of the potential utility of conducting a dedicated crab survey for eastern Bering Sea stocks including Bristol Bay red king crab (BBRKC). The current survey is a multispecies survey that has issues with respect to survey timing relative to mating, molting and egg extrusion, survey boundaries and movement, and catchability. The CIE should comment on the costs and benefits of a crab specific survey relative to other research needed to improve the red king crab stock assessment.

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: Two CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein. CIE reviewers shall have the expertise, background, and experience to complete an independent peer review in accordance with the SoW and ToRs herein. CIE reviewer expertise shall include working experience with stock assessment, estimates of survey catchability and selectivity, population dynamics, length based models, knowledge of crab life history and biology, harvest strategy models for invertebrates, and the AD Model Builder programming language.

Location of Peer Review: The CIE reviewers shall participant during a panel review meeting in Seattle, Washington to conduct a peer review of the stock assessment with the authors of the red king crab assessment in accordance to the Schedule of Milestones and Deliverables herein.

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 (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and information concerning other 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., name, contact information, birth date, passport number, travel dates, and country of origin) to the NMFS Project Clearance 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 the CIE reviewers all 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 on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review including the following:

1. Zheng, J., M.S.M Siddeek. 2008. Bristol Bay Red King Crab Stock Assessment in Fall 2008. **In** the Stock Assessment Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W. 4th Ave. #306, Anchorage, AK.
2. North Pacific Fishery Management Council (NPFMC). 2007. Environmental assessment for proposed amendment 24 to the fishery management plan for Bering Sea and Aleutian Islands king and Tanner crabs to revise overfishing definitions.
3. The BSAI king and Tanner crab FMP Amendment 24.
4. Zheng, J. 2005. A review of natural mortality estimation for crab stocks: data-limited for every stock? Pages 595-612. IN G. H. Kruse, V. F. Gallucci, E.E. Hay, R. I. Perry, R. M. Peterman, T. C. Shirley, P. D. Spencer, B. Wilson, and D. Woodby (eds.). Fisheries Assessment and Management in Data Limited Situations. Alaska Sea Grant College Program, AK-SG-05-02, Fairbanks, AK.
5. Zheng, J. and G. H. Kruse. 2000. Recruitment patterns of Alaskan crabs and relationships to decadal shifts in climate and physical oceanography. ICES J. Mar. Sci. 57:438-451.
6. Zheng, J. and G. H. Kruse. 2002a. Retrospective length-based analysis of Bristol Bay red king crabs: model evaluation and management implications. Pages 475-494. IN A. J. Paul, E. G. Dawe, R. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, and D. Woodby (eds.). Crabs in Cold Water Regions: Biology, Management, and Economics. University of Alaska Sea Grant, AK-SG-02-01, Fairbanks.

7. Zheng, J. and G. H. Kruse. 2002b. Assessment and management of crab stocks under uncertainty of massive die-offs and rapid changes in survey catchability. Pages 367-384. IN A. J. Paul, E. G. Dawe, R. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, and D. Woodby (eds.). Crabs in Cold Water Regions: Biology, Management, and Economics. University of Alaska Sea Grant, AK-SG-02-01, Fairbanks.
8. Zheng, J. and G. H. Kruse. 2006. Recruitment variation of eastern Bering Sea crabs: climate forcing or top-down effects? Prog. Oceanography 68: 184-204.

This list of pre-review documents may be updated up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the 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.

Panel Review Meeting: Each CIE reviewers shall conduct the independent peer review in accordance with the SoW and ToRs. **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 in the contract SoW. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). 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 will assist the Chair of the panel review meeting with contributions to the Summary Report. CIE reviewers are not required to reach a consensus, and should instead provide a brief summary of their 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 during the panel review meeting at the NMFS Alaska Fisheries Science Center from June 29 – July 3, 2009, as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Annex 2);
3) No later than July 17, 2009, 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 CIE Regional Coordinator, via email to David Die at ddie@rsmas.miami.edu.
4) Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2;
5) CIE reviewers shall address changes as required by the CIE review in accordance with the schedule of milestones and deliverables.

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

25 May 2009	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
15 June 2009	NMFS Project Contact sends the CIE Reviewers the pre-review documents
29 June - 3 July 2009	Each reviewer participates and conducts an independent peer review during the panel review meeting (June 29-July 3, 2009)
17 July 2009	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
31 July 2009	CIE submits CIE independent peer review reports to the COTR
7 August 2009	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot 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. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the 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 have 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 notification of 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 approved CIE reports to the NMFS Project Contact and regional Center Director.

Key Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
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NMFS Project Contact:

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

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

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, 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 detailed summary of findings, 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 proceedings and findings of the meeting, 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 as separate appendices as follows:

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

Annex 2: Terms of Reference for the Peer Review

Review of the Bristol Bay Red King Crab Assessment

. The report generated by the consultant should include:

1. A statement of the strengths and weaknesses of the Bristol Bay red king crab stock assessment and stock projection models;
2. Recommend for alternative model configurations or formulations;
3. Recommendations of alternative model assumptions and estimators.
4. A review of the results of the BSFRF Bristol Bay red king crab supplemental survey and its potential contribution to the stock assessment.
5. A review of the cost and benefit of diverting research from studies that would reduce uncertainty in key parameters used in the assessment to conduct a dedicated crab survey.
6. Suggested research priorities to improve the stock assessment.

Annex 3:

Bristol Bay Red King Crab Stock Assessment Review

NMFS Alaska Fisheries Science Center

7600 Sand Point Way NE, Building 4
Seattle, Washington
Tentative Agenda June 29-July 3, 2009

Day 1
9:00 Welcome and Introductions
9:15 Overview (species, surveys, fishery, catch levels, bycatch)
10:00 Biology (growth, natural mortality, diets, spawning areas, nursery areas, maturity curves, mating, molting frequency)
11:00 Field experiments on escapement, discard mortality, tagging
11:30 Age Determination, shell condition
12:00 Lunch
1:00 Biology continued
2:00 Harvest control rules and overfishing definition
3:00 Ecosystem considerations - Predation, prey
4:00 Summary of on-going research
Egg viability
Migrations and movement
Larval drift
Spatial modeling
Management Strategy Evaluation

Day 2
9:00 Survey methodology and analysis
12:00 Lunch
1:00 Description of Bristol bay red king crab assessment model

Day 3
9:00 Description of projection model and Continued discussion of assessment model
12:00 Lunch

Day 4 and 5 (day 5 must be off campus in hotel)
Reviewer discussions with assessment authors

Julie Pearce will serve as the point of contact for reviewer security & check-in.