Crab Plan Team Report

The North Pacific Fishery Management Council's Crab Plan Team (CPT) met April 30-May 3, 2013 at the Clarion Suites in Anchorage, AK. The meeting was also broadcast on WebEx. Documents and presentations for the meeting are posted at: tinyurl/ak-crab

Crab Plan Team members present:

Bob Foy, Chair	***(NOAA Fisheries /AFSC – Kodiak)***
Ginny Eckert, Vice-Chair	***(Univ. of Alaska – Fairbanks)***
Diana Stram	***(NPFMC)***
Doug Pengilly	***(ADF&G – Kodiak)***
Jason Gasper	***(NOAA Fisheries – Juneau)***
Wayne Donaldson	***(ADF&G – Kodiak)***
Jack Turnock	***(NOAA Fisheries/AFSC – Seattle)***
Shareef Siddeek	***(ADF&G – Juneau)***
Karla Bush	***(ADF&G – Juneau)***
Martin Dorn	***(NOAA Fisheries /AFSC)***
William Stockhausen	***(NOAA Fisheries /AFSC)***
André Punt	***(Univ. of Washington)***
Bill Bechtol	***(Univ. of Alaska – Fairbanks)***
Brian Garber-Yonts	***(NOAA Fisheries – AFSC Seattle)***

CPT members absent: *Josh Greenberg (Univ. of Alaska – Fairbanks), Heather Fitch (ADF&G – Dutch Harbor)*

Members of the public and State of Alaska (ADF&G), Federal Agency (AFSC, NMFS), and Council (NPFMC) staff present for all or part of the meeting (or WebEx) included: Steve Hughes, Scott Goodman, Ernie Weiss, Brett Reasor, Chris Siddon, Ruth Christiansen, Leah Sloan, Henry Mitchell, Jie Zheng, Wes Jones, Doug Wells, Dick Tremaine, Dan Urban, Denby Lloyd, Vicki Vanek, Dave Fraser, Bill Gaeuman, Matt Eagleton, Jeanne Hanson, Brian Lance, John Olson, Linda Kozak, Edward Poulson, Clem Tillion, Hamachan Hamazaki, Joel Webb

1. Administration

Agenda: An updated agenda with modifications for the meeting was made available and is appended to this report.

Membership: The team welcomed new members Dr. Martin Dorn (AFSC) and Dr. William Stockhausen (AFSC).

Overview of ABSC plan: Ruth Christiansen of the Alaska Bering Sea Crabbers (ABSC) provided an overview of plans for another Industry-sponsored crab symposium on September 17th, 2013 prior to the CPT meeting in Seattle. She also introduced Leah Sloan, an intern working with ABSC to survey of crab fishermen's perspectives and observations post-season on fishing conditions. Ms. Sloan indicated she would be soliciting input from fishermen and CPT members on appropriate survey questions. Results of the survey questions will be presented at the ABSC Science Symposium on September 17th.

2. Handling Mortality

Dan Urban (AFSC – Kodiak) provided a presentation on application of the "reflex action mortality predictor" (RAMP) method to estimating handling mortality of discarded crab in the commercial BSAI crab fisheries.

Urban reviewed information on the short and long term handling mortality of discarded crab relevant to crab stock assessment and development of fishery management measures, with an emphasis on EBS snow crab. Estimates of bycatch biomass during the fishery are multiplied by the handling mortality rate and that product is added to the retained catch biomass to estimate total fishery mortality. Hence, assumptions about handling mortality will affect the time series of estimates of total fishery mortality used in stock assessment models, the determination of annual OFLs, and annual total-catch accounting.

In the EBS snow crab fishery, the discarded catch of snow crab is about 1/3 of the catch of retained crab; the discarded snow crab are mainly males smaller than the size preferred by processors (4 inches carapace width). The EBS snow crab assessment model has been using 0.5 as the handling mortality rate for snow crab discarded during the directed fishery. Urban noted that there is high uncertainty on this value; consensus of the CPT discussion during the presentation was that, rather than being directly estimated from data, the 0.5 value was largely based on balancing the concerns that handling mortality could be close to 100% versus an assumption closer to 0% based on an inferred low retained-crab deadloss rate (~2%).

Urban reviewed the sources of short term handling mortality for discards during crab fisheries, which include trauma at dumping and sorting of the catch, on-deck anoxia, and temperature stress on deck. Temperature stress and freezing is a particular concern for the winter snow crab fishery, which is often conducted during sub-freezing temperatures that are known from laboratory studies to induce mortality in snow crab (e.g., Shirley and Warrenchuck) and to freeze eyestalks (ongoing project). On-deck sorting and discarding may induce short-term mortality, long-term mortality, and long-term reductions in reproductive potential. Short-term mortality can be directly studied and estimated; estimation of long-term effects is more difficult. Long-term effects could include: increased risk to predation, decreased ability to feed or mate, and increased mortality during molting. Laboratory studies have confirmed that increased mortality of molting Tanner crab after exposure to sub-freezing temperatures and freezing of eye stalks could be reasonably assumed to have long-term effects on survival and reproduction.

The RAMP approach provides a means to estimate short-term (< 2 weeks) mortality due to discarding by scoring a suite of reflex responses of crab captured during fisheries prior to their being discarded. Previous studies by Allan Stoner allow short-term mortality rates to be predicted from the RAMP reflex-response scores. With RAMP scores recorded from uninjured snow crab caught on 22 vessels during 2009/10 season, the predicted handling mortality of discards varied from 1.4% to 32% among vessels; overall RAMP-predicted mortality of discards using the data from all vessels was 5.9%. Additional studies on commercial fishing vessels were conducted on one vessel during the 2010/11 snow crab season and on four vessels during the 2011/12 season. The RAMP-predicted handling mortality from the 2010/11 study was 4.6% and from the 2011/12 study was 4.5%.

The predicted handling mortality was negatively correlated with back-deck temperature on the vessel during the time that RAMP-scoring occurred, such that temperature can be used to predict handling mortality; e.g., predicted mortality was approximately 35% at -14° C and <10% at temperatures ≥ -6° C. Directly obtaining back-deck temperatures on all vessels throughout the season is not feasible. Urban therefore used the temperatures recorded at the St. Paul airport as a proxy for on-deck temperatures to extend the results to all vessels fishing. Most of the temperatures recorded at the St. Paul airport during the 2009/10 season were at levels associated with low RAMP-predicted mortality. Urban estimated the average per-season handling mortality rate during the 1990/91–2010/11 seasons to be 4%, with the highest estimate for any single season to be 8% (during the early 1990s) using the historical St. Paul airport temperatures to estimate the freezing-related handling mortality. Urban provided ADF&G's estimates of injury rates of snow crab captured during the fishery. Those estimates of injury rates (from data collected by observers during the 1997/98 and 1998/99 seasons) are approximately 10% (it should be

noted that data on injury rates observed during the 2009/10–2011/12 seasons in conjunction with the RAMP study were lower). Urban suggested that the injury rates could be used to predict short-term mortality due to factors other than temperature.

Urban acknowledged that a determination of the true handling mortality rate is difficult, particularly when considering the long-term mortality. Nonetheless, he felt that evidence from the RAMP studies and the observed injury rates suggest that the 0.5 currently assumed for handling mortality in the snow crab assessment and for determining the OFL is too high. Urban proposed three options for handling mortality rates for use in the snow crab assessment: status quo (handling mortality rate = 0.5, a conservative approach); a constant in the range of 0.15–0.20 (based on adding the highest or average estimate of RAMP-predicted mortality and the highest observed injury rate); or using the historic St. Paul airport temperatures and applying the temperature-mortality relationship to obtain an annual handling mortality rate.

Urban concluded his presentation with a summary of the attempts to develop a RAMP-based method to estimate handling mortality for red and golden king crab. Those attempts were not successful and suggested that the RAMP approach may have no useful application to king crab. Red king crab mortality showed no relationship with reflex-response scores, whereas experimenters had a difficult time inducing the golden king crab subjects to die. Urban noted that one observation from this study was that golden king crab appear to be more hardy than red king crab. As an example, clipping the leg of a golden king crab caused only 3% mortality; significant mortality (80%) required complete severing of the leg.

The CPT discussed how to apply the findings presented for use in the snow crab stock assessment. The CPT was reminded that estimates used in the stock assessment should be unbiased and that conservation concerns due to uncertainty should enter in the consideration of the ABC. Much of the initial CPT discussion focused on the uncertainty related to long-term handling mortality and on the effects due to discarding itself (as opposed to the injuries suffered when brought on deck). The CPT felt that the weight of evidence is that 0.5 is too high, but struggled with reconciling the results presented by Urban with the uncertainty associated with other, long-term effects to survival, growth, and reproduction (e.g., predation, displacement, affects to hormone regulation, additional stresses during molting, etc). Some voiced concerns that, given those uncertainties, the CPT may be placing more weight on the results of recent studies than is warranted. With regard to some of the concerns, it was noted that most of the discards are males > 3 inches carapace width, which Urban noted may have low risk of predation relative to smaller crab. In addition, although the long-term effects will be much higher for crab that will molt, data collected on chela heights of males captured during the fishery suggest that most of the discarded males have already completed their terminal molt.

Discussion provided four options to consider for a total handling mortality rate for snow crab:

- 0.2, derived by summing the highest estimate due to freezing (0.08) with the highest estimate of injury rates (0.12); i.e., one of the options that Urban presented
- 0.25, derived as a balance between the extremes of 0.0 and 0.5; the argument for this was that it was consistent with the approach to obtain the currently-used 0.5, which was derived as a balance between the two extremes of 0.0 and 1.0
- 0.3, derived by taking the "base" of 20% handling mortality that is applied to king crab stocks and adding the highest estimate of freezing-related handling mortality (0.08) and rounding up to the nearest 0.1.
- 0.3, derived by summing the highest estimate due to freezing (0.08) with the highest estimate of injury rates (0.12) to capture the short-term mortality and multiplying that sum by 1.5 to provide an estimate that includes long-term mortality. Since there is no information on long-term

mortality, the CPT agreed that the best first-order estimate of the long-term mortality is 50% of the short-term mortality.

The consensus of the CPT was that the best current estimate of handling mortality of snow crab was 0.3, based on the argument of the last bullet (above). The CPT requested that the next snow crab assessment use 0.3 as handling mortality for all pot fisheries (crab and fish) in the base run and 0.5 as an alternative scenario (there was some discussion as to whether 0.3 or 0.5 should be the base, but if 0.3 is chosen it should be the base run so that the new handling mortality is included in the remaining alternative runs). The 0.5 run should be included so that the effects on OFL, stock status, etc., can be evaluated.

The CPT recommended that the 0.3 handling mortality not be applied to Tanner crab, neither as bycatch in the snow crab fishery or in the directed Tanner crab fishery; i.e., the recommended handling mortality for Tanner crab remains at 0.5 until sufficient data suggests otherwise. Stoner's work suggests that Tanner crab may suffer higher handling mortality than snow crab, but no data were presented at this meeting for Tanner crab similar to what were presented for snow crab. The CPT recommended that a sensitivity analysis on handling mortality be done in the Tanner crab assessment to provide impetus for research on Tanner handling mortality during the snow crab fishery because Tanner bycatch mortality during snow crab fishery has a large effect on the Tanner crab stock assessment, OFL setting, and available TAC.

Discussion turned to the results that Urban presented on king crabs, for which the RAMP approach appears to be not useful. Currently, the Bristol Bay red king crab and the golden king crab assessments assume that handling mortality is 0.2. Although on-deck injury rates for king crab during the red and golden king crab fisheries have been estimated using data collected by ADF&G during the late 1990s, no new data was presented on king crab handling mortality at the meeting. The CPT discussed the apparently greater "hardiness" of golden king crab relative to red king crab and some members of the public suggested that this observation could justify reducing the handling mortality used for golden king crab to less than 0.2. The CPT was unable to recommend a change to the golden king crab handling mortality on the basis of what was presented during the meeting and recommended that it stay at the status quo 0.2 until some data providing estimates of the handling mortality rate are presented. It was noted that both the golden king crab stocks (Aleutian Islands and Pribilof Islands) are currently managed as Tier 5 stocks, for which the assumed handling mortality rates have no impact on the retained-catch portion of the OFL or of the ABC; handling mortality would become an important consideration if the golden king crab stocks become managed under Tier 4.

The CPT emphasizes that handling mortality remains a priority research objective for king crab species and Tanner crab.

3. Advanced sampling

Bob Foy and Martin Dorn provided an overview of the advanced sampling technology (AST) program at NMFS and the work of the AST coordination committee at the AFSC. The AFSC effort is to better align the annual process for funding advanced technology with the assessment needs of FMP species. The CPT was asked to suggest specific technologies that might be important to crab assessment. Tagging methods and assessment of crab in untrawlable areas were briefly discussed. Crab stock assessment authors were asked to fill out a survey, also being sent to groundfish assessment authors, to rank the availability of information for stock assessment, and to identify the most important data gaps in the assessments.

4. Generic crab model overview

The CPT received a presentation from André Punt on progress in developing a generalized crab assessment model. This work will allow more crab stock assessments to be conducted and standardized,

ensuring model code works as intended, and facilitating their review. The project will be informed by initial work by Mark Maunder to develop a modeling framework for crab that was supported by the crab industry. Dr Athol Whitten, a Post-Doc at the University of Washington, has primary responsibility for model development, working under supervision of André. There are two nested projects: (a) to develop a set of AD model builder (ADMB) routines for use in stock assessment models (Common Stock Assessment Routines [Cstar]); and (b) to develop a generic crab model (Generalized Modeling for Alaskan Crab Stocks [Gmacs]) that employs these routines. Gmacs will be written in ADMB, but the analyst will interact with the software by using control files to select among modeling options and by using data files to input assessment data. A script in the R statistical language will be developed to facilitate evaluation of model output.

The development team is proposing that prototype Gmac applications be developed and compared to the Bristol Bay red king crab and Norton Sound red king crab assessments. This comparison is proposed for a crab modeling workshop in early 2014, and is anticipated to be the main (or only) topic of the workshop. The CPT would appreciate receiving an update on progress developing the generic crab model at its September 2013 meeting.

5. Aleutian Islands Golden King Crab

5.1. Assessment

Doug Pengilly provided the CPT with an overview of the Tier 5 assessment for Aleutian Islands golden king crab. The CPT confirmed that the OFL would be a total catch OFL, and that the model-based assessment was not sufficiently well developed to form the basis for setting the OFL for the 2013/14 fishing season. Doug summarized data from the 2011/12 fishery, noting that the catch rate for the 2011/12 fishery was the highest on record. The assessment author recommended that the same approach be used to determine the OFL as in 2012. This approach uses retained catch for the 1996/97-2008/09 seasons, the average annual ratio of bycatch mortality due to crab fisheries to retained catch in the directed fishery for the 1985/86-1995/96 seasons (fewer years for which data are confidential or are not available), and bycatch mortality due to groundfish fisheries for the 1996/97-2008/09 seasons. These choices of years reflect the recommendation by the SSC to "freeze" the years used to calculate the OFL. The CPT endorsed the author's recommendation. The CPT noted that the OFL depends on the assumed value for discard mortality (20% for AIGKC). For this stock, the impact of the choice of the discard mortality rate is limited given that this rate does not feed into a stock assessment.

The CPT recommended an ABC that is 90% of the OFL, as is standard for Tier 5 crab stocks.

5.2. AIGKC Pilot Gear Selectivity Study

The design of, and results from, this study were presented to, and discussed at, the February 2013 Crab Modeling Workshop. Doug Pengilly provided the CPT with an update to the workshop presentation, including the application of the SELECT method to estimate a contact selectivity function. Doug noted that this selectivity function mimicked the fishery selectivity patterns estimated from the preliminary model-based assessments developed during 2012 and 2013.

The CPT noted that the results of the study confirmed that small crab are present where the fishery operates, and that the lack of small crab in recent fishery length compositions likely reflects the impact of changes in fishery practices. The similarity between the contact selectivity functions and the selectivity functions estimated in assessment was somewhat surprising because the latter should reflect both availability and fishery selectivity. Doug suggested, and the CPT endorsed, that the data from the pilot study should be analyzed to account for the paired nature of the experiment.

The CPT discussed the value of the data collected from the study in the context of the model-based stock assessment, as well as the value of future data collection using commercial and research pots. The CPT agreed that the data from the pilot survey could be included in the stock assessment to help inform estimation of incoming recruitment, and to better define the fishery selectivity pattern. However, the data are collected from a fishery rather than a designed survey, which could impact its ability to estimate recruitment, particularly if signs of good (or poor) recruitment are only evident for poorly-selected size-classes. There was a suggestion that the value of the data would be enhanced if research pots could be deployed in a more systematic manner across the fishing area; that, however, would require development of a larger program with additional logistical issues.

5.3. CPUE standardization for AIGKC

Siddeek provided the CPT with an updated CPUE standardization for AIGKC. The analysis was based on the recommendations from the February 2013 Crab Modeling Workshop. The observer catch rates for retained crab were analyzed using both the delta-lognormal and negative binomial error models. The delta-lognormal approach models the probability of a non-zero catch and the catch rate when catch is non-zero independently, while the negative binomial analyzes all data (including the zeros) simultaneously. Siddeek included a new covariate (VesselSoak), which attempts to capture the amount of fishing effort during a year. As recommended by the 2013 Crab Workshop, the analyses included soak time in all models, and modeled the data for 1995/96-2004/05 and 2005/06 onwards separately. The analyses considered interactions among factors, but the final models did not include interactions. During discussion, Siddeek noted a preference for the negative binomial approach.

Siddeek et al. implemented most of the recommendations from the 2013 Crab Workshop, although influence plots were not yet available. The CPT had several suggestions for additional work:

- Estimate the overdispersion parameter when applying the negative binomial GLM, either using maximum likelihood or by profile likelihood. An initial estimate of the overdisperson parameter can be obtained by applying a GLM with a Poisson error model.
- The Q-Q plots for all models appear poor. The authors improved the Q-Q plots for the log-normal component of the model by deleting data points with large residuals. This may be acceptable, but further justification is required, and the features of the rejected data points need to be summarized.
- Pearson residuals are hard to interpret for binomial and negative binomial GLMs. Use of deviance residuals should be examined.
- The performance of the binomial model can be explored by allocating the predicted positive catch proportions to bins (e.g., in steps of 0.025), and computing the observed proportion of positive catches for each bin. A plot of the average predicted proportion versus observed proportion of positive catches should be linear.
- The influence plots should be provided.
- The negative binomial and delta-lognormal approaches lead to different trends in standardized CPUE for the EAG for 1995/96-2004/05. The reasons for this need to be determined.

The CPT anticipates seeing a revised CPUE standardization and an updated preliminary model at the September 2013 meeting.

5.4. Other

Denby Lloyd reported on activities of the Aleutian Island King Crab Research Foundation.

6. Norton Sound red king crab

Toshihide Hamazaki provided an overview of the Norton Sound Red King Crab (NSRKC) stock assessment for the fishing year 2013/14. This assessment was the focus of the February 2013 Crab Modeling Workshop, and the assessment model has been updated based on the recommendations from this workshop. Some of the data now available is bycatch from the summer 2012 commercial fishery because of the addition of observers in this fishery; however, future funding for this program is uncertain. No other fisheries catch king crab as bycatch in Norton Sound. ADFG is also considering terminating the winter pot survey. A CPUE standardization was completed by Gretchen Bishop for the February 2013 Crab Modeling Workshop, and the stock assessment author will take over the revision of this analysis in the future. The models are quite robust to CPUE standardization, so it may not be critical to include standardized CPUE in the model in the future. One of the recommendations from the workshop was to investigate the original NMFS survey data because the authors have based their trawl indices on estimates that they derived rather than estimates that Bob Foy derived from the original data. An analysis of the historical survey data is underway and will be presented at the September 2013 CPT meeting. For this stock assessment, estimates from NMFS reports were used for 1976-1991, but the updated estimates will be used in the future.

The stock assessment author reviewed a series of model runs that varied from the base model in data inputs and parameters. Scenario 1 dropped the summer pot abundance index and associated length composition data. Scenario 2 dropped the standardized CPUE data. Scenarios 3 and 4 estimated Q for NMFS and ADFG trawl surveys, respectively, while the base model sets Q=1.0. Scenario 5 reduced the effective sample size (Max N) to 20. Scenarios 6 and 7 set constant M to $0.24yr^{-1}$ and $0.30yr^{-1}$ respectively, instead of the default M=$0.18yr^{-1}$ for length-classes 1-5 and $0.648yr^{-1}$ for length-class 6. Different runs used different combinations of these scenarios.

Model improvements were minor across all the alternative models; none of the models fit the historical NMFS index data well. All models resulted in a similar fit to index data for 1996-2012 data and had similar 2013 predicted legal biomass. The author recommended runs S3-1, S3-6, or S3-7. Run S3-1 drops the summer pot survey, estimates Q for the NMFS survey, and sets Max N to 20. Runs S3-6 and S3-7 have those settings with M=$0.24yr^{-1}$ and M = $0.30yr^{-1}$, respectively. The run with M=$0.24yr^{-1}$ fits trawl survey best, and that with M=$0.30yr^{-1}$ fits overall the best, but the team noted that one of these two models (S3-6 or S3-7) has not converged, but it is not clear which one. The three models differ in terms of the estimated Q (0.70 for S3-1, 0.88 for S3-6, and 0.41 for S3-7), and the team could not understand why Q responds in this manner (one would expect that Q would change monotonically; that fact that S3-6 and S3-7 do not set M for the final length-class to $0.648yr^{-1}$ may be the reason). The team noted that several of the parameters in Table 11 behave inconsistently among the three runs which may reflect parameters hitting bounds. It is surprising that the parameter SD varies from 1323 to 0 across model options. Molting probabilities are estimated in these three model runs and are quite different.

CPT recommendations

The team selected the S3-1 model as it fit the data better with improved treatment of data from the base model, and the team was not in a position to fully evaluate the S3-6 and S3-7 models. The treatment of survey Qs in model S3-1 is more logically defensible than in the base model. The value for *M* is set to the default ($0.18yr^{-1}$) and still has increased M for the last length bin, but evaluating alternative patterns in *M* should wait until data input issues are adequately addressed. The CPT agreed to use a 10% buffer between the OFL and the ABC, for the same reasons that were selected in the past.

The team is still not confident in the data going into the model and looks forward to continued analysis of the NMFS survey time series. ADFG and NMFS surveys occur in different regions, so disagreement between these series may be a result of different spatial coverage. The 1976-1980 commercial fishery

occurred in a different area than recent fisheries and with little overlap with surveyed areas. The attempt to conduct a reanalysis raises new questions that should be addressed with regards to the utility of these historical data. The recalculated NMFS estimates will be used in the next assessment.

The model runs use a different Q for the different surveys. If ADFG Q is estimated when Q for the NMFS survey is assumed to be 1, then it is estimated to be greater than 1, which is undesirable, so the ADFG Q is set to 1 and the NMFS Q is estimated in model S3-1. The team is concerned about confounding among Q, *M*, and growth, and future runs should consider estimating Q and *M* at the same time.

ADFG has asked the CPT/SSC to set the OFL/ABC earlier, as the fishery can start as soon as the ice goes out. Additionally, the assessment author proposed, and CPT agreed to recommend, shifting the assessment cycle from Oct-Sept instead of July-June. The current cycle ending on June 30 intersects the summer fishery season (June 15-Sept 3). The CPT would like to change the OFL determination to September, as long as the summer fishery data are available.

How the winter fishery data are included in the model for OFL calculation was discussed. In the past, this catch has been small and not that influential, and catch for the previous year was used, but in 2012/13, catch doubled[1], indicating potential to vary markedly. In the future, the winter catch should be projected and included in Table 2.

Additional items to be addressed in the future include the following.

- Future model runs should examine variation in M.
- Future runs should compare the parameter value estimates for NSRKC and those for BBRKC. For example, are molting probabilities similar? Are there tagging data that can be used to inform molting probability?
- The stock assessment author should verify that the assessment document follows the terms of reference for crab stock assessment documents.
- Plots of recruitment for the different models should be included.
- List the bounds for each parameter and evaluate which parameters might be hitting bounds.
- When plotting model runs, always include the base model for comparison.
- Include the discussion of model runs in the main document, not as an appendix.
- Be sure that the figures are titled consistently. In the current document, "total crab abundance" actually means "total male crab abundance" (figures in Appendix D are very confusing and mislabeled) and "Trawl survey legal abundance" actually means "total legal abundance" (Figure 4b) – correct all throughout,
- Be sure that data in tables and figures are consistent.
- Equation 24 is missing the additional variance term.
- Figures all need unique figure numbers.
- All pages must be numbered sequentially, and all pages must have page numbers for ease of review and discussion by the team.

[1] Note: ADFG News Release dated 5/8/13 noted that the 2012/13 winter commercial crab season was the best on record – 19,600 crabs which is more than twice the previous record of 9,625 crabs caught during the 1977/78 season. 2011/12 winter season was ~8,500 crabs (preliminary information from May 2012 News Release).

7. Aleutian Islands Red King Crab Assessment

7.1 Assessment

Doug Pengilly provided an overview of the Aleutian Islands Red King Crab Tier 5 Assessment. There is no assessment model for this stock and standardized stock surveys have been too limited in geographic and temporal scope to provide a reliable index of abundance for the entire red king crab population in the Aleutian Islands west of 171° W longitude. Pengilly discussed historical management of the fishery (Table 1 in the SAFE), specifically, how the geographic scope of the fishery has changed, with the 1990/91 crab season representing a shift from the catch being geographically disperse to primarily occurring on the Petrel Bank. Recent attempts at opening the fishery occurred during 2001/02 when a test fishery was conducted, resulting in opening the directed fishery during 2002/03- 2003/04, after which the fishery was closed due to decreasing catch rates and poor representation of pre-recruit crab in the catch. Subsequent pot surveys on Petrel Bank by ADF&G in 2006 and 2009 showed no increase in the legal red king crab abundance and no signs of pre-recruit males. The fishery has remained closed through the 2012/13 season.

In recent years there has been increased industry interest to conduct a test fishery in the Adak Island area, east of 179° W longitude. For the 2012/13 crab fishing season, the CPT and SSC recommended an ABC of 0.074-million lb (34 t) to accommodate a proposed red king crab survey/test fishery and bycatch in the crab and groundfish fisheries. In late summer 2012, industry decided to forgo the fall 2012 survey/test fishery. At present, it is unknown if industry will request a pot survey in fall 2013.

The CPT discussed alternatives for data collection to improve the assessment. However, the cost of surveying the entire Aleutian Islands area, or even a portion of that area, is high. Robert Foy noted that the existing biennial Aleutian Islands trawl survey does a very poor job catching red king crab and is not likely an option for assessment.

Considering the available information for this stock, the CPT in 2012 recommended a Tier 5 assessment for 2012/13 using the same base years and mortality rates as the 2011/12 assessment. Given the strong recommendation of the SSC in June 2010, Tier 5 total catch OFL would only change if retained catch and/or bycatch estimates changed for the assessment period or mortality rates changed from the 2010 SAFE. The CPT did not identify an immediate need to revise data on retained catch, bycatch estimates for the period 1995/96–2007/08, or the assumed bycatch mortality rates. The CPT noted that prohibited species catch (PSC) in the groundfish fishery could change in the future due to Steller sea lion protection measures and/or changes in processing capacity in the Aleutians.

The CPT recommended the following 2013/14 specifications: recommended OFL is 123,867 lb (0.12-million lb; 56 t) and recommended ABC is 74,000 lb (0.07-million lb; 34 t). These are status quo values established for the 2012/13 season; the 0.07-million lb (34 t) ABC was recommended for the 2012/13 season by the SSC in June 2012 as a value that would "be sufficient to allow for bycatch and groundfish prohibited species catch in non-directed fisheries and the proposed test fishery catch" (June 2012 SSC minutes, page 10).

7.2 ACDC Proposal

In a letter to the Council, the Adak Community Development Corporation (ACDC) requested that the Council and NMFS remove red king crab in that portion of Registration Area O between 171° W and 179° W from the BSAI King and Tanner Crab FMP. Unlike the area west of 179° W longitude, the red king crab fishery between 171° W and 179° W longitude was not included in the BSAI crab rationalization program. Advocates for this request argued that the Tier 5 management of this stock does not allow for any increase in the OFL or opportunity for a commercial fishery in response to any indications of increases in stock levels. This change would confer full management authority to ADF&G

for that portion of the stock. The Council requested that the CPT review the request and provide recommendations through the CPT report to the Council. Clem Tillion spoke to the proposal during the CPT meeting, indicating the importance of the crab resource to benefactors local to Adak and Atka. He indicated the fishery would likely occur in State of Alaska waters and anecdotal evidence suggests abundance around Adak may be adequate to support a small fishery. He also cited recent a Alaska Board of Fisheries action to limit vessels to 60 feet and limit the number of pots fished to 10 within state waters of Registration Area O between 171° and 179° W longitude.

The CPT had two broad concerns with this request: biological concerns about stock structure and how that corresponds with dividing the stock; and management implications caused by overlapping State and Federal jurisdictions.

7.2.1 Biological Concerns

The Area O red king crab stock west of 171° W longitude is managed under a single OFL and ABC. Information about stock structure is highly uncertain in the Aleutian Islands. Genetic information suggests a break in stock structure somewhere in the Aleutians Islands between Bristol Bay and Aleutian Islands/Russian stocks. However, CPT members were not aware of any definitive information that would delineate stock structure in the Aleutians. Genetic information is limited and based on samples collected from 1988 labeled as "Adak" in Grant and Cheng (2012) without specification of the sample location(s). The CPT discussed the potential of localized populations in the Aleutians, but information about stock structure on a fine scale is lacking. The CPT also discussed the large historical catch, the likelihood that the stock is now at much lower abundance than historically, and the role that small localized populations could play in the population dynamics of red king crab at larger scales, The CPT also noted that a limited incidental or exploratory fishery is now being proposed.

7.2.2 Management Issues

Twelve of the original 22 FMP stocks were removed from the FMP by Amendment 24 because federal management of those stocks was no longer necessary. The majority of the catch of those stocks occurred in State waters or the State had either closed the directed fisheries or managed the fisheries as limited incidental or exploratory fisheries. The Council and NMFS found that the State had a legitimate interest in the conservation and management of those stocks. It was not immediately clear to the CPT that the Aleutian Islands red king crab stock between 171° and 179° W longitude could be removed from the FMP under the criteria described in Amendment 24. No record of CPT discussions on Amendment 24 pertaining to removal of stocks from the FMP could be found and made available as a reference. The CPT noted that, although possible, no information or data had been presented as evidence that the red king crab east of 179° W longitude are a distinct stock from the red king crab west of 179° W longitude (see Section 7.2.1 of this report). In addition, a summary of fish ticket landing data that was presented during the meeting showed that of the total 1.95 million lb harvested during the 1985/86–2011/12 seasons (seasons with only confidential data were excluded), 62% of the harvest between 171° W longitude and 179° W longitude occurred in federal waters.

The CPT also discussed the process associated with removing the crab from the FMP and specifically that National Standard 1 would no longer apply. There was concern about the coordination of management between the State and NMFS due to fishery mortality occurring in both State and Federal waters (e.g., groundfish PSC). Thus, the management issues are wedded to biological issues that involve coordination, which is not fully addressed in the proposal.

Should the Council wish to go forward, the CPT recommends the following considerations prior to initiating an amendment analysis that would remove the eastern portion of Area O red king crab from the FMP:

- develop a clear rationale as to when a stock should be removed from an FMP. This rationale should be consistent with the rationale associated the removal of the crab stocks not currently included in the FMP and, if possible, provide a discussion about why the proposed area was not rationalized;
- characterize the current level of knowledge on stock structure and whether this information supports dividing the stock as proposed;
- describe management scenarios and complexities between State of Alaska and Federal management. In particular, analyze the complexity associated with managing State and Federal fisheries east versus west of the dividing line, including an explanation about how groundfish PSC mortality could be handled;
- investigate whether this type of small scale fishery can be accommodated under the current Tier 5 ABC setting process;
- characterize groundfish bycatch by reporting area and/or at a smaller spatial scale if possible;
- provide the ratio of total catch for the eastern and western portion of Area O as defined by the proposed dividing line; and
- where possible, provide the ratio of catch in Federal versus State waters for BSAI King and Tanner Crab FMP stocks and stocks removed from the FMP under Amendment 24.

8. Pribilof Islands Golden King crab

Doug Pengilly presented the Tier 5 assessment for Pribilof Islands golden king crab. Two recommendations were made by the SSC regarding the Pribilof Islands golden king crab assessment: 1) groundfish data should be summarized by calendar year, rather than by crab fishery year, to be consistent with the calendar-year (1 January – 31 December) fishery season that this stock is managed under; and 2) use data on this stock from the NMFS EBS slope trawl survey to bring forward Tier 4 assessment calculations.

There are no changes to the Tier 5 assessment at this time. The recommended 2014 OFL (0.20 million lb) is the same as last year. The fishery would start in January 2014. The recommended 2014 ABC (10% buffer) is 0.18 million lb, the same as last year. In the last 10 years there has been either no fishing or very few vessels fishing, requiring the catch to be confidential; <3 boats have participated in the fishery during the last three years. There is 100% observer coverage in this fishery. The GHL has been 0.15 million lb since 2001.

Bill Gaeuman (ADF&G) reported on the proposed Tier 4 assessment for Pribilof golden king crab using the NMFS biennial slope survey data. Gaeuman briefly reviewed the survey and survey methods. The highest CPUE of golden king crab during the survey tends to occur in the Pribilof Canyon area, which is also the area the commercial fishery typically targets. The survey covers depths from 200 to 1,200 m with about 200 tows. The slope survey is a random stratified survey with 30 strata. The biomass estimates considered in the assessment are those for 2008, 2010 and 2012 because data for these years contain size measurements, allowing estimates of numbers of mature males (>107mm) and legal size males (>124mm) to be derived.

Craig Rose and Dave Somerton (both AFSC) communicated via email that the catchability of the slope net is less than 1.0 and probably considerably lower than the shelf net due to the differences in the foot rope and surveyed habitat. There are no studies comparing catchability of king crab for the slope survey net to shelf survey net. The shelf net has mudsweep roller gear constructed of 203 mm solid rubber disks strung over 16 mm high-tensile chain. The slope footrope is likely to allow crabs to pass below the net, while the shelf footrope is designed to hug the bottom continuously (while not actually digging into it). The forward parts of the slope footrope are also not directly attached to the net, providing additional

escape opportunities. In addition to lower catchability of the net, much of the rocky habitat preferred by golden king crab is not sampled by the slope survey.

The CPT felt that the proposed Tier 4 assessment presented by Gaeuman was overly complicated and that the approach should be simplified; a true Tier 4 assessment is problematic, given the limited years of survey data available, the biennial survey schedule of the survey, and the difficulty in estimating a B_{MSY} proxy with limited years of survey data. A suggestion was made that the survey biomass values could be used to inform the ABC from the Tier 5 assessment rather than estimate the OFL. However, the CPT recommended using the survey data to calculate an OFL without an estimate of B_{MSY} proxy, an approach that falls between Tier 4 and Tier 5 in the BSAI crab tier system, but which is conceptually the same as application of the groundfish Tier 5 harvest control rule.

The CPT recommends for September 2013 that mature male biomass for 2008, 2010 and 2012 be averaged to estimate current biomass, with F=*M* applied to estimate an OFL. The retained catch portion of the OFL and ABC could then be estimated by subtracting bycatch projections from the estimated OFL or ABC. The CPT discussed alternative areas to use for biomass estimation that may better represent the stock: 1) Pribilof Canyon slope survey strata; 2) the Pribilof District as established in state regulations (approximately 54.5 N to 58.7 N); or 3) the total slope survey area.

If the slope survey biomass estimates are useful, the CPT should request improved data collection for crab. The CPT also noted that it would like to see maps of abundance by tow or by spatial areas from the slope survey for the September meeting.

9. Snow crab

The September 2012 snow crab assessment model fit a linear growth function to determine mean growth per molt. The model applied a single intercept, but sex-specific slopes. The priors for the intercept and male slope were based on male growth data collected by Rugolo, and the prior for female slope was based on Canadian data. Model estimates of mean growth were lower for males and higher for females than the values used in the priors.

Somerton et al. (2013) estimated snow crab growth parameters based on several data sets. The best estimates came from four data sets: (1) Transit study (14 crabs); (2) Cooperative seasonality study (6 crabs); (3) Dutch harbor holding study (9 crabs); and (4) NMFS Kodiak holding study (6 crabs held less than 30 days). Separate linear models were used for post-molt vs. pre-molt data, with a break point at 36.1 mm CW. A stepwise process was applied, starting with the first data set and adding the next data set if growth is not significantly different from the growth in the data set constructed to date, to establish the linear growth models.

The current assessment included the Somerton et al. growth estimates plus two additional scenarios (1 &2) and compared standard model outputs (biomass, length compositions, residuals) with that of the September 2012 base (2012) model:

- Scenario 1: Two linear growth models with parameters equal for males and females, a likelihood penalty with the Somerton et al. growth parameter estimates and standard errors, and a separate penalty for the break point of the two linear models.
- Scenario 2: As for Scenario 1, but with separate parameters for males and females.

Mean growth for scenario 1 for male crab was less at small sizes and higher at larger sizes than the base model. Estimated growth for female crab under scenario 1 was higher than for the base model. Mean growth for scenario 2 was very similar to that for the base model. Estimated female growth was lower in the first 2 sizes bins and higher at larger size bins compared to the base model.

In relation to the September 2012 assessment, the CPT recommends:

1. Use a handling mortality of 0.3 in the assessment as recommended by the CPT (see Section 2 of this report).
2. The use of a penalty for the break point in the linear models is not the best approach. For the September assessment, re-parameterize the growth model to eliminate the need for this penalty.
3. Instead of using Somerton et al's parameter estimates as priors, use the actual data sets in the assessment model.
4. Omit female data from Somerton et al's data set for growth estimation.

10. Tanner Crab

William ("Buck") Stockhausen described his progress after assuming responsibility for the Tanner crab assessment, particularly with respect to analysis of recruitment data. Preliminary efforts have focused on the model code, including improving documentation, optimizing code, standardizing data inputs, moving hard-coded initial values for parameters to a "control" file, addressing CPT and SSC comments on differentiability, and providing parameter bounds checking. For a Tier 3 stock, there is no reliable SR relationship and$F_{35\%}$ and $B_{35\%}$ are consequently used as proxies for F_{MSY} and B_{MSY}. Because $\bar{R}$ used when calculating the BMSY proxy represents the average recruitment over a long time period when a stock is harvested at MSY, the decision issues for specifying recruitment are the time period to be considered (including potential break-points) and the method for computing averages.

Recruits were defined as model recruitment at a 5-yr lag from fertilization. The time series of model-estimated $\bar{R}$ and MMB shows large uncertainty in the early part of the time series, especially the late 1960s to early 1970s when MMB was large. Recruitment declined during the 1970s and remained moderately stable thereafter. The CPT discussed the period when the stock was at a total $F/F35\% > 0.25$, but recognized the real issue is whether the stock is above B_{MSY}. The previous assessment considered five scenarios for determining $\bar{R}$: (1966–72, 1966–88, 1982–2012 [SSC choice in 2012], 1966–2012, 1990–2012 [CPT choice in 2012], and additional options such as the time series start year. Recruitment CVs by fertilization year were <0.3 after ~1977 (except for 2012; the most recent years will usually be more uncertain), with a wide range of CVs (including very high levels when recruitment was small) before 1977. The use of ln(R/MMB) lagged back to fertilization year showed limited decadal-scale variability with a fairly consistent long-term mean and no particular breakpoint evident. However, plotting ln(R/MMB) against MMB indicated two primary periods of stock productivity, with the period after 1980 showing a more rapid decline in recruitment with increasing MMB, suggesting higher density dependence.

To compute "average" recruitment, analyses evaluated data on both arithmetic and log scales (the latter consistent with the Tanner crab stock assessment model approach; TCSAM), and four averaging methods: (1) simple average (no error structure considered); (2) variance-weighted; (3) covariance-weighted; and (4) process error plus covariance weighted. The arithmetic scale error structure did not match that used in TCSAM and variance increased with the estimates; suggesting variance is more proportionally similar for all data points. The log-scale structure, following the TCSAM approach, found variance to be more independent of the estimates. However, this approach resulted in estimates of median recruitment, instead of the mean. A shift in the covariance-weighted estimate for the log-scale approach was indicated ~1982, likely due to higher recruitments and higher variability in the early years. The CPT suggested starting the analysis from 2012 and moving backwards as an alternative future evaluation. The author's suggested use of an arithmetic scale w/standard averaging was noted to ignore observation error, suggesting a preference for use of the log-scale approach. The author noted that methods involving process error and the unweighted (standard) approach provided similar answers on the log-scale, with the standard approach being simpler, but the CPT cautioned that the covariance-weighted approach was actually the most appropriate choice and yielded different estimates when the time period included years before 1980.

Examination of potential breakpoints for the $\bar{R}$ time period involved fitting a regression of ln(R/MMB) against MMB for the entire time period, and comparing the resulting fit with the relationship when the parameters were assumed to change at a year in the time period (the breakpoint). Many potential breakpoints were considered. The "best" breakpoint according to AIC_c was for fertilization year 1985, although there were several other candidate years (e.g., 1974 and 1986) which led to similar values for AIC_c. In terms of options for estimating long-term recruitment, the recruitment workshop had suggested dropping the most recent one or two years of data as being less informed, although these years have little influence in the author's analysis because of high uncertainty.

Breakpoints in 1974 and in 1986 led to different conclusions regarding how the SR relationship changed at the breakpoint. For a breakpoint in 1974, the two periods are characterized by a change in intercept term in the regression, suggesting a downwards scaling of the SR relationship. For a breakpoint in 1986, there was a change in the slope parameter, indicating a stronger density-dependence in the SR-relationship.

Future efforts will focus on examination of a Beverton-Holt SR model and model averaging. A major aspect will include examination of potential environmental drivers of recruitment patterns, including a risk-based approach to identifying productivity regimes. The author was commended for a thorough analysis and clarity in presenting the analysis and results.

11. Bristol Bay red king crab

Jie Zheng presented potential modifications to the Bristol Bay red king crab stock assessment model for September, and reviewed responses to comments from the September 2012 CPT and October 2012 SSC meetings. The author presented seven scenarios for evaluation:

- Scenario 0: base model
- Scenario 1: The same as Scenario 0 except that:
    - The effective sample sizes are: Min(0.5*observed-size, N) for trawl surveys and min(0.1* observed-size, N) for catch and bycatch, where N is the maximum sample size (200 for trawl surveys, 100 for males from the pot fishery and 50 for females from pot fishery and both males and females from the trawl fisheries.
    - The model starts in 1975.
    - Newshell and oldshell males are combined to compute the length-composition likelihood.
    - Two levels of molting probabilities are estimated: one before 1980 and one after 1979.
- Scenario 2: As for scenario 1, except that there are no additional mortalities and maximum effective sample sizes for the trawl length-compositions are 1 during 1980-1984 and 20 during 1976-1979 and 1985-1993.
- Scenario 3: As for scenario 1, except that another set of survey selectivity parameters is estimated for 1980-1984, there are no additional mortalities, and the maximum effective sample sizes for trawl surveys are 100 during 1980-1984.
- Scenario 4: As for scenario 1 except that length/sex compositions and survey biomasses from BSFRF surveys are used instead of mature male abundances.
- Scenario 5: As for scenario 1, except that the model starts in 1983.
- Scenario 6: As for scenario 1, except that the model starts in 1985.

Zheng recommends starting the model in 1975 due to a number of problems with the pre-1975 survey data, including inconsistencies in spatial coverage, timing, and gear. The CPT would like to see the 1968 – 1974 data before removing it.

The CPT made the following recommendations:

- The Terms of Reference should be followed as a rule, not an option.
- The author should step-through all the changes between the base model and scenario 1 and present the key outputs after each change (trajectory of MMB, fit to survey, and likelihoods).
- How the molt probabilities are estimated in scenario 1 should be described better.
- Model 3 had the poorest fit to the data, leading the CPT to wonder if there is a retrospective pattern in the recruitment estimates. The author should present a retrospective analysis of recruitment estimates in the next report.
- In relation to scenario 4, the CPT was unsure whether catchability for the NMFS survey was estimated rather than being pre-specified
- The CPT would like to see more detail in both the SAFE and by presenting the likelihoods since what was provided to date made it difficult to know what was done.
- The model should be run to allow estimation of Q for the NMFS survey.
- The rationale for the extra CV of 0.5 in scenario 4 should be given and the author should use the maximum likelihood estimate for the log CV term in equation 12.
- Scenarios 2, 3, 5 and 6 should not be considered further.
- Plots to validate sample sizes should be included in the assessment document.
- Along with presenting the base model in September 2013, the author should focus on scenario 1 which has a better retrospective pattern and fits the trawl survey better, and scenario 4 which includes almost all of the BSFRF survey information (but was incorrectly implemented for the May 2013 meeting).

12. Saint Matthew blue king crab

Bill Gaeuman gave a brief update on the recently-concluded directed fishery for Saint Matthew Island blue king crab and discussed the model scenarios he plans to include in the fall SAFE chapter. The retained catch in the 2012/13 directed fishery was 1,616,054 lb (379,386 crab at 4.26 lb/crab), which was 99% of the 1.630 million lb TAC. The retained catch in 2011/12 was 1,881,000 lb, which was about 75% of the available TAC (2,539,000 lb). Although the final numbers on groundfish fishery bycatch are still incomplete, Bill was confident that the OFL would not be exceeded (i.e., overfishing did not occur during 2013/13). Fishery-reported CPUE of retained legal male CPUE was 10.2 crab/pot, which was an increase from 9.0 crab/pot in 2010/11. Seventeen vessels hauled a fishery-reported 37,065 pots. The estimated discard CPUE for females was 4.5 crab/pot, while that for males (mostly sublegal) was 11.6 crab/pot. In terms of weight, the estimated discard weight of females was 244,832 lb (discard ratio = 0.1515 discard female weight/ retained male weight) while that for males was 999,853 lb (discard ratio = 0.6187 discard male weight/retained male weight). The spatial pattern of the fishery in 2012/13 was similar to that in 2011/12.

Saint Matthew Island blue king crab is a Tier 4 stock. Status determination and OFL setting are based on a B_{MSY} proxy and an estimate of mature male biomass at spawning in the current year (e.g., Feb. 15, 2013) derived from a stock assessment model. The assessment involves a male-only, stage-based model incorporating three size classes (90-104 mm CL, 105-119 mm CL, and 120+ mm CL). The 120 mm CL is used as the proxy for the legal measurement of 5.5 in carapace width (CW), whereas 105 mm CL is used as the proxy for mature-male size. Data inputs to the model include fishery data from the directed pot fishery (retained catch numbers, stage proportions, and total catch numbers), bycatch biomass in the groundfish trawl and fixed gear fisheries, and fishery-independent data from the NMFS annual trawl survey (swept area biomass estimates, stage proportions, and total number of crab measured) and ADF&G pot survey (abundance index, stage proportions, and total number of crab measured).

The base model and six alternative scenarios were addressed in the Fall 2012 SAFE chapter. These included different weighting on likelihood components, fixing or estimating various trawl survey selectivity parameters, and fixing or estimating natural mortality (*M*). Bill intends to repeat these scenarios in the fall 2013 for re-consideration by the CPT and SSC, and to add a seventh alternative scenario requested by the CPT and SSC that combines features of two of the six models. This seventh scenario merges aspects of scenarios B and C (as described in the Fall 2012 SAFE chapter) and incorporates two time periods for *M*.

Bill noted that it was difficult for the model to successfully estimate parameters in the growth transition matrix. André Punt commented that he was able to estimate parameters in the growth transition matrix in a 5-stage model he had previously developed.

13. Research priorities

Diana Stram presented the Team with the proposed revised process for organizing and updating research priorities. A subset of plan team members, SSC members, Council and AKFIN staff have been meeting to develop the structure for a relational database for use in organizing and evaluating annual priorities. Currently Council and AKFIN staff have created a spreadsheet (which could be turned into a database) using the SSC/Council's 2012 list of research priorities. Each of the existing 2012 research priorities has been entered into the spreadsheet. The content is unchanged. In some cases, if a 'single' 2012 research priority encompassed multiple issues, the priority was divided. For each priority in the spreadsheet, staff added multiple descriptive fields as requested by the SSC in June 2012 (related council action, species/fisheries/issues affected), as well as 'status of research' fields. In April, the SSC revised these descriptive fields, added additional fields and made other revisions to the proposed database structure. The changes will be incorporated into the current spreadsheet for the June 2013 SSC review. Once finalized, staff will develop the database and design a process to automate a web-based dashboard for revising and inputting new research priorities, and for the production of reports. This dashboard would have different tools for Plan Teams that are reviewing research priorities, and SSC members that are reviewing Plan Team comments and finalizing SSC recommendations. There would be automated reports available, e.g., for each Plan Team (including only those priorities assigned to each team); for the SSC (to review Plan Team recommended revisions and priorities); or for the Council (amalgamating the SSC's final list of recommended priorities, or perhaps reporting on research priorities that have been on the list for a long time, but remain unaddressed.)

Staff also envisions that there could potentially be multiple web-based report formats that would be publicly available, based on a user's interest. For example, a member of the public could search for all research priorities that are related to salmon, or view the status of all research priorities that are underway. These report formats would ideally also be developed and made available over the summer. The CPT was presented with the revised fields as modified by the SSC. Currently staff are proposing that the spreadsheet/database will be maintained by Pacific States Marine Fisheries Commission (AKFIN); they can prepare a web interface and standardized reports that would allow authorized users to propose and make changes to the priorities as part of the process.

The team revised the wording in the existing priorities (see attached in strike-through and bold) and then individually prioritized them using a system of numerical scores to rank each priority according to their ability to improve crab stock assessments and to monitor crab fishery impacts. The individual scores were then summed and proved (see attached table). Per team suggestion, this list also includes the standard deviation to better evaluate to what extent the numerical score is an accurate portrayal of the relative consensus on prioritization.

The CPT had the following comments on the process and prioritization of the research priorities:

- Crab research priorities as revised by the Team annually should be consistent with the ones formulated by the Team the previous year (i.e., not starting from the SSC's priorities);
- Prioritization should be done consistently and reflect relative consensus;
- Better tracking of how research priorities are used by agencies such as NPRB on an annual basis

14. Norton Sound mining

Jeanne Hanson (NMFS), Matt Eagleton (NMFS), Brian Lance (NMFS) and John Olson (NMFS) provided an overview of concerns related to current mining activities in Norton Sound and the potential cumulative effects of current recreational mining as well proposed offshore mining on EFH habitat for red king crab in Norton Sound. This issue was referred for comment by the CPT from the Council in April and in conjunction with recommendations thereof by the Council's ecosystem committee.

The Crab Plan Team expressed strong concerns with the current and potential future mining activities as it pertains to juvenile and adult habitat on EFH. The Team encourages that the Council pursue immediate consultation with the Corps of Engineers specific to this issue and to provide information to Alaska DEC in their State permitting process to highlight and consider this concern.

The Team indicated that these areas deeper than 30 ft have the potential to be important as nursery areas for juvenile red king crab. Additional analyses should be conducted to verify this prior to any increased disturbance, such as an assessment of the cumulative impact of varying scales of recreational and commercial dredging on life-history stages of red king crab. Important considerations would include the timing of larval release, nearshore larval drift studies, and ontogenetic movement. If the area is a critical nursery or mating area then the footprint of the dredging operations could extend well beyond an estimate of the operational footprint as environmental disturbances such as plumes and vibration may grow exponentially.
Additional specificity on the items that should be addressed are listed below:

1- An assessment of the impact of the different scales of the recreational fishery previously and currently, as well as a comparison of the relative scale of a proposed commercial fishery. No estimate of the relative scales of the dredging operations nor their potential disproportionate scale of impact compared to their operational footprint has been done.
2- Analysis of the cumulative effects of dredging operations and impacts on different life history stages of red king crab: what is likelihood of the region being important to juvenile king crab? The team notes this is very difficult to ascertain, but studies must look at timing of larval release, life-history stages and timing in the nearshore, and larval drift data; ADFG survey data to the east includes new information on juveniles, suggesting that the juveniles surveyed there have moved from nearby regions. Ontogenetic movement should be studied: look at patterns of recruitment to deeper waters from juveniles to adults; if no regional studies are available then comparison should be made with studies in other areas to better inform information in this region.
3- More specific analysis of habitat requirements for red king crab relative to biogenic structure and other substrate characteristics.

Members of the public noted that the area where these dredges are currently operating is the same area where the fishery has observed very small crab. Subsistence fishing is contingent on sea ice movement and when the first storm arrives. The data being used to characterize the area are not representative of importance of the area as they were not collected during sea ice departure. Subsistence fisherman in Nome are extremely concerned with the impact of the cumulative recreational mining on subsistence fishing as well as the potential impact of the larger scale commercial fishery.

15. Economic SAFE report

Brian Garber-Yonts provided an update on the process for producing the 2013 Crab Economic SAFE appendix. Under Amendment 42, which goes into effect this year, the reporting deadline for Annual Crab Economic Data Reports (EDRs) will shift from June 30 to July 31. In previous years, the Economic SAFE authors have endeavored to incorporate the most current EDR data into the document for inclusion with the annual SAFE produced for the October Council meeting. This required rapid processing and analysis of data received in early July, and subsequent document production in advance of submission deadline for the September CPT meeting, which has not been met consistently. Due to the later deadline for EDR submission going into effect this year, it is no longer a realistic timeline to deliver the Crab Economic SAFE report with the most current EDR data incorporated prior to the September CPT meeting/October Council meeting. For 2013, the Crab Economic SAFE document will be updated and presented in combination with the Groundfish Economic SAFE at the Groundfish PT meeting in October and forwarded to the Council for the December meeting. Brian will coordinate a discussion between plan team leads and economists over the summer to review objectives for informing the plan teams regarding socioeconomic information from the Economic SAFE documents, and develop a consistent framework/outline for the economic summary sections to be produced for inclusion in the summary chapters of the respective SAFE reports. Brian also presented information on US import/exports of king and snow crab that is a preliminary product of ongoing research being conducted by Mike Dalton at AFSC to develop a model using export prices, exchange rates, and other current data available to make short-term price projections for Alaska ex-vessel and first wholesale crab markets. The results of this research are expected to be available for review and incorporation in the 2013 Crab Economic SAFE.

16. Egg Production Index

Joel Webb (ADF&G) reviewed the results of research on reproductive potential of eastern Bering Sea snow crab in collaboration with Gordon Kruse, Laura Stichert, and Ginny Eckert. The project started in 2006 and was motivated by a CIE review that suggested that egg production could be more informative than MMB in stock assessments (Bell 2006). The abundance of females across shell conditions varies over years in the trawl survey, so this project examined how reproductive potential might be affected. Fecundity varies among shell condition groups, and years. In general SC3 females have greater or similar fecundity to SC2 (primiparous) and greater fecundity then SC4 & SC5. Changes in fecundity were not detected within a reproductive season, suggesting that embryos are not lost during the brooding period. Fecundity is 10% higher for SC3 and SC4 females with an indicator of recent mating, suggesting that mating success may influence fecundity. This effect could be direct (sperm limitation) or indirect (e.g., females in better condition acquire greater sperm reserves than those that are not), providing evidence for potential sperm limitation. Comparing published estimates of fecundity among stocks, female snow crabs in the Bering Sea have 15-20% lower fecundity (at similar size) to crabs from Canada or Japan. Clutch fullness index is a relatively good index of fecundity. Additional research on sperm reserves indicated that EBS females have lower sperm reserves than other stocks, and there is a north-south gradient, with southern females having higher sperm reserves, potentially because availability of mates is different along this geographic gradient.

The abundance of mature females in the EBS is much higher and more variable than the abundance of mature males, so this project evaluated if this pattern drives variability in reproductive potential. Joel developed a conceptual model to look at fluctuations in shell conditions within a year to track the proportion of the population in a biennial reproductive cycle. The inferred proportion of SC3 females that are biennial is highly variable as a function of bottom temperature and shell condition and varies from 0 to > 60%. Females are smaller in the north than in the south by about ~15-20% (Orensanz et al. 2007). Inter-annual egg production is highly variable over time as a result of variation in clutch fullness, cold bottom temperatures that result in a shift to biennial reproduction, and proportion of primiparous females

in the population. The resultant egg production index that takes into account all of these factors is not significantly correlated with male abundance and predicts reduced reproductive potential in the mid to late 1990s in contrast to the high abundance of crabs at that time.

Feedback from the CPT suggested an interest to see this work published ASAP, that this is an impressive body of work, and that a next step would be to integrate this work with the snow crab stock assessment model. The current version of the stock assessment model does not rely on shell condition index, as it is not informative to understanding male population dynamics. The conceptual model of transitions between shell conditions used by Joel, while based on the best available information (Enrst et al. 2005, Fonseca et al. 2008, Ernst et al. 2012) , includes broad assumptions. When asked why indices of abundance were used in correlation analyses rather than biomass, Joel responded that females reach a terminal molt and thus do not change in size through the reproductive lifespan.

The team moved to a larger discussion of how to address female reproductive potential for other species and stocks using the presented work as a model for other species/stocks. The team questioned if this work could be used to better estimate better stock-recruit relationships. There is a need to look at the relationship between female reproductive potential and MMB to move away from the MMB, because we still need to consider effect of fishing, which occurs only on males. One contribution of this work is to help inform what other pieces of information are needed to move towards adding females to the stock assessments. The NMFS survey has recently added measurements of fecundity for a small sample size of each stock.

The Team noted to reflect any future directions for this work in research priorities.

17. BBRKC spawning effects and Crab PSC limits

Diana Stram provided an overview of recent Council action in February on two different discussion papers related to crab bycatch management measures and closed area efficacy. The first paper discussed issues related to Bristol Bay red king crab spawning areas specifically while the second addressed alternatives for establishing PSC limits for all ten BSAI crab stocks under the Crab FMP. The BBRKC paper was requested following issues raised by the CPT during the 5-year EFH review. The Crab PSC limits consideration was also initially raised by the CPT after the annual catch limit(ACL) amendment (Amendment 38) to establish ACLs and Accountability Measures for crab stocks. At that time the team noted that PSC limits in groundfish fisheries may be necessary to avoid exceeding an ACL. Currently the AM is that should an ACL be exceeded, the impact (in setting a larger ABC-TAC buffer the subsequent year) would be born solely by the directed crab fisheries. Furthermore that State has requested some guidance on establishing appropriate buffer levels for setting TAC below ABC by crab stock.

Following discussion of the relative complexity of the PSC analysis and the objectives of continuing it as well as a related discussion on the efficacy of the current Bristol Bay red king crab closures in conjunction with proposed additional habitat related measures for that stock, the Council requested an expanded discussion paper on four stocks: Bristol Bay red king crab, Bering sea Tanner crab, Bering Sea snow crab and St. Matthew blue king crab. Information to be included in this paper will include an evaluation of the existing closures for these stocks as well as information on the stock distribution and amount of PSC by groundfish gear type. Diana noted that no prioritization was placed on this discussion paper and thus it is unlikely to come back for Council review in the next year. The Council also recommended that the BSAI Groundfish Plan Team work together with the State to provide estimates of crab bycatch mortality in the respective groundfish fisheries by crab stock. This would help to reduce the uncertainty in projecting these estimates annually in TAC-setting and assist the State in estimating an

appropriate buffer level for groundfish fishery crab bycatch below the ACL. Some discussion of this is anticipated at the September Groundfish Plan Team meeting.

18. New business

Model workshop: With the approval of the Council the team intends to host a modeling workshop in 2014 to address the generic model output comparison with BBRKC and NSRKC. January 14-17, 2014, Anchorage

Upcoming CPT meetings: September 17-20, 2013 AFSC Seattle; May 13-16, 2014 Juneau (T)

The meeting adjourned at 12pm on Friday May 3rd.

North Pacific Fishery Management Council Crab Plan Team Meeting
April 30-May 3, 2013
Clarion Suites Downtown
1110 West 8th Ave., Anchorage, AK
DRAFT AGENDA 04/29/2013 version

Tuesday, April 30		
9:00	**Administration**	Introductions, approve agenda, SAFE assignments, research priorities assignments, overview of ABSC survey plans
	Handling mortality	Update on studies to evaluate
9:15		
10:15	**Advanced sampling**	Update on advanced sampling technology
10:45	**Generic crab model overview**	Update on progress towards formulation of a generic crab model for assessment purposes
11:30	**AIGKC and CPUE**	Assessment review; AIGKC commercial pot-selectivity pilot study (Vanek-Pengilly-Siddeek) , OFL and ABC recommendation Review recommendations of workshop; progress on CPUE analysis
Noon		Lunch
1:00	**AIGKC**	Continue discussion, recommendations for future of CPUE and model development
3:00	**NSRKC**	Review final assessment including model changes and CPUE analysis; OFL and ABC recommendations; plans for review in April annually
Wednesday, May 1		
9:00	**NSRKC**	Continue as needed, model modification recommendations for Sept mtg.
10:30	**Adak RKC**	Final assessment, OFL and ABC recommendation; Discussion of proposed removal of eastern portion (e of 179W) from FMP (Council request to review and comment)
11:00	**PIGKC**	Final assessment, OFL and ABC recommendation; Tier 4 assessment considerations
Noon		Lunch
	Snow crab	Review any proposed model modification for final September assessment(T)?
1:00		
2:00	**Tanner crab**	Progress on model modifications, review of any additional issues with respect to final September assessment
3:00	**BBRKC**	Review proposed model modifications for final September assessment
~~1:00~~	~~**St Matthew BKC**~~	~~Review assessment changes for 2012/13; discuss model(T)?~~
Thursday, May 2		
9:00	**Research Priorities**	Review and revise
11:00	**Norton Sound mining**	AKRO discussion of proposed mining; CPT input
Noon		Lunch
1:00	**Economic SAFE**	Review progress (T)
1:30	**Egg production index**	Progress towards and use of for crab stocks [in place of MMB]
3:30	**BBRKC spawning effects and Crab bycatch limits**	Review Council action in February; plan for future analyses
4:00	**Report review**	Review recommendations, finalize
Friday, May 3		
9:00	**Report review**	Continue as needed
10:00	**Plan Team workgroups**	Update on progress of Plan Team workgroups: survey averaging, recruitment, catch accounting, others?
11:00	**New business**	Model workshop 2014, CPT meeting 2014, CPT agenda topics for Sept 2014 mtg.
Noon	**Adjourn**	

Crab Team ranking for Research Priorities

Number	Description	Average priority	Std deviatio	Rank	Std Dev
138	Continuation of State and Federal annual and biennial surveys	1.15	0.55	0%	11%
101	Life history research on non-recovering crab stocks	1.31	0.63	2%	18%
107	Improve handling mortality rate estimates for crab	1.43	0.65	4%	24%
157	Develop and validate aging methods for crabs.	1.43	0.65	4%	24%
143	Alternative approaches to acquire fishery-independent abundance data for Aleutian Islands golden king crab	1.54	0.66	7%	40%
151	Acquire basic life history information (e.g., natural mortality, growth, size at maturity) for data-poor stocks.	1.54	0.66	7%	40%
110	Maintain the core data from the eastern Bering Sea (e.g. biophysical moorings, stomach data, zooplankton, age 0 surveys)	1.62	0.65	11%	31%
164	Develop spatially explicit stock assessment models	1.62	0.65	11%	31%
105	Spatial distribution of male snow crab	1.67	0.65	15%	36%
163	Expanded studies to identify stock boundaries	1.69	0.95	16%	96%
116	Tagging studies of king crab	1.73	0.65	18%	29%
111	Biomass indices and alternate methodologies for lowest tier species	1.77	0.83	20%	78%
136	Effects of trawling on female red king crab and subsequent recruitment	1.77	0.60	20%	15%
113	Research on spawner - recruit relationship	1.83	0.83	24%	80%
149	Quantitative female reproductive index for the surveyed BSAI crab stocks	1.85	0.69	25%	47%
194	**Research the role of habitat in fish population dynamics, fish production (growth, reproduction), and ecosystem processes**	1.91	0.70	27%	49%
147	Effects of the environment on survey catchability, particularly for Tanner crab and Aleutian Islands golden king crab	1.92	0.76	29%	55%
160	Develop and evaluate standard climate variability scenarios on recruitment and growth	1.92	0.76	29%	55%
191	Improved habitat maps	1.92	0.76	29%	55%
103	Methods for reliable estimation of total removals	2.00	0.85	35%	82%
148	Research on survey analysis techniques for species that exhibit patchy distributions	2.00	0.91	35%	95%
173	Evaluate the effectiveness of setting ABC and OFL levels for data-poor stocks	2.00	0.78	35%	64%
195	**Evaluate efficacy of habitat closure areas and habitat recovery**	2.00	0.63	35%	20%
162	Develop projection models to evaluate (a) management strategies and (b) forecast seasonal and climate related population shifts	2.08	0.76	42%	55%
170	Continue to evaluate the economic effects from crab rationalization programs on coastal communities.	2.08	0.95	42%	98%
180	Conduct prospective analyses of the robustness of alternative management strategies under varying environmental cond	2.08	0.64	42%	22%
192	Develop a GIS relational database for habitat, with historical series spatial intensity of interactions between fisheries and habitat.	2.08	0.86	42%	85%
125	Thresholds for ecosystem indicators	2.08	0.79	49%	69%
212	**Maintain moorings.**	2.09	0.83	51%	75%
220	**Collect, analyze, and monitor diet information**	2.09	0.83	51%	75%
139	Conduct routine subsistence use, fish, crab, and oceanographic surveys	2.14	0.86	55%	87%
144	Expand cooperative research efforts to assess seasonal diets and movements of fish and shellfish	2.14	0.66	55%	44%
179	Conduct pre- and post- studies of the benefits and costs, and their distribution, associated with dedicated access privileges	2.15	0.90	58%	93%
102	Catch accounting of crab sex and size	2.17	0.72	60%	51%
197	**Develop bottom and water column temperature database**	2.18	0.87	62%	89%
214	**Measure and monitor fish composition**	2.18	0.98	62%	100%
215	**Assess the movement of fish to understand the spatial importance of predator-prey interactions in response to environmental variabil**	2.18	0.75	62%	53%
217	**Assess whether changes in pH would affect managed species, upper level predators, and lower trophic levels.**	2.18	0.87	62%	89%
221	**Ecosystem structure studies**	2.18	0.60	62%	16%
156	Improve estimates of natural mortality (M) for Pacific cod and crab stocks.	2.21	0.80	71%	71%
213	**Monitor seasonal sea ice extent and thickness**	2.27	0.79	73%	65%
216	**Collect and maintain time series of ocean pH**	2.27	0.79	73%	65%
189	Quantify the effects of bycatch reduction of PSC species in groundfish fisheries on target fisheries	2.31	0.85	76%	84%
198	**Maintain sea ice formation and retreat index for the EBS**	2.36	0.81	78%	73%
196	**Develop a multivariate index of the climate forcing of the Bering Sea shelf**	2.45	0.52	80%	9%
178	Analyze current determinants of demand for principal seafood products	2.46	0.78	82%	62%
140	Identification and integration of archived data (e.g., surveys)	2.54	0.66	84%	38%
218	**Assess the synergistic effects of ocean acidification, oil, dispersants, and changes in temperature on productivity of marine species.**	2.55	0.69	85%	45%
161	Climate information overing a wider range of seasons is needed.	2.57	0.65	87%	27%
176	Develop forecasting tools evaluating climate and market demands.	2.62	0.65	89%	31%
134	Assess whether Bering Sea canyons are habitats of particular concern	2.69	0.48	91%	7%
174	Examine interactions between coastal communities and commercial fisheries	2.71	0.47	93%	5%
208	**Ecosystem indicator synthesis research.**	2.73	0.47	95%	4%
177	Develop an ongoing database of product inventories	2.85	0.55	96%	11%
219	**Monitor contaminant flux and loads in lower and higher trophic levels, and assess potential for impact on vital rates.**	2.91	0.30	98%	2%
159	Evaluate hybridization of snow and Tanner crabs.	2.92	0.28	100%	0%

Immediate_Flag	Y
Assigned to Plan Team	(Multiple Items)

2013 Evaluation of 2012 Research Priorities - Immediate Concerns

	Res_Title
Fish and Fisheries Monitoring	
101	**Life history research on non-recovering crab stocks** **Status: No Action** PlanTeam Priority: (blank) Non-recovering stocks. A pressing issue is why certain stocks have declined and failed to recover as anticipated (e.g., Pribilof Island blue king crab, Adak red king crab). Research into all life history components, including predation by groundfish on juvenile crab in nearshore areas, is needed to identify population bottlenecks, an aspect that is critically needed to develop and implement rebuilding plans.
102	**Catch accounting of crab sex and size** **Status: Partially Underway** PlanTeam Priority: (blank) Improvements are needed for catch accounting by sex and size for crab (~~genetic samples~~) in non-directed fisheries with high bycatch rates, particularly for blue king crab in the Pacific cod pot fishery in the Pribilof Islands. (currently under discussion)
103	~~**Methods for reliable estimation of total removals**~~ ~~**Status: No Action**~~ ~~PlanTeam Priority: (blank)~~ ~~Develop methods for reliable estimation of total removals (e.g., surveys, poorly observed fisheries) to meet requirements of total removals under ACLs.~~
105	**Spatial distribution of male snow crab** **Status: Partially Underway** PlanTeam Priority: (blank) There is a need to characterize the spatial distribution of male snow crab relative to reproductive output of females in the middle domain of the EBS shelf (partially underway)
Stock Assessment	
107	**Improve handling mortality rate estimates for crab** **Status: Partially Underway (snow crab)**

PlanTeam Priority: (blank)

Improve estimate of discarded crab handling mortality rate. Improved understanding on the post-release mortality rate of discarded crab from directed and non-directed crab pot fisheries and principal groundfish (trawl, pot, and hook and line) fisheries is required. The magnitude of post-release mortality is an essential parameter in the determination of the overfishing level used to evaluate overfishing in stock assessment and projection modeling. Empirical data exist for snow crab so new handling mortality data are needed for Tanner and king crab by size, sex, and fishery type with consideration of temperature..

110

Maintain the core OCEANOGRAPHIC AND ECOSYSTEM data from the eastern Bering Sea (e.g. biophysical moorings, stomach data, zooplankton, age 0 surveys)

Status: Underway

PlanTeam Priority: (blank)

Maintain the core oceanographic and ecosystem data from the eastern Bering Sea needed to support a diverse suite of models used to support the integrated ecosystem assessment program for the Bering Sea. Core data include inputs for single- or multi-species management strategy evaluations, food web, and coupled biophysical end-to-end ecosystem models (e.g. biophysical moorings, stomach data, zooplankton, age 0 surveys).

111

Biomass indices and alternate methodologies for lowest tier species

Status: ~~No Action~~ partially underway

PlanTeam Priority: (blank)

Develop biomass indices for lowest tier species including biomass indices by size, maturity and sex classes (Tier 5 for crab, Tier 6 for groundfish~~).such as sharks, and conduct net efficiency studies for spiny dogfish.~~ Explore alternative methodologies for Tier 5 and 6 stocks such as length-based methods or biomass dynamics models.

113

~~**Research on spawner - recruit relationship**~~

~~**Status: Underway**~~

~~PlanTeam Priority: (blank)~~

~~New information and data are needed that would inform our understanding of the spawner - recruit relationship for groundfish and crab with sufficient skill to project year-class strength (e.g., Tanner crab, GOA pollock, sablefish, halibut). (Underway)~~

116

Stock separation studies~~Tagging studies of king crab~~

Status: No Action

PlanTeam Priority: (blank)

Conduct studies to evaluate stock boundaries (e.g, Bristol Bay red king crab, Adak red king crab, Pribilof blue king crab). [~~a tagging studies of all red king crab in the region north of Bristol Bay to assess the movement between this region and the Bristol Bay registration area. Similar work on blue king crab in Bristol Bay relative to the Pribilof Islands is needed.~~]

Fishery Management

125

Thresholds for ecosystem indicators

Status: No Action

PlanTeam Priority: (blank)

Initiate/continue research on developing and evaluating thresholds for ecosystem indicators, including ecosystem-level management strategy evaluation.

Evaluate habitats of particular concern

134

Assess whether Bering Sea canyons are habitats of particular concern

Status: Partially Underway

PlanTeam Priority: (blank)

Assess whether Bering Sea canyons are habitats of particular concern, by assessing the distribution and prevalence of coral and sponge habitat, and comparing marine communities within and above the canyon areas, including mid-level and apex predators to neighboring shelf/slope ecosystems. (partially underway)

Fishing Effects on Habitat

136

Effects of trawling on female red king crab and subsequent recruitment

Status: Partially Underway

PlanTeam Priority: (blank)

Research is needed on the effects of trawling on the distribution of breeding and ovigerous female red king crab and subsequent recruitment. Relevant studies include effects of potential habitat modifications on the distribution of females, particularly in nearshore areas of southwest Bristol Bay (partially underway), and environmental effects (e.g., trawling overlap in warm vs. cold years). Retrospective studies, the use of pop-up tags to identify larval release locations, and larval advection using Regional Ocean Modeling System would help address this need.

Ongoing_Flag	Y
Assigned to Plan Team	(Multiple Items)

2013 Evaluation of 2012 Research Priorities - Ongoing Concerns

	Res_Title
Fish and Fisheries Monitoring	
138	**Continuation of State and Federal annual and biennial surveys** **Status: Underway** PlanTeam Priority: (blank) Continuation of State and Federal annual and biennial surveys in the GOA, AI, and EBS, including BASIS surveys and crab pot surveys, is a critical aspect of fishery management off Alaska. It is important to give priority to these surveys, in light of recent federal budgets in which funding may not be sufficient to conduct these surveys. Loss of funding for days at sea for NOAA ships jeopardizes these programs. These surveys provide baseline distribution, abundance, and life history data that form the foundation for stock assessments and the development of ecosystem approaches to management. Although an ongoing need, these surveys are considered the highest priority research activity, contributing to assessment of commercial groundfish and crab fisheries off Alaska.
139	**Conduct routine subsistence use, fish, crab, and oceanographic surveys in the Northern Bering Sea and Arctic Ocean** **Status: Partially Underway** PlanTeam Priority: (blank) Conduct routine subsistence use, fish, crab, and oceanographic surveys of the northern Bering Sea and Arctic Ocean. These surveys will become increasingly important under ongoing warming ocean temperatures because range expansions of harvested fishery resources may occur. If range expansions or shifts occur, data will be needed to adjust standard survey time series for availability.
140	**Identification and integration of archived data ~~(e.g., surveys)~~** **Status: ~~No Action~~ ongoing** PlanTeam Priority: (blank) Identification and recovery of archived data (e.g., historical agency groundfish and shellfish surveys) should be pursued. Investigate integrating these data into stock and ecosystem assessments.
143	**Alternative approaches to acquire fishery-independent abundance data for Aleutian Islands golden king crab**

Status: No Action

PlanTeam Priority: (blank)

Explore alternative approaches to the triennial ADF&G Aleutian Islands golden king crab pot survey to acquire fishery-independent abundance data on stock distribution and recruitment, including the potential for future cooperative research efforts with Industry.

144

~~A~~ssess seasonal diets and movements of fish and shellfish

Status: No Action

PlanTeam Priority: (blank)

~~Continue and expand cooperative research efforts to supplement existing surveys to provide~~ Assess seasonal or species-specific information for use in improved assessment and management (e.g., expand or continue cooperative research). The SSC places a high priority on studies that provide data to assess seasonal diets and movements of fish and shellfish, for use in studies of species interactions in spatially explicit stock assessments.

147

Catchability studies particularly for Tanner crab and Aleutian Islands golden king crab

Status: No Action

PlanTeam Priority: (blank)

~~Studies are needed to evaluate effects of the environment on survey catchability.~~ For groundfish and crabs, studies are needed on catchability, as it directly bears on estimates of the stock assessment ~~size for setting of catch quotas~~. Research to refine the estimates of survey catchability, q, used to infer absolute, rather than relative, abundance would substantially improve the quality of management advice. Particular emphasis should be placed on Tanner crab because of recent trends in stock status and on fishery and fishing gear selectivity for Aleutian Island golden king crab to improve the stock assessment model.

148

Research on survey analysis techniques for species that exhibit patchy distributions

Status: No Action

PlanTeam Priority: (blank)

Continue research on the design and implementation of appropriate survey analysis techniques, to aid the Council in assessing species (e.g., some crabs and rockfish) that exhibit patchy distributions and, thus, may not be adequately represented (either over- or under-estimated) in the annual or biennial groundfish surveys.

149

Quantitative ~~female~~ reproductive index for the surveyed BSAI crab stocks

Status: ~~No Action~~ Ongoing

PlanTeam Priority: (blank)

Advance research towards developing a quantitative ~~female~~ reproductive index for the surveyed BSAI crab stocks. Research on mating, fecundity, fertilization rates, and, for snow and Tanner crab, sperm reserves and biennial spawning, is needed to develop annual indices of fertilized egg production that can be incorporated into the stock assessment process and to model the effects of sex ratios, stock distribution, and environmental change on stock productivity. Priority stocks for study are eastern Being Sea snow and Tanner crab and Bristol Bay red king crab. (Ongoing for snow crab and red king crab)

Stock Assesment

151	**Acquire basic life history information (e.g., natural mortality, growth, size at maturity) for data-poor stocks.** **Status: No Action** PlanTeam Priority: (blank) Acquire basic life history information needed for stock assessment and bycatch management of data-poor stocks, such as scallops, sharks, skates, sculpins, octopus, grenadiers, squid, and blue king crab (Bering Sea), golden king crabs (Aleutian Islands), and red king crab (Norton Sound). Specifically, information is needed on natural mortality, growth, size at maturity, and other basic indicators of stock production/productivity).
156	**Improve estimates of natural mortality (M) for Pacific cod and crab stocks.** **Status: No Action** PlanTeam Priority: (blank) Improve estimates of natural mortality (M) for several stocks, including Pacific cod and BSAI crab stocks.
157	**Develop and validate aging methods for crabs.** **Status: No Action** PlanTeam Priority: (blank) Develop and validate aging methods for crabs to improve estimates of M for stock assessments ~~including improved independent estimates of stage-specific M (e.g., large red king crab in Norton Sound).~~
159	**Evaluate hybridization of snow and Tanner crabs.** **Status: No Action** PlanTeam Priority: (blank) Evaluate the assessment and management implications of hybridization of snow and Tanner crabs.
160	**Develop and evaluate standard climate variability scenarios on recruitment and growth** **Status: No Action** PlanTeam Priority: (blank)

	Quantify the effects of historical climate variability and climate change on recruitment and growth, and develop standard environmental scenarios for present and future variability based on observed patterns.
161	~~**Climate information covering a wider range of seasons is needed.**~~ ~~**Status: No Action**~~ ~~PlanTeam Priority: (blank)~~ ~~There is also a clear need for climate information that covers a wider range of seasons than is presently available.~~
162	**Development of projection models to evaluate (a) the performance of different management strategies and (b) to forecast seasonal and climate related population shifts** **Status: Partially Underway** PlanTeam Priority: (blank) There is a need for the development of projection models to evaluate the performance of different management strategies ~~relative to the Council's goals for ecosystem approaches to management~~. Projection models are also needed to forecast seasonal and climate related shifts in the spatial distribution and abundance of commercial fish and shellfish. (partially underway)
163	**Expanded studies to identify stock boundaries** **Status: No Action** PlanTeam Priority: (blank) To identify stock boundaries, expanded studies are needed in the areas of genetics, mark-recapture, reproductive biology, larval distribution, and advection.
164	**Develop spatially explicit stock assessment models** **Status: No Action** PlanTeam Priority: (blank) Develop spatially explicit stock assessment models~~, where appropriate~~. High priority species for spatially explicit models include: snow crab, Tanner crab, walleye pollock, Pacific cod, sablefish, yellowfin sole, rock sole, arrowtooth flounder, Pacific ocean perch, black spotted rockfish, rougheye rockfishand Atka mackerel. (partially underway for some species)
Fishery Management	
170	**Continue to evaluate the economic effects from crab rationalization programs on coastal communities.** **Status: ~~No Action~~ underway** PlanTeam Priority: (blank)

Continue to evaluate the economic effects from crab rationalization programs on coastal communities. This includes understanding economic impacts (both direct and indirect) and how the impacts are distributed among communities and economic sectors.

173	**Evaluate the effectiveness of setting ABC and OFL levels for data-poor stocks** **Status: Partially Underway** PlanTeam Priority: (blank) Evaluate the effectiveness (e.g., potential for overharvest or unnecessarily limiting other fisheries) of setting ABC and OFL levels for data-poor stocks (Tier 5 and 6 for groundfish and Tiers 4 and 5 for crab, e.g., squid, octopus, shark, sculpins, other flatfish, other rockfish, skates, grenadier, and crab). Research is needed to refine the basis for setting gamma for Tier 4 crab stocks. (partially underway)
174	**Examine interactions between coastal communities and commercial fisheries** **Status: No Action** PlanTeam Priority: (blank) Examine interactions between coastal communities and commercial fisheries (e.g. subsistence-commercial linkages, adaptations to changes in resource use, economic opportunities for coastal communities).
176	**Develop forecasting tools evaluating climate and market demands.** **Status: No Action** PlanTeam Priority: (blank) Develop forecasting tools that incorporate ecosystem indicators into single or multispecies stock assessments, to conduct management strategy evaluations under differing assumptions regarding climate and market demands. Standardization of "future scenarios" will help to promote comparability of model outputs.
177	**Develop an ongoing database of product inventories** **Status: No Action** PlanTeam Priority: (blank) Development of an ongoing database of product inventories (and trade volume and prices) for principal shellfish, groundfish, Pacific halibut, and salmon harvested by U.S. fisheries in the North Pacific and eastern Bering Sea.
178	**Analyze current determinants of demand for principal seafood products** **Status: ~~No Action~~ ongoing** PlanTeam Priority: (blank) Analyze current determinants of ex vessel, wholesale, international, and retail demand for principal seafood products from the GOA and BSAI.

179	**Conduct pre- and post-implementation studies of the benefits and costs, and their distribution, associated with dedicated access privileges** **Status: No Action** PlanTeam Priority: (blank) Conduct pre- and post-implementation studies of the benefits and costs, and their distribution, associated with changes in management regimes (e.g., changes in product markets, characteristics of quota share markets, changes in distribution of ownership, changes in crew compensation) as a consequence of the introduction of dedicated access privileges in the halibut/sablefish, AFA pollock, and crab fisheries. "Benefits and costs" include both economic and social dimensions.
180	**Conduct prospective analyses of the robustness and resilience of alternative management strategies under varying environmental and ecological conditions.** **Status: No Action** PlanTeam Priority: (blank) Conduct prospective analyses of the robustness and resilience of alternative management strategies under varying environmental and ecological conditions.
Bycatch Issues	
189	**Quantify the effects of bycatch reduction of PSC species in groundfish fisheries on target fisheries** **Status: No Action** PlanTeam Priority: (blank) There is a need to analyze the effects of recent Council actions on bycatch, including quantifying the effects of bycatch reduction of PSC species in groundfish fisheries to the target fisheries (e.g., charter and commercial halibut fisheries, salmon fisheries)
Habitat Mapping	
191	**Improved habitat maps** **Status: No Action** PlanTeam Priority: (blank) Improved habitat maps (especially benthic habitats) are required to identify essential fish habitat and distributions of various substrates and habitat types, including habitat-forming biota, infauna, and epifauna in the GOA, BS, and Arctic. (partially underway)
192	**Develop a GIS relational database for habitat, to include a historical time series of the spatial intensity of interactions between commercial fisheries and habitat.**

Status: No Action

PlanTeam Priority: (blank)

Develop a GIS relational database for habitat, including development of a historical time series of the spatial intensity of interactions between commercial fisheries and habitat. Such time series are needed to evaluate the impacts of changes in fishing effort and type on EFH.

Function of Habitat

194

Research the role of habitat in fish population dynamics, fish production (growth, reproduction), and ecosystem processes

Status: No Action

PlanTeam Priority: (blank)

Research is needed on the role of habitat in fish population dynamics, fish production (growth, r reproduction), and ecosystem processes. Such research will improve the capability to identify and protect important habitats (including essential fish habitat and habitat areas of particular concern); help design effective habitat restoration efforts; improve the design and management of marine protected areas; improve fishery-independent population surveys; and improve stock assessments. Studies are needed to evaluate relationships between, and functional importance of, habitat-forming living substrates to juvenile and adult age classes of commercially important species and their preferred prey (forage fish). (partially ongoing)

195

Evaluate efficacy of habitat closure areas and habitat recovery

Status: No Action

PlanTeam Priority: (blank)

Establish a scientific research and monitoring program to understand the degree to which impacts (habitat, benthic infauna, etc.) have been reduced within habitat closure areas, and to understand how benthic habitat recovery of key species is occurring. (This the objective of EFH research approach for the Council FMPs).

Ecosystem indicator development and maintenance.

196

Develop a multivariate index of the climate forcing of the Bering Sea shelf

Status: No Action

PlanTeam Priority: (blank)

Climatic Indicators a.) Develop a multivariate index of the climate forcing of the Bering Sea shelf. Three biologically significant avenues for climate index predictions include advection, setup for primary production, and partitioning of habitat with oceanographic fronts and temperature preferences.

197

Develop bottom and water column temperature database

Status: No Action

PlanTeam Priority: (blank)

Climatic Indicators b) Develop bottom and water column temperature database for use in EBS, GOA, and AI stock assessments.

198	**Maintain sea ice formation and retreat index for the EBS**

Status: No Action

PlanTeam Priority: (blank)

Climatic Indicators c) Maintain sea ice formation and retreat index for the EBS.

208	**Ecosystem indicator synthesis research.**

Status: No Action

PlanTeam Priority: (blank)

Ecosystem indicator synthesis research.

Environmental Influences on Ecosystem Processes

212	**Maintain moorings.**

Status: No Action

PlanTeam Priority: (blank)

Climate variability: monitor and understand how changes in ocean conditions influence managed species. a) Maintain moorings. Development and maintenance of indices of the timing and extent of the spring bloom is a high priority. For this, maintenance of moorings, especially M-2, is essential. (underway)

213	**Monitor seasonal sea ice extent and thickness**

Status: No Action

PlanTeam Priority: (blank)

Climate variability: monitor and understand how changes in ocean conditions influence managed species. b) Monitor seasonal sea ice extent and thickness: If recent changes in ice cover and temperatures in the Bering Sea persist, these may have profound effects on marine communities.

214	**Measure and monitor fish composition**

Status: No Action

PlanTeam Priority: (blank)

Climate variability: monitor and understand how changes in ocean conditions influence managed species. c) Measure and monitor fish composition: Evaluate existing data sets (bottom trawl surveys, acoustic trawl surveys, and BASIS surveys) to quantify changes in relative species composition of commercial and non-commercial species, identify and map assemblages, and monitor changes in the distribution of individual species and assemblages. Additional monitoring may be necessary in the Aleutian Islands, northern Bering Sea, and areas of the Gulf of Alaska.

215

Assess the movement of fish to understand the spatial importance of predator-prey interactions in response to environmental variability.

Status: No Action

PlanTeam Priority: (blank)

Climate variability: monitor and understand how changes in ocean conditions influence managed species. d) Assess the movement of fish to understand the spatial importance of predator-prey interactions in response to environmental variability.

216

Collect and maintain time series of ocean pH

Status: No Action

PlanTeam Priority: (blank)

Improve understanding of ocean acidification and its effects on managed species. a) Collect and maintain time series of ocean pH in the major water masses off Alaska. (partially underway)

217

Assess whether changes in pH would affect managed species, upper level predators, and lower trophic levels.

Status: No Action

PlanTeam Priority: (blank)

Improve understanding of ocean acidification and its effects on managed species. b) Assess whether changes in pH would affect managed species, upper level predators, and lower trophic levels. (partially underway for some species)

218

Assess the synergistic effects of ocean acidification, oil, dispersants, and changes in temperature on productivity of marine species.

Status: No Action

PlanTeam Priority: (blank)

Species' responses to multiple environmental stressors. a) Laboratory studies are needed to assess the synergistic effects of ocean acidification, oil, dispersants, and changes in temperature on productivity of marine species.

219

Monitor contaminant flux and loads in lower and higher trophic levels, and assess potential for impact on vital rates.

Status: No Action

PlanTeam Priority: (blank)

Species' responses to multiple environmental stressors. ~~b)~~ Monitor contaminant flux and loads in lower and higher trophic levels, and assess potential for impact on vital rates.

Basic research on trophic interactions

220 **Collect, analyze, and monitor diet information**

Status: ~~No Action~~ underway

PlanTeam Priority: (blank)

Collect, analyze, and monitor diet information (species, biomass, energetics), from seasons in addition to summer, to assess spatial and temporal changes in predator-prey interactions, including marine mammals and seabirds. The diet information should be collected on the appropriate spatial scales for key predators and prey to determine how food webs may be changing in response to shifts in the range of crab and groundfish.

221 **Ecosystem structure studies**

Status: ~~No Action~~ underway

PlanTeam Priority: (blank)

Ecosystem structure studies: Studies are needed on the implications of food web interactions of global warming, ocean acidification, and selective fishing. For instance, studies are needed to evaluate differential exploitation of some components of the ecosystem (e.g., Pacific cod, pollock, and crab) relative to others (e.g., arrowtooth flounder).