

Crab Plan Team Meeting

May 2-5, 2017

Juneau, AK

North Pacific Fishery Management Council
605 W 4th Avenue, Suite 306
Anchorage, AK 99501

Participants

Crab Plan Team members present:

Bob Foy, Chair (NOAA Fisheries /AFSC – Kodiak)

Karla Bush, Vice-Chair (ADF&G – Juneau)

Diana Stram (NPFMC)

Ben Daly (ADF&G – Kodiak)

Miranda Westphal (ADF&G – Dutch Harbor)

Jack Turnock (NOAA Fisheries/AFSC – Seattle)

Shareef Siddeek (ADF&G – Juneau)

Martin Dorn (NOAA Fisheries /AFSC - Seattle)

Gretchen Harrington (NOAA Fisheries-Juneau)

William Stockhausen (NOAA Fisheries /AFSC - Seattle)

Bill Bechtol (Univ. of Alaska Fairbanks)

Ginny Eckert (Univ. of Alaska Fairbanks/SFOS – Juneau)

André Punt (Univ. of Washington)

Crab Plan Team members absent were: *Laura Slater (ADF&G – Kodiak), Brian Garber-Yonts (NOAA Fisheries – AFSC - Seattle)*

Public

Members of the public and State of Alaska (ADF&G), Federal Agency (AFSC, NMFS), and Council (NPFMC) staff that were present (or participated through teleconference) for all or part of the meeting included: Linda Kozak, Keeley Kent, John Hilsinger, Jie Zheng, Scott Goodman, Jim Ianelli, Ruth Christiansen, Craig Lowenberg, Katie Palof, Tyler Jackson, Brooks Kaiser, Steve Martell, Ed Poulson, Nick Sagalkin, Mark Stichert, John Gauvin, D’Arcy Weber, Cody Szuwalski, Sherri Dressel, Tyson Fick, Steve Whitney, Glenn Merrill, Scott Kent, Tyler Jackson, and Chris Siddon

Administration

The attached agenda was agreed upon for the meeting. The Team notified the public that items will be taken up early if timing allows.

The following upcoming meetings were identified:

September CPT: September 18-21, 2017. AFSC, Seattle

January CPT: January 10-12, 2018. Anchorage

May CPT: May 7-9, 2018. Anchorage

Research Priorities

Research Priorities – CPT reviewed existing research priorities related to crab and updated the priority and status for each. Priorities were categorized as Critical Ongoing Monitoring, Urgent, Important, or Strategic. Status was updated as Underway, Partially Underway, or No Action. The research priority spreadsheet includes the changes and notes from the CPT. Where the CPT and Council differ in the categorization of priority, the team made sure to reconsider the existing CPT priority. A few additional points are highlighted here to capture discussion during this agenda item.

The team wished to highlight importance of current state and federal surveys on an annual basis, as these are critical to update the data used in the crab fishery management models.

Where significant progress has been made (e.g., priority #149 handling mortality and #202 estimation of total removals), the CPT decided to downgrade the priority, which should not be interpreted that the topic is no longer important, but rather that information has been gained to address the questions raised earlier.

New research priorities were added based on discussion during the meeting on additional information needed for crab management.

SSC requests

The SSC requests that the CPT discuss the model numbering guidelines presented in Guide to the Preparation of Alaska Groundfish SAFE Report Chapters (July 25, 2016) and provide a recommendation whether that would work for crab stock assessment documents and, if not, provide a recommendation for standardized model numbering.

The CPT discussed model naming conventions for crab assessments. The CPT developed two workable options, but unfortunately there was insufficient time during the CPT meeting to produce a recommendation about which option would be preferable.

The first option would be to use the naming conventions as described in the groundfish SAFE guidelines. These procedures should be straightforward to apply to crab models, and there would be some benefit to using the same conventions for both groundfish and crab assessments. The CPT agreed that using a quantitative measure of how much spawning biomass changes between models as a way to distinguish between major and minor changes may be counterproductive to goal of improving understandability, since important model changes may have a large or small impact on spawning biomass. Consequently, the CPT recommends that option C be used for crab assessments, where major and minor changes are distinguished based on logical but non-quantitative criteria.

Naming conventions in groundfish SAFE guidelines:

When a model constituting a “major change” from the original version of the base model is introduced, it is given a label of the form “Model yy.j,” where yy is the year (designated by the last two digits) that the model was introduced, and j is an integer distinguishing this particular “major change” model from other “major change” models introduced in the same year.

When a model constituting only a “minor change” from the original version of the base model is introduced, it is given a label of the form “Model yy.jx,” where “x” is a letter distinguishing this particular “minor change” model from other “minor change” models derived from the original version of the same base model.

Option C

Same as Option A, except that the distinction between “major” and “minor” model changes is determined subjectively by the author on the basis of qualitative differences in model structure rather than the performance-based criterion described in Option A.

The second option considered by the CPT is a naming convention specific to crab stock assessments that would achieve the following goals:

1. Enable model tracking between assessments, other model evaluations (e.g., May CPT meetings, Modeling Workshops)
2. Indicate when model configuration was first introduced
3. Indicate “major” (non-incremental) changes between model configurations
4. Indicate incremental changes between a series of model scenarios
5. Indicate dataset year, differences between datasets

The proposed convention is

MYYAabc.DYYabc

M: for model

YY: indicates year model configuration introduced

A: indicates “major” version for model configuration

abc: indicates series of incremental changes a+b+c (in this example) to model configuration

D: for data

YY: indicates year data corresponds to

abc: indicates series of dataset revisions relative to assessment dataset (if necessary)

Examples:

M16B.D17: model configuration B introduced in 2016, with dataset used for assessment in 2017

M16Bade.D16a: model configuration B introduced in 2016, with incremental changes “a”, “d”, and “e”, using dataset from 2016 assessment with revision “a”.

The SSC requests that stock assessment authors bookmark their assessment documents and commends those that have already adopted this practice.

Diana will add instructions on how to properly format headings in the stock assessment guidelines for authors.

The SSC recommends that the Gulf of Alaska Groundfish Plan Team (GOA GPT), BSAI GPT, and CPT encourage the continued use of multiple approaches to data weighting (not just the Francis (2011) method, but also including the harmonic mean and others).

Authors will continue to consider other data weighting in the assessments. The CPT notes that self-weighting methods and alternative data weighting options could be added to GMACs. The CPT requests the SSC outline the criteria that should be used to select between alternative weighting methods.

The SSC noted that there are methodological differences among crab assessments in the selection of years for calculation of reference points. It would be helpful to standardize the approach to the degree possible among assessments (as is done for groundfish), and provide a rationale when the assessment differs from the standard. The SSC requests that the CPT evaluate this issue in the near future.

The CPT has evaluated the selection of years for calculating reference points in the past and notes that the availability and quality of the data differs between crab stocks. Rationale for why certain years were selected is provided in the stock assessments and this information can be further highlighted in the SAFE report.

The SSC suggests that the CPT consider developing a prior probability distribution, or distributions, that might be applicable across crab stocks to aid in stabilizing the estimation of natural mortality while still propagating a reasonable amount of uncertainty in this key population parameter.

The CPT will provide standardized guidelines for stock assessment authors with regards to natural mortality parameterization. Expectations for natural mortality differ across crab stocks in part due to the level of information (selectivity, growth, etc.) available to help inform this parameter. For some crab stocks (snow, Tanner) a prior and distribution are used for natural mortality rather than a fixed point estimate. Sensitivity analyses on values of natural mortality have been evaluated in the past for some stock assessments and could be included for the author’s selected model annually.

PIGKC

Ben Daly presented the Pribilof Islands golden king crab stock assessment. The Pribilof Islands golden king crab fishery is a Tier 5 stock managed on a calendar-year (January 1 through December 31) basis therefore, this assessment is for 2018. Retained catch and total catch are often confidential throughout the fishery history due to limited participation. Participation has ranged from one to two vessels since 2009. It was requested by the SSC in June 2016, that confidentiality waivers be obtained so that the confidential

data can be viewed and evaluated by both the SSC and CPT. Waivers have been obtained from the harvesters but have not been obtained from processors for the confidential seasons. There was no directed effort and no bycatch in 2015 and 2016, therefore total effort in this fishery in 2016 is 0t. Overfishing did not occur in 2016. The GHL for the 2018 season has yet to be established. A member of the SSC expressed concerns about not having an estimate of harvest in years when the catch was confidential; while estimates cannot be released, the GHL has not been reached in recent years. The CPT recommended in 2015 that the author add a notation to tables specifying whether or not the GHL was achieved. This will be addressed by the author in the next updated assessment.

Fishery continues to be managed under authority of a Commissioner's Permit. The ABC for this stock was reduced in 2015 from 82 t (180,000 lb) to 68 t (150,000 lb) to account for bycatch mortality in the directed fishery, non-directed crab fisheries, and groundfish fisheries. The GHL in this fishery was reduced in response to the reduction in ABC from 68 t (150,000 lb) to 59 t (130,000 lb) and has remained at 59 t (130,000 lb) since 2015.

Retained catch and discard catch data have been updated with results from the 2016 directed fishery. No vessel participated and there was no bycatch in other fisheries in 2016. Bycatch estimates from discarded catch in the groundfish fisheries, listed by calendar year from 2009 to 2016, resulted in 0.24 t of bycatch mortality in 2016. Methodology for this assessment followed the recommendations from the CPT since May 2012 and the SSC since June 2012.

The CPT concurred with the author recommendation of status quo Tier level, OFL, and ABC. The status quo OFL has been in use since 2012. The ABC applies a 25% buffer to the OFL; use of the 25% buffer has been in place since the 2014 assessment and was adopted to maintain consistency with other Tier 5 stocks with similar levels of uncertainty.

Ben Daly presented results from the 2016 EBS upper continental slope survey, including the recent years survey data (2008, 2010, 2012). There is a desire to use these data as an estimate of biomass for the determination of OFL and ABC for this stock. These data use the post-2000 survey design with total biomass for male and female available starting in 2002 but information detailing mature and legal male crab only available since 2008. Size at maturity is defined at 107 mm CL with legal size defined as 124 mm CL, which is a proxy for 5.5 in CW. The EBS slope survey assesses 6 different subareas with each subarea divided into strata divided into 200m depth zones. Subareas 2, 3, and 4 are in the Pribilof District and applicable to assessment of this stock. Trends in distribution and abundance have held for the past four years of surveys with golden king crab biomass concentrated in Subarea 2 and sporadically distributed within Subareas 3 and 4.

These data were incorporated into a random effects model (re.exe) used by analysts in the past. Model results combined subareas 2, 3, and 4. The model fit poorly due to high variance and low number of data points. In analyzing Subarea 2 only resulted in similar poor model performance. Due to poor model fit, the author recommends that this remains a Tier 5 stock.

A random effects model was presented at the September 2015 meeting using EBS slope survey data from 2008, 2010, and 2012, but was not able to estimate the process error for mature and legal sized males.

Ben Daly presented the random effects model with the 2016 slope survey data included; however, the additional data point did not improve the model fit for mature and legal size male, likely because of the few number of data points (4) and the high variance. Suggestions for the September 2017 meeting included: 1) investigating whether size frequency data is available for the 2002 and 2004 surveys, so that biomass estimates for mature and legal males could be estimated and included in the model simulations; 2) investigating the sex ratios in 2008, 2012, 2012, and 2016 data. If the sex ratios are reasonably stable in each of those years, then mature and legal biomass estimates could be made in 2002 and 2004 using the sex ratios from the known survey years (i.e., use 2002 and 2004 raw survey data to get size compositions to extend time series backwards via scaling); 3) put bounds on the process error and rerun the model.

The CPT agreed with the author's recommendation of keeping PIGKC at Tier 5 until the model improves. It is also noted that the model does run through the point estimate error bars. Ben Daly, Martin Dorn, and Jack Turnock discussed process error at the meeting break, and investigated the "par" files, which showed that the model did converge and estimated zero process error. As such, an argument could be made that the model did perform adequately and could be used to estimate mature and legal male biomass.

PIRKC

Jack Turnock presented a discussion paper on the use of a random effects model to fit survey male biomass (≥ 120 mm) of Pribilof Islands red king crab. Estimation of the process error was not possible because of the high variances in the survey biomass data. Multiple methods were used to better assess the most appropriate process (vs. observed) error:

1. Model fit to survey data using fixed values for process error.
2. Use of a constant CV based on mean (did not converge without bounding parameters) or median (process error was 0.006) of mature male biomass.
3. Use of an exponential model to assess the variance ratio from which a process error was calculated to be 0.1.
4. Estimate the variance of the first difference in log biomass which resulted in a process error of 0.05.

The CPT agreed that the fixed CV method was not likely appropriate and over smoothed the data. The exponential model appeared to provide a reasonable constraint on the random effects model fit and tracked real (albeit noisy) trends within the survey biomass.

The CPT recommended that the author continue to develop the random effects model and consider the following for models at the September CPT:

1. Better describe the exponential smoother methods and bring forward one model with the exponential model result as a prior and one model with the process error based on the exponential model fixed.
2. Status quo 3-year running average.
3. Consider fitting to the female biomass to determine if assessing the effects of single sex high biomass tows are informative for determining the observed error relative to process error.

4. Consider fitting spatial models (e.g., Thorson et al. 2015) to the survey data that may better account for zero tows and high biomass tows.

Stock Prioritization

The CPT discussed the proposed strategy to shift formal assessments of some BSAI crab stocks to a non-annual frequency, such as every 2 or 3 years, for OFL and ABC determination. After ranking of BSAI crab stocks at January 2017 CPT meeting, the CPT recommended the following assessment frequencies: (1) annual - Bristol Bay red king crab, Bering Sea Tanner crab, Bering Sea snow crab, St. Matthew blue king crab, and Aleutian Islands golden king crab; (2) biennial - Pribilof Islands red king crab and Norton Sound red king crab; and (3) triennial – Pribilof Islands blue king crab, Pribilof Islands golden king crab, and Western Aleutian Islands red king crab. In February 2017 the SSC concurred with the proposed assessment frequencies with the exception of requesting that ADF&G review the costs and benefits of changing the target assessment frequency for Norton Sound red king crab from annual to biennial. A review by the State is not yet completed.

The CPT noted that changes to the assessment frequency would start following the 2017-18 assessment year. The CPT engaged substantial discussion on approaches for an off-cycle year. It was recognized that off-cycle assessments could be triggered if: (1) a stock is determined to be overfished or overfishing occurred; (2) there is new interest in a directed fishery; (3) there are unexpected shifts in survey results; or (4) there is a proposed shift in the assessment approach, such as from Tier 5 to Tier 4. It was also noted that if a stock not subject to an annual assessment is surveyed biennially, it may be more appropriate to conduct a biennial assessment (e.g., Pribilof Islands golden king crab).

The aspect of potentially increasing the buffer for years without assessments was discussed, but it was unclear that adequate information exists to revise the buffers given that stocks proposed for non-annual assessments tend to be data poor with low catch levels. Thus, it was unclear what data could be applied without appearing to be arbitrary. In addition, any major changes to the stocks under multi-year assessment cycles would likely trigger an off-cycle assessment per the previously mentioned criteria.

In summary, for years without a full assessment, a crab stock assessed on a multi-year cycle would be listed in the SAFE Introduction with updated catch information, a statement regarding whether overfishing occurred, and the OFL and ABC rolled over from the previous assessment. The CPT recommends revisiting this process in 4 years concurrent with the review by the Groundfish Plan Teams.

AIGKC assessment

A male-only stock assessment model for AIGKC has been under development for several years. The CPT recommended in January 2017 that the assessment for 2017 be based on the model output (rather than the Tier 5 methodology). The CPT also recommended that the stock be a Tier 3 stock. The SSC endorsed the CPT recommendation in February 2017 regarding the basis for the assessment.

Siddeek presented the draft assessment. It included 11 model configurations. Model 1 assumed that the proportion mature was a logistic function of length, was fitted to observer CPUE data for 1995/96 to

2015/16 and fish ticket data from 1985/86 to 1998/99, and fixed M for both stocks to be 0.224yr^{-1} . Models 2 – 11 varied the assumptions of Model 1 by: omitting the fish ticket data (Model 2), including additional observer CPUE data for 1991/92-1994/95 (Model 3), considering three rather than two selectivity patterns (Model 4), assuming higher and lower values for M (Models 5 and 6), assuming knife-edged maturity at 111 mm CL (Model 9), and assuming area-specific values for M (Model 10). Models 7 and 8 are identical to Model 1, except they consider different definitions for the mean recruitment used to define B_{MSY} . Model 11 involves knife-edged maturity at 111 mm CL and area-specific values for M . As recommended by the CPT and SSC, the assessment weights the compositional data using the 'Francis method', and sets the initial (1960) recruitment to the average of the recruitments over 1987-2012 (years selected based on estimated precision relative to SigmaR).

The assessment author recommended Model 9 (Model 1 specifications, but with knife-edged maturity at 111mm CL). The CPT noted that likelihood profile for current MMB was incorrect because the maturity function was estimated, which meant that different current MMB values equated to different specifications for maturity as a function of length. The CPT agreed with the assessment author that M should be the same for the EAG and WAG given that estimates by stock are very similar.

The data on which the maturity ogive is based was derived from a relationship between chela height and carapace width modelled using a segmented linear relationship under the assumption that animals are randomly selected by size-class. The CPT was concerned that proportions mature at length were biased (i.e., the probabilities of being mature for large sizes are less than expected). This may relate to measurement errors so that chela height is underestimated for some animals. The assessment author recommended a model (9) where maturity is knife-edged at 111mm CL. The CPT concurred with this recommendation, primarily because the maturity-at-length data appear unrealistic and the logistic function does not fit well to the data for smaller animals.

The CPT focused on Models 9 and 11 as those models were based on knife-edged maturity. The numbers-at-length for Model 9 are identical to those for Model 1, while those for Model 11 are identical to those for Model 10. The predicted MMBs for Models 9 and 11 differ from those for Models 1 and 10 because of the different maturity-at-length relationships. There is a weak retrospective pattern for Model 9 for the EAG (additional years of data lead to higher estimates of biomass), but not for the WAG.

The CPT noted that the average recruitment used to set the 1960 recruitment and B_{MSY} were based on different periods (1987-2012 and 1985-2015). This differs from the recommendation of the SSC that the same periods be used for calculating both quantities. The CPT requested the author to base the 1960 recruitment and B_{MSY} on the same set of years (1987-2012).

The CPT noted that it was necessary to provide a single OFL and ABC for AIGKC. However, the assessment is conducted for two areas (EAG and WAG). The CPT noted that there were two ways to compute an OFL in this situation:

- Apply the OFL control rule by area and sum the OFLs by area.
- Determine stock status for the whole stock by adding the estimates of current MMB and B_{MSY} by area. This stock status is then used to determine the ratio of F_{OFL} to $F_{35\%}$ by area, which is then used

to calculate the OFLs by area, which are then added together to calculate an OFL for the entire stock.

The CPT considered an appropriate buffer between the OFL and the ABC; the assessment author had recommended a 25% buffer, which was the same as in the 2016/17 assessment. However, the CPT discussed the buffers applied for other Tier 3 stocks (BBRKC, EBS snow crab and EBS Tanner crab) and the uncertainties that are specific to AIGKC. In particular, this is the only stock for which the primary data source is fishery-dependent CPUE data. The CPT therefore recommends a buffer of 20%.

The CPT recommendations related to future model development are:

- Pre-specify the maturity ogive rather than estimating it along with other model parameters.
- Consider estimating rather than pre-specifying the 1960 recruitment, which would then be used to calculate B_{MSY} .

In relation to the document, the CPT recommends that:

- Revise Fig. C.1 to clarify which data points correspond to mature and immature animals, and which linear relationships are for mature versus immature animals.
- Provide the specifications for Models 0a and 0b.
- Figures such as 18 and 37 should correctly plot knife-edged maturity as being knife-edged.
- Update the document to describe the alternatives for OFL calculation and provide the results for options “9*” and “9**”.

AIGKC survey

The CPT was briefed on an attempt to develop an assessment for the “core harvest area” by Dr. Chris Siddon. This analysis attempted to address the fact that the area fished has changed considerably over time. The core area was defined as the 2x2 NM boxes that are between 100-1000m, not on land, and with some observer data for 2005–2013. There was a decline in the area fished from 1990 to 2004, and some additional non-core areas were fished in 2013-15 due to catches during the survey. The catch and effort data for the core area were standardized and those data and the catch for the core area were included in model runs based on Model 2. The trends in MMB (Figures F.14 and F.15) are similar between the “core area” model and Model 2, but the difference between the Model 2 results and the results for “SC2core” models are greater historically than at present.

The CPT thanks the analysts for this exploratory analysis. However, it is hard to interpret the results because restricting the catch and effort data to the core zone could lead to a CPUE index that is either hyperstable or hyperdepleted, and it is unclear which is more likely. The CPT suggested that a run in which just the observer CPUE indices were replaced by the CPUE indices for the core area might be informative. However, ultimately an index of abundance based on surveys or from tagging is needed to calibrate whether the CPUE indices are hyperstable, hyperdepleted, or related directly to abundance.

There would be value in plotting CPUE distributions by year, if this feasible, to see if annual fleet effort has changed much.

BBRKC Model Selection and Gmacs

Gmacs BBRKC model

A BBRKC assessment model based on the Gmacs (Generalized Model for Alaska Crab Stocks) has been in development since May, 2016, with the ultimate goal to provide an alternative to, or replacement of, the current assessment model (developed by Jie Zheng, ADFG) using a standardized modeling framework. D'Arcy Webber (QuantFish) and Jim Ianelli (AFSC) presented an update to the Gmacs BBRKC model. The CPT noted that a substantial amount of progress had been made since the Modeling Workshop to develop a Gmacs-based model that captures the essential dynamics of, and closely matches the results from, the model used for the BBRKC assessment.

Several issues indicating mis-match between Gmacs and the assessment model that were identified at the 2017 Modeling Workshop have been resolved, including: 1) apparent poor fits to trawl bycatch (the Gmacs predicted catch was incorrectly reported due to a programming error); 2) poor fits to survey data (issues related to catch units, the timing of the survey, and the seasonal sequence of population processes were corrected); and 3) sex-specific M is now estimated, not fixed. Additional progress was made by improving input file formats, adding more control for specifying time-varying M and molting probability, and incorporating new BBRKC bycatch data obtained by separating, rather than aggregating as previously, bycatch biomass and size compositions in the Tanner crab, fixed gear and trawl gear groundfish fisheries.

D'Arcy and Jim also discussed issues that remain to be resolved between Gmacs and the assessment model. These include being able to: 1) estimate initial numbers-at-length in the same manner as is done in the assessment model (the current method does not give results similar to those from the assessment model) and 2) estimate the growth transition matrix as in the assessment model (for the results presented to the CPT, the growth matrices were fixed to those estimated in the assessment).

Results were presented from three model scenarios: "Gmacs base", "Free Q", and "Variable M". Gmacs base matched the current BBRKC assessment model in configuration as closely as was possible, Free Q estimated the catchability associated with the BSFRF surveys, rather than fixing it at 1, and Variable M estimated natural mortality (M) using a time-varying, random walk configuration rather than the time blocks used in the base model. The Gmacs base model provided the best fits to the data. Intriguingly, the Variable M model estimated elevated estimates of M in the early 1980s, consistent with the time blocks of elevated M in the Gmacs base and assessment models.

The CPT recognized that substantial progress had been made toward a Gmacs-based BBRKC assessment model that was in agreement with results from the current assessment model. The CPT recommended that the Gmacs model not be used as the basis for the 2017 assessment, but did not anticipate that remaining inconsistencies with the current assessment model could not be resolved such that the Gmacs version could be approved for the 2018 assessment. Key issues that need to be addressed before the Gmacs model can be approved for use in the assessment include:

- processes in the current assessment model that are based on estimated parameters should also be based on estimated parameters in the Gmacs version (i.e., should not have to fix growth matrices, initial abundances to achieve similar results)
- the trajectories for recruitment and MMB predicted by the Gmacs model should be similar, but not necessarily identical, to those based on the current assessment model
- management quantities from the Gmacs model should be similar, but not necessarily identical, to those based on the current assessment

Standard BBRKC model

Jie Zheng (ADFG) presented five scenarios based on the standard BBRKC assessment model as candidate scenarios to evaluate for the 2017 assessment: Scenarios 2, 2a, 2b, 2c, and 2d. Model Scenario 2 was the model (and data) accepted for the 2016 assessment (also called Scenario 2). This scenario assumed BSFRF survey size compositions reflected the availability of BBRKC (and that BSFRF capture probabilities were 1 at all sizes), while NMFS survey size compositions reflected both availability to the gear and gear-specific capture probabilities. Scenario 2a was the same as Scenario 2, except that the data was updated to include the 2016 BSFRF side-by-side survey data. Survey 2b was the same as 2a, except that bycatch data (biomass and size compositions) after 2008 were separated into components for the Tanner crab, groundfish fixed gear, and groundfish trawl gear fleets. Based on a single study, handling mortality for BBRKC in the Tanner crab fishery was assumed to be 0.25, slightly higher than for bycatch in the directed fishery. Scenario 2c was the same as 2b, except that the prior on catchability for the NMFS survey from the “double bag” experiment was removed. Finally, Scenario 2d was the same as 2c, except that NMFS survey catchability was parameterized on the logit scale to prevent “q” from being estimated greater than 1. These scenarios addressed a number of previous CPT and SSC requests.

Jie found that adding the 2016 BSFRF survey data (Scenario 2a) had little effect on the results. Splitting the 2009-2015 discards in the aggregated bycatch fisheries into explicit Tanner crab, groundfish fixed gear, and groundfish trawl gear components (2b) resulted in slightly smaller estimates of NMFS survey catchability and , while the models fit the survey data similarly well, population biomass estimates were higher for all scenarios relative to 2c because estimated values for NMFS trawl survey catchability were higher in the latter. The CPT noted that the “underbag” experiment provided a prior for the catchability of the NMFS survey gear, but that this was not the appropriate prior for the survey itself because overall availability is confounded with catchability in the survey. However, the CPT agreed with the author that the estimate of q in Scenario 2c as > 1 was unreasonable and thus Scenario 2c could be dropped from further consideration.

The CPT recommended the following scenarios be evaluated for the Fall 2017 assessment:

- Scenario 2a
- Scenario 2b
- Scenario 2d

In addition, because the discard biomass time series from the groundfish fixed and trawl gear fisheries are not split by sex, these models should be brought forward using two approaches to Francis (2011) re-weighting of the size compositions: one based on weights calculated as if all the size compositions were

sex-specific, and one based on weights calculated from the “extended” size compositions used in the models for the groundfish fixed gear and trawl gear bycatch size compositions. The former approach is based on the expectation of sex-specific changes in mean length, but does not reflect the loss of sex ratio information associated with splitting the size compositions by sex, whereas the latter approach incorporates this information while the weights are based on expectations for changes in size class across the “extended” size composition.

BBRKC bycatch

In February 2016, the Council initiated a discussion paper to look at the need for PSC bycatch limits in groundfish fisheries or other measures to minimize Bristol Bay red king crab bycatch. This paper was discussed at the January 2017 plan team meeting. At the January meeting the plan team discussed the Bristol Bay PSC limited trawl area, the nearshore trawl closure, the red king crab savings area, and the 10-minute flatfish area within the lower portion of the red king crab savings area. The plan team discussed whether different mortality rates should apply for the different areas and or different gear types within these areas. It was noted that groundfish pot bycatch has increased dramatically since 2012, and also within the savings area since 2013, but it is uncertain if the increase is related to actual increases in bycatch, crab moving due to changes in environmental conditions creating fishery overlap, or attributed to increased observer coverage. Pot gear bycatch does not accrue in the overall PSC bycatch limit.

The plan team expressed the following concerns with relation to red king crab bycatch in Bristol Bay:

- The plan team and SSC expressed concerns over the seasonality of groundfish fishing and how that impacts mating and molting of red king crab caught as bycatch,
- Calculating bycatch with respect to TAC instead OFL/ABC,
- Evaluate how increased bycatch impacts the population,
- PSC limits are based on Effective spawning stock biomass but bycatch estimates are summed without regard to sex or life stage,
- Comparisons with current EFH models.

The SSC commented that there is no purpose or need for further analysis since there is no action by the council. The SSC also noted their support of the plan team’s request for the Council to develop a clear purpose and needs statement to frame future work and development of alternatives for analysis.

At the February 2017 Council meeting, the Council requested that the plan team evaluate the effects of total red king crab bycatch in the groundfish fisheries on MSST, OFL, ABC, and TAC and provide a summary of the discussion in a report the Council.

The plan team continues to have concerns regarding red king crab bycatch in the groundfish fisheries and recommends that this issue be put forward as a research priority. The plan team recommends:

- Investigate the reasons behind increased bycatch in the groundfish pot fisheries.
- Investigate spatial component to bycatch. May be larger impacts if bycatch is concentrated spatially.

- Need whole haul sampling in trawl fisheries in order to better quantify the size/sex of crab bycatch and evaluate the accuracy of model estimates.
- Missing pelagic trawl component from model estimates. Investigate gear interaction with king crab.
- Reevaluate the goals of bycatch caps. PSC caps are so large they aren't limiting the effects on crab they are only limiting impacts on groundfish trawl fisheries. The plan team believes that if the trawl fishery ever reached the PSC limit for king crab, it would cause irreparable damage to the crab population.
- Hindcast-forecast analysis possibly in the form of a white paper. Assessing the cumulative impact of bycatch over the history of stock assessments. Assess how no bycatch could have changed the look of the stock spatially and temporally.
- Increase communication with Pollock trawl fleet on impacts of gear interactions with crab population.
- As referenced in SSC minutes, the plan team also recommends looking at Leah Sloan's research going forward. Incorporate as part of spatial analysis and compare to Pollock fleet activities with respect to Bristol Bay red king crab fishery activity.

Tanner crab

The Tanner crab assessment is in the process of transitioning from an older assessment modeling program, TCSAM2013, to a new modeling platform, TCSAM02. The purpose of this transition is to improve the modeling of fishery and population processes for Tanner crab, and to enable use of a control file to select options rather than making coding changes. This transition could not be completed during the January CPT modeling meeting when an attempt to obtain matching models proved unsuccessful. William (Buck) Stockhausen (NMFS) reported on additional work following the January meeting that ultimately was able to demonstrate "exact equivalence" between the two modeling approaches. This was done by successively modifying the TCSAM2013 code from the version presented at the January CPT meeting until it matched the assumptions of TCSAM02. The changes included using survey biomass estimates based on 1-mm size bins, using a more precise conversion of kilograms to pounds, setting capture rates and effort to zero for the BBRKC fishery bycatch for years when the fishery was closed, using median size-at-50% selection before 1991 for the directed fishery, and using median fishing mortality instead of mean fishing mortality for groundfish fishery bycatch before 1973. In addition, an error in the input data for the retained size composition in 2015 was corrected. Exact equivalence was achieved in all model output, including log likelihoods, with differences on the order of 10^{-4} . All of these changes, in addition to bringing the two models closer together, were considered improvements to the assessment, though relatively minor. The CPT agreed that this comparison was successful, and that September model runs for Tanner crab should use TCSAM02.

Next, Buck presented a set of models that addressed growth modeling issues. These models evaluated whether a prior based on Kodiak growth increment data should be used in the model, as in previous assessments, or whether actual growth increment data should be included in the model and the prior removed. In addition, sufficient growth increment data from the EBS are now available to allow evaluation of model runs that use only the EBS data. Model runs also evaluated whether the cumulative gamma function in ADMB should be used instead of the truncated gamma approximation, and whether

or not to estimate the scale parameter in the gamma function for size increment. The CPT concluded that only the EBS data should be used if at all possible, that the changes to the growth increment function should be adopted, and that the scale parameter should be estimated rather than being set to 0.75.

Buck presented an additional set of runs that evaluated a number of modeling options, including whether to model an annually-varying retention function in the directed fishery, and whether to separate the groundfish bycatch fishery into trawl and fixed gear components. CPT noted that the model seems to fit the retained male catches relatively well, but that the fit to the total catch (retained plus discard) was not as good, and that there was a tendency for the model to predict more large crab than were seen in the data. The CPT thought that this might indicate that some large crab were not being retained in the target fishery, and a discussion with crab fishermen present at the meeting confirmed that large old shell crab are frequently not retained. The CPT recommends that this issue be evaluated by modeling retention with a logistic curve that asymptotes at a value less than one. Separating out the trawl and fixed gear bycatch in the groundfish fishery appeared to be an improvement, but the CPT had some concerns about the shape of the selectivity curves, and recommends that the decisions about how to model selectivity be reassessed, and that the reliability of selectivity estimates be confirmed.

The CPT recommends that a sequence of models be brought forward in September, each of which builds on the preceding model as follows:

- B0: The matching model using TCSAM2. Note that this model is not precisely the same as the model that was used last September, but the differences are minor, and have been well documented.
- B1: B0 + cumulative gamma growth function + EBS growth increment data + removal of priors on growth parameters + estimation of the scale parameter for gamma distribution in the growth function.

This model should be used to address two further issues, 1) whether Francis reweighting of composition sample sizes is an improvement, and 2) whether the growth increment data from the EBS are adequate to estimate growth parameters, including the scale parameter, or whether the Kodiak data are also required.

- B2: B1 + include annual deviations after 1990 on size-at-50% retained in the directed fishery retention curve.

This model should be used to address two issues: 1) whether it is better to model retention with a function that asymptotes at a value less than one, and 2) whether blocking into three periods adequately captures the changes over time rather than annual deviations.

- B3: B2 + include bycatch data from groundfish fleets separated into trawl and fixed gear components, and model these with separate selectivity functions.

WAIRKC assessment

Ben Daly presented the Western Aleutian Islands red king crab 2017/18 Tier 5 assessments. The fishery is rationalized in 2005/06 under the Crab Rationalization Program for the area west of 179° W longitude (Petrel District), but not the area east of 179° W (Adak District).

The fishery has been prosecuted consistently from 1960/61 to 1995/96. After 1995/96, the fishery was opened only occasionally due to depressed stock status and has been closed since 2003/04. Cooperative red king crab surveys were performed by the Aleutian Islands King Crab Foundation (an industry group) and ADF&G in the Adak area in 2015 and the Petrel area in 2016. The Petrel survey conducted in 2016 showed a depressed status of this stock with very low CPUE (<1 crab per pot lift). There were no CPT or SSC recommendations for this stock in recent years. However, in June 2015, SSC requested the author to plot the size frequency data provided in the Appendixes of the 2016 report. The author provided these plots in this report.

The OFL and ABC are calculated under Tier 5 procedure. The 1995/96-2007/08 period was chosen to calculate the average retained catch, non-directed crab discard mortality, and groundfish discard mortality to compute the total catch OFL. Overfishing did not occur in 2015/16 because the estimated total catch (bycatch) 0.003 million lb did not exceed the OFL of 0.12 million lb. The author recommended an ABC of 0.07 million lb, consistent with recent years. However, since there is no longer a need for additional catch to accommodate cooperative research surveys (none are anticipated), the CPT recommended reverting back to the larger buffer that had been used previously because of very depressed condition of this stock.

The CPT made the following recommendations:

1. Because of very depressed status of this stock, set a 75% buffer for ABC calculation.
2. The 2015/16 groundfish bycatch was very high compared to previous years. CPT requested the author to report which groundfish gear/target fishery reported high bycatch of red king crab.

Snow crab

Cody Szuwalski presented alternative model scenarios for the Bering sea snow crab assessment. The CPT in September 2016 suggested model runs and expanded analyses, including:

1. Estimate M for mature females.
2. Document rationale for prior on M for immature crab.
3. Try starting the assessment in 1982 to check the behavior of the survey q parameters when the first survey stanza is excluded.
4. Apply priors to the survey q parameters so they are somewhat constrained.
5. Provide more detailed MCMC chain diagnostics.
6. Extract bycatch mortality from the Tanner crab directed fisheries that is currently lumped into the groundfish trawl bycatch (in a table in the assessment chapter, not necessarily in the model).

Number 6 was not addressed in this meeting.

Cody presented 6 model scenarios to address comments:

1. 'Trim data'
 - Excludes all data from the first 4 years 1978-1981, start model in 1982
 - Explores problem of anchoring of survey q and bound hitting survey selectivity parameters
2. 'Fixed obs sel'
 - a. 'Trim data' + fixing survey selectivity in era 2 and era 3 to selectivity estimated from BSFRF data outside the model
 - b. Explores implications of BSFRF data
3. 'No BSFRF'
 - a. 'Trim data' + setting the weights for the BSFRF survey likelihood components to 0
 - b. Explores the impact of the BSFRF data on model output
4. Estimate Female M and change the standard deviation for the prior for immature from 0.154 to 0.054 (same as mature male) , male and female
5. Chop growth – estimates one single line for growth
6. Estimate Female M + chop growth

The author discussed to use of Bayesian methods. Priors are needed for all parameters for implementation of Bayesian methods. The MCMC step also takes a considerable amount of computing time. In addition, the OFL calculation must be differentiable. It is also possible to develop a distribution for the OFL in a maximum likelihood framework, if a standard error for the OFL can be calculated. To accomplish this, the CPT recommends using Newton's method with a fixed number of iterations and call the function that calculates the OFL during Sdreport phase = True. The author discussed issues with some parameters hitting bounds and data in the early years that are problematic for both using Bayesian and maximum likelihood methods.

There was some discussion about whether there was catch that was not accounted for in the early years. The survey area coverage change from the second survey period to the third period may be better represented by splitting the years at 1988 rather than 1989 as in the base model. Excluding survey data from 1978-1981 would result in a change in mean recruitment and B35%.

Model scenario 2 (Fixed obs sel) with survey selectivity estimated outside the model from the BSFRF data resulted in a poorer fit to the survey data. Scenario 2 also resulted in big changes in the probability of maturing and a higher value of F35%. Fitting the BSFRF data inside the model to inform survey selectivity continues to be the recommendation of the CPT.

Some of the availability parameters for fitting the survey data hit bounds. The estimation of availability parameters in logit space with a penalty may prevent those parameters hitting bounds. A longer term solution may be to use a spline function for availability.

The priors for natural mortality estimation in the model are on the multiplier parameter (parameter * M). A better approach may be to change the prior to work with the log of the multiplier with a prior with a zero mean and an appropriate standard deviation.

To investigate the sensitivity to estimating the growth model, a piece wise linear model (the base model), one straight line model and a Beverton-Holt model were fit to growth data. The kink only influences the first and maybe second size bin in model. The Growth + M model results in an increase in survey q, higher estimates growth and some other selectivity parameters hit bounds. The change in growth at around 30-35mm in the Bering Sea data has also been reported in Canadian snow crab growth data and is attributed to when crab become adolescent.

Recommended scenarios for September 2017

Scenario 1. Leave out length bins below the kink in growth and fit one straight line for growth.

Scenario 2. Estimate M for females, males, and immatures. Change the prior on the multiplier to work in log space with a zero mean and an appropriate standard deviation.

Scenario 3. Start the model in 1982 dropping the survey data before 1982.

Scenario 4. Split the survey selectivity periods in 1987 or 1988 - check the distribution of survey sampling to have a consistent area for each era.

Scenario 5. Estimate survey availability parameters for the BSFRF survey in logit space with a penalty.

The CPT also recommends resolving problems with any parameters hitting bounds.

Tanner crab harvest strategy

The Alaska Board of Fisheries (Board) is considering updating the Tanner crab harvest strategy at its meeting on May 17 and 18. ADFG is preparing an analysis in response to the Board's request. Ben Daly (ADFG) presented the elements the harvest strategy review team had been tasked with review meeting, and explained that the analysis is ongoing. If the Board adopts an updated harvest strategy at their May meeting, it could be implemented by the 2017/2018 Tanner crab fishing season.

The CPT discussed how the State spatially manages Tanner crab in the different subdistricts and areas in the Bering Sea district. ADFG uses area survey swept estimates of mature females and legal males in the harvest strategy. A core element of the harvest strategy is a district-level mature female threshold, currently based on knife-edged CW measurements vs. morphological determinations from the NMFS survey. ADFG closes the fishery when the female threshold is not met.

Rules for the TAC in the east area (east of 166°W longitude) and the TAC in the west area (west of 166°W longitude) are based on mature male biomass thresholds. The CPT discussed the evidence of differences in Tanner crab in the east and west areas. There is not enough evidence to suggest separate stocks, but there are sufficient differences to warrant separate management measures.

A female TAC penalty reduces the TAC by 50% from computed values in the first year that the stock is above threshold after having been below threshold. This penalty is a precautionary measure to 1) buffer against the effect of erroneously determining the stock to be above threshold due to random survey error, and 2) protect against a high harvest rate on preferred-sized legal males that could occur due to the lag in maturation of males behind females. It is possible that the ratio of preferred-sized legal male crab to mature male crab is likely to be low in the first year that the stock is above the female threshold. The provision protects against such conditions.

The CPT discussed how the harvest strategy switches between elements that apply at the district level and those that apply at the area level. An analysis that examines how these elements interact would be informative. The State harvest strategy is intended to be precautionary for Tanner crab because of its extremely volatile abundance trends, but since the strategy is multifaceted it is difficult to make an overall evaluation of the risks involved when applying the strategy. The CPT discussed the history of the harvest strategy and how it evolved through the changes in abundance and the concurrent Federal status determination and rebuilding efforts.

ADF&G has computed thresholds using the model outputs in addition to the area swept estimates for analysis. The State is open to considering how to use model outputs in the future; however, this impacts how the model output interacts with the threshold and needs further consideration. The model smooths out the survey data over time to reduce the effects of observation error. The CPT discussed the utility of further aligning the stock assessment model and Federal status determination criteria with the harvest strategy elements.

The CPT was interested in the State identifying why the model is not used and whether there are ways to improve the stock assessment model so that it can be used in the harvest strategy. The CPT noted that during the process to establish ACLs, the State had agreed to annually update the CPT on the TAC setting. This includes understanding how uncertainty and crab biology parameters feed into both the harvest strategy and the stock assessment model. The goal is to provide transparency and improve how these two processes work together.

March BOF proposals

Karla Bush discussed ADF&G regulatory changes adopted for BSAI Crab FMP stocks at a March 2017 meeting of the Alaska Board of Fisheries. Of particular note:

Proposal 242 – Corrects regulatory language in the St. Matthew blue king crab harvest strategy.

Proposal 250, as amended under RC 39 – Allows a vessel fishing for *C. bairdi* in the Bering Sea

District to retain incidentally caught *C. opilio* in an amount not to exceed 35% of the *C. bairdi* reported on the fish ticket.

Proposals 252 and 253, as amended under RC 26 and 27 – Allows observed and unobserved vessels, respectively, to re-rig, bait, and set gear for a subsequent fishery before fully exiting the current fishery in which the vessel is registered and prior to registering for the subsequent fishery.

Vessels cannot have gear active in two fisheries simultaneously and must notify ADF&G of their intention to transition between fisheries prior to re-rigging and setting gear,

Proposed 257, as amended under RC 40 – Moved the eastern boundary for the Bering Sea District *C. opilio* fishery from 166° W long. to 165° W long., and allows a vessel in the *C. opilio* fishery in the Bering Sea District to retain *C. bairdi* in an amount not to exceed 5% of the *C. opilio* retained catch.

Proposal 258 – Specified vertical placement of escapement rings on pots for St. Matthew Island blue king crab fishery.

Proposal 259 – Adopt ADF&G *Chionoecetes* quick reference identification guide.

Proposal 264 – Repeal provisions allowing concurrent fishing for red and golden king crab in the Aleutian Islands.

The CPT discussed whether the revised standards under proposal 250 would introduce conflicts for stock assessments. However, it was noted that under the current data collection protocols, at-sea observers conduct whole-pot sampling regardless of the target fishery and that retained catch is based on fish ticket data.