Crab Plan Team Report

The North Pacific Fishery Management Council's Crab Plan Team (CPT) met May 9 – 12, 2016 at the Hilton, Anchorage, AK.

Crab Plan Team members present:
Bob Foy, Chair (NOAA Fisheries /AFSC – Kodiak)
Karla Bush, Vice-Chair (ADF&G – Juneau)
Diana Stram (NPFMC)
Doug Pengilly (ADF&G – Kodiak)
Laura Slater (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)
William Stockhausen (NOAA Fisheries /AFSC - Seattle)
Bill Bechtol (Univ. of Alaska Fairbanks)
Brian Garber-Yonts (NOAA Fisheries – AFSC - Seattle)
Ginny Eckert (Univ. of Alaska Fairbanks/SFOS – Juneau)
André Punt (Univ. of Washington)
Gretchen Harrington (NMFS AKRO-Juneau)

Members of the public and State of Alaska (ADF&G), Federal Agency (AFSC, NMFS), and Council (NPFMC) staff that were present (or participated through WebEx) for all or part of the meeting included: Linda Kozak, Keeley Kent, D'Arcy Weber, John Hilsinger, Jie Zheng, Ed Poulson, Scott Goodman, Mark Stichert, Toshide Hamazaki, Ethan Nichols, Jim Ianelli, Teresa A'mar, Ruth Christiansen, Cody Szuwalski, Ben Daly and Chris Siddon

Administration:
The attached agenda was approved for the meeting. All documents for the meeting are available at: http://legistar2.granicus.com/npfmc/meetings/2016/5/937_A_Crab_Plan_Team_16-05-09_Meeting_Agenda.pdf

Membership: The Team welcomed back Gretchen Harrington (NMFS AKRO) as well as new member Miranda Westphal (ADF&G).

Meeting Schedule 2016/17:
September 2016 (AFSC Seattle): September 19-23
January 2017 Modeling workshop/CPT meeting (AFSC Seattle): January 17-19
May 2017 (Juneau TBD): May 2-5.

AIGKC Assessment
Doug Pengilly presented the Tier 5 assessment for Aleutian Islands golden king crab. The Tier 5 assessment has changed little in recent years following decisions by the CPT and SSC to stabilize the historical input data to: average ratios of bycatch mortality to retained catch during 1990/91–1995/96; average retained catch in the directed fishery during 1985/86–1995/96; and average bycatch mortality in groundfish fisheries during 1993/94–2008/09.

The management area currently includes waters west of 164° 44' W, separated at 174° W into eastern (EAG) and western (WAG) areas. The CPUE, when pooled across areas, increased fairly dramatically with implementation of crab rationalization in 2005/06 to a maximum of 29 crab/pot lift in 2011/12, and then declined slightly to 23 crab/pot lift in 2014/15. As requested by the CPT and SSC, Doug also presented fishery data separately for the areas east and west of 174° W. CPUE in both areas increased with rationalization in 2005/06, to 25 crab/pot lift in the east and 21 crab/pot lift in the west, and CPUE within both areas varied little from year to year during 2005/06−2010/11. However, CPUE increased in the EAG from 26 crab/pot lift in 2010/11 to 42 crab/pot lift in 2014/15, while decreasing in WAG from 23 crab/pot lift in 2011/12 to 15 crab/pot lift in 2014/15. Beginning in 2015/16 the timing of the 9-month fishing season was shifted to open on August 1. Given that the fishery just closed on April 30, harvest and CPUE data are not yet available for the 2015/16 season. However, comments from industry representatives suggested that the 2015/16 CPUE may be comparable to the 2014/15 season.

Total allowable catch (TAC) has not always been achieved in the WAG; in some years after rationalization, the TAC could not be achieved due to limited processing capacity. Retained catch in the WAG in 2014/15 was 135 t below TAC, which an industry representative suggested was due to only two vessels fishing. In contrast, the TAC has been consistently achieved in the EAG, and the retained catch has even exceeded the TAC in recent years as a result of the inclusion of catch from cost-recovery fisheries used to generate funding for the observer program and stock surveys. One industry comment was that some historically fished areas are now avoided due to potential conflicts with the trawl fleet.

The CPT discussed increased discards of legal males; notably beginning ~2011/12. The discards are minor compared to retained catch, but the directed fishery still accounts for the largest component of discard mortality. While the discards could reflect sorting of scarred or diseased crab to meet market preferences, industry representatives questioned the magnitude of the discarding in WAG given the TAC in that area was not achieved in 2014/15. The CPT reiterated that bycatch in the groundfish trawl fishery continues to be negligible and its use in the proposed assessment model may actually be making in the development of this model more difficult.

The CPT concurs with the author's recommendation of continuing with a Tier 5 assessment for this stock for the coming season, and to apply the same data and years to determine the OFL as has been used since 2012/13.The CPT also concurred with the assessment author's recommendation of a 25% buffer for the ABC, the same buffer that has been used since 2014/15.

AIGKC – model
Siddeek Sharif presented the golden king crab stock assessment model which remains in development for use in the assessment. The model was last presented to the CPT in September 2015 where it was generally discussed that the model fit the available data well but there were broader concerns about scaling of the model relative to absolute abundance in the stock. The model separates the golden king crab into eastern (EAG) and western (WAG) stocks. In previous documents both a Tier 4 and a Tier 3 assessment were provided but only a Tier 4 assessment was presented here. The reasoning for only bringing a Tier 4 assessment was that M was being estimated in the model. **The CPT recommended bringing forward a Tier 3 assessment in addition to Tier 4** as M may not be stable. The CPT again discussed as to why the stock was at about 30% of initial conditions when the catches first start and which parameters are driving that original scaling.

Siddeek provided a brief overview of the model and then provided responses to September 2015 CPT comments and recommendations with specific model scenarios. Seventeen model scenarios were provided where the following components were considered (See Table D pg. 18 in AIGKC model report):

1. Projecting initial conditions in 1985 from an unfished equilibrium starting in 1960 or by using an exponential formula to generate the initial abundance. The year 1960 was chosen arbitrarily as about one generation prior to available data in 1985. **The CPT recommended using the equilibrium model (and no longing bringing forward the exponential model) as it better tracked the variability in the initial size classes. The author should provide a plot of the full time series to show the pattern in depletion relative to removals prior to the start of the model.**

2. Different values for natural mortality were considered: 0.18 (standard) and 0.23 based on averaging the EAG and WAG estimates when minimizing the total negative log likelihoods for multiple components in the integrated model. The average value for M was 0.216 in the WAG and 0.246 in the EAG so they were averaged without compelling evidence that they should be different. The CPT discussed the validity of the M=0.23 (relative to M=0.18) given trends in the available data. Profiles seem plausible and in EAG the minimum clearly does not support 0.18. **The author should double check the profile on CPUE and provide an estimate for how long tagged animals are out in the tagging data to calculate an independent estimate of Z** (i.e. inverse time to recapture). **The CPT recommended continuing to bring forward models with both M=0.23 and M=0.18** acknowledging that estimated M in a single species model is difficult.

3. Trawl size composition data was down weighted (scenario 4) or not included (scenarios 5-6). **The CPT recommended dropping the groundfish bycatch weight due to poor fits to the groundfish bycatch length frequency data (e.g. scenario 7). AS scenario should be provided with the groundfish data removed.**

4. Asymptotic or dome shaped (scenarios 10, 11, 14, 15) selectivity. Dome shaped selectivity would suggest movement of larger crab away from where they are being fished (e.g. older moving deeper or shallower thus decreasing selectivity). M must be fixed if you have dome shaped selectivity. **The CPT recommended continuing with the dome shaped M and doing a profile with a dome shaped M.**

5. Size-composition effective sample sizes based only on initial weighting (stage-1) or on reweighted (stage-2) according to Francis (2011, scenario 9). Stage 2 should be a multiplier of Stage 1. The author multiplied the actual sample mean by the harmonic mean which is why the length comps are being fitted and the recruits for scenario 9 stand out. **The CPT recommended putting a bound (e.g. 200) and reconsider using the weighting without increasing above the observed. The author should bring forward scenario 3 with appropriate reweighting using the Francis (2011) method.**

6. Catchability and total selectivity in golden king crab targeted fisheries varied in two separate periods or in three periods (scenario 7; due to size composition data available prior to 1995).

7. In addition to observer derived CPUE data, a separate likelihood component for retained catch CPUE from fish ticket data was considered (scenario 3) and the variability in total area fished each year was considered in the CPUE estimation in scenarios 12-15. The CPT discussed the validity of considering a spatial component in the CPUE as less than 50% (closer to 25%) of the area is actually fished. The way that the author calculated the variability in total area fished would not appropriately weight the CPUE. **The CPT recommended a low priority item to see if there are enough data to consider a spatial model where you consider differently fished areas.**

8. Total catch and total catch size composition restricted to shorter time period.

9. Down-weighting data components by 75% in the model based on minima in negative log likelihoods at low OFL levels. The CPT did not see the value in this approach.

The CPT made the following general recommendations in addition:

- Provide CVs instead of SDs throughout analysis.
- Profiling negative log likelihoods on OFL not informative. It would be better to profile on mean biomass (middle of the time series) or on depletions (mean divided by total biomass).
- Start all retrospective and biomass plots in 1960s and fishing mortality plots at least back to 1981. It is important to understand what is forcing the drop in abundance between the model startup and 1985 when data are available. Is it recruitment or catch (which looks low)? It is not likely CPUE data as model 1 and model 3 both fit the early data.
- The weightings used in the model need more detail to properly assess.

AIGKC – research update
John Hilsinger provided a presentation on the collaborative research between the Aleutian Islands King Crab Foundation and ADF&G (Chris Siddon coauthor). The topics covered included AI RKC surveys, GKC surveys, and GKC genetic studies. The collaboration involves the fleet providing vessels and ADF&G providing personnel, input into survey design, and genetic analysis.

The AI RKC surveys are being completed over two years. The Adak region was surveyed during August 2015 and the Petrel Bank region will be surveyed during September 2016. The Adak survey had 730 potlifts and caught 442 crab, with 88% of the crab caught in two pots. Only 23 legal males were caught. Genetic samples of RKC were collected. Additionally, 2,458 Tanner crab were caught, 64% of which were legal males. The survey design for the 2016 Petrel Bank survey is complete and the survey boats were able to stage their gear following the 2015/16 fishery closure. ADF&G and the fleet will meet in June 2016 to finalize details.

The AI GKC surveys are also being completed in two parts. The EAG was surveyed in 2015 and both the EAG and the WAG will be surveyed during August 2016. The survey goals are to increase the information on the spatial extent of GKC, reduce potential for hyperstability of CPUE, initiate a time series, and provide a cost-effective method to survey the stock. The proportion of total area fished historically is 50.3% in the EAG and 45.5% in the WAG based on observer data since 1995. The survey design selected 75 stations randomly from a 2x2 nm grid, stratified across three equal area sections. In the actual survey, three vessels divided the survey area (but not along the stratification regions) and sampled 321 pots on 57 strings. The total crab CPUE averaged 45 crabs per pot and 27 legal crabs per pot. The CPT highlighted the possible need calibration across vessels. John acknowledged the current vessels use different gear and the next steps in survey design and data analyses are to examine within and among string variability, explore stratification efforts among skippers, and incorporate small mesh pots to better sample juveniles and females.

The GKC genetic study collected 480 samples on the 2015 GKC survey in the EAG, with ~5 crab per string sampled. Another 480 samples will be collected in the WAG this year. The ADF&G genetics lab is developing microsatellite markers (they have 17) for GKC and should be able to finish the EAG samples this summer and provide an update at the September 2016 CPT. Sequencing of mtDNA is also progressing.

Gmacs/SMBKC
D'Arcy Webber gave the CPT an update on the general development of the Gmacs assessment model code, as well as development of a Gmacs-based assessment for St. Matthew Island blue king crab (SMBKC). Jim Ianelli (AFSC) also participated in the update via WebEx.

General progress on code development included adding within-year time steps (seasons), options to initialize the numbers-at-size, and new plotting functions in the associated R package "gmr". The first two developments addressed CPT requests from the January 2016 Modeling Workshop. Within-year time steps (seasons) are now defined by assigning proportions of total annual natural mortality to each time step, as well as within which season(s) fishing, molting and growth, recruitment, and mating (for MMB) occur. The new implementation allows fisheries to be modeled using discrete (i.e., pulse fishery; a CPT request) or continuous-time representations. However, it also "breaks" the previous analytic approach to OFL determination, which will need to be addressed if a gmacs-based assessment is to be used for St, Matthew Island blue king crab in September 2016. New plotting functions in gmr include CPUE and log(CPUE) plots, fishing mortality plots, and bubble plots.

General code developments that are "in progress" include new approaches to calculating equilibrium numbers-at-size, spawner-per-recruit quantities, and OFL (previous approaches were broken with the introduction of seasons). Andre Punt pointed out the need to use a fixed-iteration Newton's method to calculate OFL, not bisection, to keep the calculation differentiable so that OFL can be reported as an sd_report variable. D'Arcy reported that the structure (maturity state, shell condition) for incorporating crab stocks exhibiting terminal molt (snow, Tanner) is currently in the Gmacs code, but the dynamics have not been developed.

Regarding general code development, the CPT had the following requests:

- 1-year projection for calculating Tier 3 or 4 OFLs
- specify catchability as a fixed or estimated parameter or use the analytic calculation for the MLE
- specify priors (e.g., gamma) using mean and variance/standard deviation for all parameters to ease specifying priors
- include an option to calculate dynamic B_{MSY}
- add the ability to "jitter" initial parameter values
- add the ability to conduct retrospective analyses
- add ability to estimate bycatch fishing mortality rates when observer data are missing but effort data is available
- allow different phases for "rec_ini", "rec_dev" estimation

D'Arcy also reported on development of a Gmacs-based assessment model for SMBKC and comparison with the 2015 assessment model. The (original) Gmacs version incorporated four seasons: 1) start July 1, duration = 0, surveys occur; 2) duration = 0.44 yr, fisheries occur; 3) duration = 0.185 yr, MMB calculated at end of season; 4) duration = 0.375 yr, molting/growth and recruitment calculated at end of season. To compare with the assessment model, Gmacs parameters were selected to closely match the size transition matrix used in the assessment model code (which André noted was different from that reported in the assessment document). Four scenarios were evaluated using the Gmacs version, including a model ("base") intended to match the 2015 assessment model as closely as possible, one which estimated selectivity on the first two size classes ("selex") and M in 1998, one based on "selex" which also estimated additional error CV's on pot survey data ("CV"), and one based on "selex" but which fixed M = 0.18 yr^{-1} for all years ("M").

Results for the base Gmacs model did not match the 2015 assessment model as closely as D'Arcy or the CPT felt they should. The CPT requested D'Arcy and Jim make a run fixing initial conditions and recruits to the same values as in the 2015 assessment model and that the units for input data and seasonal timing be checked to make sure all were consistent between the Gmacs and 2015 assessment models. In addition, D'Arcy reported that he models that estimated selectivity ("selex", "CV", "M") all resulted in selectivities for the NMFS trawl and ADFG pot surveys > 1 for size class 2, which the CPT found questionable. The CPT suggested fixing selectivity in both stages 2 and 3 to 1 for the NMFS trawl survey (only).

Following the first presentation on Monday, Jim Ianelli on Wednesday reported that the implementation of the robust multinomial likelihood in the 2015 assessment model included an additive factor of 2*π which was not included in Gmacs, so likelihoods from the two models wouldn't match but should lead to identical results. Additionally, the 2015 model had time-varying weights. Jim re-ran the 2015 model with constant weights to compare with the Gmacs version, resulting in better but not perfect agreement for MMB after 1986.

D'Arcy reported on some additional checks, including that one parameter not used in the Gmacs model had been turned "on" inadvertently, but turning it off made no difference to the results. He also implemented time-varying weights-by-stage, time-varying season lengths, and redefined seasons used in the Gmacs version to model fishing mortality as a pulse, rather than as continuous, to match the assessment model. After these changes, running the Gmacs model with fixed initial conditions, average recruitment and rec devs, M in 1998/99 set to the value estimated in the assessment model led to substantially different results between the two models, indicating a fundamental disconnect still existed. All data units and CV's were then checked and it was found that the units for bycatch in the pot fishery were incorrect. Once these were corrected, the Gmacs model achieved much closer agreement with the assessment model.

Jim, D'Arcy and Andre continued to review Gmacs and the assessment model for further dissimilarities. On Thursday, André reported he had found an error in the assessment model code associated with applying the growth transition matrix to the numbers-in-stage vector, that values for the transition matrix reported in the 2015 assessment report and in the code were different, and that the timing of fisheries between Gmacs and the assessment model was slightly different. He also reported that he had duplicated the 2015 assessment model code in R, including the error in the growth transition matrix multiplication, and had obtained the same numbers-in-stage as the assessment model. One effect of the matrix multiplication error was to effectively introduce an additional 10% mortality on stage 3 crab. The CPT noted that identifying this type of error in the current assessment model code would have been impossible without comparing to results from completely independent code such as Gmacs.

The CPT recommends that the model using GMACs, corrected for the growth transition matrix multiplication error, be presented to the CPT in September for use in stock status and OFL determination for SMBKC. The CPT understands that the corrected version will be presented to the SSC in June for their recommendations moving forward. Pending the outcome of the SSC meeting in June, the CPT requests that some evaluation should also be included in the September report to the CPT which compares against the previous assessment model corrected for the error.

PIGKC

Doug Pengilly presented the Pribilof Islands golden king crab stock assessment. The Pribilof Islands golden king crab fishery is managed on a calendar-year basis; therefore this assessment is for 2017. 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 the 2010 season; no vessels registered to fish in 2015. The OFL and ABC were not exceeded. The GHL of 68 t applied during 2000-2014 was reduced to 59 t (130,000 lb) in response to a reduction of the ABC.

A Tier 4 assessment based on a random effects model was presented at the September 2015 meeting. Information on mature and legal male biomass from the slope trawl surveys was only available for three years (2008, 2010, and 2012), and the model runs did not appear to be able to estimate a process error term with the available data. A slope trawl survey is planned for the summer of 2016 and the CPT will re-evaluate the model with the new survey results in January or May 2017. The Pribilof Islands golden king crab stock assessment remains in Tier 5.

The CPT concurred with the author's recommendation of status quo Tier 5 level, OFL and ABC, which have been used since the 2012 season. The ABC applies a 25% buffer to the OFL; use of the 25% buffer has been in place since the 2015 season and was adopted to be consistent with the other Tier 5 stocks.

WAIRKC

Doug Pengilly provided an overview of the Aleutian Islands red king crab stock assessment. The fishery has been closed since the 2004/05 fishing season. **The CPT concurs with the author's recommended OFL and ABC based on the Tier 5 assessment.** The 2016/17 recommended OFL is 123,867 lb (0.12-million lb; 56 t) and the recommended ABC is 74,000 lb (0.07-million lb; 34 t). The OFL and ABC specifications have been unchanged since the 2012/13 fishery. Fishery catch data for estimating total catch for the 2015/16 are not yet available; overfishing did not occur in 2014/15 since the estimated total catch for that season did not exceed the recommended OFL. The 0.07-million lb (34 t) ABC was recommended for the 2013/14 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). The ABC provides a 40% buffer on the OFL.

In past years, industry has expressed interest in conducting a test fishery in the Adak Island area. However, no test fishery has occurred. In September 2015, industry and ADF&G worked cooperatively to perform a "reconnaissance survey" for red king crab in the vicinity of Adak during the 2015/16 Aleutian Islands golden king crab fishery. There was no retention of red king crab, but handling mortality was accounted for in the 2016/17 assessment. The reconnaissance survey found low number of red king crab, out of a total of 730 pot pulls, 442 red king crab were found of which only 23 were legal males (Hilsinger et al., 2016). Industry representatives indicated that there is no desire to pursue a red king crab fishery in the Adak area at this time. The CPT in 2015 discussed whether length and effort information could be recovered to inform an assessment. However, data are sparse.

Doug Pengilly discussed the current management areas for the western Aleutian Islands red king crab stock. The Alaska Board of Fisheries in March 2014 established two districts for the management of commercial red king crab fisheries west of 171° W longitude. The non-rationalized Adak District was established from 171° to 179° W longitude, and the rationalized Petrel District was established west of 179° W longitude. A single OFL is set for both areas. The NPFMC has requested an analysis to considering removing the Adak District red king crab from the FMP.

After a lengthy discussion on the ABC for this stock, where concerns were expressed by several CPT members that this stock is severely depressed and the ABC artificially high so as not to constrain other fisheries, it was agreed that this stock is most likely severely depleted; especially in light of the reconnaissance survey results. Representatives of industry stated that money was given for a red king crab survey in the Petrel District. Other industry representatives requested the CPT give industry time to complete a Petrel District survey In November 2016 and present that data to the CPT. Industry representatives also expressed concerns that red king crab bycatch handling mortality in the Aleutian Islands golden king crab fishery be considered. The CPT agreed to wait for survey results and reconsider rationale for the ABC for this stock assessment again next year.

BBRKC

The document provided to the CPT was an analysis of several ways to add the 2013-2015 BSFRF side-by-side survey data to the assessment model, as requested by the CPT in January 2016. To gain better understanding of the modeling issues involved, the CPT requested that Jack Turnock explain how data from the BSFRF survey are modeled in the snow crab assessment. Jack noted that the snow crab comparative study covered only a portion of snow crab distribution, unlike the 2013-15 RCK catchability surveys. The data that are fit in the model are total biomass and numbers by length bin and sex for the NMFS survey and BSFRF survey in the study area. Predicted numbers at length are

$$\hat{N}_{BSFRF} = N q_{BSFRF} a$$
$$\hat{N}_{NMFS} = q_{NMFS} s \hat{N}_{BSFRF}$$

where
N is the population abundance at length (the length subscript is suppressed throughout),
a is a smooth function for the availability of crab by length for the study area,
q_{BSFRF} is the proportion of the fully available crab within the study area,
s is the selectivity at length for the NMFS trawl,
q_{NMFS} is the catchability of the NMFS net,
$\hat{N}_{BSFRF}$ is the predicted numbers at length in the BSFRF survey, and
$\hat{N}_{NMFS}$ is the predicted number at length in the NMFS survey.

The primary assumption of this approach is that the BSFRF nephrops trawl captures all of the crab of all sizes within the study area. It was noted that this approach does not take advantage of side-by-side aspect of the data that were collected for the 2013-2015 catchability study for RKC.

Jie Zheng then introduced a set of model runs that responded to the CPT request that results from the BSFRF catchability survey for 2013-2015 be incorporated into the assessment. The CTP also requested that model runs be provided to evaluate the impact of including or excluding the prior on catchability from 2004 under-bag experiment (Weinberg et al. 2004).

The alternatives under scenario 1 simply continue the approach that has been used for the 2007 and 2008 BSFRF surveys. This approach treats each survey time series completely independently, with a separate catchability, with a selectivity curve estimated for each. Scenario 1 is the status quo option; Scenario 1n adds the 2013-2015 BSFRF surveys; and Scenario 1p removes the catchability prior from the under-bag experiment.

Scenario 2 is basically the same modeling approach as in the snow crab assessment, but with several modifications to make it appropriate to model RCK catchability. Since the 2013-15 BSFRF catchability survey covers the entire distribution of RKC, the catchability parameter for the BSFRF survey is assumed to equal one. In the RKC application, the availability vector, a, is used to model the movement of juveniles from nearshore areas that are not surveyed, and is modeled as a logistic curve, rather than as a smooth function. Scenario 2p is identical to scenario 2 except that the under-bag prior is excluded. The CPT regarded technical basis for scenarios 1 and 2 as appropriate.

Scenario 3 structurally identical to Scenario 2, but a new likelihood component was added that fitted the ratios of total abundance between the NMFS trawl and the BSFRF trawls by length bin for each annual survey. A bootstrap approach was used to estimate CVs for the ratios, but CVs could not be estimated for all length bins because of small sample sizes. Several alternatives under this scenario explored the impact of making different assumptions for size of the unestimated CVs.

The CPT had several comments about this approach. First, it was noted at NMFS/BSRF ratios were highly variable, and that a better approach would be to consider the ratio of the NMFS survey to the sum of two surveys NMFS/(NMFS+BSFRF). Second, an attempt should be made to fit actual tow-by-tow data rather than survey aggregates. Finally, catchability for the NMFS survey was estimated to be greater than one for some model runs (this only occurred when the prior was omitted). It was suggested that catchability could be limited to values less than one by parameterizing catchability on a logit scale. The CPT concluded that these issues needed to be addressed before scenario 3 could be adopted.

Several other ideas for modeling the BSFRF survey data were discussed by the CPT, but these could be given lower priority. One suggestion was to consider whether other likelihood functions would be more appropriate than a normal likelihood for fitting the side-by-side data. Another idea was to use established methods to estimate gear selectivity outside the model (see papers by Millar and others), and final suggestion was to model NMFS trawl catchability as a random effect, such that mean catchability and annual deviations are estimated. This may be an improved approach given the apparent changes in catchability from one year to the next.

In general, all approaches gave roughly similar results. Model runs with high biomass tended to be those that incorporated the latest BSFRF surveys and those that excluded the prior from the under-bag experiment, indicating that the data from under-bag experiment are still influencing the model fit. The CPT would like to schedule a more detailed review during the January 2017 modeling workshop of under-bag experiment and prior generated from it.

The CPT requests that the following models be brought forward in September 2016: scenario 1 (status quo), scenario 1n, and scenario 2. Since results from the 2016 BSFRF survey will be available on the same timetable as the 2016 NMFS survey, these data should be incorporated into scenarios 1n and 2.

BBRKC – research update

Scott Goodman (Bering Sea Fisheries Research Foundation, BSFRF) provided a review and update on BSFRF-NMFS cooperative research studies to provide data for estimating NMFS trawl survey selectivity of Bristol Bay red king crab (BBRKC). Goodman has presented much of this material at previous CPT meetings, most recently at the January 2016 workshop. There were time and space lags relative to the NMFS survey when the 2007 and 2008 selectivity studies were performed, and nearshore red king crab pre-recruit surveys in Bristol Bay in 2011 and 2012 attempted to cover all stations in the Bristol Bay district that showed positive samples of pre-recruit RKC. The pre-recruit sampling was completed at a higher density in nearshore stations by subdividing each NMFS survey station grid and towing once in each subdivision. Different bottom temperatures among years may have affected RKC selectivity between nets.

Studies were performed in 2013, 2014, and 2015, concurrent with the NMFS EBS trawl survey. The study area for this duration was defined as the 59 NMFS survey stations in inner Bristol Bay that contained most of the BBRKC caught during the NMFS summer survey (the entire Bristol Bay area comprises 136 NMFS survey stations). Side-by-side tows were performed in each of the 59 stations in each study year, with a NMFS survey vessel towing the standard 83-112 trawl net and a vessel chartered by BSFRF towing a Nephrops trawl net. The Nephrops net is assumed to catch all crabs in the area it sweeps (q=1.0). The survey in 2013 occurred over a relatively cold bottom-water year. For 2014 and 2015, the same general survey schedule was followed, but the Bering Sea cold pool had receded by the time of the survey. Temperature profiles from mooring buoy M2 outside of Bristol Bay showed the timing of warming coincided with the starting dates of the surveys. Therefore, towing was completed over much warmer water in 2014 and 2015.

Estimates of BBRKC selectivity for sex-size classes by the NMFS trawl were presented as the ratio of CPUEs between ands, where CPUE is number of crab per nmi^2 swept for all 59 stations. Results of side-by-side RKC net selectivity in year-3 (warm year) were more similar to year-1 (cold year) than year-2 (warm year). In the 2013 study, the ratios were 0.48 for males <110 mm CL, 0.48 for males 110–134 mm

CL, 0.66 for males >134 mm CL, 0.28 for females <90 mm CL, and 0.86 for females ≥90 mm CL. In the 2014 study, the ratios all increased relative to 2013 and were close to 1.0 for larger size classes: 0.74 for males <110 mm CL, 1.01 for males 110–134 mm CL, 0.98 for males >134 mm CL, 0.48 for females <90 mm CL, and 1.04 for females ≥90 mm CL. The 2015 CPUE ratios were lower than the 2014 CPUE ratios and generally lower than the 2013 CPUE ratios: 0.33 for males <110 mm CL, 0.51 for males 110–134 mm CL, 0.56 for males >134 mm CL, 0.35 for females <90 mm CL, and 0.77 for females ≥90 mm CL.

Evaluation of the vessel pairs used in the side-by-side studies showed that one vessel pair in 2014 was an anomaly in terms of similarity in catch between the two net types, whereas all other pair combinations for 2013-2015 showed greater catch by station using the BSFRF net relative to the NMFS net. It was reiterated that NMFS survey catch of all crab species was higher in 2014. While Goodman noted in January 2016 that a review of data on tow performance (e.g., net mensuration data, bottom contact data, speed of vessel while towing, etc.) by both NMFS and BSFRF vessels in 2014 revealed that all vessels performed their tows according to established protocols. Goodman noted differences in trawl duration and speed result in the NMFS net covering seven times more seabed than the BSFRF net. Depending on how patchily crab are distributed, these differences in towed area could have large impacts on net comparisons.

Goodman also presented data on Tanner crab that had been collected during the 2013–2015 side-by-side studies in Bristol Bay and from the BSFRF nearshore red king crab pre-recruit surveys in Bristol Bay. As discussed in January 2016, it was noted that the area surveyed during these years did not cover the of the Tanner crab population east of 166° W long.; therefore, it was unknown how much of the stock biomass was present inside vs. outside the study areas. Goodman presented plans for continued selectivity work during summer 2016, expanding the area covered by side-by-side pair tows to the 167 NMFS stations extending from inner Bristol Bay to 166° W long. This expanded study area will allow for joint evaluation of selectivity for both eastern Tanner crab and BBRKC. Additionally, 52 tows will be performed in a focused block of 13 NMFS stations where small size classes of Tanner crab (down to 20 mm CW) have been caught. The BSFRF has been in communication with the stock assessment author regarding the process of incorporating selectivity data into the Tanner crab model. Goodman expressed the importance of applying consistent methods among

Tanner crab

Buck Stockhausen presented model scenarios for consideration in the September 2016 eastern Bering Sea (EBS) Tanner crab assessment. All model scenario presentations use an update to the assessment model code used in the 2015 assessment (i.e., TCSAM2013). Prior to presentation of model scenarios, Stockhausen noted that the retained catch in 2015/16 for EBS Tanner crab fisheries east and west of 166° W longitude reached the TACs established for each area and that harvest of EBS Tanner crab in 2015/16 (~8,900 t) was “the highest in quite a while.”

Stockhausen’s presentation addressed three issues/requests by the CPT and SSC relative to the fall 2015 assessment:

- the issue of the estimated male total mortality selectivity curve for 1996 (outlying relative to other years),
- the issue of scenarios with the Gmacs fishing mortality model not converging, and
- consideration of scenarios using lognormal likelihoods to fit fishery catch biomass failing to converge.

To address those issues/requests, Stockhausen made some significant changes to TCSAM2013 since the September 2015 assessment for the model runs presented here:

- ability to jitter initial parameter values
- option to estimate ln-scale female fishing mortality/capture offsets

- option to create extended size composition from the groundfish fisheries using original sample size (as opposed to input sample sizes)
- option to fit total or discard-only mortality for males in directed fishery
- ability to implement lognormal likelihoods for fishery catch data with assumed CV's as input
- parameters added to estimate scalars to extrapolate fishing mortality in the BBRKC fishery using effort for the pre-1992 years when bycatch data were not available (as opposed to using fixed rates).
- option to use logit-scale parameters to model the probability of molting to maturity as a function of size ("P(molt-to-maturity|size)")
- ability to specify:
  - Model start year (was 1949 in 2015 assessment)
  - 1st year for historical recruitment deviations (was 1949 in 2015 assessment)

Evaluation of the importance of initial values on model convergence was evaluated through "Model 0," which was selected as the "best result" (lowest objective function and smallest maximum parameter gradient) from the 2015 assessment model where the initial values were jittered 200 times. Model 0 converged to a slightly smaller objective function (by 0.44 likelihood units) than the 2015 assessment model. Although the difference in objective function value was small between Model 0 and the 2015 assessment, there were surprisingly large differences (>2 or <-2 likelihood units) in several of the objective function components. A notable difference between the results of Model 0 and the 2015 assessment was in the estimated male total mortality selectivity curve for 1996. The 1996 selectivity curve estimated by the 2015 assessment was an outlier, shifted to smaller sizes relative to the curves estimated for other years, In contrast, the 1996 selectivity curve from the version of Model 0 with the lowest objective function was similar to the curves estimated for other years. The selectivity curve for 1996 from the 2015 assessment was a source of much vexation for Stockhausen and the CPT.. However, the 1996 selectivity curve will be closely examined in future model scenarios. Otherwise, differences between Model 0 and the 2015 assessment in other estimates of interest are minor; e.g., essentially no differences in mature male biomass estimates and the OFL estimates, a slightly smaller estimate for B_{MSY} from Model 0, and a slightly larger estimate for F_{MSY} from Model 0.

Stockhausen presented results from 12 changes to the 2015 assessment for consideration:

- Model Change A: start "current" recruitment in 1975 not 1974,
- Model Change B: construct groundfish fishery size composition data using the original sample sizes – not input sample sizes,
- Model Change C: estimate log-scale fishing mortality/capture rate for females as offsets from males,
- Model Change D: fit male discard mortality in the directed fishery,
- Model Change E: turn on fishing mortality/capture rate estimation for BBRKC, rather than set constants,
- Model Change F: set the initial estimate for historical log-scale recruitment at 11.4,
- Model Change G: estimate P(molt-to-maturity|size) using logit-scale parameterization,
- Model Change H: change the model start year to 1930, keep start year for historical recruitment deviations at 1949,
- Model Change I: enforce logistic selectivity to be 1.0 for largest size bin,
- Model Change J: use Gmacs fishing mortality model,
- Model Change L0: use lognormal (rather than normal) likelihood functions to fit fishery retained and discard mortality with moderate CV's assumed for retention and discard estimates (0.05 for retained, 0.20 for discarded), and
- Model Change L1: use lognormal (rather than normal) likelihood functions to fit fishery retained and discard mortality with small CV's assumed for retention and discard estimates (0.01 for retained, 0.05 for discarded).

Changes A through I were applied singly, one-by-one, to the 2015 assessment model. A total of 100 runs with jittered initial values were performed for each change and the "best result" (lowest objective function and smallest maximum parameter gradient) for each change presented. Stockhausen summarized the effect of each model change relative to the results of Model 0:

- Change A: negligible impact on the results
- Change B: 1) a much improved fit to the size-composition of female bycatch in the groundfish fisheries for the later part of time series (1997 and on); 2) changes size selectivity estimates for bycatch in groundfish fisheries; 3) the estimated male total mortality selectivity curve for 1996 is close to what was estimated in the fall 2015 assessment (i.e., the 1996 selectivity curve issue that Model 0 fixed re-appeared); 4) changes in size selectivity estimates for female in the BBRKC fishery; 5) some change in fully-selected fishery mortality rate in the directed fishery; 6) ~7% increase in estimates of MMB-at-mating for recent years; and 7) a 1% decrease in average recruitment over 1982+.
- Change C: 1) improved fit by almost 40 likelihood units while adding only three model parameters; 2) much improved fit to female bycatch in the snow crab fishery; and 3) substantial changes to selectivity curves for female bycatch in the groundfish fishery.
- Change D: 1) small changes in estimates of MMB-at-mating and average recruitment; and 2) degraded fits to size-compositions of retained catch size and total catch for the directed fishery.
- Change E: 1) degraded the fit to the bycatch mortality in the BBRKC fishery; 2) improved fits to mature male and immature female size-compositions in the survey; and 3) shifted the estimated male total mortality selectivity curve for 1996 to smaller sizes (i.e., the 1996 selectivity curve issue again).
- Change F: not relevant given the initial values are jittered..
- Change G: removed the decline from 1 in P(molt to maturity) for males at largest size class, although it reduced the overall model fit (a decrease by 3.2 likelihood units).
- Change H: made little difference.
- Change I: no model runs converged for model change I, possibly due to exacerbating the inconsistencies between Model 0 and the data (inconsistencies resolved by model change C).

Stockhausen thought recurrence of the 1996 selectivity curve issue in some model results was likely due to the small sample size for the male catch size composition in 1996 and the 100 "jittered runs. The CPT recommended that a penalty of changes in the size-at-50%-selectivity be added. It also agreed that the jittering approach provide the best available way to ensure that the results presented correspond as closely as possible to the true minimum of the objective function.Given the results of the one-by-one model change exercise, Stockhausen recommended keeping model changes A, B, C, G, and I and not keeping model changes D, E, F, and H for consideration in future assessments.

Stockhausen proceeded to provide results for incremental additions of the model changes to Model 0, starting with adding change B (Model B), proceeding with adding changes A and C to Model B (Model A-C), adding model changes D to Model A−C (Model A−D), and so on to Model A−I. Models were evaluated using jittered initial values. Models B through A−I produced similar time series since 1980 for estimated mature survey biomass, retained catch biomass, total (male) catch mortality in the directed fishery, male bycatch mortality in the groundfish, snow crab and BBRKC fisheries, MMB, recruitment, and male fishery selectivity and retention curves (except for that annoying 1996 selectivity issue noted for the Model B results, above). Nonetheless, estimated final MMB and average (1982+) recruitment estimates decreased slightly from the model B estimates as model changes were incrementally added. Differences among model results were also noted in estimated female bycatch mortality in the non-Tanner fisheries and bycatch fishery selectivity curves for females estimated from Model B generally shifted to smaller sizes when estimated by Models A-C and above.

Finally, additional changes to Model A−I were examined that included model change J (use of the GMACS fishing mortality model) and model changes L0 and L1 (use of lognormal likelihood functions to fit fishery retained and discard mortality). From a likelihood perspective, Model A−I fit the data much better overall than Model A−J, due largely to a poorer fit by Model A−J to the total male size compositions in the directed fishery catch. Results from the addition of model change L0 to Model A−I (Model A−I.L0) and to Model A−J (Model A−J.L0) were presented; models that added model change L1 to Models A−I and A−J provided results so poor that they were dismissed as warranting no further consideration. The addition of model change L0 has the effect of fitting small values of fishery mortality (especially for female bycatch mortality) better at the expense of a poorer fit to the largest values of fishery mortality (i.e., for males in the directed fishery); that, in turn, has effects on the estimated fishery selectivity curves. The CPT concluded that, the use of a normal likelihood function for the fitting of fishery mortality is probably more appropriate for the Tanner crab assessment model.

The CPT found the presentation of the results from the jittered-initial-value runs and application of the various model changes to the 2015 model. **The CPT requested that six model scenarios be presented for evaluation at the September 2016 CPT meeting**:

- **Model a: Model 0, as presented at this meeting**
- **Model b (the base model): Model a, with model changes A, B, C, E, G, I, and J added**
- **Model c: Model b, with estimation of effort expansion factors and removal of minimum F's**
- **Model d: Model c, with removal of F penalties**
- **Model e: Model c, with lognormal likelihoods for fishery mortality (i.e., model change L0); assuming C works – otherwise, apply to Model b**
- **Model f: Model d with lognormal likelihoods for fishery mortality (i.e., model change L0)**.

Stockhausen also presented results from progress to overhaul the TCSAM2013 assessment code to produce a new version of the assessment code, TCSAM2015. His goal is to provide a "bridge" between a future GMACS assessment model and the current, TCSAM2013-based assessment model. Features provided by TCSAM2015 that are not provided by TCSAM2013 include:

- ability to define multiple time periods for any model process via input files,
- ability to specify data aggregation level via input files,
- exclusive use of the Gmacs fishing mortality model,
- re-parameterization of some model processes to improve convergence properties,
- ability to specify Bayesian-like priors on any parameters, and
- ability to do Tier 3-type OFL calculations directly within a model run, rather than post-processing model results using stand-alone code.

Performance of TCSAM2015 was tested by applying it to a 1950-2014 data set that simulated the population, fishery, and survey dynamics of the EBS Tanner crab stock using parameter values that have been estimated from TCSAM2013. TCSAM2015 was run for six scenarios, with different model parameters either fixed or estimated. Results confirmed that TCSAM2015 works very well when the data match model assumptions. An attempt to emulate TCSAM2013 model scenarios A-J and A-J.L0 (see above), however, revealed the need to "tweak the code some."

The CPT noted the value of using simulated data to test and evaluate models-in-development, as performed by Stockhausen. After discussion of development of TCSAM2015 relative to current plans to develop GMACS for use in assessments and the timeline Stockhausen expects for finalization of TCSAM2015 relative to that expected for development-to-implementation of GMACS, **the CPT recommended that Stockhausen move forward with development of TCSAM2015 with the goal of using it in the September 2017 Tanner crab assessment**. The CPT will try to put TCSAM2015 on the agenda for the January 2017 Crab Modeling Workshop (the agenda for that meeting is been filling up)

and requested that, if possible, Stockhausen update the CPT on any further development of TCSAM2015 in September 2016.

Eastern Bering Sea Snow crab

Jack Turnock (AFSC) presented the results of analyses based on a set of models developed to address previous SSC and CPT comments, and to investigate the properties of the approach used to find the maximum likelihood estimates for the values of the parameters of the assessment model for EBS snow crab.

The first set of models explored the reasons why the results from models 0 and 1 from September 2015 did not match exactly, given they only differed in terms of how selectivity was parameterized. This was found to be due to the models converging to different minima of the objective function rather than due to structural differences between the two models. This was confirmed using a 'jittering' algorithm. The CPT noted that 'jittering' the initial values of the parameters followed by applying the minimization algorithm many times should increase the chances of finding the true minimum of the objective function, but noted that this cannot guarantee that the minimum has been found. However, the approach to find best estimates for the model parameters for EBS snow crab using 'jittering' differed from that used for EBS Tanner crab. **The CPT agreed that a standard approach to 'jittering' needs to be selected and used for all crab assessments.**

Models 1a and 1b showed that convergence was much improved when some of the growth parameters were assumed to be known. Fixing the values for some of the growth parameters is, however, not justified as there is no objective basis for doing so at present (model 0 is not the global minimum of the objective function) so the CPT does not support taking models 1a and 1b forward. The CPT was pleased to be informed that additional growth data are being collected for snow crab. These data will be available for the 2016 assessment.

Many of the model changes did not lead to markedly different results. An exception to this was model 18c in which the 'Francis method' was used to weight the size-composition data. This model led to estimates of the mature biomass of females that were about half of those for model 13 and to survey catchabilities larger than 1 for females. The CPT was concerned about implementation of the 'Francis' weighting scheme because the equation in the document was incorrect. Jack later confirmed that the equations in the model code were correct, and that the only error was in the document. The CPT did not support the models in which the smallest length class was eliminated exceeded one. All these models led to unrealistic results. Models 14, 15 and 16 changed the weights on the growth likelihood, but these changes did not lead to improved fits owing to a conflict between the growth increment and the size-composition data.

The CPT has the following recommendations related to changes to the model structure and analyses:

- **The analyst should fully document the approach used for jittering (perhaps using a flowchart), but an approach similar to that used in Stock Synthesis where the jittered values for the model parameters are based on normal distributions about a set of initial values is preferable to the current approach for which the amount of jittering depends on the initial value for the parameter.**
- **The average fishing mortality for the groundfish fishery was pre-specified in past snow crab models. In future, this parameter should be estimated as it leads to better fits to the data (as was shown by diagnostic statistics for model 9).**
- **The assessment in September 2016 should show fits to the pot CPUE data and also provide retrospective analyses.**

- **The assessment in September 2016 should report the weights for the size-composition data from the 'Francis' method as well as plots of observed and model-predicted mean lengths.**
- **Catchability for all surveys should be bounded at one; at present the female catchability parameters are offsets from those for males and can consequently exceed one.**

The CPT recommends that the following models be presented at the September 2016 meeting (convergence of all models should be checked by jittering all parameters·

- **Model 0: to ensure comparability with the 2015 assessment**
- **Model 4a-9: which estimates the average fishing mortality for the groundfish fishery, drops the penalties on the fishing mortalities from 1992 to the present, estimates separate vectors of fishing mortality deviations from 1978/79 to 1990/91 and 1991/92 to present, and estimates a constant of proportionality between fishing effort in the pot fishery and fishery mortality for females in this fishery – penalties on fishing mortality have been shown by Cody Szuwalski to lead to biased estimates of mature male biomass.**
- **Model 11: as for model 4a-9, except that priors on the probability of maturity for males and females in dropped – these priors were imposed before data on growth were available.**
- **Model 13: as for model 11, except that there is a higher weight on the second difference penalty for the probability of maturing and in which the 50% selectivity parameter for female discard is estimated – these changes should lead to a smoother relationship between length and the probability of maturity and to better fits to the female length-composition data.**

The several of the models differ by more than one factor from the models in which they are nested. The analyst should change one factor at a time and be prepared to show the consequences of single changes for each model. However, the assessment document should focus on the four models above.

Ecosystem

Ben Daly (AFSC, Kodiak, via WebEx) gave a presentation on ecosystem considerations material in development for the CPT. Ben started with a brief recap of Stephanie Zador's December, 2015 presentation to the Council on the 300-page Ecosystem Considerations report included in the 2015 Groundfish SAFE. The report includes ecosystem report cards for the BSAI and GOA, and two major sections comprised of ecosystem assessments and ecosystem indicators. The document is updated annually, with an evolving selection of indicators with each iteration. The intent of Ben's presentation is to test whether reviewing the information from the December report at the May meeting is useful to the CPT. Martin Dorn pointed out that some of the climate indicator forecasts are produced more or less continuously, and could be updated with the most current information (i.e., later than the previous December) for use in crab assessments, and the CPT agreed that this would be useful.

Ben reviewed the presentation and discussion of crab ecosystem topics at the January CPT meeting. At the January meeting, the CPT consensus was that the crab SAFE should have its own ecosystems chapter, amended from the chapter that was published with the 2011 crab SAFE report, rather than amending the ecosystem report that accompanies the Groundfish SAFE to include more crab-specific indicators. The CPT had also agreed on using the report card approach, and that each stock should be treated separately with its own report card rather than producing a single ecosystem-level summary of indicators. Ben presented the draft BBRKC report card developed for this meeting. Both the Total RKC biomass (includes males and females) and RKC Pre-recruit biomass indicators have been relatively stable since the 1980's, and both the status and trend for the respective indicators during the most recent 5 years has been within 1 s.d. of the mean. Bob Foy noted that the apparent stability in both indicators is relative to the earliest part of the time series and suggested shortening the time series to the 1980's forward, so that deviations are calculated with respect to the post-regime shift period and would more effectively show more recent shifts in production. Ben agreed to do that for the next iteration. The bottom temperature indicator exhibited an increasing trend during the 5-year window, and Ben presented figures comparing bottom temperatures in Bristol Bay and the Bering Sea as a whole, indicating that Bristol Bay has warmed relative to the Bering Sea. The 'Proportion cold pool' indicator exhibited a downward trend, opposite to the bottom temperature indicator, as expected. Ben noted that the cold pool extent impacts the spatial distribution of RKC, especially ovigerous females, which tend to be pushed nearshore along the northern margin of the Alaska Peninsula.

The CPT discussed alternative points of evidence for the effect of temperature on productivity of RKC. Ben noted that interannual variability in fecundity has been observed, but that there is no conclusive evidence of a direct temperature effect, and Bob Foy noted that efforts to tie temperature to assessment model inputs have been inconclusive, and efforts to identify a temperature effect on fecundity have indicated no effect. Ben is currently working on a project to examine the effect of temperature on larval drift, investigating the hypothesis that colder temperatures promote distribution of larvae into more favorable habitat and result in improved recruitment. Karla Bush noted evidence that lower groundfish (Pacific cod) predation has been proposed as explanatory of improved recruitment during cold periods.

Ben presented the competitor biomass indicator (benthic invertebrates, average biomass per survey station) and benthic forager biomass indicator, both of which displayed variation within 1 s.d. of the long-term mean during the 5-year window, with decreasing trends over the most recent period, and the pelagic forager indicator showed variation within 1 s.d. and an increasing trend over the period. Plots for the three indicators show increasing difference over the period between values measured in Bristol Bay compared to the Bering Sea generally in each case, and with the observed trends being more pronounced in Bristol Bay than in the Bering Sea generally. Some additional indicators are in development (not included in the draft BBRKC report card), including an ovigerous female dispersion index, which measures the extent of the ovigerous female population relative to total abundance, and a larval drift indicator; both of these may be indicative of periodic variation in population distribution toward more favorable larval habitat in the nearshore areas in the southwest of the Bristol Bay, which appears to be correlated with colder bottom temperature. An indicator of benthic habitat disturbance caused by trawl gear and using observer data is also in development.

Ben briefly reviewed the content of the 2011 crab ecosystem SAFE appendix, noting that it was produced before the report card convention had been developed, and prompted discussion of the purpose of producing the full chapter given the current focus on a more succinct summary of indicators. Ben noted that the next steps as outlined during the January meeting, if the draft report card for RKC meets the CPT's approval, are to 1) prioritize stocks for report cards, 2) identify indicators for each stock, 3) complete a spatial analysis for each indicator, specific to each stock, and 4) begin updating the crab ecosystem chapter, and asked the CPT for guidance on how to proceed.

The CPT discussed indicators to incorporate into the report card. Some suggestions include:

- an indicator of predation that is more specific to crab (e.g. predator abundance weighted by percentage of diet made up by crab) such as an index of Pacific cod abundance rather than all predators combined, an indicator for biomass of crab of size classes smaller than pre-recruits (given greater vulnerability to predation), and an index of jellyfish biomass (which are both predators and competitors).
- indicator for total fishery removals

The CPT agreed that the next priority would be to develop additional indicators as discussed, and then develop draft report cards with these indicators for Bering Sea snow crab and Tanner crab. The CPT agreed on the objective of using the report cards to draw attention to ecosystem effects, with placement toward the front of the assessment chapter for each stock, and more complete documentation of methodology for the indicators to be included as an appendix to the SAFE; depending on how distinct the set of indicators end up being for the respective stocks, the methodology appendix may ultimately require separate subsections for each stock, as will become clearer as the report cards are more fully developed.

The CPT discussed the utility of continuing to produce the longer version of the crab ecosystem report, i.e., as a revision of the 2011 chapter. **The CPT recommends that a more succinct document, focused on methodology and supporting documentation for the report card indicators is preferred for inclusion in the SAFE, and a more comprehensive report could could be produced on a longer (e.g., five year) cycle as a technical report, rather than as an appendix to the SAFE.**

The CPT recommends that the annual report cards and supporting documentation be presented annually at the May CPT meeting, and revised over the summer following input from the CPT's review, for inclusion in the assessment chapters for September. Revisions following the CPT review in May would be limited to refinements rather than larger methodological changes, and would not include additional survey data points from the latest groundfish or crab surveys (the latter could potentially be added if time allows, recognizing that incorporating the last data point into the report cards in time to be useful to assessment authors may not be feasible). **The CPT recommends that the BBRKC report card and supporting methodology documentation be completed for the September 2016 meeting of completing. For the May 2017 meeting, the CPT recommends prioritizing completing report cards for the next two stocks (snow and Tanner) and supporting documentation, and production of the climate indicator report based on the December Groundfish report, updated with new (post-December) forecast results where available.** The CPT commends the authors on their work on this project.

EFH review/update

The CPT received an update on the EFH 5-year Review from Matt Eagleton, NMFS, and Steve MacLean, Council staff. The Magnuson-Stevens Act requires the review of EFH based on new scientific evidence or other relevant information. Matt explained the process for reviewing and revising the existing EFH species descriptions and maps in the Crab FMP. A preliminary review by AFSC scientists resulted in suggestions for new maps, new descriptions, updated FMP text, and updated habitat assessment tables based on new scientific information. The next step is for the CPT and crab stock assessment authors to review the EFH species descriptions and maps.

John Olson, NMFS, presented a brief overview of the new species description and fishing effects models being developed for the EFH 5-year review. The fishing effects model is derived from both the Alaska Long-term Effects Index and New England fishing effects model and now incorporates vessel monitoring system (VMS) data and a wider range of impact and recovery data for 26 biological and geological habitat types. The species distribution GAM models predict species life stages based on habitat characteristics, including substrate and other physical parameters. CPT members asked about groundtruthing of the species description model results. For example, the model shows snow crab in Bristol Bay when no other scientific information supports that distribution. The model authors are continuing to improve the model and incorporate other data sources. Once finished, the EFH analysis output from the models will provide an estimate for each species of habitat reduction from fishing. The model can also show habitat impacts over time (as % habitat reduction) from changes in fishing. The CPT will have the opportunity to learn more about the model in September.

PIRKC

At the September 2015 CPT presentation by Cody Szuwalski, CPT commented that the male-only Pribilof Islands red king crab model produced an abundance trend that did not closely match trend (which was highly variable). In addition, size composition data and the survey trend were in conflict .The CPT requested the author to examine the lack of fit to the historical survey abundance data by differently scaling the survey CVs and down-weighting the survey length frequency data to see if fits to survey estimates could be improved

The author formulated a number of model scenarios to address the above issues and presented the results to the CPT included

Reducing the effective sample sizes and reducing survey CVs resulted in improvements in the fits to survey abundance, suggesting that primary issue for the assessment is relative weight given to the survey trend and the length composition data. The CPT appreciated author's attempt to improve the model fit to survey abundance data and made the following **recommendations for further improvement:**

1. **Continue the work on survey biomass and length frequency weighting issues to improve the model fits to abundance data;**
2. **Implement the Francis tuning method to estimate length composition effective sample sizes; and**
3. **Provide results for a random effects model and three-year weighted average for the September meeting**

Research Priorities

The CPT reviewed and revised annual research priorities. The revised priorities are attached. The following comments relate to changes to the numbered priorities listed below:

196: Note that increasingly important issues due to increased overlap, cannot bring in to sell as cannot retain hybrid opilios off opilio grounds and concern for population dynamics and fishery management issues

223: Note potential for crab to be affected by climate change

Two new priorities were identified by the CPT:

- Collect growth data for Bering Sea crab stocks
- Natural mortality estimation for crab stocks

Research priority changes were forwarded to Council staff for compilation with other Plan Team input for SSC review in June.

The meeting adjourned at 12:30pm on May 12th.

North Pacific Fishery Management Council Crab Plan Team Meeting
May 9-12, 2016
Hilton Hotel, Anchorage AK
DRAFT AGENDA 5/06/2016 version

Monday, May 9		
09:00	**Administration**	Introductions, agenda, meeting minutes, documents/timing for June Council; meeting planning 2016/17
09:30	**AIGKC**	Model assessment and recommendations
Noon	LUNCH	
1:00	**AIGKC**	Final Tier 5 Assessment: OFL and ABC
1:30	**AIGKC**	Aleutian King Crab Research Foundation research update
2:00	**GMACS**	i. Model development update ii. Application to SMBKC iii. Discussion of SMBKC model and scenarios for September iv. BBRKC & TC plans
Tuesday, May 10		
9:00	**PIGKC**	Final Assessment: OFL and ABC
9:30	**WAIRKC (Adak)**	Final Assessment: OFL and ABC
10:00	**BBRKC**	i. Model discussions and scenarios for September assessment ii. Inclusion of new selectivity on model performance
Noon	LUNCH	
1:00	**BBRKC & TC selectivity**	Bering Sea Research Foundation research update
1:30	**EFH**	EFH review and update
3:30	**Ecosystem**	Ecosystem
4:30	**PIRKC**	Response to CPT comments on assessment
Wednesday, May 11		
9:00	**Tanner crab**	Model discussions and scenarios for September assessment
Noon	LUNCH	
1:00	**Snow crab**	Model discussions and scenarios for September assessment
3:30	**Research Priorities**	Review and revise
Thursday, May 12		
9:00	**Finalize SAFE introduction**	Finalize 3 Intro summaries; minutes
12:00	**New business**	As needed
12:30	**Adjourn**	

ResearchID	Title	Council Priority	Current CPT Priority	New CPT Priority	Current Research Status
145	Continuation of State and Federal annual and biennial surveys	Critical Ongoing Monitoring	Critical Ongoing Monitoring		Underway
431	Develop tools for analyzing coastal community vulnerability to fisheries management changes	Important	Critical Ongoing Monitoring	important	Underway
241	Develop bottom and water column temperature database and indices	Important	Critical Ongoing Monitoring		Partially underway
147	Life history research on data poor or non-recovering crab stocks	Important	Urgent		No action
167	Alternative approaches to acquire fishery-independent abundance data for for unsurveyed stocks of golden king crab	Urgent	Urgent		Underway
178	Develop a framework for collection of economic information	Urgent	Urgent		Partially underway
149	Improve handling mortality rate estimates for crab	Important	Important		Partially underway
163	Conduct routine fish, crab, and oceanographic surveys in the northern Bering Sea and Arctic Ocean	Urgent	Important		Partially underway
164	Effects of trawling on female red king crab and subsequent recruitment	Important	Important		Underway
169	Studies on factors that affect catchability particularly for King and Tanner crab	Important	Important		Underway
170	Quantitative reproductive index for the surveyed BSAI crab stocks	Urgent	Important		Underway
179	Conduct pre- and post-implementation studies of the benefits and costs, and their distribution, associated with dedicated access privileges	Urgent	Important		Partially underway
190	Collect and maintain time series of ocean pHÂ	Critical Ongoing Monitoring	Important	critical ongoing monitoring	Underway

ResearchID	Title	Council Priority	Current CPT Priority	New CPT Priority	Current Research Status
191	Assess whether changes in pH and temperature would affect managed species, upper level predators, and lower trophic levels.	Strategic	Important		Partially underway
202	Methods for reliable estimation of total removals	Urgent	Important		Underway
238	Develop a GIS relational database for habitat, to include a historical time series of the spatial intensity of interactions between commercial fisheries and habitat.	Strategic	Important		Underway
232	Develop management strategy evaluations that incorporate changing climate and market economic conditions.	Urgent	Important		Underway
226	Continue to evaluate the economic effects from fishery policy changes on coastal communities.	Critical Ongoing Monitoring	Important		Partially underway
367	Continue to improve stock assessment methodology with respect to uncertainty	Urgent	Important	Urgent	Underway
148	Spatial distribution and movement of crabs relative to life history events and fishing	Urgent	Strategic	Urgent	Partially underway
150	Maintain the core biological and oceanographic data (e.g., biophysical moorings, stomach data, zooplankton, age 0 surveys) necessary to support integrated ecosystem assessment	Critical Ongoing Monitoring	Strategic		Underway
158	Research ecosystem indicators and their thresholds for inclusion in ecosystem-level management strategy evaluation.	Important	Strategic		Partially underway
165	Conduct routine surveys of subsistence in the northern Bering Sea and Arctic Ocean	Urgent	Strategic		Partially underway
172	Develop and validate aging methods for crabs.	Urgent	Strategic		Underway
174	Develop spatially explicit stock assessment models	Urgent	Strategic		
177	Conduct prospective and retrospective analyses of changes in the spatial and temporal distribution of fishing effort in response to management change	Strategic	Strategic		Partially underway
183	Research the role of habitat in population dynamics and ecosystem processes	Important	Strategic		Partially underway

ResearchID	Title	Council Priority	Current CPT Priority	New CPT Priority	Current Research Status
184	Evaluate efficacy of habitat closure areas and habitat recovery	Important	Strategic		Partially underway
186	Collect and maintain zooplankton and meroplankton biomass and community composition time series	Critical Ongoing Monitoring	Strategic		Partially underway
196	Evaluate hybridization of snow and Tanner crabs.	Strategic	Strategic	Important	Partially underway
197	Develop methodologies to monitor for new/emerging diseases and/or parasites among exploited species and higher trophic levels	Urgent	Strategic		No action
208	Research on stock- recruit relationships	Urgent	Strategic		Underway
220	Research on survey analysis techniques for species that exhibit patchy distributions	Important	Strategic		Partially underway
229	Evaluate the effectiveness of setting ABC and OFL levels for data-poor crab stocks	Urgent	Strategic		Partially underway
230	Conduct ecosystem structure studies	Important	Strategic		Partially underway
237	Improved habitat maps	Important	Strategic		Underway
233	Develop an ongoing database of product inventories	Strategic	Strategic		No action
234	Analyze current determinants of demand for principal seafood products	Strategic	Strategic		Partially underway
240	Develop a multivariate index of the climate forcing of the Bering Sea shelfÂ	Important	Strategic		Partially underway
242	Collect and maintain primary production time series	Strategic	Strategic		Partially underway
223	Develop and evaluate global climate change models (GCM) or downscaled climate variability scenarios to assess impacts to recruitment, growth, and spatial distributions.	Strategic	Strategic	Important	Underway
224	Climate and oceanographic information covering a wider range of seasons	Strategic	Strategic		Partially underway
194	Identification and integration of archived data	Strategic	Strategic		Partially underway
147	Life history research on data poor or non-recovering crab stocks	Important	Urgent		No action
167	Alternative approaches to acquire fishery-independent abundance data for for unsurveyed stocks of golden king crab	Urgent	Urgent		Underway
178	Develop a framework for collection of economic information	Urgent	Urgent		Partially underway
NEW	Collect growth data for Bering Sea crab stocks			Urgent	
NEW	Natural mortality estimation for crab stocks			important	