

Crab Plan Team Report

The North Pacific Fishery Management Council's Crab Plan Team (CPT) met September 18-21, 2012 at the Alaska Fisheries Science Center in Seattle, WA.

Crab Plan Team members present:

Bob Foy, Chair	<i>(NOAA Fisheries /AFSC – Kodiak)</i>
Ginny Eckert, Vice-Chair	<i>(Univ. of Alaska – Fairbanks)</i>
Diana Stram	<i>(NPFMC)</i>
Doug Pengilly	<i>(ADF&G – Kodiak)</i>
Jason Gasper	<i>(NOAA Fisheries – Juneau)</i>
Wayne Donaldson	<i>(ADF&G – Kodiak)</i>
Jack Turnock	<i>(NOAA Fisheries/AFSC – Seattle)</i>
Shareef Siddeek	<i>(ADF&G – Juneau)</i>
Karla Bush	<i>(ADF&G – Juneau)</i>
Lou Rugolo	<i>(NOAA Fisheries /AFSC – Kodiak)</i>
André Punt	<i>(Univ. of Washington)</i>
Bill Bechtol	<i>(Univ. of Alaska – Fairbanks)</i>
Brian Garber-Yonts	<i>(NOAA Fisheries – AFSC Seattle)</i>
Heather Fitch	<i>(ADF&G – Dutch Harbor)</i>
Steve Martell	<i>(IPHC - Seattle)</i>

CPT members absent: *Josh Greenberg (Univ. of Alaska – Fairbanks)*

Members of the public and State of Alaska (ADF&G), Federal Agency (AFSC, NMFS), and Council (NPFMC) staff present for all or part of the meeting included: Jack Tagart, Gary Stauffer, Scott Goodman, Ray Nomura, Kevin Kaldestad, Brett Reasor, Paul Duffy, Chris Pugmire, Lance Farr, Jie Zheng, Heather McCarty, Arni Thomson, Bill Gaemann, Steve Hughes, Chris Arnim, Tom Casey, Dave Schwartmiller, Anne Vanderhoeven, Sarah Melton, Yuk Cheng, Denby Lloyd, Linda Kozak, Joel Cladouhos, Glenn Merrill, Pat Livingston, Farron Wallace, Jim Ianelli.

1. Administration

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

Document availability: The team made the following policy decisions regarding the dissemination of documents for consideration at CPT meetings. All draft assessments and documents are to be posted on the Council website one week prior to the start of the meeting (thus emailed to Diana no later than 8am Alaska time on the Monday one week prior). Only pages where revisions were made should be provided if emergency revisions to a document are necessary after it has been distributed. A table noting where changes are present should be provided if substantial revisions occur through the document. A revised document (or changes thereof) will be posted on the Council website with emailed notification to team and the public regarding its availability.

Website/Google docs: In an attempt to make additional model output available during the meeting, a google docs folder was established as a repository for all in-meeting documents. An invitation was made to all members of the public who requested access. Bob and Diana will continue to explore the possibility of a website (as is the case for groundfish) as a more comprehensive repository of all of the meeting documents. It was suggested that all pre-meeting documents in addition to the in-meeting documents be saved to the google docs folder as well as posted to the Council website. A site has been established at

www.tinyurl.com/AKcrab which will be used for future meetings (similar to what was established for the Groundfish Plan Teams).

Meetings 2013: Crab Modeling workshop: AIGKC and NSRKC February 26-March 1, 2013 Anchorage.

CPT meeting 2013: April 30-May 3, 2013 (Anchorage); September 17-20, 2013 (Seattle)

Status of stocks determination: The CPT notes that the SAFE report does not (and should not) provide the final determination of status of stocks given that it contains draft recommendations to the SSC. The CPT requests the SSC explicitly include final status of stocks information in their minutes (i.e., Tables 3 and 5 from the Crab SAFE intro modified for any SSC changes). The team further requests that an additional column be included in Table 5 indicating when a stock is rebuilt for clarification regarding stock status and changes thereof. Assessment authors requested clarification on what catch should be included in the tables and hence form the basis for evaluating whether overfishing occurred during the last year (observed vs. modeled). The team clarified it should be the modeled catch, but that the model predicted catch should be very similar to observed catch values.

2. Plan Team Workgroup Reports

The CPT received progress reports from several combined plan team workgroup efforts over the past year. Jim Ianelli (AFSC) provided an overview of two of the reports (survey averaging and retrospective analyses) while Jason Gasper provided an overview of total catch accounting. The team received a report in May 2012 from the recruitment workgroup.

2.1 Survey Averaging

The main tasks for the workgroup was to evaluate:

1. how to produce a “reliable” estimate of biomass for stocks/complexes managed under (groundfish) Tier 5;
2. how to use survey data for area apportionments; and
3. how to “fill in” gaps in areas or years which weren’t covered by surveys.

Only #1 is applicable at this time to crab stocks, notably the two Pribilof stocks where survey biomass is used to define stock status and OFL and ABC specifications. The workgroup’s main relevant recommendation was to use the Kalman filter rather than averaging survey estimates. Whilst inapplicable to crab, Andre suggested consideration be given to accounting for spatial correlation in process error when applying the Kalman filter when there are years with missing abundance estimates for some areas.

2.2 Retrospective Analyses

The workgroup reviewed a 2009 ICES report (Legault et al. 2009) regarding recommended approaches for two different retrospective analyses. A ‘historical’ retrospective analysis is conducted by examining the results of each final assessment for a number of years in a row and determining whether there was a consistent pattern of overestimating or underestimating assessment values in successive years. This type of retrospective pattern can be caused by changes in the data, type of assessment model, or assessment model formulation, and is most important to managers because it relates directly to the management choices made in the past based on the information available at that time.

In contrast, the ‘within-model’ retrospective analysis uses the recent (base case) assessment model formulation and trims the most recent year’s data in successive runs of the same model. ‘Within-model’

retrospective patterns are most useful for determining internal inconsistency of the data because the only changes among the different runs are the number of years of data used in the model.

The workgroup noted that there is currently no definition of what an ‘acceptable’ level of retrospective pattern is. The workgroup made some short-term recommendations for the groundfish assessment authors to follow in the subsequent year for age-structured assessments (Tier 3 and higher):

- run retrospectives back to 2002 (where 2002 would be a terminal year) for the base-case assessment in 2012, i.e., sequentially drop 10 years of most recent data;
 - construct two figures for each run: (a) spawning biomass; and (b) change in spawning biomass relative to the terminal (base) model.

The workgroup also requested that the groundfish teams examine the range of retrospective patterns in November 2012, that the workgroup investigate defining the “severity” issue, and recommended that authors evaluate parameters suspected of causing the pattern. The CPT suggested that the workgroup also consider forecasting given the actual catch for each retrospective analysis, prospective analyses, and windowing periods over scales of Q.

The CPT notes that conducting both types of retrospective analysis is already in the terms of reference for crab stock assessments.

2.3 Total catch accounting

Jason Gasper (NOAA) provided an overview on the workgroup progress toward meeting total catch accounting requirements. NMFS is currently developing new guidelines for NS1 (having published an ANPR), thus guidance may change in the future and efforts to explicitly incorporate all catches into assessments are moving forward slowly.

The current practice of continuing to include research catches in the assessment only as an appendix is the recommended approach. The same dataset provided to the groundfish assessment authors will also be provided to the crab assessment authors. The data is prepared by the Alaska Regional Office (AKRO) and made available to assessment authors through AKFIN. Crab assessment authors not having access to AKFIN can obtain the data directly from the Alaska Regional Office. One problem that needs to be resolved is the issue of the timing of surveys as the data are currently reported by calendar year. Jason will work with assessment authors to identify any current data gaps including State research catches and BSFRF catches, and will work to calculate these amounts to incorporate into the overall data set. Information on size or sex is not included in the dataset.

3. Survey Overview

Bob Foy (AFSC) summarized preliminary results from 2012 NMFS survey. The standard 376 survey stations were sampled on the eastern Bering Sea shelf and 20 stations were resampled in Bristol Bay at the end of the standard survey due to cold water effects on the red king crab reproductive cycle. Water temperatures were relatively cold this year, with the cold pool extended to the Alaska Peninsula and far into Bristol Bay. The 20 stations resampled in Bristol Bay warmed from -1 – 0°C in early June to 4-6°C in late July.

Additional data and sample collection occurred for seven special projects including: nearshore sampling in Bristol Bay; pathology; *Chionoecetes* spp. reproductive potential; bitter crab syndrome; preservation methods of reproductive tissue; snow crab reproductive biology; and population genetic studies of *Paralithodes* and *Chionoecetes* spp.

Abundance estimates and spatial distributions by sex and size were briefly summarized and new figures were presented showing the centers of distribution for each stock. It was noted that while corner stations are sampled south of St. Matthew Island, there is a station north of the island which has been a hotspot in the recent past, and perhaps corner stations should be added to the north. This survey was also noteworthy for an increase in the number of *Chionoecetes bairdi/opilio* hybrid crabs that were aggregated north of the Pribilof Islands.

Stock assessment authors should document how the raw survey data provided to them by Bob are used to compute the abundance estimates and size-composition information used in the stock assessment. Care should be taken when labeling figures and tables in the survey report, noting that there are different definitions (functional vs. regulatory) for “mature biomass.” Observed biomass from the survey should be labeled as such, and data that have been analyzed for use in stock assessments should be called something else.

3.1 Inshore Survey

Scott Goodman from the Bering Sea Research Foundation (BSFRF) presented preliminary results from the 2012 near shore survey. This survey was similar to the 2011 near shore survey where 95 stations were sampled concurrent to the NMFS survey. As noted earlier, water temperatures were much colder this year. Nine additional inshore survey stations were identified as trawlable with the NMFS survey gear. There was a greater distribution of red king crab (all size/sex categories) inshore this summer, likely due to the effects of the cold pool. Results suggest a near shore extension of the standard survey in cold years may be justified, although it was noted that this could impact the current survey time series.

Estimates of abundance from the BSFRF survey were generated using both area-swept and geostatistical modeling methods. BSFRF abundance estimates for areas sampled by both surveys were higher than those estimated by the NMFS survey. Variance around the BSRF estimates was also higher, although the cause wasn't clear. The CPT thought the survey work could be useful for estimating selectivity and ‘q’ inside the assessment model. The CPT looks forward to seeing a final report and encouraged the foundation to work with assessment authors so that the data can be included in the assessment.

3.2 CIE Review

Bob Foy presented an overview of the CIE review. The reviewers commented that the survey is good for all crab species with the exception of blue king crab. Comments that were applicable to crab included: reducing the survey towing time from 30 to 15 minutes; evaluating the time series without the hotspots; reevaluating the high density sampling stations (corner stations); following a GLM/GAM approach on survey data for estimating abundance indices; treating the re-tow stations in Bristol Bay as an independent survey; and adding strata for *opilio* and Tanner crabs.

Bob noted that he has completed analyses that remove the hotspot and corner stations, and that these will be presented in the future. The CPT discussed how moving from 30 to 15 minute tows could reduce sorting time and subsampling error, but would likely be problematic for the crab assessments because it changes catchability and increases variance. Past studies have also shown that abundance estimates for crab increase as tow duration decreases. The CPT discussed several other CIE suggestions including: reducing the number of crab lengths collected; randomizing the tow starting point; and applying GAMs that consider catchability indicators.

4. Tanner Crab Assessment and OFL

Jack Turnock (AFSC) and Lou Rugolo (AFSC) presented the assessment of EBS Tanner crab. The base model (model 0) was identical to that presented to the CPT and SSC in May 2012, except that the

2011/12 survey and fishery data had been included in the assessment, and a minimum of 4 had been imposed on the effective sample sizes for the size-composition data (as recommended by the CPT in May 2012). The assessment reflected the recommendations by the CPT and SSC that the assessment for EBS Tanner crab be based on the TCSAM and that the OFL be based on the Tier 3 control rule.

The CPT noted that most of the short-term recommendations from the May 2012 SSC and CPT meetings have been implemented, the exceptions being:

- Plot input sample sizes for LF data vs. effective sample sizes inferred by the fit of the model.
- Add an appendix which details the effort series and their derivations.
- Add confidence intervals on the data to the summary plots for the compositional data.

The CPT recommended that these tasks be completed for the May 2013 CPT meeting. The CPT also endorsed completion of the longer-term research tasks identified by the CPT and SSC during May 2012. In addition, the CPT had the following comments and recommendations:

- The description of the model should be carefully checked. Two errors in model description were noted: (a) fishing mortality by the Bristol Bay red king crab and EBS snow crab fisheries is related to effort not catch; and (b) selectivity for bycatch by the EBS snow crab fishery is assumed to be dome-shaped and not asymptotic.
- The parameter table (Table 8) is useful but (a) some parameters were missed, (b) the upper and lower bounds for the parameters were missing, and (c) some derived quantities (length at 50% selectivity for the fishery) were reported but the standard errors were incorrect.
- Correct the labels on Figures 24 and 25.
- The estimates of the length-at-50%-selectivity for the fishery for 2009 and 2010 seem anomalously high. The seemingly anomalous values may be due to confounding among parameters and need to be explored further.
- The fits to the groundfish length-frequency data (e.g., Fig. 51) and to the total catch are unexpectedly poor. Model configurations which better capture the data should be explored.
- The caption to Fig. 46 should indicate this figure pertains to the directed fishery and not all fisheries.
- There is still a residual pattern in the fit to the size-composition data for the survey. This could be due to time-varying growth, which should be examined as an alternative model for May 2013.
- The tables of model-predicted discards should start when the model first predicts discards. Similarly, the tables of model-predicted MMB and recruitment should include all years included in the model.

A major concern for the CPT was the inability of the model to match the magnitude of the discards in the EBS snow crab and Bristol Bay red king crab fisheries (as the evaluation of whether overfishing occurred depends on the estimates for the most recent year of these discards). The CPT requested the analysts conduct further analyses in which mimicking the observer data was given higher weight.

The CPT examined the three model configurations included in the document. The team recommends use of model 0 (base model) because model 2 (a minimum of 4 on the effective sample sizes) led to effectively identical results to model 0, and because model 1 (estimating a change in immature as well as mature M), although better from the viewpoint of the likelihood, needs to be explored in more detail before it can form the basis for a base model. The CPT noted the considerable value of having the full results of all three models available electronically because it made review of the alternative models simpler and recommended that this practice continue.

The CPT requested that the analysts include the effort series in the report for the SSC.

The CPT agreed that EBS Tanner crab should be a Tier 3 stock. This requires the calculation of $F_{35\%}$ and the corresponding MMB-per-recruit as well as the mean recruitment for $B_{35\%}$ calculation. The analysts presented four options for how this mean recruitment could be calculated. They presented a time-series of $\log(R/MMB)$ values and suggested that no change in $\log(R/MMB)$ had occurred. The CPT plotted $\log(R/MMB)$ and found evidence for reduced R/MMB with increasing MMB, i.e., an indication of an effect of MMB on recruitment. Further details of the analysis of the relationship between $\log(R/MMB)$ and MMB are outlined in the SAFE introduction and an appendix to the assessment.

5. General

The CPT requests clarification from the SSC of the general utility of the current maxABC control rule. The current maxABC control rule as formulated with a $P^*=0.49$ and with an uncertainty calculation in the OFL that does not consider non-model estimated uncertainty as mandated by Amendment 38 to the Crab FMP results in an ABC which is almost identical to the OFL for all stocks in Tiers 1-4. Thus for all practical purposes instead a 10% buffer has been applied for reasons of consistency with the Tier 5 control rule. However, there is no obvious link between the ABC control rule resulting from Amendment 38 and a 10% buffer. If the indication is that the maxABC control rule for Tier 1-4 stocks is mis-specified/inappropriate then the CPT recommends that the SSC comment on the utility of this as a maxABC control rule. If it is correctly specified then the CPT would appreciate the rationale for employing a straight 10% buffer across all stocks regardless of tier level and information availability as it would help the CPT when it develops advice regarding ABCs.

There is a need for consistency in what the minimum requirements are for assessments. One specific recommendation is that information should be reported in assessments regarding whether parameters are hitting bounds. This is included in the TOR, but not given in most assessments. The team struggled with how to encourage assessment authors to follow the TOR. Bob volunteered to develop a checklist of key TOR requirements. One idea is to assign a separate CPT member (from the designated rapporteur) to evaluate the whole assessment against the SAFE guidelines and provide that information to the assessment authors and the team during the review of assessments (if not sooner in order to facilitate revising the assessment to meet the requirements prior to finalization). The degree of complexity of the model should relate to the complexity of the diagnostics needed for checklist. Simplified models such as SMBKC meanwhile may not require the same comprehensive list as it will not be as informative to the model evaluation. Some consideration should be given to this in drafting the list of minimum requirements. This topic is discussed further under “new business”.

6. Snow Crab

Jack Turnock (AFSC) presented the eastern Bering Sea snow crab assessment based on revised survey and fishery data up to 2012. The base model chosen for this year was model 6 from the 2011 assessment. There were no changes to the model code, and only the new survey and fishery data for 2011/12 were incorporated. An alternative scenario was presented based on including a new growth model in the assessment (Model 1). The major structural difference between the two models is that the base model assumes molt-increment is a linear function of carapace width, whereas model 1 assumes a curvilinear function, with molt-increments decreasing with increasing carapace width.

The length of the fishing season this year was protracted in comparison to previous years, and the distribution of fishing effort was more towards the southwest than in previous years. Ice cover was a major problem for the fishery this year.

Model estimates of mature male biomass trends are consistent with the survey data in the past two years in both the base model and model 1. Trends between the two models are nearly identical, with model 1 having a lower estimate of MMB in February 2013. Model selection based on likelihood ratio tests favor the base model that uses linear growth.

The CPT and assessment team members had extensive discussion regarding the utility of the empirical data on growth being used in the assessment. An unpublished manuscript by Somerton et al. indicates that a piecewise linear model fits the empirical molt-increment data the best, but there is very little evidence to reject any of the growth functions explored based on information theoretic (AIC scores) grounds. The policy implications, however, were very sensitive to the assumed growth function where OFL limits were 67.8 and 51.6 thousand tons for the base model and model 1, respectively. The reference points $B_{35\%}$ and $F_{35\%}$ were lower under model 1.

Other notable comments included:

- The parameter correlation matrix for the two alternative models should be provided electronically to better understand the confounding among key parameters that determine the reference points.
- The fit of the curvilinear model to the empirical molt increment data suggest a better fit, but there does not appear to be much statistical support for rejecting the linear, or piecewise linear models.
- The molt increment data should be integrated into the assessment model rather than using the results of the study as a prior mean with an assumed CV of 0.1.
- Industry commented that uncertainty in growth has been a long-standing issue, and research has been directed towards resolving this uncertainty. It is frustrating for industry to not see the research results incorporated into the assessment.
- A model averaging approach could be used to integrate over the structural uncertainty when the data are insufficient to resolve two or more alternative structural assumptions. However, the debate then shifts to how much weight should be assigned to each model.

CPT recommends the use of model 0 for status determination and the setting of the OFLs and ABCs in this cycle, with the strong caveat that further evaluations as suggested above should be conducted for the May 2013 CPT meeting and model formulation which incorporates the new empirical data on growth should be provided. ABC recommendation: recommend below maximum permissible ABC as $ABC = 90\% \text{ OFL}$.

7. Bristol Bay Red King Crab

Jie Zheng (ADF&G) provided a summary of the 2012 Bristol Bay red king crab assessment, based on the “Scenario 7ac” assessment model of 1968-2012 NMFS trawl survey and fishery catch data. Scenario 7ac assumes natural mortality varies from a fixed $M=0.18\text{yr}^{-1}$ for males in 1980-1984 and for females in 1980-1984 and in 1976-1979/1985-1993. NMFS survey catchability for males and females is estimated in the model for 1970-1972 and is otherwise assumed to be 0.896 (based on Weinberg 2004); survey catchability curves are estimated separately for males and females in each of two time periods, 1973-1981 and 1982-2012. Three levels of molting probability are assumed to have existed for males over the modeled time period. Data on female from post-survey re-tows are used; only the standard survey data for males is used.

Response to CPT/SSC comments:

Jie addressed comments on the assessment model from recent CPT and SSC meetings. The SSC suggested that the model should explore application of a different survey selectivity during the early 1990s rather than high-M. The SSC noted that the use of increased M in the early 1980s needs more justification, particularly when the Ecosystem Chapter offers notes that there is no evidence for high

predation by groundfish on king crab during that period. Jie stated that the hypothesis of increased predation during the early 1980s has not been adequately tested and rejected by the available predation data; the sampling period for the predation data is not adequate to test the hypothesis. Bob Foy notes that, on the other hand, there is no data that confirms the high predation in the early 1980s.

Jie addressed the SSC's question on why the post-survey re-tow data on males are not used in the assessment by reviewing the history of results and patterns for males in standard survey and re-tow stations during 1999-2011. Results suggest that males tend to move slightly northward between the standard survey and re-tows and that occasional inclusion of near-shore stations can affect the comparison of the standard survey versus the re-tows. Results of this comparison suggest that only the standard survey data (and no re-tow data) for males should be used in the assessment. Jie noted that he had previously used the average of the standard and re-towed stations for males. He now feels that using only the standard survey data is appropriate for males, agreeing with the SSC recommendation that "the estimate based on more dispersed distributions may be the best estimate of biomass" for males. The re-tow area is designed for mature females and does not adequately cover the distribution of males.

General review of data and results:

During Jie's review of the catch history for the stock Bob Foy asked for clarification on what is meant by "pot" and "trawl" in the bycatch estimates. Jie said that "pot" means crab fisheries and that "trawl" means groundfish fisheries; groundfish pot fisheries are included in the "trawl" bycatch category, but there is little bycatch due to groundfish pot fisheries.

In reviewing the fishery CPUE trend relative to NMFS survey area-swept estimates, Jie noted that CPUE has generally increased since the mid-1990s, and especially since rationalization. The observation that the directed fishery CPUE of 28 retained legal crabs per pot in 2011/12 was high, although the area-swept estimate of legal crabs in the 2011 NMFS survey was the lowest since rationalization, led to discussion amongst CPT and representatives of the industry on 2011/12 fishing performance.

Jie's review of survey size frequency distributions from late 1960s through 2011/12 highlighted the low representation of smaller (<90 mm CL) crab in the 2008-2012 NMFS surveys. Except for the 2011 survey, which showed a very high catch of crab <60 mm CL, there has been no sign in the survey of small crab since 2008. In particular, the high catch of <60 mm CL in 2011 did not track into the 2012 survey. The 2008-2012 NMFS survey size distribution of males and females has gradually shifted to more mature- and large-size crab and shows little recruitment to the mature-sized crab and legal-sized males.

Jie compared results for females in the 2012 NMFS post-survey re-tows. Whereas crab in old-shell condition dominated the large (>100 mm CL) females captured during the standard survey, large females captured during the re-tow were virtually all in new shell condition (i.e., molt and growth of mature females occurred between standard survey and the re-tows).

Jie showed a comparison of the "observed survey", 2012 Scenario 7ac model, and the 2011 model trends. The trend in survey biomass (males and females combined) has been decreasing gradually since 2007. Mature-sized males and females separately have declined since 2007/2008.

Jie reviewed the Scenario 7ac survey selectivity curves for 1970-1972, 1973-1981, and 1982-2012. The 1970-1972 selectivity is markedly lowest, reaching a maximum of approximately 0.5 for males and 0.2 for females. The selectivity during the 1973-1981 and 1982-2012 periods both have maximum values of 0.896 for males and females, but selectivity for smaller crab during 1973-1981 is slightly higher than for 1982-2012

Jie reviewed the model's molting probability at size and compared the three model curves for molting probability at size with estimates from tagging data. The model uses one curve for 1968-1979 and two levels that can switch between years for 1980-2012.

A comparison of observed versus model-predicted size frequency of males and females shows that in some years, especially 1984, the fit to survey data can be poor. Jie suggested that the poor fit in such years is due to "hotspot" tows of small crab. Retained and discard male size frequency appear to be well fit. The size frequency of females in the directed fishery did not fit well in some years (e.g., 1997).

Andre Punt noted that the model estimates for 2011 and 2012 just barely hit the upper confidence interval for the observed data (model fit is higher than observed) and suggested that this observation should be recalled during discussion regarding ABC.

A retrospective analysis showed that previous model estimates of mature-sized males and females and legal-sized males drop with new survey data in recent years. Steve Martell noted that the survey data trend indicates that the stock has gone down in the last 5 years, but the model has not come down as quickly; i.e., the model is slow to respond to the decreasing trend in the observed data. Andre noted that the model can deal with high value at the end of an assessment period by "adding" recruitment, but can't deal with a "drop" due to the constant mortality. Steve noted that this could be another consideration when discussing the ABC.

Choice of period of recruitment to use for $B_{35\%}$:

Jie noted that assuming a 1976/77 regime shift would point to using 1984-2012 as the recruitment period for estimation of $B_{35\%}$ and gave a detailed presentation to support the use of 1984-2012 as the recruitment period. Jie added that no regime shift points to starting the recruitment period during 1969-1983 or for using 1969-2012 as the recruitment period.

Estimates for the mean recruitment during 1969-1983 are four times higher than 1984-2012. Also the estimated spawner-recruit relationships are very different between 1969-1983 and 1984-2012. Ln(recruit/spawner) vs. MMB plots are different for the two periods. Mean(R/MMB) is lower during the later period than during the earlier period. Jie related those observations to trends in the PDO index and mean bottom temperature trends (warmer temps since 1978). He also related this to the shift in center of distribution of mature females from the 1970s as opposed to the 1980s-2000s (shift to NE). That shift is related to the so-called "RKC juvenile nursery areas and the expected effects on larval advection: cool years leads to more settlement in nursery area, warm years leads to settlement in northern Bristol Bay (notes the appearance of RKC in northern BB and north of area T towards Nunivak. Bob Foy noted that although this survey year was the coldest year yet, the mature females were not at B08 (near Amak), although they were "hugging" the near-shore area. [It was clarified that "cool" means "cool during the survey period."] Jie also related the recruitment periods to a sharp increase in predator (yellowfin sole and Pacific cod) biomass after 76/77. From the audience, Gary Stauffer noted low abundance of Pacific cod during the 70s. Jie also hypothesized effects of larval prey availability (spring plankton bloom timing relative to hatching) on recruitment trends.

The choice of recruitment period chosen has a large effect on the proxy for B_{MSY} and OFL and status predicted for 2012/13:

- 1969-1983: highest B_{MSY} , lowest OFL; stock overfished (28% of B_{MSY})
- 1984-2012: lowest B_{MSY} , highest OFL; not overfished (96% of B_{MSY})
- 1969-2012: intermediate; stock close to and approaching overfished (51% of B_{MSY})

Bob Foy asked if the most recent year should be added to the recruitment period in future assessments; CPT consensus was: “yes, unless you have moved out of that regime.” Andre Punt noted that research has shown that changes in stock productivity regime can take at least 5 years to detect and that a “moving window” of time for the period could be used to better track any changes in stock productivity regime in future years.

Recommended OFL and ABC for 2012/13:

2012 assessment model estimates for overfishing are as follows:

- $B_{35\%} = 60.706$ mill lb (27.54 thousand t)
 - MSST = 30.4 mill lb (13.77 thousand t)
- $F_{35\%} = 0.31$
- OFL = 17.533 mill lb (7.96 thousand t) for total catch

The recommended ABC was based on a 10% buffer, the status quo approach established by the SSC in 2011. The “ $P^* = 0.49$ ” approach for establishing the “ABC-max” has negligible buffering; hence the team believes that the $P^*=0.49$ approach does not adequately account for uncertainty, especially given the retrospective pattern discussed earlier. Last year, the team suggested an ABC based on the results of the retrospective analysis. However, the SSC feels that approach is not valid. So, the team recommends the status-quo 10% buffer established by the SSC in 2011.

Recommendations for future assessments and research:

For future assessments, the CPT **recommends** that the authors:

- Look at a model beginning in 1983 to see what – if any – impact there would be on results for current and recent years. It seems that there are many issues with the data prior to 1983 (e.g., survey catchability) and the assessment is using post-1983 for the recruitment period to estimate $B_{35\%}$.
- Give more explanation on the Q for 1968-1972. One question to address is, “why is the Q different in 3 particular years – 1970-1972, but not for 1968 and 1969?”
- Include plots of effective sample sizes.
- Include more explanation on the use of two levels of molting probability during 1980-2012.
- Look at fitting the model to biomass rather than to number of crab to see what effects – if any – there are on results. Fitting to biomass may lower the influence of large, “hot spot” survey catches of small crab that do not track in the survey and that could change our assessment of the model fit in recent years.
- Incorporate the BSFRF data on BBRKC survey catchability going back to the 2007 and 2008 work (NOT the nearshore work outside of the survey area) for estimating on survey catchability for the 1982-2012 trawl survey using the approach that was used for snow crab (i.e., bring the data into the model rather than estimating catchability outside of the model).
- Table 5 (“summary of parameter estimates) should have the upper and lower bounds (constraints) imposed on the parameter so that it can be seen if an estimate is hitting a parameter bound.

The CPT also encourages future work on estimating catchability of BBRKC during the NMFS survey by conducting side-by-side tows, similar to the BSFRF-NMFS study on snow crab catchability.

8. St. Matthew Blue King Crab

Bill Gaeuman (ADF&G) presented the St. Matthew blue king crab stock assessment. The fishery was prosecuted as a directed fishery from 1977 to 1998, first developing when ten U.S. vessels harvested 1.202 million pounds during 1977/78. The peak harvest was 9.454-million pounds landed by 164 vessels in 1983/84. Annual harvests averaged 1.252-million pounds from 1986/87 to 1990/91, then increased to

3.297-million pounds during the 1991/92 to 1998/99 seasons. The fishery was declared overfished and closed in 1999 when the stock size estimate was below the MSST. A rebuilding plan for the St. Matthew Island blue king crab stock was adopted in November 2000 and included a harvest strategy established in regulation by the Alaska Board of Fisheries, an area closure to control bycatch, and gear modifications. The MMB was above B_{MSY} in 2008/09 and 2009/10, and the stock declared rebuilt. The 2011/12 harvest of 1.88 million lb, including deadloss, represented 74% of 2.54 million lb TAC; the 2011/12 CPUE of 9.0 crab/pot was down 11% from the 2010/11 CPUE. Total discard mortality of 10.5% in 2011/12 was similar to that in 2010/11.

Area-swept estimates from the 2012 trawl survey were down for all crab. Regarding survey considerations, the author pointed out a survey station north of St. Matthew that accounted for 30% of the 2012 trawl survey catch but is outside of the pot survey area. The assessment applies a 3-stage model using only “mature males,” defined as males ≥ 90 mm CL. A base model and six alternative models are considered in the current assessment with model configuration differing in: treatment of M (fixed at 0.18 yr^{-1} or estimated for some or all years); weighting of trawl survey and pot survey abundance compositions; and treatment of trawl survey selectivity by crab stage. In discussing model outputs, the author presented various diagnostics, including aspects related to potential parameter confounding.

The CPT discussed two primary issues with the base model: poor fits to the size-composition for the trawl survey (in particular beginning about 10 years ago) and Q values >1.0 . Model B formulations address Q value concerns but model C fits the trawl survey size compositions better. The CPT felt that selectivity estimates for the models suggest dome-shaped selectivity with one of the stages anchoring the selectivity curve and $Q >1.0$. This could indicate a problem of model misspecification due to something such as different mortality rates for different crab stages or a bias in the assumed stage transition matrix. Industry members pointed out that the fishery used to occur in September when large crab were closer to shore and where trawl survey is less effective, perhaps indicating time-varying changes in gear selectivity. In response to a CPT request, the author evaluated the effect of a range of weights of 5.0, 12.5, and 50.0 on the M deviations and corresponding retrospective plots and OFL values; as weighting on M deviations increased, model C results approached the base model results as weighting increased. Regarding selectivity, the CPT questioned how Q could be >1.0 and what it means to be more than fully available.

While there are obvious issues with selectivity and/or model misspecification, the CPT could not resolve the issues at this time based on the available model alternatives. The base model represents an obvious improvement over SMBKC assessments prior to 2012 and was identified as the preferred model in May 2012. Given neither of model formulations B and C are ideal, the CPT recommends using the base model for calculating biological reference points. The author recommends, and the CPT concurs, to use the full time series of data for B_{MSY} estimation because there is no additional information to suggest productivity changed over time. The author discussed the recommended ABC based on the $P^*=0.49$ approach, with a 10% buffer because of substantial uncertainty over the input parameters. The author also noted this is the first implementation of the Tier 4 approach for SMRKC and a Tier 3 approach is not yet warranted.

The assessment author was commended for the elegance and simplicity of the model and the efforts to make the model understandable without getting lost in the details. The CPT discussed diagnostic tools and how one size doesn't fit all, noting that the utility of a particular diagnostic will vary among assessments. It may be useful to add something similar to Table 6 with residual values and number of estimated parameters to indicate how much of the residual variance is explained by different alternatives. The serial autocorrelation in the residual patterns from the all model scenarios indicate something happened about 10 years ago, and the CPT suggested looking at retrospective estimates of Q for stage 2 crab in May 2013. For May 2013 the CPT also requests that the author explore a model alternative that merges characteristics of models B and C, perhaps allowing flexibility in M while bounding Q .

One potential contributor to misspecification is the growth transition matrix, and the CPT suggested exploring whether additional information could be used to inform this matrix. The current matrix allows crabs from stage 1 to grow to stage 2 and then to stage 3 (all with a probability of 1 each year) but does not allow crab to grow from stage 1 to stage 3. The author is also encouraged to evaluate the use of biomass instead of abundance as the way to summarize the survey data.

9. AIGKC

Shareef Siddeek (ADF&G) presented an updated analysis of the standardization of CPUE data from the Aleutian Islands golden king crab that included observer and fish ticket data. The goal of the analysis was to develop a method to standardize catch and effort for observer pot sample data and retained catches (fish ticket data) for future input to the assessment model. The analysis incorporated recommendations made by the Crab CPT at its May 2012 meeting and the SSC at its June 2012 meeting:

- confidence intervals should be estimated for the combined CPUE index;
- nonlinearity of soak time and depth effects should be explored using a Generalized Additive Model (GAM);
- the assumption of independence between pot castings should be investigated;
- Interactions between variables should be investigated, particularly year vs. soak time and soak time vs. gear; and
- lognormal fit of CPUE needs to be bias corrected.

The authors responded to some of these recommendations. However, the CPT recommends further investigation of the following:

- The authors need to include interactions between variables to examine area effects. The authors used the GVIF to investigate co-linearity between predictor variables. However, this test does not provide information about interactions in predictions of a dependent variable. The CPT recommends the authors add the interactions year:area and area:depth. These interactions would allow the authors to investigate an east versus west influence on CPUE and other potential data issues such as differing effort levels between areas.
- Model diagnosis showed patterns in the residuals for the fish ticket data that could not be resolved by CPT. There were two prominent Pearson residual patterns. The CPT recommends investigating: (a) the residual variation dramatically increases in 1993 and continues through the time series; and (b) the residuals show a distinct pattern around the 1:1 line.
- Include captain as a predictor variable and not use the variance inflation factor. The interaction between captain and vessel should also be investigated.
- The CPT noted that month was selected as a covariate for observer data, but not the fish ticket data. The authors should verify this is correct given observer data is nested with the fish ticket data.

The CPT also discussed a question from industry whether the increase in CPUE corresponded to rationalization of the fishery that occurred in 2005. The trend suggested an increase occurred prior to 2005, with a pronounced increase in the eastern area for 2004. The CPT could not associate this increase with any known event.

10. Norton Sound red king crab

Hamachan Hamazaki (ADF&G) presented a brief update on Norton Sound Red King Crab and plans for the modelling workshop in February 26 - March 1, 2013. Gretchen Bishop and Jie Zheng are conducting an analysis of standardizing CPUEs. Once this is finished, it may be incorporated into model. For the workshop, suggestions from May CPT and SSC will be integrated into the model and presented at the workshop. The CPUE standardization will be presented at the modeling workshop. Andre Punt

requested that an “advance look” at the model and CPUE standardization report be available by early January.

11. Pribilof Island Red King Crab

Bob Foy (AFSC) presented the 2012 PIRKC SAFE. No major management changes were in effect for this stock in 2011/12. There were no changes in the PIRKC survey boundaries relative to 2011. Survey results indicated a larger proportion of small crab than usual in the size-class distribution, and mature females were more widely distributed spatially. There were a few large tows at the south end of the island. PIRKC are usually distributed along the edge of the cold pool, but in the 2012 survey were entirely within the cold pool.

Bob outlined the changes in the assessment for 2012/13. Fishery retained and discarded catch time series was updated with 2011/12 data. Following recommendations of the CPT and SSC, MMB estimation employed calculation of a 3-year moving average centered on the current year rather than averaging the current and two prior years. Weighting presented in the initial draft was the inverse of the CV, but changed in the final assessment to inverse variance. Estimation of the OFL distribution employed bootstrapping to represent uncertainty.

Estimated mean MMB increased for 2012/13 to 3,302 t, and the OFL increased to 569 t. The sigma b was specified as 0.45, resulting in $ABC=0.8*OFL=455$ t. Bob noted that he did not include calculation of an ABC based on a 10% buffer in the assessment. Further development of catch-survey analysis model is on hold.

The CPT recommended the following for the 2013 assessment: include CV's in tables of abundance estimates and include CI's in the table of weighted moving averages estimates of abundance (Table 5). Bob noted that the next iteration of the assessment will include use of the Kalman filter as an alternative to moving average for estimation of MMB.

12. Pribilof Island Blue King Crab

The stock assessment author took the CPT through Pribilof blue king crab survey results and the stock assessment. No major management changes occurred during the 2011/12 season. The State of Alaska closed additional statistical areas to crab fishing, based on survey locations in which blue king crab were found in or near the Pribilof District. A revised rebuilding plan was approved by the Council in June 2012 and will soon go through final review by the Secretary of Commerce. The revised rebuilding plan closes the Pribilof Habitat Conservation Zone to Pacific cod pot fishing.

As part of the rebuilding plan process, blue king crab bycatch data as well as survey data includes an additional 20 nm east of the Pribilof District are now included as part of the Pribilof blue king crab stock. The additional 20 nm affected the mature male biomass time series most in 1983 when the MMB estimate was its highest, decreasing MMB estimate by 9 percent. In other years when the biomass estimates were relatively high, MMB estimates decreased by 5 to 7 percent. In order to review the validity of the choice of the additional 20 nm, the author showed actual bycatch numbers by federal statistical area, few blue king crab were found in federal statistical areas east of 165 W longitude, however effort was not presented and no recommendations were made by the CPT.

Bycatch data have improved, and now instead of being based on federal statistical area 513 is derived from a catch in areas database that calculates groundfish bycatch specific to the Pribilof District and the additional 20 nm to the east of the district. The database uses VMS data to isolate catches within the newly defined Pribilofs. Unobserved groundfish harvest uses blue king crab bycatch rates from the St.

Matthew area. Bycatch data from the catch in areas database was only applied to 2011/12 in this stock assessment. The CPT would like to see historical data from this database for comparison, being that using this database for the 2011/12 season showed a significantly higher level of blue king crab bycatch. It may be possible to get this data back to 2003. Most of the blue king crab bycatch this year was driven by the hook and line fleet, most of the catch from the continental shelf break.

Based on September 2011 CPT and SSC comments, biomass estimates are now based on a 3-year weighted average, centered on the current year. The stock assessment chapter weighted the average using an inverse square of the CV, the author then recalculated using an inverse variance weighting scheme. A Loess method was also tested, however over-smoothed inter-annual variability.

The stock assessment author and the CPT recommend an OFL calculation using average catch from the status quo time series. The author presented an alternative method using biomass estimates for calculating the OFL. Neither the CPT nor the author recommended using this approach given the high uncertainty surrounding this stock and the already low OFL. Uncertainty in biomass estimates could lead to an ABC of 0 and could have large management repercussions. Biologically this stock is not responsive to management measures given an already low OFL. The current method has been used since 2008 based on average catch. Before considering alternative approaches, the CPT would like to see historical groundfish bycatch data from the catch in areas database in order to more accurately assess historical catch.

The author recommended using a 10 percent buffer for the ABC calculation. An alternative approach was presented that added an additional 0.5 t in order to account for the high level of uncertainty.

The Pribilof blue king crab stock is overfished, however overfishing did not occur during the 2011/12 season.

13. Economic Overview

Brian Garber-Yonts (AFSC) presented the economic status and trends in commercial crab fisheries under the Federal Management Plan that are detailed in the draft Economic Status Report chapter (dated 9/18/12). He presented two key economic indicators to describe the recent trends in major BSAI crab fisheries with attention to the subset of fisheries included in the crab rationalization program. The two indicators highlighted are: 1. gross ex-vessel and first-wholesale production and value, and 2. Vessel crew and processing employment and income. Price increases in Bristol Bay red king, Aleutian Islands golden, St. Mathew blue king crabs, and Bering Sea snow crabs continued for a second year in 2011, exceeding recent peaks and, in the case of Bristol Bay red king, reaching historical highs. Preliminary data on 2012 snow crab ex-vessel sales indicate a continuing trend of price increases. The surge in Berents Sea and Russian North Pacific red king crab harvest that occurred in 2005-2007, which depressed wholesale prices internationally, does not appear to be recurring in response to recent price increases; future updates of the Economic Status Report will include more detailed reporting on import/export activity by port of origin to support improved discussion of near-term market trends. Across all BSAI crab fisheries, 2011 revenue in the crab harvesting and processing sectors were approximately 14% and 28% higher than the average over the previous five years. Crew earnings over all fisheries increased substantially from 2010, particularly average daily earnings due to the more rapid execution of the Bristol Bay and snow crab fisheries.

Brian presented a summary table of economic performance metrics prepared for annual reporting to NMFS Office of Science and Technology, as part of a nation-wide effort to coordinate economic performance monitoring and reporting for catch shares programs. Reported metrics are grouped into Catch and Landings,, Effort, Revenues, Price, and Cost Recovery, describing the performance of IFQ fisheries after rationalization. Values are reported for the post rationalization fishery performance (2005/06-2011/12), along with baseline values averaged over seasons 1998/99, 2001/02, and 2004/05.

OST protocols for economic performance reporting are a work in progress, and changes in the computation of current metrics as well as additional metrics will be introduced as the program develops further.

The plan team discussed at length how the economic report should be incorporated into the crab SAFE document. There was a query about whether the full report should be incorporated if it will be published separately an AFSC processed report. The team decided that a concise crab econ report will be included to the SAFE report as a chapter, with access to extended time series data tables and other supporting material provided through the AFSC Economic and Social Science Research program website for groundfish and crab SAFE Economic Status Reports.

14. New Business

The CPT discussed some membership issues. Josh Greenberg has not participated for several years and the team would like to either confirm his participation or remove him from the CPT. Diana will send a letter to Josh requesting confirmation of his participation.

The team expresses frustration with the lack of participation of some key members during the meeting week. The team does not agree that it is appropriate for assessment authors that are members of the plan team to excuse themselves from the meeting in order to work on their assessments. The team requests that these authors either remove themselves from the plan team altogether or commit to participating in a more meaningful manner outside of their specific assessments. The team understands that plan team members are often committed to more than one meeting at a time and have accommodated scheduling requests as needed.

The team would strongly encourage authors to follow the TOR in so much as it is applicable to individual assessments and encourages authors to seek internal review to improve the quality of the documents. The team requests that a meeting occur between the PT chairs, Council staff, RO staff and the heads of the respective agencies to discuss the need to improve the quality of the assessment documents being reviewed by the team on an annual basis.

For May meetings, have a review of each author's progress toward addressing SSC or CPT comments for the upcoming assessment cycle. The team intends to assign team members to each assessment to comment in May on the 2013? assessment and where it must be modified to meet the TORs and/or improve clarity.

Members of the public commented on some issues that the team should plan to address in the future including: hybrids and how to integrate them into the management process, selectivity issues with red king crab and other crab species and requesting that assessment authors spend additional effort to evaluate the sensitivity of these parameters in their assessment. This would assist industry in identifying and prioritizing additional funding efforts for cooperative research. Industry representatives also requested that authors endeavor to conduct sensitivity analysis on handling mortality prior to the May meeting.

North Pacific Fishery Management Council Crab Plan Team Meeting
September 18-21, 2012
AFSC, Seattle, WA

DRAFT AGENDA

9/14/2012 version

Tuesday, September 18

9:00 **Administration** Introductions, approve agenda, SAFE assignments,
9:15 **2012 EBS Survey results** NMFS bottom trawl results, AFSC/BSFRF nearshore survey results, **CIE review BSAI survey**
10:45 **PT Workgroup reports** ~~Recruitment report~~, total catch accounting report, retrospective analyses
11:30 **Tanner crab** Final assessment, OFL and ABC recommendation.
Noon Lunch
1:00 **Tanner crab (cont)** Continue discussion

Wednesday September 19

9:00 **Snow Crab** Final assessment, OFL and ABC recommendation.
Noon Lunch
1:00 **BBRKC** Final assessment, OFL and ABC recommendation
3:00 **St. Matthew BKC** Final assessment, OFL and ABC recommendation

Thursday September 20

9:00 **AIGKC** Discuss model issues/development, **plans for model workshop**
Proposed modifications for 2013/14 specification cycle
Noon Lunch
1:00 **NSRKC** **CPUE data standardization**, plans for model workshop
BSFRF Tanner selectivity study results
2:00 **Tanner crab rebuilding** Review projections with recommended base model, plans for rebuilding alternatives/analysis
4:00 **PIRKC** Final assessment, OFL and ABC recommendation
4:30 **PIBKC** Final assessment incl stock boundary issues, OFL and ABC recommendation

Friday September 21

9:00 ~~**Snow crab Effective spawning biomass**~~ ~~**Snow crab reproductive biology (Joel Webb). Potential plans for revising use of MMB in specifications/assessments**~~
9:00 **Economic SAFE review** Summary information for Crab SAFE Intro
10:00 **Report review** Final revisions 2012 SAFE introduction, specifications, tables
Noon Lunch
1:00 **Report review cont.** Final revisions 2012 SAFE introduction, specifications, tables
3:00 **New business , continue work on minutes as needed**
5:00 **Adjourn**