North Pacific Fishery Management Council

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Crab Plan Team

REPORT
Jan 14-17, 2020
Kodiak Fisheries Research Center
Kodiak, AK

Members in attendance:

Martin Dorn, **Co-Chair** (AFSC-Seattle)
Katie Palof, **Co-Chair** (ADF&G-Juneau)
Jim Armstrong, **Coordinator** (NPFMC)
Ben Daly (ADF&G-Kodiak)
Ginny Eckert (UAF/CFOS-Juneau)
Brian Garber-Yonts (AFSC-Seattle)
Krista Milani (NMFS-AKRO-Dutch Harbor)
André Punt (Univ. of Washington)
Shareef Siddeek (ADF&G-Juneau)
William Stockhausen (AFSC-Seattle)
Cody Szuwalski (AFSC–Seattle)
Miranda Westphal (ADF&G-Dutch Harbor)
Jie Zheng (ADF&G-Juneau)

Members absent: William Bechtol (UAF-Homer)

Others in attendance:

Jen Bell (ADFG Nome)
Kevin Clark (ADFG Kodiak)
Erin Fedewa (AFSC Kodiak)*
Jennifer Gardner (AFSC Kodiak)*
Jamie Goen (ABSC)
Scott Goodman (NRCC)*
Hamachan Hazaki (ADFG Anchorage)*
Kendall Henry (ADFG Juneau)
Luke Henslee (ADFG Kodiak)
John Hilsinger
Tyler Jackson (ADFG Kodiak)
Scott Kent (NSEDC)
Owen Larson (ADFG Kodiak)
Mike Litzow (NMFS Kodiak Lab Director)
Chris Long (AFSC Kodiak)*
Andy Nault (ADFG Kodiak)*
Maxime Olmos (UW/AFSC)*
Phil Pryzmont
Ric Shepard (ADFG Kodiak)
Madison Shipley (NRCC)
Mark Stichert (ADFG Kodiak)
Dan Urban (AFSC Kodiak)
Vicki Vanek (ADFG Kodiak)*
Bo Whiteside (ADFG Dutch Harbor)*
Leah Zacher (AFSC Kodiak)

** Presented to CPT*

Attended remotely via WebEx: Kalei Shotwell (AFSC Juneau), Julie Ayres (ADFG Dutch Harbor)

1. Administrative

The Crab Plan Team (CPT) meeting began at 8:10 a.m. January 14, 2020. During introductions, all in attendance observed a period of silence for the men lost New Year's Eve in the sinking of the F/V Scandies Rose. The CPT reviewed assignments and logistics for the meeting, including finalizing the SAFE introduction and this CPT Meeting Report. Web/Teleconference broadcast of the meeting was provided throughout the meeting, and connection information was posted to the CPT meeting agenda page. Martin Dorn and Katie Palof are CPT Co-Chairs and chaired the meeting.

2. Fishery update

Ben Daly from ADF&G gave an update on crab observer data, catch data estimation, and future assessment needs. Ben reviewed comments from the May 2019 CPT meeting. He stated that there has not yet been any guidance from stock assessment authors on whether additional data collection is needed.

The CPT discussed whether the length-weight regressions derived from the NMFS EBS trawl survey should be used in fishery catch estimation, as is current practice. The length-weight regression may not be appropriate to use in the fishery because the survey is conducted in the summer, and crab fisheries take place primarily in the winter. The CPT noted that one possibility is to have crab observers collect weight data while on the vessel. ADF&G responded that since observers do not have designated workstations it might be difficult for them to maintain and operate motion-compensated scales. Other sampling may need to be reduced to obtain these data. However, obtaining weights of retained crab through dockside sampling may be feasible.

ADF&G is currently working to re-calculate the time series of total catch using standardized methods, with the objective to obtain a revised time series though a process that is transparent and repeatable. The raw data and code will be given to the stock assessment authors when complete. Revised estimates are expected to be ready before the May 2020 meeting. The CPT stressed the importance of complete documentation. ADF&G is looking at making raw data available to stock assessment authors through AKFIN (or other on-line application), but this is still several years away.

Ben outlined the limitations of the crab observer data. Collection procedures were continuously evolving and growing in the early years. Ben proposed starting the time series for observer data in 1995 to avoid some of the errors and lack of documentation that are found further back in time. The year 1995 was chosen because it is the first year where observer data was entered into a database instead of being kept in spreadsheets and word documents. The CPT agreed with the 1995 start data for revising the catch time series, however this may cause challenges for assessments where the directed fishery was closed for long periods after 1995.

Fish tickets record the retained catch, and act as an invoice for the vessel. Effort is also entered on the fish tickets. Effort data depend on the accuracy of the information reported by the captain. Fish tickets also do not distinguish between incidental catch and directed catch, which can make it difficult to assign effort to the appropriate fishery. This is particularly an issue for Tanner crab, which has been retained incidentally in both red king crab and snow crab fisheries.

There is interest from industry to move to multi-species Chionoecetes fisheries to reduce discards. While reducing discards is a worthwhile goal, there are potential ramifications of this change on catch estimation and fishery selectivity that will need to be evaluated. Escapement mesh size differs by the directed fishery, so changes in selectivity could occur. Fish tickets do not identify the directed catch and the incidental catch, and length frequency data collected by observers is not linked to fish tickets. If incidental catch becomes substantial, procedures would be needed to link length frequency data by trip to catch estimates, and to identify incidental catch and directed catch. Sampling both incidental and directed crab at each delivery may be difficult due to time constraints.

The CPT recommends that all stock assessment authors evaluate the impact of the revised post-1995 total catch time series by including these data in the base model from last year's assessment for consideration at the May CPT meeting. If the results are deemed acceptable, the revised time series should then be used all other model configurations being considered.

3. Ecosystem and Socioeconomic Profiles

Erin Fedewa presented on BSAI crab Ecosystem and Socio-economic Profiles (ESPs). The ecosystem initiative began with the development of the Crab Ecosystem Considerations Chapter in the 2011 SAFE.

Subsequently, a report card format was developed to summarize ecosystem indicators for individual crab stocks. These were presented to the CPT by Ben Daly in 2016. Erin updated report cards for BBRKC, snow crab and Tanner crab and presented these to CPT in May 2019. At that time the CPT recommended moving forward with stock specific report cards. The crab-specific report cards were used last year during the State TAC setting process to communicate environmental uncertainty. The CPT recommends that the report cards be maintained and updated for snow crab, Tanner crab, and BBRKC, and included in the SAFE stock assessments. Draft report cards should be presented and reviewed by the CPT in May to inform the assessment for the fall SAFE. The CPT did not see a need for a separate ecosystem status report for crab, but it would be worthwhile to give thought to making the existing Eastern Bering Sea ecosystem status report more relevant for crab stocks.

The current emphasis is on developing ESPs using a standardized framework, and to integrate ecosystem and socio-economic factors in the stock assessment process and TAC setting. Erin and several CPT members participated in the ESP workshop in May 2019, and developed an ESP for SMBKC as a working example. The SMBKC ESP was presented to the Council in October 2019 during rebuilding plan discussions with positive feedback from the SSC and suggestions for improvement. The SMBKC ESP was also included in the December SMBKC Environmental Assessment presented to Council in December. A second ESP modeling workshop is planned for March 2020.

Erin presented an updated figure showing current and final target data classification scores (i.e., gap analysis) for crab stocks, which is designed to help prioritize stocks for ESP development. The CPT was concerned about the accuracy, consistency, and utility of the data classification table for crab stocks. Erin acknowledged that the scores for each stock could be modified with additional CPT/assessment author feedback to more accurately reflect data classification. It was noted that this exercise is part of a national effort to score fish stocks.

SSC indicator recommendations include OA index for stocks with high vulnerability, community engagement and dependency patterns, changes in harvest and processing diversity (fishing portfolios, fleet sizes, and utilization rates have changed), and a habitat vulnerability indicator. The SSC has emphasized community information, but it is apparent that further conceptual development of the ESP is needed on how best to incorporate socio-economic information. Erin presented ideas for new BSAI crab-specific indicators such as fecundity, movement, bitter crab syndrome, Pacific cod predation, body condition, OA effects, spatial distribution indices, early life history indicators, multivariate climate indicators, community engagement, social and economic drivers, and benthic production indicators. Erin mentioned that we need to think about how best to develop predation given the temporal mismatch of the survey and when molting happens. The CPT concurred and highlighted the importance of considering spatial distribution of predators and crab.

The CPT recommends that Bristol Bay RKC be the next crab stock for developing an ESP, due to concerns about its continued decline. The CPT recommends that an ESP “team” be formed to develop the ESP, rather than being the responsibility of the assessment author. There was some discussion about the timing of indicator updates and it was noted that it will likely be difficult to update all indicators with the current year survey data in time for inclusion in the final SAFE, which gets presented to the CPT in September. The CPT mentioned that it may be acceptable to have some indicators lag by one year from the current assessment year. For crab ESPs, the first draft of a stock-specific ESP should be presented to the CPT at their May meeting, with a shorter update on the final version presented to the CPT at the September meeting. In addition, the CPT would like to continue to hear the Bering Sea Ecosystem status report at September CPT meeting.

4. Norton Sound RKC - Final 2020 Assessment

Toshihide Hamazaki presented the assessment Norton Sound red king crab based on the suite of models decided in September 2019 using updated data sets. The model selected in September was the base model

developed in 2018. Key points of discussion included the treatment of discards, appropriateness of natural and discard mortalities, the utility of using shell condition within the model, documentation standards, and advice on buffers.

A range of methodologies for calculating discards was presented, but, given the relatively sparse documentation for the methods, the CPT was unable to effectively evaluate the various methodologies. The author suggested that the discards are less important to the assessment and management process than reliable survey data, a sentiment that was echoed by local managers. The CPT emphasized that federal guidelines require that OFLs be based on total removals, which requires an appropriate accounting for discard mortality. The CPT also stressed the need to be consistent in definitions of 'discards' and 'total' catches across stocks.

Historically, natural mortality was specified as $0.18yr^{-1}$ for all size classes except the largest size class. Models were presented in which a single value of natural mortality was used in response to questions of biological explanations for the major change in natural mortality-at-size implied by the assessment. Discard mortality has historically been set at 0.2 for both the summer and winter seasons. The possibility that mortality rates vary between winter and summer was raised given the harsh conditions encountered during winter. The utility of shell condition for Norton Sound red king crab was discussed given uncertainties around shell condition in other stocks. Difficulty in estimation of molting probabilities when shell condition was excluded in previous iterations of the assessment was listed as the reason for the continued inclusion of shell condition. Nevertheless, a model run without shell condition data (with perhaps a fixed molting probability) would address whether the estimates of high terminal M is being driven by inaccurate shell condition data.

The CPT recommended the use of the *status quo* model with a buffer between OFL and ABC increased to 25% to reflect very low recent catch per unit efforts and unusually large amounts of old shell crab in the fishery. A potential recruitment event is apparent in the length composition data, but is not expected to enter the fishery until 2-3 years. The CPT emphasized the need for appropriate documentation of methodology to facilitate discussion and the importance of appropriately plotted data and model output in this process.

The CPT recommends the following:

- The calculation of discards from the available data needs to be better documented to facilitate discussion by the CPT. In particular, all symbols in equations must be defined and clear descriptions of the differences among the various assumptions around methods of calculating discards should be provided.
- Comparisons of model estimates of discards to different potential calculations of discards should be presented in a figure.
- Develop a rationale for whether or not the bias correction should be applied to the discard data. Document the bias correction with enough depth to facilitate discussion by the CPT.
- Ensure that the definitions of 'total' catch and 'discard' catch are consistent with other assessments.
- Explore potential differences between handling mortality in the summer and winter.
- Consider the impact of ghost fishing of lost pots from the winter fishery.
- Figure 4 needs a representation of uncertainty for both the data and the model output. Any other figures missing representations of uncertainty should be revised.
- The dots on figures representing 'projections' (e.g. fig 4 & 5) were confusing, please join the line with the dots representing 'projections'.
- Check equations 3, 6, and 7 for changes in the index 't'.
- Provide one main assessment document that includes tables and figures. Include all other information and analyses in a single appendix.
- Consider reducing the resolution of figures to control the size of documents.

- Ensure numbers in the front matter (e.g. MMB in the tables in which the OFLs are listed) are correct.
- Attempt to achieve 10-year peels for retrospective analyses. Consult published literature on how to assess the significance of the Mohn's rho estimate.

5. St Matthew Island blue king crab rebuilding plan update

Katie Palof gave an update on the initial review draft on the St. Matthew Island blue king crab rebuilding plan. St. Matthew Island blue king crab was declared overfished in October 2018 by the NMFS and a rebuilding plan must be developed and implemented within two years. Katie and James Armstrong developed this draft for the CPT and submitted it to the Council for initial review in December 2019. The draft includes three chapters: introduction, alternatives, and other considerations, rebuilding analysis and socio-economic impacts.

Based on National Standard 1 Guidelines, the minimum time for rebuilding a stock (T_{min}) and the maximum time for rebuilding a stock to its B_{msy} (T_{max}) need to be calculated. T_{min} is estimated to be about 14.5 years, and T_{max} is estimated to be about 28.5 years, equal to T_{min} plus a generation time (about 14 years). Two alternatives were proposed: 1) no rebuilding plan and using ABC in projections, and 2) rebuilding with two options: 1) no harvest during rebuilding and 2) rebuilding with the current state harvest strategy. Alternative 1 and alternative 2 option 1 bracket potential rebuilding times, while the rebuilding time for alternative 2 option 2 is within that range. Because bycatch of St. Matthew Island blue king crab in the groundfish fisheries has very minimal impacts on rebuilding times, no alternatives are proposed for restricting groundfish bycatch. Three recruitment scenarios were used to evaluate the alternatives: random recruitment from the entire period (1978-2018), random recruitment from the recent period based on recruitment breakpoint analysis (1996-2018), and a constrained Ricker S-R model.

In initial review in December 2019, the SSC recommended the current draft adequate for the rebuilding plan and suggested some revision and expansion of the document and analysis. The Council supported alternative 2 option 2, which provides management flexibility. In April 2020, the social economic analysis needs to be finalized and the Council needs to take final action on the rebuilding plan.

The CPT recommends the following:

- Document the data and the assumptions used to fit the Ricker S-R model, and the other data used in projections.
- Document the data and method to estimate the generation time.
- Include the projection envelopes to show the uncertainties of the projections.
- Provide more thorough analysis of socio-economic impacts for each alternative.

6. Aleutian Is. golden king crab proposed model runs

Siddeek (ADF&G) presented the work conducted since September 2019 on the stock assessment for Aleutian Islands Golden king crab, and the proposed model scenarios for the May 2020 assessment for this stock.

A retrospective analysis was conducted to determine the reasons for the large recent recruitment and the retrospective patterns evident in past assessments. The CPT notes that the basic approach is appropriate but (a) the retained catch time-series should be included in all analyses, and (b) the peels should explore removing total catch and size-composition separately to better detect the reasons for the large recent recruitments and the retrospective patterns. The results of retrospective analyses should be shown for biomass and recruitment.

The CPT reiterates the SSC request for a brief description of the cooperative survey in the assessment document, including the area sampled, size composition and a summary of results.

In relation to the proposed changes to the basic modeling approach:

- *Revised approach to select mean recruitment*. The proposed approach sets mean recruitment to the average over the years for which the standard deviations of the recruitment estimates are 70% of the assumed standard deviation of inter-annual variability in recruitment. The choice of 70% is the lowest percentage at which a contiguous set of years would be selected. The CPT agrees with the general approach, and requests that the authors include the basis for the 70% in the next report.
- *Revised approach for standardizing the fishery catch-rate data for 1985/86-1998/99*. The negative binomial distribution leads to much better q-q plots; the CPT supports this change.
- *Revised approach for standardizing the fishery catch-rate data for 1995/96 – 2018/19*. The CPT supports the approach of creating blocks and using this in the standardization, but notes that basis for the specific blocks chosen needs to be more clearly documented. The weight assigned to each block is currently the maximum of the number of 1^0x1^0 cells fished in any year, but this needs to be the total number of 1^0x1^0 cells ever fished. One potential problem with this approach is that there are blocks x years with no (or very few) data. The approach proposed to handle this potential problem is that of Campbell (2014), but that approach is most appropriate for a stock that changes its distribution in response to changes in abundance. Rather, the CPT suggests that the analysts fit a model of the form where is the index of biomass for year *i* and block *j*, A_i is a year factor, and C_j is a block factor, and use this model to infer the biomass index for blocks x years with no (or very limited) data. The validity of this model can be checked by seeing how well it fits the values. Cross-validation would be a useful metric to check the predictive power of the model. The variance of the total biomass index should be computed as:

$$Var(B_i) = \sum_j (N_{max\ ,j})^2\ var\left(CPUE_{i,j}\right)$$

where $N_{max,j}$ is the total number of 1^0x1^0 cells ever fished in block *j*, and is the expected CPUE index for year *i* and block *j*. Note that account needs to taken of the variance of biomass indices inferred for years x blocks with limited or no data.

- *Analysis of the cooperative survey data*. The use of a mixed-effects model is appropriate. However, the choice of covariates needs additional justification. For example, it was not clear that vessel * pot number should be treated as a fixed effect rather than pot number random within vessel. Similarly, a hierarchical structure for strings * block should be considered, such as string random within block, which is itself random. In general, the model for the analysis of the survey data should be more closely aligned with the design of the survey. One possible model would be:

Sumcatch ~ Year + (1|vessel/pot number) + ns(soakdays,ns=9)+ns(Depth,df=6)+(1|block/string)

The analysts should also re-evaluate pre-specifying the number of knots (e.g., 9 for soakdays). This can be evaluated using model diagnostics such as AIC and plots of the results functional forms (e.g. present a figure of the smooth relationship between 'sumcatch' and 'soakdays'). Stepwise model selection is generally a poor idea--see Whittingham, MJ et al. "Why do we still use stepwise modelling in ecology and behaviour?" in the Journal of Animal Ecology. (doi:10.1111/j.1365-2656.2006.01141.x) for a discussion of issues and alternative approaches.

- *Improved maturity ogive*. The assessment document included use of cut-line and bend point-based approaches for designating animals to be mature or immature, followed by use of logistic regression to estimate a maturity ogive. The results of the cut-line and bend point approaches are not convincing because the evidence for two clusters of CH/CL are not evident. Additional samples of smaller animals (e.g. from small mesh pots) may rectify this, but the resulting data may still be uninformative. Small mesh pots are difficult to deploy, so an analysis of the predicted utility of the data would be helpful before additional data collection. Future analyses of maturity data should show the fit of the logistic model to the data and report the standard errors for the parameters of the

logistic function. Further, please label graphs in normal space rather than log space. The data in the plot can still be in log space, but it is difficult to interpret the axes in log space.

The assessment report included several possible models for May 2020. The CPT recommends not changing the current assumption of male maturity at 111mm CL, and hence recommends the following models in addition to the model accepted in May 2019 (19.1).

- Model 19.1b As for model 19.1 but with revised periods of years for defining mean recruitment (EAG: 1985-2016; WAG: 1987-2016) and the fish ticket CPUE data standardized assuming a negative binomial distribution.
- Model 19.1d. As for model 19.1b except that the EAG 2015-2019 cooperative survey CPUE index is included in the assessment.
- Model 19.2. As for model 19.1b, except that the 1995/96 – 2018/19 CPUE data are standardized using year*area interactions.
- Model. 19.2b. As for model 19.1b, except that both the EAG 2015-2019 cooperative survey CPUE index and the 1995/96 – 2018/19 CPUE data are standardized using year*area interactions are included in the assessment.

7. Bering Sea fisheries ecosystem plan

Ben Daly is also a member of the Council's Bering Sea FEP Team, and he reviewed a range of FEP concepts and processes to make the CPT more aware of how the Council is putting EBFM into practice. The BS FEP provides strategic EBFM support to the Council through a Core FEP and ongoing action modules, but does not directly guide Council management actions in the way that FMPs do. The Core FEP consists of ecosystem goals, and objectives as well as research objectives. Ben reviewed the existing action modules, each of which is supported by its own "taskforce". The CPT discussed the interaction of the FEP process with the CPT and other plan teams. It is clear that there was good coordination in the developing the St. Matthews BKC ESP last year, and the Bering Sea ESR is routinely presented to the CTP. ESR reports and research priorities that come from it will be an important area of communication between the Plan Teams and FEP Team. As action modules are completed the expectation is that the results would be incorporated into the Council process. This may create a greater need for coordination between the FEP process and the CPT and other Plan Teams directly involved in the Council management of fish and crab stocks.

8. Snow crab spatial stock assessment model

Maxime Olmos (UW) presented an overview of a spatial assessment model for snow crab in the EBS that he is developing as part of a post-doctoral project with Andre Punt (UW), Cody Szuwalski (AFSC), and Jim Thorson (AFSC). General reasons for developing a spatial stock assessment model include: 1) populations are spatially patchy and locally structured, but most stock assessments treat them as homogeneous over the stock area and 2) spatially-aggregated population models are likely to yield biased estimates of population quantities. For snow crab, spatial considerations include a spatially-structured fishery, ontogenetic migrations, and the association of the stock with the EBS cold pool.

In previous work, Jie Cao, Andre, Cody, and Jim developed a spatial assessment model for snow crab that combined a population dynamics sub-model with a species distribution sub-model in an integrated statistical framework and tested the concept using simulated data (Cao et al., 2019). The population dynamics sub-model is a size-structured model for population abundance which combines theory and methods from population dynamics and geostatistics under the assumption that population density varies continuously across space. It accounts for size-structured population dynamics and fishing mortality, and estimates the joint distribution for density at all locations within the stock area accounting for unmodeled processes (e.g., movement or spatial variation in growth or natural mortality) as process error. The current model is a two-sex model with a directed male-only fishery. A Poisson delta model is used to fit observed, spatially-explicit survey biomass data by location and time while spatially-referenced fishery data is fit

using a lognormal likelihood. The spatially-explicit assessment model was tested by Cao et al. (2019) using three scenarios based on combinations of (no) measurement error and (no) movement in simulated data from a spatially-explicit operating model. The results indicated that it was possible to capture the underlying spatial structure of simulated data even under the most strenuous test scenario of combined measurement error and movement.

The objective of the current project is to apply the model to actual data for snow crab in the EBS. Maxime discussed his efforts (after starting the post-doc three months ago) to assemble appropriate snow crab data for use in fitting the model. He used VAST as a tool to explore spatial variation by size bin in the NMFS survey data for snow crab (VAST also forms the underlying spatial model for the assessment model). Due to changes in survey coverage prior to 1989, he decided to use the survey data since 1989. The VAST results indicated the population center-of-abundance was further south early in the time series and that size classes with high abundance occupied a smaller spatial footprint than those with lower abundance. Maxime also showed maps of spatially-referenced fishery data that demonstrated the spatially-concentrated nature of the fishery. Next steps include fitting the survey and fishery data in the spatial assessment model, developing separate single-sex models for males and females, incorporating auxiliary information on survey catchability/selectivity (e.g. Somerton's work), and investigating approaches to incorporate movement into the model.

The CPT discussed the implications for the model of potential differences in spatial patterns in the survey data vis-a-vis in the fishery data due to movement of crab between the summer survey and the winter fishery, but came to no conclusions regarding the potential effects. It also suggested that the model might be able to revisit the so-called "ratchet" hypothesis for snow crab. The CPT supports this research effort and provided the following recommendations:

- use the standardized survey time series (filtering out non-standard tows with haul type code , no retow data or special tows)
- consider using ADFG tagging data as information on movement (available as an ADFG publication)

9. Economic SAFE

Brian Garber-Yonts presented the economic SAFE for Bering Sea crab, which contains fisheries economic data through the calendar year 2018, including information on revenue, costs, and income, along with quota markets and holdings. The document is available on the NPFMC website and also at: https://www.afsc.noaa.gov/REFM/Socioeconomics/SAFE/default.php. Data summaries for specification in the economic SAFE are available online through the Alaska Fisheries Information Network (AKFIN) https://reports.psmfc.org/akfin.

In response to SSC recommendations, several updates to the economic SAFE are being developed, including creating a report card, develop net earnings for processing sectors, develop ownership decomposition to determine how much of quota is harvested by owners or leaseholders, spatial/community disaggregation of wages, and a full time series for a limited number of indices for each crab fishery. Providing more detail in the economic SAFE can be complicated due to complex ownership systems of both processors and quota, limited data availability, along with confidentiality associated with more specific information. Even though it is difficult to disaggregate community-level economic information, information that is available is being combined with the information from the groundfish economic SAFE into a community-specific economic SAFE. It was also noted by the SSC that clarification is needed with regards to community impacts as a result of decreasing crab TACs, noting that increases in prices are not able to mitigate all community impacts.

TACs were lower in all Bering Sea fisheries and up slightly in the Aleutian Islands fisheries. Wholesale and ex-vessel prices have been on a gradual upward trend with increases going more toward the ex-vessel

sector. Work has begun on price forecasting however, current pricing information for forecast analysis can be delayed up to a year and a half.

Processing capacity has been on a downward trend with only two CPs currently operating and very few floating processors. Currently 12 active processing facilities are taking crab across all stocks. The decline in processing capacity is potentially a serious concern for some areas. There are only three providers of custom processing, which is nearing a monopoly for this sector. The smaller number of active plants limits the options for custom processing giving processors more power and control.

Employment and income in 2018 decreased in both the harvesting and processing sectors. Between 2017 and 2018, there were six fewer vessels in the harvesting sector, the single biggest decrease in the current time series. The number of crew positions remained steady with 2017 but the number of processing hours declined for the third year in a row. Wages have been declining the last two years attributed to a decline in the number of overtime hours associated with lower crab fishery quotas.

Over time the amount of costs attributed to leasing quota have gone up consistently although, it is impossible to determine the lease rates on a vessel's own quota. The inter-cooperative exchange has implemented a voluntary lease cap rate (the proportion of ex-vessel revenue paid to the quota holder) which has maintained a consistent lease rate between 62 to 63% in Bristol Bay red king crab, 46% in Bering Sea snow crab, and variable rates for Tanner. Overall, 81% to 88% of all quota shares are leased. Lease costs are 39% to 42% of ex-vessel gross revenue. The Council has expressed interest in monitoring annual lease rates.

The vessel income statement includes a limited amount of income factors due to the wide spectrum of vessel costs. Costs that can be estimated are increasing slightly as a function of overall revenue in Bering Sea snow crab and is variable for Bristol Bay red king crab. Quota costs are a way of redistributing income through the fishery, although much of the quota has integrated ownership between many individuals.

Priorities for the 2020 crab economic SAFE are to develop report card metrics for as many key economic indicators that are relevant and highlight deviations form 5-yr averages, using the same types of figures as in the ecosystem status reports. NOWcasts are also being developed to predict recent season prices using forecast methods already used in the groundfish economic SAFE. Additional goals are to include demographic detail at the community level, and to create economic performance reports or socio-economic reports for selected fisheries.

10. ADF&G crab observer program

Bo Whiteside presented an overview of the ADF&G crab observer program. He summarized crab observer duty priorities by vessel type- catcher vessels and catcher processors. He explained the purpose of various summary entry forms: (a) confidential interview form that serves as a daily chronological record of all fishing activity, (b) catch report form that records daily fishing and sampling effort, and (c) logbook form that details all observer sampling and vessel fishing activities.

The Dutch Harbor ADF&G office pre-registers all vessels that intend to fish during the coming season. In partial coverage fisheries, a certain number of vessels from the registration list are randomly selected for observer coverage. The selected vessels are expected to carry one observer for the entire season except for the Aleutian Islands golden king crab fishery. Observer deployment in the Aleutian Islands golden king crab fishery is on a trimester basis, which was presented in detail at the September 2019 CPT meeting.

Observers sample a daily sampling quota of measure and count pots that depend on the target fishery. From the measure pots, they sort the catch by species, identify sex, count the number of crabs, determine legal status, assess shell condition, assess clutch condition, and take carapace length/width measurements on commercially important crabs. They also document parasites, diseases, and fresh injuries. For count pots, observers identify the species, sex, and legal status. They record the data on standard forms and provide them to data entry personnel after the fishing trip is completed. Data entry personnel check the data for

accuracy, and any discrepancy is reconciled before the data are entered into the database. Furthermore, observers undertake miscellaneous duties such as measuring male chela heights, recording tag return information, taking photos of hybrid crabs, recording marine mammal sighting, etc.

Observer and dockside sampling activities and new research requests are discussed at the annual April meeting in Dutch Harbor. If there are special projects or collection requests, the observer program needs to know before the April meeting. Periodic observer training is conducted before the start of each major crab fishing season. Observer employment and retention is a recurring problem and new observers are trained and deployed on vessels every year.

An open question regarding observer sampling is whether the current mix of measure and count pots (different by target fishery) is the best for meeting management and assessment needs. Meaure pots provide detailed size, sex and maturity data, while count pots provide only catch rate information. Both measure and count pots are used to estimate CPUE, and thus total catch. Measure pots require substantially more time to work up than count pots. One step toward addressing this question would be to generate variance estimates of CPUE and total catch. These estimates could be used to support an analysis of different sampling strategies.

The CPT recognizes the important contribution of observers to assessment and management of commercially important crab stocks.

11. Research Priorities

Jim Armstrong discussed how NPFMC is addressing research priorities at the Council level. MSA mandates that Councils establish research priorities for 5-year periods and update them as necessary. NPFMC has 152 research priorities in a database that was created in 2012 that is updated annually; this database is available on their website under “Publications”. To date, the process for updating involves review and selection for 3-5 top priorities by individual Plan Teams, which is then submitted to the SSC and Council in Spring/Summer. This year the comprehensive NPFMC review is occurring in April. Historically the Council develops a top-10 list based on the top priorities identified by the individual Plan Teams. In February, the Council will consider how it plans to do the review in April. The Council is considering streamlining the process and updating every 3 years. Council staff are also talking with NPRB on how to best provide input for future funding opportunities.

Council staff aggregated the existing research priorities into 10 larger categories. The CPT reviewed the 10 larger categories and their subcategories. The CPT likes this categorization and suggested ways to improve it, including evaluating potential redundancy (e.g. MSE shows up a few places). A total of 65 research priorities are specific to crab.

The CPT considered the process at the plan team level and updated CPT priority categories for items in the database that had not yet been prioritized by CPT or where there was a discrepancy with prioritization by the SSC.

The CPT reviewed the Top 5 CPT priorities from May 2018 (refers to # in the database): 1) 148, 2) 225, 3) 196, 4) 592, 5) 174. CPT recommends updating the CPT priority for four of these to “Urgent” (if not at that level) but to keep 196 at “Important”. CPT did not address research priorities in 2019 because of the government shutdown and low attendance at the January 2019 meeting.

Priority ideas discussed at this meeting:

- Discard mortality is an important parameter in the models – the RAMP work with snow/Tanner is good but not applicable to king crab. The Norton Sound assessment uses the same discard mortality for the summer and winter fisheries, which might not be realistic given seasonal differences in temperatures on deck. (This priority is in the database as #149)

- Management strategy evaluations are very important both for evaluating current and proposed harvest strategies for crab, and for evaluating the effect of climate stressors on crab stocks. (#225 is in the top 5 for 2018 and 2020)
- Growth, radiometric aging, natural mortality: life history information (#147, 171) – both of these should be categorized as "urgent" and they could be combined. (This priority is in the top 5 for 2020)
- Impacts of trawling on the benthic habitat and crab stocks. It was noted that as trawlers move into fishing grounds for AIGKC, the CPUE plummets. Questions raised included whether crabs are disturbed by the gear or are moving into areas that are disturbed as food is uncovered by the trawls. This lends itself to Cooperative Research with Industry and would be of interest to NPRB. Research priority #164 could be made more general to incorporate this concept.

The CPT agreed to take 196 & 174 off the top 5 list (they were on it in 2018). The CPT identified its top 5 priorities for 2020 as follows:

- 148--Spatial distribution and movement of crabs relative to life history events and fishing.
- 225--Develop projection models to evaluate management strategies under varying climate, ecological, and economic conditions and evaluate impacts to managed resources and coastal communities.
- 592--Maturity estimates for Bering Sea and Aleutian Island crab stocks.
- 147/171--Acquire basic life history information (e.g., natural mortality through radiometric aging or other methods, growth, size at maturity) needed to inform the crab assessment models.
- New research priority called "Studies on physiological responses to climate stressors". Description: "Investigate how observed environmental changes (temperature, OA, etc.) affect physiological condition & survival of multiple life stages and reproductive output. Consider interactions among multiple stressors."

The CPT discussed that the long list of research priorities is difficult to manage and recommends a more streamlined approach. In particular, there are a number of priorities that are overlapping (for example 147 and 171). Some priorities are broader and some are more specific. It might be beneficial to assign Council staff or a small working group to develop a hierarchical approach to listing research priorities, and to condense the list by removing redundancies and overlaps.

12. Kodiak crab research

The CPT received briefings on ongoing research projects from scientists with the AFSC shellfish assessment program and the ADF&G crab research program in Kodiak. Scott Goodman of BSFRF also gave a presentation on BSFRF research activities. Following these presentations, the CPT and other meeting attendees were provided with a tour of the laboratory facilities at the Kodiak Fisheries Research Center, including large seawater tanks used for holding or conducting experiments. Local researchers discussed lab design and recent experimental work. The CPT observed live red king crab adults that were on hand for work on satellite tags and were also shown experimental designs for crab bycatch reduction in cod and halibut pots.

The presentations included the following:

- Chris Long (AFSC shellfish assessment program) presented research on snow and Tanner crab to evaluate the effect of ocean acidification on embryos and larvae. Future research will use a similar experimental design but cross different pH levels with different temperature levels consistent with future climate change scenarios.
- Jennifer Gardner (AFSC shellfish assessment program) presented research on the snow crab reproductive cycle. She found that the prevalence of biennial spawning showed a strong north-south gradient for multiparous crab in the EBS.

- Leah Zacher (AFSC shellfish assessment program) presented preliminary results on a tagging experiment in which red king crab were tagged using acoustic tags, and a saildrone with an acoustic receiver was sailed along a survey grid to search for tags. The goal of this research is to characterize seasonal movement patterns of red king crab in Bristol Bay. Of the 148 tagged crabs, 50 were located by the saildrone. Leah is also attempting to construct and populate a database of historical king crab tagging data, which extends back to the 1950s.
- Vicki Vanek, the lead for the king crab research program at ADF&G, summarized research activities by the program. Current activities include conducting pot surveys of different king crab stocks, tagging with pop-up satellite tags, field sampling to obtain chela height data, and collecting specimens for studying king crab diseases.
- Andy Nault (ADF&G king crab research program) is studying the impact of tagging crab with satellite tags by monitoring behavior in holding tanks. Based on preliminary results, no strong differences were observed in movement and righting behavior between tagged and untagged crabs.
- Scott Goodman summarized ongoing research activities by BSFRF, including the collection of pre-molt snow crab for growth increment estimation, collaborative research with AFSC on red king crab movement using acoustic tags and saildrones, surveying index sites for juvenile Tanner crab, and a pot modification study to reduce crab bycatch. A Tanner crab MSE supported by BSFRF is approaching completion. BSFRF is seeking input on future research priorities.

13. Gmacs Workshop

Andre Punt (UW) gave a detailed introduction to the General Model for Alaskan Crab Stocks (Gmacs) for CPT members and assessment authors participating in the two day Gmacs workshop. Gmacs is an open source C++ modeling framework for size-structured stock assessments under continuing development in collaboration among University of Washington, NMFS, ADFG, and industry with the objective of providing a unified code base and toolset for BSAI crab stock assessments. Gmacs uses ADMB libraries to facilitate parameter estimation in a maximum likelihood and Bayesian statistical framework. Source code for the project is hosted as a repository on github, with the most recent version on the "development" branch, and is publicly available at https://github.com/seacode/gmacs. The gmacsbase.tpl file contains the standardized code relevant to create a stock assessment model; user-specific model output can be obtained by editing the "personal.TPL" file (i.e., that is relevant to stock-specific output for management purposes, and perhaps the state harvest strategies). The executable code based on these two tpl files is gmacs.exe.

Andre's presentation covered the formats for the input (.DAT, .CTL, and .PRJ) files required to define and run a Gmacs model. Standardized output is provided in two formats: 1) a human-readable format (gmacsall.out) and 2) a R-readable format (gmacs.rep) to facilitate plotting results and diagnostics using gmr.

The current Gmacs code is suitable for lithodid crabs (red, blue, and golden king crabs), but not for crabs that undergo a terminal molt (snow and Tanner crab). Gmacs models have been developed for, and are used in stock assessments of, Pribilof Islands red king crab, St. Matthews blue king crab, and Bristol Bay red king crab. Cody Szuwalski (AFSC) is currently working to develop code to implement terminal molt dynamics to extend Gmacs for use in Chionoecetes (snow and Tanner crab) assessments.

Detailed workshop recommendations (their status at the end of the workshop, and priority) regarding input/output formats include:

- DAT file:
    - will need to add annual observed maturity as new data type
    - in output dat file, add labels for fleet, sex, type, as a comment etc.
    - in output dat file, currently need to have a label for a survey even if no survey (Completed during the workshop)
    - check indices for catch types

    - need to add maturity index classification to relative abundance indices (Completed during the workshop).
    - add "index" column for relative indices to explicitly identify index (Completed during the workshop)
    - add growth options to
        - specify size class index rather than size class midpoint
        - add growth data type based on pre-molt, post-molt sizes and add corresponding likelihood component (*ala* Tanner crab)
- CTL file
    - revise labels for recruitment distribution parameters
    - remove custom natural mortality rates option (Completed during the workshop)
    - add column headers/row labels to diagnostic "input" CTL file identifying sex, size, etc.
    - expand input years specifying growth and molt periods to include first year of model
    - put column headers, row labels on diagnostic "input" CTL file where possible
    - selectivity options 0, 1, 4 should be reviewed and revised as necessary
    - add cubic spline to selectivity options
    - implement double normal selectivity
    - add ability to mirror selectivity functions or parameters between different fleets
    - move the specification of length-class numbers to the DAT file (to check the length data) (Completed during the workshop)
    - correct the "aggregation option" (to include shell and maturity stage - longer-term?)
    - document the headers for the columns in the likelihood specification
    - include an option to force the recruit sex ratio to be 1:1

Recommendations that will require more work (and thus are longer term) include:

- need to know fleet and recapture time to apply correct selectivity for tag recaptures
- add year to growth data input, remove index to relevant transition matrix, and assign the index based on the year
- add ability to build up population from 0 using recruitment (as in the present Tanner crab model)
- PRJ file
    - Modify the first row input values to a yes/no input

The current version of Gmacs includes a personal.tpl file with code associated with specific implementations of Gmacs. Some preferred to see this file to be removed entirely since it is contrary to the objective of Gmacs to implement a standardized modeling package for crab assessments. The group generally agreed that if a personal.tpl were used, it should be used sparingly, and then only for generating output that would be written to a personal.rep file, rather than appended to either gmacs.rep or gmacsall.out. Useful output should ultimately be included in the gmacs.rep and and the gmacs.all.

The group discussed approaches to work flow, including the use of a make.bat file, and how to use Rstudio to pull and push Gmacs from the GitHub repository.

GMR is an R package that reads Gmacs output and generates figures that show model results and diagnostics, and can be incorporated into assessment documents. GMR currently resides within the Gmacs repository, but it was agreed that it should be moved to its own repository on GitHub. Continued development of GMR will enhance the utility of Gmacs.

Gmacs wish list and prioritization:

Tasks for May 2020:

- Selectivity
    - Options (0,1) should be reviewed and revised (Andre)
    - Options (0,1) check nclass and nclass-1 (Andre, Jie request)

    - Add ability to mirror selectivity functions or parameters between different fleets (Andre; Completed)
    - Create option 4 (double normal) - (Buck)
    - Selectivity options needed for NSRKC (Andre)
- Jittering (add in prelim calcs - Andre)
- Terminal molt (Cody)
- Restructure likelihood section (Andre)
- Ensure likelihoods can handle maturity partitions (Andre)
- Growth
    - specify size class index rather than size class midpoint
- Include an option to force the recruit sex ratio to be 1:1 (Andre)
- Get 'gmr' package running for output visualization (Cody/Katie)

Longer-term tasks:
Selectivity - add cubic spline (Andre)
Retrospective analysis (more code stability before implementing - Andre)
Projection module - additional options for recruitment (long-term - add as needed)

- Estimating stock-recruit relationship internally
- Input mean and standard error instead of sampling from a period (Andre)

Options to fit "observed maturity" ogives (longer term - Cody/Buck)
Growth - add growth data type based on pre-molt, post-molt sizes and add corresponding likelihood component (as in Tanner crab assessment)

Housekeeping (mostly Andre):

- revise labels for recruitment distribution parameters
- add column headers/row labels to diagnostic "input" CTL file identifying sex, size, etc.
- put column headers, row labels on diagnostic "input" CTL file where possible
- document the headers for the columns in the likelihood specification
- Error check on the size transition pointer for growth data
- Error check for negative growth increment
- Revise comment on input years specifying growth and molt periods to include first year of model (later- Buck)
- Verify equations for instantaneous seasons

GMR package for output

- Put gmr as a separate github repo
- Get gmr working with new output (ASAP - Cody/Katie)
- Functions to get table output - standard SAFE tables

14. Discussion/responses to specific SSC Comments

The projected mature male biomass (MMB) in the tables in the SAFE introduction and the assessment executive summaries is the biomass associated with the OFL catch. Since the catch is constrained by the TAC, it may be much lower than the OFL. The SSC in its October 2019 minutes recommended that a more realistic catch scenario be used to project MMB. The CPT is willing to implement this, but to do so would require two projections, one to project the OFL, and another to project the MMB, and consequently the SAFE tables would contain values from several model runs. The CPT would like confirmation from the SSC that this is what is intended, since it may be a source of potential confusion. A possible alternative might be to add a short-term (5 or 10 years) projection table in the SAFE that would show projected catches under the State's GHL.

15. New Business

There was a reminder to Team members about the correct use of model numbering. Additionally, approaches to reduce file size and number of files associated with SAFE chapters will be practiced in the future.

The May 2020 CPT meeting will be held in Juneau from May 4-8. Proposed agenda items include:

- Final AIGKC SAFE
- Proposed model runs for September (Snow, Tanner, BBRKC, SMBKC)
- Tier 5 OFL/ABC for PIGKC and WAIRKC
- PIGKC - Tier 4 assessment
- Review of updates to Gmacs and discussion of modeling options
- Update on snow crab individual-based model research
- VAST model and standard survey estimate comparisons for crab stock assessments
- BSFRF empirical survey catchability/selectivity estimation. Compare different methods for incorporating BSFRF data into the assessment including current nested method and TBD methods for priors on selectivity
- Update on research to evaluate ocean acidification impacts on EBS crab stocks
- Alaska Board of Fisheries update including Tanner crab harvest strategy

The September 2020 CPT meeting will be held in Seattle and has been set for September 14-18, 2020.