Crab Plan Team
REPORT

May 17-20, 2021
Online Meeting

Members in attendance:

Martin Dorn, **Co-Chair** (AFSC-Seattle)
Katie Palof, **Co-Chair** (ADF&G-Juneau)
Jim Armstrong, **Coordinator** (NPFMC)
William Bechtol (UAF-Homer)
Ben Daly (ADF&G-Kodiak)
Ginny Eckert (UAF/CFOS-Juneau)
Erin Fedewa (AFSC-Kodiak)
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)

Others in attendance:

Rachel Alinsunurin (ADFG, Dutch Harbor)
Jen Bell (ADFG, Nome)
Kevin Clark
Jason Conner
Lee Cronin-Fine
Maria Davis (NPFMC)
Kenny Down (Seaquest)
Sherri Dressel (ADF&G)
Austin Estabrooks (APA)
John Gauvin (ASC)
Shannon Gleason (NPFMC)
Jamie Goen (ABSC, Seattle)
*Scott Goodman (BSFRF, Seattle)**
Gretar Gudmundsson (F/V Valiant)
Toshihide Hamazaki (ADFG, Anchorage)
*Gretchen Harrington (NMFS AKRO)**
Jeremy Harris
Madison Heller-Shipley (BSFRF)
Kendall Henry (ADFG, Juneau)
Leonard Herzog (F/V Tempo Sea)
John Hilsinger (AKCR)
Anne Hollowed (AFSC, Seattle)
*Tyler Jackson (ADFG, Kodiak)**
Wes Jones (NSEDC)
Frank Kelty (City of Unalaska)
Linda Kozak (FVOA)
*Ned Laman (AFSC)**
*Cory Lescher (ABSC)**
*Mike Litzow (AFSC, Kodiak)**
*Megan Mackey (NMFS)**
Sarah Marrinan (NPFMC)
Steven Minor
Andy Nault (ADFG, Kodiak)
*John Olson (NMFS)**
*Jodi Pirtle (NMFS)**
Edward Poulsen (BSFRF)
*Jonathan Richar (NMFS Kodiak)**
Matt Robinson (BBEDC)
Chris Siddon (ADF&G)
Megsie Siple
Caitlin Stern
Mark Stichert (ADFG, Kodiak)
*Jim Thorson (AFSC, Seattle)**
Vicki Vanek (ADFG, Kodiak)
Jon Warrenchuk (Oceana)
Ernie Weiss (Aleutians East)
Bo Whiteside (ADFG, Kodiak)
Paul Wilkins
*Leah Zacher (AFSC, Kodiak)**
*Molly Zaleski (NMFS AKRO)**

**presented to CPT*

1. Administrative

The May 2021 Crab Plan Team (CPT) meeting was held online via the Adobe Connect meeting platform, and connection information was posted to the CPT eAgenda. The meeting began shortly after 8:00 a.m. on Monday, May 17, 2021 with technical set up and overview of the meeting application. The CPT reviewed assignments and timing for meeting deliverables, including presentations, and this CPT Meeting Report. CPT Co-Chairs Martin Dorn and Katie Palof reviewed guidelines for the meeting, including public

comments. Jim Armstrong reviewed Council actions at the February and April 2021 meeting that were directly or indirectly relevant to BSAI crab fishery management.

2. Summer survey contingency planning for Sept assessments

Mike Litzow from the Shellfish Assessment Program at AFSC Kodiak gave an update on summer survey planning and the timeline for data availability. Mike stated that they are planning a full Eastern Bering Sea (EBS) and Northern Bering Sea (NBS) survey this summer 2021. The survey will consist of two vessels and will start on May 25 and end on August 28. One vessel will be delayed by six days from the original plan, which will have some implications on data availability. A full suite of special projects involving crab are scheduled to occur during the survey.

Stock assessment authors will receive data a little later than in prior years due to the vessel delay. Area-swept estimates and haul data should be available by August 17 (two days later than prior years) and VAST estimates may not be available until August 25 (five days later than prior years). Instead of recalculating the entire time series, only area-swept estimates for 2021 will be calculated in order to get the area-swept estimates out by August 17. Bering10K ROMS model forecasts for June 2021 suggest that the cold pool will extend well into Bristol Bay during Leg 1 of the survey, and that BBRKC retows are possible. If retows are necessary, estimates of females will not be available until August 22.

The CPT asked if some of the estimates could come out after the first leg, specifically for BBRKC and EBS Tanner crab. This year, however, the survey will involve many new scientists due to staff turnover, and there is some concern about the ability to report data at that time. The CPT asked if it would be possible to get the BBRKC Leg 1 crab data without the haul data after Leg 1is completed. Mike thought this may be possible and that the catch data could be shared informally. The CPT asked about the timeline for the NBS data. Mike thought these data might be available September 6. The snow crab assessment author clarified that NBS data for snow crab are not currently used in the assessment, but those data may eventually be added.

The CPT discussed how this timeline would affect assessment authors. SAFE chapters must be submitted by September 1 for internal review and are due to the Council by September 3. The CPT meeting is September 13-17. Given the abbreviated timeline, the CPT felt it might be best not to ask assessment authors to incorporate estimates of VAST abundance indices into the assessments. Currently, none of the stock assessment authors are planning on using VAST in their preferred model for September 2021. Stock assessment authors stated that running the models does not take as much time as the interpretation of the model run outcomes. It was also suggested to keep the number of model runs down to a reasonable number. The CPT is not expecting stock assessment authors to complete VAST model runs unless the author feels there is time to do so.

3. VAST model - discussion

Jon Richar (AFSC-Kodiak) updated the CPT on his progress evaluating the implementation of VAST for the crab survey data, and provided a summary of current VAST models for three major crab stocks: BBRKC, EBS Tanner crab, and EBS snow crab. Jon has addressed many of the requests the CPT and SSC had made earlier this year. Due to time constraints, he did not provide spatial Pearson's residuals to compare to the DHARMa diagnostics, and he did not scale maps comparing spatial residuals between models at the same scale. In some of the spring hindcasts the size of the spatial residual maps was increased for better visual clarity. Jon intends to do this for all maps in the fall. The examples presented to the CPT were much improved and more readable.

Work is on-going on methods to better define model acceptability, and as part of this process a VAST-expert review committee was initiated and used for the spring hindcast results. Currently, large differences between the VAST estimates and the design-based estimates in some years and for some stocks are being

investigated for potential issues with the VAST approach. The barrier approach, which is still under development by the VAST group to take land barriers into account when modeling, was applied to survey data for SMBKC. Since this stock is now in a biennial assessment cycle with the next assessment review in May 2022, work will continue to be done to evaluate the utility of this method for SMBKC. An additional request from the CPT had been for Jon to follow-up on DHARMa p-values, which he did through discussions with Cole Monnahan. This feedback suggested that the p-values provided on the residuals plots are not to be taken at face value, and the residuals should instead be used for a visual interpretation of large differences.

Jon reviewed some of the 26 models that he produced for the spring hindcast for the authors to use in their models. He was successful in conducting multiple model runs this spring, and is confident that a 10 day production time in the fall can be accomplished. One of the CPT's continuing concerns about using VAST estimates in the assessment models is the timing of the availability of these estimates compared to the design-based estimates (Aug 25th compared to Aug 15th, with model drafts being due for internal review on September 1st).

The VAST models for BBRKC showed that both total biomass and biomass of male crab greater than 65mm biomass performed well with good diagnostics. However, the VAST estimates for females, despite having adequate diagnostics, had difficulty fitting the spatial distribution and there were also issues with female estimates in the late 2000s.

The models provided for Tanner crab were run for the entire Eastern Bering Sea (EBS), as well as the western management area (W166), and the eastern management area (E166). Overall, the diagnostics for those runs looked good. However, the DHARMa residual plots showed positive trends at the highest observations/predictions where the model was underestimating compared to the design-based. Additionally, some of the models were problematic to fit, specifically the eastern district females. CPT suggested that the Tanner crab VAST model should be run for the total EBS population, and then subdivided geographically for biomass in the eastern and western management areas, rather than running additional separate models for the two management areas. There was concern that separate analyses for eastern and western portion of the stock would create discontinuities where none exist.

The VAST models for snow crab had more issues compared to the other two stocks, particularly for total male abundance and females. The diagnostics for these plots were problematic, with the Q-Q plots having heavy tails and the model underestimating at the highest observations – similar to, but more concerning than, the Tanner crab models. However, the male estimates had close correspondence with the design-based estimates, but this was not the case for the females. There was some discussion on how the model was dealing with immature snow crab abundance, including how it deals with inconsistent spatial coverage of the survey in the early part of the time series. The stock assessment author uses two separate survey selectivities to explain these differences in the design-based estimates, but this approach would not be usable for VAST estimates. CPT discussion centered around which would better explain these spatial differences – separate selectivity estimates or allowing VAST to interpolate – both of which would be explored when VAST estimates are ready to be more fully examined in the assessment model.

Overall, the CPT would like to acknowledge the continued efforts to improve the implementation of VAST by the analysts and supports further work that is needed on the model fits for Tanner and snow crab. The runs for BBRKC are promising with reasonable diagnostics suggesting this may be a good stock to use as a pilot for considering VAST estimates.

The CPT recommends that VAST estimates are produced for this fall's assessment cycle if time allows, specifically for BBRKC. Based on the model runs reviewed at this meeting it is unlikely that the CPT would consider models for setting assessment specifications for Tanner or snow crab that include VAST estimates. Instead, the CPT supports the analysts' time being spent improving model fits, continued improvement of visualization of the diagnostics (which includes displaying the confidence intervals for both design-based

and VAST on the biomass figures), and initializing incorporation of the Northern Bering Sea data into this process – specifically for snow crab.

4. Length-weight updates

Jon Richar (AFSC-Kodiak) presented updates to model parameter estimates from size-weight regressions that are used to calculate EBS crab biomass estimates. Current size-weight regression models do not account for factors affecting crab weight such as shell condition, clutch fullness, and thermal regime, and as such, may bias biomass estimates. Jon reviewed suggestions from the January CPT meeting that included applying bias correction methods, providing biological rationale for re-evaluating model parameters, and including females and SMBKC in new analyses. Suggestions were incorporated, and work is currently underway to include temperature as a continuous variable in size-weight models. Using log-transformed carapace size and weight data collected on the EBS bottom trawl survey from 2000 onward, Jon developed regression models for four crab stocks grouped by maturity and/or shell condition. Biomass estimates were then calculated using final parameter estimates and compared to baseline estimates from current size-weight models.

Jon presented model results for each stock. Overall, bias corrections minimally affected parameter estimates and model outputs. Models, including shell condition, did not differ significantly from baseline models for BBRKC, SMBKC, and EBS snow crab. Old shell male and female Tanner crab models differed significantly from the baseline model. Jon also examined percent difference in biomass estimates between baseline and updated models. Percent differences in biomass estimates were relatively high for legal and mature male Tanner crab relative to the three other stocks. Jon mentioned that, except for Tanner crab, results indicate little support for updating parameters. He also noted that anomalies in percent differences of female biomass estimates are apparent and still being explored. Future work will include applying bias correction procedures to current model parameters, developing nonlinear models for size-weight parameters, and including temperature.

The CPT discussed the relatively high percentage differences in Tanner crab biomass estimates and expressed concern that biases in model parameter estimates may result in overestimating large crab in the stock assessment model. Jon will send Buck Stockhausen the bias-corrected model parameter estimates for new and old shell Tanner crab in time for September model runs. The CPT thanked Jon for his efforts and expressed support for future work on refinements to size-weight models.

5. Update on catch time series standardization ADF&G

Ben Daly and Tyler Jackson (ADF&G Kodiak) updated the CPT about the ongoing standardization effort for historical fisheries catch data (retained catch fish ticket data, retained catch offload dockside data, and at-sea observer data). There has been a loss of institutional knowledge through staff retiring, moving to other positions, etc. As such, ADF&G has been working to increase data transparency by re-establishing new historical data products including total catch estimates. The plan moving forward will be to supply the full time series for each data source, code for data filtering and catch expansions, and outputs that match stock assessment data requests while remaining flexible to accommodate stock assessment needs. This process will likely result in a time series that differs from past total catch estimates.

Some of the challenges in the time series standardization is centered around establishing historical fishing effort (number of pot lifts). The high catches, fast pace, and incidental retention in historical derby fisheries inflates effort, especially for Tanner crab fisheries. Fish tickets accurately record crab delivered, but effort data depend on the accuracy of the information reported by the captain. Historical fish tickets do not differentiate between directed and incidental catch, thus Doug Pengilly (ADF&G; now retired) used raw fish tickets to manually apportion historical (pre-2005) Tanner and snow crab catch data. Unfortunately, there is no documentation of this process and repeating this effort would be time-consuming and likely not

result in improved results. As such, it is recommended that this effort time series be used as is. Post-2005 data are better documented and parsing out directed and incidental fisheries catch data by fishing trip has been automated. Some of the other complications with the data series concern the management of CDQ allocations as separate fisheries and shifting management boundaries.

Total catch is calculated by multiplying observer CPUE, total fishery effort, and average weight (for a given group, e.g., legal males, sublegal males, females, etc.). Discards have been estimated using qualitative observer reported legal, but not retained, numbers in the past; the current approach will use the subtraction method (total catch – retained catch = discards).

The BSAI crab observer program began in the early 1990s to monitor compliance with fishery regulations. The first year of standardized protocols and organization of the observer program was in 1995, when data were entered into a database. While ADF&G is providing total catch data back to 1990, it is recommended that assessment authors truncate the data to 1995 to avoid potential data issues during the early 1990s in at least some model scenarios, as recommended by the CPT and SSC in recent meetings.

For Bristol Bay RKC, data summarization for total retained catch, total catch, and total bycatch in other crab fisheries, and size composition from 1990-2019/20, are available on GitHub. Directed fisheries include all IFQ, CDQ, and test fisheries for RKC in Bristol Bay. Bycatch in the Tanner crab fishery is currently restricted to east of 166° W longitude for simplicity even though the Bristol Bay boundary is 168° W longitude. Historical bycatch estimates for RKC were restricted to east of 163° W longitude although these waters have been closed to Tanner crab fishing since 1996. Efforts to standardize data and make them available on GitHub for the other BSAI fisheries is progressing with hopes to provide the Bering Sea snow crab standardized data by July 2021. The CPT recommends thoroughly documenting the process of this data standardization.

Efforts are currently focused on data standardization for BSAI stocks, but progress towards variance estimation will progress once the standardized catch data time series are completed. It was noted that catch CVs are used in assessments, but it is unknown how these are derived by individual authors. Preliminary analysis suggests that observer pot CPUE CVs are small (~1-2%). It was noted that extra variance is added to the CPUE in the AIGKC model (i.e., extra variance can be added in the model to compensate for under-estimation in reported variance). The CPT supports having justification for the CVs used in the assessment models since the CVs currently used are not documented and their origins are unknown. The CPT still encourages the routine estimation of variance in addition to the point estimates of catch, but agrees that variance estimation has lower priority, and can come after methods have been standardized and documented.

Ben also reported that the 2021 St. Matthew Island blue king crab pot survey has been cancelled due to unavailability of a survey vessel. The survey will be scheduled for 2022.

6. BSFRF survey catchability/selectivity - discussion

William “Buck” Stockhausen (AFSC Seattle) presented research into survey trawl catchability using the side-by-side tow data collected during several studies by BSFRF. Side by side tow data refer to tows conducted by BSFRF using a *Nephrops* trawl alongside standard survey tows by NMFS during the Bering Sea bottom trawl survey. Side-by-side studies that inform Tanner crab catchability were done in 2013, 2014, and 2015-2018. Data for the 2018 study has not yet been made available by BSFRF. Buck described two analytical approaches external to the assessment model that he has been exploring to provide information on the catchability of the NMFS survey net. One approach considers data for each experiment in aggregate, while the other approach takes advantage of the side-by-side nature of the data. Both approaches assume that the BSFRF *Nephrops* trawl catches all the Tanner crab in the path of the net. After accounting for differing areas swept, the catch rates for the BSFRF net are typically higher than the NMFS

catch rates, suggesting that the NMFS survey net only captures a fraction of the Tanner crab in the path of the net.

For the aggregate approach, catchability at size was estimated using a log linear model with a smooth function of size as the predicator. The data used in the model is the ratio of abundance of the NMFS estimates in the study over the BSFRF estimates for each size bin. Size bins were weighted by the total number of crab in a size bin. The CPT inquired whether the assumptions of log normality and independence are reasonable. Buck noted that the ratio of two log-normal distributions is log-normal itself, supporting the log-normality assumption. However, independence of different size bins seems unlikely, though this assumption is very common.

Results for the aggregate approach showed variation between years, but the regression using all years showed an asymptotic curve, with a catchability of approximately 0.6 for the males and 0.4 for the females, with increased uncertainty for the largest size bins. In the plot showing the results for the all-years regression, the CPT suggested coloring the data points by year to highlight differences between years. The CPT also suggested that a hierarchical approach be considered, in which an overall mean and year effect is estimated. The CPT also suspects that studies in some years are probably more informative than other years. Side-by-side data that is collected over a small part of the range of Tanner crab, or close to the edge of the range is likely to be of less utility in estimating Tanner crab catchability than surveys that cover most of the range, highlighting the importance of studies in 2015-2018, which had better geographic coverage.

The approach to analyze the haul-level side-by-side data likewise involved a regression approach. The logit of the number of crab by size bin in the NMFS survey divided by the total number of crab in both surveys by size bin was modeled as a function of size and other covariates such a substrate (e.g. grain size) and bottom temperature. This regression provides an estimate of trawl efficiency, a tow-level analog to the survey-level concept of catchability.

Regression results found significant interactions between most main effects in the model for males but fewer interactions for the female model. Interaction surfaces were complex and difficult to interpret. Applying the regression results to estimate survey catchability involved predicting values of the trawl efficiency at the trawl stations occupied by each survey and then either simple averaging or inverse variance averaging across stations. Estimated catchabilities showed considerable variation between years but the overall picture was similar to the aggregate analysis, with estimating increasing curves with size and estimated catchabilities of 0.5-0.6 for the males and 0.2-0.25 for the females. One notable difference with haul-level analysis is that catchability appears to decline for the larger crab for both the males and the females. It was not clear to the CPT what was driving this result.

Although the CPT considered these results to be too preliminary to be used in the September assessment model, the CPT is strongly supportive of this research, and recommends that it continue. The method currently used to incorporate the BSFRF data into crab assessments is awkward and does not make full use of the BSFRF studies. The CPT provides the following recommendations:

- The CPT thinks it is too soon to conclude whether that aggregated approach or the haul-level approach will be most useful for crab stock assessment. Therefore, the CPT recommends that work continue to refine both approaches.
- A priority for BSFRF is to work up the data for the 2018 study and provide it to the analyst. This is a necessity for any eventual inclusion of catchability estimates in the Tanner crab assessment.
- There are clear conceptual advantages to haul-level side-by-side analysis. However, there is a need to better understand what is driving the results, and in particular the predicted decline in catchability for the largest crab. The estimated interaction surfaces were not intuitive and need to be linked with plausible hypotheses about how temperature and substrate might affect catchability.

- Additional thought needs to go into how to estimate survey-level catchability from the haul-level trawl efficiencies. It was not clear to the CPT that either an overall average or an inverse-variance weighted average was the best approach.
- Additional work is needed on how to incorporate the results of these catchability analyses into the assessment model, while appropriately taking in account their uncertainty.
- Once these methods are considered well established enough to be implemented for Tanner crab, similar approaches should be considered for BBRKC and snow crab.

7. AIGKC Final 2021 SAFE

Siddeek (ADF&G Juneau) presented the final assessment for Aleutian Islands golden king crab, including the responses to past requests from the CPT and the SSC, alternative models, results of model runs and diagnostics, and values for the OFL under the Tier 3 control rule. The fishery in EAG was complete at the time of the assessment (March 26, 2021), but only 77% of the TAC for the WAG had been harvested at the time of the assessment. The fishery has subsequently closed and final retained catch data will be available soon, but final bycatch data will not be available until the end of June.

Previous CPT and SSC comments
Siddeek briefed the CPT on responses to the January 2021 CPT and February 2021 SSC comments on the January 2021 model runs. The approach used to compute the observer CPUE index when allowance is made for area*year interactions was corrected from the January 2021 analysis. The assessment included updated diagnostics for fits to the length-frequency data and the CPUE standardization process.

Concerning the SSC comment about the approach to select the period used to define mean recruitment, CPT notes that earlier analyses were based on the standard error of log(recruitment), which is essentially the CV of recruitment. The analysts still need to address the second part of this comment to estimate how many years it takes crab that are recruited to the model (assumed to be distributed over 101-125 mm CL) to recruit to the fishery (e.g., to the size-at-first-selectivity), which could inform the last year of the period used to define mean recruitment.

Assessment and alternative models
The assessment used revised observer fish ticket size composition data, corrected for some data errors in earlier analyses. The CPUE indices for the post-rationalization period were updated based on the data for 2020/21 fishing season.

The assessment authors examined ten model scenarios. Model 19.1 was last year's base model with the period for mean recruit calculation defined as 1987-2012. Model 21.1a was the same as Model 19.1, except that mean recruitment was defined as the 1987-2017 average rather than the 1987-2012 average. Model 21.1b was the same as Model 21.1a but with three total selectivity periods, while Model 21.1c extended model 21.1a by basing the observer CPUE index on a standardization that included year*area interactions. Models 21.1a1 and 21.1a2 extended Model 21.1a by allowing maturity to occur at 116 mm CL and to be a logistic function of size with a size-at-50%-maturity of 117 mm CL. Models 21.1b1 and 21.1b2 extended Model 21.1b in the same way that Models 21.1a1 and 21.1a2 extended Model 21.1a. Similarly Models 21.1c1 and 21.1c2 extended Model 21.1c. Appendix C shows the impact of including the data from the cooperative survey in Model 21.1a, and Appendix F shows further preliminary applications of GMACS to Aleutian Islands golden king crab.

The CPT agreed in January 2021 that basing mean recruitment on the years 1987-2017 was an improvement over the period 1987-2012. The CPT welcomed the analyses to improve estimates of maturity as a function of size (Appendix D of the assessment). However, the approach for estimating a logistic relationship between proportion mature and size was based on unrealistic inputs, owing to how the segmented regression was interpreted. The estimate of maturity from the breakpoint in the segmented regression may be a better estimate of when maturation occurs. However, a full presentation of the approach and hence additional

review is needed before the estimate can be adopted. The CPT encouraged collection of addition chela height data, especially on smaller size crab, and use of methods such as those of Olson et al. (2018) [Royal Society Open Science 5(3): https://doi.org/10.1098/rsos.171802] and Somerton and Macintosh (1983) [Crustaceana 45: 169-175; https://doi.org/10.1163/156854083X00596). Thus, the CPT recommends retaining the assumption of maturation at 111 mm CL for management of the 2021/22 fishery.

Model 21.1b, with three selectivity periods, led to a less extreme retrospective pattern for the EAG. However, that model appeared to converge to a local minimum (the negative log-likelihood for Model 21.1b is larger than that for Model 21.1a even though Model 21.1a is nested within Model 21.1b). Model 21.1c involves accounting for the year*area interactions when constructing the CPUE index for the post-rationalization period. However, the basis for selecting the degree of the smooth for depth and soak time was not clear, and the resulting smooths were not available for review. The reduction in CPUE for the WAG for the last three years for the standardization with area*year interactions should be understood. The CPT therefore agreed that status determination and the OFL and ABC should be based on Model 21.1a.

Selection of an ABC Buffer

This is the only crab assessment that relies solely on fishery CPUE as an index of abundance, with the CPUE index standardization process subject to past CPT and SSC review and this is a key reason for the 25% buffer between the OFL and the ABC in past years. Other reasons noted by the SSC as the rationale for the 25% buffer include uncertainties in size at maturity, including the untested regression approach involving chela height against carapace length; uncertainty in natural mortality; the limited spatial coverage of the fishery with respect to the total stock distribution; and the small number of vessels on which CPUE is based. The CPT agreed that these reasons for the 25% buffer still remain. Additional sources of uncertainty include the retrospective pattern for the EAG and that the CPUE standardization is still subject to some methodological concerns. New uncertainties identified this year are: (a) there have been fewer large animals in the total catch length-frequency for the EAG between 2016 and 2020, (b) there were catches from the WAG that were not included in the assessment, (c) the CPUE index for the WAG declined more when account was taken of year*area interactions, and (d) the size at maturation may be larger than currently assumed. These new sources of uncertainty can be addressed through additional research. The CPT recommends not increasing the buffer from 25% this year, but recommends that these uncertainties should be monitored and reevaluated in future assessments, which could potentially lead to change to the buffer recommendation.

CPT Recommendations

Analysis-related

- The analysis of the maturity data should be repeated using, for example, the methods of Olson et al. (2018) and Somerton and Macintosh (1983). The results of the analyses should be presented to the CPT.
- Consider including the NMFS Aleutian Islands trawl survey as an additional index of abundance. The first step in this process should be to compare the depths at which the survey is conducted to those at which AI golden king crab are found/fished.
- The CPUE standardization for the post rationalization years:
    - explore why the index for the WAG is lower in the last three years based on area*year interactions;
    - explore why the index for the WAG is more precise in the earlier years based on area*year interactions; and
    - better justify the degrees of freedom for smooths, and plot the smooths.
- The specifications of smooths when analysing the cooperative survey should be selected using the survey data and not taken from analyses of other indices.
- Model 21.1b was unable to provide a better fit to the length-frequency data for the EAG. The reasons for the change in total length-frequency in recent years need to be better understood before new models are formulated. Edward Poulsen noted that the number of vessels in the EAG was less

in recent years than before and that the higher CPUE areas tend to have higher abundance of smaller animals, which may be part of the reason for the change in the total length-frequency.
- 92% of the WAG TAC was taken at the time of the meeting. Adjusting the catches to reflect the final catch is not likely to impact the TAC set by the State (which is usually well below the ABC). However, future assessments should be based on the best projection of total catch when the season is not complete.
- Progress towards further GMACS implementation for this stock is expected for the next cycle in 2022.

Presentational
- Correct the x-axis labeling in Fig. CPT2.
- Colors should be used to distinguish observed and predicted length-frequencies in Figures 11-13. However, it would be better to use plots such as Figures 11-13 to show observed length-frequencies and plots of observed vs. predicted length-frequencies (with results shown for multiple models) shown individually by year.
- The rationale for conducting separate assessments for the EAG and WAG should be integrated into the narrative of the assessment.
- Avoid showing fits of models such as 21.1c to observed data used to fit different models.
- Plot selectivity for all models on the same plot to better allow comparisons.
- Use consistent y-axis ranges in similar figures – see Figure 12a (top panels do not go to 0 vs. bottom panels that do include 0).
- Include page numbers in the review draft.
- Increase line width in figures for easier viewing of model runs (e.g., Figures 14 and 32).

8. PIBKC Final 2021 SAFE

William "Buck" Stockhausen (AFSC Seattle) presented the PIBKC stock assessment, which uses a random effects (RE) model Tier 4 approach to determine MMB and stock status, but uses a Tier 5 approach to establish the OFL/ABC. The model code was originally developed by Jim Ianelli (AFSC Seattle) and is similar to the RE model used for Tier 5 groundfish assessments, but has been subsequently been modified for the PIBKC assessment. The CPT questioned whether using the more recent version of the random effects model would be advantageous. Buck suggested that there may be more options in the model for groundfish to deal with issues such as apportionment across multiple management areas, but that these were unnecessary for the PIBKC assessment. However, the CPT recommended exploring any advantages the groundfish version might offer. The CPT suggested that a VAST analysis with spatiotemporal autocorrelation may be worth exploring. It was noted that using VAST may be problematic when very small numbers of animals are caught at only a handful of stations (as with PIBKC) although there may still be some value in exploring the analysis. The CPT also noted that the biomass estimates from VAST may not be reliable, and estimated confidence intervals may be even less so. The CPT questioned whether interannual variability in the survey estimated CVs is appropriate. The CPT suggested exploring smoothing the CVs starting by using the median CV value for all years. Based on this discussion, the CPT recommends 1) exploring VAST for PIBKC assessment, and 2) exploring smoothing the survey point-estimate CVs (e.g., apply median CV for all years).

Buck provided an overview of a study by Jennifer Stoutamore on BKC genetic stock structure among eastern Russian waters, the Chukchi Sea, the Bering Sea, and the Gulf of Alaska. Clustering analysis found differences between PIBKC and SMBKC, but they were the most similar of sites that exhibited significant differences. The study showed significant temporal changes in allele frequencies over a 20 year period at the Pribilof Islands and Saint Matthews Island, and no evidence of population bottlenecks. It was suggested that temporal changes in overharvesting may have led to lottery-type recruitment, with recruits in any given

year being related to only a small number of mother crabs. The study also suggested that the mating system is single paternity (i.e., one female mates with a single male).

There was some discussion about the use of the Tier 5 approach for OFL and the Tier 4 approach for stock status. Buck presented the Tier 4 OFL calculations as a sensitivity analysis, not as a recommendation. These would have resulted in no retained catch mortality (directed F_{OFL}=0) and a very small amount of discard mortality based on the average of recent discard mortality as a fraction of recent MMB (OFL = 270 kg). It was noted that the Tier 5 OFL is based on average fishing mortality during 1999/2000-2005/2006, reflects the conservation needs associated with this stock, and acknowledges existing non-directed catch mortality. The CPT saw no reason to alter the existing method for OFL determination or the 25% buffer for ABC, and concurred with Buck's recommendation: OFL=1.16 t, ABC=0.87 t.

The CPT discussed the SAFE stock specification table with respect to PIBKC being a biennial assessment and whether the assessment should be brought back to a September CPT meeting cycle in order to fully account for any bycatch that occurs through the end of June. The advantages of an assessment review in September assessment are that the most recent survey and bycatch data through the end of the June fishing year would be available, and there would be no need to revise the assessment with the final catches. The disadvantage is that it would add incrementally to the September workload, both for the assessment author and CPT. It was noted that the September workload has been reduced during odd years by shifting the SMBKC assessment to a biennial cycle. Therefore the CPT recommends that future PIBKC assessments (starting in 2023) should be conducted for September meetings.

9. BSFRF update, snow crab workshop report.

Scott Goodman provided an overview of BSFRF activities. He first summarized a snow crab workshop held via Zoom January 21-22, 2021, and described a second workshop that will be held in October (TBD). These workshops have three goals: consider population-level implications of reduced male size at maturity, consider causes and effects of the high discard rates seen in recent years in the fishery, and refine eastern Bering Sea snow crab research priorities in the context of specific management improvements and recommendations. The focus of the January workshop was on biology and research, while the October workshop will focus on research and management. In the January workshop, four presenters (Cody Szuwalski, Ben Daly, Bernard Sainte-Marie, and Darrell Mullowney) reviewed available biological information from the US and Canada (workshop presentations are available for public dissemination). Scott summarized a few issues highlighted during the meeting and mentioned that a workshop report with recommendations will be available soon. Regarding shifts in size of terminal molt – experimental work is in progress in Kodiak, and there are plans to continue collecting chela height data on this summer's EBS and NBS bottom trawl surveys. These data may inform changes in terminal molt size over time and increased discards in the fishery. Analyses of climate drivers and effects of temperature in early life history stages are underway in Canada and the EBS and in modeling efforts.

Scott also provided updates on current BSFRF research:

- A saildrone is currently in Bristol Bay tracking acoustically tagged red king crab.
- A snow crab growth study recently collected 184 male snow crab, of which 170 molted in the NMFS Kodiak lab. These data will be directly used in the assessment model to inform snow crab growth.
- BSFRF data accessibility work is in progress with the goal of a more accessible BSFRF database.
- An October BBRKC tagging project is planned, details TBD.
- Bycatch Reduction Engineering Program (BREP) research is continuing in Kodiak. A report was presented to the NPFMC in February.
- BSFRF is supporting the NMFS EBS bottom trawl survey by providing science staff for legs 2 and 3.

- A crab and climate mini-symposium is planned for May 26.
- Scott showed an opportunistic video of cod pots containing many snow crab.

10. Snow crab - Proposed model runs for Sept

Cody Szuwalski (AFSC Seattle) presented a report to the CPT on his work to reduce retrospective patterns in the snow crab assessment model, an alternative approach for determining OFL ("Tier 3.5"), and proposed models for September. Cody noted that the snow crab assessment was the subject of a CIE review in March 2021, but reports from the review are not yet available. However, much of the discussion focused on retrospective patterns, their causes, and methods to reduce them or account for them when making harvest recommendations. Cody also produced a draft risk table for the snow crab assessment based on similar risk tables used in groundfish assessments. The risk table is discussed more fully in the agenda item on risk tables.

Dealing with retrospective patterns in the snow crab assessment was the primary focus of the report. Cody provided a review of the two assessment configurations presented in September 2020: the status quo assessment model and a model based on the GMACS platform. The SSC chose the status quo model over the GMACS implementation for snow crab in October 2020 as a result of retrospective patterns and large estimates of the recruitment for 2015 from GMACS. The large estimates of recruitment from GMACS led to large OFLs and resulted primarily because GMACS fit the last two years of survey biomass better than the status quo model. Cody pointed out that when forced to fit the final two years of survey MMB as well as GMACS, the status quo model produced estimates of recruitment and the OFL comparable to it. He also noted that a large recruitment pulse in 2015 is supported in the survey data up to 2018, and the real question is what happened in 2019. There is some suggestion from the survey data from the northern Bering Sea (NBS) that a fraction of the stock had migrated northwards, crossing the line delineating the EBS from the NBS. Cody also argued that retrospective patterns were present in both the status quo model and the GMACS model. When confronted with retrospective patterns in a stock assessment, Cody noted that three options are commonly considered: 1) incorporate more model structure to allow the necessary flexibility to fit the data (e.g., allow a process to vary over time that was not previously varying over time), 2) perform post hoc adjustments of the management quantities based on the magnitude of retrospective patterns (similar to what the CPT suggested by increasing the buffer to 50% for the ABC in 2020), or 3) use a survey-based index of abundance or biomass to set the OFL (similar to the Tier 4 harvest control rules). Cody addressed the first approach by developing model scenarios that included time-varying processes and the third approach by developing a "Tier 3.5" approach to status determination and OFL setting. The CPT noted that it was also possible that modifying the weights placed on the data sources might reduce the retrospective patterns by reducing conflicts among the different sources, and that this possibility had not yet been explored thoroughly.

Cody presented results from seven Tier 3 assessment model configurations for consideration: 1) 20.1—last year's accepted model (status quo) fit to last year's data; 2) 20.1g—last year's GMACS model fit to last year's data; 3) 20.2—last year's accepted model (status quo) fit to last year's data with down-weighted size composition; data (all weights equal 100, rather than 200); 4) 20.2q—20.2 + time-varying survey catchability from 1989-present; 5) 20.2m—20.2 + time-varying natural mortality for mature males and females; 6) 20.2qm—20.2 + time-varying survey catchability from 1989-present and time-varying natural mortality for mature males and females; and 7) 20.2v—20.2 + VAST survey estimates. In order to achieve convergence in the models with time-varying processes, growth had to be estimated outside the model and subsequently fixed inside the model. In order for results to be directly comparable with these models, growth was also fixed in Model 20.2. All models produced a positive-definite Hessian and had maximum gradient components less than 0.004, except 20.2mq, which had a maximum gradient component of 0.01 for one of the recruitment deviations for males (the rest were < 0.004). The smallest viable smoothing penalties tested were 1 and 10 for natural mortality and catchability (respectively) when they were the only

additional time-varying process in the assessment. When both processes were allowed to vary, the penalty for natural mortality had to be increased to 15 or the model did not converge.

Cody reported that the patterns in estimated recruitment by sex were similar for both GMACS and status quo models, but the GMACS estimates were more variable than the status quo estimates. There was a considerable amount of variability in the estimated 2015 recruitment among the models, with GMACS having the highest estimates. Cody noted that the size of this recruitment is a strong driver of the current year MMB and OFL. The survey MMBs produced using the VAST indices of abundance were somewhat higher than the status quo model and the fits to the index were correspondingly higher.

Reducing retrospective patterns

The models with time-varying processes reduced the retrospective patterns, as evidenced by smaller values of Mohn's rho for these models, but this was expected simply because the increased number of parameters allowed the models more freedom to fit the data. Status quo models that allowed at least one additional time-varying process (20.2q, 20.2m, 20.2mq) all had mean catchabilities similar to the BSFRF implied catchability. However, the variability in catchability for 20.2q and 20.2mq was large, with estimated values ranging from ~0.2 to ~1. Estimates of mean natural mortality were smaller for models in which natural mortality was allowed to vary over time than for those in which natural mortality was constant over time. Natural mortality sharply increased in the last several years for 20.2m, but only rose sharply in the last three years for 20.2mq and reached higher mortality levels. Cody suggested that the data were inadequate to identify which of multiple time-varying processes was most likely to be correct, but that this was key to providing reliable management advice: mis-specified models provide misleading estimates of population processes. He found that allowing model processes to vary in time led to unstable models and produced patterns of variation in M or q were not particularly plausible but with drastically different management implications.

Tier 3.5 assessment for snow crab

Cody noted that much is known about snow crab life history and recruitment, but that the Tier 3 model estimates of terminal year biomass may be considered unreliable because of the retrospective pattern. He proposed a "Tier 3.5" assessment for consideration, in which terminal year biomass and B_{MSY} were determined directly from survey MMB (Tier 4), while Tier 3 proxies for F_{MSY} and MSY could be estimated using spawning biomass per recruit (SBPR) approaches. This Tier 3.5 approach consisted of using a random effects model to obtain a smoothed time series for survey MMB to calculate terminal year MMB and B_{MSY} (as an average over an appropriate time period) and $F_{35\%}$ (the Tier 3 proxy for F_{MSY}) determined using SBPR calculations based on results from a population dynamics model that used empirically-derived quantities from observed data. Cody noted that MMB is currently based on morphometric maturity, which includes all large-clawed males regardless of carapace size and leads to high values for F35% because most morphometrically-mature males are smaller than legal size. He questioned whether smaller mature males were equal to larger males in reproductive contribution, and consequently considered several different minimum sizes for defining MMB (78, 95, and 101 mm CW). In order to obtain an estimate for survey catchability, Cody used the BSFRF side-by-side studies that focused on snow crab to empirically derive catchability curves for the NMFS survey. He noted that it was possible to use these curves to "correct" survey biomass estimates to obtain stock-level estimates of MMB (similar in concept to what the assessment model does). He was also able to derive empirical estimates for natural mortality, fishery selectivity, growth, and maturity from available data. These were in fairly good agreement with estimates from the assessment model, though some notable differences exist in the probability of maturing at size and total fishery selectivity. Using a bootstrapping approach, Cody found that the distribution of $F_{35\%}$ (as an equivalent exploitation rate) made using his Tier 3.5 approach was primarily driven by the definition of MMB: the results were quite similar to the assessment results when the probability of terminal molt from the assessment was used (80% exploitation rate), while the exploitation was almost 100% if MMB was based on the observed ratios by size of new shell large chela males to all new shell males. The OFLs produced via this methodology ranged from 3.6 kt to 239 kt. The OFL and MMB were highest when

maturity was defined as crab > 78 mm CW. Cody noted that there was room for improving the methodology, such as incorporating fishery selectivity into the OFL calculation.

CPT comments and recommendations
The CPT appreciated Cody's efforts to incorporate time-varying processes in the status quo and GMACS models, as well in developing the "Tier 3.5" approach and analysis. The CPT did not, though, consider the latter appropriate for determining stock status and OFL in September. State biologists on the CPT noted that ADFG uses post-hoc adjustments of the assessment model results, at least informally, in setting TAC for crab stocks. Results generated in the Tier 3.5 approach could be very helpful in the TAC-setting process, which incorporates a comprehensive approach to considering factors such as perceived model adequacy and uncertainty, as well as ecosystem considerations and other factors not addressed in the assessment model.

The CPT noted that the results generated in the Tier 3.5 analysis were useful as diagnostics for the Tier 3 models, but that it was premature to consider this approach as a basis for determining stock status and recommending the OFL. The CPT suggested that the Tier 3.5 approach might not be a long-term solution because survey trends can be misleading. For example, at least some of the retrospective pattern in the current assessment occurs because of a run of high historical survey biomass estimates that model is no longer able to fit adequately because recent data is not consistent with those estimates. It was also noted that the values for Mohn's rho from the Tier 3 models were large, but not as extreme as has been seen in other situations. The size composition data could have been given too much weight in the likelihood, leading to apparent time variation in selectivity as years were peeled back in the retrospective analysis. In addition, time-varying natural mortality may not be represented well in the model because it probably varies with both size and age, and chela height may not be as directly related to terminal molt as currently assumed, and thus the processes determining male maturity may not be represented well in the model. Overall the CPT is not convinced that current assessment (or GMACS) has thoroughly evaluated enough to justify a change in assessment modeling approach.

The CPT recommended were the following:

- continue to develop the GMACS snow crab model
- revisit the weighting of different data sources in the assessment model to potentially reduce retrospective patterns
- reconsider how male maturity is determined in the data and fit in the model

Proposed models for September

The CPT would like to see the following models, updated with 2021 data, brought forward for status determination in September:

- 20.1 (status quo model)
- 20.1g (GMACS version of the status quo model)
- 20.2 (status quo + down-weighted size compositions using one or more tuning methods (i.e., Francis or McAllister-Ianelli)
- 20.2q (20.2 + time-varying fishery selectivity)

The CPT noted that time-varying selectivity could be implemented as time blocks (e.g., pre- and post-rationalization rather than annually-varying) to improve model stability.

11. Red king crab EFP - final report

The CPT received a presentation and a written report (Exempted Fishing Permit # 2019-01) from Alaska Pacific University M.S. student Cody Lescher on a project involving red king crab (RKC) caught in bottom trawl fisheries for Bering Sea and Aleutian Islands yellowfin and rock sole. The CPT received a previous presentation on this project in September 2018. Project objectives were: to compare RKC catch estimation

accuracy between whole-haul census and observer sub-sampling; and to examine vitality indices used to predict delayed discard survival for RKC. Results from efforts to compare whole-haul to subsampling of snow and Tanner crabs were not presented. For RKC, the study considered 14 potential viability metrics, ultimately selecting seven based on lab studies. Crab were assessed at initial capture, and then after 2, 4, 6, 12, 24, 48, and 72 hours. A NOAA exemption was required to delay discard timing of RKC in order to collect pertinent scientific data. Unfortunately, permitting delays due to federal government shutdowns in 2018–2019 resulted in missing the optimal timing for RKC sampling, and a seasonal increase in Pacific cod and Pacific halibut required participating vessels to move from the preferred study location due to bycatch considerations. For the participating catcher-processor, sampling included 37 RKC from the deck and 18 from the factory area over two fishing trips. The vitality indices appeared to provide reasonable measures. Crab collected from the factory had higher initial impairment and greater injuries than deck-sampled crab. During the holding period, six crab died (~11%; only 1 legal male). The focus of this study was narrow and the intent not to determine overall handling mortality rate of bycatch red king crab. The CPT appreciates the presenter's efforts and recognizes the small sample size in this study reflects the difficulties of field studies.

12. BBRKC - Proposed model runs for Sept

Jie Zheng (ADF&G Juneau) presented eight models for Bristol Bay red king crab. In addition to base model (19.3) accepted by the CPT and SSC in September 2020, models included updated observed data (19.3c), updated sample sizes for retained and total size composition data (19.3d), and explorations of the number of and priors on survey catchability parameters (19.3e and 19.3f). Model 19.3g built on model 19.3d, but used VAST estimates for NMFS survey trawl biomass and CVs. Model 19.3i estimated additional CV for model 19.3g and model 19.6 changed the natural mortality from 0.18 to 0.257, based on Then et al. (2015).

Although model 19.6 was not recommended for inclusion in the September assessment, the CPT noted that using the '1% rule' as justification for the currently assumed natural mortality is outdated and the Then et al. (2015) paper is preferable. Further, the likelihood profiles indicate that there is currently strong information in the model about M and suggest M may be higher even than the estimates from Then et al.'s methodology. The CPT was concerned that the 'information' content of the data with respect to natural mortality could be related to strong assumptions elsewhere in the model, and recommended further exploration of natural mortality after September and suggested attending the June 2021 CAPAM workshop on natural mortality, which may provide some insights into best practices. A large increase in estimated natural mortality would likely increase fishing mortality reference points, with management implications.

The CPT recommended presenting Models 19.3d, 19.3e, and 19.3g in September with updated data. Model 19.3d includes both the updated observer data and improved sample sizes, which were seen as clear improvements over the status quo. Model 19.3e incorporates different survey catchability coefficients for males and females, which is consistent with what is done with other stocks and makes biological sense given differences in behavior between the sexes. Model 19.3f uses VAST estimates for the NMFS summer survey. Results presented during the VAST agenda item indicated that the VAST estimates for BBRKC showed good diagnostics and were reasonably consistent with the area-swept estimates.

Additional points:

- The CPT was interested in more exploration of the retrospective patterns, which seem to have increased since the last assessment despite no new data being added. Reported Mohn's rhos were starting to reach concerning magnitudes in the proposed models.
- Model 19.3c probably should have been labeled model 21.0, given the large change in inputs.
- When calculating the probability of being overfished via MCMC, it is necessary to calculate $B_{35\%}$ for each draw to compare the MMB from that draw. If this is not done, the comparison is not consistent.

13. NSRKC growth data research update

Leah Zacher (AFSC-SAP) gave an update on the Norton Sound red king crab (NSRKC) growth and functional maturity project. This project has two goals: to determine fertilization success of male NSRKC near the minimum size at maturity (94 mm CL); and to determine growth increments of male and female NSRKC. In October 2020, 12 males (78-91 mm CL) and 17 mature females (72-83 mm CL) were shipped to Kodiak to conduct the lab study. Males molted in October-November, and females molted and mated in January-March, 2021. Males molted to larger than desired sizes (>94 mm CL) to assess functional maturity, therefore the experiment will need to be repeated next year to obtain this information. All males grasped the females and 11 of 12 males successfully fertilized clutches (≥99% fertilization success). One male (102 mm CL) grasped four females, but never induced clutch formation. Male growth increments ranged from 10.5 mm CL to 15.8 mm CL while female growth increments ranged from 6.6 mm CL to 9.9 mm CL. The potential for laboratory effects on growth data is low for males due to shorter holding times, but females were held for over 3 months, and Leah cautioned that laboratory effects on female growth data may occur.

Leah presented male growth increment data from historical NSRKC tagging studies that are currently used in the NSRKC assessment model There are two disjoint clouds of male growth increments in relation to pre-molt size; one data cloud > 8 mm and the other around 0 mm. The lab-derived estimates of male growth increments overlapped with larger (>8 mm) growth increments from past tagging studies. The CPT discussed whether near-zero growth increments derived from tag recaptures represent true growth or measurement error. Leah pointed out that data with small positive growth increments were considered true growth in the NSRKC stock assessment model, while small negative growth increments were considered measurement error and not used in the assessment, although one would not expect measurement error to be directional. There was discussion about the interpretation of measurement error and it was pointed out that in Aleutian Islands golden king crab tagging data summaries, growth increments <8 mm CL were omitted as measurement error (e.g., 1991 Aleutian Islands golden king crab tagging report).

The CPT agreed that small growth increments in the NSRKC tagging data likely represent measurement error and only growth >3 mm CL should be treated as true growth increments and included in the model. The CPT recommends re-assessing near-zero growth increment data in the NSRKC stock assessment model to determine a threshold for considering these measurements as belonging to crab that skipped molting (i.e., actually zero growth, but with a small measurement error) versus a crab that actually molted. The CPT suggests that a follow-up study be conducted to quantify measurement error in carapace lengths.

Leah plans to continue the maturity and growth study with smaller NSRKC and conduct a long-term holding study with large (>123 mm CL) and small (94-122 mm CL) mature male crab to assess size-dependent natural mortality rates. The CPT supports continuation of this project because NSRKC growth and maturity information is lacking. Furthermore, CPT queried the time frame for long-term holding of crab for natural mortality determination.

14. Tanner - Proposed model runs for Sept

Buck Stockhausen presented a summary of work on the EBS Tanner crab assessment since September 2020 and proposed model options for the September 2021 assessment. The work conducted since September 2020 addresses:

- Eleven estimated parameters hit their upper or lower bounds. These parameters were related to selectivity, catchability, and growth increments per molt.
- Whether to use VAST-estimated NMFS trawl survey biomasses and CVs for the assessment.

- Whether to assume normal or lognormal likelihoods when fitting fishery catch and bycatch biomasses.
- Poor fits to male growth data in the assessment models.

To address these issues, Buck evaluated 20 models including model 20.07, the base model for 2020. Two models utilized the VAST biomass estimates, a model that used the CVs produced by VAST, and another that estimated an additional CV term. Various approaches were evaluated to reduce, if possible, the number of parameters that hit bounds. These included expanding the bounds on the survey catchability parameters, fixing maximum retention parameters, using tail compression in the likelihoods, using half-normal rather than logistic curves for selectivity, removing size compositions with small sample sizes, and using Dirichlet-multinomial likelihood for some or all size composition data. Models that used fixed growth parameters estimated outside the model, and used fixed survey catchabilities estimated outside the model were also explored.

VAST reduces CVs for the NMFS survey biomass substantially (average 50%, 42%, and 39% for males, immature females, and mature females, respectively). The low CVs result in better fits to the survey biomass data at the expense of poorer fits to the size composition data. Estimating additional CVs had the opposite impacts on the fits to biomass and size composition data. In addition, model 21.00 results in an estimated constant capture probability over size for NMFS survey females during 1982-2109.

Replacing the normal with the lognormal likelihood for fishery catch and bycatch biomass data aligns the model with other Alaska crab stocks, but also is a better approach statistically within a multiplicative framework. Several models were used to eliminate problems of estimated parameters at bounds, and although the number of estimated parameters at bounds was reduced somewhat, these approaches were generally not very successful. Models 21.21 and 21.22 with expanding survey catchability bounds and fixing some selectivity parameter values at bounds solved the problem of bounded parameter estimates. The management quantities, such as $B_{35\%}$, terminal year biomass, OFL, and F_{ofl}, are similar among models 21.21 and 21.22 and their respective parental models (21.04 and 21.13).

Male growth is still a challenge. The growth data appear to be good, but the assessment model fits them very poorly. As a terminal molt stock, maturity is strongly associated with growth. Consequently, there is a tradeoff between growth and maturity in the assessment model. Maturity may be more related to age than growth, so that faster growing crab mature at larger sizes than slower growing ones. Because intermolt duration is temperature-dependent during the early benthic instar stages, temporal and spatial changes to the stock relative to bottom temperature may affect the distribution of size at maturity even though molt increment is not influenced by temperature (as is the case for snow crab). Thus, there may be some important biological processes that the assessment model does not adequately capture. Since the growth data are easily fit outside of the assessment model, a good alternative is to estimate the growth increments per molt outside of the assessment model.

The CPT thanked Buck for his work, made some suggestions for model improvements in the future, and noted:

- The data may not support so many selectivity parameters. A reduction in the number of selectivity parameters may be needed.
- The CVs for the VAST-based index could be selected about a loess-based smoother rather than from the VAST output.
- The early data quality seems not very good and may have an inappropriate influence on some parameter estimates. One approach is to start the model in 1982 and to estimate size compositions and total abundance in the initial year. An additional benefit of this approach is to reduce some impacts of spatial and temporal changes of the stock on parameter estimates.

- Some selectivity parameters may be estimated with an AR1 or random walk approach within some year blocks. For example, a selectivity parameter for the 120 mm size group within a certain year block may be estimated using an AR1 approach. A penalty is needed for time-varying changes.
- Tanner crab assessment models have undergone many changes over time. It may be beneficial to look at the early assessments to see how earlier models fit the data, especially the early data.
- The CPT recommended the following three models for September 2021:
    - Base model 20.07 from September 2020.
    - Model 21.22, which implemented the all changes that eliminated the problem of parameters hitting bounds and uses the Dirichlet-multinomial likelihood for size compositions.
    - Model 21.22 + pre-specifying the growth increments per molt based on estimates obtained outside of the model.

15. Research priority update from SSC

Jim Armstrong gave an informational update on the Council process for reviewing research priorities. No decisions are required from the CPT at this time. Jim noted that the CPT discussed research priorities at the January 2021 meeting, and the Council and SSC completed their triennial review of research priorities at the April 2021 Council meeting, with the next review scheduled for April, 2024. Jim gave an overview of the Council's current list of "top-10" highest priority research items, of which three are specific to crab (including the recently added Norton Sound red king crab case study item), and an additional four are directly relevant to crab stocks/fisheries.

Jim presented an overview of draft recommendations that the SSC presented to the Council at the April 2021 meeting for improving the research priority process under the 3-year review cycle adopted by the Council; the SSC will finalize its process recommendations at the upcoming June meeting. Under the current cycle, FMP plan teams are directed to review research priorities and report to the SSC annually; under the SSC's draft recommendations, plan teams will undertake full consideration of research priorities on a three-year cycle, in advance of the SSC and Council review so as to provide substantive input. Assuming the SSC's recommendations are adopted, the CPT should begin preparing its review in late 2023, to be finalized at the January 2024 CPT meeting.

Jim outlined additional changes to the review process recommended by the SSC. In addition to the FMP plan teams, the Bering Sea Fisheries Ecosystem Plan Team (BSFEPT) and Social Sciences Planning Team (SSPT) will participate in the triennial review of research priorities, including review of project status, priority ranking, providing comments on current research items, and recommending projects for inclusion in the SSC's "top-10" list. Additional "on-ramps" for development of research priorities and would expand the scope of research issues considered to areas not generally covered by FMP plan teams, such as marine mammals, sea birds, and salmon. Jim noted that the public comment process allows for members of the public to raise issues related to research priorities at any plan team or other Council committee meeting where research priorities are on the agenda, potentially raising research recommendations for formal endorsement by the plan teams/committees. Jim also briefly outlined the plan for the timing and activity of the SSC's research priority subgroup during the two Council meetings leading up to the formal triennial review meeting.

In response to a question, Jim clarified the current status and timing of the research priority review process, noting that the Council finalized research priorities at the April 2021 meeting, which will be in effect until 2024; the research priority item included on the SSC agenda for the June 2021 meeting is limited to finalizing plans for the review process going forward. A concern was raised that the CPT did not undertake a complete review of research priorities at the January 2021 meeting, and suggested that the team should plan for a thorough review in advance of the Council and SSC's next triennial review. Jim noted that the

SSC will begin its review process at the December, 2023 meeting, such that the CPT would ideally complete its review and finalize recommendations at the September 2023 CPT meeting. The team discussed options for spreading out discussion of research priorities over 2023 at the January and May meetings, and agreed that the main discussion should be scheduled for the May 2023 meeting, with final recommendations to the SSC to be finalized the following September. Given the large time commitment required for complete review of research priorities, it was agreed that CPT members will need to be well-prepared for the discussion when it is on the agenda.

16. GMACS update/ priorities for Sept.

Katie Palof updated the CPT on progress with GMACS. Andre Punt has been working with Shareef Siddeek to implement the AIGKC assessment into GMACS, while Cody Szuwalski has been working with Hamachan Hamazaki on getting the NSRKC assessment into GMACS. Siddeek mentioned that the AIGKC GMACS model is nearly complete and ready for review, but progress was put on hold to complete the traditional assessment for the May CPT meeting. He will resume progress shortly after the current CPT meeting. The CPT asked about the timeline for using the GMACS model for the AIGKC assessment; there are a few glitches, but most of the population dynamics are matching the traditional "base" assessment. Siddeek thought it would be possible to present both the GMACS and traditional assessment at the January 2022 CPT meeting, with preferred model approval at the May 2022 meeting. The GMACS model presented at the January 2022 CPT meeting should be a final version (not preliminary) for comparison to the base model. It was also recommended that Siddeek present GMACS progress at the September 2021 CPT meeting.

Cody provided an update on his work with Hamachan on the implementation of the NSRKC assessment in GMACS. Little progress has been made since January 2021. The NSRKC assessment is operating in GMACS but various components still need to be implemented (e.g., tagging data are not incorporated to estimate growth, and it is not yet possible to replicate the numbers at size matrix). The tentative plan is to show progress at the September 2021 CPT meeting, and then map out the timeline for the GMACS implantation.

Cody mentioned that he will be starting a postdoctoral scholar very soon, who will be working on various projects, including unit testing to merge the GMACS snow crab assessment into the base model, writing GMACS documentation, and updating the R package used for visualization (gmr).

The CPT discussed GMACS tpl file updates and version control. Any GMACS changes should be documented so that the CPT can provide input at the January 2022 CPT meeting. Terminal year recruitment needs to be resolved for the BBRKC GMACS model; Andre will explore this issue but is concerned that two diverging "branches" between the BBRKC and snow crab models will create confusion and inefficiency. Cody will address this issue during unit testing, highlighted changes in how terminal molt is handled in GMACS, and advised Andre to proceed with GMACS development with glitches to be resolved later.

Jie has been running the BBRKC assessment in GMACS and is exploring options for terminal year recruitment. Jie mentioned this importance for future projections. Zheng emphasized the need for options (i.e., changing years for determining average recruitment vs random draws).

Short-term GMACS tasks from the January 2021 workshop were discussed. Much work is ongoing, and work towards establishing a unified base code will further advance progress in switching assessments to GMACS.

17. Risk Table discussion - Snow/SMBKC

The CPT discussed the use of risk tables for crab stocks. Martin Dorn presented information on the use of buffers for ABCs by the CPT and SSC for crab stocks, the structure and use of risk tables, and preliminary information from the SSC risk table workshop in February 2021. Katie Palof gave an example risk table with Saint Matthew Islands blue king crab (SMBKC) and Cody gave an example for Bering Sea snow crab (BSS).

Because the maximum permissible ABC for crab stocks is based on a P* of 0.49, typically resulting in a very small buffer between ABC and OFL, the CPT and SSC generally recommend a lower ABC than the ABC resulting from application of P* method. Higher tier levels (larger tier level numbers) are associated with stocks that have less information available, and therefore, the SSC has established the general approach of increasing the buffer between ABC and OFL for stocks in the higher tier levels. The SSC has also made an effort to standardize buffer considerations by tier level. However, determining the buffer size to use for a particular stock for a given year has been approached in a somewhat ad hoc way for crab stocks, and has been based on considerations of known problems with the assessment model, concerns regarding fishery performance, and uncertainty regarding the influence of recent environmental factors on stock productivity. The use of a risk table framework to determine the buffer based on the most current information about the model, stock, environment, and fishery may help standardize and clarify the manner in which the CPT and SSC increases or decreases buffers between ABC and OFL. As defined by the SSC, the "risk" that the use of risk tables should reduce is that the ABC exceeds the true, but unknown, OFL (in which case overfishing would occur if the ABC were taken). The risk table approach should allow the CPT and SSC to recommend larger buffers under more extreme circumstances, and smaller buffers under more normal circumstances, in a more transparent and comprehensible manner.

The four major considerations for crab risk tables are: assessments, population dynamics, environmental and ecosystem, and fishery performance. There are also four levels of concern, with level 1 being the lowest level of concern and level 4 being the highest. Some examples of indicators that may raise the level of concern include, but are not limited to, poor model fits, poor stock recruitment, a change in ecosystem productivity, and the CPUE within a fishery not being consistent with stock assessment predictions. It was noted that the risk table framework should be consistent across stocks and years, but should also be considered as a set of guidelines and not hard and fast rules.

The CPT observed that these considerations may be difficult to quantify and will remain fairly subjective, making it difficult to determine which level of concern to assign to each of the considerations for any given stock. However, the use of risk tables during the assessment process provides a means for the CPT and SSC to evaluate ABC/OFL buffers using the same general framework every assessment cycle. The use of risk tables also provides support and documentation for any changes recommended to the buffer.

In June 2021, the SSC will review the risk table report from the SSC workshop and that there may be some new recommendations. Final recommendations for the risk tables are scheduled for the October 2021 Council meeting. The CPT should review any new recommendations or comments from the report at the September 2021 CPT meeting and supply comments to the SSC for their October 2021 meeting before they are finalized.

The preliminary recommendations from the SSC workshop report generally concluded that the risk table framework is working well in groundfish and should be produced each year for all groundfish and possibly crab stocks. The report also recommended that the fishery performance column in the recommended risk table format focus on informing the biological status of the resource and not the economic performance of the fishery, encouraged the inclusion of LK/TK/S (local and traditional knowledge) sources, and suggested changing from four levels of concern to three.

The CPT noted that the SSC workshop report is recommending that risk tables be assessed yearly for all stocks. However, there are several crab stocks that are on biennial or triennial assessment cycles and the

ABC/OFLs are set two or three years at a time. ABCs are not considered every year for these stocks. It was noted that doing risk tables every year could help inform the CPT and SSC if stocks are on track even in an off cycle year. However, at this time the CPT does not recommend completing risk tables for stocks that are not in cycle because the ABC/OFL has already been set. The CPT would like clarification from the SSC on their recommendation for handling off cycle years.

Cody presented the work he has done on the risk table for snow crab. He noted that he found the process to be fairly straightforward with the exception of the ecosystem considerations section. He assigned a level 3 concern for the assessment-related considerations mainly due to poor model fit; a level 4 concern for the population dynamics consideration due in part to a large estimated recruitment event; and a level 2 for fishery performance due to a general decline in CPUE, high discard rates, and spatial change in where the fishery has been taking place. He assigned a level 1 concern to the environmental and ecosystem consideration mainly due a lack of predictive information.

The CPT discussed the definitions of the concern levels and whether they were meant to be set according to the baseline for a specific stock or if they should be compared to other stocks in the same tier. The snow crab risk table did not consider other stocks in the same tier. Instead, it relied on the stock assessment author's experience with the snow crab model and stock. It was noted that historically the CPT has often referred to other stocks when setting ABC/OFL buffers. However, the SSC workshop report states that concern levels should be given specifically to a species or species complex. Comparison across stocks may be useful but is not the prescribed method. It is likely that most crab stocks will show some level of elevated concern in at least one of the categories.

The snow crab risk assessment included time-variation in natural mortality, maturity, fishery selectivity, and survey catchability under the population dynamics consideration category. The CPT discussed whether these elements should be in the population dynamics consideration category or in the assessment-related consideration category. These elements might not be population concerns *per se* but instead the result of not being modeled correctly. However, this is unclear because the assessment might be indicating a population concern but there is some uncertainty.

Katie indicated that having an ecosystem and socioeconomic profile (ESP) in place when working on the SMBKC risk table was very helpful. The ESP might not have a predictive role in the model but does include elements, such as warming trends, that are generally reflective of expectations for recruitment. These could be listed under the environmental and ecosystem consideration category as something to watch and would not necessarily increase the level of concern. The CPT discussed whether it was appropriate to include elements in the environmental and ecosystem consideration category if they were not being used to inform the ABC/OFL buffer. Some members of the CPT thought it might be possible to look at environmental and ecosystem elements to set baselines and track trends and degree of change over a period of time. However, other members pointed out that there is little direct evidence that these elements actually affect the stock. It was acknowledged that all of these considerations are important for managing crab stocks long-term. However, they may not play a role in preventing the true OFL from being exceeded in the short term. The CPT asks for clarification from the SSC on how environmental and ecosystem considerations should be treated in the risk table if there is no direct evidence these elements are affecting the stocks.

Katie presented her work on the SMBKC risk table. She assigned a level 2 concern for the assessment-related considerations mainly due to inconsistencies between the ADF&G and NMFS surveys; a level 2 concern for the population dynamics consideration largely because the stock is overfished and there is poor recruitment; and a level 1 for fishery performance because the directed fishery is closed and there is very little bycatch. She assigned a level 1 concern to the environmental and ecosystem consideration mainly due a lack of predictive information. It was again noted that it can be difficult to determine if a consideration should be a level 2 or level 3 because it is subjective.

The CPT discussed whether risk tables should be pursued for crab and, if so, on what timeline. The CPT agreed that these would be helpful in justifying buffers and would provide a clear historical record of how buffers have been set historically. CPT members from ADF&G stated that the state already does something similar when setting the TACs and it might be helpful if the CPT also went through this process. In addition, risk tables would provide additional transparency for stakeholders about how buffers are set.

The CPT recommends that the snow crab and Bristol Bay red king crab (BBRKC) assessments include draft risk tables for the September 2021 CPT meeting. It was noted that the SSC might have some additional recommendations on risk tables after the June 2021 SSC meeting and the stock assessment authors should review the SSC report for any new guidance. An effort should also be made to send the ESP for BBRKC to the stock assessment authors before the September 2021 CPT meeting to inform the risk table evaluation. When completing the groundfish risk tables, stock assessment authors work with someone assigned to the assessment from the group of ecosystem researchers that work on the ESPs and the ecosystem status reports. A similar arrangement may be helpful to crab stock assessment authors as well. The CPT also recommends having the ecosystem status report presentation at the September meeting before the CPT takes up the snow crab and BBRKC assessments. It was also pointed out that these would be draft risk tables and do not necessarily have to include information in all consideration categories.

18. EFH 5-year review

Gretchen Harrington, Ned Laman, Jodi Pirtle, Molly Zaleski, John Olson, and Megan Mackey (NMFS Alaska Region and AFSC-RACE) gave an overview of the 2022 Essential Fish Habitat (EFH) 5-year Review Plan, and highlighted six of the EFH components that relate to crab. The most recent 5-year review was completed in 2017. In April 2020, NOAA provided an EFH discussion paper on the 2022 5-year EFH review to the SSC and presented it at both the June 2020 and April 2021 meetings. The information presented to the CPT included refinements based on the feedback from the SSC. Initial NPFMC review is planned for October 2022 with final action in December 2022.

Ned Laman and Jodi Pirtle reviewed advancements to EFH descriptions and maps for the 2022 5-Year Review. The Magnuson-Stevens Act definition of EFH is "those waters and substrate necessary to fish for spawning, feeding, or growth to maturity." The EFH has four levels of information: 1) distribution, 2) abundance, 3) vital rates, and 4) production rates. A research objective from the 2017 review was to develop EFH Level 1 information for life stages and areas where missing, and to raise EFH from Level 1 to Level 2 or 3, where possible. NOAA staff have made significant progress towards these goals. They have added data from 2015-2019 bottom trawl surveys to historical data going back to 1982, updated terrain and ROMS covariates, updated life stages and maturity schedules, refined methodology to use numerical abundance, advanced EFH for all models to Level 2 (abundance), and introduced Level 3 (vital rates).

Examples of ensemble-predicted abundances and EFH maps were presented for Tanner, red king, and snow crabs. The first US Arctic model-based EFH analysis was presented and includes snow crab. Level 3 EFH information is in development for groundfish and could be applied to crab in the future.

Molly Zaleski described opportunities for involvement by the CPT in EFH review. Stock assessment authors have the opportunity to review and recommend updates to EFH text, tables, and maps. Stock assessment authors include the following: red king crab--Jie Zheng, Hamachan Hamazaki, Cody Szuwalski, and Ben Daly; blue king crab--Buck Stockhausen and Katie Palof; golden king crab--Shareef Siddeek and Ben Daly; snow crab--Cody Szuwalski; Tanner crab--Buck Stockhausen. The EFH team is looking for subject-matter experts to partner with the EFH team, and stock assessment authors to review EFH products for each crab species by September 1, 2021. Additional volunteers for review include: Miranda Westphal and Bill Bechtol. Others can reach out to Molly Zaleski (molly.zaleski@noaa.gov) to volunteer. The CPT provided feedback on timing, as the September 1 EFH review deadline conflicts with stock assessment deadlines for the September CPT meeting. The EFH team responded that they can reach out to the stock assessment authors sooner for their feedback.

John Olson presented an evaluation of the effects of fishing on EFH, as mandated by the Magnuson-Stevens Act. To this end, a fishing effects model was developed during the 2015 EFH cycle and includes disturbance from bottom trawls, bathymetry, benthos susceptibility and recovery potential, and biogenic and geologic habitat features throughout the Bering Sea. The model outputs cumulative habitat reduction and can output reduction by gear type or habitat features. The model estimates a total of 2-5% habitat reduction from fishing. Future models could be developed for each stock. A crab example from 2017 was presented and no effects of fishing on crab EFH were found at that time, although localized impacts were highlighted for BBRKC in southwestern Bristol Bay (i.e., Cod Alley). The fishing effects model will be run with updated information for the 2022 EFH Review, and stock assessment authors can provide input, planned to take place during January/February 2022. Bottom contact effects of pots and longlines are being evaluated using information from the literature in other areas. The analysts are also working with Oregon State University to develop an imaging system to determine bottom contact impact area.

The final presenter, Megan Mackey, gave a general overview of Habitat Areas of Particular Concern. The HAPCs include four considerations: ecological function, habitat sensitivity, potential for development impacts, and rarity of the habitat. The NPFMC chooses to identify HAPCs as specific geographic sites. After the EFH 5-year review in June 2022, NPFMC will consider proposals for HAPCs. The Council will send relevant crab proposals to the CPT as a part of the process, if any are received. The current BSAI HAPC areas include skate egg sites and coral areas.

An overview of CPT actions for the 5-year review include: 1) review of the current FMP text descriptions and tables, 2) review of species distribution model results, EFH maps, and habitat information, 3) review of prey habitat text and tables, 4) review of the fishing effects model given updated data and new maps, and 5) providing information for the HAPC proposal review process in June 2022.

Scott Goodman (BSFRF) started the discussion session and asked about fishing effects and bottom contact estimates by gear type. John Olson responded that gear used for fishing in Alaska are a bit different than in other locations. A 2017 paper on RKC looked at the efficacy of closure areas, and this topic is of interest. More work could be done. NOAA relies on the stock assessment authors to follow the fishing effects process. An earlier CIE review was very critical of the flow chart used to determine fishing impacts in 2017.

Cory Lescher (ABSC) expressed his appreciation to the presenters and thanked them for highlighting HAPCs and reviewing the proposal process and timeline. Cory mentioned the comment letter Alaska Bering Sea Crabbers submitted at the April 2021 Council meeting (link here) and noted the incorporation of industry feedback in these presentations. The crab industry appreciates the work of these authors and continues to encourage HAPC designations across BBRKC life stages.

Jon Warrenchuk complimented the presenters and raised questions to the CPT and to the NOAA analysts about how the results of the fishing effects model will be presented. The model results are reported as the cumulative disturbance of habitat, with the various geologic and biogenic features of the habitat considered equally important in determining disturbance. Jon thought that it may be important to report disturbance by habitat feature in addition to overall disturbance. This more detailed reporting could help inform impact evaluation if particular habitat features are known to be of importance to a species. The CPT thought that this request seemed reasonable and could provide useful information. John Olson responded that the data validation is very limited at this point, as the model lacks spatially explicit habitat data.

The CPT discussed the timeline for stock assessment author input and the EFH team clarified that they are looking for input within the next few months. This timing would work well for the crab stock assessment cycle, as August and September are busy months for assessment authors. The CPT recommends that the EFH team prioritize preparing crab EFH documents to allow assessment author-expert partnerships more time for review before September CPT deadlines.

The CPT expressed concern that EFH is defined by species, and data products are of limited utility for identifying EFH specific to each crab stock. The CPT would be interested to see smaller scale species

distribution models produced for individual crab stocks, especially given that many stocks are currently at depressed levels. Jodi Pirtle mentioned that dynamic habitat models are in development and could be developed for crab. The CPT thanked the EFH team for the informative presentations and discussion.

19. Update TOR for SAFE documents

The CPT reviewed the Terms of Reference (TOR) for BSAI SAFE chapters in January 2021 and created a list of suggested changes. This is seen as an opportunity to improve the consistency of information provided in SAFE chapters, which may involve some initial formatting changes in some of the documents. A draft template prepared and distributed by Jim Armstrong at this May CPT meeting attempted to clarify the structure of the SAFE chapters. Consistency in SAFE chapters will be achieved along two tracks - one to establish formatting and organizational standards, and one to incorporate those standards into R-Markdown for eventual use in all assessment chapters. As a consideration, some authors already use R-Markdown to prepare their assessment reports, and so there is expertise available to help other authors with the R-Markdown approach, perhaps during the January 2022 CPT workshop. It was also suggested that the large tables called for in the TOR (e.g., annual population numbers at size) could be provided within a SAFE chapter as a zipped folder with csv files for the relevant tables.

The CPT agreed that having templates in both R-Markdown and in MS Word will provide greater flexibility to assessment authors. The CPT supports creating a subcommittee to establish figure formats that would be consistent across assessments. ADF&G currently requires documents to be readable by color blind readers. The CPT agreed to apply SAFE chapter templates in the next full assessment cycle so that the 2022 SAFE reflects the agreed upon standards. This will make the 2022 NSRKC assessment the first one in the standardized format. Jim will distribute a MSWord document in which formats are defined (e.g., font style and size for different headings and text). In September, the intent is to provide a revised TOR in response to recommendations provided by the CPT at the January 2021 meeting.

20. New Business

Proposed dates for upcoming meetings:

Sept 13-17, 2021
Location: Online

Jan 10-14, 2022
Location: TBD (CPT very interested in a meeting in Dutch Harbor when the snow crab fishery is active)

May 16-20, 2022
Location: Juneau (tentative)

Proposed September 2021 Agenda Items:

Stock	2021 SAFE Action	Additional actions
Snow	Final assessment	Review CIE reports
BBRKC	Final assessment	Review CIE reports
Tanner	Final assessment	
PIRKC	Update bycatch	

PIBKC	Update bycatch	
SMBKC	Update bycatch	
NSRKC		Proposed model runs including GMACS
AIGKC	Update total removals	GMACS check in
PIGKC	Update bycatch	
WAIRKC	Update bycatch	

- Election of Officers
- Trawl survey update
- Catch update
- EFH update?
- Review ABSC fishery questionnaire
- Final TOR for SAFE chapters, progress on report template
- Ecosystem Status Report, PEEC report?
- Risk table - comment on workshop report and SSC June 2021 minutes (final SSC review of this is in Oct.)
- ESP - draft indicators for snow crab, BBRKC indicator update
- Research update?
- BSFRF update