North Pacific Fishery Management Council

Simon Kinneen, Chair | David Witherell, Executive Director
1007 W. 3rd Avenue, Suite 400, Anchorage, AK 99501
Phone 907-271-2809 | www.npfmc.org

Crab Plan Team

REPORT

May 16-18, 2023.

Hybrid Meeting: AKRO Juneau, AK

Committee Members in attendance:

Mike Litzow, **Co-Chair** (AFSC-Kodiak)
Katie Palof, **Co-Chair** (ADF&G-Juneau)
Sarah Rheinsmith, **Coordinator** (NPFMC)
William Bechtol (UAF-Homer)
Ben Daly (ADF&G-Kodiak)
Ginny Eckert (UAF/CFOS-Juneau)
Erin Fedewa (AFSC-Kodiak)- in person/zoom
Brian Garber-Yonts (AFSC-Seattle)-Zoom
Tyler Jackson (ADF&G-Kodiak)
Krista Milani (NMFS- Dutch Harbor)
André Punt (Univ. of Washington)
William Stockhausen (AFSC-Seattle)
Cody Szuwalski (AFSC–Seattle)
Miranda Westphal (ADF&G-Dutch Harbor)-Zoom

Others in attendance:

Andy Nault
Anne Vanderhoeven
Angel Drobnica
Austin Estabrooks
Bo Whiteside
Brent Paine
Caitlyn
Carli Stewart
Cassie Whiteside
Chris Siddon
Cory Lescher
Craig Lowenberg
Dana Hanselman
Dana Rudy
Danielle Lampe
Darrell Brannan
Emily Ryznar
Ernie Weiss
Ethan Nichols
Frank Kelty
Gretar Gudmundsson
Heather Mann
Heather McCarty
Henry Tashjian
Jamie Goen**
Jared Weems
Jeff Kaufman
John Gauvin
John Hilsinger
Kendall Henry
Kenny Down
Kristin Stahl-Johnson
Linda Kozak
Lisa Hasan
Maddie Heller-Shipley
Marc Solano
Mark Stichert
Martin Dorn
Mason Smith
Mateo Paz Soldon
Merrill Rudd
Mike Vechter
Molly Zaleski
Nikolai Silverstol
Noelle Yochum
Paul Wilkins
Rachel Alinsunurin
Rachel Baker
Ruth Christiansen
Scott Goodman **
Sherri Dressel
Steve Fathom
Steve Ricci
Stephanie Madsen
Susie Zagorski
Tim Loher
Tom Meyer
Vicki Vanek
Wes Jones

** denotes a presenter

Simpler modeling workshop report

Sarah Rheinsmith (NPFMC) reported on a March inter-agency working group that involved CPT and SSC members. The working group's focus was on exploring simpler "base" models for snow, Tanner, and BBRKC. Another aspect was to examine differences between State and Federal harvest control rules and the currencies used in each. The working group focused discussion on three main objectives: (1) create a more robust Tier 3 model for each stock; (2) compare State/Federal harvest specification processes; and (3) explore "fallback" model options for situations when previously-accepted models are confronted with new data and unexpectedly fail to converge or otherwise are not judged to be trustworthy for setting management reference points. The discussion focused on the three stocks that have traditionally supported the largest commercial fisheries for BSAI crab: Bristol Bay red king crab (BBRKC), Tanner crab, and snow crab; however, the working group recognized that some of these approaches may be applicable to other federally managed crab stocks.

For creating a more robust Tier 3 model, the group identified three potential approaches that could be applied for all of these stocks: (1) pre-specify growth and maturity from analyses outside of the model; (2) consider using BSFRF data to inform a prior on Q and/or survey selectivity rather than treating the BSFRF data as separate survey to be fit by the model; and (3) combine all mortality sources other than the directed fishery into a single "fleet" to avoid estimating multiple time-series of fishing mortality rates for bycatch fisheries. If moving models into GMACS, building up a simple model in GMACS may eliminate the need to bridge from legacy models. Although some model aspects aren't currently available in GMACS, the working group suggested starting with a simpler GMACS model, and then building up as needed to include some legacy features.

Working group recommendations for creating a more robust snow crab model included incorporating the best biological information available, but setting F=M on exploitable biomass and using Tier 4 reference points. The CPT, however, noted that this is not necessarily a simpler approach and may not resolve convergence issues. For Tanner crab, the CPT agreed with the working group recommendation to prioritize moving the Tanner crab assessment model into GMACS first, and then building complexity to the base model. For BBRKC, which has issues estimating Q for the NMFS trawl survey and also retrospective patterns, a revised model could include the three commonalities and the assessment could explore the use of a prior on Q, along with different constraints on that prior. The CPT noted that aspects such as these can be addressed in future January CPT modeling workshops.

The comparison between State and Federal harvest specifications found that exploitation rates under State strategies range from 5 to 22% of mature male abundance or biomass depending on stock and stock status. State harvest specifications are typically well below the Federal ABC. The State process also considers additional management and scientific uncertainty not accounted for in the ABC buffer considerations. Estimates of stock status for the upcoming fishing year

also differ, with the Federal estimate based on projected stock status but the State estimate based on the most recent survey.

The simplest fallback model to bring forward for these assessments would involve a Tier 4 approach in which B = survey-estimated mature male biomass, the OFL=B*M (adjusted by stock status as defined in the FMP), and the ABC=OFL*buffer. The Tier 4 approach is viewed as a fallback alternative while authors continue to work on existing assessments. The CPT discussed use of "sufficient statistics" - when the information used to derive the parameter estimate does not provide information for other parameters within the model - and that ideally we would only pre-specifying parameters outside the model that fit this criteria. In addition, a Tier 4 approach assumes Q=1 (i.e., the survey catches all crab that are present within the area swept by the net), which is expected to result in an underestimate of actual biomass.. The CPT discussed the fact that several east coast fisheries have also applied fallback options for "failed" assessments, and noted that these approaches may provide a useful template for BSAI crab fallback models. While specifying values outside the model is a viable approach for reducing the number of parameters being estimated inside the model, the CPT noted that pre-specifying parameters values outside the assessment limits the ability of other data sources within the assessment to inform these defaults. The CPT proposed to address many of these issues at the 2024 January CPT modeling workshop. While the initial working group meeting only involved CPT and SSC members, future model explorations will be presented as part of the regular CPT meetings. Overall, attendees found the working group meeting to be very helpful, and the CPT encourages similar working groups in the future that involve participation from members of the SSC.

General ESP updates

Kalei Shotwell (AFSC) provided an overview and update on Ecosystem & Socioeconomic Profiles (ESPs). Erin Fedewa leads crab ESPs and coauthored the presentation. Kalei reviewed the overall Alaska Fishery Science Center timeline of ESPs, which started in 2014 and were formalized in 2017. The National ESP initiative started in 2022. ESPs can be used to inform risk tables and identify context, mechanisms, models, and indices for use in informing fishery management. The workflow for ESPs begins with ecosystem and socioeconomic information that informs a suite of indicators that are useful for stock assessment purposes. There are currently seven North Pacific stocks with ESPs, including three crab stocks: Saint Matthew blue king crab (SMBKC), Bristol Bay red king crab (BBRKC), and Eastern Bering Sea snow crab (EBSSC). Report cards for these stocks are produced on the same schedule as the SAFEs.

Kalei reviewed the ESP plans for this year (2023). The BBRKC and EBSSC report cards are in progress and will be presented at the fall CPT meeting with updated indicator data. A new project involves comparing different statistical approaches in the modeling framework, using sablefish as a test case to see which statistical approaches are most useful to move forward. Preliminary results on this project will be presented later this summer. The CPT asked whether

these quantitative approaches are using stock assessment model output, such as estimated recruitment, as a response variable, and then using identified environmental relationships with the model output as a new model input, which would produce a circular analysis. Erin Fedewa responded that survey data, rather than model estimates, are used as response variables in the crab ESPs. The CPT discussed how ecosystem information currently informs crab stock assessments. Public comment noted that correlations don't necessarily inform population dynamics, and that mechanistic linkages are needed to understand environmental drivers, although these mechanistic linkages may be changing over time. Another new project addresses streamlining the ESP reports and making them more reproducible. The reports are being developed using an R package that is available through GitHub. The package connects to AKFIN and an ESP database of indicators, and produces standard graphics and report templates in R Markdown. A 2-page R Markdown report template is in development for use nationally.

Kalei reviewed the plans for 2024. There is a plan to initiate an EBS Tanner crab ESP and present progress at the May 2024 CPT meeting. Complete report cards for SMBKC, BBRKC, and EBSSC will be available for the September CPT meeting. An AKFIN data management tool supports access to data, and additional functionality is in development, which will include submission of more complex datasets along with automatic updates to existing datasets. Requests for Information (RFI) are open for people who want to contribute to the ESPs, and the request process is being streamlined. Although the RFI will provide a list of needed indicators based on dominant drivers for each stock, it will also be open to a broad range of responses.

The CPT discussed the need to better understand how socioeconomic information is used in ESPs. Although socioeconomic consequences of fisheries variability can be measured, the socioeconomic drivers for crab fisheries are poorly understood. Socioeconomic data are not a good predictor of crab fishery harvests because these fisheries are fully exploited and the TAC is fully taken. A broad call about ecosystem and socioeconomic information is not helpful if it does not include information to specifically inform fishery management. The national ESP program will allow for sharing of approaches and learning across regions. Interfacing with stakeholders through skipper surveys (as was done for EBSSC) is an example of new information that could be incorporated in the future. Public comment questioned how closed fisheries will affect socioeconomic indicators and vice-versa. It would be helpful to better understand what socioeconomic information the State needs for their TAC setting and management purposes. Public comment suggested that DFO in Canada may have an approach to integrate socioeconomic information into fishery management that could serve as a template for BSAI crab ESPs.

The timeline for ESPs includes 1) requesting an ESP and priority setting, 2) a Request for Information (RFI), 3) ESP, and 4) a report card. The CPT asked how an RFI is distributed. Right

now, RFIs are distributed among existing networks through e-mail and the intent is to broaden that in the future.

The national ESP initiative is underway and includes regions throughout the country. A preliminary workshop was held virtually in 2022 that included representatives from all NOAA Science Centers. A series of focused workshops are planned for summer 2023 to refine and coordinate approaches. The CPT asked if there had been any international collaborations; ICES has reached out with questions, so a future opportunity might include an ICES workshop. The scope of ESPs will be broadened as more are developed. Overall, the ESP process provides an ecosystem-based fishery management approach that is advancing.

The CPT discussed that it would be helpful to see the complete process of how an ecosystem indicator is successfully integrated into a stock assessment. An example of a success would be a situation where an ecosystem indicator is used to inform a management decision. It was noted that even if the ESP is not used in a model, it is still informative when creating risk tables. How the socioeconomics fit in is less clear. The CPT also recognized that an example of a failure may also be valuable. The CPT concluded that these ESP updates are useful, and thanked Kalei for the presentation.

WAIRKC final SAFE

Ben Daly (ADF&G) presented the final SAFE for the Western Aleutian Islands red king crab (WAIRKC) stock. This stock is managed as a Tier 5 stock and assessed on a triennial cycle, whereby the total catch OFL is calculated using annual retained catch, non-directed crab discard mortality, and groundfish discard mortality averaged over the reference period 1995/96-2007/08. The rationalized Petrel District and non-rationalized Adak district have not experienced fishing activity since 2004. Bycatch mortality of WAIRKC has been very low in recent years. The relative increase in the proportion of WAIRKC bycatch during 2017/18-2019/20 was attributed to the Pacific ocean perch bottom trawl fishery. Daly noted that the two years in which a fishery and survey were both conducted suggest comparable trends in fishery and survey legal male CPUE. The most recent industry-cooperative surveys in the Petrel Bank and Adak areas indicate very low population levels in all size/sex categories. The author and CPT also expressed concern that the EFH 5-year review fishing effects evaluation suggested high levels of habitat disturbance in the Petrel Bank area.

New data in the 2023 assessment included retained catch, discarded catch, and estimates of bycatch mortality in crab and groundfish fisheries during 2020/21, 2021/22, and 2022/23, although these data are not used in the calculation of the recommended OFL. Since the last assessment in 2020, overfishing did not occur during the 2020/21-2022/23 seasons because the estimated total catch did not exceed the Tier 5 OFL established for those years (56 t; 123,867 lb).

The CPT supports the status quo methodology and author-recommended harvest specifications for 2023/24, 2024/25, and 2025/26, resulting in an OFL = 56t (123,867 lbs) with a 75% buffer and an ABC = 14t (30,967 lbs.), which could support small exploratory fishery/survey efforts. The CPT recommends a 75% buffer on the OFL to reflect the depressed status of the stock and the lack of new data sources. The CPT also emphasized that although stock status cannot be determined for Tier 5 stocks, extremely low survey CPUE levels since 2002 support the perspective that the WAIRKC stock is in fact overfished. There was some discussion about possible pathways for formally declaring Tier 5 stocks overfished, recognizing that the process for doing so is not currently in place in the FMP. Although a formal overfished declaration cannot be implemented, the CPT urges consideration of other conservation measures such as habitat protection for this severely depressed stock.

PIGKC final SAFE

Tyler Jackson (ADF&G) presented the final Pribilof Islands golden king crab (PIGKC) SAFE to CPT. This is a Tier 5 stock that is managed on a calendar-year basis (January 1 - December 31), with assessments occurring every three years. The last assessment was conducted in 2020, and the results of this year's assessment will be used to set the OFL and ABC for calendar years 2024-2026. Participation in this fishery is sporadic. The fishery has been managed with a guideline harvest level (GHL) of 59 t since 2015. Retained catch in 2021-2022 ranged between 16 and 49 t, and the total catch ranged between 21 and 52 t. Total catch in 2021 and 2022 was below the OFL of 93 t, so overfishing did not occur.

In addition to the Tier 5 approach, Tyler presented a Tier 4 approach and a Tier 4/5 approach based on the spiny dogfish assessment. The Tier 4 approach was conducted with values of 0.18 and 0.22 yr^{-1} for M, and the Tier 4 and Tier 4/5 approaches used fisheries-independent data from the NMFS slope survey. The CPT discussed the potential benefits and drawbacks of moving the stock to Tier 4. It was noted that the Tier 4 approach more accurately reflects the uncertainty that is associated with old survey data, as uncertainty for MMB estimates increases with the length of time since the last available data point. However, this may also be a drawback for PIGKC, since there are currently no plans for a regular slope survey and relying entirely on old survey data (the last survey was conducted in 2016) would result in continual increases in uncertainty using the Tier 4 approach. In the absence of any plans to reinstitute the slope survey, the CPT recommends that Tier 5 remains the best approach for managing this stock. However, Tier 4 would be a better approach for assessing the stock because it does allow for dynamic population estimates, and the CPT looks forward to revisiting the Tier 4 approach once new survey data become available.
The CPT concurred with the author recommendations for OFL and ABC. The ABC applies a 25% buffer to the OFL; use of the 25% buffer has been in place since the 2014 assessment and was adopted to maintain consistency with other Tier 5 stocks with similar levels of uncertainty.

PIBKC - proposed model runs for Sept.

William ("Buck") Stockhausen (AFSC) presented the candidate model for the 2023 Pribilof Islands blue king crab (PIBKC) stock assessment, which is used for the Tier 4 calculation for MMB and associated stock status determination. Buck noted that the survey MMB estimates have large CVs and that VAST estimates have had issues possibly related to island effects and the limited BKC catch and spatial distribution. The current Tier 4 approach applies a state-space random walk model to design-based survey estimates of MMB using a model coded in ADMB (i.e., the "bespoke" model). Buck proposed using the *rema* R package to fit the same model. The *rema* package was developed for groundfish Tier 5 assessments, uses TMB rather than ADMB, and has a larger user community for future development. Buck presented the ADMB and *rema* model fits to survey data and differences in model results were, as expected, negligible. Buck recommended adopting the *rema* package for the 2023 PIBKC assessment, noting that this recommendation is not a change in model structure, but essentially an update to the model implementation. The CPT agreed with this change.

AIGKC Final 2023 SAFE

Tyler Jackson (ADF&G) presented the final 2023 assessment for Aleutian Islands golden king crab (AIGKC) to the CPT. Longtime ADFG assessment author Siddeek Sharif led the assessment team but retired prior to the CPT meeting. Tyler's presentation included responses to past requests from the CPT and the SSC, alternative models, results of model runs and diagnostics, and values for the OFL and ABC under the Tier 3 control rule. AIGKC is a Tier 3 stock that is managed on a "crab year" (July 1-June 30) basis and is assessed annually; the last assessment was in 2022. This is the only Tier 3 assessment based completely on fishery-dependent data. This year's assessment will be used to set the OFL and ABC for the stock for the 2023/24 crab year. Although AIGKC is regarded as a single stock for setting OFL and ABC, the State manages the stock on a two-area basis, with separate TACs for areas east and west of 174°W longitude (referred to here as the EAG and WAG, respectively). Separate models are fit to data from the two areas in this assessment. At the time the assessment models were run (March, 2023), the fisheries in the two areas were still open, with ~90% of the area-specific TACs taken. Consequently, season-end retained catch and total catch mortality for the 2022/23 season were estimated. The combined TAC for the 2022/23 season was 2,291 t and the estimated combined retained catch was 2,369 t.; the combined OFL was 3,761 t while the estimated total catch mortality was 2,612 t. Stock status with regards to overfishing will be determined in September based on final season-end values for retained catch and total catch mortality.

Previous CPT and SSC comments

Tyler addressed several previous CPT and SSC comments and requests. Because of Siddeek's retirement and handover to a new assessment author, some of these could not be completed in time for the meeting. These included: 1) justifying the time period for average recruitment based

on a plot of the variances of the recruitment deviation ("rec devs") parameters; 2) fitting a single-area model to the combined EAG and WAG data and providing diagnostics to compare with the area-specific models; 3) plots to illustrate the extent of variation in standardized CPUE among sub-areas (sub-area partial residuals plots, which the CPT found very informative, were presented as a first step toward a more extensive analysis); and 4) analysis to identify the data sources that preclude the EAG models from fitting the CPUE data very well. Requests that were completed included: fits to the three CPUE time series reported on different plots, and documentation in the SAFE report of the rationale for the year:(sub-)area interaction term in the CPUE index standardization. The CPT recognized the time lags associated with a transition between assessment authors and looks forward to Tyler bringing "new eyes" to this assessment.

Data

Tyler presented data on catch and "raw" CPUE trends. The CPT raised a question about a time series plot and table of TAC and harvest in the EAG in which total harvest exceeded the TAC in several years; Tyler explained that the apparent discrepancy was due to the inclusion of cost-recovery fisheries (not counted against the TAC) in the total harvest. Tyler also discussed the industry-cooperative pot survey conducted again this past year in the EAG. The survey has been conducted annually since 2016 (except 2020) within three sub-areas with equal numbers of grid cells. Sample locations are randomly selected within each sub-area and a string of pots is fished at each location. For each sample, CPUE and size compositions are available.

CPUE index standardization

Tyler discussed the two approaches to CPUE index standardization using a generalized linear model (GLM): one based on a year effect null model and one based on a year:block null model. Candidate terms entering into the models were month, vessel, captain, gear, soak time, and depth. In addition, the year effect model also included an area effect. Final models were selected based on AIC and R^2 criteria, while the degrees of freedom for the soak time and depth "smooth" terms were determined based on AIC. CPT discussion suggested that the models were essentially GAMs (generalized additive models) such that the degrees of freedom for the "smooth" terms were better evaluated using the "mgcv" R package. For the EAG, both standardization approaches yielded indices very similar to the raw CPUE data for the post-rationalized time period, as did the year:block model for the pre-rationalized time period, whereas the standardized index from the year model for the pre-rationalized time series had much less of a trend than was evident in the raw data. The standardization approaches yielded qualitatively similar results for the WAG, although the discrepancy between the raw data and the year:block model indices was not as large as for the EAG. A concern was raised, however, regarding a large discrepancy between the year:block model index and the post-rationalized raw CPUE data in 2009 for the WAG.

Tyler was not able to show plots of the "smooths", and CPT discussion focused on how "wiggly" the smooths had been in the past due to the number of degrees of freedom used and whether it was better or not to let the smooths "soak up" the noise. It was suggested that using mgcv would allow the author to appropriately reduce the number of degrees of freedom used in the smooths. The CPT found the partial residuals plots Tyler showed for the year:block models very informative and helpful.

Tyler also presented the standardized index for legal males that Siddeek developed from the cooperative survey CPUE data. He noted that Siddeek excluded data from small mesh pots and pots falling into the extreme quantiles of soak time and depth as unrepresentative of the survey in general, then he fit the remaining data using a random effects model with vessel/string nested within block (sub-area) as the random effects and year, captain, depth, and soak time as fixed effects (the latter two as smooths). Discussion focused on how this index was used in the subsequent alternative assessment models for the EAG. Tyler pointed out that these models were exploratory in nature, and that it involved simply replacing the fishery CPUE index over the 2015-2022 time frame. It was thus assumed to have the same selectivity and catchability as the remainder of the fishery index, which the CPT and Tyler agreed was unlikely given that the randomized nature of the sample locations in the survey would not be similar to the spatial pattern of the fishery. The CPT recommended that the correct way to incorporate the survey data into the EAG model was to include it as a separate fleet, with selectivity and catchability independent of the fishery indices. It also noted that the survey index had not been used in assessment models before, so the manner in which it was used was completely open to development by Tyler.

Assessment and alternative models

The assessment authors examined three model scenarios applied in common to both the EAG and WAG this assessment cycle. Model 22.9c was the 2022 assessment model, modified for comparison with the equivalent GMACS model and updated with 2022/23 data. Model 22.1e2 was the equivalent GMACS version. The two versions produced almost identical results. This model configuration included three catchability periods, knife-edge male maturity size at 116 mm CL, M set to 0.22 yr^{-1}, a fixed period (1987–2017) for reference point calculation, and the addition of new data for 2022/23. Model 22.1f was identical to 22.1e2 but was fit to CPUE data that included a year × block effect in the CPUE standardization procedure.

Two additional models for the EAG, Models 22.1g and 22.1h, were also examined: these were based on Models 22.1e and 22.1f (respectively) but with the 2015-2022 cooperative survey data substituted for the total catch CPUE. The CPT noted that the cooperative survey data should have been added to the model as an additional fleet, not simply replacing the existing total catch CPUE indices, because the latter approach assumes the same selectivity applies in the fishery and survey and that catchability is the same for the survey and commercial fleet.

For the EAG, the three "common" models provided very similar results. All three fit the retained catch, total catch, and groundfish bycatch data well, except that model 22.9c did not fit the retained catch data at the start of the time series. Otherwise, the three models fit the catch data almost identically. All three models also fit the standardized CPUE indices similarly, but the overall fits were poor. The fits to the retained catch and total catch size compositions were good, except for the smallest size bin for total catch prior to 2005/06, where the models substantially underestimated the relative abundance. This, however, was likely due to this bin acting as an accumulator for all crab smaller than the model size range, although the reasons why so many small crab should have been caught in this time period remained unknown. The CPT noted that, in any case, standard procedure would be to exclude crab smaller than the modeled size range from the size composition data but also cautioned that it might be necessary to drop the early data as suspect. CPT also noted that fitting these data may in part explain the large change in fishery selectivity between the pre- and post-rationalization periods.

For the WAG, all three models fit the respective catch data and standardized CPUE indices equally well and produced similar estimates for recruitment and MMB time series. The models followed the trends in standardized CPUE much better than was the case for the EAG model. However, the issue with the high relative abundances of small crab in the total catch size compositions was also evident in the data for the WAG.

The authors' preferred models were 22.1f for the WAG and 22.1e2 for the EAG, noting that a case could be made for including the year × block interaction term in the CPUE standardization for the WAG but not the EAG. The CPT noted several potential issues with the year × block standardization for the WAG, including a large spike in CPUE in 2009 in block 5 and apparent quantization in the associated partial residual plots for several other blocks. The consensus recommendation by the CPT was to use 22.1e2 for both areas.

The CPT recommends that this stock be managed as a Tier 3 stock in 2023/24. A single OFL and ABC is defined for the AIGKC stock as a whole. However, separate models are available for each area. During its May 2017 meeting the CPT recommended that stock status be determined by adding the area-specific estimates of current MMB and B_{MSY} to ensure that there would only be one stock status for the AIGKC stock. In contrast, area-specific stock status is used to determine the ratio of F_{OFL} to $F_{35\%}$ by area, which is then used to calculate the OFLs by area, which are then summed to calculate an OFL for the entire stock. The SSC has concurred with this approach. The CPT recommends that the B_{MSY} proxy for the Tier 3 harvest control rule be based on the average recruitment from 1987-2017, years for which recruitment estimates are relatively precise.

Selection of an ABC Buffer

This is the only crab assessment that relies solely on fishery CPUE as an index of abundance. The CPUE index standardization process, subject to past CPT and SSC review, is a key reason for the 25% buffer between the OFL and the ABC used in past years. Sources of uncertainty raised in recent assessments are summarized in the following table:

Source of Uncertainty	Year Expressed	CPT 2023 concern?	Reason
Only crab assessment that relies entirely on fishery CPUE as an index of abundance	2020	Yes	No change
Uncertainty in natural mortality	2020	Less	A revised estimate for natural mortality based on a peer-reviewed study (Siddeek et al., 2022) was used
The limited spatial coverage of the fishery with respect to the total stock distribution	2020	Yes	No change
The small number of vessels on which CPUE is based	2020	Yes	No change
Retrospective pattern for the EAG	2020	Yes	No change. Retrospective patterns were not presented, but assumed to be similar to those seen last year.
CPUE standardization is still subject to some methodological concerns	2020	Less	No change. Principal methodological concerns have been met, but some issues remain

Catches from the WAG that were not included in the assessment	2021	Less	Method to extrapolate retained and total catches to year end has been documented; CPT accepted the method used.
Model convergence concerns reflecting potential parameter confounding (jitter analysis resulted in multiple solutions for MMB and $B_{35\%}$ at same likelihood values)	2021	No, but…	A jitter analysis was not conducted for CPT-recommended models

The SSC adopted a 30% buffer for the ABC in 2021/22 based primarily on concerns raised by a jitter analysis that suggested the model may be converging to local minima, exhibiting multiple values for reference points associated with a single value for the likelihood. In 2022/23, the CPT recommended, and the SSC concurred with, reducing the buffer for the ABC back to 25%, its value before 2021/22, principally because no problems of this sort occurred for the 2022 recommended models, though no jitter analysis was performed, and the CPT found reasons to reduce or eliminate several other concerns. For 2023/24, the CPT found that several previously expressed concerns continued to exist, the principal one being the retrospective patterns for the recommended EAG model. Thus, the CPT recommends continuing to use a 25% buffer, its value last year, on the OFL for the ABC.

CPT recommendations

The CPT repeated the following recommendations from the previous year to the assessment authors:

- Continue work to obtain an index using the cooperative pot survey data for use in the EAG assessment model.
- Identify and eliminate the conflict between the model and the data giving rise to the retrospective patterns for EAG models.
    - Revisit the analysis considering a model with time-varying catchability, but impose a penalty on the devs to allow the index data to inform the model
- Plot observed vs. predicted values for fitted data to help diagnose misfits.
- Add confidence intervals to plots of fits to catch data (i.e., retained catch, total catch) reflecting assumed data uncertainty.
- Perform retrospective analyses for all models that have the potential to serve as the basis for calculating reference points.

- Calculate reference points using both combined-area and area-specific size-at-maturity values.
- Re-evaluate the time frame over which to calculate mean recruitment every year by, for example, using a plot of the variance in estimated recruitment deviations.

It also made the following new recommendations:

- Continue work to obtain an index using the cooperative pot survey data for use in the EAG assessment model.
- The cooperative survey should be fit as an additional CPUE index, not substituted for existing indices as was done for models 22.1g and 22.1h.
- Size-composition data should not include a "minus" group (i.e., crab smaller than the smallest size bin used in the model).
- The data used to determine the total catch size-compositions in the two areas should be re-examined to determine whether the abundances in the smallest size bin from 1990 to 2004 are correct.
- Explore models that provide better fits to EAG CPUE data.
- Use GAMs rather than GLMs to standardize the CPUE indices (e.g., use the R package "mgcv").
- Show both the original CV's and effective CV's (i.e., incorporating additional variance) when showing fits to the CPUE index time series.
- In the SAFE document
    - Add a note to explain that retained catch can exceed TAC in some years due to the cost recovery fishery associated with the cooperative survey.
    - Drop Appendix D.
    - Remove tier designation from area-specific management tables.
    - Add explanation for extrapolation of total catch in final year.

ABSC updates on climate resilient fisheries work

Jamie Goen from the Alaskan Bering Sea Crabbers (ABSC) presented a draft action plan for building resilient crab fisheries. There is a national focus on building climate resilient fisheries, and ABSC would like to see some of that effort shift from a discussion on climate change to actionable disaster planning, which would allow for a rapid response when fishery disasters occur. Jamie pointed to a U.S. climate resilience toolkit that could be expanded to include fisheries. The goal of a fisheries resilience toolkit would be to plan in advance for disasters, instead of reacting after the disaster has occurred. FEMA, for example, has disaster planning roadmaps already in place before a disaster occurs. A member of the NOAA Leadership Program (Aja Szumylo) was detailed to work with ABSC to develop a draft framework on crab fishery disaster planning.

Jamie flagged several items to consider when planning for fishery resilience, including finding ways to stabilize the fleet, creating opportunity, and looking to the future. Managers, scientists, and industry could play unique roles in addressing each of these issues. The overall goal would be to ensure that fishing businesses could weather a disaster and to find opportunities to keep skippers and crew employed. For example, to provide stability to the fleet, managers could create a roadmap of existing resources, including information about financial relief. Scientists could partner with industry on research, thus providing income for the vessels and crew and producing valuable research. Industry could gather information on the minimum ex-vessel value required to survive a disaster. To create opportunity, managers could consider the potential for vessels to diversify, so that if one fishery is in crisis, vessels would have additional opportunities elsewhere. Science agencies could invest in social scientist capacity. Industry could work as a fleet to coordinate and identify options available to them. When looking to the future, managers could build a framework to facilitate rapid responses to fishery declines. Scientists could look at research for crab enhancement and industry could work on carbon policy initiative programs.

Some of the hurdles for fleets trying to survive a fisheries disaster include the cost of diversifying, latent reduction efforts across fisheries, stringent regulations for catch share and limited access programs, a limited number of entry-level fisheries, and difficulty in developing new regulations quickly. A main concern is how to create stable fisheries while still allowing flexibility in case of a crisis.

ABSC is planning on further developing this initiative and is looking for feedback from the CPT on how this process could be used as a roadmap moving forward. CPT members asked if the crab fleet was able to move to other fisheries, would they be able to sustain themselves. Jamie stated that it varies greatly among vessels based on each vessel's margins and overall business plan. Some vessels already have other options available to them (for example, tendering or having licenses to participate in other fisheries such as the Pacific cod pot fishery). However, currently available options are not adequate for buffering stakeholders against the financial losses associated with the present crab fishery closures. The capacity of stakeholders to be resilient to the current crisis will also depend on the duration of the crisis. If the fisheries recover within a year, a large part of the fleet could survive, but if crab fisheries are depressed for many years current opportunities available to the fleet may not be enough to sustain them.

CPT members asked what kind of resilient management structure ABSC would have liked to have seen in place had the snow crab crash been predicted in advance. Jamie stated that it currently takes two to four years to receive fishery disaster relief funds and it would be helpful to redesign this process to provide more timely relief. In addition, the ability to put conservation efforts into effect quickly (such as closed areas) might facilitate a faster rebound of the stock. Even the current emergency rule process is slow and is only in effect temporarily. Developing regulations that allow for vessels to diversify would also be helpful.

The CPT discussed what the process should be to get these initiatives started. The ABSC plans on presenting this information to the Climate Change Taskforce (CCTF) and to organizations outside the Council process. For the Council to reiceve information on the initiatives, it was suggested that ABSC and collaborators continue to present at advisory bodies such as the CPT, the SSC workshop on climate change modeling, and the CCTF, and the Council will receive updates through the plan team reports, CCTF reports, and SSC reports.

Predicting fishery disasters is difficult and often these kinds there exists substantial uncertainty in the predictions. However, CPT members asked if there was some value in developing these predictions even though they often do not come to fruition. The current snow crab collapse was not predicted in any model. Jamie stated they would rather see some climate modeling effort shifted to developing quicker response plans for disasters instead.

Currently there is limited environmental information available, but if more information becomes available, it might be possible to make more accurate predictions. Collaboration between fisheries scientists and physical scientists would be beneficial in trying to understand the radical shifts currently occurring in the Bering Sea. Some CPT members suggested ABSC consider adding the need to collect data on oceanographic conditions and environmental drivers to their initiatives.

The CPT asked if anyone had ever assessed vulnerability across fleets. This kind of assessment might be useful to fully understand fleet diversity and identify fleets that are at higher risk during a fishery disaster. Better information from the fleet on what they are experiencing could be helpful. Some of this information might be available already in the Economic SAFE, but that information is summarized with a two year lag and is therefore unlikely to be helpful in decision-making. This kind of information may be valuable to include in the ESPs, which are used in management decision-making. The CPT highlighted the need to provide more up to date information through the Council process on fleet vulnerability to better inform climate resilient fisheries, and noted that it would be beneficial to better understand the economic impacts of crab closures. It was also noted that the ten-year review of the Crab Rationalization program is upcoming, and some of this information might be beneficial to include in this review, including a fleet vulnerability assessment. The CPT supports further effort on this initiative in the future.

Bering sea red crab stock structure template

Katie Palof (ADF&G) presented draft information for a stock structure template to explore or help understand connectivity across five Bering Sea red king crab (RKC) stocks: Bristol Bay (BBRKC), Pribilof Islands (PIRKC), Western Aleutians (WAIRKC), the Northern District, and Norton Sound (NSRKC). A stock structure template format has been established to guide decisions on lumping/splitting populations or stocks for assessment and management, and this presentation was on the initial application of this template to RKC stocks in response to a SSC request to the CPT. Many of the current stock delineations are based on historical fishing

grounds and convenient landmarks for setting boundaries. Grant and Chang (2012), using analysis of mitochondrial DNA, found three main groupings among Alaskan RKC stocks: (1) NSRKC and WAIRKC are isolated genetically, (2) BBRKC genetically groups with PIRKC and the Gulf of Alaska, and (3) Southeast Alaska is genetically independent. It was noted that Northern District RKC fall into the state's St. Matthew Island Management Area, but there has been no fishery in this area and data for assessing connectivity for that stock are lacking. It is not entirely clear what the overall objective of the SSC request is – are we looking at stock management units? We have non-genetic information such as size composition, growth, and recruitment pulses, and also an awareness of physical or oceanographic barriers, that can be compared to the history of spatial management units. Some tagging work is underway that may inform understanding of stock connectivity. The CPT noted that designated stock definitions allow for fishing mortality to differ among stocks, which provides a rationale for "splitting" stocks that is independent of biological considerations such as gene flow. However, it was noted that this consideration may not apply to NSRKC and WAIRKC, which appear to be distinct from the other stocks based on available genetics and growth data. Future analyses should perhaps focus on the southeast Bering Sea area, with a focus on survey data, a summary of tagging data around Bristol Bay, and the question of whether Northern District crab are part of the currently-defined BBRKC stock. Future work should also include increased genetic sampling within Bristol Bay, more in-depth consideration of oceanographic information, and potential larval flow. The CPT noted that RKC distributions may be changing due to climate change, and understanding current connectivity would be helpful in characterizing these changes. Katie hopes (1) to bring preliminary results to the SSC at the upcoming meeting to clarify whether questions have been answered and (2) have a final document available by September.

BBRKC - Proposed model runs for Sept

Katie Palof (ADF&G) presented proposed models from the Bristol Bay red king crab (BBRKC) stock assessment. The proposed models focused on responding to previous CPT and SSC comments, including changing the start date for the model and exploring rationale for priors on natural mortality (M) and survey catchability (Q). She also explored the impact of the retow data on estimated management quantities. The newest GMACS code was used and Katie noted some differences between the reference points when identical model parameterizations were run with this version and the previous version of GMACS, which Andre Punt suggested may be attributable to the number of years the stock is projected to 'equilibrium'. These differences require further inquiry.

Natural mortality has historically been pre-specified in the assessment at 0.18 yr^{-1} for males, based on an assumed maximum age of 25 and applying the 1% rule, with an offset estimated for females. Models were presented that handled M in several ways: Model 23.0 used a specified M = 0.257 yr^{-1} based on recently published meta-analyses (Then et al. 2015); Model 23.0a estimated a constant M for males within the model; and Model 23.0b used a specified M = 0.31

yr^{-1} based on previous likelihood profile work. Differences in *M* resulted in sometimes large follow-on effects to estimates of recruitment, selectivity, and resulting management quantities. Higher target fishing mortality rates were estimated with higher natural mortality, mirroring concerns seen in snow crab about the usefulness of $F_{35\%}$ for crab. The CPT recommended using the natural mortality calculator from the Barefoot Ecologist website (barefootecologist.com.au) for a prior on *M* and citing Hamel and Cope (2022) for the methodology.

Retows of selected Bristol Bay stations on the NMFS survey have historically been conducted in years when a threshold proportion of mature females have not completed the mate-molt at the time of sampling on leg 1 of the survey. The goals of these retows are to: 1) provide sufficient post-molt data to provide a good estimate of female size composition; 2) to more accurately assess the abundance of mature females, which tend to be in inshore areas outside the survey grid prior to completion of molt/mate; and 3) to accurately estimate the proportion of post-molt barren mature females in the population as an approach for assessing any evidence of male limitation. . Retows have occurred in eleven years since 1999. Model 23.2 removed the retow data and used the regular (pre-retow) data from leg 1 of the survey in the calculation of the survey index of biomass for females to test the impact of retow data on model biomass estimates. Removing the retow data results in a markedly lower trajectory of female biomass, which suggests that retows are an important component of the assessment when the molt/mate cycle is delayed. However, the author pointed out that in years when retows were triggered by The CPT concurred with the author's opinion.

Ultimately, the author recommended bringing forward the based model (21.1b), Model 23.0a (or another similar model with an updated prior from Hamel and Cope, 2022), Model 22.0, and a simple tier 4 calculation of the OFL. The CPT agreed with the authors' recommendations.

The CPT agreed with the author's approach of bringing forward a smaller document for the May meeting that directly describes the explorations undertaken and removes the background material that is presented in September. CPT noted that confidence intervals for the estimated MMB and parameter names on the tables would be useful. A figure of the implied NMFS selectivity from the BSFRF data with sample sizes may facilitate thinking about how to best use those data. Suggested future directions for model explorations include:

- reconsidering which growth parameters are estimated vs. specified,
- specifying all growth parameters outside of the model,
- a more thorough consideration of how to estimate survey catchability from the BSFRF data without the strong prior on catchability that has been historically used,
- reconsider the shape of the survey selectivity curve,
- revisit the blocking on the molting probability estimated from the tagging data.

Unobserved mortality discussion next steps

Sarah Rheinsmith (NPFMC) led a discussion about the next steps for addressing unobserved fishing mortality after presenting background context for the motivation behind making progress on this issue. Craig Rose presented his work in estimating crab injury and mortality from trawl encounters during the May 2022 CPT meeting. The SSC recommended the formation of a working group "to develop a framework for how to estimate the magnitude of unobserved mortality for crab stocks and how these estimations may be utilized in BSAI crab stock assessments" at the October 2022 Council meeting, and the Council subsequently supported this recommendation in December 2022. The CPT discussed the utility of a working group versus a workshop, the notable difference between the two being that a working group would not need to be public, and membership is constrained to include only agency staff thereby restricting inclusion of expertise outside of agencies and stakeholder input. Workshop participation could be more broadly inclusive, would be public, but would likely be limited in temporal duration (i.e., a one-time event). The CPT agreed about the utility of a working group and noted a possible strategy of a working group for continued effort to promote long-term work towards this topic but to include one or more workshops to allow inclusion of a broad range of perspectives. Scott Goodman noted that the Bering Sea Fisheries Research Foundation (BSFRF) has initiated some work to look at improving estimation of unobserved mortality for crab stocks and endorsed the formation of a working group to further examine pathways for advancing unobserved mortality estimates.

Sarah solicited feedback from the CPT about how to identify research priorities to inform estimation of unobserved fishing mortality and the associated timeline for incorporation into assessments. The CPT discussed whether the sole objective was to incorporate estimates into assessments, or if there are additional objectives for the working group. A point was made that the objectives for the working group versus workshop(s) would be related but could differ. The CPT members highlighted that a better understanding of unobserved mortality is useful for informing conservation measures even if not included in stock assessments directly. It was mentioned that part of the working group could identify the priority gear types relevant to unobserved mortality. Two objectives for the working group would likely be focused on examining current information relative to crab stocks and to recommend future research. The CPT noted the existing fishing effects model could be the base for developing additional information with the end goal of partitioning unobserved mortality estimates by crab stock and by year. New research projects would need to identify how to incorporate new information into the existing stock assessment models. Some work by assessment authors has been done but there is room to improve estimation methods. Mike Litzow mentioned that there is research planned for 2024 to refine fishing effects model output by crab stock and stock management boundaries. It was noted that examining fishing effects relative to location of crab and molt timing would be important.

Initial discussion by the CPT proposed a working group meeting with inter-agency members, followed by a workshop to aid in incorporating additional information from stakeholders that may be beneficial in moving forward with estimates for unobserved mortality. There was discussion about expertise to consider for the working group and workshop membership, such as NOAA and ADF&G staff, Craig Rose, Noel Yochum, NOAA Alaska Regional Office staff, authors of the fishing effects model, members of the essential fish habitat (EFH) group, BSFRF staff, research members with expertise in the Bycatch Reduction Engineering Program (BREP) group, and other private interest groups. The working group timeline should be considered so that information can be acquired as soon as possible, recognizing longer term progress will also be needed. A tentative timeline for the first working group time would likely be early 2024.

Catch accounting updates - EM

At CPT request, Krista Milani (AKRO) gave a presentation with Josh Keaton (AKRO) and Mike Vechter (AFSC) on the federal electronic monitoring program (EM), the proportion of different fleets moving to EM, and the catch estimations for crab resulting from this alternate observer program.

The EM deployment on pelagic trawl pollock vessels began in 2020 and is expected to be fully implemented by 2025. Video cameras must remain on at all times and discarding of most species, including crab, is prohibited, except for jellyfish and large animals (e.g. sharks). Vessels are required to record discards in the vessel's logbook. All video is reviewed for catch handling. On-shore observers monitor offloads and take random samples of the catch. If present, crab bycatch is weighed and counted at the offload by the processor receiving the delivery. Currently these data are being used for prohibited species catch accounting and should be available for integration into stock assessment by 2025. Overall, few crab are seen in pelagic trawl offloads.

Use of EM on vessels with hook-and-line (longline) and pot gear began in 2018 and is an option for vessels greater than or equal to 40 feet in overall length (partial coverage). Cameras must be on for selected trips only and not all video footage is reviewed. Implementation is limited due to funding constraints. Vessels are permitted to discard as normal, and all crab and other prohibited species must be discarded. Hook-and-line and pot gear EM video is reviewed to identify discards, but crab can be difficult to identify to species and therefore are not counted towards any stock removals.

During EM video review, reviewers select the haul to "sample", which includes recording the identification, number, and fate of all organisms. The goals for reviewers are 1 in 3 pots for single pot gear, 1/3 of all sets for longlined pots, 2/3 of all hook-and-line sets,. Video is also evaluated for compliance with the vessel monitoring plan. Currently, the estimation process for EM hook-and-line and pot gear uses at-sea EM data to derive discard rates in time and space to the extent possible to the fishing trip. Discard rates are then applied to total groundfish retained. Discard rates and estimated number of crab are specific to crab stock area. Crab weights are not

estimated by the EM reviewer or the EM software and are instead sourced from other observer-collected data from the previous year. Haul-level EM accounting is employed when available but for unidentified crab, the catch estimate is zero and that zero rate is applied to all EM trips.

The EM program for fixed gear vessels faces some challenges. Most vessels fishing hook-and-line (greater than or equal to 40 feet in overall length) are catcher processors and are monitored by on-board observers while most pot gear vessels are not monitored by EM or on-board observers. There is a significant lag in EM data since it is currently taking about six months to review the EM video after it is mailed in by the vessel, so the data are not available for inseason management decisions. As stated earlier, EM reviewers can count crab but are often unable to identify them to species. All crab seen in EM video review are consequently treated as unidentified with all crab bycatch coming from sablefish and halibut hook-and-line vessels and all crab bycatch on pot vessels coming from Pacific cod trips. Crab that are not identified to species are not easily accessible in the catch accounting program nor accounted for in stock assessments.

Upcoming work for crab accounting is focused on reconciling differences between prohibited species accounting and bycatch estimates used in stock assessments. Implementation of the Pacific cod trawl rationalization program will result in full coverage on all BSAI trawl vessels and vessel-specific estimates for quota monitoring. For hook-and-line and pot groundfish fisheries, upcoming work will include incorporating a stock-area component into prohibited species estimates, evaluation of partial coverage stratification definitions, and developing methodology for identifying crab species on EM video.

Snow crab - Proposed model runs for Sept, GMACS

Cody Szuwalski (AFSC) noted that the assessment of eastern Bering Sea (EBS) snow crab has experienced several difficulties in recent years, including convergence problems, bimodality in management quantities, unrealistically high target fishing mortality rates, large retrospective patterns, and difficulties finding the most appropriate way to model survey selectivity and population processes such as natural mortality. He noted that estimates of the target fishing mortality of $F_{35\%}$ from the *status-quo* model implied that most commercially-vulnerable male crab should be harvested each year. The March 2023 crab simpler modeling workshop recommended that alternative reference points for EBS snow crab such as an F_{MSY} proxy equal to natural mortality (M) should be considered (implying EBS snow crab would be assessed under Tier 4).

Cody compared five models: (a) the *status-quo* model (the GMACS model used for the 2022 assessment), (b) a bespoke “research” model that allowed for time-variation in natural mortality and in the probability of maturing, (c) two GMACS-based “bridging models“ based on the

status-quo model that included some desirable features from the research model, and (d) a Tier 4-like model in which the assessment was based on a survey index and the assumption that the proxy for F_{MSY} is M. The research models were presented as the first steps to finding a more robust approach to providing management advice for EBS snow crab based on a "letting the biology drive the model formulation" and not being constrained by past model formulations. A summary of the *status-quo*, "research" and one of the "bridging" models is:

	Status quo	**Research model**	**Bridge**
Sex	Male + female	Male	Male + female
Maturity	Single estimated ogive	Input as yearly data	Input as yearly data
BSFRF.data	Treated as an additional survey with estimated availability	Treated as prior on survey selectivity	Treated as prior on survey selectivity
Survey.sel.	Logistic by sex (1982-1988; 1989-present	Non-parametric	Non-parametric; shared by sex 1982-present
Growth	Linear estimated	Linear specified	Linear estimated
Natural.M	Immature + Mature by sex; offset in 2018 and 2019	Immature + Mature; time- varying	Immature + Mature by sex; offset in 2018 and 2019

The research model captured the dynamics of the data sources included in the analysis well and produced reasonable estimates of population processes with more conservative retrospective catch advice than the *status quo* model when using M as a proxy for F_{MSY}. It was simulation tested and found to be able to estimate time-variation in natural mortality. However, it needs additional tuning and ultimately the goal is to use GMACS for the assessment.

The bridging models also fitted the data well. However, the estimates of historical fishing mortality were very high for some years, and the version of the bridging model with time-varying natural mortality needed more work before it could be used for management purposes. It thus proved infeasible to include some desirable features (e.g., a time-varying probability of having terminally molted and BSFRF priors on survey selectivity) in the

status-quo model. The variant of the bridging model provided to the CPT has a lesser retrospective pattern than the *status-quo* model.

Cody identified several key questions related to next steps for the assessment:

- How should the reference period for annually varying biological processes (e.g., probability of terminally molting or natural mortality) be selected?
- Should natural mortality vary annually or should only large mortality events be modeled?
- How should the estimated parameters be chosen?
- How to define B_{MSY} when using Tier 4?
- How should the early survey period (1982-1988) be treated?
- What data should be fit?
- What is the relative confidence in each data set available for snow crab and how does this relate to data weighting schemes and the estimation of parameters inside or outside of the model?

The CPT noted that allowing the probability of maturing to be time-varying was realistic, and expected given that the animals in a size-class may represent multiple cohorts. It was agreed that the time-dependent probability of maturing should be pre-specified in future bridging models, but this implied that the survey selectivity needs to be more flexible than the current logistic formulation. Cody noted that the probability of maturing was set to the average over time for years in which data are not available, but that some model formulations (results not shown) explored setting the probability of maturing in years with missing data to an average of years close in time.

The CPT supported using the BSFRF data in the assessment in the form of a prior on survey selectivity, but noted that various approaches existed in terms of how to include these data in the assessment, e.g., as done by the author, using a jacknife procedure to quantify uncertainty and hence weight the data, and how these data are used to compute year-specific survey selectivity curves in the assessment of Tanner crab.

The CPT congratulated Cody on his exploration of alternative models, which while not final, has highlighted several areas for future work. Three models were identified for possible adoption in September 2023:

- The *status-quo* model.
- A bridging model in which natural mortality is time-invariant except for 2018 and 2019, the proportion maturating is pre-specified by year, and survey selectivity is non-parametric and estimated within the assessment.
- A Tier 4 analysis based on the suggestion of the SSC, with B_{MSY} defined as the average biomass from 1984.

Note that the second of these models may not converge based on preliminary results to date, and this model will only be considered for adoption in September if convergence is possible.

The CPT highlighted that creating a Tier 4 based on the current assessment of EBS snow crab needs to occur carefully because the original formulation of the Tier 4 approach involved applying a fishing mortality of gM to MMB and not to exploitable biomass.

The CPT identified some additional areas for future work (but not possible adoption in September 2023). These areas aim to model EBS snow crab more simply, but provide the information needed for management decision making.

- A (simple) model that considers only males and ignores groundfish bycatch should minimize conflicts caused by trying to fit the data for females and bycatch.
- A model that includes males and females (but not groundfish bycatch), which estimates selectivity and recruitment by sex, but with a penalty of how much recruitment can vary between the sexes. This is a variant of model #1, which includes females but is parametrized to minimize the possibility of misfits to the data for females impacting the results for males (i.e., no strong linkage between males and females).
- Models in which growth (or at least the mean relationship between growth increment and pre-molt size) is pre-specified.
- A model that drops the survey size-composition for 1982-88 given the poor fits to these data.

Tanner crab - Proposed model runs for Sept

William (“Buck”) Stockhausen (AFSC- Seattle) presented model explorations and proposed model runs for Tanner crab for the 2023 assessment. He presented both Tier 3 model explorations and a Tier 4 option recommended from the simpler modeling workshop (March 2023). Buck presented updates to the base (last accepted) model that included updating to the newest version of ADMB and pre-specifying a parameter that was hitting bounds. Both of these updates had minimal impacts on the assessment outputs and model 22.03b is essentially the same as 22.03 (2022 accepted model). The CPT agreed that this version – model 22.03b – would be acceptable as the base model moving forward.

Model explorations centered around three branches: one that explored 1-mm size bins for the population length structure (two models: the 23.01x series), one that explored fitting to survey estimates based on VAST and time varying *M* (model 23.02 and four models: the 23.05x series), and one that explored fixed growth and fixed selectivity (both estimated outside the model; four models: the 23.03x series). The first branch explored 1-mm size bins, which would potentially better capture growth and the probability of terminal molt. The second branch explored fitting to VAST estimates of survey biomass and also added an annually varying *M*. The third branch

pre-specified growth from analysis outside the model, which was a suggestion of the simpler modeling workshop. These models then used the BSFRF survey information on selectivity to pre-specify selectivity in the model variants to either a dome shaped function, as suggested by the BSFRF survey data, or one that had an asymptotic shape.

Models 23.01 and 23.01a, had similar but slightly worse fits than the base model but had a substantial increase in the number of parameters. These models were not seen as viable candidates moving forward.

Model 23.02 is not directly comparable to the base model due to differences in survey data. However, NMFS survey biomass estimates fit better but at the cost of poorer fits to the size-composition and other data sources. There were also convergence issues with this model, with most of the jitter runs not converging to the apparent MLE. Investigation of model output identified high *F* values which were not supported by the data, either for some early years in the directed fishery or the last year of bycatch in the BBRKC fishery. The CPT suggested that this model might not be converging to the MLE, but rather a local minimum and encouraged the author to explore this model for September 2023 if these issues could be resolved.

Models in the 23.05 branch generally were improvements to the 23.02 survey fits and size compositions. However these still had convergence issues in the jittering runs unless smoothers were implemented to the annual *M* estimates. The CPT suggested that time-varying *M* might benefit from being paired with pre-specified growth for future model explorations. These model runs were informative in understanding the variability on an annual basis that was being explained through *M* estimates, but were not considered to be viable candidates for model specifications in the fall.

Models in the third branch – 23.03x – generally fit worse than the base model, with some runs having both convergence issues in the jittering runs and some parameters hitting bounds. None of these models appeared to be improvements over the base model.

The CPT commends the author for the large amount of exploration and work done on model runs and recommends that the author bring forward model 22.03b as the base model for specifications in the fall. While the CPT agreed with the author that model 23.02 was potentially a good alternative model, it still needs development with both convergence issues and parameters hitting bounds. The CPT encourages the author to bring forward work on model 23.02 in the fall but cautions that the CPT will be hesitant to use a model that has not been vetted at our May meeting for setting specifications. The CPT also agrees with the author on the direction of future work which includes continuing to develop models with annually-varying M and obtaining the 2018 BSFRF data to complete the SBS study analysis. Additional work on using the BSFRF data as a prior on selectivity or to estimate selectivity was discussed as a potential topic for the January modeling workshop since all three Tier 3 assessments use the data in some way and the sharing of methods between the assessments may be helpful.

Buck explored a detailed approach to a Tier 4 model exploration, which involved building a simple model, yet one that was more complex than decided upon at the simpler modeling workshop. The CPT commended the author on his efforts but cautioned against such a complex Tier 4 model as a "fallback" option to the current Tier 3 model. The CPT encouraged the author to bring forward in September the Tier 4 option that was decided upon at the simpler modeling workshop. This involved using smoothing of the area-swept MMB estimates and applying $F = M$ for OFL determination. There was discussion upon which set of years to use for setting status determination using this method, and CPT members suggested reviewing the last accepted Tier 4 model – i.e., before the Tier 3 model was accepted – for reasoning as to the years that were used for status determination at that time.

GMACS updates

Katie Palof provided a brief update on GMACS progress since the January CPT meeting. She noted that ADF&G users have a running list of needed adjustments that should be made to the GMACS development version. It was noted that such lists should be noted as an 'issue' on GitHub so they get incorporated into the work plan. The current postdoctoral scholar working on GMACS development (Dr. Mattheiu Veron, UW) finishes in June 2023, and there is currently not a plan for a new post doctoral scholar to take over. The next step is for Mattheiu to publish the manuscript and then make the GitHub repository public. From there, it remains unclear where GMACS should be housed and maintained. Andre Punt noted that an agency-managed repository would be a more appropriate place than an academia-managed repository. Cody Szuwalski suggested that NMFS's Fisheries Integrated Modeling System may provide a suitable framework to house the GMACS for future maintenance and development. Norton Sound red king crab is the next stock for development of a GMACS-based assessment, and will be revisited at the September CPT meeting.

BSFRF update

Scott Goodman gave a brief update on Bering Sea Fishery Research Foundation (BSFRF) ongoing research projects and recent efforts to secure funding. Scott announced the addition of Dr. Tim Loher to BSFRF's panel of science advisors, and noted the recent improvement in the foundation's budgetary status. In contrast to the typical $1 million annual research budget, new funds in reserve from 2022 were limited to $125,000 and planned research expenditures for 2023 were limited to $40,000 with minimal expectations for proceeds from 2023 crab fisheries. However, several new sources have provided substantial funding coming on-line later in 2023, including congressionally designated funding, NPRB, disaster relief research funds, and several others. Budget and research planning given the new resources is currently ongoing.

Scott gave an overview of ongoing research projects, and presented preliminary results from BSFRF's recently completed Collaborative Pot Sampling Project (CPS1), which he noted is the

first pot sampling of BBRKC during winter/spring; previous efforts, including those pre-dating the NMFS summer survey, all used trawl gear. This effort was quickly organized and executed, funded almost entirely by NMFS and ADFG. BSFRF provided two vessels on 25 day charters, conducting pot sampling and tag deployment. Scott noted that development of the project began in December 2022, and the survey was executed in March, with excellent coordination between vessels (F/V Silver Spray and F/V Summer Bay) and onboard science teams. Scott announced the public distribution of data produced from the survey via Github and reviewed the data use guidance provided to users, including the difference in survey pot gear configuration used compared to the commercial fishery such that survey CPUE is relatively, but not directly, comparable to that of the commercial fishery.

Scott reviewed preliminary results of temperature readings, bathymetry, and savings area boundaries overlaid with sampling data, including number of pot lifts, RKC catch and CPUE by size and sex, bycatch of other crab and fish species, and number of tags placed. It was noted that pop-up tags deployed (which will release in early June) will not support updating of RKC growth estimates. Across size/sex classes, results indicate presence of RKC to be highest in the central, north and east portions of the survey area, including in the savings area, with minimal catch in the southwest portion of the survey area. Preliminary analysis indicates that temperature and latitude are important predictors of RKC survey results across size and sex groups, and with public distribution of the survey data, Scott expects further analyses to emerge. Scott noted that CPS1 was a successful pilot and emphasized the intent to continue the CPS effort in future iterations, noting that most elements of the study design are suitable to maintaining consistency in sampling methods, while changing the timing of the survey could be considered and could enable improved catch, particularly of mature females which may avoid entering pots during this stage of the breeding cycle.

New Business

September agenda items:

- Summer trawl survey results
- 2022/23 fishery summary (directed and bycatch)
- Ecosystem status report
- Economic status of the fisheries (T)
- ESP report cards for BBRKC / snow
- Final SAFE:
    - BBRKC
    - Snow
    - Tanner
    - PIBKC
- Proposed model runs - NSRKC
- Overfishing updates: WAIRKC, PIRKC, AIGKC

- January modeling workshop planning
- Spatial snow crab MSE (Cody)

Upcoming meetings:
Sept 2023 (9/11-9/15 (T) - AFSC Seattle, WA)
Jan 2024 (1/08-1/12) (Anchorage?)
May 2024 5/13 to 5/17 (T) (Location TBD)

Note:
Potential for a January 2024 interagency meeting