C1 BSAI Crab

The SSC received a report on the September 2024 Crab Plan Team (CPT) meeting from Anita Kroska (NPFMC), Diana Stram (NPFMC), and the CPT co-chairs, Mike Litzow (NOAA-AFSC) and Katie Palof (ADF&G). The SSC appreciates the CPT's efforts to streamline their presentation to the SSC. Not all CPT agenda items were presented to the SSC, though they were detailed in the CPT report. Items on which the SSC provided comments are below.

General Crab Comments

The SSC suggests the following guidance for constructing and interpreting jitter analyses.

1) In a good jitter analysis, many models should fail to converge to the maximum likelihood estimates (MLE), which is indicative of exploring a broad region of the parameter space; conversely, if all models return to the MLE, the analysis was not a strong test. All those that do converge have to be at the MLE being used as the base, as there would never be a better solution than at the MLE. This is a one-sided test that doesn't indicate the model converged, only that a better solution was not found than the one reported.

2) The results of models that fail to return to the best solution (the MLE) are not useful for statistical inference; restarting those models from the local minima in which they stopped with a perfect solving algorithm would always return to the MLE, and so the results are an artifact of imperfect diagnostic tools.

3) Uncertainty in management quantities (e.g. small changes in the likelihood can correspond to large changes in biomass) is best expressed with likelihood profiles on key model scaling quantities, not unconverged model results.

The SSC would like to see additional residual diagnostics other than raw residuals for length composition data from GMACS models. The SSC encourages crab authors to collaborate with groundfish assessment authors regarding the use of One-Step-Ahead and Pearson residuals.

The SSC requests that the CPT consider whether distinguishing between full and update assessments, as in the protocol recently adopted for groundfish assessments, would be useful for crab assessments. Flagging an assessment as an update when the model from the previous assessment is carried forward with no or minor modification would reduce the effort required of the author, and potentially lead to efficiencies in CPT and SSC review.

The SSC suggests the CPT live link assessments and other documents in their report to facilitate review.

The SSC reiterates their request from previous reports, including the October 2023 SSC Report, that the CPT develop a process for ensuring that authors have provided a response to all previous (including at least, the last assessment) SSC recommendations, even those for which no work has been completed, so these requests can be more easily tracked over time.

Ecosystem Status Report Preview

The SSC received presentations by Elizabeth Siddon (NOAA-AFSC), Bridget Ferriss (NOAA-AFSC), and Ivonne Ortiz (University of Washington) previewing the Ecosystem Status Reports (ESR) for the Eastern Bering Sea (EBS), the Gulf of Alaska (GOA) and the Aleutian Islands (AI). The SSC appreciates the authors and contributors providing near real-time data that are within months to days of collection. This is only

possible because of the dedication of the ESR team, the rapport they have fostered with data contributors, and the value placed on this information by all involved in the Council process. Presenters provided an overview of the Alaska-wide climate, showing a transition from El Niño conditions in early 2024 to anticipated La Niña in late fall, with projected near normal sea surface temperatures through March 2025 in all regions, except for cool temperatures in the eastern GOA and warm temperatures in the Western Aleutian Islands. The GOA had only a moderate response to the relatively strong El Niño, and there are no concerns for groundfish or their prey at this time. One concern requiring further investigation was that pink salmon had unexpectedly low returns. The SSC recommended investigating potential competitive interactions associated with changes in pink salmon abundance, in addition to potential bottom-up effects on upper trophic levels. The SSC also notes the importance of considering biomass in addition to numbers when evaluating the potential effects of the salmon populations on other ecosystem components.

For the AI, last winter was one of the ten warmest on record, but eventually cooled to the long-term mean, except for the western AI. Crab-relevant indicators in the AI show bottom temperatures near the long-term mean and no increases in crab predators - only a 2% increase in Pacific cod biomass and the continued high abundance of rockfish is of little concern as they are not known predators of king crab.

For the EBS, specific to crab stocks, it was noted that oceanographic conditions of sea surface temperature, ice, and cold pool extent were near the long-term averages with no red flags, suggesting good conditions for both pelagic and benthic life stages of crab. There was positive news from most climate indicators, including rare occurrences of marine heatwaves during the past three years. However, it is important to note that conditions reflect cool conditions near long-term means, not cold conditions by historical standards. For example, SSTs during the past ten years have been unlike any prior period, and the cold pool extent continues a ten-year trend of remaining at or below the long-term mean. Another consistent pattern is warm fall conditions with continued late formation of sea ice, even though ice might reach average extent later in winter. The SSC noted that continuing declining pH levels have become an indicator more closely watched, even though current levels are not considered to impact crab populations.

The Bering Sea cold pool is broadly defined as bottom temperatures < 2°C; however, there were references to other cold pool temperatures with respect to juvenile snow crab in the ESP. The Groundfish Assessment Program calculates cold pool temperature proportions at 1°C intervals between 2°C and -2°C. The SSC recommends evaluating whether there is a benefit to quantifying specific temperature ranges within the broad definition of the cold pool when assessing conditions for different size-classes or species of crabs. The SSC also requests that when physical data from a model output (e.g., ROMS) are first used that comparisons with available in situ data be provided (spatially if relevant) to assess potential biases.

As anticipated and discussed at the October 2023 SSC meeting, although many physical indicators have returned to baseline and many biological responses are favorable, there are exceptions. For example, large copepod biomass in the fall has remained low following the heatwave years, chlorophyll-a is still below the long-term mean in some regions, and some fish condition metrics remain low, despite cooling in recent years. The SSC appreciates the ESR team's continued efforts to explore new ways to visualize data, make data available and discoverable, and consolidate data in more integrated ways. For example, the new wind, ice, and temperature integrated maps of the Alaska-wide climate overview are particularly informative.

Trawl Survey Updates

The SSC received a presentation on the 2024 EBS bottom trawl survey results relevant to BSAI crab from Mike Litzow (NOAA-AFSC, CPT co-chair). **The SSC continues to be impressed with the rapid turnaround of the survey data and commends the crab assessment authors for updating model runs and assessment documents on the short timeframe necessitated by the survey and management timing.** There was oral testimony from Scott Goodman (Bering Sea Fisheries Research Foundation; BSFRF).

The SSC notes that in addition to the standard survey, the bottom trawl survey is also comparing slope/shelf gear as a part of the ongoing survey modernization efforts. These efforts required dropping corner stations around the Pribilofs and St. Matthew Island as well as dropping the northern Bering Sea portion of the survey, which has impacted assessments. In addition, AFSC and ADF&G survey and assessment staff decided that the reproductive status of the female BBRKC did not warrant a retow of Bristol Bay stations. The SSC commends AFSC survey staff for completing the bottom trawl survey in 2024, in addition to the fieldwork to increase efficiency and modernize the bottom trawl surveys. The SSC appreciates the AFSC efforts to update survey methods and design through their modernization efforts and looks forward to continued progress on this front. The survey modernization effort is discussed further under the SSC comments for B4 AFSC agenda item.

Survey results continue to vary among stocks. The mature male abundance of Bristol Bay red king crab (BBRKC) increased compared to 2023, but mature females did not change relative to 2023 (noting that both are within the confidence bounds). Overall abundance of this stock remains depressed relative to the long term mean. Pribilof Island red king crab (PIRKC) and St. Matthew blue king crab (SMBKC) mature males and females decreased relative to 2023. It was suggested during the CPT presentation that it is likely the result of lower sampling density due to corner stations being dropped. For the first time, no Pribilof Island blue king crab (PIBKC) were captured on the 2024 survey. The CPT noted this did not have an impact on the stock's rebuilding status.

The SSC was encouraged by positive trends in survey results for snow crab. Though overall abundance in some size-sex categories are still relatively low, snow crab abundance increased across all population components. In particular, the SSC highlights the large increases in small and legal males, and in both immature and mature females. The SSC requests consideration of the mechanisms behind such a remarkable increase in abundance of the large size class of immature crab not previously observed in the time series and potential relationships to water temperatures during hatching. Unusually, high density areas of snow crab were observed further south and closer to the longer term mean distribution than in recent years. The SSC requested that the survey authors consider the apparent lack of small snow crab in Pacific cod stomachs as presented in the ESR, despite high abundances of small snow crab.

Finally, Tanner crab also increased in 2024 in both management areas, with the abundance of total females in 2024 being the highest on record. Importantly, the survey is observing increased survival and growth to larger sizes, alleviating some of the concerns regarding previous cohorts that disappeared prior to recruiting to the fishery. The SSC recommends the development of maps and tracking indices of spatial overlap between Tanner crab and snow crab, as well as for hybrid crab.

With the continued depressed state of most crab stocks, the SSC continues to register concern for loss of data collection supporting the assessment of BSAI crab stocks. The loss of the survey corner stations requires additional consideration if this change becomes permanent. As mentioned during the CPT presentation, this might include survey modernization exercises, where they could be accounted for in changes to the survey design, but also could include exploration of model-based approaches that could account for changes in the survey footprint over time and comparisons of alternative design-based estimates over time. The SSC notes that these various approaches are already under consideration by the survey team and the CPT. Finally, the SSC notes the survey results were presented from 1988 forward; however, some crab assessments include survey data prior to 1988. The SSC requests that the survey authors provide a clear overview of the survey's historical standardization with years used by any of the stock assessments.

BSAI Crab Harvest Specifications and SAFEs

Table 1 includes the stock status determination criteria and Table 2 includes the October 2024 SSC recommendations. The SSC endorsed the OFL and ABC recommendations of the CPT, with the exception of EBS snow crab (Table 2).

Table 1. Stock status in relation to status determination criteria for 2023/24 as estimated by the most recent assessment. Hatched areas indicate parameters not applicable for that tier. Values are in thousands of metric tons (kt). Status determination recommendations made by the SSC are based on the best scientific information available and final status determination will be made by NMFS Headquarters following SAFE review.

Ch.	Stock	Tier	MSST[1]	B_{MSY} or B_{MSY} proxy[1]	2023/24[2] MMB	2023/24 MMB/ MMB_{MSY}	2023/24 OFL	2023/24 Total Catch	Rebuilding Status
1	EBS snow crab	3	95.9	191.81	106.52	0.56	15.44	0.07	
2	BB red king crab	3	9.35	18.69	18.65	1.00	4.42	1.34	
3	EBS Tanner crab	3	20.00	40.01	88.21	2.20	36.20	1.09	
4	Pribilof Islands red king crab	4	0.85	1.71	3.88	2.27	0.685	0.004	
5	Pribilof Islands blue king crab	4	2.10	4.20	0.181	0.043	0.00116	0.001	**overfished**
6	St. Matthew Island blue king crab	4	1.48	2.93	1.41	0.48	0.066	0.005	**overfished**
7	Norton Sound red king crab	4	0.99[3]	1.98[3,4]	2.40	1.19	0.31	0.20	
8	AI golden king crab	3	5.77	11.54	12.72	1.10	4.18	2.76	
9	Pribilof Islands golden king crab[2]	5					0.114	Conf	
10	Western AI red king crab	5					0.056	0.001	

[1] MMB on 2/1/2023 for Norton Sound red king crab as estimated in the 2023 assessment and on 2/15/2024 for all other Tier 1-4 stocks using the 2024 assessments (this footnote is corrected from February 2024 and draft June 2024 SSC reports).

[2] PIGKC specifications are set on a calendar year basis.

[3] Values are corrected from February 2024 and/or draft June 2024 SSC reports.

[4] B_{MSY} proxy basis years for NSRKC are 1980 - 2023.

Table 2. SSC recommendations for Eastern Bering Sea crab stocks. Stocks for which specifications are rolled over between assessments (Pribilof Islands red king crab, Pribilof Islands blue king crab, Pribilof Islands golden king crab and Western Aleutian Islands red king crab) or were set in February (Norton Sound red king crab) are also included. Biomass values are in thousand metric tons (kt). Tier designations in this table are based on the projected stock status in 2024/2025. Stocks for which the SSC recommended different harvest specifications from the CPT are bolded. Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle). Chapter 7 was set in February 2024.

Ch.	Stock	Tier	F_{OFL}	B_{MSY} or B_{MSY} proxy	B_{MSY} basis years[1]	2024/2025[2] MMB	2024/25 MMB / B_{MSY}	Natural Mortality (M)	2024/25 OFL	2024/25 ABC	ABC Buffer
1	E. Bering Sea snow crab	3b	25.07	191.81	1984-2023	96.77	0.50	0.28	**19.6**	**6.86**	**65%**
2	Bristol Bay red king crab	3b	0.33	18.69	1984-2023	15.43	0.83	0.23	5.02	4.02	20%
3	E. Bering Sea Tanner crab	3a	1.23	40.01	1982-2023	56.06	1.40	0.23	41.29	33.03	20%
4	Pribilof Is. red king crab	4a	0.21	1.709	2000-2021	3.879	2.27	0.21	0.685	0.51	25%
5	Pribilof Is. blue king crab	4c	0[3]	4.20	1980/81-1984/85; 1990/91-1997/98	0.181	0.04	0.18	0.00116	0.00087	25%
6	St. Matthew blue king crab	4b	0.11	2.93	1978-2023	1.53	0.52	0.23	0.129	0.097	25%

[1] For Tiers 3, 4 where BMSY proxy is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years from which the catch average for OFL is estimated.
[2] MMB is estimated on 2/1/2024 for Norton Sound red king crab and on 2/15/2025 for all other Tier 1-4 stocks, using the current assessments.
[3] The F_{OFL} of 0 for PIBKC is indicative of a closed directed fishery.
[4] AIGKC OFL and ABC are calculated by combining two separate assessment models for the EAG and WAG, as presented in the current assessment. Sub-tiers are set separately for each model and are detailed in the assessment document.
[5] PIGKC specifications are set on a calendar year basis

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Ch.	Stock	Tier	F_{OFL}	B_{MSY} or B_{MSY} proxy	B_{MSY} basis years[1]	2024/2025[2] MMB	2024/25 MMB / B_{MSY}	Natural Mortality (M)	2024/25 OFL	2024/25 ABC	ABC Buffer
7	Norton Sound red king crab	4a	0.18	2.02	1980-2024	2.5	1.24	0.18	0.333	0.233	30%
8	Aleutian Is. golden king crab[4]	3	0.55 (EAG), 0.44 (WAG)	11.54	1987-2020	11.39	0.99	0.22	3.725	2.794	25%
9	Pribilof Is. golden king crab[5]	5	-	-	-	-	-	-	0.114	0.085	25%
10	W. Aleutian Is. red king crab	5	-	-	-	-	-	-	0.056	0.014	75%

[1] For Tiers 3, 4 where BMSY proxy is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years from which the catch average for OFL is estimated.
[2] MMB is estimated on 2/1/2024 for Norton Sound red king crab and on 2/15/2025 for all other Tier 1-4 stocks, using the current assessments.
[3] The F_{OFL} of 0 for PIBKC is indicative of a closed directed fishery.
[4] AIGKC OFL and ABC are calculated by combining two separate assessment models for the EAG and WAG, as presented in the current assessment. Sub-tiers are set separately for each model and are detailed in the assessment document.
[5] PIGKC specifications are set on a calendar year basis

EBS Snow Crab

The SSC received an overview of assessment results and CPT discussions on snow crab. Written and oral public testimony were provided by Scott Goodman (BSFRF), and oral testimony by Frank Kelty (City of Unalaska) and Cory Lescher (Alaska Bering Sea Crabbers). Testimony highlighted the importance of the snow crab fishery and the challenges caused by the closure of the fishery in recent years. Concern was raised over the apparent inconsistency between assessment results and observations from the 2024 survey. Also covered was a summary of recent and upcoming research projects, including the potential to use underwater photography to locate and measure mating crab.

While snow crab has been at its lowest historical level over the past four years, the SSC noted the positive trends observed in the 2024 EBS bottom trawl survey. These included a 47% increase in industry-preferred males, large increases in all other male size classes, and much larger increases in female abundance. Centers of abundance in the EBS appear to have shifted back toward the south in 2024, and length frequency data indicated a time series high abundance of immature female crab. It was noted that many of these immature female crab were relatively large, which is atypical for this species. Despite these positive trends, both the CPT and author highlighted the very low recent biomass of large male snow crab preferred by the fishery.

The SSC acknowledges the work completed during 2024 to better inform the proxy values for B_{MSY} and F_{MSY} applied to this stock, and to understand the implications of a change in the definition of mature male biomass (morphometric, > 95 mm, > 101 mm). This included an extensive analysis using the Clark (1991) 'Maximin' approach to find the spawning potential ratio (SPR) and fishing mortality rate that would maximize the yield across all potential levels of stock productivity (in this case, stock-recruitment steepness and size of crab contributing to reproductive output).

Two Tier 3 models were provided for consideration: 24.1, last year's accepted model, and 24.1a, last year's model with a corrected approach to the treatment of molting probabilities. Two additional calculations were made: 1) using >95 mm as the definition of mature male biomass (labeled 24.1b) and 2) using the results of the Maximin analysis to use $F_{45\%}$ instead of $F_{35\%}$ as the F_{MSY} proxy and $B_{45\%}$ instead of $B_{35\%}$ as the B_{MSY} proxy (labeled 24.1c). Two Tier 4 calculations used male biomass >101mm as the mature biomass and natural mortality as the proxy for F_{MSY}. The author's preferred Tier 4 calculation decremented the REMA-smoothed survey biomass estimate for natural mortality (using the prior mean) between the time of the survey and the time of the fishery and used the average biomass over 1982-2022 as the proxy for B_{MSY} and the basis for the harvest control rule. The second Tier 4 approach did not apply a harvest control rule or decrement for natural mortality.

The author recommended that the Tier 4 calculation be used for management. This choice was based on concerns over the performance of the Tier 3 model (underestimation of large males and wide range of model results from jittering analyses) and the implication that a very high fishing mortality rate would be applied to large males. Removing virtually all of the model-estimated industry-preferred male crab would be possible given that morphometric maturity and terminal molts for most crab are estimated to occur prior to reaching the size selected or preferred by the commercial fishery. The CPT disagreed with the author and instead recommended the use of the Tier 3 option (Model 24.1b), which would place emphasis on the reproductive potential of large males and result in a lower fishing mortality rate on that portion of the population.

The SSC had considerable discussion regarding the evidence for small males successfully contributing to reproduction for this species. Canadian research where mating was only observed for male crab >95 mm was noted to be weak and not necessarily applicable to the Bering Sea. Lab studies have shown that small male crab are capable of mating, but may be outcompeted if larger males are present. Long term declines have been observed in the biomass of large males, yet the clutch fullness observations suggest relatively high and consistent female fertilization. Ultimately the SSC concluded that it was premature to entirely dismiss the reproductive potential of smaller males. **The SSC highlighted that more research is needed**

on the basic reproductive biology of snow crab, specifically addressing the question of whether small males can and do mate with large females and produce progeny that will be large males under the right environmental conditions. The SSC strongly supports the proposed collaborative research to explore in situ observations of mating crab using a camera sled.

The SSC identified that the choice of reference points should be considered in two parts: the first focusing on accurately describing the biology of the species and the size of males important for mating and the second reflecting the appropriate harvest rate to provide for reproduction and fishery yield. **Noting the uncertainty in mating dynamics, the SSC disagreed with the author and CPT and instead recommended using the Tier 3 model 24.1a, with $F_{35\%}$ and $B_{35\%}$ as proxies for MSY to set the OFL. After a lengthy discussion, the SSC recommended a buffer of 65% between the OFL and ABC, reflecting the potential for very high fishing mortality rates on larger crab if the full OFL were removed from the stock.** The SSC recognizes that this buffer is larger than last year and based this increase on uncertainty in the reproductive capacity of small males, continued concern over issues with the Tier 3 model (recommendations below), the recent large mortality event from which the stock has yet to recover, and the potential for persistent truncation of the size/age structure of male crab. The SSC further expressed concern that the effects of a revision to the bycatch estimates included in the model were added after the CPT meeting and the full model results were not available. The SSC noted that the use of such a large buffer is a temporary solution, pending additional biological and assessment research. Based on the recommended model, **overfishing is not occurring for snow crab, and the stock is not currently overfished (MMB is above the minimum stock size threshold) but will remain under a rebuilding plan until it has rebuilt to the B_{MSY} level.**

The SSC has the following prioritized recommendations for the next stock assessment (including several repeated from previous SSC reviews):

The highest priority would be to continue to refine the Maximin analysis as requested by the SSC in June 2024, specially using values of steepness of 0.50, 0.67, and 0.80, and considering both the Beverton-Holt and Ricker stock recruitment relationships. The yield analysis also indicated that fishing mortality rates much lower than $F_{35\%}$ achieved a high percentage of MSY, indicating potential flexibility in specifying reference points. The SSC suggested that some type of collaborative work during the spring, perhaps including SSC members and/or others might facilitate additional progress on this topic. The SSC is interested in developing a wider range of options for reference points for snow crab for consideration in the next assessment cycle.

For the Tier 4 fallback model requested by the SSC, the SSC recommends standardizing the approach to the Tier 4 fallback across BBRKC, Tanner and snow crab assessments so that the same methods are used for each including all mature male biomass, a B_{MSY} proxy based on the time-series of REMA-smoothed survey estimates and an F_{MSY} proxy based on the best estimate of natural mortality (from the Tier 3 model). As the SSC intends the Tier 4 calculation only as a fallback if the Tier 3 analysis fails to converge, no other Tier 4 calculations need to be included in future assessments.

The SSC again requests an analysis of the probability of maturing/terminal molt which addresses the observation error in these data and the lack of a monotonically increasing curve. A hierarchical analysis that treats years as random effects might be a starting point. The SSC would also like to better understand the sampling design for the molt data and is concerned about the weighting of the spatial samples in the analysis; weighting should be based on abundance if the sampling rate differs by area (which it would, unless abundance were uniform and/or the targets were in direct proportion to abundance).

Investigate whether there is information outside the assessment model (e.g., larval or post-settlement data) or in the model, supporting estimated skewed sex-ratios at recruitment and the mismatch between recent large recruitments for males and females occurring in different years. Explore whether the estimated large differences in male and female recruitment years could be related to the lack of fit to molt-increment data.

Geostatistical (e.g. VAST) modeling of trawl survey data including both the NBS and EBS should be prioritized. This could help understand some of the inconsistent recruitment/growth trends observed in recent years as well as prepare for potential changes in stock distribution or productivity under future warming of the Bering Sea. Geostatistical modeling should evaluate alternative error distributions and other model configurations as appropriate.

Tanner Crab

The SSC received a presentation on the 2024 stock assessment for the Tanner crab stock in the Bering Sea. Scott Goodman (BSFRF) provided oral public comment. The SSC supports BSFRF efforts to quantify interannual variation in the spatial overlap between Tanner and snow crab, and their ongoing research to evaluate crab management strategies in collaboration with University of Washington. The SSC thanks the assessment author for their extensive work documenting and addressing previous SSC and CPT requests. While the SSC appreciates the author's attention to detail, the SSC highlights that the SAFE and the included Appendices are over 700 pages long, which makes review a daunting task. The SSC suggests that consideration should be given to streamlining the material included in future assessment documents.

The Tanner crab stock has been a Tier 3 stock since the 2012/13 assessment cycle, given the informative nature of fishery, survey, and life history information for this stock. The SSC highlights that the Tanner crab fishery was open in both the eastern and western ADF&G management areas in 2023/24, and the TAC set for Tanner crab by the State of Alaska was significantly below the OFL.

Tanner crab biomass in the 2024 EBS shelf bottom trawl survey increased for both sexes and in both management areas. The increase in the western area was particularly striking (86% increase for large males, and 275% increase for mature females). The survey size-composition was consistent with a cohort entering the population that was seen previously in the 2021-2023 surveys, an important outcome since previous pulses of small Tanner crab observed in 2017-2019 failed to appear in subsequent surveys.

The author and CPT recommended Model 22.03d5 for harvest specifications. This model differs from the previous assessment by the inclusion of the 2018 BSFRF side-by-side (SBS) survey biomass size composition data and slight changes to 2013-2017 BSFRF data, and the inclusion of the 2023/24 fishery and EBS shelf survey data. The assessment author addressed the SSC's primary concern in June about parameters hitting bounds by fixing the two Dirichlet-Multinomial effective sample size parameters for the BSFRF size compositions near their upper bounds. While this addresses the immediate issue, fixing parameters is not a long-term solution, and evaluation of whether these parameters can be reliably estimated should continue.

Model 22.03d5 generally exhibited reasonable fits to indices of abundance and removals in the directed and bycatch fisheries, had a small maximum gradient at the MLE, indicating model convergence, a low retrospective bias in MMB, and no parameters hitting bounds. A jitter analysis was successful in identifying a MLE solution. Results are consistent with the 2023 assessment, but similar issues remain, such as overestimation of the abundance of large crab in the recent year and model predictions failing to capture multi-year high and low periods in the bottom trawl survey index. Due to Tanner crab maturing at sizes below those selected by the fishery, the F_{OFL} is relatively high, a situation that is similar to snow crab, though less extreme. If an approach is developed to address this problem for snow crab, consideration should be given to whether it is applicable for Tanner crab as well.

The SSC supports using Model 22.03d5 for 2024/25 harvest specifications. Concerning the reference time period for calculating B_{MSY}, the SSC concurs with the author's recommendation to use the entire recruitment time series since 1982, except to drop the most recent recruitment estimate. **The current biomass is above B_{MSY}, placing this stock in Tier 3a.** Since the current MMB is above MSST, t**he BSAI**

Tanner crab stock is not overfished. The overall catch in 2023/24 (1,090 t) was less than the 2023/24 OFL (36,200 t), therefore, overfishing did not occur.

The SSC appreciates that a Tier 4 model based on survey biomass was developed according to SSC guidance as a "backup," should the Tier 3 assessment prove unusable for some reason.

The CPT continues to recommend a buffer of 20% between OFL and ABC for this stock, which was recommended by the SSC last year. Since the major uncertainties and concerns about the assessment have not changed, **the SSC continues to recommend an ABC buffer of 20% for Tanner crab.**

The SSC appreciates the draft risk table in Appendix D of the SAFE, especially the thorough and detailed evaluation of potential factors for each category of concern. The draft risk table noted increased concern for population dynamics in part due to uncertainty in the quantification of reproductive output, but no elevated concerns for other categories. The SSC suggests this uncertainty is more associated with the stock assessment, rather than population dynamics. While there is some subjectivity and room for disagreement in the evaluation of factors, the SSC finds the process of comprehensively evaluating a broad range of factors that could potentially impact the stock and the assessment to be extremely valuable.

The SSC agrees with the assessment author and the CPT on the following priorities for improving the Tanner crab assessment in the coming year:

- Transition the assessment model to GMACS. This transition could be used as an opportunity to simplify the assessment, as noted previously by the SSC, although a parallel version of the status quo assessment within the GMACS platform will be necessary.
- Develop a consistent approach for using the BSFRF survey data to inform bottom trawl selectivity and catchability for Tanner crab, snow crab, and Bristol Bay red king crab, rather than fitting these data as a separate index.

The SSC reiterates several previous recommendations that remain unaddressed:

- Directly incorporate annual molt to maturity data, as implemented in the EBS snow crab assessment, if sufficient data are available.
- Explore differences in the spatial distribution of small male crab in the NMFS survey, to identify if the distribution of small crab encountered in 2003-2005 and 2008-2010, which successfully propagated to larger sizes, showed differences in habitat use compared with the cohort first observed in 2017-2019, which did not propagate to larger sizes. Likewise, the SSC recommends that a comparison of environmental conditions experienced by small crabs during these periods may help to elucidate why some cohorts appear to propagate and others do not.

In addition, the SSC notes that for a number of years, the author and CPT have expressed concerns that the recommended models are overly optimistic. **The SSC recommends exploring the reason for this characterization through exploring likelihood profiles and other diagnostics and sensitivities of important scale related parameters (e.g., natural mortality, catchability and mean recruitment).**

Bristol Bay Red King Crab

The SSC received an overview of the BBRKC stock assessment and CPT recommendations. The SSC received written testimony from Scott Goodman (BSFRF). There was no oral testimony.

The BBRKC fishery was open in 2023 after two years of closure. Survey results were minimally different from 2023 and any changes were within the confidence bounds. There has been no substantial recruitment since the early to mid-2000s.

The stock assessment model has been implemented in GMACS since 2018. The SSC appreciates the author's response to many of the previous comments, in particular the details about tight priors on M and catchability, which are important factors in the SSC's evaluation of uncertainty in the OFL.

Model inputs included updates to fisheries bycatch, crab fisheries catches (directed, cost-recovery, and bycatch), 2024 survey data, and updated length composition data for directed and non-directed fisheries. In addition, the terminal year of recruitment for reference point calculations was updated. Two model scenarios and a Tier 4 option were compared based on CPT and SSC recommendations in May 2024. The base model, Model 23.0a, was the accepted 2023 model with new data and Model 23.0c was the base model with removal of the 1975-1979 molt probability block so that molt probability was constant throughout the time series. It was noted that the timing of the MMB estimation was moved to the correct season in both models, per May 2024 CPT discussions. As requested by the SSC for BBRKC, Tanner, and snow crab stock assessments, a Tier 4 assessment was also provided as a fallback.

Results from both Tier 3 models were similar, with only small differences in the early part of the time series. Both models continued to have a concerning retrospective pattern, although it was noted that it is getting better and may have been due to anomalous survey data a number of years ago that are becoming less influential in the model. **The SSC supports the author and CPT recommendation to use Model 24.0c for harvest specification,** placing BBRKC stock in Tier 3b. **This stock is not overfished and overfishing did not occur in 2023/24..** Even when using recent (2013-2023) low recruitments for projections, the BBRKC stock is not approaching an overfished condition. **The SSC supports the CPT's recommended ABC buffer of 20%, based on uncertainty due to retrospective patterns, effects of cold pool instability, the very tight constraints on both M and Q, and lack of fit to the BSFRF data inputs in the model.** As described in the October 2023 SSC report, the SSC recognizes the importance of low biomass/abundance and recent recruitment, but notes that it is already accounted for in the model results and control rule application and so should not be 'double counted' in the consideration of the ABC buffer.

The SSC recommends that the authors revisit previous SSC recommendations from recent years that were not included in the SAFE. In particular, removing shell condition, considering the BSFRF data as a survey selectivity prior, expanding the size bins used in the model to include additional bins for large crab, and generation of standard Bayesian diagnostics of posterior distributions all remain important considerations in future models. The SSC also reiterates its request to evaluate whether crab biomass and fishing mortality in the northern district should be included. Regarding the CPT discussion on handling mortality in fixed gear, the SSC recommends the author revisit previous CPT discussions and rationale on whether 50% handling mortality is appropriate for both pot and longline gear and to provide additional information in the next assessment.

The SSC thanks the authors for the work on the BBRKC ESP report card. The indices presented are valuable for an understanding of ecosystem relationships to this stock. **The SSC recommends that future ESPs consider the following**:

- Provide clear units on ESP indices.
- Provide some discussion on the linkage from the indices being considered such as how the skipper survey data may be relevant to the assessment. Another example is clarifying how the shift in the salmon index relates to crab competition or predation.

- Consider where to best report indices that are reported in the ESR as being potentially important to individual crab stocks, as these may be candidates for inclusion into species-specific ESPs.

- Separate socioeconomic indicators into separate panels for the pre- and post-crab rationalization period, as recommended by the CPT.

St. Matthew Blue King Crab

The SSC welcomes the new author and thanks the CPT for their presentation on the SMBKC stock assessment. This assessment occurs every two years, with the last full assessment in 2022. The SMBKC stock was declared overfished in 2018, and there hasn't been a directed fishery since the 2015/16 season. A rebuilding plan has been in place since 2020, with no changes to fishing regulations, and recent analyses have focused on recruitment.

A significant change occurred in the 2024 NMFS bottom trawl survey, where the "corner stations" around St. Matthew Island were not sampled. These stations, added in 1983, are areas of higher crab density and have played a key role in estimating crab abundances. The decision to not sample these stations was made to prioritize survey modernization fieldwork, and their inclusion in future surveys is uncertain. The assessment showed that removing these stations reduced biomass estimates (19%) but didn't alter size composition significantly. The biomass estimates are now computed based on a single stratum, instead of high and low-density strata with corner stations. This change has introduced a consistent downward bias, possibly due to the exclusion of the corner stations, or a previous upward bias when they were included. This discrepancy deserves further investigation, highlighting the potential benefits of model-based estimates that incorporate historical corner station data to address any biases. For this assessment, using the corner stations prior to 2024 is acceptable, but this issue should be addressed in the next full assessment. This may include developing an integrated pot and trawl index, as suggested in October 2022. The expectation is that the removal of the corner stations should increase uncertainty but not introduce consistent bias unless they regularly have higher crab density than the parent station to which they are a corner of. **The SSC recommends that the producers of the crab trawl survey estimates should explore showing both high and low-density strata estimates without the corner stations, alongside the one-stratum estimate seen in this assessment, to better understand potential biases.**

Five model scenarios were presented to assess the impact of excluding the corner stations, with models without these stations generally estimating lower biomass and OFL values. The assessment team recommended a model (24.1) that retained the corner stations and adopted a higher natural mortality rate (M = 0.23), as it better fits the data and reflects the stock's current condition. The CPT maintained the 25% buffer for the ABC, concluding that while these changes likely introduced some bias, they did not increase uncertainty. **The SSC supported the recommendation from May to use the higher natural mortality rate and concurs with the CPT recommendation of Model 24.1. Since possible bias caused by the absence of corner stations in 2024 would be a downward bias, the SSC agrees that maintaining the 25% buffer is reasonable at this time.**

Although the stock is above the MSST under both model configurations (with or without corner stations) and shows signs of improvement, it remains under a rebuilding plan until it reaches B_{MSY}. **The stock remains overfished** for the 2023/24 year, and although projections for 2024/25 indicate an increase in biomass, recent recruitment continues to be low. **Catch in 2023/24 was below the OFL, therefore overfishing did not occur.**

In Table 8, it was noted that the SDNRs (Standardized Deviance Residuals) and MARs (Mean Absolute Residuals) for the surveys are all listed as zero, which is likely not the case. The SSC recommends the authors re-evaluate these diagnostics if they are included in future assessments.

Overfishing Status Updates

The SSC received overfishing status updates for five stocks in off-years for full assessment reviews, including Western Aleutian Islands red king crab (WAIRKC), Pribilof Island golden king crab (PIGKC), Aleutian Islands golden king crab (AIGKC), Pribilof Islands blue king crab (PIBKC), and Pribilof Islands red king crab (PIRKC). Total catch mortality for each of these stocks was below the OFL, so overfishing did not occur in 2023/2024 (2023 for PIGKC because specifications are on a calendar year basis). PIRKC and AIGKC estimates of MMB are above MSST and are, therefore, not overfished. PIBKC remains overfished. Both WAIRKC and PIGKC are Tier 5 stocks, and an overfished status determination cannot be made.

Norton Sound Red King Crab Model Runs

The CPT chairs presented proposed models for the 2025 final assessment for Norton Sound red king crab (NSRKC). This is an annual Tier 4 assessment that uses three survey data sources - the NMFS EBS trawl survey, the ADF&G trawl survey and the NMFS NBS trawl survey - along with catch information from the summer commercial, winter commercial, and the winter subsistence fisheries. This assessment has substantial challenges, including higher than observed abundance-proportions of large crab, poor model fits to trawl survey abundance, model parameters hitting bounds, and unknown trawl survey selectivity, to name a few. In response to CPT and SSC recommendations, the author stepped back from these and focused on transitioning the accepted model (21.0) to GMACS.

For the 2025 draft assessment, the author implemented Model 21.0 in GMACS (24.0). Model 24.0 data and configurations closely matched 21.0 but the two models differ in structure, selectivity parameterization, and likelihood calculation, so direct comparisons between them are not possible. Qualitative comparisons of modeled trawl survey abundance, summer commercial standardized CPUE, survey and fishery size compositions and MMB all indicate the models produce similar fits to data. However, the SSC noted and recommends that the authors consider why the GMACS model estimates higher MMB in the most recent years and results in a higher B_{MSY} and OFL. Natural mortality, molting probability, selectivity, and transition probability are also similar between the models and *post hoc* RMSE for abundance indices and negative log-likelihoods for length-shell compositions were also similar. Initially, the Model 24.0 OFL was nearly twice that of Model 21.0, but the author identified an issue with the GMACS implementation of the Tier 4 F_{OFL} in which each fleet was being assigned the full F_{OFL}, resulting in an erroneously large value. This was corrected by calculating the OFL using the SSC-adopted OFL formula for multiple directed fleets. This is not currently a feature of GMACS. The Model 24.0 multi-fleet OFL (0.63t) is higher than the 21.0 OFL (0.58t).

The CPT recommended bringing forward Models 21.0 and 24.0 (GMACS) for final specifications, conducting retrospective and jittering analysis for Model 24.0 (see jittering guidance in General Crab Comments), as well as plotting fits to the different trawl time series separately. The CPT also endorsed the continued use of the multiple directed fleets OFL calculations and recommended that GMACS be updated to include these calculations.

The SSC commends the author on the successful implementation of the model in GMACS and appreciates the substantial collaboration provided by Tyler Jackson (ADF&G-Kodiak).

The SSC recommends that Models 21.0 and 24.0 be provided for review in December and concurs with all the CPT recommendations and requests. In addition, the SSC requests further exploration of the scaling difference in the OFLs resulting from Models 21.0 and 24.0.

The SSC appreciates the author's effort to address previous requests for more information on the trawl surveys and gears and anticipates revisiting these as well as other latent responses to previous SSC recommendations once GMACS implementation is complete. The SSC requests that the author seek and incorporate editorial review prior to posting the draft SAFE document going forward. Finally, the SSC looks forward to seeing the VAST/sdmTMB model-based indices of the three trawl surveys planned for presentation at the January modeling workshop.

Aleutian Islands Golden King Crab Model Runs

The CPT chairs presented results from twelve GMACS models for the May 2025 AIGKC assessment for both the EAG and WAG, as well as two additional GMACS models for the EAG that incorporated the EAG cooperative pot survey. AIGKC is managed as a Tier 3 stock with a single OFL and ABC. The ADF&G manages the fishery on a two-area basis (EAG and WAG) with a harvest strategy based on model-estimated mature male abundance that splits the TAC and specifies a maximum harvest rate for EAG and WAG.

Previous CPT and SSC recommendations for this assessment include exploration of data weighting, addition of the cooperative survey, a combined EAG and WAG model, improvements to observer CPUE standardization and evaluating area specific size at maturity. This cycle, the author focused on data clarifications and updates, use of 1993/94 season catch and size comps in EAG and WAG, model initial conditions, data weighting and EAG models with cooperative survey data.

Models were constructed and examined in a stepwise process beginning with Model 23.1, the base model, which was accepted for specifications in May 2024. First, intermediate bridging models were developed to document potential changes in model performance associated with data changes and updates (23.1 update), and an increase in the number of seasons defined in the model from 5 to 6 to allow for output on June 30th of the terminal year (23.1 season). The progression from 23.1 (Base) to 23.1 (Season) resulted in no changes to model results. The software and season upgrades and addition of the updated total size composition and total catch time series (i.e., including additional pot types) resulted in the new version of the base model, Model 23.1.

Model 23.1 starts from an equilibrium size structure in 1960, with data to inform the model starting in 1981. Based on a CPT recommendation, Model 23.1c implemented a revised bias correction strategy for recruitments during the 1960-1980 "spin-up" period to address negative recruitment deviations. The author and CPT agreed that the correction was appropriate but did not resolve the issue, which stems from the difference in population scale between 1960 and 1981. A new model, 25.0, eliminated the "spin-up" period altogether and estimated the initial size structure starting in 1981. Overall, model results from 23.1, 23.1c, and 25.0 for recruitment and MMB were similar except that recruitment in the EAG for Model 25.0 was slightly higher. Following up on CPT and SSC concerns regarding potentially over-weighted size compositions in the model-fitting process, a series of models (25.0a, 25.0b, 25.0b2, 25.0c, and 25.0d) explored different data-weighting approaches. None of the changes to data weighting resolved the poor fit to the post-rationalized CPUE indices in the EAG. The author and CPT agreed that 25.0b, which employed equal likelihood weighting, and size composition weights based on variability in data, was the best of the data-weighting models. However, they noted that there was some (unaccounted for) spatially or temporally varying process in the EAG post-rationalized period that was resulting in large additional variance and poor fits. Finally, for the EAG only, Models 25.1 (EAG) and 25.1b (EAG) included data from the AIGKC cooperative survey as an additional fleet. The author and CPT agreed that while the development of these two models improved the handling of the survey data, several issues were yet to be resolved before the data could be used in a model to set harvest specifications. The CPT provided recommendations for further exploration and agreed with the author that models incorporating the cooperative industry survey data were best kept on the back burner until the data conflicts were resolved.

The CPT agreed with the author's recommendation to bring Models 23.1c and 25.0b forward for setting specification in May 2025 and requested that a risk table be brought forward as well.

The SSC appreciates the author's responsiveness to prior CPT and SSC comments and considers the thorough and systematic model update and exploration of multiple model configurations to be exemplary.

The SSC concurs with the author and CPT recommendations to bring Models 23.1c and 25.0b forward for setting specification in May 2025 and to provide a risk table.

The SSC also supports the proposed future work outlined by the author and CPT, including simulation studies looking at time-varying parameters in EAG, revisiting the appropriate size at maturity to use for calculating management-related quantities, and examining spatial/vessel effects in the post-rationalization fishery data to identify potentially time-varying processes such as catchability or selectivity. In addition, the SSC supports future development of a model that includes the cooperative survey data (e.g. Model 25.1).

Risk Table Implementation

The SSC commends the progress made to develop risk tables for BSAI crab stocks. Draft risk tables are now available for three major crab stocks, including EBS snow crab, Tanner crab, and BBRKC. The CPT noted some aspects of implementation merit additional discussion and is planning to develop a set of SOPs at their May 2025 meeting. The SSC acknowledges that the implementation of risk tables for crab stocks may necessitate alternative approaches to those used for groundfish, and guidance to crab assessment authors may differ as a result. One key difference identified during SSC discussion is the application of ABC buffers for each species group. Risk tables for groundfish stocks are used to identify if a buffer is needed to reduce the ABC from a maximum ABC based on factors external to the assessment model or tier, whereas for crab stocks, an ABC buffer from OFL is set based on an evaluation of uncertainty relative to the previous year and a general range of buffers for stocks in a tier. It would be helpful for the CPT to describe the basis for the current buffers and the SSC recommends that the CPT consider the approach in a situation where all risk table categories are normal or no concern. Increased communication with groundfish assessment authors would be helpful to develop the range of options that could be considered. The SSC also notes that there are multiple resources available to the CPT as they develop their SOPs, including the SSC's Risk Table Workshop report (June 2021 SSC Report Appendix A), Council motions, and previous SSC and GPT comments on the implementation of risk tables for groundfish stocks. Finally, the SSC suggests that, to the extent possible, the implementation of and process used to develop BSAI crab risk tables mirrors that of groundfish to maintain consistency among managed stocks and Council's goals for risk tables as defined in their December 2019 motion (collaboration and communication among stock assessment scientists and those in other disciplines and increasing transparency and consistency in the rationale for reducing the ABC not already addressed in the stock assessment, tier system, and harvest control rules).. To address concerns over double counting uncertainty in the stock assessment and risk table process, the SSC requests that the CPT develop a table that lists where different types of uncertainty are accounted for in the development of OFL and ABC recommendations. This would help clarify the role of risk tables in the specification process.

The SSC looks forward to further discussions following the CPT meeting next May, and to the next iteration of risk tables for crab stocks in 2025.

BSFRF Research Update

The SSC appreciates the updates provided to the CPT on research conducted by the Bering Sea Fisheries Research Foundation (BSFRF) and their written and oral comments submitted under C1 BSAI crab. The research conducted by this group provides critical information needed to improve management of BSAI

crab stocks and is currently incorporated into several assessments in a variety of ways. Current BSFRF work is focused on continuing their Collaborative Pot Survey, which occurred in 2023 and now 2024. Data analysis for the 2024 survey is ongoing. A third survey is planned for 2025. BSFRF also has several projects focused on snow crab, including a workshop aimed at increasing international collaborations and a pilot survey project in the Bering Sea with the primary goals of improving understanding male distribution and survey calibration efforts.