SCIENTIFIC AND STATISTICAL COMMITTEE
DRAFT REPORT TO THE
NORTH PACIFIC FISHERY MANAGEMENT COUNCIL
February 6th – 7th, 2023

The SSC met from February 6 – 7th, 2023 in Seattle, WA. Members present in Seattle were:

Sherri Dressel, Co-Chair
Alaska Dept. of Fish and Game

Franz Mueter, Co-Chair
University of Alaska Fairbanks

Alison Whitman, Vice Chair
Oregon Dept. of Fish and Wildlife

Chris Anderson
University of Washington

Amy Bishop
University of Alaska Fairbanks

Curry Cunningham
University of Alaska Fairbanks

Martin Dorn
University of Washington

Mike Downs
Wislow Research

Robert Foy
NOAA Fisheries—AFSC

Jason Gasper
NOAA Fisheries–Alaska Regional Office

Dana Hanselman
NOAA Fisheries—AFSC

Brad Harris
Alaska Pacific University

Michael Jepson
Independent Contractor

Kailin Kroetz
Arizona State University

Kathryn Meyer
Washington Dept. of Fish and Wildlife

Andrew Munro
Alaska Dept. of Fish and Game

Chris Siddon
Alaska Dept. of Fish and Game

Ian Stewart
Intl. Pacific Halibut Commission

Patrick Sullivan
Cornell University

Robert Suryan
NOAA Fisheries—AFSC

C2 BSAI Crab

The SSC received a report on the January 2023 Crab Plan Team (CPT) meeting from Sarah Rheinsmith (NPFMC), Katie Palof (ADF&G), and Mike Litzow (NOAA-AFSC). There was no public testimony for BSAI CPT agenda items or the Norton Sound red king crab (NSRKC) assessment.

General BSAI Crab SAFE Comments

The SSC wishes to congratulate Shareef Siddeek (ADF&G) on his upcoming retirement and thank him for his work on advancements to the BSAI Aleutian Islands golden king crab assessment, his work on other crab assessments, and his many years of participation on the Crab Plan Team.

BSAI Crab SAFE and Harvest Specifications

The SSC reviewed the NSRKC SAFE chapter and information provided by the CPT with respect to the stock status information from 2022/2023 relative to total catch during the 2022/2023 season (Table 1). In addition, Table 2 contains the SSC recommendations for 2023/2024 catch specifications. The remaining crab SAFEs will be reviewed, and harvest specifications set, at the June and October SSC meetings.

Table 1. Stock status in relation to status determination criteria for 2022/23 as estimated in October 2022. Hatched areas indicate parameters not applicable for that tier. Values are in thousands of metric tons (kt).

Chapter	Stock	Tier	MSST[1]	B_{MSY} or B_{MSY} proxy	2022/23[2] MMB	2022/23 MMB/MMB$_{MSY}$	2022/23 OFL	2022/23 Total Catch	Rebuilding Status
1	EBS snow crab	3			55.0		10.32		
2	BB red king crab	3			17.0		3.04		
3	EBS Tanner crab	3			47.58		32.81		
4	Pribilof Islands red king crab	4			3.88		0.685		
5	Pribilof Islands blue king crab	4			0.18		0.00116		
6	St. Matthew Island blue king crab	4			1.31		0.07		
7	Norton Sound red king crab [2]	4	0.95	1.90	2.42	1.27	0.30	0.16	
8	AI golden king crab	3			11.94		3.76		
9	Pribilof Islands golden king crab [3]	5					0.093		
10	Western AI red king crab	5					0.056		

[1] As estimated in the 2023 assessment.

[2] For Norton Sound red king crab, MMB on 2/1/2023 is estimated using the current assessment in January 2023. Stock status for NSRKC is determined in February.

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

Table 2. SSC recommendations for EBS crab stocks. Stocks for which specifications are rolled over between assessments (PIBKC and PIGKC) or were set in February (NSRKC) are included. Biomass values are in thousand metric tons (kt). Tier designations in this table are based on the projected stock status in 2023/2024. 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 is set in February.

Ch.	Stock	Tier	F_{OFL}	B_{MSY} or B_{MSY} proxy	B_{MSY} basis years[1]	2023/24[2] MMB	2023/24 MMB/ MMB_{MSY}	Natural Mortality (M)	2023/24 OFL	2023/24 ABC	ABC Buffer
1	E. Bering Sea snow crab										
2	Bristol Bay red king crab										
3	E. Bering Sea Tanner crab										
4	Pribilof Is. red king crab	4a	0.21	1.71	2000-2021	3.88	2.27	0.21	0.685	0.51	25%
5	Pribilof Is. blue king crab										
6	St. Matthew blue king crab	4b	0.06	3.26	1978-2021	1.31	0.40	0.18	0.07	0.05	25%
7	Norton Sound red king crab	4a	0.18	1.98	1980-2023	2.4	1.21	0.18	**0.31**	**0.22**	30%
8	Aleutian Is. golden king crab [3]										
9	Pribilof Is. golden king crab [4]										
10	W. Aleutian Is. red king crab										

[1] For Tiers 3 and 4, where B_{MSY} 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 average catch for OFL is estimated. MMB on 2/1/23 is estimated using the current assessment for NSRKC.

[2] MMB is estimated on 2/1/2023 for NSRKC and on 2/15/2023 for all other Tier 1-4 stocks, using the current assessments.

[3] AIGKC OFL and ABC are calculated by combining two separate assessment models for the EAG and WAG, as presented in the current assessment

[4] PIGKC specifications are set on a calendar year basis

Norton Sound Red King Crab

The SSC thanks the CPT and the author for the final 2023 assessment and being responsive to the SSC's requests. The assessment author presented results from one model (21.0) with updated data for status determination and OFL/ABC calculation. This model assumes a constant natural mortality (M) of 0.18 yr-1 for all length classes except the largest length-class, which had an estimated M of 0.62 yr-1. The SSC appreciates the exploratory models with different retention probabilities and length-specific natural mortality, but notes that they were not being put forward as alternatives for harvest specifications.

The SSC believes that its previous recommendation for estimating M across length bins was imprecise and was interpreted by the author as estimating M for each length bin, rather than estimating a single M for all length bins. Assessments for NSRKC over multiple years have indicated that the data suggest a higher M than currently used. The high M at just one length group has questionable biological rationale. It would be more parsimonious to estimate just one M parameter across all lengths of crab for a future model. The base value for M for NSRKC has been estimated using the maximum age of 25 with the 1% method and fixed in the model. More recent papers using maximum age as a way to estimate M would yield values between 0.22 (Then et al. 2015) and 0.26 (Hamel et al. 2015) using age 25 as the maximum age.

Previously, a rationale for maintaining the current value of 0.18 was that a higher M may result in a higher OFL. The SSC does not agree with this rationale and the assessment should explore a higher value for M if that may be the best description of the stock's dynamics. The SSC recommends a variant of model 21.0 for next year's assessment with one estimated value of natural mortality for all sizes, perhaps with a prior distribution using the previously mentioned updated methods.

The SSC agrees with the CPT and the author to use Model 21.0 for setting harvest specifications and supports the proposed 30% buffer, which is a reduction from last year's 40% buffer as the previous steady increase in buffers implied that less has been known about NSRKC over the years, which is surely not the case. The SSC appreciates the table providing a of rationale for the buffer and the comparison to the previous assessment. **The SSC disagrees with the CPT's recommendation to only use retained catch for OFL determinations and recommends total catch OFL again for 2023, as this is best practice for assessing stock status**. The SSC encourages the author to continue to provide total catch OFL with whichever method the author prefers. The stock is above MSY and in Tier 4a.

The SSC has the following specific recommendations as time allows:

- Prioritize transitioning the model to GMACS.

- Consider an update to the standardized commercial fishery CPUE model, which is developed external to the assessment model.

- Continue to develop VAST or other model-based survey estimates of abundance.

- Consider using NSRKC as a case study for the incorporation of LK/TK and subsistence information for Council decision-informing analyses as previously suggested. and for reasons previously articulated (e.g., there is both a commercial and subsistence NSRKC fishery, multiple community protection management measures were implemented over the years though they werebut never evaluated for their efficacy, it is a relatively small fishery, participants in the fishery are likely to include holders of IK/TK and/or LK, and the fishery occurs in a region where fishery related climate change concerns are paramount, among others). Additionally, This couldIt is assumed that this work would be led by ASFC social science personnel (or other similarly qualified researchers) and would involve inputs from the LKTKS Task Force and the CCTF. The

authors could facilitate such an effort because, as noted in this year's BSAI Crab SAFE, "the ADF&G NSRKC biologists are members of the Nome community and are acquainted with many local fishermen and staff of community organizations such as [the] Norton Sound Economic Development Corporation and Kawerak, exchanging information and research ideas about crab biology and fisheries", indicating the existence of established personal working relationships considered key for the co-production of knowledge that would make for a useful case study. The SSC would welcome a presentation on recent work done by the AFSC in this area.

- Based on the recent work from Zacher et al., .test the sensitivity of the assessment model to a much lower size at maturity.

- A more thorough description on how the tagging data areis being fit and the source of the form of the multinomial component of the likelihood in the appendix would be helpful, including some diagnostic plots of the fit to the data.

- In Figure B, the scale of the different color dots should be defined if this figure is to be included in future assessments.

- Define "tau" in the likelihood, presumably it refers to recruitment deviations.

- A small-scale observer program should be considered for the NSRKC fishery. The program should be designed to provide information on the quantity and size-composition of discards that could be used in the assessment to update selectivity and retention curves and allow total catch (retained catch plus discard mortality) be estimated.

Finally, the SSC shares the general frustration of the author and the CPT that significant headway has not been made on some of the key issues with this stock and recognizes that the review process as currently structured can have some duplication of previous recommendationsduplicity. However, constructive language in the SAFE document is required to continue to work towards the collective goal of providing as accurate an assessment of the NSRKC stock as possible for use in management.

Pribilof Island Golden King Crab Model Runs

The SSC commends the authors for their work addressing previous CPT and SSC comments to improve this assessment. The Pribilof Islands golden king crab stock is currently a Tier 5 stock, with the OFL determined by average catch over a specified time frame. The assessment is conducted every three years and the last assessment was conducted in 2020. Several candidate models were previously requested by the SSC to conduct the PIGKC assessment. These fell into 3 broad categories:

1. The previously-accepted Tier 5 model with updated catch estimates;

2. Tier 4 models that use a random effects approach to fit NOAA EBS slope survey data for PIGKC mature male biomass (MMB), determine a proxy for BMSY from average model-estimated MMB and estimate a projected MMB, and use M as a proxy for FMSY; and

3. A mixed (groundfish) Tier 4/5 approach that uses the "raw" estimates of survey biomass to determine the current biomass based on a straightforward average of survey MMB.

The NOAA EBS slope survey provides the only basis for fishery-independent data to assess the PIGKC stock, but the data are limited in temporal extent to (2002, 2004, 2008, 2010, 2012, 2016), and size composition data were lacking for the first two survey years and mature male biomass in those years had

to be inferred from other surveys. An important limitation is there has been no slope survey in seven years, which constrains the ability to evaluate current abundance. The random effects approach used the recently updated software for groundfish Tier 5 stocks and gave reasonable results given the uncertainty of the survey estimates, and indicated relatively stable temporal trends.

The SSC continues to recommend The authors lacked time to development of a GMACS model for the stock and toor explore the use of VAST to provide model-based estimates of survey biomass. To explore a tier 4 assessment and use the random effects model, it was necessary to compute an estimate and variance for the 2022 and 2024 MMB estimates as there were no length compositions available. The calculation was improved byThis calculation THowever, theye were able to improve the calculation of CVs was improved (from that used in the 2020 assessment) by using the approximation of the variance of a ratio. These estimates (in addition to the rest of the time series of the EBS slope survey) were subsequently used in for the 2002 and 2004 MMB estimates using the variance for the productmultiplication of random variables and by to usinge the "rema" R package developed by groundfish assessment authors to fit random effects models to the slope survey data as part of the Tier 4 approaches evaluated.

The CPT recommended continuation of the Tier 5 approach given the lack of a recent survey, and noted that all three approaches performed similarly. The SSC generally supported the CPT recommendation on a preferred approach, but requests that all three approaches be brought forward in the final assessment for CPT and SSC consideration in May/June. One advantage of the random effects approach is that it can carry the uncertainty in the assessment estimates forward into projections. In addition, the SSC recommends:

- using M=0.22 yr-1, or another value consistent with the AIGKC assessment, in future Tier 4 models to be considered when more data become available; and

- revising the terminology used for M in Appendix B to an exploitation rate.

- developing a GMACS model for this stock

- exploring the VAST model for biomass estimatesfor the stock and toor explore the use of VAST to provide model-based estimates of survey biomass.

Going forward the SSC agrees with the assessment author to consider alternative data collection designs that would promote the gathering of relevant survey information including those collected from the slope, shelf, and NBS surveys, to improve and extend thus creating some hope that the PIGKC survey time series can be extended in the future. The CPT and the SSC believe that this would support moving the assessment to Tier 4. An advantage of the random effects approach is that it can carry the uncertainty in the assessment estimates forward into projections. By ignoring this uncertainty, management is operating in the dark.

Aleutian Islands Golden King Crab Model Runs

The SSC was presented with a list of the proposed models to be brought forward for the annual assessment of the Aleutian Islands golden king crab stock (AIGKC) at the May 2023 CPT meeting. The models recommended by the CPT are:

- Model 21.1e2: The base model from the May 2022 assessment, except that the pre-specified value of M was changed from 0.21yr-1 to 0.22yr-1 based on a re-analysis of historical tagging data.

- Model 21.1f: As for model 21.1e2, plus observer CPUE data standardized including Year: Block interactions.
- Model 21.1g: As for model 21.1e2, but with the EAG cooperative survey standardized CPUE included.
- A model similar to 21.1g but with 21.1f as the base rather than 21.1e2

The SSC appreciates the work by the assessment author and others to transition this assessment to the GMACS framework as well as the detailed bridging analysis. **The SSC agrees with the CPT that the May 2023 assessment be conducted using GMACS only and that the legacy model not be brought forward for the May assessment. However, the SSC requests that the base GMACS model EAG21.9c (modified 21.e2), which closely follows the legacy model, be included in discussions to facilitate comparisons with the previous bridging exercises.**

The SSC endorses the GMACS assessment model alternatives 21.e2 and 21.1f as recommended by the CPT to be prioritized for consideration and be brought forward in May 2023. In addition, if time permits, a modification of alternative 21.1f to include the cooperative survey might also be considered for presentation. However, not all permutations of model alternatives with and without the cooperative survey are needed for consideration.

The SSC appreciates the author's efforts to address past CPT and SSC comments.

The SSC recognizes that alternative recruitment scenarios exist, and that results were provided for variants of model 21.1e2 in which the period used to define average recruitment was changed from 1987-2017 to 1987-2019, 1987-2020, and 1987-2021, but it was unclear from the CPT report which time series was used. **The SSC agrees that the 1987-2017 recruitment time period be used for this assessment, but that for future assessments the authors continue to consider other recruitment time periods (including routinely adding a year to the series as is done in other assessments) and modeling scenarios and provide document the final recruitment scenario chosen and the justification for the finalis choice.**

Regarding projections, the SSC requests clear documentation of what elements are treated as stochastic (e.g. recruitment, mortality) and which are fixed (e.g. catchability, selectivity) even if they were represented as stochastic in the assessment model. Such choices will influence the uncertainty captured in the projections.

GMACS Modeling Workshop

The SSC received a summary of the modeling workshop held during the January CPT meeting. The SSC appreciates the update, and the continued effort of the workshop leads, CPT, and assessment authors to improve GMACS, such as merging the king crab and snow crab coding branches, the 'gmr' R package, and the introduction to the base level of GitHub interactions. Additional updates that are underway include: simulation code, environmental variable linkages, and improved documentation. The SSC is also encouraged that GMACS will likely be ready for NSRKC and Tanner crab assessments in the near future. These workshops provide an excellent opportunity to make significant progress in a short time and the SSC supports similar workshops in the future. The SSC further supports continued efforts to ensure GMACS will be appropriately curated and accessible into the future, which should include planning for long-term funding.

Start Date Workshop

The SSC received an update on the criteria to be used for changing start dates of assessment models. This discussion was based on an October 2022 SSC request to ensure consistent rationale were applied if/when different model start dates were proposed. The CPT recommended and the SSC supports the following criteria/methods when considering a change to an assessment start date:

1) More data are generally better and that using all the standardized data available should be the default for selecting a start date.

2) The SSC notes that model start date and the date that non-catch data start are not the same, so start date default should be when reliable catch data exist

3) Consistent with groundfish best practices for which trawl survey data to use:

- Aleutian Islands: 1991 - present
- Eastern Bering Sea: 1982 - present (standard gear), 1987 - present for species that inhabit the northwest corner of the survey which was added in 1987.

2) Consider removing early data if:

    a. Data quality is suspect or deemed inappropriate to use.

    b. Inconsistencies between current data and historic data exist that lead to convergence issues or divergent trajectories for the stock.

    c. Ecosystem driver or regime shifts have occurred present difficulties in modeling periods with markedly different population dynamics.

Additionally, any proposed new start date should include diagnostics to show how the removal of earlier data may affect the current reference point calculations or stock status determinations.

The SSC also recommends that stock assessment authors continue to report on the entire timedata series of available data even if start dates change in order to maintain the historical perspective that may be informative into the future.

Model Complexity Working Group

The SSC received a brief update on the initial discussion to create a working group to address the SSC's October 2022 recommendation for simpler models for snow, Tanner, and BBRKC stocks. The SSC recognizes that size-structured models are inherently challenging, and that assessment model complexity can increase over time. The CPT discussed the general goal for the working group was to establish a simpler "base" model for stocks and then add features from there (for each stock), and to bridge the differences between the State and Federal processes. Members of the working group were initially selected during the CPT and included both CPT and SSC members. Additional SSC members were added to the working group during the SSC meeting and the whole group will consist of: Katie Palof, Buck Stockhausen, Cody Szuwalski, Franz Mueter, Ian Stewart, Curry Cunningham, and Dana Hanselman. The SSC discussion supported this working group using the first meeting, slated for March 27-28, 2023, to determine the explicit goals and objectives for the work and focus on exploring simpler models, with the State-Federal interaction for crab assessment and management as a secondary objective.

Research Updates

The SSC received research updates on a number of new and ongoing crab projects: BBRKC cooperative research, crab tagging, ocean acidification, and on BBRKC bycatch distribution. The SSC was excited for the opportunity to hear about these projects.

The BBRKC cooperative research is a new project not yet underway between BSFRF, ADFG, and NOAA to provide a better understanding of the winter distribution and movement of BBRKC. This project also seeks to provide information on reducing regulatory discards of crab in the directed fishery and provide some economic relief to crab vessels and their crews due to the recent fishery closures.

Research on crab tagging done by Leah Zacher (AFSC) and Jared Weems is intended to better understand crab movement. Early results from Zacher's work showed evidence that male RKC moved into the RKCSA in the fall, westward in the winter and then back eastward. Female crab in the spring showed some evidence of movement into eastern Bristol Bay potentially for molting/mating. Weem's project focused on using AUVs to track Tanner crab movement around Kodiak island. This early study provides some proof of concept to track crab and to collect oceanographic data.

Emily Ryznar presented recent work on BBRKC distribution models to better understand the spatial distribution of legal-sized crab in non-summer months within the yellowfin sole and northern rock sole fisheries. Model results generally fit well to observed centers of distributions except during years of low bycatch. A number of suggestions were made during the CPT to improve this work into the future, and . the SSC encourages the author to work with groundfish trawl and pot gear participants as appropriate.

A brief update of Darren Pilcher's (NOAA-PMEL) and Chris Long's (AFSC) work on ocean acidification was presented. The SSC was very supportive of all the work on ocean acidification and would like to see a more detailed presentation including how this research will inform the Council process as time allows in the SSC schedule.

The SSC received brief updates on planned winter BBRKC surveys and tagging.