Appendix D

Norton Sound red king crab 2021 SAFE assessment model review by CPT (Jan & Sept 2021) and SSC (Feb & Oct 2021).

CPT: Jan 2021

Toshihide ("Hamachan") Hamazaki (ADF&G, Anchorage) presented the assessment for Norton Sound red king crab. A single model was presented at the request of the CPT from the September 2020 meeting (Model 19.0). The CPT appreciates Hamachan's responsiveness to the numerous requests made (including VAST GMACS explorations and providing pot loss data). Jen Bell (ADF&G, Nome) also presented information on the extent and future direction of research efforts aimed at understanding NSRKC population dynamics. For instance, pot loss data were presented in response to a CPT request, and Jen also described studies to understand where lost pots are moved by shifting ice. Other areas of investigation are the high abundances of male crab that track consistently from one year to the next in both surveys and harvests, infrequent but significant occurrences of barren females, and male functional maturity. Analyses of tagging data in years during which surveys were not available were particularly useful in better understanding cohort dynamics. The CPT expressed enthusiastic support for continued investigations of the research questions presented. Several members of the public also contributed to productive discussion around OFL calculations and historical perspectives.

The CPT accepted model 19.0 for use in management. Although the assessment author supported continued use of a retained catch OFL, the CPT endorsed the LNR2 method for accounting for discards to support calculation of a total catch OFL. The various methods for accounting for discards gave similar results, and the LNR2 method produced an OFL close to the median of the various methods. The author updated the relationship between carapace width and carapace length used to determine what crab are legal, but the CPT recommends that the methods be better described. The CPT recommended continuing the 30% buffer on ABC chosen by the SSC last year. The SSC justified the 30% buffer based on ten points (see table below). Some of these points are less of a concern this year, which might suggest reducing the size of the buffer would be appropriate. However, the CPT identified several new issues that should be addressed within the assessment such as fishery timing with respect to cohort progression, estimates of growth, changes in the definition of legal crab based on updated data used to translate between carapace length and width, and the way in which the OFL is calculated using 'legal' size (≥4 ¾" CW) crab, rather than a selectivity curve reflecting the 'exploited' crab (≥5" CW). The CPT considers that these points, at the very least, are a counterbalance to the issues that might be excluded from the SSC's list of concerns in the table below, which informed the CPT decision to retain the 30% buffer.

Although the assessment has used the abundance of legal male to define OFL/ABC, the CPT recommends that future assessments use standard methods with estimated selectivity and retention curves to define the OFL/ABC. Industry selection for larger than legal crab could result in higher F than F_{OFL} for retained crab and unaccounted discard for legal crab under market size. The CPT noted that the total catch OFL was very similar across all model scenarios examined.

The CPT had several requests for the author:

- Explore and document the reasons for the changes in the relationship between carapace length and carapace width. Document which data sources are excluded or included and for what reason.

- Plot the legal biomass over time using the different proportions of legal size crab to better understand the magnitude of the impact of the change.
- The OFL should be specified based on total catch including retained catch and non-surviving discard. Specifying the OFL based on legal crab would result in higher OFLs than if based on retained crab. This would then translate to higher exploitation rates on the exploitable crab than the target rates and increased discard mortality on non-preferred size crab that must be sorted through to achieve the OFL.
- Revisit growth assumptions. Growth appears to be consistently overestimated in the assessment, producing too many large crab. The CPT looks forward to seeing the results from the laboratory studies on growth for NSRKC at the next meeting.
- Revisit natural mortality assumptions. Both the assumed natural mortality for small crab and the larger natural mortality for crab greater than 123 mm CL should be better justified. The author noted that the maximum age observed in the tagging studies was 12 years, which is much lower than the assumed value of 25 years. Further, the "1% method" used by the authors to calculate a natural mortality generally provides lower estimates of M than empirical studies (see the tool at Barefoot Ecologist Toolbox for examples).
- Future figures of clutch fullness should include confidence bounds.
- Further consider which of the methods to account for discards are most appropriate for NSRKC given probable future data availability. The CPT realizes that no method will be perfect, but an imperfect consideration of discards is better than ignoring them.
- Explore having Jon Richar work on a VAST model for Norton Sound trawl surveys.

A list of SSC concerns that directed the adoption of a 30% buffer in 2020 with indications of whether the concern was still an issue and a brief explanation if it is not.

SSC Feb 2021

Martin Dorn (NOAA-AFSC) presented the 2021 assessment for NSRKC. Several members of the public also contributed testimony concerning model uncertainty, observations from the grounds, and historical perspectives in oral testimony. Public oral testimony is summarized below. There was also written testimony provided.

Wes Jones (Norton Sound Economic Development Corporation; NSEDC) testified about his concerns regarding the model and the current state of the stock. He clarified a point in the presentation, indicating that there was no market because the Alaska Board of Fisheries had closed the Norton Sound district to summer crab fishing. Mr. Jones clarified that if there were crab to buy, there may have been a market. Mr. Jones stated concerns about the low amount of NSRKC caught in the trawl survey and that the subsistence catch was the lowest on record. Current reports from this winter are revealing that the majority of the catch is sublegal, with very few crab of market size. Testimony was provided that the model has been overestimating growth, so the recruitment pulse seems to be a year ahead in the model rather than what the fishery is seeing on the grounds, and that the model is predicting a quicker recovery than reality. Therefore, a large buffer is warranted.

Charles Lean (Norton Sound Fishery Advisory Committee) testified that the current abundance indicates that the stock was still in rebuilding mode after taking large catches prior to 2018. He had concerns about the model producing too high a biomass estimate. His testimony referred to "passive management", and that State regulations and the management strategy were being disregarded. Mr. Lean also believes that pot loss rate is severely underestimated because, at the end of the season, there is no requirement to report lost pots. He has observed that when the ice is thinner, the pots drop quicker and closer to Nome, while in

years of thicker ice, they may be transported in the ice all the way to the Chukchi Sea. Since females reach sexual maturity about a year before males, there was a lull in clutch fullness because the pulse of young males was not mature yet. He noted that every time there have been clutch fullness issues, it coincided with heavy male harvest. He also described that handling mortality in the winter is much higher than the summer, so there is a need to establish two seasonal discard mortality estimates.

Scott Kent (NSEDC) described his experience as a fishery manager and developer of the harvest strategy. He noted that the harvest strategy was developed around the notion that the stock was rebuilt and that the local small boat fishery would not harm the stock. Initially, it was going to be a typical ramp harvest strategy, but there was a desire for more flexibility for managers to be able to apply a more conservative harvest rate. Mr. Kent stated that since then, the harvest rate has been set so that the GHL has been pretty close to the ABC every year. This seemed to be working early on, but now greater conservation is warranted. He suggested that the SSC should consider a larger buffer.

The SSC appreciates the NSRKC presentation and the work of the CPT and assessment authors. Responses to past SSC comments presented at the beginning of the document were thorough. The SSC also thanks the public for their useful testimony and observations from the grounds and the fishery. The NSRKC stock supports three fisheries: summer commercial, winter commercial, and subsistence. The summer commercial fishery, which accounts for most of the catch, reached a peak in the late 1970s, but catches have averaged around 10% of that peak recently. The commercial crab fisheries did not operate in 2020 and only winter subsistence catch occurred.

A single model was presented (19.0) as a viable model for setting specifications. A GMACS model was developed to mirror the existing model, but was not ready for full consideration. **The SSC supports the CPT recommendation to use Model 19.0 for specifications. Based on Model 19.0, stock biomass is above MSST so the stock is not overfished, and retained catch during 2020 did not exceed the OFL for this stock so overfishing is not occurring.** The SSC commends the state of Alaska for conducting their trawl survey during a pandemic. The 2020 survey biomass estimate was very low compared to 2019, yet the model does not follow that data point, and instead continues to predict an increase. Fishery CPUE had declined precipitously until 2019, and there is no CPUE value for 2020. Without these data, a valuable indicator of abundance and fishery performance is missing in this year's assessment. In addition, there was no NMFS 2020 trawl survey. The recommended ABC is more than double the 2020 ABC despite many indications that the stock may not be that healthy.

Some of the SSC's previous concerns were alleviated, such as the majority of the crab catch is occurring inside the survey area (>95% in nearly all years). The work on barren females was appreciated and seemed to be of lesser concern this year. The SSC thanks the authors for the information on pot loss and the potential impact of ghost fishing mortality. The information on using electronic trackers on the ice to consider where lost pots may end up was interesting and the SSC encourages further exploration. The authors report trouble with implementing the VAST model for NSRKC survey data and the CPT reported that Jon Richar's analyses suggest the NSRKC was not a very good candidate compared to other crab stocks. The successful tagging work showed fairly strong westward movement and the SSC encourages the upcoming efforts to increase tagging in 2021. The SSC notes that the tagging work might shed light on how closed the population is, and that future tagging work should include random releases to better understand whether crabs tagged offshore behave similarly to those tagged close to shore.

The most significant past CPT and SSC request was to shift to total catch harvest specifications. The author provided additional details on methodology to estimate discards in Appendix G. **The move to a total catch OFL and ABC in this assessment represents the best available science and the SSC supports this change to be consistent with other assessments and national standards for federal fisheries.** As the CPT stated, an uncertain estimate is better than ignoring discard mortality altogether. The method recommended by the CPT and the SSC produces similar OFL estimates as the other methods of estimating

total catch OFL and ABC. It also included a correction factor for the observer effect. The SSC believes that this is the best method at this time, but recommends the author continue to explore ways to improve discard estimation, either through refinement of the currently selected method, or through alternative data sources. The SSC has several clarifications and requests related to this methodology described in Appendix G.

- The CPUE methods use a denominator of pot lifts. Please describe whether soak time was relatively consistent, variable, or is completely unknown.

- The information presented in the Appendix G discussion was confusing and the SSC requests some clarification on the comparison among methods.

- Also, justification for not using the model estimated discards might be helpful to provide some context.

The SSC appreciates the CPT table documenting previous concerns expressed by the SSC when adopting the 30% buffer for NSRKC in 2020/2021 and whether they still represent major concerns. As stated above, some of these issues may have lessened slightly. However, in addition to those ongoing concerns, there are now some additional considerations listed below:

1. The ADF&G survey abundance is much lower in 2020 than 2019, and the model is not fitting this new observation very well.

2. The retrospective bias was 0.18 for the 10-year peel, but the SSC is unsure how confident to be in that estimate because of the different data streams and fixed retention probabilities. The Mohn's rho of 0.26 in the recent 5-year peel presented is somewhat more substantial and is positive. In other words, the model is overestimating MMB by 26% each year on average. The overestimation of growth may be contributing to this retrospective pattern.

3. One of the selectivity parameters is on a bound, and it appears to be survey selectivity which could contribute to the poor fit to the recent ADF&G survey data point. This also raises questions about if the model has properly converged.

4. The recommended ABC is increasing when the only available 2020 survey estimate is low, and fishery CPUE has steeply declined in past years. Since there was no commercial fishery in 2020, there is no fishery CPUE estimate which increases uncertainty. The fit to recent low commercial CPUE values is poor, similar to the trawl survey. There also were no NMFS trawl survey data to evaluate.

5. While an improvement, the minimal data informing the estimate of total catch OFL further emphasizes the uncertainty in the estimation of discards.

6. The high recruitment discussed last year was supported by a high survey biomass estimate. The low biomass estimate in 2020 lowers confidence in the magnitude of this recruitment pulse. This potential large recruitment is still mostly below the preferred commercial size.

The CPT recommended continuing with the 30% buffer recommended by the SSC last year. However, for the above reasons, and previous concerns identified last year that remain unresolved, the SSC recommends increasing the buffer from 30% to 40% this year (Table 2).

Overall, there has been a great deal of work that has been done for this stock and the SSC recognizes the effort by the assessment authors to address some long-standing and complex issues associated with this assessment. The SSC supports the CPT's list of suggestions and looks forward to considering a GMACS version of the model next year.

Beyond the concerns listed above, the SSC encourages continued progress on the following priorities:

General:

- Investigations into size at maturity for this stock, referencing that of other red king crab stocks if useful.

- The inclusion of local, traditional and subsistence knowledge (LKTKS) information in the assessment, an effort the SSC understands cannot be fully pursued until appropriate protocols are developed and pandemic conditions ease. This particular issue is also discussed further in the SSC comments on the progress report from the LKTKS Taskforce (Agenda Item D-2).

- Reporting on pot loss, especially in regard to potential pot losses at the end of the season as noted in public testimony.

- Continue exploration of data-weighting assumptions. Provide clarification and justification for the current data weighting scheme utilized in the model.

Assessment document:

- The authors' responses to CPT and SSC comments could be reorganized by topic, as opposed to review body, to reduce redundancy and clarify the authors' responses.

- In the Analytic approach, more descriptive text should be included in the sections describing the model and its assumptions, to reduce referring to Appendix A.

- Furthermore, a thorough description of the model selection and evaluation criteria, and most particularly, the results of the author's recommended models (and the base model, if they differ) is a basic requirement for a complete assessment document. A list of figures and tables is not an acceptable description of results.

- Finally, the figures should be reviewed with respect to the caption descriptions and legends. There were some inaccuracies or conflicting statements found.

- Please explain how the SD was determined for the CPUE as it is the same from 2000 - 2019. Is this a fixed SD? If so shouldn't the CV be fixed rather than the SD?

CPT Sept 2021

Toshihide (Hamachan) Hamazaki presented responses to CPT and SSC comments for the assessment for Norton Sound red king crab, summaries of current research, and two versions of the stock assessment model with updated data. Two key requests arose from Hamachan's responses to the CPT's management-related comments. First, participants in the industry reiterated the request to plot the market size crab so they can understand how many of the crab in the legal size are actually marketable. This request is not a change to the model, rather it is a spreadsheet exercise using the output of the model. Second, Hamachan suggested that a total OFL would not be presented going forward because no discard estimates would be available in the future due to cancelled ADFG surveys. The CPT emphasized that our goal is to provide OFLs based on total catch and requested Hamachan to bring forward methods to use historical data to estimate discard rates. A simple method of doing this would be to use the previous ratios of discard to retained catch to calculate discard from retained catch. A more complicated method

could involve models that predict discards from covariates such as retained catch, depth, and season.

The CPT previously requested that Hamachan examine several ecologically-motivated questions, including revisiting natural mortality and growth assumptions, investigating size at maturity, and female clutch fullness. Requests around M and growth arose from concern around how to address the discrepancy in model output and observations of large crab. Hamachan's presentation emphasized that the growth increments of tagged crab are well-fit, given fishery selectivity and M has been estimated repeatedly in the past, but estimates of M were higher than the currently used value and not adopted. Size-at-maturity from other stocks was not helpful for NSRKC, due to differences in apparent growth rates. Consequently, Hamachan did not recommend any changes to the current biological assumptions of the model.

No summer commercial fishery occurred during 2021, the winter fishery was very small, and the total harvest was 0.007 million pounds. The ABC was 0.35 million pounds, so overfishing did not occur. Poor weather reduced the ADFG survey area in 2021 and 80% of crab were caught at only three stations. Other on-going research was discussed, and included laboratory explorations of size-dependent mortality, identifying the size at which males are functionally (rather than biologically) mature, and satellite tagging of crab to identify movement into and out of Norton Sound. Based on preliminary data analysis, it appears that large male crab are not moving out of Norton Sound.

Hamachan presented two models with updated data for consideration: Models 21.0 and 21.1. Model 21.0 is Model 19.0 with discards estimated using the proportion method, a revised methodology for standardizing CPUE, and two retention probabilities estimated for both the summer and winter commercial fisheries. Model 21.1 is Model 21.0 plus $M = 0.18$yr-1 for all size classes. Some of the larger changes in model output appears in estimated selectivity for the winter pot fishery and the associated retention curve. Large differences in estimated abundance occurred when assuming a size-invariant natural mortality (Model 21.1 had generally lower estimates of abundance). Although the CPT was not opposed to the modeling changes presented in Model 21.0, they were not supplied with the appropriate documentation to evaluate the changes appropriately. Further, the CPT requests that 'bridging' analyses be conducted to demonstrate the successive changes made between models. Changes need to be made (and presented) one at a time so that the resulting effects can be clearly understood. Bridging analyses need to start with (and present) last year's accepted model.

SSC Oct 2021

The SSC received a presentation on proposed Norton Sound Red King Crab (NSRKC) model runs for February. The SSC thanks the authors for their responses to the SSC comments and suggestions. In addition to the base model (19.0), two new models were presented, Models 21.0 and 21.1. Model 21.0 is Model 19.0 with discards estimated using the proportion method, a revised methodology for standardizing CPUE with three time blocks, and two retention probabilities estimated for both the summer and winter commercial fisheries. Model 21.1 is Model 21.0 plus M = 0.18 for all size classes. The change in natural mortality in 21.1 results in a lower overall biomass trajectory, as expected with a lower M. The SSC requests that authors examine and describe differences among models caused by standardizing CPUE into three separate blocks.

The SSC supports the CPT recommendations to bring forward both Models 21.0 and 21.1 in February, in addition to the base model, 19.0, with updated data. Better documentation in the future is necessary to compare changes in models, including the change in retention probabilities and the CPUE separately, or other bridging analysis models. The draft assessment suggests that the model would be better fit with a higher M, and the authors should attempt to estimate overall M rather than fix all length classes at the lower value. The SSC recognizes that the author brought forward alternative models 19.4 and 19.5 in 2020, but suggests this be evaluated again for further contrast with Model 21.1. The rationale that it may result in a higher OFL should not prevent exploring a higher value for M if that may be the best description of the dynamics. **If feasible for February, the SSC would like to see a variant of 21.0 with an estimated natural mortality.** The SSC still hopes to see a GMACS version of the model, but recognizes this may not be possible by February. A verbal update on the status of the GMACS model would be helpful for the SSC at that time.

The SSC looks forward to learning about the mortality and maturity studies being done at the Kodiak lab as well as results from the recovered satellite tags when they are fully analyzed.

The authors noted that the State observer program was cut due to lack of funding since the last assessment, which will present a serious challenge for calculating discards and total OFL for future assessments. Alternatives should be explored including local knowledge. **The SSC agrees with the CPT that the OFLs should be based on total catch** and requests that the authors bring forward methods to use historical data to estimate discard rates.

The SSC had requested that the authors determine why the standard errors were all the same for the CPUE index since 2000. Appendix B (Table B-5) shows they are now slightly variable for that time period, but they are much lower than the earlier years in the model. The authors explain that the log SDs are "exponented (sic) back to normal space." This is not typically how log-sds should be used, so further clarification of the CPUE index in Appendix B and how the year effects are extracted would be helpful.