2018 Benchmark Stock Assessment of Main Hawaiian Islands Kona Crab

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Summary

A benchmark assessment for the Main Hawaiian Island (MHI) Kona crab was prepared for the Western Pacific Stock Assessment Review (WPSAR) process, which was conducted September 10-14, 2018 in Honolulu HI. The review panel consisted of two reviewers contracted through the Center for Independent Experts (CIE): Dr. Malcolm Haddon (Australia), Dr. Nick Caputi (Australia), and a member of the Western Pacific Fisheries Management Council (WPFMC) Science and Statistical Committee (SSC) who also served as the chair of the review panel: Dr. Steven Martell.

The assessment document describes data sources, historical fisheries regulation changes, and the previous 2015 stock assessment used for Kona crab. New in this assessment are changes to the format of the fisheries data (identification of individual fishers through the years and identification of single-reporting-day as the unit of effort), adjustments for female fishing mortality, 12 additional years of catch and effort data, a new CPUE standardization, the use of Bayesian state-space framework, and, the introduction of sensitivity tests and forward projections. The new assessment splits the time series into two

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blocks, 1958 – 2006 and 2007 – 2016, corresponding to the year in which the retention of female Kona crab was prohibited at the end of 2006. The assessment uses the Pella-Tomlinson surplus production model, conditioned on catch and fitted to the standardized CPUE data. Prior distributions for key model parameters used in this assessment were developed using well-reasoned arguments based on literature values and using the historical catch data to develop an informative prior for the carrying capacity.

A number of sensitivity tests were conducted for the draft report, and the review panel also asked for a number of additional sensitivity runs and other tests to better understand how the data was informing the model. One model feature of particular interest was the addition of a fixed amount of observation error as additional variance component to the total likelihood. The intent behind the addition of this fixed observational error term was to explicitly capture potential effects of inter-annual variability in fisheries catchability. However, model runs with the removal of this extra fixed error term resulted in overall improvements in the statistical fit to the data relating to an expansion of the estimated process error. It was also noted, that the overall model scaling increases with the addition of this fixed variance term. The review panel felt that, while it might be warranted to consider time-varying changes in catchability, it would be better to remove this fixed observational error term as it tends to result in increasing the overall model scaling and smoothed over variations in CPUE.

Catches in the last 3 years (2014-2016) are markedly reduced, down to less than 5% of the maximum catches observed in the mid-1970s. It is very difficult, when conditioning the stationary production model on the observed catch series, to have the biomass continue to decline over a 30+ year period of declining catch. There are no additional auxiliary data (e.g., trends in mean size of the catch) that would provide additional information on the current stock status, or provide evidence for shifts in production over time, or resolve changes in fisheries catchability. Given the qualitative differences in the recent CPUE trends (with low effort) and biomass trends, the review panel is concerned that the projection model may be optimistic.

Additional scientific information would be required to resolve the global scaling and the potential for non-stationarity in the underlying production function (e.g., time-varying changes

in K). A number of options were discussed amongst the review panel and the authors how to proceed with new studies that would help inform the model on global scale. For example, an independent survey to estimate absolute abundance, or experiment to measure catchability. Or, the use of an intensive mark-recapture program to directly measure the harvest rate combined with improved estimates of unreported catch. Or providing a more informative prior for K by using density estimates from more pristine grounds, and extrapolating to the total abundance using estimates of Kona crab habitat area. Continued reliance on fishery-dependent catch statistics and assumptions about units of effort alone will not resolve the uncertainty in population scaling.

The review panel greatly appreciates the tremendous amount of effort by PIFSC staff in preparing excellent documentation that is extremely well written, as well as, clear and concise presentations that complement the written documentation. The panel also thanks all staff and members of the public for detailed discussions to bring this review panel up to speed on the nature of fisheries operations, data wrangling, and endless running of models to help the review panel get a sense of how the data are informing the model.

The panel discussed the assessment materials in the context of the terms of reference provided for this review. The following paragraphs summarizes the panel's findings for each of the terms of reference (TOR).

TOR 1: Data quality and filtering methods.

Yes, the review panel all agreed that the new approach of developing an effort day index from the fisheries-dependent data was an overall improvement from the previous assessment. Corrections for female discard mortality since 2006 were incorporated based on the mark-recapture field work that was recently conducted. In addition, the tracing of individual fishers through the time-series enabled the inclusion of individual license holder as a factor in the standardization and opens the possibility of focusing attention on the primary contributors to this fishery. The primary challenge with these data is developing a time series of fishing effort that is representative of targeting Kona crab. Much of the Kona crab fishing is conducted in conjunction with other commercial fisheries (trolling and bottomfish).

TOR 2: CPUE standardization.

All members of the review panel answered "yes". The panel discussed a number of issues related to improvements in knowledge with experience. The "novice" group did not seem to have a large influence in the overall CPUE standardization. The review panel also requested a number of other model runs with different factors, in addition to looking at only fixed effects. The review panel all agreed that the major (available) factors influencing the variability have been properly used in the CPUE standardization.

It is uncertain to what extent that each record represents a single day fishing event. A considerable number of records (about 21% overall) contained daily catches of more than 500 pounds. Removal of these records from the CPUE index, and re-running the model with a modified index did not result in any appreciable difference in biomass estimates or reference points. Therefore, the review panel feels that any effects associated with multi-day trips appear to have little influence on the trends over time.

TOR 3: Assessment models: reliability, application and appropriateness.

All members of the review panel answered "yes". The assessment fit a Pella-Tomlinson state-space surplus production model to trends in annual CPUE data. The primary assumption of surplus production models is that CPUE is proportional to stock biomass. The model is appropriate for these types of trend data. In this application, the CPUE data were divided into two time-blocks, representing a major change in regulations (male only retention). This division of data was deemed appropriate, and the model was appropriately parameterized to accommodate the time blocking.

The residual patterns in the fit to the CPUE data could represent a number of factors including changes in catchability, changes in the underlying surplus production, or combinations of both. The review panel did discuss the merits of potential changes in

catchability over time associated with the changes in the number of active participants in the fishery. There were discussions of trying to model a random walk process for time-varying changes in catchability, but implementing such features were not possible during this review, nor was it clear that it would provide any changes in the final estimates of stock status and reference points.

There was a lot of discussion on the statistical properties of the estimator, where 3 variance terms were included in the model. The addition of a fixed observation error term (variance = 0.20) was added to try and implicitly capture potential changes in time-varying catchability. While in principle, this seems like a good idea, there is no way to measure this variance. Furthermore, increasing values of this variance term result in increasing in the overall scale of the biomass estimates. The review panel felt that a parameterization that involved only two variance components was more suitable. As its currently parameterized, it effectively adds a lower bound to the informative prior that is used for the observation error variance parameter.

TOR 4: Input parameters and decision points.

Yes, all panel members agreed that the input parameters and prior pdfs are reasonable chosen. Parameter values for prior distributions were obtained both from the literature and using the time series data itself to develop reasonable bounds for the carrying capacity, and the shape parameter *m*. The panel requested a number of model runs with alternative prior density functions, to gain insight into how the data are informing the model parameters. These perturbations of the prior distributions were very instructive about understanding how the currently available data are not informative enough to resolve the overall population scaling. The panel greatly thanks the assessment team for conducting a number of model runs during the course of the review. The decision points derived from standard reference points described in the Hawaiian FEP and as such are well founded.

TOR 5: Are primary sources of uncertainty documented?

Yes, all sources of uncertainty were described and well documented. Prior distributions for estimated model parameters were all defined. Structural uncertainty is limited given the model form, but appropriate for available data. The additional sensitivity analyses also reaffirmed model convergence and robustness of the estimates. This assessment is easily repeatable from the documentation, data and code provided.

TOR 6: Are model assumptions reasonably satisfied?

The review panel had extensive discussions on the model assumptions at a number of stages in the assessment. The primary assumption is that CPUE is proportional to biomass, and violations in this assumption could lead to biases in estimates of stock-status and reference points. The time blocks, marking the change to a male only fishery, is very appropriate. Factors that could potentially affect catchability were discussed extensively, and we were not able to conclude if these CPUE data would more likely hyper stable, or hyper depleted. Given this uncertainty, and the lack of information in the CPUE data about the underlying surplus production, the panel feels that "**yes"** the assumptions are reasonable, along with the informative priors for r, k, and m, and provide reasonable estimates of the lower bounds for stock biomass, but the upper bound remains highly uncertain.

The panel also discussed alternative sources of data, or alternative management tools, that could be used to better inform the upper bound in this assessment.

TOR 7: Scientifically sound results

All panel members answered "yes". The panel felt that the results from this model can be used to address management goals and be used for setting Annual Catch Limits. A caveat, given that these data are not informative about the upper bounds of stock biomass, is that we urge that annual routine monitoring of catch and effort continue to ensure that trends in CPUE do not continue to decline. If declines in CPUE continue with stable or increasing catches, then more immediate action may be necessary.

TOR 8: Projection methods

Yes, the methods used to project future population status are appropriately applied. The review panel noted that the stock projections need to be corrected to account for the female discard mortality rate .

TOR 9: Which, if any, model results should not be applied

The panel felt all results from this model can be used for management purposes with the following minor change: remove the fixed observation error term in the likelihood and double the observation error prior mean. The aforementioned model run was conducted during the course of the review, and the review panel concluded that the addition of the fixed variance term scales the stock biomass upwards.

TOR 10: Recommendations

The panel discussed a number of research recommendations outlined in bullet points below. These recommendations are organized into short-term (the next 2 months), medium-term (1-5 years) and long-term (5+ years), and are presented in order of priority.

Short-term recommendations:

- Remove the fixed variance term.
- Correct the projection results to account for the female discard mortality.
- Add a figure with the effort time series, displaying the proportion of trips with multiple species caught.
- Construct a time-series of mean weight (based on records with both numbers and pounds).

Medium term recommendations:

- Condition the model on fishing standardized fishing effort (i.e., the effort obtained by dividing the catch by the standardized CPUE) and fit to catch. The current implementation is conditioned on catch and fit to catch/effort, which assumes the catch is known without error (incl. the addition of unreported catch estimates).

- Tagging program to estimate harvest rates, along with movement, and other aspects of the stock dynamics. The over-arching goal would be to establish an anchor point to establish better information on the upper bound of this stock scaling.

- Continue with the CPUE standardization efforts in light of any new information.

- Have a closer look at the year-area interactions in the CPUE data (e.g., contraction and expansion of the fishery), or other possible factors (e.g., wind, currents, mean weight of the catch).

- Develop a time series of catch and effort data just for Penguin bank, where the vast majority of Kona crab are harvested. It would be useful to compare how the other 22 of 23 block are influence the trends observed just on Penguin bank.

- Conduct a scientific investigation if a male only fishery is appropriate given the sex ratio of the catch is now 49% male:51% female and a minimum size limit of 4". Under such circumstances and taking into account the discarding of undersized crabs, more than double the effort is required to achieve the same desired harvest rate; potentially doubling the amount of discarding, doubling the mortality rate on males for the same catch, and lowering the overall profitability of the fishery. This could also lead to some females not being mated if the sex ratio becomes skewed to females. Furthermore, if the fishery is restricted by an annual catch limit, retention of both sexes has the potential to reduce overall total mortality on all sizes of Kona crab.

- Explore other management tools for this stock. For example, SPR-based metrics for monitoring Kona crab mortality.

- Examine establishing a cost-effective fishery-independent survey of key fishing areas (e.g. Penguin Bank) with the collaboration of the 3-4 key fishers that take the majority of the catch and fish in the areas designated for surveys.

- Another approach that could be adopted to estimate catchability and biomass estimates would be a depletion study. This species appears to be well suited to a novel depletion approach based on a star pattern of fishing that has been developed by Liese Carleton (**lcarleton@vims.edu**) and John Hoenig (**hoenig@vims.edu**) (Virginia Institute of Marine Science). This would make for an excellent field project with the potential to collaborate with industry and open up additional sources of funding (e.g., The Saltonstall-Kennedy Grant Program).

- Examine if there are any environmental drivers affecting the recruitment that led to spikes in catches in the early 1960s, early 1970s and 1990s. Also, is there any shared covaration with other stocks that show similar trends in productivity during these same time periods.

Long term recommendations:

The committee made no long term research recommendations.