Crab Modeling Working Group
REPORT

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Crab Modeling Working Group

An interagency working group of SSC, CPT members (a number of which are also crab assessment authors) met 03/27/2023- 03/28/2023 at AFSC in Seattle, WA. The working group was initiated based on the SSC request in October 2022 to discuss the recent challenges faced in the assessment models for snow crab, Bristol Bay red king crab (BBRKC), and Tanner crab and to develop potential solutions, recognizing that the concepts discussed for these three stocks may be applicable to other crab stocks.

1. Objectives

The objectives of the working group were to:

I. Explore simpler (or more 'focused') 'base' models for at least snow crab, Tanner crab, and BBRKC to better understand and support the use of Tier 3 size-structured models with greater model parsimony and stability
   A. Identify the minimum aspects (data and parameterization) that are needed to start a model from scratch.
   B. Identify complexity that could be reduced through different parameterizations or simpler assumptions
   C. Identify specific features of recent models that may be causing convergence issues, such as parameters with very large variance estimates or maximum likelihood estimates occurring on or very near bounds
II. Allow authors the opportunity to explore building new models by adding features to simpler base models rather than limiting authors to only incremental changes from legacy models
III. Define the underlying assumptions of the Federal models/harvest control rules and the estimates/harvest strategies used by the State to establish TACs and identify where they differ.
IV. If time allows, explore a different Tier approach that could be included in assessments to serve as a 'fallback' if unexpected and/or major problems in Tier 3 calculations arise due to new data.

The objectives were set out as a loose guideline to structure the discussion. Over the span of two days, the working group broadly discussed each of the objectives and put forth recommendations, if applicable. This report summarizes the discussion into three main sections: (1) A summary of the discussion on the steps to reduce complexity and/or create a parsimonious Tier 3 model and appropriate processes for each stock, (2) A summary of the differences between the State and Federal harvest strategies, and (3) Introducing an alternative model for each of the three stocks that will act as a fallback option should the current challenges in the assessment models persist.

2. Steps to create a more robust Tier 3 model

Each assessment author provided an overview of their current assessment model and highlighted the current challenges faced in their respective models. Through discussions and comparison of challenges in the models, the working group identified three commonalities among the assessment models that could be addressed in the future:

  a. Specify growth and maturity relationships outside of the model rather than estimating within the model.
  b. Consider using the BSFRF data to inform a prior on Q and/or selectivity instead of modeling it directly.
  c. Collapse all small sources of mortality, such as bycatch fisheries, into one 'fleet' (holding bin) and estimate or fix selectivity.

Since utilizing GMACS has been deemed a priority for crab stocks, it would be better to build a focused GMACS model and add features as needed rather than spending the extra time bridging all legacy features to GMACS and then simplifying. This would allow authors a "fresh start" to use only necessary complexity.

2.1. Eastern Bering Sea Snow crab

A key challenge for snow crab management is that all commercially-sized males can be harvested if the biology of the stock is modeled as the best available data suggest, morphometrically mature male biomass is used as the currency of management, and the spawners-per-recruit proxies for management targets (F35% and B35%) are retained. In response to this, the working group concluded that moving forward, the assessment author would work on producing a model that incorporates the best available information on biological processes but establishes F=M on the exploitable biomass. This approach would place the assessment in Tier 4, based on the Tier 3 calculations being incompatible with maturity occurring largely prior to fishery selectivity and therefore generating F proxies at unreasonably high values..

2.2. Tanner Crab

As suggested in the commonalities section above, the Tanner crab assessment should move towards building a simpler (more focused) model in GMACS and add features from the legacy model at the discretion of the author, rather than spending the extra effort bridging all current features from the current model into GMACS first.

2.3.   Bristol Bay Red King Crab

The challenges in the BBRKC model focus on the estimation of Q for the NMFS trawl survey and retrospective patterns. It was noted that growth specification in this model appeared to be simpler and more robust than for Tanner or snow crab, likely due to the lack of a terminal molt. The working group suggested exploring the common areas addressed under the robust Tier 3 models in addition to exploring the origin of the current prior on Q, and other potential prior configurations.

2.4.   Process for proposed model integration

The working group recommended that the assessment authors integrate the recommended changes to the assessment model to the best of their ability but did not set a specific timeline requirement, recognizing that each assessment model has varying limitations and may require additional time to accomplish the working group's recommendations. The working group also suggests that, given the potentially large changes to these models and the urgency of achieving more stable approaches, it would be logical to allow authors to present this work as 'new' models rather than providing a detailed bridging analysis. Removing the bridging analysis will also reduce the required workload on assessment authors as they work to investigate how to incorporate the working group's recommendations into their assessment models. As assessment authors incorporate updates into their respective models, authors will maintain the review process through the Crab Plan team (CPT) and the Science and Statistical Committee (SSC) to retain feedback and recommendations.

3.   State and Federal Harvest Specification Process

The working group received presentations from Benjamin Daly (ADF&G) on the State total allowable catch (TAC) setting process and the State harvest strategy (SHS) with emphasis on snow crab, BBRKC, and Tanner crab harvest strategies.

A review of State harvest control rules was given: SHSs generally apply an exploitation rate of 5-22.5% (dependent on stock and stock status) to mature male biomass (or abundance). It was noted that these exploitation rates are generally lower than those used when calculating the OFL. Discussion was largely focused on other differences between the State and federal processes. The State incorporates numerous factors into its TAC setting process (as outlined in Section 8.2.2 of the Fishery Management Plan (FMP)), including estimates of stock status, estimates of exploitable biomass, estimates of recruitment, estimates of thresholds, economic considerations, *additional uncertainty*, and other factors pertaining to the health and status of the stock or ecosystem. Additional uncertainty includes management uncertainty (i.e. uncertainty in the ability to restrain catch below the ABC) and *scientific uncertainty identified and not already accounted for in the ABC* (e.g., estimates of trends and absolute estimates of size composition, molt status, reproductive condition, etc., and the quality and amount of data available for these variables). The State also considers market demand and the interests of harvesters and processors when determining the likely exploitable size range for different crab species. Under the FMP authority, the state considers the reliability of various population estimates (raw survey area-swept vs model-based) when implementing SHSs. As such, the inputs to SHSs may not be consistent with those used by the assessments when calculating the OFL. For example, survey area-swept data has been used as SHS input for snow crab TAC setting in recent years because of concerns about high model uncertainty, whereas the OFL is based on model-population estimates and, as such, are inherently higher because those estimates

are magnified by effects of survey selectivity. Additionally, the application of stock status in the federal F_{OFL} control rule is inconsistent with that of State harvest controls, where the federal F_{OFL} control rules applies projected stock status (i.e., projected MMB/B_{MSY}) and the State applies current stock status (i.e., current MMB/B_{MSY}). This is generally considered a nuance that has not been highlighted in the past; however, the current/projected stock status in the 2022 snow crab assessment was below/above the F_{OFL} control rule closure threshold. Because the State considers *current* stock status, the State harvest control rule implemented a fishery closure, whereas the assessment did not. Other inconsistencies between the federal and State processes were explored, including currency of management, definitions of B_{MSY}, etc. Concerns from the public about "double buffering" the TAC (i.e., ABC buffer via the assessment and some added buffer by the State) was briefly discussed, and it was noted that double buffering does not occur because the ABC buffer applies to the ABC itself, not other model-based estimates used as inputs to the SHS and associated TAC computations such as MMB, legal male biomass, etc.

The working group discussed the variability between the crab ABC and the TAC for these three main crab stocks, noting that for snow crab, as an example, the ABC has been on average 60% higher than the TAC in the last 10 years. The difference in the estimation of uncertainty between the State and federal process was explored. At this time, the working group did not have any formal recommendations but noted that the presentations were informative and useful in determining the differences between the State and Federal harvest strategies. Insight into the State harvest strategy proved beneficial for working group members to gain a better understanding of how the Federal process and state processes merge to provide management of the crab fisheries. Although constrained by the OFL and ABC, the SHS functions largely independently of the federal process. The working group found that future efforts to bring these approaches closer together could be beneficial for the prioritization of research efforts and transparency to stakeholders.

4. Proposed "Fallback" model options

In addition to addressing the separate assessment models, the working group hoped to establish a path forward detailing a basic model to act as an alternative option if the challenges in the current assessment models persist. The working group concluded that the most simple model to bring forward would be a basic Tier 4 approach in which B= survey-estimated (ideally using the REMA package) vulnerable male biomass (male crabs likely to be susceptible to both directed and incidental catch fisheries), OFL= M (adjusted by stock status)*B, ABC= buffer*(OFL), where the ABC buffer would be determined by guidance in the FMP and the common practice of buffering the ABC based on model uncertainties that has been documented by the CPT/SSC in meeting reports.To qualify as Tier 4, a measure of stock status would be necessary (e.g., B_MSY = average B over a fixed time period). Alternatively, the model could be Tier 5 using a "Tier 4-like estimate" to avoid the necessity of stock status and control rules. This would make these estimates most analogous to Tier 5 groundfish stock assessments that use the M*B type of harvest strategy. The working group supported bringing forward the proposed alternative model for all three stocks (snow, Tanner, BBRKC) at the May 2023 CPT meeting during the discussion of proposed model runs. The working group emphasized that this approach is not their preferred assessment model, and the assessment authors will continue to work on making adjustments to their assessment model through the avenues discussed above, but this alternative approach would allow the reviewing bodies to have a fallback option should the more complex models not converge during the fall meetings where OFL and ABC specifications need to be set. This would also provide a means of comparing like quantities

across crab stocks. In addition to, but not in place of the basic Tier 4 model described above, the subgroup supported authors also bringing forward a slightly more complex Tier 4 model (e.g., the Tier 3.5 snow crab model last year) if they choose that captures the growth and mortality between the survey and the fishery to calculate the biomass used in the HCR. Some of the working group was concerned that added complexity to the simple Tier 4 approach would undermine the effort to provide a transparent, simple estimate.

5.   Concluding thoughts

This working group was designed to provide for unstructured discussion and sharing of ideas among authors, CPT (a number of which were also crab assessment authors) and SSC members, following up on recommendations from previous reviews. The workshop participants recognized that they did not represent the opinions of the full CPT or SSC, and that further public discussion and review of all topics would be conducted through the May CPT meeting and subsequent SSC reviews. The working group recommendations provide a pathway forward for stock assessment authors to begin addressing the challenges that are faced in the crab assessment models. The working group recognizes that many of the topics discussed can be applied to other crab stocks not reviewed at this meeting. There is not another working group meeting scheduled at this time, but the members of the working group, CPT, or SSC can request another meeting if warranted to discuss ongoing challenges and further discuss crab modeling approaches. Overall, this workshop highlighted the value of informal discussion outside of the standard assessment cycle and Council process between assessment authors, Council staff, State scientists, CPT and SSC members.