# NPFMC January 2016 Crab Modeling workshop

A modeling workshop was convened from Wednesday at 2:30 pm through to Friday at 1:30 pm Jan 13-15th, 2016 at the Hilton Hotel in Anchorage, AK. Participants on the first afternoon included several members of the CPT, and issues covered (Appendix A) followed the terms of reference and some notes from the 2015 CIE review are provided in appendix A. Participants to the full workshop included: Bob Foy, Diana Stram, André Punt, Martin Dorn, Buck Stockhausen, D'arcy Webber, Cody Szuwalski, Kelli Johnson, Lee Cronin-Fine, Caitlin Allen Akselrud, Jack Turnock, Jim Ianelli (Workshop chair) Jie Zheng, Siddeek, Hamachan Hamazaki, and Scott Goodman.

## Application of GMACS and documentation

D'arcy Webber updated the progress and provided an overview of the GMACS software development and model specifications. Improvements included modifications to the plotting software, core model code, documentation, reference list, GitHub repository, and support code (e.g. Makefiles). A link to the presentation can be found here.

The selectivity code specifications were modified to allow flexibility for time-varying parameters and prior specifications. This included testing to ensure that previously functioning input files continued to be operational and efficient in terms of computational speed. The option to have selectivity coefficients was completed and is included in the GMACS assessment for the St. Mathew blue king crab (SMBKC) stock. In general, most developments continued to be tested with the data for Bristol Bay red king crab (BBRKC) (updated to include the 2015 data).

The ability of GMACS to handle size-composition data generically was added. Specifically, the capability of having variable numbers of size bins by sex was added and also the ability to aggregate observations, such that they can be fitted as combined (e.g. males and females fitted together in the multinomial). This latter feature affects the ability of the model to estimate sex-specific (or say shell-condition) processes.

Documentation of the code and all the activity is available on the website (e.g., the wiki at https://github.com/seacode/gmacs/wiki).

## Migration of an assessment to GMACS for ADFG/CPT/Council/NMFS specifications purposes

During the workshop, the main advances were to implement GMACS for BBRKC, SMBKC, Norton Sound red king crab (NSRKC), and Pribilof Islands red king crab (PIRKC). Side-by-side evaluations for BBRKC were limited during the meeting, partly because there had been mis-communication on which values (e.g., for the time series of natural mortality estimates) were to be used. The group with experience with the SMBKC assessment were generally satisfied with the performance of GMACS for this stock and were encouraged with its potential for acceptance as the assessment approach for presentation at the May 2016 CPT meeting (D'arcy's presentation of this work is available here). During the workshop, a number of SMBKC model configurations were evaluated and this served to highlight priority modifications that are needed. One such modification was to implement an option to allow greater control of the catchability coefficients for survey data (the initial model specification allowed a prior along with the analytical solution for this value). The ability to pre-specify catchability or estimated it as a normal parameter was developed during the workshop.

For SMBKC the following specifications were developed and presented to the group during the workshop

- M = Set (or allow to estimate) a pulse event in 1999
- Q=1

- Multinomial fixed sample size
- No added CVs for trawl or pot surveys

Additionally, the workshop requested that plots of discard mortality (ADFG estimated data versus model estimates) and fishing mortality be presented. Alternatives to compare with this "base trial" included

- Added CV for pot survey
- Added CV for pot and NMFS surveys
- Use Dirichlet likelihood for size compositions and estimate alpha

For NSRKC, Hamachan updated the files and made progress on getting **GMACS** to fit the available data. Workshop participants noted that as with the other stocks, accounting for seasonal patterns of crab survey, fishery, growth, and recruitment is needed. Presently, the input files for **GMACS** allow for seasons to be specified, but seasons still need to be implemented within the code and the dynamics.

Regarding PIRKC, Cody Szuwalski adapted his data files to test working within **GMACS** and found that due to the growth mis-specifications, the far off-diagonal elements of the growth transition matrix were exceedingly small and causing numerical overflow issues. The group discussed this issue and noted that a similar problem had occurred for earlier versions of the snow crab model and that this was rectified by setting the near zero values to zero.

The within-code simulation feature of **GMACS** was evaluated and tested to ensure that it was still working relative to all the changes in the code.

## Future Gmacs development and collaboration plans

Workshop participants agreed that the following features/options would be added **GMACS**, ideally early enough before the May CPT meeting that those working towards presenting an assessment in May would have time to thoroughly test the option:

1. The option to "spin-up" the assessment model by estimating as series of recruitments prior to start of the assessed period should be added. These recruitments could be either set to a mean value (on a log scale), or annual deviations could be estimated,
2. **GMACS** needs to provide options for estimating the OFL (and ABC) for Tier 3 and Tier 4 stocks for a one year projection.
3. The option for a catastrophic natural mortality event (i.e., one year with higher M) does not appear to have been implemented correctly, and requires further work. This option will be needed to compare to the current base model for SMBKC.
4. The annual cycle needs to be split into at least two seasons, one with both fishing mortality and natural mortality, and another with only natural mortality. The ability to calculate mature male biomass on February 15, and to account for the seasonality of crab fisheries are needed to apply the NPFMC harvest control rules for crab correctly.
5. Options are needed to fix survey catchability (q) at a pre-specified value and to estimate catchability with a prior, rather the analytical procedure for catchability currently implemented in **GMACS**. *NOTE: This was completed the last day of the workshop but not during session discussion period.*

At the close of the workshop participants discussed how best to plan for the 2016 OFL/ABC specifications cycle. For SMBKC, the group agreed that provided that there was close collaboration between the developers (mainly Webber and Zheng) that a completed assessment was feasible for consideration for acceptance in this specifications cycle (May/September). For BBRKC, it seemed likely that a **GMACS** version could be provided to be May CPT meeting and available as an alternative and/or included in an appendix. A coordinating meeting (or just conference call) at least one month prior to the CPT will help facilitate and notify progress on activities.

Extending applications to a broader group continues to be under consideration. The workshop focused solely on the needs for Alaskan crab stocks and noted that identifying contributors and other interested users would be required. The group discussed plans for project "ownership" and noted that the current option to identify core developers and ensure that contributions/roles from Council, Universities, ADFG, AFSC, and BSFRF people continues. The need to draw in new members and interest was highlighted. These issues should be revisited in conjunction with **GMACS** discussions at the May 2016 CPT meeting.

## Other issues examined

André Punt presented results from simulations on spatial or time variations in selectivity. He found that small changes in selectivity (between shots in this case, but also between years) affects the expected value of proportions by length and that the variance of the proportions depends on the length class and abundance to which the proportion relates. He noted that we should consider multivariate normal likelihood functions, and that plotting the variances of the proportions from the surveys relative to that expected under a multinomial distribution would be useful diagnostic on data collection properties.

## Appendix A Terms of reference

The main goals for ensuring progress of software development for crab modeling can be summarized as:

1) **Application of Gmacs and documentation**
   a) Update of progress and overview of gmacs software development and model specifications
      i) Minor updates to plotting software, core model code, documentation, reference list, GitHub repository and support code (e.g. Makefiles)
      ii) Major updates to the selectivity code
         (1) Improved prior and bound specification
         (2) Unit testing to ensure that this additional flexible did not slow down the code
         (3) Fitting the model to BBRKC and investigating the changes
         (4) Updated BBRKC input files to include one more year of data
      iii) Major updates to the size-composition handling
         (1) Allows any combination of size-compositions to be fitted simultaneously (e.g. males and females fitted together in the multinomial)
      iv) User experiences (Jie?)
2) **Migrate an approved assessment to Gmacs for use in specifications**
   a) BBRKC side-by-side evaluations and reconciliations
      i) "fixed" parameter values to same as BBRKC assessment model
      ii) Alternative evaluations (and summary of where differences occurring)
      iii) Simulation testing
   b) SMBKC model development and configuration tests
      i) Comparisons with scenario 1 of 2015 assessment
      ii) Evaluation of alternative scenarios (in principle)
      iii) Simulation testing

   c) NSRKC

      i) Update from Hamachan

3) **Future Gmacs development and collaboration plans**

   a) Plan forward for consideration in 2016 specs cycle including plan for May CPT review and what is needed to get there.

   b) Planning for Stage #2 timing/etc for broader workshop to pull in outside assessment folks interested in application to stocks outside of AK (and/or also other AK stocks?).

   c) Follow up on planning for broader Seattle-based workshop to increase usage/knowledge base of Gmacs application (need to contact potential contributors/interested users etc), timing

   d) Develop plan for ownership i.e., relative contributions/roles from Council, Universities, ADFG, AFSC, and BSFRF

## Points and notes identified from CIE review

- The current implementation of GMACs uses a continuous-F approach that operates with instantaneous fishing mortality rates across a full year. As a preliminary step to getting the assessment software functional this is a good first approximation, but to adhere to the generic technical specification (Maunder, 2012), and to allow for the idiosyncrasies of each fishery it will be necessary to convert the equations describing the dynamics into a step-wise seasonal interpretation of events, with the duration of each 'step' being approximated by the proportion of natural mortality imposed during each such 'step'.
- Include a SR relationship with a suitable lag (not urgent)

- Add an option for environmental forcing (not urgent)
- Add features to do snow crab growth and biology, i.e., a terminal molt  (not urgent)
- Not all features in existing crab assessments should be added to GMACS. But enough to make valid side-by-side comparisons
- Audit of key characteristics of crab fisheries and biology for Alaska crab stocks  (not urgent)

Other important things to do (see the gmacs GitHub repository issues list for a more comprehensive list of specific tasks https://github.com/seacode/gmacs/issues):

- Decide between the continuous F approach and the Hybrid F approach. This could be a key outcome of the workshop and could be coded during the workshop
- Add the coefficients selectivity option (will be done before January workshop)
- Ongoing improvements side-by-side comparisons (between Gmacs and Jie's model)