Modelling hake cannibalism and inter-species predation: Comments from the 2016 International Stock Assessment Workshop, progress to date, and pending work

A. Ross-Gillespie, A. Fourie, D.S. Butterworth and M. Bergh

Two separate hake cannibalism and inter-species predation models were presented to and discussed at the 2016 International Stock Assessment Workshop (IWS2016) held at UCT in December last year. These two models will be referred to as the OLRAC model (OLRAC 2016) and the MARAM model (Ross-Gillespie and Butterworth 2016). Fourie *et al.* (2016) details the differences and similarities between the two models, both in terms of model structure and results.

Comparison between the OLRAC and MARAM "predation-off" models

The panel for IWS2016 made the recommendation that the two models be compared in their "predation-off" modes (i.e. a version of the model where natural mortality is fixed with time, rather than varying with predation). Only once the "predation-off" results are comparable (or the differences are understood), can the full-predation models be effectively compared (Dunn *et al.* 2016).Particular emphasis was put on the use of the same stock-recruitment relationships between the models and that the natural mortality rates in the older hake classes are matched. These "predation-off" results should also be compared to the results from the standard single-species stock assessment model (referred to as the "Rademeyer" model, see Rademeyer and Butterworth 2017).

In order to achieve this, the following four steps were identified:

1. Set up a common data base with the most up-to-date data, to ensure that the OLRAC, MARAM and Rademeyer models all use the same input data.
2. Set up the full specifications for the Rademeyer model, to ensure that the methodology between the OLRAC, MARAM and Rademeyer models is as comparable as possible.
3. Compare the OLRAC and MARAM "predation-off" results in a similar manner to MARAM/IWS/DEC16/Hake Pred/P3, and include a comparison to the Rademeyer model results.
4. Compare the OLRAC and MARAM "predation-on" results.

Step (1) has been completed, and an excel spreadsheet (latest version is "20170214 V1.0 Input Data Master File.xlsx") has been circulated to the modellers as well as to D. Durholtz and T. Mc Gahey at DAFF. This spreadsheet contains the data that will be considered in this comparison exercise – no further data updates will be considered at this point in time.

Step (2)has been completed by R. Rademeyer, and the specifications as well as the latest assessment results are available in Rademeyer and Butterworth (2017).

Step (3) has not yet been undertaken at this point, but is next on the agenda.

Step (4) will be attempted only once Step (3) has been completed. Regarding this comparison, the panel made the comment that the equilibrium population set-upfor the two models should be compared, as for the same mortalities the set-up should be very similar. Ideally the two models should start with similar initial conditions as these can influence the subsequent dynamics substantially (Dunn *et al.* 2016)

Note that despite Steps (1) and (2), there will be still be some differences between the MARAM predation model and the other two, namely that the MARAM model is sex-aggregated, does not fit to age-length keys,

uses a Baranov formulation of the catch equation (as opposed to Pope's approximation) and uses a monthly time-step (in contrast to a biannual time-step in the OLRAC model and an annual time-step in the Rademeyer model).

Recommendations made specifically for the MARAM model

The following suggestions and recommendations were made specifically for the MARAM predation model, and are currently being addressed.

1. Correct the error in the implementation of the predation constraint. Furthermore, the predation constraint should not come into play at equilibrium.
2. Ascertain why the consumption by 14 year old and 15 year old hake is so different – it is more than the difference in predator numbers.
3. Plot the proportion of hake in diet by predator and prey species and age and by year, and examine the equilibrium proportions.
4. Investigate the "switching" and convergence issues, specifically try to identify which parameter(s) might be causing this.
5. Conduct a literature review of mortality on age 15 white fish.
    a. An M of 0.2 at age 15 means that they will live for typically another five years.
    b. Check the New Zealand hake age-structure for comparison.
    c. Check the longline catch age-structure when fishery started.
    d. Check the trawl age structure from when it is first available.
6. Combine diet data for West and South Coast, or alternatively develop a spatial predation model.
7. Scale prey-by-species information upwards to account for unidentified hake.

Recommendations made specifically for the OLRAC model

1. Extend the hake predation model in MARAM/IWS/DEC16/Hake_Pred/P1 to:
    a. Allow for time-varying amounts of hake in the diets of hake predators.
    b. Consider a constraint that the basal natural mortality rate decreases with age.
    c. Consider iterating the calculation of natural mortality to avoid assuming that the total mortality rate for year y is the same as that for year y-1 when computing predation mortality (or consider shorter time-steps).
2. Consider a sensitivity test in which the basal natural mortality rates are higher at low and old ages than at intermediate ages. The support for such a sensitivity test could be explored by examining age-composition information for longline-caught fish, ideally those caught during the early years of the longline fishery when untrawlable grounds were first intensively fished.

References

Dunn, A., Haddon, M., Parma, A.M. and Punt, A.E. 2016.International Review Panel Report for the 2016 International Stock Assessment Workshop.18 November – 2 December 2016, UCT.

Fourie, A., Ross-Gillespie, A., Bergh, M. and Butterworth, D. 2016.A comparison between the hake cannibalism and inter-species predation model presented in Bergh *et al.* (2016) and Ross-Gillespie (2016).Document MARAM/IWS/DEC16/Hake Pred/P3.

OLRAC. 2016. Method used to include cannibalism and inter-species predation in the species, sex, age and size disaggregated hake stock assessment model. Document MARAM/IWS/DEC16/Hake Pred/P1.

Rademeyer, R.A. and Butterworth, D.S. 2017. Specifications of the South African Hake 2016 Reference Case Assessment. Document FISHERIES/2017/FEB/SWG-DEM/07.

Ross-Gillespie, A. and Butterworth, D.S. 2016. Hake cannibalism and inter-species predation model: A summary of a PhD thesis and the development of the model since IWS 2015. Document MARAM/IWS/DEC16/Hake Pred/P2.