# Some key results from the hake predation model

*A. Ross-Gillespie and D. S. Butterworth*[1]
*email: mlland028@myuct.ac.za*

## Introduction

A selection of results is presented from the hake cannibalism and inter-species predation model (referred to as the hake predation for ease of reference) that forms the basis of a recently submitted PhD thesis (Ross-Gillespie 2016). Since the thesis is currently under review, these results are of a preliminary and confidential nature.

The hake predation model is based on the standard assessment model of Rademeyer and Butterworth (2014), but incorporates an additional term effects in the natural mortality rate to account for hake-on-hake predation and cannibalism.

## Results and discussion

Figure 1 compares the biomass-dependent natural mortality rates estimated by the hake predation model to those assumed by Rademeyer and Butterworth (2014), which are time-invariant and fixed on input. The mortality rates for the hake predation model are shown for the pre-exploitation equilibrium population structure (corresponding to the year 1916), and as average values over the most recent decades.

The high natural mortality-at-age values assumed for the Rademeyer and Butterworth (2014) Reference Case assessment have previously been something of a concern, as values as high as about 0.5 for 4-year-old hake seemed large for a fish of that age for which one would customarily assume too big for predators to have much impact. These high values were, however, necessary to explain the small numbers of older fish present in catches and surveys without having to invoke extreme extents of selectivity doming. The predation model, however, now provides a more objective basis to ascertain likely values of natural mortality-at-age. Up to age six these values are estimated to be even higher than Rademeyer and Butterworth (2014) assumed, so that the predation model confirms these highish natural mortalities at intermediate ages, which arise from the predation of hake upon itself.

Figure 2 shows various measures of population size for the Rademeyer and Butterworth (2014) model and for the hake predation model. The cohort biomass-at-age speaks to optimal size at first capture, which essentially corresponds to the age at which this biomass-at-age reaches its peak. Under the Rademeyer and Butterworth (2014) model, clearly hake are preferably not captured below age 2 (about 25 cm), whereas for the predation models this drops to age 1 (about 15 cm). Thus in terms of yield-per-recruit, catches down to a size as low as some 15 cm are not compromising the yield achievable from the hake resource, as above this size losses to natural mortality outweigh gains in mass. If reproductive output is taken into account, however, a case could be made for minimising catches of hake below about age 5 (some 50 cm); however this is not a high priority, given that hake assessments suggest stock-recruitment plot steepnesses not far below 1.0.

## References

Rademeyer, R.A. and Butterworth, D.S. 2014. Specifications of the South African Hake 2014 Reference Case Assessment. International Stock Assessment Workshop document MARAM/IWS/DEC14/Hake/P2.

Ross-Gillespie, A. 2016. Modelling cannibalism and inter-species predation for the Cape hake species *Merluccius capensis* and *M. paradoxus* . PhD thesis, University of Cape Town, submitted.

[1]MARAM (Marine Resource Assessment and Management Group), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa.

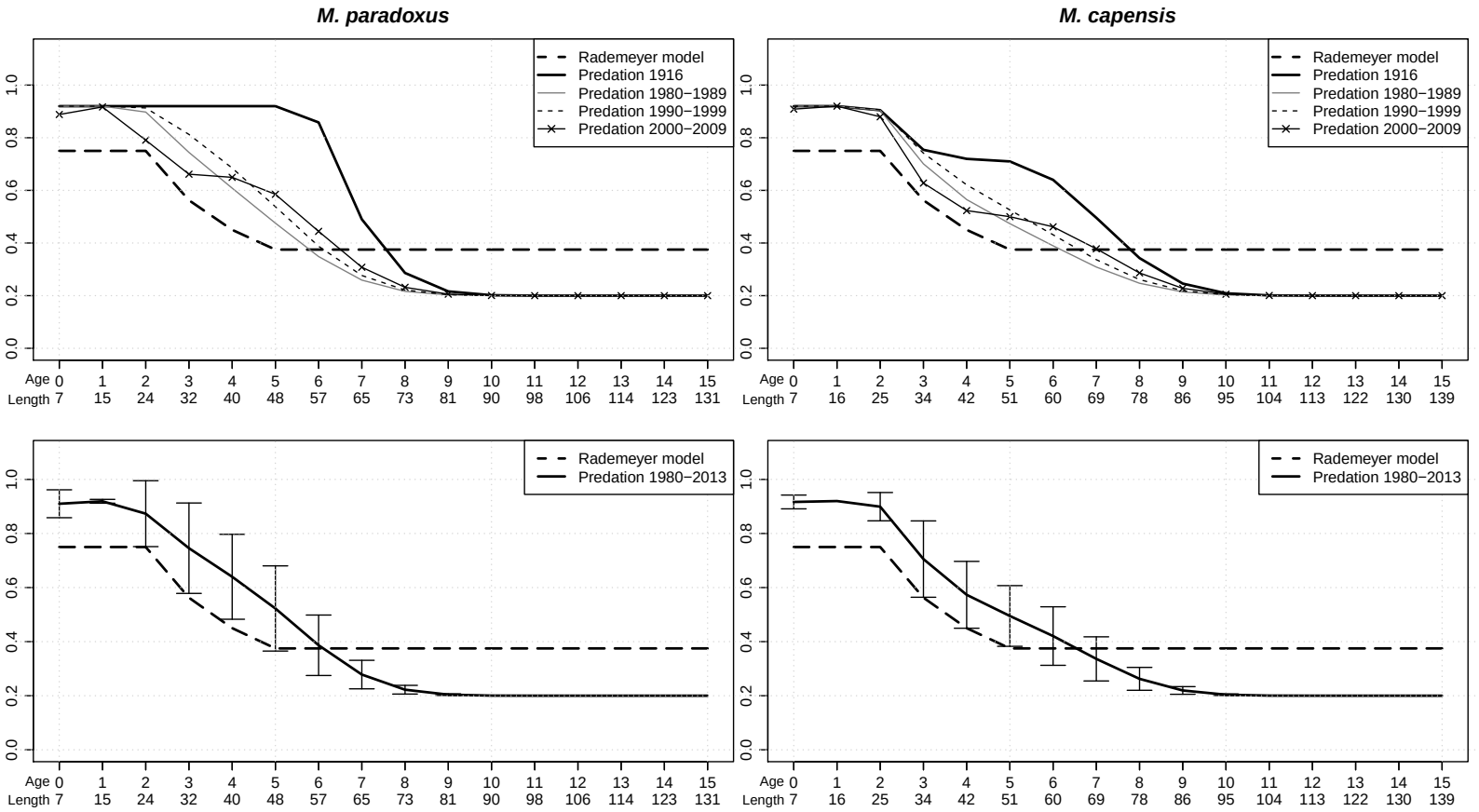


**Figure 1:** The natural mortality rates (consisting of the age-independent basal mortality of 0.2 yr-1 and the age-dependent predation mortality rate) are shown for the hake predation model. The top panel shows the 1916 pre-exploitation mortality rates, as well as the average mortality rates for the periods 1980-1989, 1990-1999 and 2000-2009. The bottom panel shows the average natural mortality rates for the period 1980-2013 along with the approximate 95% probability interval given by twice the standard deviation over the years 1980-2013. In all plots the natural mortality rates assumed for the Rademeyer and Butterworth (2014) model are shown by black dashed lines.

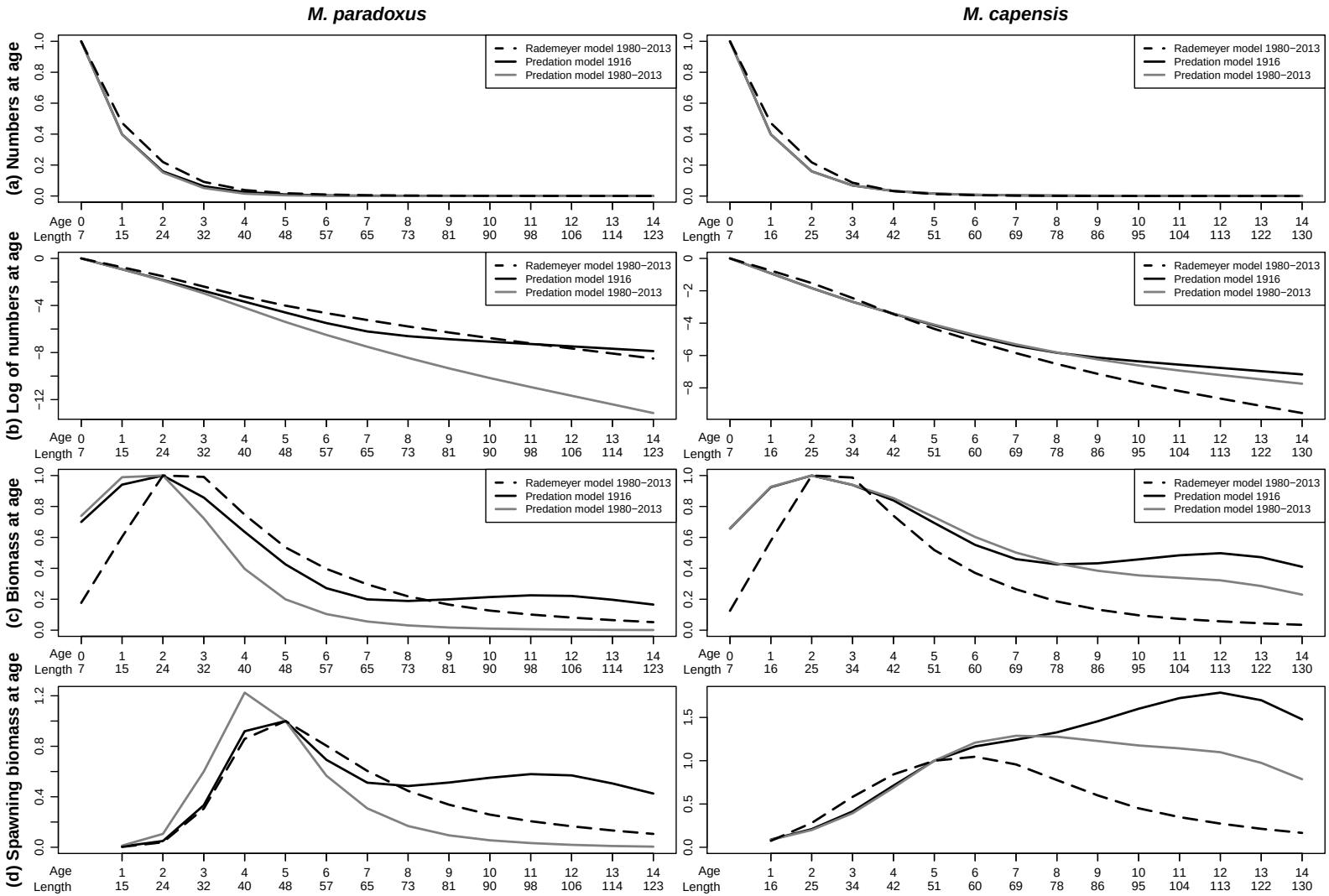


**Figure 2:** The *M. capensis* and *M. paradoxus* population sizes are given for the hake predation model in terms of (a) absolute numbers at age (normalised to equal 1 at age 0), (b) log of the numbers at age normalized similarly, (c) cohort biomass at age (normalised to equal 1 at age 2), and (d) cohort spawning biomass at age (normalised to equal 1 at age 5). These quantities are shown for the Rademeyer and Butterworth (2014) model, as average values over the years 1980-2013 for the hake predation model, and for the pre-exploitation equilibrium in 1916 for the hake predation model. Hake lengths in cm corresponding to each age are also shown.