Update on progress in modelling cannibalism and inter-species predation in Cape hake (*Merluccius spp.*)

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Background and past work

The work aims to build on that done by Punt and Leslie (1995)[2] in the development of a multispecies model for the two Cape hake species, *M. capensis* and *M. paraodoxus*. The authorsaimed to construct a model which included hake, seals and "other predatory fish" and then to use this model to assess the consequences of different levels of consumption of hake by seals on the hake fishery in the context of the change in the size of sustainable hake *TAC*s and catch rates. They also aimed to investigate the effect of seal culling on the fishery.

In the years that have passed since, more data have become available, and the hake assessment models have been continuously developed. The aim is to update the work done by Punt and Leslie (1995) with new data, and to extend the model to the level of the current hake assessment model (Rademeyer, 2012). Research will also be undertaken into other work done in the Cape hake multispecies realm (e.g. OLRAC, 2008 and 2011), as well as related multispecies models in fisheries (e.g. Kinzey and Punt, 2009), to investigate different possible methods for incorporating cannibalism and inter-species predation into the hake model.

Recommendations made at IWS December 2011

The proposed work was presented at the annual International Workshop (IWS) held at the University of Cape Town in December 2011. It was reviewed by a panel of international experts who recommended that the work be completed in roughly two to three stages, starting off as simply as possible to set up the model, and then gradually including more complicated components. A summary of the recommendations is given in Table 1.

Table 1: Recommendations made by the IWS panel in December 2011 for the development of the multispecies hake model.

Stage 1	Stage 2 or Stage 3
South Africa only	Since Namibia is important for modelling cannibalism, incorporate Namibian data in Stage 2 or 3 if possible, noting that data may be too scarce to accomplish this.
West Coast only	Stocks are assumed to be common across both West and South Coasts, so ideally both coasts should be included in Stage 2 or 3. It was noted that West and South Coast stomach content data need to be treated separately since hake are opportunistic feeders, and feeding will therefore be impacted by the environment.
No offshore (depth) structure	To be included at a later stage?
No sex-structure	Extend the model to something similar to Rademeyer's current hake assessment model (Rademeyer, 2012).
No "other predatory fish" or seals to be included in the model.	If there has been a change in the seal population over the years, try to take this into account in the mortality. A suggestion was made to use the reverseHolling Type II feeding relationship to take random effects into account in diet percentages (OLRAC 2011).
No fit to catch-at-length data (CAL) and age-length keys (ALKs)	Fit to CAL and ALKs, or for simplicity restrict to years for which ageing has been conducted and age-distributions can be calculated by combining ALK and CAL distributions external to the model fitting process.

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[2] See also Punt *et al.* (1995), Butterworth *et al.* (1995), and Punt and Butterworth (1995).

Use Holling Type II feeding relationship	Try implement Kinzey and Punt (2009) feeding model (although ADMB doesn't like estimating powers); Holling Type III (adjust to use a piece-wise linear function instead); Foraging Arena (EwE).
Use time-independent feeding relationships	Given more and longer time series of feeding data, attempt to allow feeding relationships to have an estimable temporal component.

Data to be used in the assessment

Table 2 gives a summary of the data that are available for use in the proposed multispecies assessment. Note thatrecent feeding data are currently in the process of being validated by the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF). An update on the progress of this validation process is given in FISHERIES/2013/FEB/SWG-DEM/03.

Table 2: Summary of available data

Data type	**Years**	**Coast**	**Species**
1. Catch data			
Offshore trawl fleet	1917-2011	South and West Coast*	*M. paradoxus* and *M. capensis*
Inshore trawl fleet	1960-2011	South Coast*	Assumed to be *M. capensis*
Longline fleet	1983-2011	South and West Coast*	*M. paradoxus* and *M. capensis*
Handline fleet	1985-2011	South Coast*	Assumed to be *M. capensis*
2. CPUE data			
Historic ICSEAF data	1955-1977	South and West Coast	Species aggregated
GLM standardised CPUE	1978-2011	South and West Coast**	*M. paradoxus* and *M. capensis*
Survey abundance estimates	1985-2012***	South and West Coast	*M. paradoxus* and *M. capensis*
3. Catch-at-age-data(Stage 1)			
Survey	1986-2006***	South and West Coast	*M. paradoxus* and *M. capensis*
Offshore fleet	1975-1996	Coasts combined	Species aggregated
Inshore fleet	1989-2000	South Coast	Assumed to be *M. capensis*
Longline fleet	1994-2000	South Coast	Assumed to be *M. capensis*
4. Length frequencies(Stage 2 or 3)			
Survey	1985-2012***		
Offshore fleet	1975-1999 2005-2007	South and West Coast Coasts combined	Species aggregated
Inshore fleet	1981-2000	South Coast	*M. capensis*
Longline fleet	1994-1997	South Coast	*M. capensis* and species aggregated
5. Age-length keys(Stage 2 or 3) – 1988-2012***			
6. Stomach content data			
Predator information	Age, length, mass and maturation state of hake predator		
Stomach content information	a. Classification of hake stomachs into empty, full and everted		
	b. Digestion state and mass of stomach contents		
	c. Classification of each prey item into lowest possible taxon, and, where possible, length of each prey item.		

*Note that for Stage 1, the catches will be split only by species, not by coast.

**Note that for Stage 1, a coast aggregated GLM CPUE series will be used (Rademeyer *et al.*, 2008)

*** Years vary depending on survey in question

Progress and Work plan

Unfortunately the process of feeding data validation is taking longer than anticipated, and this has in turn delayed the updating of the Punt and Leslie (1995) model with the new feeding data. Work has instead been focussed first on independently replicating the Rademeyer *et al.* (2008) model, with the aim of creating a framework which can later be developed to incorporate the cannibalism and inter-species predation effects, once the data are made available from DAFF. This replication process is in the final stages of troubleshooting.

The proposed work plan is as follows:

1. Replicate the Rademeyer *et al.* (2008) model with the aim of creating a framework which can later be developed to incorporate the cannibalism and inter-species predation effects, once the data are made available from DAFF.
   Progress: This replication process is in its final stages
2. Develop and formalise the proposed methodology for incorporating cannibalism and inter-species predation effects (i.e. setting out the population dynamics, likelihood function and model parameters).
   Progress: Research into various methodologies has commenced. The proposed work for this thesis was presented at an international stock assessment workshop in December 2011, and the comments from the international review panel will be taken into account in this step.
3. Include cannibalism and inter-species predation effects in the model developed in (1)
   Progress: Once the validated data have been made available, step (3) can commence. Should the data not be available once (1) and (2) have been completed, step (3) could commence using the available un-validated data, and then the work would need to be revised once the validated data are available.
4. Extend (3) to the level of the current Rademeyer (2012) assessment model.
   Not commenced yet
5. Extend (4) to include the effects of seal predation.
   Not commenced yet

References

Butterworth, D.S., Punt, A.E., Oosthuizen, W.H. and Wickens, P.A. 1995.The effects of future consumption by the Cape fur seal on catches and catch rates of the Cape hakes. 3. Modelling the dynamics of the Cape fur seal *Arctocephaluspusilluspusillus*, *South African Journal of Marine Science,* 16:1, 161-183.

Kinzey, D. and Punt, A.E. 2009. Multispecies and single-species models of fish population dynamics: comparing parameter estimates. *Natural Resource Modeling*22(1): 67-104.

OLRAC. 2008. Overview of methods and selected results from making allowance for inter and intra-species hake predation in hake stock assessments.Document MCM/2008/JUN/SWG-DEM/23.

OLRAC. 2011. Use of size preference information in hake assessments which include inter and intra-species predation. Document FISHERIES/2011/MAY/SWG-DEM/13.

Punt, A.E. and Butterworth, D.S. 1995.The effects of future consumption by the Cape fur seal on catches and catch rates of the Cape hakes. 4. Modelling the biological interaction between Cape fur seals *Arctocephaluspusilluspusillus* and the Cape hakes*Merluccius capensis* and *M.Paradoxus, South African Journal of Marine Science*, 16:1, 255-285.

Punt, A.E. and Leslie, R.W. 1995. The effects of future consumption by the Cape fur seal on catches and catch rates of the Cape hakes. 1. Feeding and diet of the Cape hakes *Merluccius capensis* and *M.Paradoxus*, *South African Journal of Marine Science,* 16:1, 37-55.

Punt, A.E., David, J.H.M. and Leslie, R.W. 1995. The effects of future consumption by the Cape fur seal on catches and catch rates of the Cape hakes. 2. Feeding and diet of the Cape fur seal *Arctocephaluspusilluspusillus*, *South African Journal of Marine Science,* 16:1, 85-99.

Rademeyer, R.A., Butterworth, D.S. and Plagányi, É.E. 2008.Assessment of the South African hake resource taking its two-species nature into account.*African Journal of Marine Science* 30(2): 263-290.

Rademeyer, R.A. 2012. The evolution of management procedures for the South African hake resource in the 2000s.Unpublished PhD thesis.University of Cape Town.