REVIEW OF TWO ANALYSES RELATED TO THE ROBUSTNESS OF THE MANAGEMENT PROCEDURE FOR SOUTH AFRICAN HAKE TO ASSUMPTIONS RELATED TO A STOCK DISTRIBUTION FOR *M. PARADOXUS* THAT EXTENDS INTO NAMIBIA

André E. Punt
Professor and Director, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195-5020, USA

Background

I have been asked to provide a brief written review of two documents 'to provide broad overview advice as to whether, given the data available, their analyses are consistent with best scientific practice, and sufficient to justify whether the management approach proposed by the South African client is adequate to cater for the possibility that the *M. paradoxus* resource may be shared to some extent between South Africa and Namibia.'

Best practice for the selection of management strategies[1] for exploited fish and invertebrate stocks is Management Strategy Evaluation (MSE)[2]. MSE is based on the premise that there are always multiple sources of uncertainty when managing natural resource populations and the most appropriate response to this is to develop a management strategy that can be shown to be robust a broad range of plausible hypotheses and to identify scenarios in which performance of the chosen management strategy will be unacceptable. MSE therefore involves identifying hypotheses, representing these using mathematical models of the system's population dynamics, the monitoring scheme, and relationship between actual removals from the population and implemented management regulations, and fitting these models to the available data. Projections are then undertaken for each operating model (usually dividing the operating models into a more plausible (or 'reference') set and a less plausible (or 'robustness') set and summarizing the results using performance metrics chosen to capture the (agreed) management objectives.

MSE has been applied to South Africa hake (*Merluccius capensis* and *M. paradoxus*) since the early 1990s, with management strategies changing in response to changes to the identified range of uncertainties and management objectives. I have been a member of the International Panel that has reviewed the assessments for the Cape hakes and the basis for selecting management strategies for them, and as such am fairly familiar with the biology of the species (as it is understood) and their fisheries. Most recently, I was involved in the Panel (2019) that reviewed the genetics information for the two Cape hake species.

The two papers

It is now recognized that genetic panmixia (i.e. an inability to reject the null hypothesis of panmixia) is plausible for *M. paradoxus* found off Namibia and South Africa. However, population models capture dynamics of demographic and not genetic populations (Waples *et al*., 2008; *Fish & Fish* 9) and genetic panmixia implies some interchange (at least genetically) among subpopulations, leading to a plausible range of hypotheses regarding stock structure for *M. paradoxus* from a single homogenous population to local populations (perhaps divided near the Namibian border) with limited interchange (sufficient to eliminate a signal of genetic differentiation but sufficient that the local populations are largely demographically isolated). An ideal MSE would involve (amongst others) operating models that span this range of

[1] Referred to as 'operational management procedures (OMPs)' in South Africa
[2] Also often referred to as closed loop simulations

population structure hypotheses, and in which the management strategies applied in Namibia and South Africa are tested simultaneously. The challenge in applying this ideal is that hardly any data to condition the Namibia component of operating models are available to the South African analysts.

The solutions taken in the two papers are: (a) to conduct projections for a 'two player game' in which Namibian management is unresponsive to the state of the shared stock (Butterworth and Ross-Gillespie, 2020a), and (b) in which the *M. paradoxus* population off Namibia and South Africa constitute a single homogeneous stock (Butterworth and Ross-Gillespie, 2020b). The latter case is not inconsistent with the genetics information but in the absence of further data from Namibia, it should be considered an upper bound of the stock that is subject to harvesting of South Africa.

The first analysis (Butterworth and Ross-Gillespie, 2020a) allows for an additional constant catch that is taken in Namibia from the "South African stock" under the assumption that some proportion of the South African *M. paradoxus* stock is found in Namibia. The assumption of a constant catch is an example of a 'two player game' where one player (South Africa) is responsive to monitoring and the other player (Namibia) is not. The premise of this type of game is that the first player will change their management actions given the decisions of the other player. By its nature, at some level of catch by Namibia (>80,000t) nothing that is done in South Africa can avoid undesirable levels of depletion. It would be expected that the scenarios considered are extremes in that Namibia should be conducting monitoring and its management strategy should respond to depletion due to excessive catches. As such the analysis in Butterworth and Ross-Gillespie likely over-estimates risk. It is clear that the management strategy for South Africa behaves expected (e.g. Fig. 2) by reducing catches. The management strategy for South African hake also includes an Exceptional Circumstances provision. The Appendix to Butterworth and Ross-Gillespie (2020a) reports the probability of Exceptional Circumstances being triggered but the consequences of this (likely further reductions in catch) are not simulated – as such the results again likely over-estimate risk.

The assessments based on the assumption of a homogeneous population also assume that fishery selectivity for Namibia and the offshore portion of the South African west coast are the same, and that 75% of the catch off Namibia is *M. paradoxus*. Violation of these assumptions could impact conclusions regarding stock status and biomass but in the absence of data off Namibia seem appropriate. The historical catches of *M. paradoxus* off Namibia are substantially higher than off South African in the years before 1990, and these higher catches imply greater biomass at least initially. The much lower catches off Namibia since 1990 (relative to those before 1990) support the conclusion that the stock should have rebuilt, and the fits to available data (all for South Africa) are not appreciably poorer when the Namibian catches are added to the South African catches. These fits are better (but again not appreciable so) when allowance is made for a regime shift in carrying capacity. While it is clearly preferable include Namibian data in an assessment that covers both Namibia and South Africa, the approach taken is adequate and the results follow well from the data.

Conclusions

- The papers I reviewed are not the ideal I would wish for - an assessment / MSE that uses data for Namibia and South Africa is the ideal. However, this appears not to be feasible at present, but the requests for data to be provided should continue.
- While there are clearly policy considerations here, the Butterworth and Ross-Gillespie (2020a) analysis is appropriate to justify that the management procedure for South

African hake shows robustness to the *M. paradoxus* stock being shared with Namibia. The analysis probably over-estimates risk because it assumes that no management action will be taken by Namibia irrespective of what monitoring may indicate. The analysis also over-probably over-estimates risk because the Expectational Circumstance provision will be triggered with higher probability for the cases where conservation performance is poorer than expected, but the consequences of such triggering are not explicitly taken into account.

- The assessment made under the assumption of complete demographic panmixia and homogeneity is technically correct in that if a population is perfectly homogenous, one does not need data over the whole range. The results should be interpreted with caution because it includes no abundance index data for a large portion of the range. Nevertheless, the conclusion that stock status is more optimistic follows from the assumptions made and the differences in the time-trajectories of historical catch.
- Overall, the analyses seem appropriate given the challenges of data availability and provide a reasonable basis to understand the consequences of the management system in place off South Africa if the *M. paradoxus* stock is shared demographically with Namibia.