First cut at broad model specifications for the development of transboundary hake stock assessments

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The November 2014 ECOFISH hake biology workshop (MARAM/IWS/DEC14/Hake/P9) identifies three stock structure hypotheses for *M. paradoxus* and five stock structure hypotheses for *M. capensis* - Figures 2 and 3 of that report are reproduced below as Figures 1 and 2.

Once these hypotheses have been refined and finalised during the workshop, and the data available to which to fit the population models have been clarified, there will then be the need to move to specifications of the associated joint assessments (see MARAM/IWS/DEC14/Hake/P1).

To provide a framework for that discussion, we offer the following structured approach as a "first cut"..

Stage 1:

1) Model fleets as areas (as in MARAM/IWS/DEC14/Hake/P2 with selectivity used as a surrogate for movement). This is the current approach for the existing country-specific assessments and is widely used internationally; it is relatively robust, and there is considerable experience in applying it locally. It seems the obvious choice for a first step.

2) Fit to catch-at-age and catch-at-length (for years without age-length keys) data for simplicity, rather than fitting to age-length keys and catch-at-length data. The latter approach, though applied for the current South African hake assessment, is complex and has not seemed to lead to major benefits or differences from the former, which was used beforehand; hence simplicity is preferred for this first stage.

3) Disaggregate by species. Clearly this is essential, but care will need to be taken in the specification of how to deal with period/data-type combinations where the information available is in species-aggregated form only.

4) Disaggregate by sex. This is a less obvious choice, particularly as it adds complexity and the data available which are disaggregated in this way are doubtless rather limited, but our preference is dictated by experience with the longline data in the most recent South African hake assessment (MARAM/IWS/DEC14/Hake/P2), for which satisfactory fits were not realised unless these data were disaggregated. This revealed important differences by sex in, for example, selectivity at length.

5) Commence population trajectories assuming unexploited equilibrium at the commencement of catches. This does raise difficulties with lack of the disaggregations above for earlier data, and there is the alternative available of estimating starting age-structures for some subsequent year. However this would omit the earlier ICSEAF-period CPUE series from the 1960s and 70s which are highly informative for the assessments as this is when the major reductions in abundance occurred, so that this would seem to be the preferred approach (unless some strong case for a regime shift can be made).

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6) Hard boundaries for both species. These would be set in the centre of any overlap regions indicated for some scenarios (as for example in Figures 1 and 2) in the interests of initial simplicity.

7) Selectivity. Maintain the current observation error approach for fixed forms for specified periods. The motivation is essentially the same as in 1) above.

Stage 2:

1) Take explicit account of overlap by allowing stocks to mix in hypothesised overlap areas instead of taking the boundaries to be hard.

2) The question that then arises is how to estimate the proportions by stock of catches in these overlap areas, given distribution models for the stocks themselves. Do genetic data offer this possibility for *M. capensis*, say?

3) Allow for process error in selectivity (e.g. SAM-type random walk variation from year to year).

Stage 3:

1) Model movement between areas explicitly. The suggestion would be to attempt this first using the gravity model (MARAM/IWS/DEC14/Hake/P5), given its fewer numbers of parameters compared to more general approaches (MARAM/IWS/DEC14/Hake/P3). Approaches such as GeoPop might provide a basis to put priors on some of these parameters.

2) Fit directly to age-length keys and catch-at-length data.
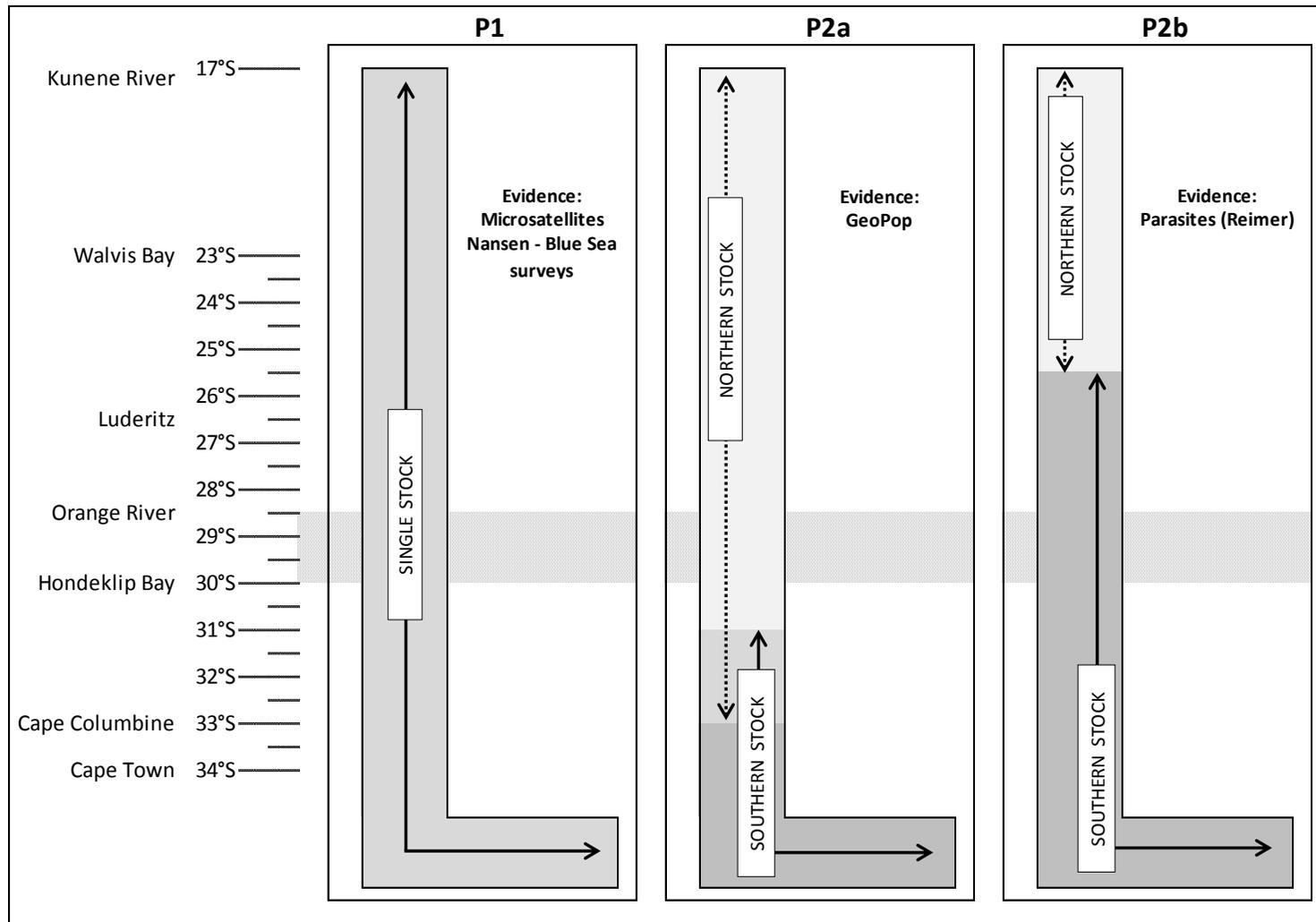
Figure 1: Schematic illustration of the revised *M. paradoxus* stock structure hypotheses arising from the November 2014 ECOFISH workshop. The border between Namibia and South Africa is indicated with the horizontal shaded area (the boundary on the coast is at the Orange River).
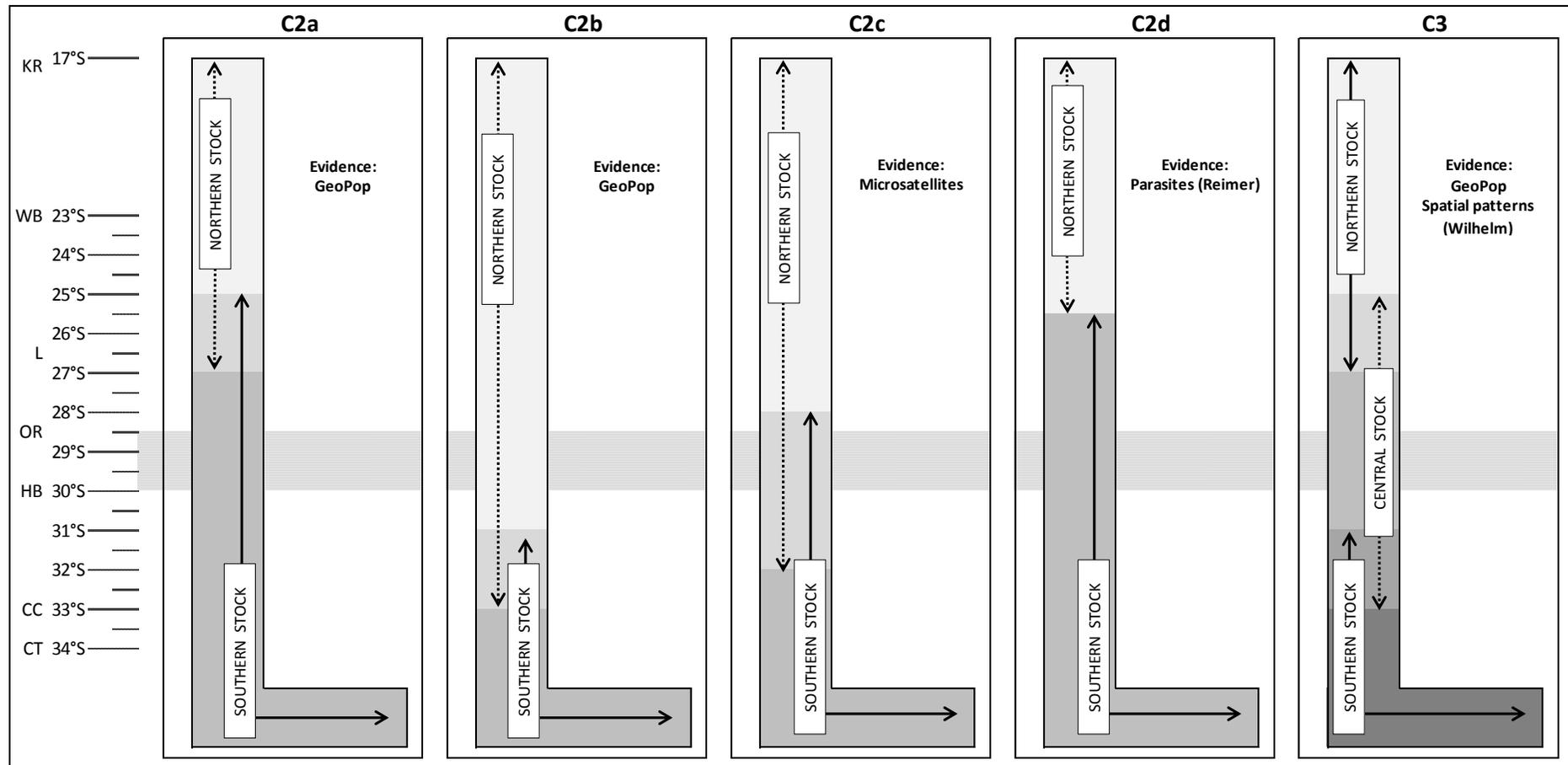
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Figure 2: Schematic illustration of the revised *M. capensis* stock structure hypotheses arising from the November 2014 ECOFISH workshop. The border between Namibia and South Africa is indicated with the horizontal shaded area (the boundary on the coast is at the Orange River).