REPORT ON DISCUSSIONS ON MODELLING STUDIES OF POSSIBLE INTERCHANGE BETWEEN THE C1 AND C3 BREEDING SUBSTOCKS OF SOUTHERN HEMISPHERE HUMPBACK WHALES, CAPE TOWN, DECEMBER 2008

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BACKGROUND

Over the week of 8-12 December, 2008, an International Stock Assessment Workshop was held under MARAM's auspices at the University of Cape Town. This Workshop reviewed and discussed further lines of research for assessment analyses of five Southern African marine populations. One of these was Breeding Stock C of the Southern Hemisphere humpback whales, with a focus on modelling of possible interchange between breeding sub-stocks C1 and C3. The specific intent in the humpback case was to identify work usefully carried out prior to the IWC Intersessional Meeting (on Assessment Methodology to take account of Mixing/Interchange between Southern Hemisphere Humpback Populations) scheduled for Seattle in February 2009, so as to facilitate progress at that meeting.

Drs A E Punt (University of Washington, USA) and A D M Smith (CSIRO, Australia) served as a review panel for the Cape Town Workshop, with those involved in the humpback discussions including a number of scientists who have attended past IWC Scientific Committee meetings: P Best, D Butterworth, C Edwards, K Findlay, S Johnston, A Punt and L Witting.

The documents provided to Workshop participants included the Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks from the 2008 IWC SC meeting in Santiago, and two of the documents authored by Johnston and Butterworth presented to that meeting:

a) SC/60/SH38rev: Updated assessments of Southern Hemisphere humpback breeding stock C and its component sub-stocks, and
b) SC/60/SH37rev: Capture-recapture analyses of humpback population sizes and increase rates: Breeding stocks C1-C3.

This Report provides a brief summary of the humpback-related deliberations at the Workshop.

DATA FOR INPUT TO ASSESSMENTS

In addition to data already used in SC/60/SH38rev and 37rev, Best and Findlay identified certain other sources of information on Breeding Stock C humpbacks that might either also be included in fitting population models, or at least provide qualitative insight into the plausibility of alternative interchange models. This further information will be summarised in a document to be prepared for the February meeting in Seattle.

INTERCHANGE MODELS

The Workshop identified an initial four alternative conceptual interchange models for humpbacks on the C1 and C3 breeding grounds (see Figs 1-3). Such interchange is distinct from mixing in the Antarctic feeding grounds, where the approach used in SC/60/SH38rev equations 3 to 7 (complete mixing, with annual catches assigned to sub-stocks each year in proportion to the relative abundances of those sub-stocks) was seen to be the most appropriate.

Resident model (Fig. 1)

No interchange on the breeding grounds between the C1 and C3 sub-stocks (as assumed for the assessments reported in SC/60/SH38rev and in the 2008 IWC SC meeting report).

Sabbatical model (Fig. 2)

There is a probability (α^{C1}) in any year that a C1 sub-stock whale, instead of swimming to the C1 breeding area off the east coast of Africa, will instead move to the C3 breeding area off Madagascar. Similarly a C3 sub-stock whale may instead move to the C1 breeding area. This does not affect the situation the following year, where the whale remains the more likely to move from the Antarctic to its home breeding area. A whale will visit *ONLY ONE* of the two breeding areas in any one year.

Migrant model (Fig. 2)
This is similar to the Sabbatical model, except that if a C1 whale travels to the C3 breeding area in one year, it then joins the C3 sub-stock (rather than being more likely to travel to the C1 breeding area again the next year), and behaves thereafter as a C3 whale (unless it happens to migrate again in a later year).

Tourist model (Fig. 3)
This is as for the Resident model, except that in any one year in addition to returning to the C1 breeding area, there is a probability (γ^{C1}) that a C1 sub-stock whale may *ALSO* visit the C3 breeding area (and similarly for a C3 breeding stock whale).

For most of the data available, it is clear how they relate (in different ways) to model constructs for each of these conceptual models. The one exception is the Cape Vidal shore-based count index, which could relate only to whales moving to the C1 breeding area in the year concerned, or include also a proportion of the whales moving to the C3 breeding area which might pass Cape Vidal before moving across the Mozambique channel to Madagascar. (Fig. 4 illustrates the latter possibility for a proportion δ of the C3 humpbacks.) However Best reported that few humpbacks had been seen in mid-channel during sighting surveys, and participants considered that this latter scenario to be of low plausibility relative to the former.

MODELLING STUDIES

Discussions in the Workshop led to the development of the following three suggestions for work desirably conducted for consideration at the February 2009 IWC meeting in Seattle, both to further existing assessment analyses for breeding stock C and to illustrate simulation testing of assessment methods which include estimators of interchange probabilities:

"1. The initial analyses for humpbacks should be based on four conceptual models (resident, migrant; sabbatical, tourist). Operating models should be based on the last three of these four models.

2. The analyses to be presented at the February 2009 IWC humpback workshop should be based on four variants of the sabbatical operating model and two estimation methods. The operating models should consider the impact of uncertainty in the true visitation rate and the number of animals which are marked. The two estimation methods should be based on the 'resident' and 'sabbatical' models.

3. The estimation methods are based on the Bayesian paradigm. For efficiency reasons within a simulation testing framework, they should continue to be implemented using the Sample-Importance-Resample method."

Note that the estimator initially considered for the sabbatical model will involve inclusion of the likelihood term in SC/60/SH37rev (see equations 7 to 11 thereof) that makes allowance for possible interchange between the C1 and C3 sub-stocks into the resident model estimation approach of SC/60/SH38rev. The Bayesian approach of that document seems preferable to a frequentist estimator in this instance because of the low numbers of re-sightings of humpbacks first photographed in the C1 breeding area. This means that the primary point of interest will be the statistical uncertainty associated with any estimate of interchange probability (and consequently current abundance), and Bayesian methodology offers probably the most straightforward approach to estimate the extent of this uncertainty. Specifications were suggested for the four variants of the sabbatical operating model to be used to illustrate simulation testing. Further discussion will be needed on how best to summarise the abilities of the various Bayesian estimation approaches to estimate measures of uncertainty (such as 90% probability intervals, for example).

Analyses for the Seattle meeting would be based on data as available and agreed for incorporation in assessments at the 2007 IWC SC meeting in Santiago (see Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks). Though photo-id data for further years are now available, it was considered that they should await endorsement by the Seattle meeting prior to incorporation in further calculations conducted after that meeting for report to the 2009 IWC SC meeting.

Figure 1a: *Resident* model map.

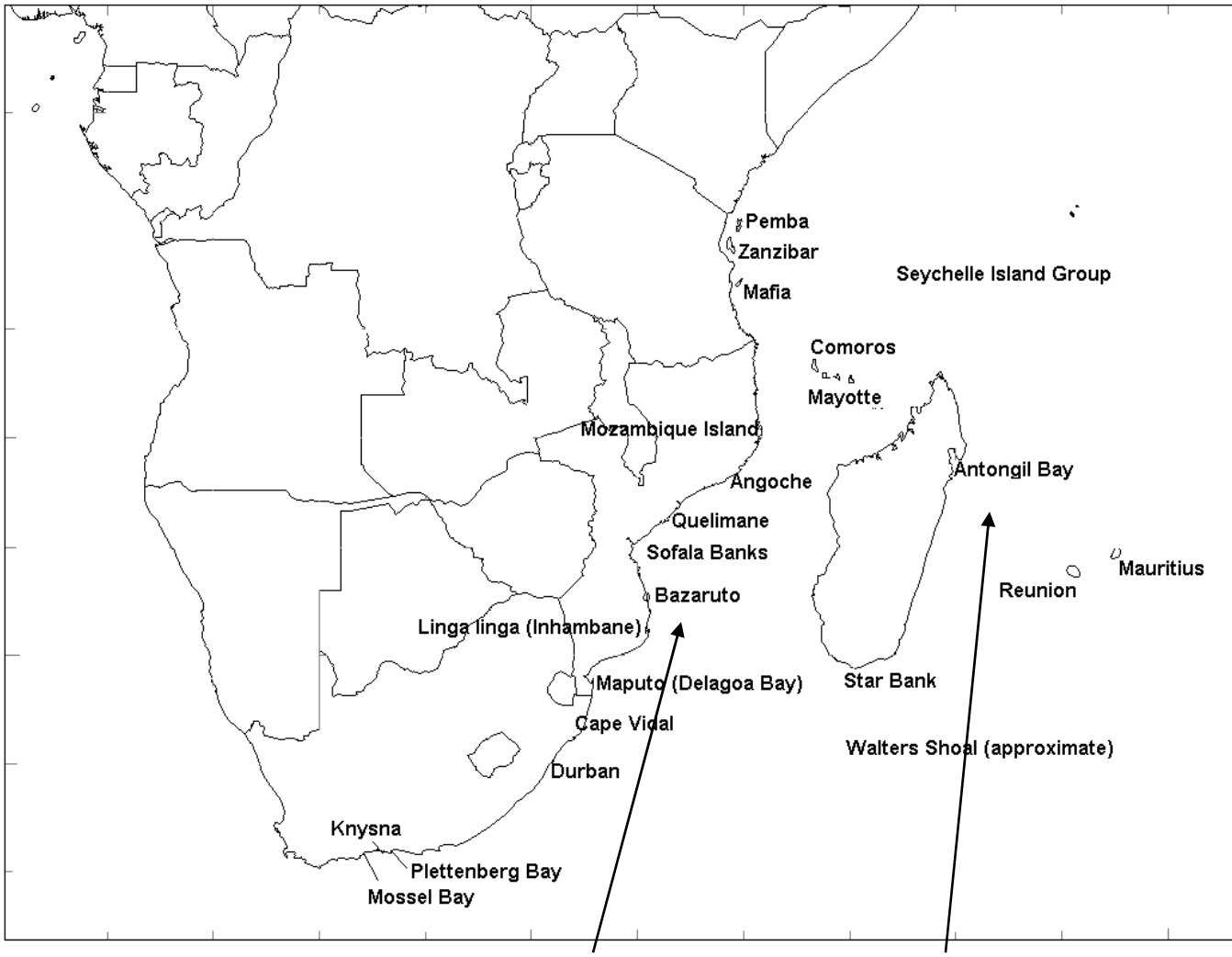

Figure 1b: *Resident* model - schematic

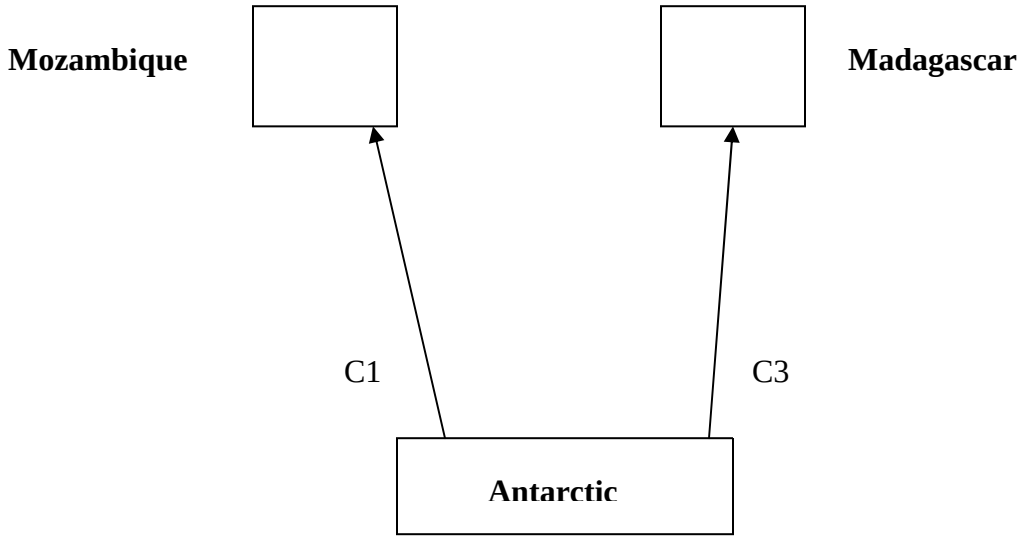

Figure 2a: *Sabbatical* and *Migrant* models map

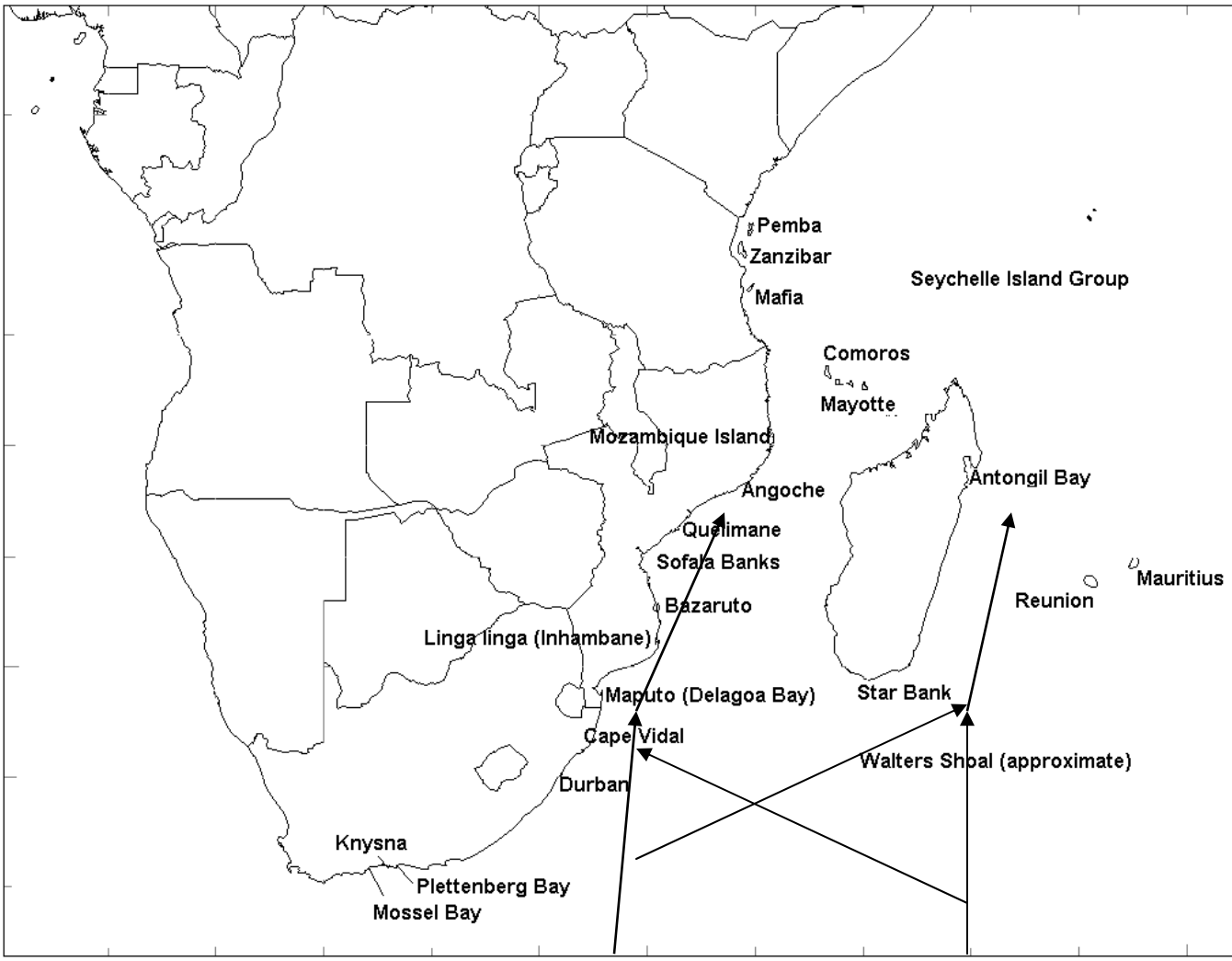

Figure 2b: *Sabbatical* and *Migrant* models – schematic: α^{C1} is the probability that a C1 whale moves to Madagascar rather than Mozambique in any one year, and similarly α^{C3} for a C3 whale moving to Mozambique rather than Madagascar. For the *Sabbatical* model the first mentioned whale is the more likely (probability 1-α^{C1}) to return to Mozambique the next year; whereas under the *Migrant* model once having moved to Madagascar it behaves thereafter as a C3 whale.

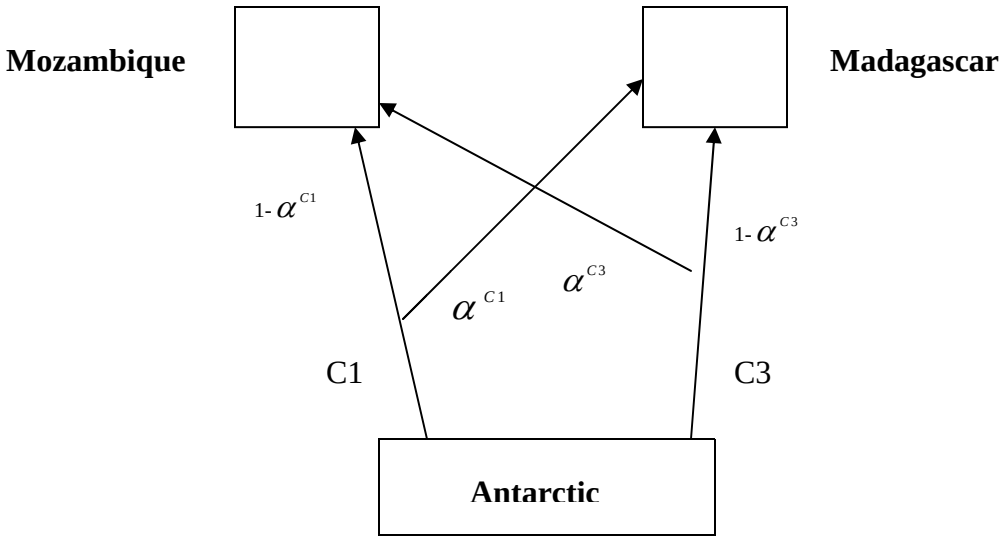

Figure 3: *Tourist* model – schematic: in any year, a C1 whale in addition to returning to Mozambique, has a probability γ^{C1} of visiting Madagascar as well that same year.

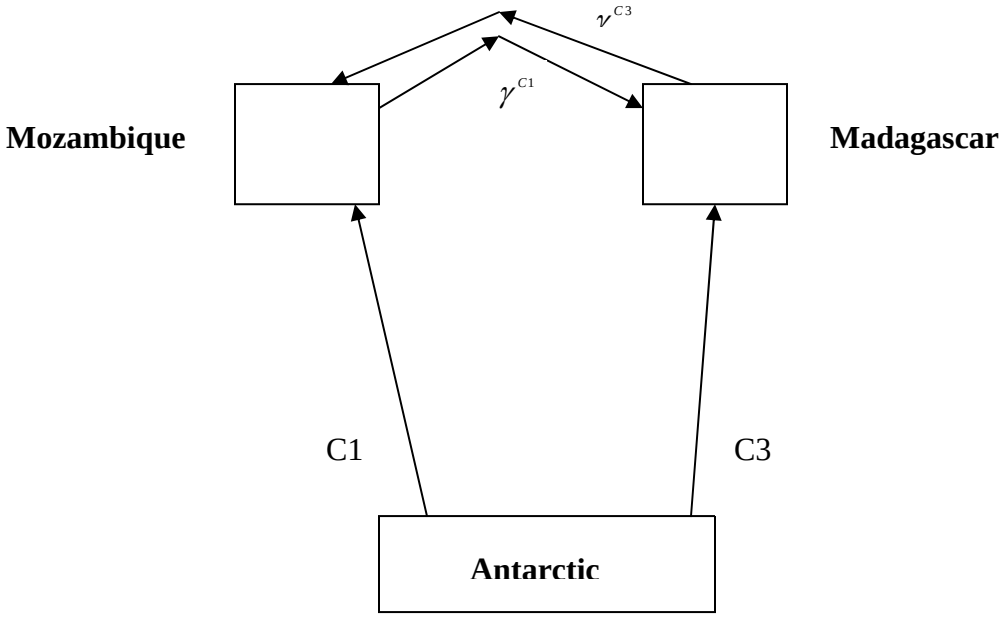

Figure 4a: Alternate Cape Vidal treatment map.

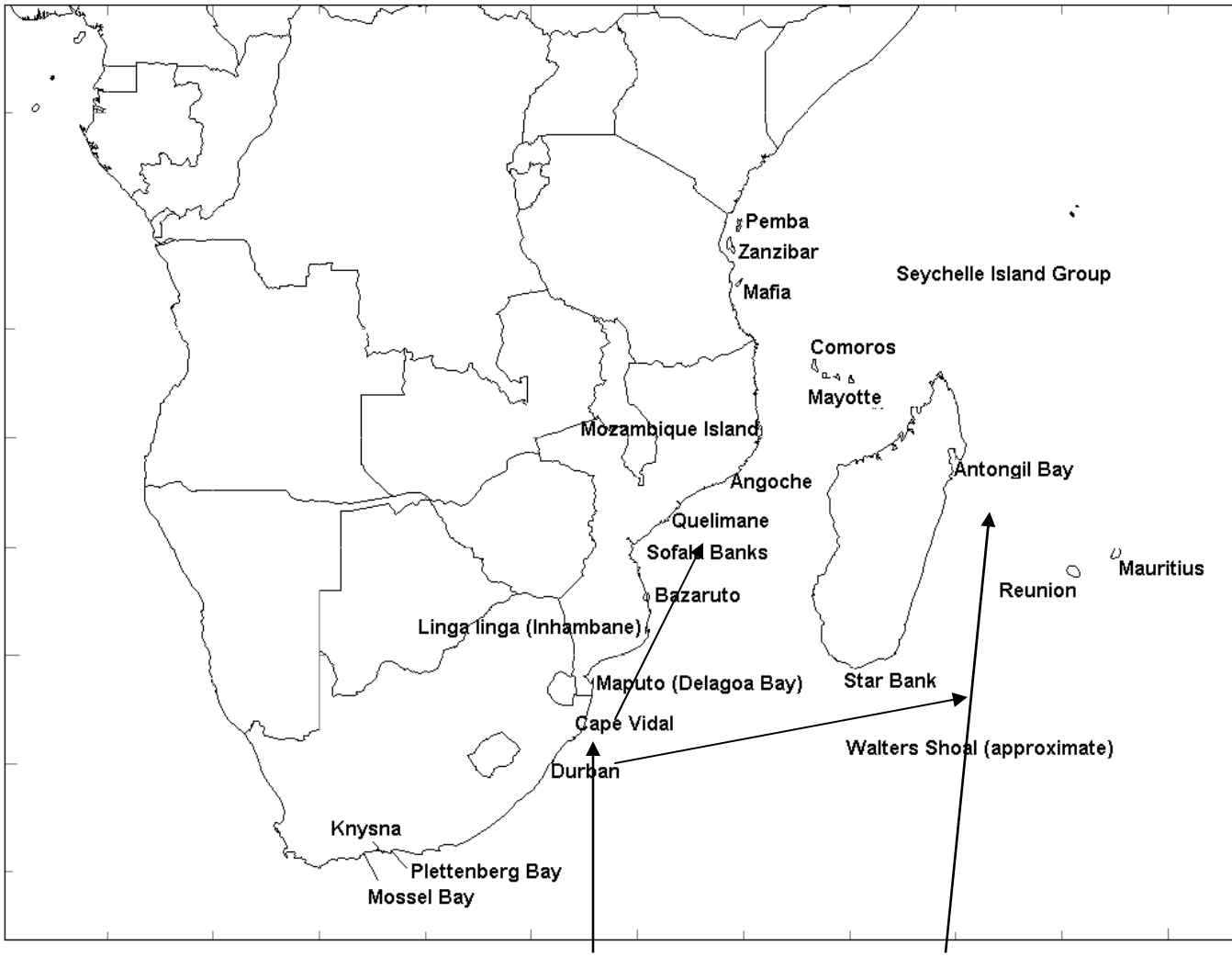

Figure 4b: Alternate Cape Vidal treatment – schematic: a proportion δ of the C3 whales pass Cape Vidal before moving across to Madagascar.