# Further Possible Movement Hypotheses for C1-C3 humpback whales

S.J. Johnston and D.S. Butterworth

---

This document lists some further hypotheses for the dynamics of the C1 and C3 humpback substocks, additional to those implicit in documents MARAM IWS/DEC08/HB3 and 4. They are intended to span a range of possibilities; hence some are perhaps on the extreme ends of the range of realism.

**Important Question**: are the abundance indices from Cape Vidal observations proportional to C1 or C1+C3, i.e. could some of the C3's travel as far as Cape Vidal before moving to C3 breeding area? This is reflected in the pairing of what would otherwise be five possible Hypotheses below.

Hypothesis 1: Totally separate movement from Antarctic to either C1 or C3 breeding areas (the current basis for assessment as in HB4).

Hypothesis 2: Both sub-stocks mixed between Antarctic and Cape Vidal, after which they split into C1 and C3 breeding areas.

Hypothesis 3: As Hypothesis 1 but including some visitor-based interchange with a probability each year of *q1* that a C1 whale visits the C3 breeding area (and so a probability 1-*q1* that it remains in the C1 breeding area), and similarly a probability *q3* that a C3 whale visits the C1 breeding area (the basis for the model in HB3).

Hypothesis 4: As Hypothesis 2 but including some visitor-based interchange as for Hypothesis 3.

Hypothesis 5: As Hypothesis 3, but the annual probability *p1* of movement of a C1 whale to the C3 breeding area results in permanent relocation of the whale concerned to the C3 breeding sub-stock, and *vice versa*. Note that in this case, for pre-exploitation equilibrium: $p1*K1=p3*K3$.

Hypothesis 6: As Hypothesis 2 but some permanent relocation as for Hypothesis 5.

Hypothesis 7: Totally separate northward movement from the Antarctic to either the C1 or C3 breeding areas, but a proportion *k1* of the C1 animals continue around the north of Madagascar to reach Antongil Bay where they mingle with C3 breeding animals.

Hypothesis 8: As Hypothesis 2 but continued movement of some C1 animals around the north of Madagascar to reach Antongil Bay as for Hypothesis 7.

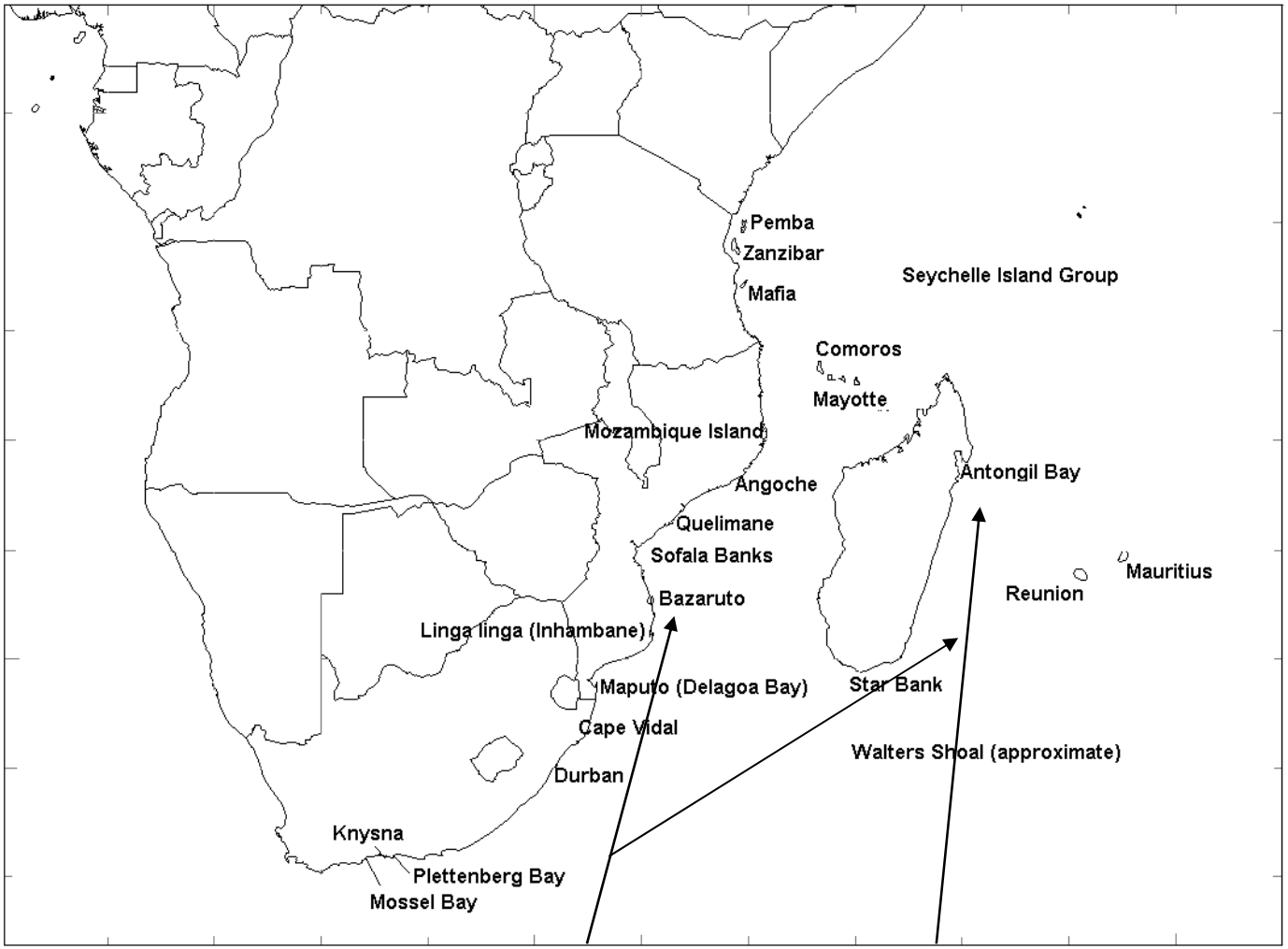
Hypothesis 9: As Hypothesis 7 but continued movement of a proportion *k3* of C3 animals (instead of continued movement of some of the C1 animals) around the north of Madagascar to mingle with the C1 breeding animals.

Hypothesis 10: As Hypothesis 2 but continued movement of some C3 animals around the north of Madagascar to reach the C1 breeding area as for Hypothesis 9.

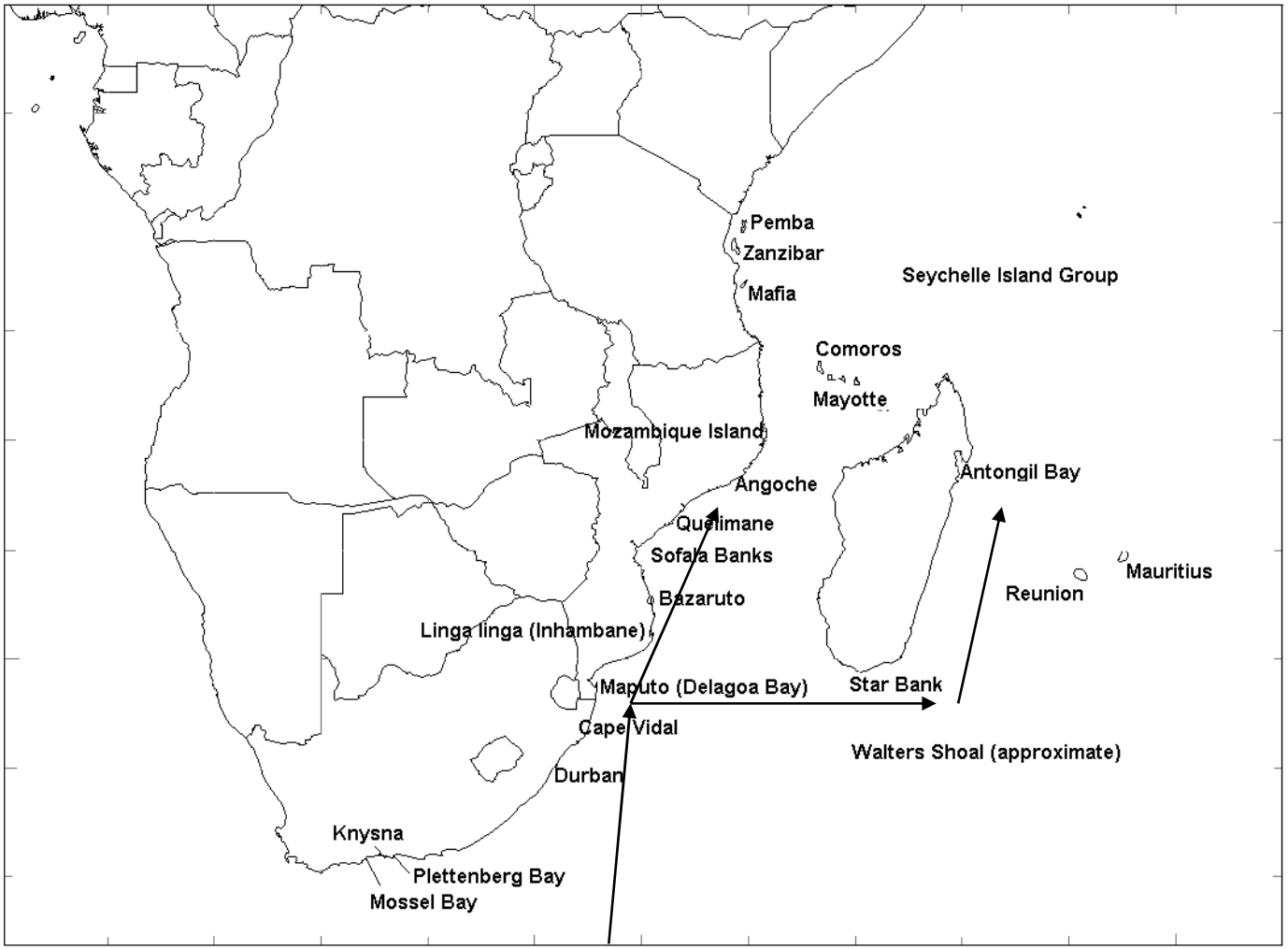
Note that all Hypotheses assume full mixing on the Antarctic feeding grounds, so that the Antarctic catches each year are allocated to C1 and C3 in proportion to their breeding stock sizes each year.

Table 1: Implications for interpretation of data for likelihoods and catch allocation – the various data sources could account for C1, C3 or some combination of C1+C3 whales.

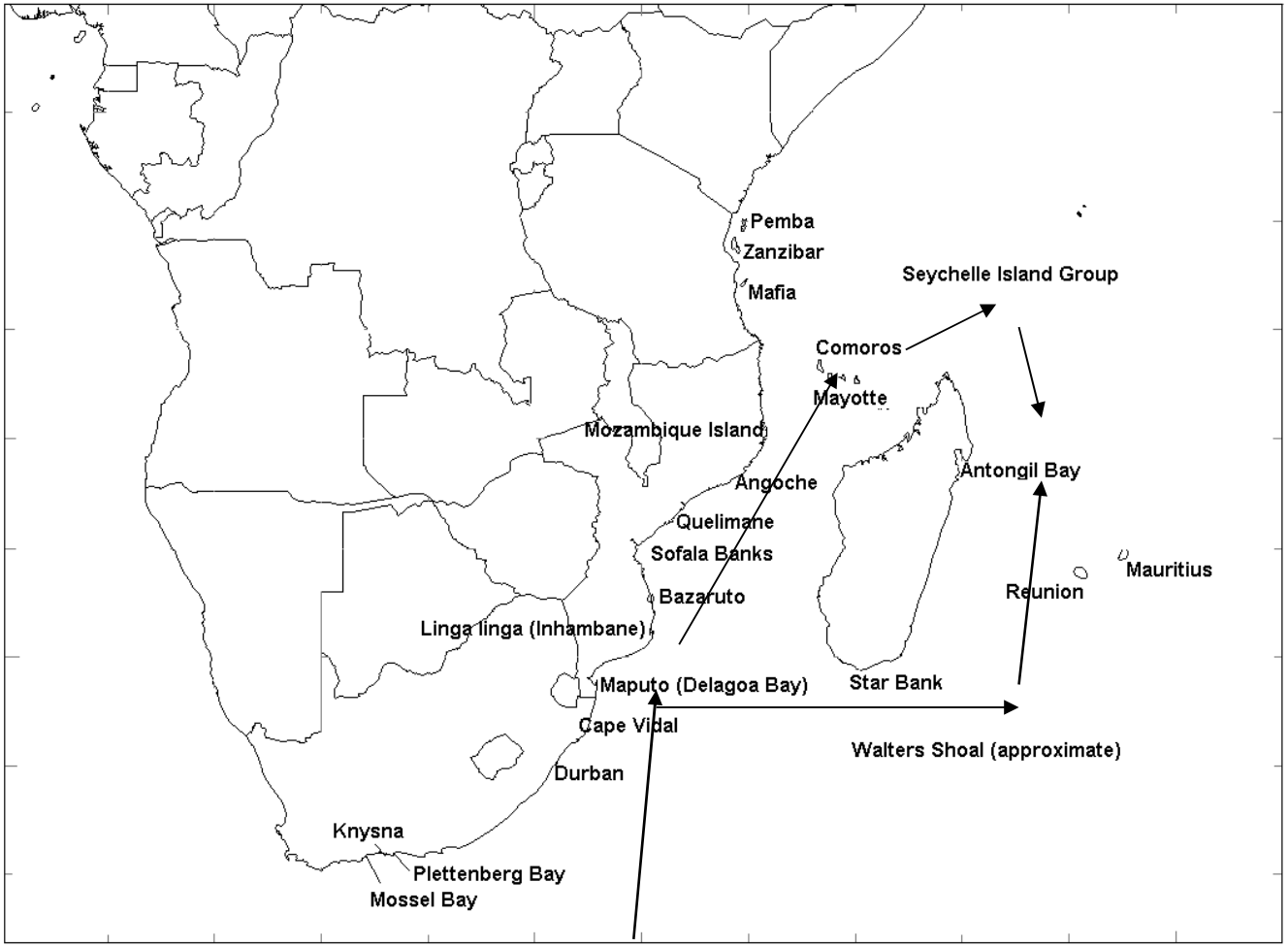
| Hypothesis | Low latitude catches | Old trend data For C1 | Photo-ID | | Cape Vidal (shore-based counts, Findlay and Best 1996; 2006) | Ship survey (Findlay *et al*. in press) |
|---|---|---|---|---|---|---|
| | | | East Coast | Antongil Bay | | |
| 1 - HB4 | C1 | C1 | C1 | C3 | C1 | C1 |
| 2 | C1 | C1+C3 | C1+C3 | C3 | C1+C3 | C1 |
| 3 – HB3 | C1+*g*3*C3 | C1+*q3**C3 | C1+*q3**C3 | C3+*q1**C1 | C1+*q3**C3 | C1+*q3**C3 |
| 4 | C1+*g*3*C3 | C1+C3 | C1+C3 | C3+*q1**C1 | C1+C3 | C1+*q3**C3 |
| 5 | C1+*p*3*C3 | C1+*p3**C3 | C1+*p3**C3 | C3+*p1**C1 | C1+*p3**C3 | C1+*p3**C3 |
| 6 | C1+*p*3*C3 | C1+C3 | C1+C3 | C3+*p1**C1 | C1+C3 | C1+*p3**C3 |
| 7 | C1 | C1 | C1 | C3+*kl**C1 | C1 | C1 |
| 8 | C1 | C1+C3 | C1+C3 | C3+*kl**C1 | C1+C3 | C1 |
| 9 | C1+*k*3*C3 | C1 | C1+*k*3*C3? | C3 | C1 | C1+*k*3*C3? |
| 10 | C1+*k*3*C3 | C1+C3 | C1+C3 | C3 | C1+C3 | C1+*k*3*C3? |




Hypothesis 1: Totally separate movement from Antarctic to either C1 or C3 breeding areas




Hypothesis 2: Both sub-stocks mixed between Antarctic and Cape Vidal, after which they split into C1 and C3 breeding areas.




Hypothesis 8: As Hypothesis 2 but continued movement of some C1 animals around the north of Madagascar to reach Antongil Bay where they mingle with C3 breeding animals.