FURTHER INFORMATION ON HUMPBACK WHALES FROM THE SOUTH WESTERN INDIAN OCEAN (BREEDING STOCK C)

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Abstract

Available abundance and trend data for the Breeding Sock C humpback whale population are reviewed, along with migration information, and abundance estimates currently not utilised in the Comprehensive Assessment are identified. The similar northward and southward migration stream abundance estimates from Cape Vidal in 1990, along with the 1991 abundance estimate from Mozambique and the presence of whales on the Madagascar Ridge south of Madagascar late in the season suggest migration streams to each of C1 and C3. Further sources of currently unanalysed information (particularly photo-identification material) are identified.

Introduction

The migrations of Southern Hemisphere humpback whales (*Megaptera novaeangliae*) from summer high-latitude feeding grounds to winter breeding grounds in low-latitude waters have been identified from both whaling data and tag and natural mark returns. Seven major breeding stocks (termed Breeding Stocks A to G by the IWC) have been identified within the low latitudes of the Southern Hemisphere (IWC, 1998), each of which has been linked to one (or possibly more) of seven feeding Areas (termed I, II, IIIW, IIIE, IV, V and VI). Certain of the breeding stocks (for example, the C or E stocks) show possible longitudinal subdivision across their winter breeding grounds.

The IWC Scientific Committee's Southern Hemisphere Whale Sub-Committee has been involved in the Comprehensive Assessment of Southern Hemisphere humpback whales since their 2000 meeting (IWC, 2001). Assessments to date have been based on a sex-aggregated production model (IWC, 1998) using either maximum likelihood estimation (e.g. Findlay and Johnston, 2001; Findlay et al, 2000), and more recently Bayesian estimation (e.g. Zerbini, 2004, Zerini *et al.*, 2006), and have been carried out by Breeding Stock. Model runs of assessments in each of these years since 2000 have included updated and new information on catches and on abundance estimates, trends and stock structure.

Humpback whales of Breeding Stock C (in the southwestern Indian Ocean) have winter aggregations off the coasts of Mozambique (Olsen, 1914; Findlay *et al.* 1994), Madagascar (Angot 1951; Bermond, 1950; Rosenbaum *et al.* 1997; Best *et al.* 1996), and the islands of the Mozambique Channel. Localities of places referred to in the text are shown in Figure 1. Three migratory corridors and breeding grounds were hypothesized by Best *et al.* (1998) in the southwest Indian Ocean, namely:

- the Southern African east coastal stream (identified in Best and Ross 1996; Findlay and Best, 1996) taking whales to a breeding ground in the coastal waters of Mozambique (Findlay *et al.*, 1994; Findlay et al, in press) - C1,
- a mid Mozambique Channel corridor conveying animals to the central Mozambique Channel islands of the Comoros Archipelago, Aldabra, and possibly the other Seychelle islands - C2, and,
- the Madagascar Ridge and Plateau corridor through Walters Shoal conveying whales to the coasts of Madagascar (Best *et al.* 1998) – C3.

While a further breeding region, C4 in the Mascarene Islands has been mooted, little or no contemporary or catch data are available for this region, and the population is possibly small. The basis for the division of the C breeding ground into three major sub-regions (C1, C2 and C3 and the associated Breeding Sub-Stocks C1, C2 and C3) by the IWC was originally based on co-incident presence of whales on the grounds (for example the densities of whales recorded by Findlay *et al.* (1994) off the coast of Mozambique in August/September, and by Best *et al.* (1996) off Madagascar at the same time of year, and the marked different catch histories from the C1 and C3 migration corridor and breeding grounds; whereas catches on the C1 whaling grounds (both breeding ground and migratory corridor) had declined by 1917, catches on the C3 grounds remained high in two eras in 1937 to 1939 and 1949 to 1950.

Information currently utilized in the Comprehensive Assessment of BSC

The information required for the Comprehensive Assessment, defined by the IWC Scientific Committee as “an in-depth evaluation of the status of all whale stocks in the light of management objectives and procedures” includes current absolute abundance estimates, trend estimates and an accepted catch history series. While the initial assessments of the C Breeding Stock were carried out using a combined catch series, and out by summing the abundance estimates across the three Breeding Grounds (initially the C1 estimate of Findlay *et al.* (1994) and the C3 estimate of Best *et al.* (1996) were used, while the C2 abundance as ignored), more recent assessments of the C Breeding Stock have been stratified between Breeding Sub-Stocks C1 and C3+C2, with complete overlap assumed between C2 and C3. The information currently utilized for the assessment of the C Breeding Stock has been described by Johnston and Butterworth (2009 – SC-F09-SH3). Areas or regions from which data have been collected are shown in Figure 2.

The absolute abundance data used in analyses are:

- A line transect survey abundance estimate of 5965 (CV = 0.17) for breeding stock C1 in the 2003 winter season (Findlay *et al.*, in press). Based on catches from historic whaling grounds on the Mozambique coast, this survey is believed to have covered the greater component of the C1 Mozambique breeding grounds,

although some component of the population of whales would have been to the north and to the south of the survey area during the survey period.

- Upper and lower abundance estimates for breeding stock C2+3 (obtained using the MARK program) applied to capture-recapture data from both photo-ID and genotypic data collected from Antongil Bay in the northeast of Madagascar), are provided in Cerchio *et al.* (2008a) as 6737 (CV=0.31) and 7715 (CV=0.24) for the year 2002. However, earlier assessment model runs utilized the point estimate from a line transect survey across the southern waters (south of 22°S) of Madagascar (Best *et al.* 1996).

Sources of trend information are available for sub-stock C1 including relative abundance estimates of northward migrating humpback whales from Cape Vidal, South Africa each year between 1988 and 1991, and in 2002. (Findlay and Best, 2006). Furthermore, other relative abundance trend data from the Durban whaling ground have been utilized (as reference data) including catch per unit effort data from Durban for 1910-12 (Olsen 1914) and four sets reported in Best (2003) including:

- Catch per unit effort data over the period of 1920-1928
- Catch per unit effort data over the period of 1954 – 1963
- Sightings per unit effort data from catcher vessels over the period of 1969-1975
- Sightings per unit effort data from spotter aircraft over the period of 1954-1975.

No trend data are available for C2 or C3.

Based on Discovery mark returns, the Area III feeding ground in the Southern Ocean corresponding to the Breeding Stock C was defined as between longitudes 10°E and 60°E (IWC, 1998). This longitudinal range spans summer concentrations of humpback in the region of 30-40°E as identified by Mackintosh (1942) and Omura (1973). IDCR/SOWER survey estimates (adjusted for areal comparability) provided by Branch (2006) are available for the Area III feeding ground (10^{o}E-60^{o}E) for 1978, 1987 and 1993.

One issue in the assessment of Breeding Stock C is the degree of overlap between Breeding Sub Stock C1 and C3. In 2008, photo-identification data from C1 and C3 (Antongil Bay) were presented to investigate the degree of mixing of whales across the C1 and C3 Breeding grounds (Cerchio *et al.*, 2008b). While comparisons have been carried out between single sites in C2 (Mayotte) and C3 (Antongil Bay), no comparisons have been carried out between C1 and C2.

Other information currently not included in the assessment

The C1 Breeding Sub Stock

As described in Findlay and Best (2006) the relative abundance index from Cape Vidal over 1988-1991 and 2002, is calculated from a narrow 19 days window common to each year. However the survey duration carried out in 1990 covered the peaks of the northward and southward migration (June to October), while the 1991 survey spanned the peak of the northward migration (June to August), and abundance estimates from these years (see Table 1) can be viewed as minimal point estimates of the population migrating along this coast. The estimates of the northward and southward migrations in 1990 are similar, suggesting equal proportions of the population making northward and southward migrations on this coast.

Both 1990 migration corridor estimates are similar to the 1991 northward migration population estimate and the abundance estimated of 1954 (CV = 0.38) from the Mozambique line transect carried out in August – September, 1991 (Findlay *et al.*, 1994). Although these line transect and shore based migration survey estimates are not directly comparable, the across year results suggest that the northward migration stream passing Cape Vidal in June to early August and the southward migration stream passing Cape Vidal in late September and October from Cape Vidal is similar in size to the C1 Breeding Ground population off Mozambique in late August – early September. Alternatively if a major portion of the Cape Vidal northward migration and southward is moving directly to C3 without visiting the C1 Mozambique grounds, then a similar proportion of whales must arrive on and leave the C1 Mozambique breeding grounds via an alternate migratory corridor.

The C3 Breeding Sub Stock

The initial assessments of the C Breeding Stock utilized the line transect survey estimate of Best *et al.*, (1996) from the coastal waters of Madagascar south of 22°S in August 1994. Humpback whales were found throughout the area surveyed and the number of humpback whales in the area surveyed was estimated as 2532 (CV = 0.27). However as noted by Best *et al.* (1996), Bermond (1950) divided the catches of humpback whales in 1938,1939 and 1949 into 5 zones around the coast of Madagascar. Approximately 90% (1938), 78% (1939) and 79% (1949) of these catches were from the sector to the east of 44°10'E and to the south of 24°30S (the southern and southeastern sector of the coast of Madagascar). Best *et al.* (1996) noted further that the bimodality of catches by 10 day decade in these seasons suggested that the migration proceeded some distance north of 24°30’S.

Figure 3 shows the abundance estimates currently utilized in the assessment of Breeding Stock C along with those previously used and the minimal population estimates from the migration stream at Cape Vidal.

Recently shore-based observations of migrating humpback whales have been made from the Ehoala Peninsula, in Southern Madagascar during the 2005 Season (Jacques Whitford, 2007). Numbers of sightings were found to increase steadily from June, peaking in August and September, and then decreasing in October and November. Generally whales without calves moved in a northeasterly direction in June and July, and in a southwesterly direction in August and September. Migration of whales with calves was in a general southwesterly direction, apart from the four groups sighted in October. However considerable variation in the direction of movement is apparent in the results.

Of particular interest in the migration of whales to and from Madagascar is the presence of concentrations of humpback whales at Walters Shoal (a shallow bank of less than 20 m depth at 33°13' S; 43°54' E). Best *et al.*, (1998) reports of incidental sightings and dedicated research sightings (made during the IWC Madagascar blue whale cruise in 1995) from the region as late as December. Although no northward migration (or early season concentration of animals has been recorded on the Walters Shoal area (presumably reflecting the lack of research in the area), the presence of animals so late in the season at Walters Shoal (including an increasing incidence of calves as the season progresses), and both the bimodality in catches and the direction of movement off South Eastern Madagascar suggests a migration along the Southwest Indian and Madagascar Ridges. Furthermore the similar sizes of the northern and southern migrations off Cape Vidal suggests that the migration southward over the Madagascar Ridge must be complimented by a northward migration (that is not detected from Cape Vidal).

It should be noted that further feeding ground abundances might be estimated from further SOWER cruises to Area III since 2000. However, the time-frames for the analyses and inclusion of such information are unknown.

Photographic identification material

As stated above photographic identification material has recently been compared across the C1 and C3 Breeding Regions. To date these comparisons have only included tail fluke material collected over the 2000 to 2006 year seasons, and while much of this C1 material arises from the migration stream (both northward and southward migrations – collected opportunistically at St Lucia some 30 km south of Cape Vidal) and all of the material from Madagascar arises from Antongil Bay, material from other years or locations in both C1 and C3 may or do exist.

While little or no data are available on the distribution or abundance of humpback whales on the west coast of Madagascar (C3), on the coast of the African Mainland to the north of 15°S (C1), or from many of the central Mozambique Channel islands (C2), initial attempts have been made to obtain photographic identification material from certain of these areas. It is believed that there is an urgent need to both expand the collections of identification material across the entire C Breeding Region, and to curate and compare further existing material

from the C1 Migration Corridor (Plettenberg Bay and later years from St Lucia) and Breeding Region (Bazaruto and Tanzania and possibly northern Mozambique), the C2 Region and the C3 Region (the Star Bank and possibly Isle St Marie). Furthermore, existing photographic and genetic individual identification material from Breeding Region C could be compared to material collected from the Antarctic Area III during recent SOWER and other cruises. The current delineation of the feeding ground utilized by Breeding Stock C is based on two Discovery Mark Returns (Rayner, 1940) and the understanding of the feeding area (and its associated Catch History) utilized by the C Breeding Stock (or even at a more refined scale of each of the C1 and C3 Sub-Stocks) may be considerably strengthened by such comparisons. While the common cataloguing of all material may be time consuming, some material may be achievable in the short term.

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Table 1. Population estimates of humpback whales of Breeding Stock C (1990 – 2003), After Findlay and Best 1996 (C1 Migration); Findlay et al., 1994, Findlay et al. (in press) (C1 Breeding Ground); Best et al. 1996 (C3) and Cerchio et al. 2008a (C3).

YEAR	C1 Nth Migration	C1 Sth Migration	C1 Breeding Ground	C3
1990	1711	1647		
1991	1777		1954 (0.38)	
1992				
1993				
1994				2532
1995				
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003			5965 (0.17)	
2004				
2005				6737 (0.31) (lower) 7715 (0.24) (upper)
2006				

Figure 1. Locations of places referred to in the text.

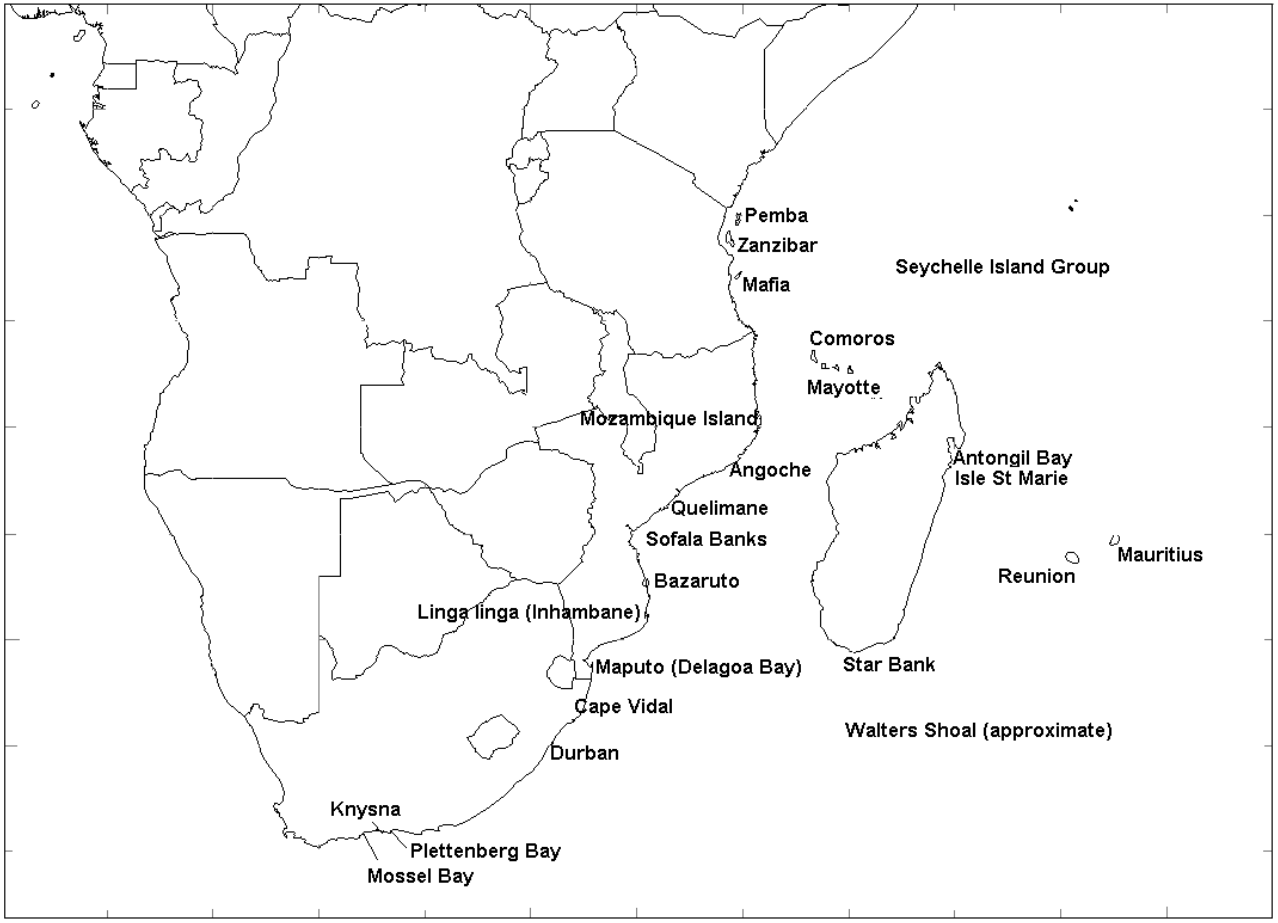

Figure 2. Provenance of abundance estimate and trend information from Breeding Stock C and locations of photo-identification material.

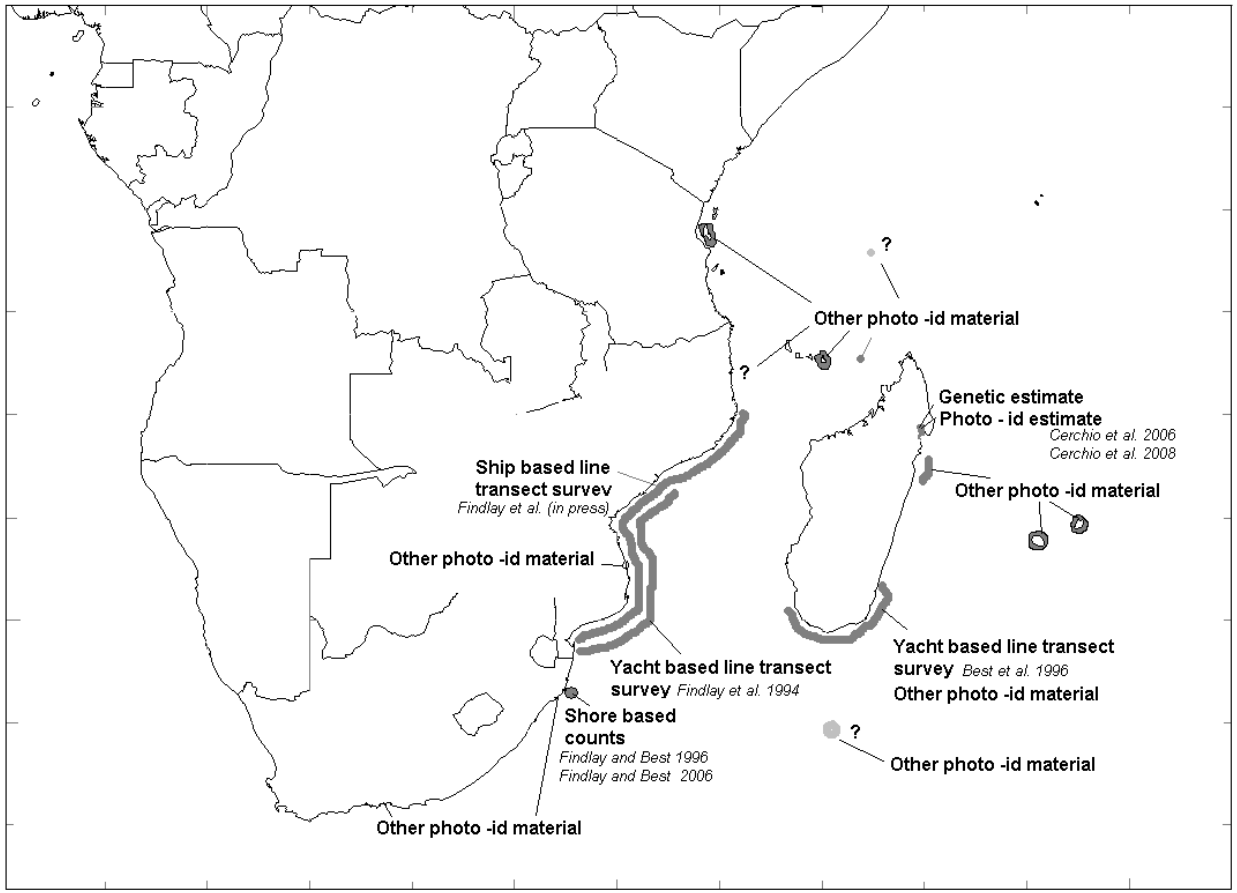

Figure 3. Population estimates of humpback whales of Breeding Stock C (1990 – 2003). Data from Findlay and Best 1996 (C1 Migration); Findlay et al., 1994, Findlay et al. (in press) (C1 Breeding Ground); Best et al. 1996 (C3) and Cerchio et al. 2008 (Average of upper and lower C3).