Summary of the data and information available for the assessment of breeding stock C of the Southern Hemisphere humpback whales

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Extract from 2006 Hobart workshop

- Fair amount of evidence to suggest three possible substocks C1 (Mozambique, and South African East Coast migration corridor), C2 (Mayote, Comores and other Islands of the Mozambique Channel) and C3 (Madagascan waters including Antongil Bay)
- SC/A06/HW38 – suggests separation of C1 from the other, and lumping C2 and C3
- C2 considered small

Wording from the Hobart Report:
On the basis of what is known of the stock structure of humpback whales off the East coast of Southern Africa, five potential sub-regions were identified:
(1) C1 South (C1-S) including East South Africa and Mozambique as far north as Mozambique Island (15° S). Elsewhere the Report notes "There is evidence of breeding in sub-region C1 from approximately 28°S to possibly as far north as Tanzania/Kenya, while a migratory corridor exists the south of 28°S."
(2) C1 North (C1-N) extending northwards from Mozambique Island to the northern limit of the range (Southern Tanzania possibly into Kenya).
(3) C2 including Mayotte Island, the Comoros Islands and the Mozambique Channel;
(4) C3 around Madagascar.
(5) C4 extending across the Mascarene group of islands, including Mauritius and Reunion.
The Workshop agreed that the delineation between C1-S and C1-N may be a cline rather than a definite line, although given the current deficiency of data to the north of Mozambique Island the border can presently be considered a latitudinal line in the region of Mozambique Island (15° S). The links described above suggest that C2 and C3 may not be separate.
In considering seven models of stock structure , the Workshop agreed that the most plausible was that linking C1-N and C1-S into one breeding sub-stock and the linking of C2 and C3 into another.

SUBSTOCK C1

Abundance Estimates for C1

The year in brackets is the year to which the estimate refers.

1) Findlay *et al*. 1994 (yacht-based line transect survey) : 1954 (1991)
2) Findlay *et al*. (in press) (ship-based line transect survey): 5965 (CV=0.17) (2003)
3) Findlay and Best 1996 (shore-based counts - based on 1991 northward migration count 17 June to 6 Aug): 1777 (1991).

A suggestion would be to use the Findlay *et al.* (in press) estimate of 5965 (CV=0.17) for year 2003 as the most recent absolute abundance estimate.

Trend Information for C1

1. From the breeding grounds – there is the Findlay and Best (2006) paper on the migration of whales past Cape Vidal and a preliminary estimate of an increase rate. The estimates of the rates of increase over 1988-2002 (6-22 July series) are 12.3% [95% CI= 4.7%-19.9%] and over 1990-2002 (6-30 July series) 9.04% per annum [95% CI = -25.6%-43.7%].

   The relative abundance values from this paper which could be used are:

Whales sighted 6-22 July		**Whales sighted 6-30 July**	
Year	Abundance	Year	Abundance
1988	358		
1989	249		
1990	359	1990	695
1991	587	1991	1093
2002	1673	2002	2406

   It is suggested that the 6-22 July series only is used for assessment purposes, due to the very wide confidence intervals associated with the 6-30 July series.

2. From the feeding grounds there are the IDCR/SOWER survey estimates (Branch *et al.* 2006) which could also be used as relative abundance indices to provide a relative trend. These estimates correspond to 10^{o}E – 60^{o}E, so would cover both the C1 and C2+3 substocks – but if used as trend information only this is not too important (i.e. the assumption would need to be made that the feeding ground trends are the same for both substocks). Branch could be requested to disaggregate these data further if agreement can be reached on a longitudinal split for C1 and C2+3 in the feeding grounds.

   These data, which have each been adjusted to correspond to all of the areas south of 60^{0}S are:

CPI	1979	1043	(CV = 0.62)
CPII	1987	926	(CV = 0.57)
CPIII	1993	2391	(CV = 0.41)

Photographic capture-recapture data from C1 – from SC/60/SH33 (Cerchio *et al.* 2008) [*n* = number of different identified individuals sighted each year, *m* = total recaptures between pairs of years]. Note $m^{C1,C1}$ refers to individuals captured in C1 and recaptured in C1, whilst $m^{C3,C1}$ refers to individuals captured in C1 and recaptured in C3.

N							
	2000	2001	2002	2003	2004	2005	2006
	3	24	49	115	21	134	112

$m^{C1,C1}$							
	2000	2001	2002	2003	2004	2005	2006
2000	X	0	0	0	0	0	0
2001		X	1	0	0	0	0
2002			X	1	1	0	1
2003				X	0	0	0
2004					X	1	0
2005						X	2
2006							X

$m^{C3,C1}$							
	2000	2001	2002	2003	2004	2005	2006
2000	X	0	0	0	0	0	0
2001		X	0	0	0	0	0
2002			X	0	0	0	0
2003				X	0	0	0
2004					X	0	0
2005						X	0
2006							X

SUBSTOCK C2+3

Abundance Estimates for C3 (nothing available for C2)

1) Best *et al*. 1996 (sightings survey): 2532 (1994) CV = 0.27 [from southern Madagascan waters)].
2) Cerchio *et al*. 2006 (capture-recapture): From Antongil Bay (NE Madagascar). The authors' recommendations are a lower bound estimate of 5197 (CV=0.35) for a mid-year of 2000, and an upper bound estimate of 7458 (CV=0.29) for a mid-year of 2002. These are photo-ID based capture-recapture estimates.
3) Cerchio *et al*. 2008 (capture-recapture): From Antongil Bay (NE Madagascar). The authors' recommendations are a lower bound estimate of 6737 (CV=0.31) for a mid-year of 2005, and an upper bound estimate of 7715 (CV=0.24) for a mid-year of 2005 (These estimates are from the Chapman's Modified Patersen estimator applied to the **photo-ID** mark-recapture dataset.)
4) Cerchio *et al*. 2008 (capture-recapture): From Antongil Bay (NE Madagascar). A lower bound estimate of 8348 (CV=0.32) for a mid-year of 2005, and an upper bound estimate of 10123 (CV=0.24) for a mid-year of 2005. (These estimates are from a Chapman's Modified Petersen estimator applied to the **genotypic** mark-recapture dataset.)

Convention has been to use such estimates for C3 as applying to the combination of C2 and C3 as the abundance of humpback whales associated with C2 is considered likely to be small compared to C3.

Trend information for C2+3

From the feeding ground, as for sub-stock C1, the Branch (2006) IDCR/SOWER survey estimates from the feeding grounds area III could be used.

Photographic mark-recapture data from C3 – from SC/60/SH33 (Cerchio *et al.* 2008a and b) [*n* = number of different individuals sighted each year, *m* = total recaptures between pairs of years]. Note $m^{C3,C3}$ refers to individuals captured in C3 and recaptured in C3, whilst $m^{C1,C3}$ refers to individuals captured in C3 and recaptured in C1.

n							
	2000	2001	2002	2003	2004	2005	2006
	89	159	16	126	151	144	158

$m^{C3,C3}$							
	2000	2001	2002	2003	2004	2005	2006
2000	X	2	1	3	1	0	1
2001		X	1	3	3	3	2
2002			X	3	0	0	0
2003				X	2	1	3
2004					X	4	3
2005						X	4
2006							X

$m^{C1,C3}$							
	2000	2001	2002	2003	2004	2005	2006
2000	X	0	0	0	0	0	0
2001		X	1	0	0	0	0
2002			X	0	0	0	0
2003				X	0	0	1
2004					X	0	0
2005						X	0
2006							X

The Cerchio *et al.* (2008a) paper suggests the lower and upper estimates for C3 using the MARK program in conjunction with the photo-ID data are:

lower 6737 (CV=0.31) for the 2003-2006 dataset
upper 7715 (CV=0.24) for the 2004-2006 dataset.

Cerchio *et al*. (2008a) also give a tentative ROI estimate of 0.063 using these data.

Genotypic mark-recapture data from C3 – from SC/60/SH33 (Cerchio *et al.* 2008a) [*n* = number of different individuals sighted each year, *m* = total recaptures between pairs of years]

n							
	2000	2001	2002	2003	2004	2005	2006
	114	161	28	185	163	161	153

m							
	2000	2001	2002	2003	2004	2005	2006
2000	X	4	1	2	2	0	0
2001		X	2	6	2	1	2
2002			X	6	1	1	1
2003				X	2	2	3
2004					X	2	4
2005						X	3
2006							X

Cerchio *et al*. (2008a) caution that the ROI from the genotypic data of 0.136 is biologically improbable.

Historic Catch Data

The breeding ground catches are split by region so that they could be apportioned to C1 and C2+3: for C! lump the SW Cape, S Cape, Natal and Mozambique, and for C2+3 use the West Indian Ocean catches in Allison's database.

The feeding ground catches are reported at 10^{o} longitude intervals.
The Core feeding area for BS C (in total as currently defined) as 10^{o}E – 60^{o}E.
Two plausible alternative catch-splitting scenarios are:

Option 1: C1 = 10^{o}E - 30^{o}E
C2+3 = 30^{o}E - 60^{o}E
Option 2: C1 = 10^{o}E - 40^{o}E
C2+3 = 40^{o}E - 60^{o}E

Prior on the *r* growth rate parameter
If some trend information (such as IDCR/SOWER relative abundance estimates from the feeding grounds) or if the mark-recapture data are incorporated, a prior which is uniform between plausible demographic bounds (e.g. [0; 0.106],) could be used i.e. we let the data inform us about the *r* distribution.

If trend information is not available (or is considered unreliable) then a prior on the *r* parameter needs to be specified. One option is to use a posterior distribution from Bayesian assessments of other Southern Hemisphere breeding stocks.

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