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An update on biological data published on Southern Hemisphere humpback whales following their Comprehensive Assessments 2006-2014

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INTERNATIONAL WHALING COMMISSION

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This document summarizes Southern Hemisphere specific publications on humpback whale distribution, abundance, trend, connectivity, genetic resources, threats and impacts which have become available since the Scientific Committee comprehensive assessment of each relevant breeding stock and sub-stock. This summary was compiled from documents submitted to the IWC Southern Hemisphere sub-committee, publications in the Journal of Cetacean Research and Management, and a search of 'humpback whale' on Web of Science, dated back to 2006. Breeding stocks BSD and BSE1 are not listed here, as no new relevant studies/datasets have been identified as becoming available since their assessment in 2014.

Data table with all relevant data collected on each Southern Hemisphere humpback whale breeding stock since each assessment was completed

Population	**Assessment date**	**Distribution information**	**Abundance and trend information**	**Population connectivity** (BB=breeding-breeding stock, BF=breeding-feeding ground)	**Genetic data**	**Threats and human impacts**
Breeding Stock A (Brazil)	2006	Satellite telemetry data on winter humpback distribution and habitat use shows widespread movement along Brazilian coast [1]. Occasional winter sightings off Venezuela (7-14°N) may be northernmost range of this breeding ground [2] Humpback whales	2008 aerial survey along Brazilian coast, (g(0) = 0.68) yields N_{2008} = 9330, CV=0.16 [4]. IWC SC concerns over accounting for perception bias. Correct g(0) for the survey not known.	BB: Female movement from BSA to Madagascar (BSC3) (n=1) [5]. BB: Photo-ID resight of female between BSA and Colombia (BSG) [6] BF: Satellite telemetry tracks from Abrolhos Bank show strong connection (n=7 of 11 tracked whales) to South Sandwich islands (22-24°W) and southern boundary of	~300bp of mtDNA control region sequences from 158 humpback whale bones collected from South Georgia [9]	Wintering ground not protected by MPAs in majority of its range [1]. Unusual mortality event, apparent spike in strandings in 2010, cause unknown. Annual strandings highest Sept-October, majority of stranded animals immature and predominantly male.

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		sighted off Trindade Island (20.3°S, 29.19°W) July-August 2007. Unknown whether resident or migratory [3]		ACC. One whale travelled east towards mid-Atlantic ridge, then south [7] BF: Photo-ID resight (n=1) between Abrolhos Bank and Shag Rocks, South Georgia (37'7°W) [8]		*Vibrio* detected but unclear whether causative, or product of poor health [10, 11] Entanglements recorded in fishing gear [n=3, 11] Parasite *Cyamus boopis* identified in 6 humpbacks as part of parasitological study of Brazilian cetaceans [12]
Verdict: New breeding-feeding ground connections consistent with high latitude catch allocations used in 2011 assessment. New data not likely to significantly change 2006 assessment outcomes.						
Breeding Stock B (BSB1, BSB2) (west coast of Africa)	2012	Northwestern component of BSB1 described in waters off Guinea, Guinea-Bissau, The Gambia, Senegal. Equivalent search effort with no humpbacks encountered off Mauritania, western Sahara and Morocco [13] June/July humpback		BF: Satellite telemetry from Gabon shows southward migratory movement along Angolan coast, and movement offshore close to Walvis Ridge, tracking that oceanographic feature [15] Photographs of flukes, dorsal fins and cookie-cutter scars collected from Namibia during northbound migration suggest Namibia is visited on	Population structuring of BSB1 and BSB2 investigated using mtDNA and microsatellite markers, shows WSA summer feeding ground and late season	Satellite telemetry suggests Gulf of Guinea wintering habitat is coincident with oil platforms and shipping [15]

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		whale sightings in Cape Verde suggest possible northward extension of BSB into Northern Hemisphere breeding ground [14] Whales satellite tracked in Gabon moved throughout Gulf of Guinea, incl. 2 cow-calf pairs travelling north late season, potentially to another breeding area to the northwest [15]		migration, with high incidence of fresh cookie cutter scars (compared to low incidence in WSA) suggesting whales join coastline at Namibia from high latitude feeding grounds, rather than passing through WSA [16]	migrants to be significantly differentiated from Gabon [17]	
Verdict: Some updates on data available during 2012 assessment, with sightings information from Namibia suggesting a BSB1/BSB2 mix, or predominantly BSB1 whales on northward migration. Range of low latitude catch allocations (between BSB1/BSB2) explored in 2012 assessment [e.g. Sen B4, 18] with little impact on *r*, *K* and recovery. Therefore new data not likely to significantly change 2012 assessment outcomes.						
Breeding Stock C1 (east coast of Africa)	2010	Satellite tracking indicates use of waters off Somalia, Northern Kenya, Aldabra (see connectivity) [19]		BB: Satellite telemetry shows direct movements between eastern Madagascar (BSC3) and northern BSC1 waters off Somalia, Northern Kenya, Aldabra [19]		
Breeding Stock C2 (Mozambiqu	2010[1]			BB: Satellite telemetry shows 1 within-season movement between BSC2 and BSC3		

[1] Assessed as part of BSC3 in 2010 assessment

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e Channel)				[20] BF: Satellite telemetry shows some BSC2 whales migrate south along Madagascar west coast [20]. Tracks (n=2) end at Crozet Plateau (48°E), and also 27°E, west of 'core' BSC feeding grounds		
Breeding Stock C3 (eastern Madagascar)	2010	Satellite telemetry reveals widespread wintering habitat along east coast of Madagascar [19]		BB: Of 320 fluke photo-IDs collected from Reunion (BSC4), 3 match with BSC3, suggesting some exchange [21]		
Breeding Stock C4 (Mascarene Islands)				See BSC3 above.		
Verdict: Catch allocations in 2010 assessment consistent with breeding-feeding ground connections observed by satellite telemetry (one in core area, one in B/C mixing area 10-30°E). Supports potential BSB/BSC joint assessment in future, to better allocate catches on common high latitude grounds. Additional connections between sub-stocks BSC2/3 and BSC3/4 have been established by photo-ID matching since the 2010 assessment, but at present no abundance/trend for BSC2 to enable distinct assessment of this sub-stock or explicit inclusion in future assessment model. BSC4 may be migratory route for BSC3; further work required. Current data not likely to significantly change 2010 assessment outcomes or enable a more fine-scale assessment of the breeding sub-stocks.						
Breeding Stock E1 (East Australia)	2014			BF: One photo-ID match with Adélie Land		

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Breeding Stock E2 (New Caledonia)	2014 (grouped as 'Oceania' single stock with E2, E3 and F2)		Trend derived from photo-identifications 1996-2012 in southern lagoon of New Caledonia, (and surveys from southerly seamounts 2008-2011) [22]. Trend= 15% p.a (95% CI 11-20%), above biologically plausible natural reproductive limits.			
Breeding stock F2 (French Polynesia)	As above	Winter survey of Tuamotu/Gambier Islands 2010: photo-identifications (n=7 unique IDs) and biopsy samples (n=10) collected [23]. Winter survey of Austral islands 2013: photo-identifications (n=22				

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		unique IDs) and biopsy samples (n=34) collected [24].				
Verdict: The 2014 assessment grouped the Oceania breeding sub-stocks BSE2, BSE3 and BSF2 as one unit. In order to assess the sub-stocks separately, abundance (and trend where possible) are required from individual Oceania breeding grounds. Continued collection of photo-identifications and biopsy samples to build a mark-recapture dataset for French Polynesia is particularly important, as the mark recapture abundance estimate for French Polynesia has the poorest precision [25]. There is no data here that will change the 2014 assessment outcomes or enable a more fine-scale assessment of breeding stocks.						
Breeding Stock G (Central America, Ecuador, Colombia, Peru)	2006 (repeated with updated abundance estimate in 2011)	Satellite telemetry of n=15 whales off Panama shows widespread use of wintering ground and within-season connectivity with Colombia [26]. 2007 photo-ID/sighting survey in Panamanian waters yields no recaptures with previous years, [27] 2002-2012 surveys of waters of Gulf of Chiriqui, western Panama yield n=267 unique photo-IDs, with an inter-annual re-sight rate of 9%	Photo-identifications from 2003-2009 in La Perlas Archipelago, Panama used with open population model. N_{2009} = 1041 (95% CI 664-1546) [26] Annual abundance and trend estimated for Magellan Strait feeding ground with fluke photo-IDs 2002-2012 using a Complete Data	BB: No mtDNA genetic differentiation detected between Ecuador and Colombia [38] BB: Photo-ID comparison across BSG reveals 4 matches between Ecuador (n=1289) and Costa-Rica/ Panama (n=98) [39] BB: Photo-ID comparison Ecuador (n=1470) and Peru (n=96) yields 2 matches [40] BF: No genetic differentiation between Ecuador and Antarctic Peninsula; significant F_{ST}/Φ_{ST} differentiation between Ecuador and Magellan Strait	mtDNA from n=182 whales collected 2002-2008 off Ecuador [38]	Entanglements n=13 off Santa Elena Peninsula, 2004-2008, consequence of two ports and intense artisanal fishing [31] Photo catalogue from Ecuador examined for unusual skin conditions: 160 anomalous cases, 45 considered in detail. Study speculates on possible origins of these conditions [47] Ship strikes are a potential threat for humpback whales in Panamanian waters

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		(SC/65a/SH04). Updated to n=396 unique photo-IDs in 2013 with average resight rate of 13% [28] A 2009-2011 sighting survey from Punta Avita, Costa Rica characterizes local distribution [29] 1996-2007 photo-ID survey from Machalilla National Park, Ecuador, n=1172 identified whales- 7% recaptured over survey period [30]. Distribution of humpbacks characterized around Santa Elena Peninsula, Ecuador 2001-2008 [31] Sightings surveys in Galapagos indicate possible year-round presence [32] Distribution and habitat survey in waters of	Likelihood mark recapture model. N_{2012} = 88 (95% PI 81-95). Median growth 2004-2012 = 3.2% (95% PI 1.9-4.5%) but appears constant from 2005 [37]	[38]. BF: Photo-IDs from Ecuador (n=1172) compared with rest of BSG, n=56 matches with WAP, n=4 matches with Magellan Straits [41] Updated: n=1560 photo-IDs from Ecuador reveal 64 matches with WAP (n=611) and 2 with Magellan Straits [42] BF: Photo-identifications connect Panama with West Antarctic Peninsula (WAP), (n=8) and also (n=1) Chilean waters [26] BF: Photo-identifications connect Costa Rica with West Antarctic Peninsula (n=7), no Magellan comparison [43] BF: Photo-ID analysis across BSG and Magellanic Strait/WAP suggests higher than expected connectivity between Central America and Magellanic Strait, possible breeding/feeding ground		and in the Magellan Straits. A simulation study indicates that with the current population parameters, one adult whale collision every 3 years could generate a population decline on the Magellan Strait feeding ground [37].

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		Northeastern Peru indicates this area is also used for breeding/calving [33]. Feeding ground: Summer sightings north of Magellan Straits suggest possible feeding off Isla de Chiloe, Corcovado Gulf, may be northern extent of Magellan Strait feeding ground [34, 35] Feeding ground: Satellite telemetry of 11 whales on WAP feeding grounds shows WAP (BSG) feeding range includes western Weddell Sea (n=1 tracks east to 50°W) [36]		substructure [35] BF: Photo-ID match between Ecuador and South Orkney Islands (46°W), western South Atlantic, whale also sighted in WAP, suggesting eastern presence of BSG in Orkneys/western Weddell Sea [44] BF: Satellite tracking of humpbacks from Ecuador suggests solo adults travel south offshore, mothers with calves travel close to coast. One direct connection with WAP [45] FF: Photo-IDs (n=17) from Chilean Corcovado Gulf compared with Magellan Straits and Antarctic Peninsula catalogue, no matches [46] One match between Isla de Chiloe (n=22 flukes) and Magellan Strait [34]		
Verdict: Good potential for an updated assessment of this area. Abundance has been estimated for Magellan Strait feeding ground, and multiple comparisons of breeding ground/feeding ground photo-ID catalogues qualitatively indicate connectivity between Ecuador/Colombia and the Antarctic						

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Peninsula, and possibly connectivity between Central America and Magellan Strait feeding grounds, although data are sparse and application of a quantitative framework for evaluating connectivity/exchange would be extremely useful. Satellite tracks from Ecuador suggest possible differences in migratory route depending on reproductive status, with mothers/calves travelling along the South American coast/ adults offshore; is it possible that coastal catches may have therefore predominantly been mothers/calves? Core catch allocation 50-100°W used in 2011 assessment [48] is consistent with observations of whales in western Weddell Sea, so core BSG catch boundaries not updated by recent data.						

SUMMARY

Of all the breeding stocks, BSG is the only one currently with sufficient new information to enable a more in-depth assessment than previously attempted.

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