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Photographic Evidence of Interchange Between East Australia (BS E-1) and West Australia (BS – D) Humpback Whale Breeding Populations

Gregory Kaufman[1], Douglas Coughran[2], Judy M. Allen[3], Daniel Burns[4], Chris Burton[5], Cristina Castro[6], Simon Childerhouse[7], Rochelle Constantine[8], Trish Franklin[4,9], Wally Franklin[4,9], Paul Forestell[1,10], Rosemary Gales[11], Claire Garrigue[12], Nadine Gibbs[13,] Curt Jenner[14], David Paton[15], Michael Noad[16], Jooke Robbins[17], Elisabeth Slooten[18], Franz Smith[19], and Peter Stevick[3]

[1.] *Pacific Whale Foundation, 300 Ma'alaea Rd., Suite 211, Wailuku, Maui, HI, USA 96793*
[2.] *Department of Environment and Conservation, Nature Protection Branch, Western Australia*
[3.] *Antarctic Humpback Whale Catalogue, College of the Atlantic, 105 Eden Street, Bar Harbor, ME 04609, USA*
[4.] *Southern Cross University Whale Research Group, Marine Ecology Research Centre, Southern Cross University, P.O. Box 157, Lismore, NSW 2480, Australia*
[5.] *Western Whale Research PO Box 1076, Dunsborough WA 6281 Australia*
[6.] *Pacific Whale Foundation, Barrio Luis Gencon, Puerto López - Manabí - Ecuador*
[7.] *Australian Marine Mammal Centre, Australian Antarctic Division, Channel Highway, Kingston, TAS 7050, Australia*
[8.] *School of Biological Sciences, University of Auckland, Auckland, New Zealand*
[9.] *The Oceania Project, PO Box 646 Byron Bay NSW 2481 Australia*
[10]. *C.W. Post, 720 Northern Boulevard, Brookville, NY 11548 USA*
[11.] *Marine Mammal Conservation Program, Department of Primary Industries, Parks, Water and Environment, 134 Macquarie Street, Hobart, TAS 7000 Australia*
[12.] *Opération Cétacés BP 12827 98802 Noumea New Caledonia*
[13.] *Department of Conservation P.O. Box, 5086 Wellington, New Zealand*
[14.] *Centre for Whale Research, P.O. Box 1622, Fremantle, WA 6959 Australia*
[15]. *Blue Planet Marine, P.O. Box 919, Jamison Centre, ACT, 2614 Australia*
[16.] *School of Veterinary Science, University of Queensland, Australia*
[17.] *Provincetown Center for Coastal Studies 5 Holway Avenue, Provincetown, MA 02657*
[18.] *Department of Zoology, 340 Great King Street, University of Otago, Dunedin, 9016, New Zealand*
[19.] *P.O. Box, 10-934 Wellington, New Zealand*

Contact author: Gregory Kaufman; email: greg@pacificwhale.org

ABSTRACT

Documentation of humpback whale movements between east and west Australian breeding grounds have been restricted to limited historical data from 'Discovery' marks, and implied from song analysis and molecular data. We report on the first inter-ocean movement of a humpback whale between the Pacific Ocean, east Australia (BS-E1) and the Indian Ocean, west Australia (BS-D) confirmed by photo-ID. A single humpback whale from BS-E1 (1987) was re-sighted to BS-D (1995) breeding grounds. The identification photographs of this single whale were then compared to fifteen fluke ID catalogues containing 15,011 fluke identifications (not reconciled for duplications between catalogues) collected from 1981 - 2011, and one catalogue containing 3,555 left and 3,572 right lateral body images collected from 1990 – 2010.

Catalogues searched represent individual humpback whale fluke IDs from Breeding Stocks A, B, B1, B2, C1, C2, C3, D, E1, E2, E3, F, F2, G; New Zealand (migratory corridor); and feeding areas of Antarctic Peninsula, Areas I-VI and Chile, and lateral body IDs from BS-D. This re-sight record across breeding stocks provides further evidence of longitudinal movement of humpback whales in the southern hemisphere and highlights the value of both opportunistic data collection and the importance of comparing identified individuals among catalogue holders working in adjacent and non-adjacent breeding regions.

INTRODUCTION

Humpback whales (*Megaptera novaeangliae*) can be individually identified from photographs of the ventral fluke patterns and lateral body surfaces (Katona *et al*., 1979; Kaufman *et al*., 1987, 1993). In the southern hemisphere, photo-identification has provided new insights into movements of individual humpback whales previously described by 'Discovery' marks, among Antarctic feeding Areas IV, V and VI (Chittleborough 1959, 1965; Dawbin 1964, 1966). The use of both fluke ID and lateral body photographs have been demonstrated effective in tracking movements, residency rates, pod characteristics and life histories of humpback whales (Gill and Burton, 1995, Clapham, 2000; Forestell *et al*., 2003, Franklin *et al*., 2010, Forestell *et al*., In Press).

Photographic matches have been established between Area V and east Australia (E1) (Kaufman *et al*., 1990; Rock *et al*., 2006; Franklin *et al*., in press) and between Antarctic Area IV and Western Australia (Gill and Burton, 1995). Additional matches, using photo-ID, have been made between Brazil and Antarctic Area II (South Georgia) (Stevick *et al*., 2006), between the western coast of Central America (Costa Rica and Panama) and the Antarctic Peninsula (Rasmussen *et al*., 2007; Guzmán *et al.,* 2009), and between American Samoa and Antarctic Area I (Robbins *et al.,* 2011).

Long-distance movement at low latitudes involves individuals traveling mainly between adjacent breeding grounds (Chittleborough 1959; Darling & Cerchio 1993; Salden *et al.,* 1999; Garrigue *et al.,* 2000; Pomilla & Rosenbaum 2005; Forestell & Urban 2007; Garrigue *et al*, In Press a,b). With few barriers to restrict their movements across ocean basins, Southern Hemisphere humpback whales (both male and female) have been shown to engage in extensive longitudinal movement (some >9,800 km) in their migrations (Stevick *et al.,* 2010, 2011; Robbins *et al.,* 2011).

Humpback whales that migrate along the west and east coasts of Australia are thought to be part of Southern Hemisphere breeding stocks D and E-1 respectively, with the former spending the austral summer in Antarctic Area IV (70º E-130º W) and the latter in Area V (130º E-170º W). However, it has been suggested that Antarctic Area V is an area where different breeding stocks of whales mix during the summer months (Dawbin, 1956; Constantine *et al.,* 2011). During the austral winter, west Australia humpback whales frequent the low latitude breeding grounds from Perth to the Kimberley region, while east coast humpbacks may be found from Eden northward along the Great Barrier Reef (Chittleborough 1965; Dawbin 1966, 1997; Kaufman *et al.,* 1990, 1993; Burton, 1991; Dawbin & Gill, 1991; Chaloupka & Osmond 1999; Jenner *et al.,* 2001; Forestell *et al.,* 2003; Franklin *et al*., 2010; Kaufman *et al.,* 2010).

Discovery marks were employed to uncover the first exchange between east and west Australia breeding grounds when, during the summer of 1958–59, ten whales originally marked in Area V were recovered in Area IV. Two of the ten marked Area V whales were killed off the Western Australian coast later that winter. Chittleborough (1965) and Dawbin (1966) identified this exchange as limited, 'discreet'. Noad *et al.* (2000), report observations of west Australian songs introduced into, and adopted by, east Australian humpbacks, apparently due to migration between the two locations. Chittleborough (1965), Dawbin (1966), Darling *et al.* (1996) and Baker *et al.* (1998) have all suggested that movement between breeding grounds may provide an opportunity for gene flow between otherwise separate populations. Anderson and Brasseur (2007), examining molecular data, found moderate gene flow between breeding stocks D and E but failed to find any genotype matches.

We report on the first photographic documentation of an inter-ocean movement of an individual humpback whale from the Pacific Ocean, east Australia (BS-E1) to the Indian Ocean, west Australia (BS-D). Further, we describe a test case effort to determine if this whale, shown to migrate to at least two southern hemisphere breeding grounds, has been sighted in other southern hemisphere breeding or feeding grounds or migratory corridors.

METHODOLOGY

Humpback whales were individually identified from photographs of the ventral fluke patterns and lateral body surfaces (Katona *et al.*, 1979 Kaufman *et al.*, 1987). An opportunistic collaboration occurred in 1999 when West Australia Marine Wildlife Officer Douglas Coughran (Department of Environment and Conservation, Nature Protection Branch) sent humpback whale fluke ID images to Pacific Whale Foundation (PWF). Coughran collected his images opportunistically during vessel patrol operations off Fremantle, West Australia in October 1995. He matched fluke images (WAXXXXDON-XX1 - 4) to animal E0344 contained in a Pacific Whale Foundation catalogue (Kaufman *et al.*, 1993). The match was confirmed by PWF. Whale E0334 was next compared to a geographically extensive collection (fully reconciled) of 5,738 individual identification images held by PWF (Table 1).

Animal E0334 and Coughran's WAXXXDON-XX3 were then sent for comparison to the curators of fifteen Southern Hemisphere catalogues comprised of 15,011 fluke IDs collected between 1981 – 2011 (Table 2). These catalogues, reconciled within themselves, represent individual humpback whale fluke IDs collected from Breeding Stocks A, B, B1, B2, C1, C2, C3, D, E1, E2, E3, F, F2, G; New Zealand (migratory corridor); and feeding areas of Antarctic Peninsula, Areas I-VI and Chile. In a similar test, lateral body images of animal E0334 were also compared to one west Australian catalogue (CWR) containing 3,555 left and 3,572 right lateral body images collected between 1990 – 2010 (Table 2).

Catalogue holders applied quality controls as a basis for including individual whales in the search, such as YONAH (Smith *et al.*, 1999) and SPLASH (Cambolkidis *et al.*, 2008) criteria, although some catalogues used all available images in the search (listed as NONE) (Tables 1 & 2). There was no attempt to reconcile these catalogues with each other.

RESULTS and DISCUSSION

Fluke and lateral body identification photographs of E0344 were matched to fifteen Southern Hemisphere humpback whale catalogues, containing 15,011 fluke IDs and 3,555 left and 3,572 right lateral body images compiled over 30 years. J. Allen, P. Stevick and R. Seton, from College of the Atlantic in 2004, and, subsequently, the curators of the other referenced catalogues also independently confirmed the match between PWF E0334 and Coughran's WAXXXDON-XX3. No additional re-sightings of animal E0334 were discovered.

Animal E0334 was first identified by PWF off North Stradbroke Island, Queensland, Australia (27.47120°S 153.55715°E) on September 15, 1987 in a surface-active pod comprised of four adults and two sub-adults. A female was identified in the pod through genital photographs. E0334 was re-sighted on September 24, 1987 off North Stradbroke Island (27.45530°S 153.56140°E) in a surface-active pod of four adults, later joined by a fifth animal. On September 25, 1987 E0334 was observed in a surface-active pod of three adults (two animals in the pod were observed swimming belly-to-belly) off North Stradbroke Island (27.43213°S 153.57578°E) (Figures 1 & 2). All observations of E0344 were as a competitive adult in surface-active groups. Such behavior has been generally associated with males (Glockner, 1983; Baker and Herman, 1984; Clapham, 2000; Clambokidis *et al.*, 2001, 2008).

The whale was re-sighted eight years later (October 1995), swimming alone, by Coughran, who photographed E0344 off Fremantle, West Australia (approx 32.06043°S 115.68759°E) (Figures 1 & 2).

The re-sighting of E0334 represents the first photographic evidence of the inter-oceanic movement of a humpback whale between the Pacific and Indian Ocean breeding grounds. This record is important because it highlights the usefulness of photo-identification as an effective tool that remains largely underutilized to evaluate exchanges between distant or less plausible breeding and feeding areas. The recent discovery of large longitudinal movements of individual humpback whales between oceans (Stevick *et al.*, 2010, 2011), coupled with our finding reported here, suggest the prevalence of inter-breeding ground exchanges of southern hemisphere humpback whale populations is poorly understood and warrants further study with all available data. Utilization of all available spatially and temporally extensive data holdings, coupled with faster digital imaging and archiving technology not previously available (e.g. Kniest *et al.*, 2010; Stevick *et al.*, In Press), are likely to yield effective and efficient means of testing historical humpback whale breeding stock boundaries.

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Table 1. Pacific Whale Foundations Southern Hemisphere Humpback Whale Catalogue

CATALOGUE	LOCATION	YEARS	NO. FLUKE IDs	SORTING CRITERIA
PWF	BS-D West Australia	1985-1986, 1988-1991, 1995	353	SPLASH
PWF	BS-E1 - East Australia	1984-2010	5285	SPLASH
PWF	BS-E3 - Tonga	1985-1986, 2003-2007	79	SPLASH
PWF	BS-E3 - American Samoa	1994	1	SPLASH
PWF	New Zealand	2002	1	SPLASH
PWF	Antarctic Peninsula	2010	14	SPLASH
PWF	Feeding Area I	1983, 1988, 1889	3	SPLASH
PWF	Feeding Area V	1986	2	SPLASH
		Total Ids Compared	**5738**	

Table 2. Summary of Southern Hemisphere humpback whale catalogues searched, and Key of catalogues available with the name of the catalogue curator.

CATALOGUES SEARCHED	LOCATION	YEARS	NO. FLUKE IDs	NO. LEFT DORSAL IDs	NO. RIGHT DORSAL IDs	SORTING CRITERIA
COA/AHWC	BS-A - Brazil	1988-2004	936			YONAH
COA/AHWC	BS-B - St. Helena	2003	2			YONAH
COA/AHWC	BS-B1 - Gabon, Ghana	1999-2006	79			YONAH
COA/AHWC	BS-B2 - So. Africa	2005-2006	7			YONAH
COA/AHWC	BS-C1 - eastern So. Africa	2008-2010	4			YONAH
COA/AHWC	BS-C2 - Mayotte, Madagascar	2005-2006	84			YONAH
COA/AHWC	BS-C3 - Ile St. Marie, Madagascar	2001-2010	209			YONAH
COA/AHWC	BS-D West Australia	1990-2010	248			YONAH
CWR	BS-D West Australia	1990-2009	2303	3555	3572	NONE
WWR	BS-D West Australia	1985-2010	1200			NONE
Burns	BS-E1 - East Australia	2003-2005	609			NONE
COA/AHWC	BS-E1 - East Australia	1981-2010	49			YONAH
Franklin/Franklin	BS-E1 - East Australia	1992-2009	2822			SPLASH
Gales	BS-E1 - East Australia	2007- 2010	84			NONE
Noad	BS-E1 - East Australia	2002-2004, 2008-2009	169			NONE
Paton	BS-E1 - East Australia	2005	315			SPLASH
Paton/Burns	BS-E1 - East Australia	1998-2004	600			NONE
Garrigue	BS-E2 - New Caledonia	1995-2010	757			NONE
COA/AHWC	BS-E3 - Tonga	2004-2010	45			YONAH
Slooten	BS-E3 - Tonga	2003	62			NONE
COA/AHWC	BS-E3 - American Samoa	2003-2009	213			YONAH
COA/AHWC	BS-F - New Zealand/Tahiti	1990-1997	2			YONAH
COA/AHWC	BS-F2 - Fr. Polynesia	2008	2			YONAH
COA/AHWC	BS - G - Costa Rica/Panama/Colombia	1986-2007	767			YONAH
Castro	BS - G (Ecuador)	1996-2010	1752			NONE
Bott	New Zealand	1994-2010	100			NONE
COA/AHWC	Antarctic Peninsula	1981-2011	1087			YONAH
COA/AHWC	Feeding Area II	1988-2006	23			YONAH
COA/AHWC	Feeding Area III	1997-2007	117			YONAH
COA/AHWC	Feeding Area IV	1993-2009	108			YONAH
AWE	Feeding Area V	2010	59			NONE
Bott/Childerhouse/Smith	Feeding Area V - Balleny Islands	2006	11			YONAH
COA/AHWC	Feeding Area V	1996-2010	99			YONAH
Garrigue	Feeding Area V	2010	2			SPLASH
COA/AHWC	Feeding Area VI	1991-2001	7			YONAH
COA/AHWC	Feeding Area Chile	1999-2007	78			YONAH
		Overall Total	**15011**			

KEY	CATALOGUE CURATORS
AWE	R. Constantine, S. Childerhouse
Burns	D. Burns
Bott	N. Bott
Bott/Childerhouse/Smith	N. Bott, S. Childerhouse, F. Smith
Castro	C. Castro
COA/AHWC	J. Allen, P. Stevick
CWR	C. Jenner
Franklin/Franklin	T. Franklin/W. Franklin
Gales	R. Gales
Garrigue	C. Garrigue
Noad	M. Noad
Paton	D. Paton
Paton/Burns	D. Paton, D. Burns
PWF	G. Kaufman, P. Forestell
Slooten	L. Slooten
WWR	C. Burton

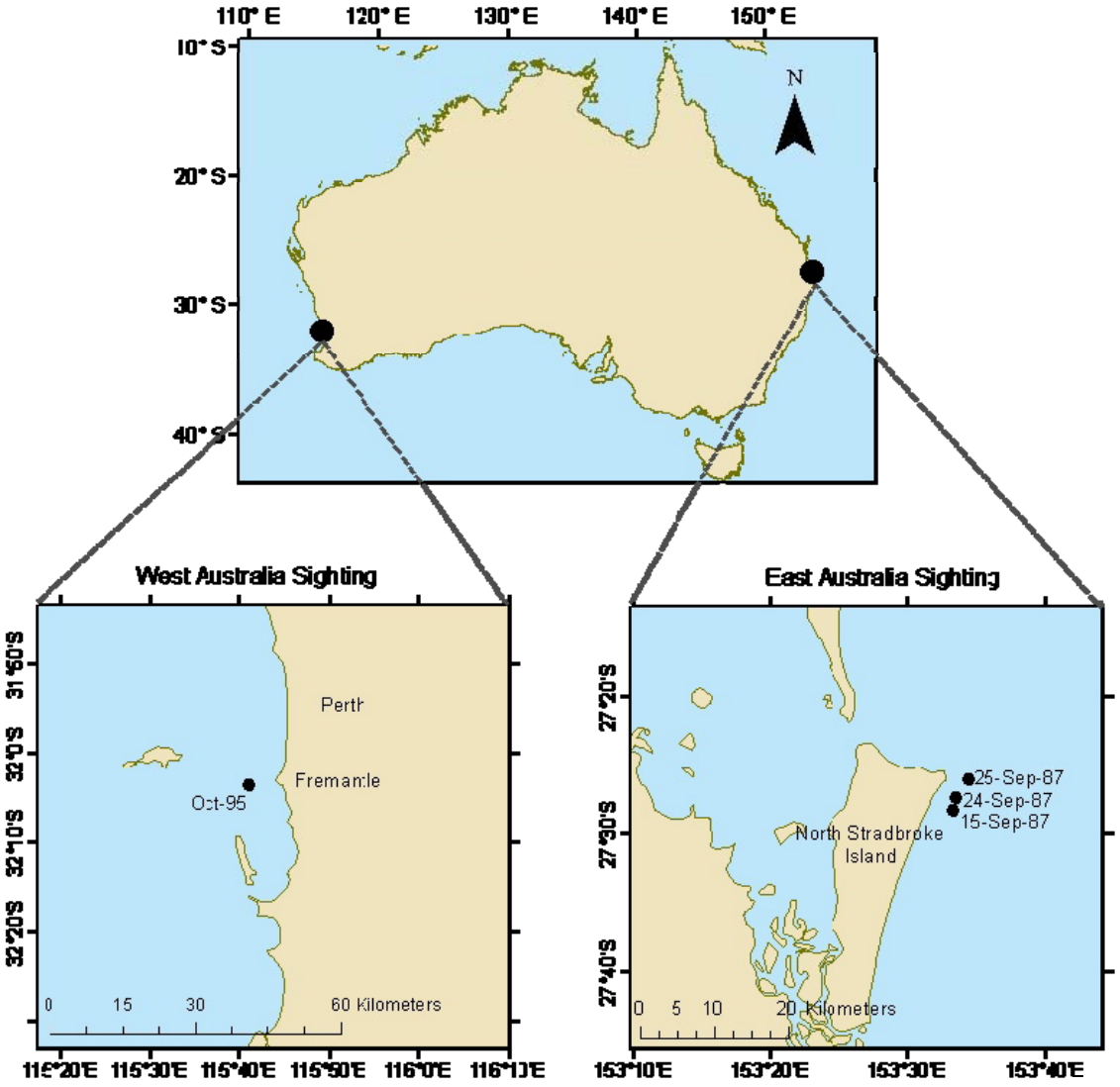

Figure 1. Map of locations where humpback whale E0334 was sighted in West Australia (left) and East Australia (right)

Figure 2. Photographs used to match animal E0334 between East and West Australia catalogues.

FLUKES	LATERAL BODY IMAGES
	
Animal E0334 September 15, 1987	Animal E0334 September 15, 1987
	
Animal E0334 September 24, 1987	Animal E0334 September 24, 1987
	
Animal E0334 September 25, 1987	
	
Coughran's WAXXXXDON-XX3 October 1995	