Comprehensive photo-identification matching of Antarctic Area V humpback whales

ROCHELLE CONSTANTINE[1], JUDY ALLEN[2], PETA BEEMAN[3], DANIEL BURNS[3], JEAN-BENOÎT CHARRASSIN[4], SIMON CHILDERHOUSE[5], MICHAEL C. DOUBLE[5], PAUL ENSOR[6], TRISH FRANKLIN[3,7], WALLY FRANKLIN[3,7], NICK GALES[5], CLAIRE GARRIGUE[8], EMMA GATES[3], NADINE GIBBS[9], AMANDA HUTSEL[10], CURT JENNER[11], MICHELINE JENNER[11], GREG KAUFMAN[10], ANNE MACIE[10], DAVID K. MATTILA[12], ADRIAN OOSTERMAN[13], DAVID PATON[14], JOOKE ROBBINS[15], NATALIE SCHMITT[5], PETER STEVICK[2], ALDEN TAGARINO[16], KIRSTEN THOMPSON[1]

[1]*School of Biological Sciences, University of Auckland, Auckland, New Zealand*
[2] *Antarctic Humpback Whale Catalogue, College of the Atlantic, Bar Harbor, ME, USA*
[3] *Southern Cross University Marine Ecology Research Centre, Lismore, New South Wales, Australia*
[4] *Département Milieux et Peuplement, Aquatiques Muséum National d'Histoire Naturelle, 75231 Paris, France*
[5] *Australian Marine Mammal Centre, Australian Antarctic Division, DEWHA, Hobart, Australia*
[6] *Governors Bay, RD1 Lyttelton 8971, New Zealand*
[7] *The Oceania Project, Byron Bay NSW, Australia*
[8] *Opération Cétacés, BP 98802, Noumea, New Caledonia*
[9] *Department of Conservation, Wellington, New Zealand*
[10] *Pacific Whale Foundation, Wailuku, HI 96793, USA*
[11] *Centre for Whale Research (Western Australia), Fremantle, WA, Australia*
[12] *Hawaiian Islands Humpback Whale National Marine Sanctuary, Kihei, HI, USA*
[13] *Norfolk Island Whale Survey, Scarborough, QLD, Australia*
[14] *Blue Planet Marine, Canberra, ACT, Australia*
[15] *Provincetown Center for Coastal Studies, Provincetown, MA, USA*
[16] *Department of Marine and Wildlife Resources, Pago Pago, American Samoa*

ABSTRACT

This paper reports on a comprehensive matching of humpback whale fluke photographs from Antarctic Area V to the migratory corridors and breeding grounds from Western Australia in the west to American Samoa, South Pacific in the east, and to the other Antarctic regions. A total of 61 unique whales were identified in Antarctic Area V during January 2010 by the French CETA project (n = 2) and February – March 2010 by the Antarctic Whale Expedition (n = 59), a joint research effort by Australia and New Zealand. These images were placed on an open access web-site and researchers compared their existing catalogues to the AWE dataset. These images were matched against a total of 17,243 fluke identification images (including an unknown number of duplicates) collected from 1984 – 2010; west Australia (n = 1,664), east Australia (n = 9,994 images), Norfolk Island (n = 6); New Zealand (n = 100); west Oceania (n = 1,806); Breeding stocks A – G (n = 2,403) and Antarctica Peninsula, Chile and feeding areas II – VI (n = 1,270). Forty-one percent (n = 25) of the 2010 Antarctic images matched to existing catalogues; 24 matched to east Australia and 1 matched to New Caledonia. The majority of the 2010 whales were photographed in the vicinity of the Balleny Islands, which adds support to previous opportunistic studies linking individuals in this region of Area V to east Australia but not to west Australia or Oceania. Similar results have been reported with molecular data from tissue samples collected during the same 2010 surveys (Steel *et al*. 2011). These data clearly show that the Balleny Islands are an important feeding ground for east Australian humpback whales but that the feeding grounds for the west Australia and endangered Oceania whales remain poorly described and understood.

KEYWORDS: PHOTO-ID, HUMPBACK WHALE, STOCK E, AREA V, ANTARCTICA, EAST AUSTRALIA, WEST AUSTRALIA, OCEANIA

INTRODUCTION

Photo-identification of the unique patterns of pigmentation and nicks along the trailing edge of humpback whale (*Megaptera novaeangliae*) flukes is a well-established method of tracking movements, residency rates and life history of these large migratory animals (Katona *et al*. 1979; Clapham 2000). Considerable effort has been made to establish catalogues of whale flukes throughout the world with northern hemisphere researchers establishing successful collaborative efforts (e.g., YONAH, SPLASH) covering large ocean basins and linking breeding and feeding ground data (Smith *et al*. 1999; Calambokidis *et al*. 2008).

In the southern hemisphere the feeding grounds of humpback whale stocks remain mostly inaccessible, with the possible exception of the Antarctic Peninsula, although this still provides a number of logistical challenges. Therefore, the majority of the southern hemisphere feeding grounds are not surveyed on a regular basis and links between the breeding and feeding grounds remain poorly described and mostly unknown. Historically *Discovery* tags from the whaling era provided information on the movements of individual whales between the IWC feeding Areas IV, V and VI (Chittleborough 1959; Dawbin 1964). More recently photo-ID records and the use of molecular markers have linked whales between their low latitude breeding grounds and high latitude feeding grounds revealing interesting and sometimes unexpected insights into whale movements (Steel *et al*. 2008; Stevick *et al*. 2010; Robbins *et al*. 2011; Franklin *et al*. In Press).

The Antarctic Humpback Whale Catalogue (AHWC) was established to collate fluke images from the Southern Ocean into a single catalogue and has been very successful in encouraging data sharing and making inter-catalogue matches easy (Allen *et al*. In Press). In addition, there have been some significant regional catalogue comparisons from the South Pacific/Oceania region already, including, between breeding grounds within a single ocean basin (e.g., Oceania; Garrigue *et al.* In Press a), and between different breeding sub-stocks of whales (e.g., east Australia (E1) and Oceania (E2, E3 and F); Garrigue *et al.* In Press b). Based on existing evidence (e.g. *Discovery* tag recoveries, catch histories, satellite tagging), it is suspected that Antarctic Area V is an area where different breeding stocks of whales mix during the summer months. Dawbin (1956) reported the Balleny Islands and Ross Sea as likely feeding grounds for whales from the western side of the South Pacific. Previous opportunistic surveys have resulted in six photo-ID matches between Area V to east Australia (E1) but to date there have been no matches outside of this region (Kaufman *et al*. 1990; Rock *et al*. 2006; Franklin *et al*. In Press). Of interest though is the recent report of whales from American Samoa (E3) migrating to Area I; a considerable distance from the closer feeding grounds in Area V or VI (Robbins *et al.* 2011).

Here we briefly describe the results of a large-scale collaborative effort to match fluke photographs collected during the joint Australian-New Zealand 2010 Antarctic Whale Expedition (AWE) in Area V (150ºW to 150ºE) and the first year of the French CETA programme (IPEV 1014 – Cetacés en Terre Adélie) in Area V (140° to 145°E) . The AWE was the first collaborative expedition undertaken as part of the IWC supported Southern Ocean Research Partnership (SORP). These images were matched to humpback whale fluke catalogue holders from the migratory corridors and breeding grounds of west Australia (Breeding Stock D), east Australia (E1), New Zealand (migratory corridor), Oceania (E2 and E3) and the AHWC holdings of Breeding Stocks A-G and feeding Areas I – IV. This work represents the largest ever collection of fluke images from Area V so contributes data to help resolve the gap in knowledge about the breeding ground origins of whales in this region. A companion paper to this one (Steel *et al*. 2011) using molecular markers will also be presented and collectively these reports substantially improve our understanding of humpback whale movements between their breeding and feeding grounds.

METHODOLOGY

The AWE travelled from Wellington, New Zealand on the *RV Tangaroa* on 2nd February and returned on 15th March 2010. The vessel travelled through the IWC Antarctic Area V between 150°W and 150°E spending approximately 30 days south of 60°. During this time, approximately 5,800nm were covered, with a particular focus on areas where whales were reported from previous IDCR/SOWER surveys (Gales 2010). Sightings surveys were maintained for up to 14 hours on each day of the voyage and all cetacean sightings were recorded, including, species identification, GPS coordinates, group size and composition, and if the opportunity arose, photo-ID images were taken from onboard the *RV Tangaroa*. When possible, a small boat was deployed and attempts were made to photo-ID, biopsy and satellite tag whales.

The French CETA programme is undertaken by marine mammal observers collecting cetacean sightings from the French research and resupply vessel *RV L'Astrolabe* as it travels from Hobart, Australia to the French Dumont D'Urville Antarctic base (66°40'S 140° 01'E) in Adélie Land (IWC Area V, 65-66°S and 140-145°E) (Garrigue *et al*. 2010a; Garrigue *et al*. 2010b). The vessel travelled through Area V waters from 10th to 22nd January 2010 conducting an

oceanographic survey and was used as a ship of opportunity for whale work. The vessel was able to manoeuvre to collect photo-ID and tissue biopsy samples but no small-boat deployments were possible.

Humpback whales were identified from photographs of natural markings on the underside of their flukes (Katona *et al*. 1979). Photographs were sorted by encounter and images of average to excellent quality were included in the AWE online catalogue. These were then made accessible to researchers via a website curated by the Australian Antarctic Division (http://www.marinemammals.gov.au/australia-new-zealand-antarctic-whale-expedition) and participants agreed to undertake matching of their individual catalogue holdings to the AWE catalogue and report findings back for inclusion in this manuscript. This process was open to all data holders conducting non-lethal research (as one of the objectives of SORP) within the greater region and we made extensive calls for interested parties. Although not all data holders chose to participate, or were able to provide results within the time frame for development of this paper, we are confident that we have broad coverage of the region. All participants held catalogues that had been subjected to a variety of quality control requirements. Each catalogue had been internally reconciled (i.e. an individual only appears once within each catalogue) but many of the catalogues have not been reconciled with each other. The sum of individuals across catalogues almost certainly includes duplicate images of the same individuals and therefore, the total reported here exceeds the actual number of individual whales.

The results from the 11 catalogue holders that undertook matching were then reported back to RC and any matches were double checked. As a result of double-blind checking of the AWE catalogue, two individuals in the original catalogue were identified as having been assigned two different numbers which was corrected in the final reporting.

RESULTS

A total of 61 individual whales were photo-identified in the AWE and CETA survey areas, 59 from the AWE voyage and 2 from the CETA voyage. Fifty-seven of these whales were photographed in the vicinity of the Balleny Islands; two to the east of the Balleny Islands and two from Adélie Land (Table 1). These 61 individuals were matched to 17,243 images from the areas described in Table 2. Forty-one percent (n = 25) of the whales matched to catalogues of individuals outside of Antarctica, 24 to east Australia and 1 to New Caledonia (Figure 1; Table 3). The earliest match was to a whale on 10 October 1984 and the most recent was 10 October 2009, both off east Australia. Using a simple presence/absence measure, these 25 whales matched to an average of 1.7 locations (range = 1 – 4; Figure 2) with several east Australia catalogues holding images of the same individual whale. Several whales (n = 16) were sighted more than once and counting each whale once per location per annum there was an average of 2.2 sightings per individual. Including the date that the whale was observed in Antarctica in 2010, there was an average of 6.7 years from the initial sighting of the whale outside Antarctica to their Antarctic sighting.

Of the matched whales there were 9 females, 4 males and 12 individuals of unknown sex. The biopsy samples from 57 individuals on the AWE voyage showed a sex ratio of 29 males: 28 females so even though the sex is not known for all whales in the AWE photo-ID catalogue, this same ratio is likely to apply.

DISCUSSION

This paper provides the largest contribution of humpback whale photo-ID images from the poorly understood feeding grounds in Antarctica Area V. The high number of matches from the AWE catalogue to whales catalogued along the migratory path and breeding grounds of east Australia adds strength to previous reports (Kaufman *et al*. 1990; Rock *et al*. 2006; Franklin *et al*. In Press) that the Balleny Islands are an important feeding ground for east Australian humpback whales.

There was only one match to New Caledonia (of a whale photographed near the western edge of Area V) and no matches to west Australia, the other islands of Oceania or the migratory corridors of New Zealand and Norfolk Island. Matches to the latter two might have been expected given the proximity of these regions to the study area and the large catalogues from each of these regions. Just under half of the catalogued whales outside of the AWE catalogue were from areas other than east Australia and the lack of matches to these locations adds weight to the importance of the Balleny Islands as a feeding ground for east Australia humpbacks. There were no matches to almost 1,300 catalogued humpback whales from the other feeding grounds and southern migratory corridors (e.g. Chile) of Antarctica but it should be noted that the majority of those individuals are from the well surveyed Antarctica Peninsula region in Area I (~5,000 kilometres away from the Balleny Islands where most of the AWE whales were identified). There were few fluke identifications from Areas IV (n = 108) and VI (n = 7) to the west and east of Area V, and with Area VI as a likely feeding ground for the endangered Oceania whales, further data should be collected from this region of the Southern Ocean. The results from matching genotype data collected from tissue samples during the AWE voyage show similar results to those reported here, with only one match to New Zealand and all other matches (n = 6) to east Australia (Steel *et al.* 2011).

Whilst data on the exact feeding grounds of the Australian and Oceania humpback stocks remain unknown, there are an increasing number of links between the breeding and feeding grounds being reported (e.g. Hauser *et al*. 2010). Gales *et al.* (2009) showed humpbacks primarily moving south or south-east of Australia and a similar pattern was suggested for the early part of the southern migration of whales from New Caledonia (Garrigue *et al*. 2010c, Garrigue et *al.* 2011). Movements of two whales have recently been reported from American Samoa to Antarctica Area I, including the longest return migration ever reported (Robbins *et al*. 2011). Similar long-range movements have been reported for other southern hemisphere humpbacks (Stevick *et al*. 2010) which is not surprising as the Southern Ocean is mostly free of large land-masses that limit ocean basin movements in the northern hemisphere. With recent advances in satellite telemetry, continuation of the SORP and CETA projects, and large-scale comparative matching efforts as reported in this paper, other long-distance movements are likely to be reported in the future (e.g., Kaufman *et al*., 2011).

ACKNOWLEDGEMENTS

Many thanks to the Australian and New Zealand governments for funding the AWE voyage including excellent support from the Australian Antarctic Division (AAD) and National Institute for Water and Atmospheric research (NIWA) logistics staff and *RV Tangaroa* crew. The CETA program is supported by IPEV (the French Polar Institute), the French Ministry of Ecology and Sustainable Development (MEDDTL), the Muséum National d'Histoire Naturelle (MNHN), Opération Cétacés and Université de La Rochelle. Many thanks to Todd Dennis, University of Auckland, for creating the location map, and to Debbie Steel, Oregon State University, for reviewing this paper. Thank you to all the people who have financially supported our research and contributed to the thousands of photo-ID images that were used as part of this study.

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Table 1. Summary of photo-ID catalogue numbers, date and location for humpback whales from the AWE (n = 59) and CETA (n = 2; AWE 62 & 63) voyages.

Catalogue number	Date	Latitude (°S)	Longitude (°E)
AWE1	12-Feb-10	69.16489	166.89817
AWE2	13-Feb-10	69.685	176.1402
AWE3	21-Feb-10	66.9065	163.0568
AWE4	21-Feb-10	66.9319	163.799
AWE5	21-Feb-10	66.9319	163.799
AWE6	21-Feb-10	66.9319	163.799
AWE7	21-Feb-10	66.9408	164.3204
AWE8	21-Feb-10	66.9408	164.3204
AWE9	21-Feb-10	66.8858	164.182
AWE10	21-Feb-10	67.013	163.6745
AWE11	21-Feb-10	66.9447	163.6953
AWE12	21-Feb-10	66.9365	163.69
AWE13	21-Feb-10	66.9365	163.69
AWE14	21-Feb-10	66.9365	163.69
AWE15	21-Feb-10	66.899	164.0757
AWE16	21-Feb-10	66.8926	164.2757
AWE17	22-Feb-10	66.8694	163.6245
AWE18	22-Feb-10	66.8967	162.8515
AWE19	22-Feb-10	66.5922	163.5413
AWE20	27-Feb-10	66.9984	164.9019
AWE21	28-Feb-10	67.1115	169.2829
AWE22	28-Feb-10	67.5458	168.4474
AWE23	28-Feb-10	67.5458	168.4474
AWE24	1-Mar-10	67.8806	166.7805
AWE25	1-Mar-10	67.9456	166.6941
AWE26	1-Mar-10	67.9716	166.732
AWE27	1-Mar-10	68.0954	167.1461
AWE28	1-Mar-10	68.0991	167.1212
AWE29	1-Mar-10	68.0991	167.1212
AWE30	1-Mar-10	68.1159	167.0272
AWE32	1-Mar-10	68.1784	167.1304
AWE33	1-Mar-10	68.1784	167.1304
AWE34	2-Mar-10	67.5075	164.2858
AWE35	2-Mar-10	67.5075	164.2858
AWE36	2-Mar-10	67.5088	164.23
AWE37	5-Mar-10	69.2755	166.1918
AWE38	5-Mar-10	69.2755	166.1918
AWE39	5-Mar-10	69.2834	166.2504
AWE40	6-Mar-10	69.2175	166.2056
AWE41	6-Mar-10	69.2146	166.2104
AWE42	6-Mar-10	69.2146	166.2104
AWE43	6-Mar-10	69.2146	166.2104

AWE45	6-Mar-10	69.2146	166.2104
AWE46	7-Mar-10	69.1517	166.5847
AWE47	7-Mar-10	69.158	166.5519
AWE48	7-Mar-10	69.158	166.5623
AWE49	7-Mar-10	69.1533	166.5808
AWE50	7-Mar-10	69.0664	166.5754
AWE51	7-Mar-10	68.8859	166.8441
AWE52	7-Mar-10	68.8859	166.8441
AWE53	7-Mar-10	68.8857	166.8424
AWE54	7-Mar-10	68.8857	166.8424
AWE55	7-Mar-10	68.8857	166.8424
AWE56	7-Mar-10	68.8859	166.8441
AWE57	7-Mar-10	68.8297	166.9798
AWE58	8-Mar-10	66.8287	163.7018
AWE59	8-Mar-10	66.7506	163.7778
AWE60	8-Mar-10	66.812	163.5108
AWE61	8-Mar-10	66.8239	163.6513
AWE62	16-Jan-10	66.6674	143.5029
AWE63	16-Jan-10	66.6674	143.5029

Table 2. Summary of the catalogue sizes represented for the different regions, broken into sub-regions as appropriate. The catalogue curators' initials from the author list are in brackets after each location.

Location	Breakdown	Total
West Australia (CJ, MJ)		1,664
East Australia		9,994
Ballina/Byron (DB, PB, DP)	1,633	
Hervey Bay (TF, WF)	2,593	
East coast (Port Douglas - Eden) (GK)	5,601	
Gold Coast (PB)	167	
AHWC Breeding (JA, PS)		2,403
Breeding stock A	887	
Breeding stock B	88	
Breeding stock C	225	
Breeding stock D	242	
Breeding stock E	159	
Breeding stock E1	27	
Breeding stock E3	18	
Breeding stock F	4	
Breeding stock G	753	
AHWC Feeding (JA, PS)		1,270
Antarctic Peninsula	910	
Chile	73	
Feeding area II (e of 45°W to 0°)	18	
Feeding area III	117	
Feeding area IV	108	
Feeding area V	37	
Feeding area VI	7	
New Zealand (NG)		100
Norfolk Island (AO)		6
New Caledonia (CG)		645
Vanuatu (CG)		6
Fiji (DP)		13
Tonga (RC)		923
Niue (RC)		8
American Samoa (DKM, JR)		211
OVERALL TOTAL		17,243

Table 3. All AWE/CETA whale matches (*n* = 25) to other regions. EA = east Australia; NC = New Caledonia. The catalogue curators' initials from the author list are in brackets after each location. Where known, the sexes of matched whales are reported. The year(s) of the matches are reported, with only a single report for each year.

Catalogue number	Sex	Location	Years
AWE5	U	EA (DB, GK)	2005; 2006
AWE6	U	EA (PB)	2009
AWE7	F	EA (TF, WF)	2001; 2003
AWE9	U	EA (DP, TF, WF, GK, PB)	2005; 2007; 2008
AWE12	U	EA (DP)	2001
AWE15	F	EA (TF, WF, DP)	1997; 1998; 2001; 2002; 2003
AWE18	M	EA (JA, PS, GK)	2005
AWE24	F	EA (DB, TF, WF)	2004; 2008
AWE26	M	NC (CG)	2007
AWE29	U	EA (TF, WF, DP, GK)	2000; 2001; 2002; 2004; 2007
AWE30	F	EA (TF, WF, DB)	2002; 2003; 2004; 2005; 2006; 2008
AWE33	U	EA (TF, WF, GK)	2003; 2004; 2009
AWE35	M	EA (GK)	2007
AWE38	U	EA (TF, WF, DB, GK)	2003; 2006
AWE42	U	EA (TF, WF, GK)	1999; 2005
AWE45	F	EA (GK)	2008
AWE47	U	EA (GK)	2007
AWE53	U	EA (DB)	2003
AWE54	F	EA (TF, WF)	2002
AWE55	U	EA (DP, DB)	2000; 2003; 2004
AWE56	F	EA (GK, DP)	1984; 1985; 1997; 1999; 2005
AWE59	M	EA (DP)	2005
AWE60	F	EA (GK, DB)	1998; 2004
AWE61	U	EA (GK)	2007; 2008
AWE63	F	EA (TF, WF, GK)	2002; 2008

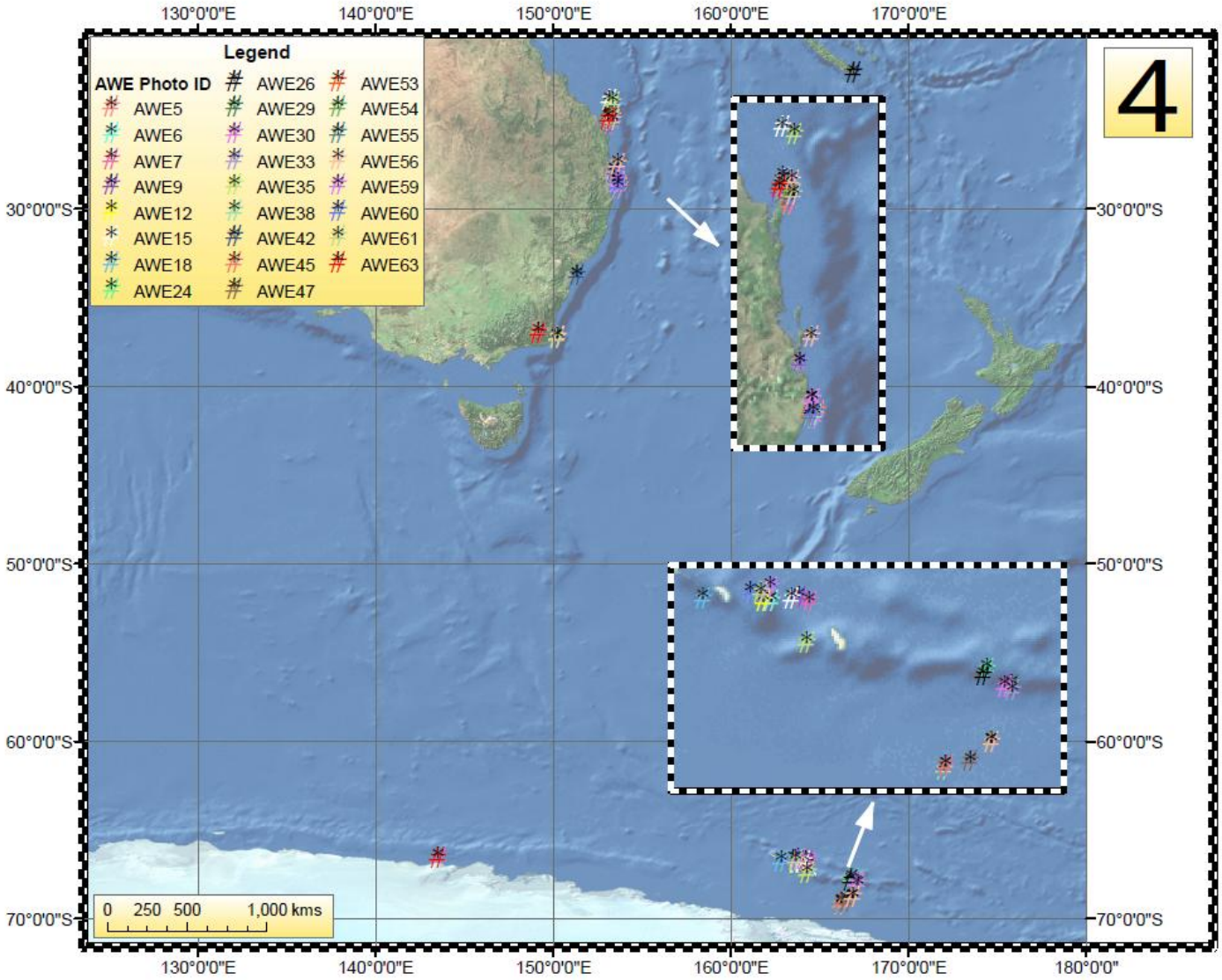

Figure 1. Map showing the Antarctic location of the 25 photo-identified AWE whales that matched to other catalogues and the corresponding location on the east Australia coast and/or New Caledonia. Whales are noted in each location sighted, with one record per location. The insert boxes highlight the Balleny Islands and Ballina – Hervey Bay.

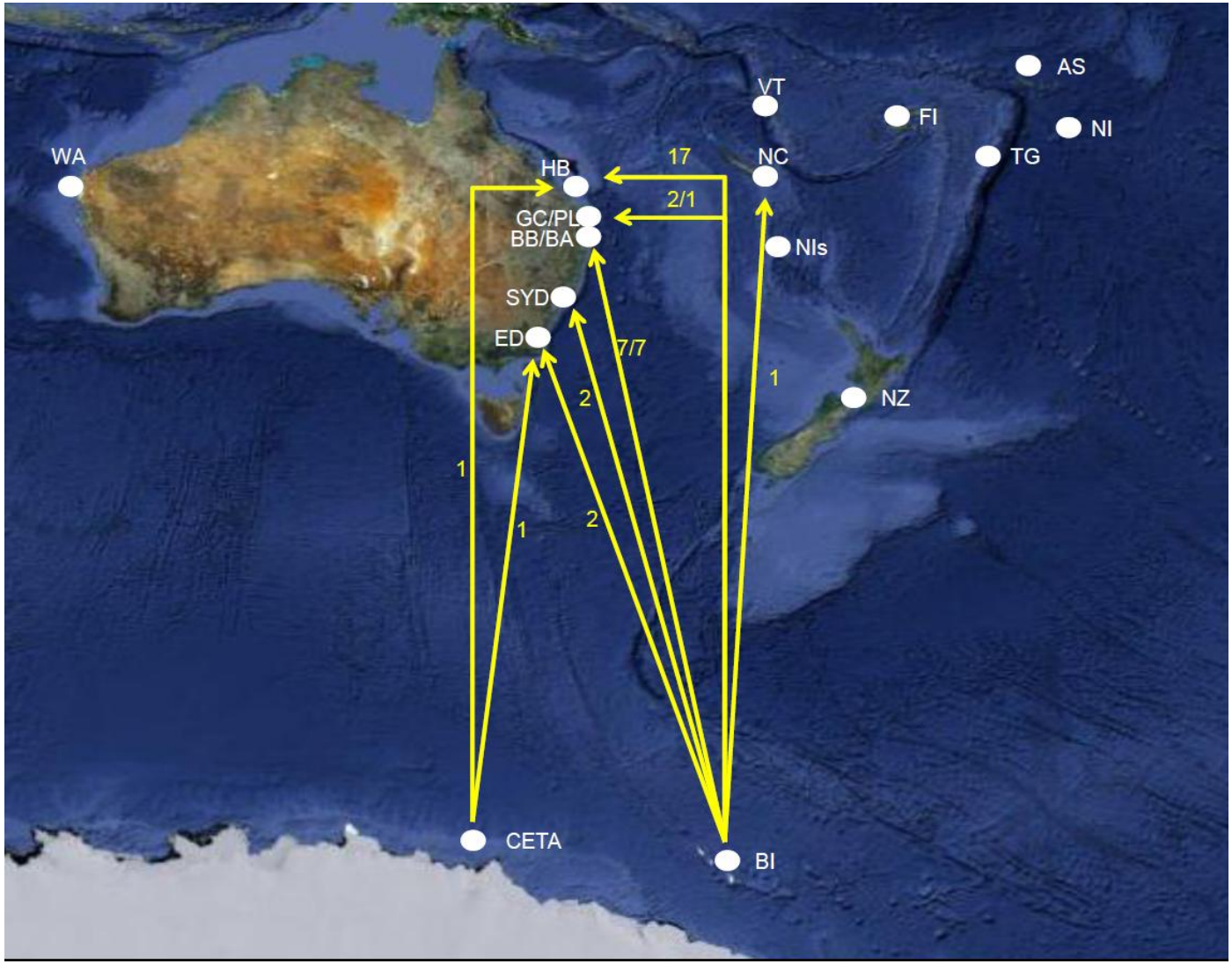

Figure 2. The number of individual whales that matched to each location away from the AWE and CETA regions is noted next to the yellow lines. Note: The lines do not infer the whales' path of travel and only one match per individual whale per location per year is reported. Sites shown are: WA (Western Australia), ED (Eden), SYD (Sydney), BB (Byron Bay), BA (Ballina), GC (Gold Coast), PL (Point Lookout), HB (Hervey Bay), NIs (Norfolk Island), NC (New Caledonia), VT (Vanuatu), FI (Fiji), TG (Tonga), AS (American Samoa) and NI (Niue).