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**Status report: Photo-Identification of Humpback Whales at Multiple Aggregation Areas along east coast Australia.**

Gibson, Q.[1], Kaufman, G.[1], Forestell, P.[1,2]

[1]Pacific Whale Foundation, 300 Ma'alaea Rd., Suite 211, Wailuku, HI, USA 96793
[2]Long Island University, 720 Northern Blvd., Brookville, New York, USA 11548

Contact email: HYPERLINK "mailto: Quincy@Pacificwhale.org" Quincy@Pacificwhale.org

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## ABSTRACT

This report summarizes the continuing work of Pacific Whale Foundation to examine migratory patterns of east Australian humpback whales through its photo-identification work over 25 years. A catalogue of 4,196 uniquely identified animals has been developed since 1984. Images obtained from multiple sites along the east coast of Australia since 1984 have been examined for evidence of multiple sightings of identified animals at different locations both within and between years. The data suggest complex patterns of migratory movement that may require reassessment of current definitions of breeding stocks. Continued photo-identification effort, to include new areas in the far north, along with collation of images with those from Oceania and the Antarctic are proposed in order to test current hypotheses about migratory corridors.

## INTRODUCTION

Humpback whales, *Megaptera novaeangliae*, which migrate along the east coast of Australia, are known to include animals from the Area V (130 E-170 E) Southern Ocean stock (Donovan 1991). In the western South Pacific, the International Whaling Commission recognizes several breeding stocks (BS) that feed in Area V and likely Area IV and western Area VI: east Australia (BS E1), New Caledonia (BS E2), Tonga/Fiji (BS E3), and Tahiti, Cook Islands and American Samoa (BS F) (IWC 2005).

Historically, it has been suggested that Area V humpback whales segregate after feeding in Antarctic waters and return along the east Australian and New Zealand coasts towards their northern breeding grounds (Dawbin 1966). Humpbacks migrating along the east coast of Australia are believed to breed in the northern tropical waters of the Great Barrier Reef Marine Park and beyond (Chaloupka and Osmond 1999, Forestell et al. 2003).

Assumptions about the migratory movement of humpback whales in the southwest Pacific came from the Discovery marking and recovery program between the 1950's and 1960's (Dawbin 1959 and 1964; Paton and Clapham 2006). The results mainly pointed to a north-south migration

between Antarctic Area V and the east Australian coastline. Recent photo-identification studies have identified matches between Antarctica and eastern Australia (Kaufman et al. 1990, Rock et al. 2006), and the Balleny Islands and eastern Australia (Franklin et al. 2007).

Longitudinal movement (some extensive) of BS E and F humpbacks have been documented, but movement between those regions is currently believed to be infrequent. Discovery tags showed limited exchange between east Australia and New Zealand (three marks), and east Australia and Fiji (one mark recovered) (Chittleborough 1959, Dawbin 1964). Limited interchange between east Australia and Oceania, and within Oceania has been documented more recently using photo-ID (Garrigue et al. 2000, 2007). A photographic match between America Samoa (BS F1) and the Antarctic Peninsula (Area I) has been reported (Robbins et al. 2008). Utilizing DNA samples, genotype matches have been found between Tonga (BS E2) and Antarctic Area I (Steel et al. 2008) and between French Polynesia (BS F) and Colombia (BS G) (Donoghue 2008). Results from a satellite tagged humpback in the Cook Islands (BS F1) showed it traversing the border of Area VI and Area I (Clapham et al. 2008). Despite these findings, complete migratory pathways and rates of interchange between (and within) feeding and breeding areas are not yet fully understood.

Kaufman et al. (1993) reported that approximately one third of the whales observed in the Capricorn/Bunker Group in the southern portion of the Great Barrier Reef had been re-sighted in either Hervey Bay or off Stradbroke Island. However, only about 10% of the whales observed in either Hervey Bay or North Stradbroke Island were identified further north. That is, whales found in Hervey Bay and off North Stradbroke Island appear not to be a representative sub-set of the whales found in the Great Barrier Reef and in other areas to the north. Comparison of photo-IDs from east Australia and Oceania suggests that some whales may branch out from central Queensland during the northward migration to a variety of destinations (Garrigue and Gill 1994; Garrigue et al. 2000, 2001, 2007; Forestell et al. 2003). Forestell et al. (2003) found a low rate of interchange among the primary known areas of aggregation along the whales' east Australia migratory range. Only 8.7% of photo-ID whales were observed at more than one location along the east Australia coastline during their study (Whitsunday Islands – Hervey Bay – Byron Bay – Eden).

Our findings, as well as increasing evidence from studies in both the North and South Pacific suggest far more complex migratory patterns than a simple north-south movement. There is less reliable data supporting the concept of north-south migratory corridors and increasing information that suggests more complex broadly based movement patterns with extensive east-west dispersal.

In this report we describe our BS E/Group V catalogue and document initial data summaries on movements within east Australia. Our data includes photo-identification efforts from Whitsunday Islands, Hervey Bay, and Point Lookout, Queensland as well as from Eden, New South Wales. We continue to test the validity of the assumption of north-south corridors through a combination of additional photo-ID analysis, data collection from other areas of Australia, and increased collaboration with other research groups.

## CURRENT CATALOG HOLDINGS

Since 1983, data has been collected by Pacific Whale Foundation and/or submitted from collaborators working in the following areas in eastern Australia and Oceania: the Whitsunday Islands, Great Barrier Reef (excluding WI), Hervey Bay and Point Lookout, Queensland; Byron Bay, Coffs Harbour, Eden, New South Wales; Tonga, American Samoa and Antarctica. To date, our existing catalogue contains the fluke photo-identification records of 4,196 individual Breeding Stock E/Area V humpback whales (across all areas). Of these individuals, 620 are known mothers and an additional 35 are known females with no history of calves. Further details of our holdings are presented in Table 1. For the purposes of identifying individual identifications suitable for re-sight analysis, all images were scored according to the Cascadia Research Collective's fluke image screening criteria (Calambokidis et al. 2008).

### Interchange Summary

The following summary considers two general sets of data collected from multiple sites along the east Australian coast. From 1993 – 1999 we collected photo-ID images from Eden, Hervey Bay & Whitsundays during each season. Those data provide an opportunity to look at how many of the identified animals were observed in one, two or three locations within the same season. One might reasonably assume that if animals are moving along a migratory corridor there should be a high incidence of re-sights in multiple areas. The second set of data considers images collected between 1984 – 2007 from all the sites noted above plus Point Lookout. These observations were not collected in all areas in each year, but are useful for looking at patterns of interchange across seasons during 24 years of photo-identification effort.

Interchange between sites was determined on an inter- and intra-season basis for all available data. Survey efforts for each site vary considerably across years (Table 2). The summaries presented here have not yet been corrected for differences in yearly or regional efforts.

### Within Season Interchange: Whitsunday Islands, Hervey Bay & Eden (1993–1999)

From 1993 – 1999 there were 1,543 individuals photographically identified in the Whitsunday Islands, Hervey Bay and Eden a total of 2,013 times. Of the total number of sightings, 1,940 (96.4%) were sightings of animals seen in only one location in a given year. Seventy-two of those sightings (3.5%) were sightings of animals seen in two locations in a given year. In one year, one animal was seen in three locations. Clearly the interchange rate within season was at an extremely low rate and is inconsistent with the concept of a simple north-south migratory corridor.

### Across Season Interchange: Whitsunday Islands, Hervey Bay, Point Lookout & Eden (1984 – 2007)

Between 1994 and 2007 there were 3,917 unique individuals identified at the four study sites. Of the total number of individuals sighted 3,391 (86.6%) were only observed in a single location over the 24 years included in our data set. There were 450 individuals (11.5%) observed in two sites across all years. Sixty-six individuals (1.7%) were observed at three sites. And only 10 animals (0.3%) were observed at all four sites across years.

Of the 10 individuals sighted at all four locations, two were known mothers while the remaining eight were of unknown sex. On average, the sighting histories for these individuals spanned 16.4 years (range: 10 – 21 years).

**Re-thinking Breeding Stock Boundaries & Migratory Pathways**

Historical data collected along the east coast of Australia led some to assume that the whales followed a predominantly north-southward migration (Chittleborough 1965). Additional work using Discovery tags (Chittleborough 1959, Dawbin 1964) strengthened the assumption of north-south corridors all the way to the feeding grounds – although occasional exceptions were noted. Even today, the boundaries for Breeding Stock E are sliced into a series of vertical corridors arranged in a west to east configuration: BS E1 (east Australia), BS E2 (New Caledonia), and BS E3 (Tonga). Increasingly, however, photo-identification and satellite tagging data demonstrate considerable latitudinal movement. The re-sighting of a humpback whale observed in American Samoa (BS F) and off the Antarctic Peninsula (eastern Antarctic Area I -- a known destination for whales that winter off areas of western Central and South America), demonstrates migratory pathways may be far more complex than a simple north-south corridor (Robbins et al. 2008). Whales from Oceania can exhibit extensive lateral displacement of up to 108 longitudinal degrees. A Discovery tag placed at Tonga and recovered in the Bellingshausen Sea indicates large horizontal displacements may not be an anomaly (Dawbin 1956, 1964, 1966; Brown 1957).

Additional re-sights (using photo-ID and Discovery tags) have shown BS E1 whales ranging from feeding Area IV to Area VI (Kaufman et al. 1990, Rock et al. 2006, Franklin et al. 2007, Chittleborough 1959, Dawbin 1964, Paton and Clapham 2006). It should also be noted that genotype matches have been found between Tonga (BS E2) and Area I (Steel et al. 2008) and between French Polynesia (BS F) and Colombia (BS G) (Donoghue 2008). A humpback whale satellite tagged in the Cook Islands (BS F1) was tracked to a location bordering Area VI and Area I (Clapham et al. 2008).

Increasing examples of interchange between BS E1, E2 and E3 are also emerging. As noted earlier, the Discovery marking and recovery program between the 1950's and 1960's showed exchange by at least three whales between east Australia and New Zealand and at least one whale between east Australia (E1) and Fiji (E3) (Chittleborough 1959; Dawbin, 1964, 1966). Garrigue et al. (2000, 2007) documented interchanges between east Australia (E1) and New Caledonia (E2), east Australia (E1) and Tonga (E3), and within Oceania (E2/3- F1/2).

We propose testing alternative hypotheses for configuring BS E, and establishing more clearly the relationship between east coast Australia and other areas in Oceania and further to the east. We believe E1 waters may serve as an important destination for whales that move northward from the feeding grounds along the east Australian coastline as far as Point Lookout and then disperse widely eastward to areas E2, E3 or even BS F. On the southward migration, whales from E2 and E3 or BS F may return to the feeding grounds on a southwesterly path from Oceania to Eden.

Aerial surveys off Point Lookout determined that 7.1% of groups were seen beyond 10 km on a line running north-south off Point Lookout (Noad et al. 2008). Noad et al. (2008) also reported a small number of whales much further offshore than previously reported, more than 40 km from

Moreton Island (just north of Pt. Lookout) (Bryden 1985, Brown 1996). Noad et al. (2008) speculated these whales might be heading toward breeding grounds other than the Great Barrier Reef.

The concept of different breeding stocks overlapping during portions of their migrations is not novel. Humpback whales migrating along the west coast of Latin America show a northerly migration through Ecuadorian breeding waters. Photo-identification studies have linked whales migrating past Ecuador to the northern breeding areas of Costa Rica, Panama and Columbia (Stevick et al. 2004, Acevedo et al. 2007a, Rasmussen et al. 2007, Acevedo et al. 2008, Castro et al. 2008). Whales wintering in Costa Rica and Panama have been largely found in the lower latitude feeding grounds in the Magellan Straits, while whales from Columbia and Ecuador are mainly found feeding in Area I along the Antarctic Peninsula (Acevedo et al. 2007b, Acevedo et al. 2008, Castro et al. 2008).

A similar pattern of shared portions of the migratory pathway by humpback whales has been demonstrated in the North Pacific with whales wintering in the lower latitude breeding areas (Okinawa, Philippines/Asia in the west, and mainland Mexico, and Central America in the east) found feeding in the lower coastal feeding areas. Whales wintering in the Revillagigedo Archipelago and Hawaii are found feeding in the more central- and northern-feeding areas (Calambokidis et al. 2008). Therefore, while whales migrating along the west coast of North America may appear to be one breeding population, they are actually comprised of animals from Hawaii, Revillagigedo Archipelago, mainland Mexico, and Central America breeding grounds. Animals from the same feeding or breeding area can have very different patterns, including movement in opposite oceanic directions (Calambokidis et al. 2001).

Chaloupka and Osmond (1999) suggested the main calving grounds for the east Australia breeding sub-stock is in the extensive southern Great Barrier Reef lagoon waters defined northward by the Whitsunday Islands and reefs and eastward by the Pompey/Swains reef complex. Forestell et al. (2003) showed a low rate of interchange along the whales' east Australia migratory range with only 8.7% of photo-ID whales observed at more than one location. The low rate of both within season and across season interchanges we report along the east coast of Australia supports the notion that not all whales are traveling along a north-south corridor and that considerable east-west deviation is occurring. We hypothesize that the whales found near the Whitsunday Islands may represent the 'true' E1 sub-stock and that those animals seen further south, particularly those found off Eden, represent a mixed group that contains E2 and E3 animals, and may contain BS F whales.

## CONCLUSIONS & FUTURE DIRECTIONS

Migratory movements and population structure of humpback whales in the southwest Pacific may be more complex than has been previously described. Based on our current data, we suggest that subsets of the BS E whales may be using the east Australia corridor for a portion of their migration and then branching off to other breeding grounds. We propose the following hypotheses: 1) migration does not follow a simple north-south path, 2) Breeding Stock E cannot be characterized by a number of sub-stocks migrating along a series of longitudinal bands stretching from east to west, and 3) individuals from separate breeding areas (E1, E2, E3 and BS F) may be overlapping along portions of the same migratory pathways.

Matching photo-ID data from the entire east Australian coast to Oceania catalogues is critical to determining the proportion of E2, E3 or BS F individuals mixing along the southeast Australian coast. In 2009 we intend to expand our research efforts to the Port Douglas region and will resume data collection in the Whitsunday Islands in 2010. The data obtained from this effort, combined with our long-term photo-ID holdings of BS E/Area V animals, will help refine our understanding of interchange and migratory movements along east Australia.

Pacific Whale Foundation continues to make our photo-ID catalogue available to other groups for comparison. We are currently in discussions with the South Pacific Whale Research Consortium regarding limited analysis of our combined holdings, and are in the planning phase for a collaborative effort with the College of the Atlantic to establish a comprehensive Southern Ocean Catalog for humpback whales.

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## TABLES

**Table 1.** Current Pacific Whale Foundation Catalogue Holdings[1]

| Location | Time Span | No. of IDs |
|---|---|---|
| Whitsunday Islands | 1990-1999 | 383 |
| Great Barrier Reef | 1984-1990 | 110 |
| Hervey Bay[2] | 1987-2007 | 3204 |
| Point Lookout | 1984-1991 | 402 |
| Byron Bay[3] | 1996-1997 | 106 |
| Coffs Harbour | 1985-1989 | 19 |
| Eden[4] | 1993-2007 | 1032 |
| Tonga | 1985-1986, 2003-2007 | 95 |
| American Samoa | 1994 | 1 |
| Antarctica[5] | 1983, 1986, 1988-1989 | 5 |
| **TOTAL IDs** | | **5357** |

[1]All holdings are reconciled through 2007, with the exception of 20 individuals from Tonga. Images curated by Pacific Whale Foundation include images submitted by a number of individuals.
[2]Photo-ID effort not undertaken in Hervey Bay during 2001 or 2003
[3]Submitted by David Paton
[4]Includes images submitted by Ros Butts as well as images obtained during Pacific Whale Foundation field work
[5]Includes images submitted by Alan Ward and Susie Elsner

**Table 2.** Summary of Photo-ID Survey Effort for Selected Years and Locations[1]

| Year | Location | Hours on water | Number of Pods | Number of Whales | Number of IDs |
|---|---|---|---|---|---|
| 1984 | Point Lookout | 57.2 | 11 | 30 | 18 |
| 1985 | Point Lookout | 256.0 | 74 | 161 | 105 |
| 1986 | Point Lookout | 246.7 | 88 | 178 | 94 |
| 1987 | Point Lookout | 484.9 | 175 | 350 | 157 |
| 1988 | Point Lookout | 55.2 | 15 | 30 | 8 |
| 1989 | Point Lookout | 114.3 | 38 | 76 | 37 |
| 1990 | Point Lookout | 193.6 | 80 | 132 | 73 |
| 1993 | Eden | . | . | . | 3 |
| | Whitsunday Is. | 267.6 | 58 | 131 | 70 |
| | Hervey Bay | 422.2 | 266 | 566 | 212 |
| 1994 | Eden | . | . | . | 28 |
| | Whitsunday Is. | 207.1 | 54 | 82 | 46 |
| | Hervey Bay | 478.2 | 240 | 492 | 174 |
| 1995 | Eden | . | . | . | 29 |
| | Whitsunday Is. | 115.0 | 26 | 49 | 24 |
| | Hervey Bay | 142.5 | 107 | 228 | 90 |
| 1996 | Eden | 111.3 | 54 | 109 | 52 |
| | Whitsunday Is. | 194.4 | 89 | 164 | 107 |
| | Hervey Bay | 180.8 | 131 | 273 | 127 |
| 1997 | Eden | 144.6 | 105 | 262 | 189 |
| | Whitsunday Is. | 83.9 | 25 | 52 | 16 |
| | Hervey Bay | 199.1 | 166 | 368 | 163 |
| 1998 | Eden | 156.7 | 81 | 188 | 110 |
| | Whitsunday Is. | 123.5 | 64 | 125 | 82 |
| | Hervey Bay | 230.5 | 260 | 561 | 236 |
| 1999 | Eden | 91.7 | 56 | 128 | 75 |
| | Whitsunday Is. | 170.5 | 68 | 142 | 65 |
| | Hervey Bay | 277.2 | 209 | 431 | 189 |
| 2000 | Eden | . | . | . | 13 |
| | Hervey Bay | 360.2 | 294 | 583 | 219 |
| 2001 | Eden | . | . | . | 34 |
| 2002 | Eden | . | . | . | 18 |
| | Hervey Bay | 337.5 | 353 | 769 | 168 |
| 2003 | Eden | 125.5 | 89 | 197 | 124 |
| 2004 | Eden | . | . | . | 76 |
| | Hervey Bay | 217.6 | 186 | 357 | 235 |
| 2005 | Eden | 62.7 | 57 | 121 | 92 |
| | Hervey Bay | 501.3 | 564 | 1328 | 452 |
| 2006 | Eden | 14.9 | 25 | 54 | 153 |
| | Hervey Bay | 510.9 | 688 | 1602 | 587 |
| 2007 | Eden | 52.5 | 60 | 179 | 64 |
| | Hervey Bay | 507.6 | 584 | 1310 | 650 |

[1]Data on hours on water, pods and whales observed is missing for years in which Pacific Whale Foundation did not conduct fieldwork, but images were submitted by other researchers.