THE Oceania PROJECT

Report on Research in Hervey Bay

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By

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1 – Introduction

Commercial Whale Watching was initiated in Hervey Bay in 1987 when local fishermen realised that their customers were showing more interest in the visiting humpback whales than fishing (Per Com Brian & Jill Perry). This summary of research conducted in Hervey Bay in the following years is based on early literature on the establishment of the Hervey Bay Marine Park (Attachment I) and subsequent research outcomes, from the late-1980s till the present, by Author (Attachment II) and by Year (Attachment III)

2 - Hervey Bay

Hervey Bay is a broad, shallow, protected bay located at 25^0S, 153^0E, on the southeast coast of Queensland. The bathymetry and physical processes of the bay were recently described (Ribbe 2014). It is formed by Fraser Island, the largest and oldest sand island in the world (Boyd et al. 2004), and the mainland coast of Australia. The Bay is located a short distance southeast of the putative breeding and overwintering grounds of the eastern Australian humpback whales, within the lagoon of the Great Barrier Reef (Simmons and March 1986; Chaloupka and Osmond 1999; Smith et al. 2012). Long-term water quality data collected by Drs Trish and Wally Franklin, The Oceania Project, in collaboration with Queensland Department of the Environment, between 1993 and 2003, revealed that Chlorophyll-a levels in Hervey Bay were closer to oceanic levels than coastal levels (Moss et al 1998, 2004), which likely

contributes to the suitability of the Hervey Bay habitat for humpback whales. The use of Hervey Bay by migrating humpback whales was first reported by Dr Robert Patterson (Paterson 1991) who reported that some humpback whales deviate from the southward migration pathway and enter Hervey Bay. Paterson was the first to describe a stranding of humpback whales in Hervey Bay (Paterson and Van Dyck 1991). Paterson also investigated the status of the eastern Australian population (Paterson et al. 1994, 2001) following the devastating impact of commercial whaling on the population (Clapham et al. 2005, 2009)

3 – Early literature on Marine Park and Whale Watch Regulations

Commencement of commercial whale watching in 1987 triggered a Queensland Government process to establish Hervey Bay as a Marine Park (Chaloupka 1990; Stevens and Chaloupka 1992b) and, in conjunction with Queensland Parks and Wildlife Service and the Hervey Bay Whale Watch Industry, the implementation of Whale Watch Regulations, on board interpretive and education program and a QPWS Ranger Monitoring program of Hervey Bay Whale Watch operations (Stevens 1991; Stevens and Paton 1992b; Jeffrey 1993; Franklin 1995). The Hervey Bay Marine Park was formalised and gazetted by the Queensland Parliament as the *Nature Conservation Act 1997* (QEPA 1997). This preceded the development and implementation of the Great Sandy Marine Park incorporating the earlier Hervey Bay Marine Park (NPAQ 2005).

The Queensland Government contracted Professor Michael Bryden of Sydney University in 1988, based on two pilot studies (Bryden et al. 1988a and b) to conduct a four-year Humpback whale research program in Hervey Bay to inform the Marine Park process. Fieldwork was led by Dr Peter Corkeron (Bryden and Corkeron 1989a and b, 1990, 1991). Two independent whale research organisations were also attracted to and commenced study of humpback whales in Hervey Bay: Pacific Whale Foundation in 1984 (Dr Paul Forestell and Greg Kaufman) and The Oceania Project in 1989 (Drs Trish and Wally Franklin). The Queensland Government contracted Pacific Whale Foundation to continue ongoing research, which resulted in a series of reports and publications (Kaufman et al 1987, 1993; Forestell et al. 1993, 2003; Forestell and Brown 1995). A proposal to develop scallop farming within the Hervey Bay whale management and monitoring area (Dredge et al. 2000), created a potential conflict with use of the habitat by humpback whales (Franklin and Franklin 2003). An overall report on Humpback whales in Hervey Bay was also produced by the Queensland Environment Protection Agency (Vang 2002) and research and management opportunities in Hervey Bay were described in two earlier conference presentations (Franklin 1996; Franklin T & Franklin W 1998).

4 - Early science outcomes

Pacific Whale Foundation (PWF) data was used to investigate abundance, survival and calving rates of humpback whales in Hervey

Bay for the ten-year period 1987 to 1996. Abundance showed variability in the early years ranging from 554 in 1988, peaking at 1040 in 1991 before declining by mid-1990s, with a high rate of survival (0.966 (95% CI: 0.87 to 1.00), (Chaloupka et al. 1999, also see Forestell et al. 2006a). PWF also studied lateral body photo-identification marks and orca scarring on humpback whales (Kaufman et al. 1987, Naessig and Lanyon 2004) and produced and published the first photo-id fluke catalogue of Hervey Bay humpback whales (Kaufman et al. 1993) and as well as calving rates and intervals (Forestell et al. 2006b). Finally, Dr Paul Forestell documented the observations of 'Migaloo', the white humpback whale, including visits to Hervey Bay in 1992, 1993 and 1998 (Forestell et al. 2003).

Data from the Bryden/Corkeron fieldwork resulted in important publications. Aerial surveys (Corkeron 1993) revealed that humpback whales enter and leave Hervey Bay to the north and that they aggregate in the eastern Bay against the shoreline of Fraser Island (Corkeron et al. 1994). Corkeron also studied the responses of humpback whales to Whale Watch Vessels (Corkeron 1995; Corkeron and Brown 1995). Finally, Corkeron reported on the use of Hervey Bay by Humpbacks whales, noting that mother-calf pods occur during the latter season, September and October (Corkeron et al. 1994). However, Corkeron reported that insufficient data were available to determine the classes of humpback whales using Hervey Bay and that at least five-years of photo-

identification data would be required for that investigation (Corkeron et al 1994).

5 – Classes and timing of humpbacks whales using Hervey Bay

In 1992, Drs Trish and Wally Franklin initiated a long-term photo-identification study of humpback whales in Hervey Bay to investigate timing and classes of humpbacks whales using the Bay, as well as pod characteristics, population dynamics, abundance, migratory movements and behaviour. The study involved 10 weeks of fieldwork each year during August, September and October, for seventeen-years between 1992 and 2009 (outcomes comprehensively reported in Franklin 2012; Franklin 2014). Investigation of pod characteristics confirmed that mother-calf pods dominate during September and October, while pod characteristics during August were consistent with the presence of immature humpback whales and mature females during August (Franklin et al. 2011).

Dr Trish Franklin investigated the question of the timing and classes of whales using Hervey Bay by analysis of long-term data of known individual whales, by maturity, gender and reproductive status (Franklin et al 2018). The study confirmed that mature females accompany the immature cohort in Hervey Bay during August, while lactating females with new season calves dominate September and October overall, few mature males visit Hervey Bay. Furthermore, the study showed that calves return to Hervey Bay the following year to join the immature

cohort. More importantly, the study reported a unique female-biased sex ratio (2.9:1 females to males, Franklin et al. 2018). The paper argued that the geographical location and bathymetry of Hervey Bay relative to the breeding grounds, together with the timing and classes of whales using Hervey Bay contribute to Hervey Bay being a globally unique whale watching destination (Franklin et al. 2018).

6 – Relationship of Hervey Bay humpbacks to east Australian population - Abundance and Population Dynamics

Several recent studies of abundance of humpback whales in Hervey Bay have been conducted by Pacific Whale Foundation (Hoffman et al. 2010; Forestell et al. 2011; Rankin et al 2014).

Dr Wally Franklin used robust design modeling of long-term capture histories of individual humpback whales in Hervey Bay over 21 years (1992 to 2012) to address core questions: What is the role and function of Hervey Bay during the migration of eastern Australian (Group E1) humpback whales? How many humpback whales use Hervey Bay within season and over years? What is the residency of humpback whales in the Bay? Is there site-fidelity to Hervey Bay? What proportion of eastern Australian humpback whales are using Hervey Bay? (for comprehensive results see Franklin 2014).

The estimated yearly abundance of humpback whales visiting Hervey Bay increased from 791 in 1997 (95% CI, 407-1176) to 4406 in 2009 (95% CI, 3343-5470). The trajectory of increase in estimated abundance

over the 17 years was near linear and slightly greater than the trajectory of increase in the estimated abundance of the whole eastern Australian humpback whale population. A relatively constant proportion of eastern Australian humpback whales visited Hervey Bay each year (mean = 34%, standard deviation = 5.3%).

Between years apparent survival was estimated to be relatively constant over years at 95% (SE = 0.012, 95% CI, 0.918:0.966) and near to the upper limits of biologically plausible survival levels for humpback whales. The near constant proportion of whales occurring in Hervey Bay from the eastern Australian population and the very high site-fidelity of some of those whales in Hervey Bay, suggest that the same cohorts of humpback whales return regularly to Hervey Bay. The study provided the first evidence that a specific sub-group from the eastern Australian humpback whale population uses Hervey.

Between week entry probabilities display a regular form over years, with variation in the proportion of yearly visitors present prior to the beginning of sampling in each season (mean = 17%, SD = 6.5%), which may be related to the shifts in the timing of the migration. Within season abundance is heavily skewed to the first half of the season, with approximately 83% of entries occurring in the first five weeks of the season and 17% of entries occurring during the last five weeks of the season. There are two distinct peaks in abundance within season; the highest in week 3 and the second highest abundance occurs in week 8

each year. The lowest probability of entry (1.2%, 95% CI, 0.0004-0.028) and the lowest between week apparent survival (1.3%, 95% CI, 0.062-0.262) occurs between weeks 5 and 6. These results coincide with the mid-season departure of the mature female, immature and older male and female cohorts, and the arrival of lactating females with older calves and accompanying mature male escort cohorts that dominate the latter half of the season.

Temporary emigration was estimated to be constant over years at 14.1% (SE = 0.038; 95% CI, 0.081:0.234) and is consistent with a hypothesis that two cohorts – each comprising of breeding females depending upon their breeding status - visit Hervey Bay in alternate years. The typical residency time of humpback whales visiting Hervey Bay is about 1.4 – 2.0 weeks (mean = 1.6 weeks, SD = 0.34).

The observed proportion of calves to whales in Hervey Bay (weekly average 1997 to 2009 = 17.9%) is consistent with the estimated growth rate of the eastern Australian population and calf survival of humpback whales that utilise Hervey Bay may be higher than for the eastern Australian population as a whole. Modelling of the population trajectory of humpback whales utilising Hervey Bay reveals that observed abundance estimates exhibit a logistic trend with a faster growth rate in the mid-1970s, near linear growth during the early and mid-2000s and a slightly decreasing growth rate by 2009 (Franklin et al. a and b In Preparation).

7 – Migratory movements and genetic studies.

Pacific Whale Foundation (PWF) reported migratory movements of an individual humpback whale between Hervey Bay and the Balleny Islands feeding area (Kaufman et al. 1990; also see Rock et al. 2006) and between Hervey Bay and west Australia (Kaufman et al. 2011). A migratory movement of an individual whale was also reported between Hervey Bay and New Caledonia (Garrigue et al. 2000) and between Hervey Bay and East Antarctica (Garrigue et al. 2010). Migratory movements of individual humpback whales off the east coast of Australia, including Hervey Bay, provided relative timing of the migration along the east coast (Burns et al. 2014). PWF also reported on bias arising from lack of inclusion of available data when matching catalogues, photo-identification of humpback aggregations along Australian coastline and feeding observation (Gibson et al. 2008; Gibson et al. 2008-9; Kaufman et al. 2010, 2011, 2013; Silva et al. 2011).

A major photo-identification match in 2004 - organised by Dr Claire Garrigue of the South Pacific Whale Research Consortium - between Humpback fluke catalogues across the Pacific and eastern Australia yielded photo-identification matches between New Caledonia, New Zealand and Hervey Bay (Garrigue et al. 2007, 2011). Those matches provided data for a formal analysis of the eastern Australian humpback whale population, the New Caledonia population and humpback whales which migrate through New Zealand waters. Those analyses revealed

that, although there were low levels of interchange of humpback whales between eastern Australia and New Caledonia, the two regions were separate populations and that eastern Australian humpback whales migrate through New Zealand waters, to and from Antarctic feeding areas (Franklin et al. 2008b, 2014). Matches between the Balleny Islands and eastern Australia, including Hervey Bay, provided data for an analysis between the two regions. The results supported the hypothesis that Antarctic Area V waters in the vicinity of the Balleny Islands are a primary summer feeding area for eastern Australian humpback whales (Franklin et al. 2007, Franklin et al. 2008a, 2012). Dr Trish Franklin obtained a fluke catalogue from Greenpeace of humpback from the antarctic coast south of western Australia and, arranged for those flukes to be matched to an east Africa Catalogue, a western Australian catalogue and also the Hervey Bay catalogue. Although no matches were found there was sufficient evidence from the analysis to support the hypothesis that the Antarctic humpback whales were from the western Australian population (Franklin et al. 2008c, Franklin et al. 2017a). Two humpback whales satellite tagged of Eden, were matched against the Hervey Bay catalogue. One of the whales turned east after leaving Eden and travelled towards New Zealand. The other whale, accompanied by a calf, travelled down the coast of NSW and Victoria, crossed Bass Strait, passing the northwest coast of Tasmania and travelled southwards towards the antarctic coast, south of western

Australia. This indicated that the feeding destinations of eastern Australian humpback whales are much more widely spread and diverse than previously reported (Franklin et al. 2017b). The South Pacific Whale Research Consortium undertook a comprehensive matching of Antarctic Area V Humpback whales to Pacific and eastern Australian catalogues and a review of remote feeding areas in Antarctica for south pacific humpback whales, including Hervey Bay (Constantine et al. 2011; Constantine et al. 2014).

Genetic studies of humpback whales have investigated connections between western Australia, eastern Australia and Pacific regions and linkages between breeding and feeding areas, including Hervey Bay Humpback whales (Anderson and Brasseur 2007; Anderson et al. 2010; Steel et al 2011; Anderson 2013).

8 – Behaviour of humpback whales in Hervey Bay

PWF studied the distribution patterns of humpback whales in Hervey Bay and reported distinct spatial segregation based on pod composition (Martinez et al. 2015; Stack et al. 2020). Sarah Mccullough, in collaboration with Drs Trish and Wally Franklin, studied and compared the behaviour of humpback whales in the Gold Coast Bay and Hervey Bay (McCullough et al. 2021).

Dr Trish Franklin studied the long-term (14 years) behaviour of humpback whale pod associations, non-agonistic social pods and competitive pods in Hervey Bay. Non-agonistic social behaviour was

observed more frequently during August when mature females, including early pregnant and resting females, co-occur and socially interact with immature males and females. Overall, relatively few mature males visit Hervey Bay. Agonistic competitive behaviour was observed with increasing frequency during September and October when mother-calf pods, with few escorts predominated. Mother-calf pods in Hervey Bay spent the majority of their time alone involved in maternal care. Agonistic competitive behaviour is related to the decreasing numbers of potentially estrous females towards the end of the season. Non-agonistic social behaviour and agonistic competitive behaviour were more frequently observed in larger and newly associated pods. Overall, non-agonistic social behaviour pods were more prevalent than agonistic competitive social behaviour pods (Franklin et al. In Review).

9 - Other Cetaceans and marine species using Hervey Bay

Anecdotal sightings of several species of Cetacea using Hervey Bay include two species of Bottlenose Dolphins, Common Dolphins, Bryde's Whales, Minke Whales, Pilot whales and a stranded Sperm Whale. Formal reported sightings of other species of Cetacea in Hervey Bay include Risso's Dolphin (Corkeron and Bryden 1992); Southern Right Whales (Brigden 2001; Franklin and Burns 2005) and Indo Pacific Dolphins (Cagnazzi et al. 2011). Finally, dugongs occur extensively in Hervey Bay (Sheppard et al. 2006).

10 – Swim-with humpback whale research

Dr Stephanie Stack (PWF) has undertaken a three-year study of 'swim-with' operations in Hervey Bay and presented a preliminary report on the first year of data to the Scientific Committee of the International Whale Commission (IWC) in 2019.

The aims of this study were to 1) examine short-term behavioural responses in whales before, during and after swim-with-whale tours, and 2) investigate behavioural responses of whales throughout swim-with-whale tours compared to whale watch tours. Data were collected from commercial vessels, where *before, during* and *after* data were collected during swim-with-whale tours (250 hrs observation time) and whale watch tours (150 hrs observation time). Within the swim-with-whale tours, behavioural changes were detected *before, during,* and *after* the vessel approached and placed swimmers in the water, with the majority of significant changes occurring in the *during* and *after* phases. The number of direction changes made by the whales was highest when swimmers were in the water and the whales did not resume undisturbed behaviour *after* the vessel departed. There was a 50% reduction in the proportion of time that whales spent resting *during* swims compared to *during* whale watch tours. In both tour types, the time spent engaging in various behaviours was impacted by the distance between the vessel and the whale(s) (Stack et al. 2021; Stack et al In Review; also see Gero et al. 2016).

11 – Multi-feature AI Algorithm automatic photo-matching

PWF developed and tested a 'crowdsourcing' system for identification of humpback whales using the 'crowdsourcing' system (Stack et al 2014) and also evaluated the efficacy of 'citizen scientist' cataloguing humpback whales (Stack et al. 2015)

Dr Trish Franklin investigated the long-term (1992-2009) stability and/or changes in natural marks on ventral-tail flukes, dorsal-fin shapes and lateral body marks of humpback whales and reported no significant difference between the proportion of changes in primary and secondary ventral tail fluke marks and the proportion of changes in primary dorsal-fin shape characteristics plus secondary lateral body marks. The results of the study substantiated the value and reliability of using ventral tail-flukes, together with dorsal-fin shapes and lateral body marks, as multiple complementary tags in the photo-identification process and the development of AI Multi-feature Algorithms for automatic photo-matching of humpback whales (Franklin et al. 2020). The results of this paper were presented to the Photo-ID Working Group at the IWC Scientific Committee meeting in May 2021.

12 - Planned Research 2021 season.

12.1 The Oceania Project

Collaborations with Jason Holmberg, WildMe.org and Ted Cheeseman, Happywhale.com on development of automated AI Algorithm multi-feature photo-matching technology will be progressed.

A Southern Cross University Student will commence work with Ted Cheeseman in July 2021, to load the Hervey Bay fluke Catalogue onto the Happywhale platform. The main focus for this will be to have the data available contribute to a proposed South Pacific basin-wide study of migratory movement and feeding, breeding ground connections.

Similarly, the Hervey Bay Fluke Catalogue is in the process of being loaded onto the Flukebook platform to make it available for matching on a collaborative basis by scientist working on humpback whales. In addition, Jason Holmberg will be loading the comprehensive resight photography of the 683 resight histories of individual Hervey Bay Humpback whales compiled by Dr Trish Franklin between 1992 and 2017. This photography will be used to train evolving multi-feature AI Algorithms.

Submission of the population dynamics and abundance papers to the journal 'Frontiers in Marine Science', will be progressed during 2021 (Franklin et al. In Review a and b)

12.2 Pacific Whale Foundation

Pacific Whale Foundation has spent much of the past year reconciling their photo-id catalogue and uploading it to Happywhale.com for automated matching and to make it available to potential collaborators. This catalogue is now available to view at this URL: https://happywhale.com/org/494

In 2021, PWF will begin a new monitoring study to use innovative technologies, such as UAS (drones) and CATS cam tags, to study mother-calf humpback whales and their health. We will use aerial photogrammetry to measure the body condition of individual mother-calf whales and the energy transfer from mother to calf during nursing. Additional goals include quantifying the proportion of the population that has been previously entangled, by measuring external scarring.

Pacific Whale Foundation is also beginning a dolphin monitoring project and our initial aims are to develop photo-id catalogues for the 3 species of dolphins that are most commonly encountered: T. truncatus, T. aduncus, and S. sahulensis. We will also investigate fisheries interactions as a potential threat to dolphins in Hervey Bay. To accomplish this, we will use photo-ID and drone imagery to document the rate of external scarring and injuries that are caused by interactions with fishing gear.

Community science (also called citizen science) opportunities:

Mobile app: Our free Whale & Dolphin Tracker app is the latest iteration of a long-term community science program for monitoring and collecting data on marine wildlife. With this free app available to the public, you can now log your humpback whale sightings in real time and upload photos from your mobile device. Your contributions will aid

our researchers in their studies and contribute to informed management of the East Australia population of humpback whales.

Photo donations: Members of the public are encouraged to submit their whale and/or dolphin photos to Pacific Whale Foundation for incorporation into our catalogues. Photo-identification of whales and dolphins has been part of our long-term research at Pacific Whale Foundation, and by donating photos, community scientists can help us monitor the life history traits, population trends, and habitat-use patterns of whales and dolphins around the world.

12.3 Amanda Peterson, University of Sunshine Coast

Amanda Peterson will commence a three-year study in Hervey Bay in 2021, titled:

'The abundance, environmental influences, predator interactions, and genetic relatedness of Hervey Bay's humpback whale population'

The project will study the humpback whale population that utilises the Whale Heritage Site of Hervey Bay, Queensland during seasonal migrations.

A multi-state open robust design capture-recapture model will be applied to three seasons of photo-identification data to estimate abundance. These abundance estimates will be compared and combined with historical estimates and environmental data to identify trends. In particular, the project will explore factors, including water

temperature, which may have contributed to the below-average number of humpback whales reported incidentally in Hervey Bay by whale watch operators during the 2020 migration, and the concurrent increase in numbers reported in the more southern location of Moreton Bay during this same season. Predictions for the future of humpback whales visiting Hervey Bay will be explored based on projected climate change models for this region.

Parentage and kinship within the Hervey Bay population will be examined utilising single nucleotide polymorphisms (SNPs) derived from double-digest restriction-site associated DNA sequencing (ddRAD), which will further the understanding of the social organisation and reproductive success of these animals. Genetic material will be obtained from historically (The Oceania Project) and newly collected sloughed skin samples.

Interactions between humpback whales and potential predators (large sharks, orcas) will be explored through the correlation of known migratory pathways with previously tagged shark data. Of particular interest is the assumption that an increase in whale numbers results in an increased abundance of sharks, which this project plans to assess. UAVs will be deployed during surveys to monitor these interactions.

12.4 Raphael Mayaud, Griffiths University

Raphael Mayaud will commence fieldwork in Hervey Bay in August 2021, as part of his study titled:

'Traffic in the playground: Establishing the ecological importance of Moreton Bay to migrating humpback whales'

Four-years of systematic, boat-based line transects in Moreton Bay have revealed high bay usage by humpback whales during their southward migration. A high proportion of these sightings were mother-calf pod groups utilising the shallow waters of the bay, suggesting the role of Moreton Bay as a potential nursing stop-off for migrating humpback whale mothers and calves. This finding carries significant management and conservation implications, due to the importance of such habitats for mother-calf pods, coupled with the high density of commercial and recreational vessel traffic that occurs in Moreton Bay. In order to provide additional support for this finding, prior to policymaker engagement, this project aims to undertake a direct, within-season comparison between Moreton Bay and the well-recognized nursing stop-off, Hervey Bay. Boat-based line transects will be replicated both in Hervey and Moreton Bay during the humpback whale's southward migration, collecting abundance and distribution data as well as important life-history behavioural data. It is anticipated that findings will have major conservation outcomes for Moreton Bay, and will contribute to a first Nations people-led bid to have Moreton Bay declared as a World Heritage site. Furthermore, the spatial data collected in Hervey Bay should provide a powerful contribution for the current re-zoning plan of the Great Sandy Marine Park.