RESEARCH PUBLICATION NO. 112

Report to the Great Barrier Reef Marine Park Authority on the

Dwarf Minke Whale Tourism Monitoring Program (2003–2008)

Dr Alastair Birtles,
Assoc. Prof. Peter Valentine,
Dr Matt Curnock, Dr Arnold Mangott,
Dr Susan Sobtzick and
Prof. Helene Marsh.

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info@gbrmpa.gov.au

Comments and inquiries on this document are welcome and should be addressed to:

Chief Scientist, Director Science Coordination
stig@gbrmpa.gov.au

www.gbrmpa.gov.au

RESPONSE TO THE REPORT

This report provides a comprehensive account of interactions with dwarf minke whales by swimming-with-whales (SWW) endorsed vessels in the Cairns/Cooktown Management Area of the Great Barrier Reef Marine Park over the period 2003 to 2008. It makes a significant contribution to our knowledge of this unique aggregation of dwarf minke whales, their interactions with humans in the Great Barrier Reef Marine Park and the sustainable management of these interactions. It highlights the value of a strong partnership between researchers, operators and management agencies.

The Great Barrier Reef Marine Park Authority (GBRMPA) has carefully considered the report's recommendations and will factor them, as appropriate, into its strategic planning and the ongoing development of research and management priorities.

Management recommendations (quoted verbatim) for GBRMPA	Comment
Based on the management successes achieved since the introduction of permits to limit the scale of the SWW activity in the Great Barrier Reef Marine Park, and the potential risks associated with unmanaged, non-endorsed interactions, we recommend that the SWW activity continue to be regulated and managed via marine parks permits and SWW endorsements, with minimum conditions that SWW-endorsed operators comply with the Code of Practice and contribute to monitoring of the SWW activity. Additionally, the SWW-endorsements should not be too readily or immediately transferable between operators (e.g. in the case of the sale of a business) to ensure that SWW interactions are managed to a high standard (i.e. vessel crew must be familiar with management protocols and be responsible for supervising in-water interactions) and that monitoring data collection obligations are met to an adequate standard. Due to the high turnover of crew among several SWW-endorsed operators identified by Curnock (2010), the requirement for special crew training and/or accreditation as a further condition of the SWW endorsements should be evaluated.	***Recommendation supported.*** All the sub-elements of this recommendation are already being implemented as part of current management arrangements. No change to current management required.
As the long-term and cumulative impacts of the SWW interactions on the whales have not yet been fully established, we strongly recommend ongoing monitoring of the SWW activity. The Minke Whale Project has established methodologies for the collection and analyses of such data for long-term monitoring (e.g. Whale Sighting Sheets, Vessel Movement Logs, passenger questionnaires) and is committed to the ongoing evaluation of the sustainability of the swimming-with-whales activity. The PhD study by M Curnock (2010) was successful in involving key stakeholders in the development of Quadruple-Bottom-Line sustainability objectives, and the three PhD studies have contributed substantially to the evaluation of a suite of sustainability indicators to address these objectives. Implementation of these sustainability indicators will require the support and involvement of all key stakeholders. Over the last 15 years, we have established a highly successful collaboration with the SWW-endorsed operators that has facilitated improvements every year in their voluntary collection of a wide range of monitoring data (in terms of both quantity and quality). Continuing this collaboration with such 'platforms of opportunity' represents the most cost-effective means of studying dwarf minke whales in the Great Barrier Reef and monitoring potential impacts of the SWW activity, as well as for achieving high levels of compliance with management protocols.	***Recommendation supported.*** Ongoing monitoring of the SWW activity is a condition on the permit and is also being considered as part of ongoing research by the minke research team. No change to current management required.

Management recommendations (quoted verbatim) for GBRMPA	Comment
Based on the finding of a near doubling of the total annual encounter time over the six-year monitoring period, and the PhD study by M. Curnock (2010) attributing this growth to shifting patterns in industry effort, we recommend that industry effort data be incorporated into standardized monitoring of dwarf minke whale encounters involving SWW-endorsed vessels to assess changing patterns of industry use and encounter rates at key sites for minke whale interactions (e.g. Lighthouse Bommie).	***Recommendation supported**.* Ongoing monitoring of the SWW activity and the time each operator spends at each dwarf minke interaction is a condition on the permit and is also being considered as part of ongoing research by the minke research team. GBRMPA will liaise with the researchers to determine if standard monitoring forms need amending to capture additional information.
To ensure a high standard of monitoring data quality and good compliance with management regulations and the Code of Practice, we recommend that annual workshops involving industry, managers, researchers and other key stakeholders be continued. Pre-minke season workshops held in Cairns during the Dwarf Minke Whale Tourism Monitoring Program provided an excellent opportunity to inform and update SWW-endorsed operators on monitoring data requirements and on management protocols (e.g. for the benefit of new crew; NB. The PhD study by M. Curnock found a high turnover of crew in this industry). Over the Monitoring Program, a steady improvement was recorded each year in the industry's total monitoring and research data returns.	***Recommendation supported but will not be funded by GBRMPA.*** Changing priorities within the agency has meant that GBRMPA funding for these annual workshops has discontinued. The number of operators permitted to conduct the SWW activity is very limited (<9), so GBRMPA will utilise other mechanisms for communication of key information to operators who have a SWW endorsement. The potential impact of the GBRMPA not funding these annual workshops is considered a very low risk.
As part of an adaptive management approach, we recommend that the Code of Practice continue to be reviewed and revised as necessary with the involvement of the industry, researchers, managers and other key stakeholders in workshops, as new findings from research and monitoring come forth. The model established via the Dwarf Minke Whale Tourism Monitoring Program has been recognised as a world-leading approach toward sustainable management by numerous stakeholders (including representatives of international wildlife conservation NGOs) and has resulted in strong industry support for the current Code of Practice.	***Recommendation supported**.* Any review of the SWW activity will be reflected within the Code of Practice.
New and updated interpretative material is needed to assist crew management of SWW interactions and passenger compliance with the Code of Practice. During the Dwarf Minke Whale Tourism Monitoring Program, the Minke Whale Project research team provided annual updates to SWW-endorsed vessels' interpretive tools (including developing an interpretive DVD), however some of these are now outdated (e.g. the CRC Reef brochure: "Dwarf Minke Whales in the Great Barrier Reef – Current State of Knowledge 2002") and supplies of such materials have run out. These interpretive tools have been shown to be valuable resources for vessel crews (especially new crew members) and provide explanations of the reasons for specific management protocols in the Code of Practice.	***Recommendation supported but will not be funded by GBRMPA.*** Changing priorities within the agency has meant that there are limited resources to update relevant interpretative material regarding the dwarf minke whale and the SWW program. The potential impact of GBRMPA not funding updates to interpretive material is considered a very low risk.
Based on the PhD findings of A. Mangott (2010), risk management procedures (e.g. in the form of a handbook) should be developed and implemented to minimize the risk of potential harm to swimmers and whales during in-water interactions with highly interactive individual whales (i.e. those that display behaviours of concern in very close proximity to swimmers, the vessel and/or objects in the water including ropes) and with cow-calf pairs. Crew and passengers on SWW-endorsed vessels must be made aware of the risks involved in swimming with dwarf minke whales, and be able to recognise potentially high-risk	***Recommendation not supported by GBRMPA.*** The *Code of Practice for dwarf minke whale interactions in the Great Barrier Reef World Heritage Area* outlines the environmentally responsible way to approach and interact with dwarf minke whales. It has been developed specifically for the permitted tourism operators with an endorsement for swimming-with-

Management recommendations (quoted verbatim) for GBRMPA	Comment
situations and act accordingly (e.g. exit the water and remove ropes if necessary). Periodic assessments of risks associated with behaviours of concern are recommended as the longer-term effects of the SWW interactions on the whales are better understood.	whales in the Great Barrier Reef Marine Park, and it incorporates existing legal requirements. In this document it clearly states 'it is the responsibility of the vessel skipper and crew to ensure that all passengers and crew comply with the rules outlined in the pre-swim briefing.' It is considered the responsibility of the SWW operators to develop and implement this risk assessment.
As noted above in our response to the Great Barrier Reef Marine Park Authority's question 4.12 "Does the high degree of visitation by endorsed operators to Lighthouse Bommie require any specific management actions", we reiterate that the establishment of a Special Management Area in this vicinity may be appropriate as a precautionary management tool to control and monitor the extent of the SWW activity. Further detailed discussions of issues and implications associated with such spatial management must involve industry stakeholders, researchers and other key stakeholders in a transparent process to achieve an agreeable and workable outcome.	***Recommendation not supported by GBRMPA.*** It is considered that visitation at popular sites, such as Lighthouse Bommie, is already well controlled through the Cod Hole and Ribbon Reefs Operators Association (CHARROA) mooring booking system, without imposing another regulatory burden in the form of a Special Management Area.

Research recommendations (quoted verbatim) for GBRMPA	Comment
The expansion of the current Minke Whale Project Whale Sightings Network, by encompassing areas outside the range of the endorsed SWW operators, to examine the extent of dwarf minke whale interactions with humans elsewhere in the Great Barrier Reef Marine Park and assess the full extent of potential impacts and cumulative effects.	***Recommendation supported but not funded by GBRMPA.*** GBRMPAs 'Eye on the Reef' platform provides a mechanism for wildlife sightings to be reported and stored in a spatially-linked database. The researchers can access this database from the web to determine the extent of dwarf minke whale sightings and interactions elsewhere in the Great Barrier Reef.
The continuation of long-term population studies using photo-identification. Such data will be needed to assess longer-term behavioural changes of individual whales, as well as survivorship within the interacting population and cumulative interaction times of individuals.	***Recommendation supported but not funded by GBRMPA.*** GBRMPA will support researchers to seek external funding to further demographic research on dwarf minke whales.
Habitat modeling of eastern Australian waters and the south-west Pacific to investigate potential correlations between dwarf minke whale distribution in the northern Great Barrier Reef and the environmental variables of the adjacent region in order to predict currently unknown habitats and potential feeding grounds outside the northern Great Barrier Reef (e.g. around sea mounts in the south-west Pacific).	***Recommendation supported but not funded by GBRMPA.*** GBRMPA will support researchers to seek external funding to further this research.
Migration and movement studies (including the potential use of satellite tags), to contribute to more complete assessments of risks and threats to dwarf minke whales both within and beyond the Great Barrier Reef Marine Park.	***Recommendation supported but not funded by GBRMPA.*** GBRMPA will support researchers to seek external funding to further this research.
Systematic surveys of dwarf minke whale distribution and abundance in the Great Barrier Reef Marine Park (i.e. from dedicated research platforms including vessels and aircraft).	***Recommendation supported but not funded by GBRMPA.*** GBRMPA will support researchers to seek external funding to further this research.
Behavioural studies of the whales' activity budgets when in the Great Barrier Reef Marine Park (via remote sensing and observation from dedicated platforms) and changes associated with the SWW activity.	***Recommendation supported but not funded by GBRMPA.*** GBRMPA will support researchers to seek external funding to further this research.
Genetic studies of key biological and population parameters (e.g. including stock structure, potential variation and phylogeography of sub-populations).	***Recommendation supported but not funded by GBRMPA.*** GBRMPA will support researchers to seek external funding to further this research.

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EXECUTIVE SUMMARY

This report provides a comprehensive account of interactions with dwarf minke whales by swimming-with-whales (SWW) endorsed vessels in the Cairns/Cooktown Management Area of the Great Barrier Reef Marine Park over the period 2003 to 2008. Results presented in this report are primarily based on analyses of Great Barrier Reef tourism industry-collected Whale Sighting Sheets. Key management processes and outcomes, arising from bi-annual stakeholder workshops (held pre- and post-season) during the 2003–2008 Great Barrier Reef Marine Park Authority-funded Dwarf Minke Whale Tourism Monitoring Program are also summarised and discussed. During the latter three years of this program, three PhD studies (by Mangott, Sobtzick and Curnock) contributed significantly to our knowledge of this unique aggregation of dwarf minke whales, their interactions with humans in the Great Barrier Reef Marine Park and the sustainable management of these interactions. Some of the key findings of these three PhD studies are included in this report.

Over the six year period, 90% (1334/1477) of reported Great Barrier Reef dwarf minke whale encounters occurred during June and July. The greatest level of interaction occurred in the Ribbon Reef 9/10 Area, which accounted for more than two-thirds (66.9%; 1388/2074 hours) of the total reported encounter time for the Great Barrier Reef Marine Park for the study period. Encounters at a single dive site known as 'Lighthouse Bommie' (a small and relatively isolated coral pinnacle in the vicinity of Ribbon Reef 10; $14^o52.5$'S, $145^o41.3$'E) represented over a third (36.4%) of the total encounter time for the entire Great Barrier Reef. The number of encounters at Lighthouse Bommie and in the Ribbon Reef 9/10 Area increased substantially over the six seasons (Lighthouse by 129%, from 24 to 55 encounters; Ribbon 9/10 Area by 121%, from 81 to 179 encounters), however the mean duration of encounters for these locations showed no discernable trends or significant differences.

The total interaction time with dwarf minke whales nearly doubled over the six-year reporting period (90% increase 2003-2008), with this growth occurring primarily in the Ribbon Reefs and in the Ribbon Reef 9/10 Area in particular. It is considered that this trend is an indication of increasing industry 'effort' by the SWW-endorsed live-aboard vessels, which have increased their use of dive sites in areas where dwarf minke whales are more likely to be encountered (e.g. Lighthouse Bommie and nearby sites). This increasing effort was confirmed in the PhD study by M. Curnock (Curnock, 2010) which analysed industry effort data that was provided voluntarily by the SWW-endorsed operators. With only 6% (89/1477) of Whale Sighting Sheets submitted by non-SWW-endorsed vessels and 2% (16/782) of encounters in the Ribbon Reef 9/10 Area reported by non-SWW-endorsed vessels, it is clear the growth trend is attributable to the same few SWW-endorsed live-aboard operations that regularly access the Ribbon Reefs and their shift in effort to sites with higher whale encounter rates.

Based on an analysis of the status of the vessel when a dwarf minke whale encounter was initiated, it is clear that the whales were initiating approaches to the vessels. Encounters are defined as a sighting and/or interaction with one or more whales, during which an in-water interaction (where divers or snorkelers are present in the vicinity of a whale) may or may not eventuate. Over the six seasons, 73% (1062/1447) of encounters were initiated when the vessels were not underway (either anchored or moored). Of the total encounters reported by vessels in the Great Barrier Reef, 64% (949/1475) resulted in an in-water interaction. For 87% (824/949) of in-water interactions, a rope was deployed from the vessel for use by snorkelers and/or scuba divers.

The PhD study by S. Sobtzick (Sobtzick, 2010) involved the identification and cataloguing of individual whales over three minke whale seasons (2006–2008). This study drew upon a broad sightings network involving photos and video footage donated by 13 different vessels, providing valuable biological information about within and between season re-sightings and residence times

of individual whales. Her study reports that more than one-third of all completely identified whales were resighted within each season (for 2006 and 2007), which indicates that the interacting population is smaller than expected from previous, less comprehensive studies such as Birtles *et al.* (2002). An initial population estimate for the interacting Great Barrier Reef dwarf minke whale population is included in the PhD study (Sobtzick, 2010). Low mean residence times (8 days in 2006 and 10 days in 2007) suggest that the interacting population is open (i.e. subject to immigrations and emigrations during the season). The high proportion of within-season re-sightings and long encounter times (the overall mean in-water interaction duration from the WSS was 120 minutes) potentially result in high cumulative interaction times for some individual dwarf minke whales with vessels. This raises concerns about cumulative impacts on these whales, especially among those highly interactive individuals.

Sobtzick's PhD study also used videogrammetry to provide accurate length estimates of individual whales. This study found that while every size class of whale (including calves, juveniles and sexually mature animals) was present over the course of a season, the majority of dwarf minke whales interacting with the primary research vessel *Undersea Explorer* in 2006 (63%) and 2007 (65%) were sexually immature.

The PhD study by A. Mangott (2010) investigated the behaviour of interacting dwarf minke whales around vessels and swimmers. This study showed that the whales voluntarily initiate and maintain contact with vessels for prolonged periods of time and not only show a clumped distribution around vessels (<60m from the vessel), but actually aggregate around swimmers. The whales' voluntary initiation and maintenance of close contact for prolonged periods contrasts with most wildlife-human interactions where the wildlife either tolerate humans and/or show no interest in interacting with people unless there is a more tangible benefit, such as food. The behaviour of interacting dwarf minke whales was shown to change over time. The passing distance to swimmers decreased significantly during an in-water interaction, and this response was more pronounced in whales belonging to a large group (*NB. The mean number of whales for in-water interactions reported in the WSS was 3.7; estimates ranging from 1 to >25*). Passing distances of re-sighted dwarf minke whales were significantly less in subsequent interactions (by a mean of 1.5m) than for their first recorded in-water interaction. Thus the more familiar the whales were with the stimulus (i.e. resighted individuals) the more inquisitive the whales behaviour appeared to be.

Mangott assessed the risks associated with a range of dwarf minke whale behaviours, to both the whales and swimmers, in relation to their proximity of occurrence. The immediate overall risk of harm to the swimmers and/or the whales for the majority of the dwarf minke whale behaviours is regarded as low for both the swimmers and the whales. However, highly interactive whales that make very close approaches (defined as <1m) to humans and objects (e.g. ropes) are at a greater risk of causing harm to humans and/or themselves (e.g. from physical contact with swimmers, objects and/or entanglements in ropes). Most behaviours that were considered to pose a risk of harm to swimmers were displayed by only few known, individual whales. Mangott interviewed 21 expert key informants (including cetacean scientists and managers; 60% of whom had previously seen dwarf minke whales and all of whom had expertise on cetacean biology or their management) to evaluate these risks and assess their views and concerns about the management of the SWW activity. The current view of most Key Informants about the conduct of the Great Barrier Reef SWW activity was positive, however respondents expressed concerns for longer-term cumulative impacts on the whales (e.g. disruption of important behavioural states and negative influences on time-activity budgets), potential industry expansion and the potential for discontinuation of research and monitoring of the activity. To ensure that the SWW activity is managed sustainably, the Key Informants agreed that the activity requires (a) continuous monitoring and (b) further studies to identify potential long-term impacts and address key knowledge gaps (e.g. migration, population parameters).

The PhD study by M. Curnock (submitted 2010) investigated mechanisms for assessing the sustainability of the SWW activity. Outcomes of the study included the identification and

evaluation of a range of sustainability indicators (based on sustainability objectives that were developed collaboratively with key stakeholders) and the assessment of industry-generated data for cost-effective sustainability monitoring. Surveys of passengers on board the SWW endorsed vessels (n=2,171) revealed significant differences between live-aboard operations and day-trips, including a much lower proportion of day-boat passengers experiencing in-water interactions with minke whales (17% compared to 97% of live-aboard passengers). Significant differences were also found between individual operators for passenger ratings of how well their minke whale encounters were managed by the vessel crew. There was a large variation between vessels in the proportion of their passengers who indicated they were not adequately prepared for their minke whale interactions (ranging from 4.3% to 26%), as well as the proportion who indicated that they were not familiar with the Code of Practice (ranging from 2.7% to 78% for one vessel in 2008). Crew briefings and preparation of passengers emerged as the most important method of managing SWW participants.

The Great Barrier Reef SWW activity represents one of the world's few permitted and managed swim-with-cetaceans programs, and the collaboration between the Great Barrier Reef SWW industry, Reef managers and Minke Whale Project research team has been acknowledged by representatives from international wildlife conservation organisations (e.g. the Whale and Dolphin Conservation Society and the International Fund for Animal Welfare) as a world-leading example of adaptive management to achieve a sustainable whale watching industry. Many unresolved management issues however, remain (e.g. prevention of entanglements, risk management of highly interactive individual whales and cumulative longer-term impacts of interactions) and some key questions cannot yet be answered due to insufficient information about the wider Great Barrier Reef dwarf minke whale population (e.g. population characteristics, migration paths and external threats). The Minke Whale Project research team strongly advocate the continuation of long-term monitoring of the SWW activity and the initiation of new research to address these knowledge gaps. Without ongoing monitoring, stakeholder involvement and a commitment to adaptive management processes, as well efforts to improve our understanding of this special phenomenon, the sustainability of the Great Barrier Reef SWW activity cannot be guaranteed.

BACKGROUND

Each austral winter a unique aggregation of an undescribed subspecies of whale occurs at the edge of the east Australian continental shelf in the Great Barrier Reef Marine Park. The occurrence of these whales, now recognised as dwarf minkes (*Balaenoptera acutorostrata* subspecies) in remote offshore areas of the Great Barrier Reef Marine Park to the north of Cairns was first documented in the 1980s via reports from an emerging scuba dive tourism industry (Arnold, Marsh and Heinsohn 1987; Arnold, 1997; Arnold and Birtles, 1999). Increasing reports during the early 1990s revealed that in-water interactions were occurring between these whales and scuba divers at sites along the Ribbon Reefs, and that the interactions appeared to be initiated and voluntarily maintained by the whales.

Since the mid-1990s, swimming-with-whales activities have been advertised by a small but growing industry (Birtles, Arnold and Dunstan, 2002; Valentine, Birtles, Curnock, Arnold and Dunstan, 2004), based in the Cairns/Cooktown Management Area of the Great Barrier Reef Marine Park (Fig. 1). In 1996, researchers began working with dive tour operators to study this little known whale, as well as the interactions between whales and swimmers to ensure that the interactions were not harmful to the whales. Due to the remoteness of the interactions and the infrequency of an enforcement presence, a voluntary Code of Practice for managing the whale-swimmer interactions was developed in 1999 to assist the industry to self-regulate and minimise its potential impacts on the whales.

From 2003, all operators offering commercial swimming-with-whales programs were required to have a permit to continue undertaking the activity. A cap of a maximum of ten permits was set initially and nine permits were issued for the 2003 season, remaining at this level since then. These tour operators are referred to hereafter as SWW-endorsed operators. Permit conditions include following the *Code of Practice for dwarf minke whale interactions in the Great Barrier Reef World Heritage Area* (Birtles *et al.*, 2008a) and recording all encounters on a standardised record sheet, the Whale Sighting Sheet (WSS). Details of SWW-endorsed vessels that operated during the 2008 June–July minke season are shown below (Table 1).

Recognising the need to evaluate the effectiveness of managing the swim-with-dwarf minke whales activity, in 2003 the Great Barrier Reef Marine Park Authority entered into an arrangement with James Cook University to analyse and evaluate the WSS submitted by the industry for the next six years (up to and including the 2008 season). Results of the WSS are presented below, including an analysis of trends in the WSS data over the six-year period 2003–2008.
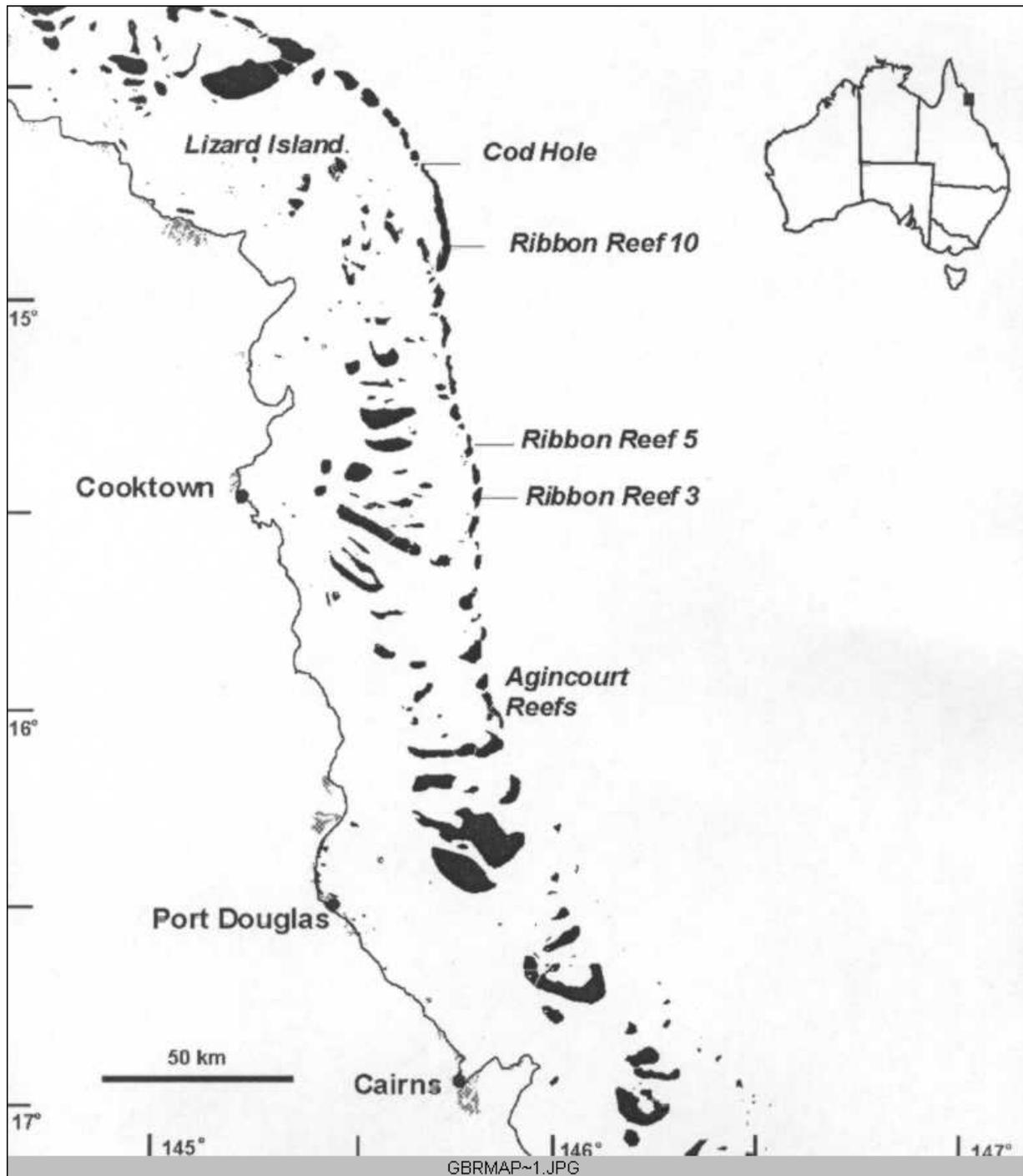
Figure 1: Study area for the Dwarf Minke Whale Tourism Monitoring Program.

Table 1: Details of swimming-with-whales endorsed vessels in 2008.

Permittee	Vessel name(s)	Length	Cruising speed	Passenger capacity	Description of itinerary
Barbara Wright, Peter Lawrence Wright (T.A. Poseidon Cruises)	Poseidon III	24m	25kn	90	Day trips from Port Douglas to Agincourt Reefs.
Blue Oceanic Reef Pty Ltd (T.A. Undersea Explorer)	Undersea Explorer	25m	8kn	21	Research vessel. Six day trips to Ribbon Reefs. Departs Port Douglas.
Chartercorp Reef Tours Pty Ltd (T.A. Aristocat Reef Cruises)	Aristocat V	31m	32kn	100	Day trips from Port Douglas to Agincourt Reefs.
Explorer Ventures (Australia) Pty Ltd.	Nimrod Explorer	21m	9kn	18	Three, four and six day live-aboard trips to Ribbon Reefs and Osprey Reef. Departs Cairns and Cooktown.
Gordon Oke, Marcus William Oke (T.A. Floreat Reef Charters)	Floreat	15m	12kn	11	No set itineraries. Available for charter.
*John C Rumney (T.A. Eye to Eye Marine Encounters)	a. M.V. Phoenix b. M.V. Sinbad c. S.V. Vivid	a. 18m b. 38m Details for vessel c unavailable	a. 9kn b. 8 kn Details for vessel c unavailable	a. 12 b. 8 Details for vessel c unavailable	No set itineraries. Various vessels available for charter.
Mike Ball Dive Expeditions Pty Ltd	Spoil Sport	28.8m	12kn	31	Four day live-aboard trips to Ribbon Reefs. Departs Cairns and Lizard Is.
*Ecrolight Pty Ltd (T.A. Deep Sea Divers Den)	Taka	30m	11kn	30	Three and four day trips to Ribbon Reefs and Osprey Reef. Departs Cairns.
Sable Lake Pty Ltd (T.A. Silver Series)	Silver Sonic	29m	28kn	162	Day trips from Port Douglas to Agincourt Reefs.

*Indicates transfer of permit to new owner (shown) in 2008.

MATERIALS AND METHODS

Terminology

Based on terminology described by Birtles et al. (2002), in the following results an 'encounter' with dwarf minke whales is defined as a sighting of and/or interaction with one or more whales, beginning at the time of first sighting (by any person on the vessel or in the water nearby) and ending at the time a whale is last sighted, which may occur as the vessel departs the area or when the whales leave the area. An 'in-water interaction' occurs when one or more dwarf minke whales are observed by a person or people in the water (who are likely to be using either snorkel equipment or SCUBA). Thus all in-water interactions are encounters, however not all encounters will result in an in-water interaction.

Whale Sighting Sheets (WSS)

All whale encounter data were reported via Whale Sighting Sheets (copies of the Whale Sighting Sheet are available for download at http://www.minkewhaleproject.org/. The completion and submission of the WSS for every minke whale encounter by SWW-endorsed operators has been a formal requirement under the operators' permit conditions since SWW-endorsements were issued by the Great Barrier Reef Marine Park Authority in 2003. Key data fields in the WSS included the vessel name, date, time and location of whale encounters, as well as the number of whales, vessel status (i.e. moored, steaming, drifting or anchored) details of any in-water interaction, the occurrence of any particular behaviours, and the availability of any photos or video footage that might assist with photo-identification of individual whales.

WSS data entry and statistical analyses

Whale sightings data were entered into a MS Access database. Some assistance was provided by volunteers with the entry of WSS and vessel effort data into their respective databases. Volunteers that assisted with data entry were trained individually and supervised closely whilst they worked. Frequent checks of entered data were made and frequency analyses were performed on completion of data entry to assist with the identification of any input errors.

Data analyses were performed using MS Excel and SPSS statistics package. Statistical tests for significant differences included the One-Way ANOVA and non-parametric Mann Whitney U and Kruskal Wallis tests. Normality of each variable was checked using histograms, P-P plots and Levene's Test of Homogeneity of Variance prior to selecting the most appropriate test for significance. Unless otherwise stated in the results, all statistical tests were performed with α-levels at .05.

Pre- and post-season workshops for industry and stakeholders

Pre-season workshops, hosted by the Minke Whale Project research team, were held in Cairns prior to the start of each core minke whale season (in late May or early June). All SWW-endorsed operators were invited to attend and were encouraged to bring as many vessel crew along as possible. Additional pre-season information sessions were held specifically for the benefit of SWW-endorsed day-boat vessel crew in Port Douglas (as very few of these crew were able to attend the main workshop in Cairns) to help raise their awareness of dwarf minke whale sightings, data collection and their management of encounters via the Code of Practice. At each workshop, industry data collection sheets were explained in detail and crew were encouraged to collect these data as completely and accurately as possible.

Post-season workshops were held after each minke whale season in November/December in Cairns. Preliminary results of the WSS were produced after data were collated from each season and were reported back to industry, managers and other key stakeholders at these workshops. Overall, a high level of interest in the results from each season was shown by workshop participants, and awards (i.e. certificates of appreciation and chocolates) were presented to operators and crew members for collecting the highest proportion of each data instrument (e.g. WSS, effort logs, passenger questionnaires and images for minke whale photo-identification).

Detailed minutes were taken from each workshop and draft minutes were circulated to participants for comments before being finalised and uploaded to a password-protected website (accessible to all participating stakeholders).

Interpretive material to encourage industry data returns

A range of interpretive tools were developed by the Minke Whale Project research team prior to each minke whale season and were distributed to SWW-endorsed operators at each pre-season workshop. Interpretive materials were designed to encourage crew and passenger compliance with the Code of Practice and facilitate their contributions to research data collection over each minke whale season. The interpretive material included: laminated colour posters, a minke whale information package (updated annually), a minke whale interpretive DVD (2007), colour brochures and copies of annual research newsletters produced by the Minke Whale Project.

Overall, industry data returns increased over the six-year period and a high willingness to participate in minke whale research data collection was observed among many crew members on the SWW-endorsed vessels.

Summary of aims and methods of the three PhD studies

PhD study by M. Curnock

Thesis title: Mechanisms for assessing the sustainability of swim-with-whales tourism in the Great Barrier Reef

Research objectives:

1. Define, in collaboration with key stakeholders, sustainability objectives for the Great Barrier Reef swimming-with-dwarf minke whales tourism activity.
2. Identify and evaluate a range of key social and managerial sustainability indicators for monitoring the Great Barrier Reef swimming-with-dwarf minke whales tourism activity.
3. Evaluate the reliability of monitoring data generated by the SWW-endorsed tourism operators and SWW participants.
4. Develop an adaptive management model to assist with the long-term monitoring and sustainable management of the Great Barrier Reef swimming-with-dwarf minke whales tourism activity.

Methodology (for each of the above research aims):

1. A Participatory Action Research (PAR) three-step iterative process was employed, involving: (i) A suite of Quadruple-Bottom-Line sustainability objectives (encompassing ecological, social, economic and management goals) were developed based on published literature and with input from cetacean scientists, (ii) 16 Stakeholder Key Informants were then interviewed to refine the objectives and explore issues relating to their implementation, (iii) The objectives were subsequently reviewed, fine-tuned and formally adopted by stakeholders in a series of facilitated workshops.
2. Sustainability indicators were developed from a range of qualitative and quantitative data including (i) Whale Sighting Sheets (documenting details of encounters with dwarf minke whales), (ii) Vessel Movement Logs (documenting vessel movements and site use, i.e. 'effort') and (iii) passenger questionnaires (documenting SWW-participants' experiences, expectations and perceptions of encounters with dwarf minke whales).
3. A range of crew and passenger-completed data collection tools were evaluated, including: (i) Whale Sighting Sheets, (ii) Vessel Movement Logs, and (iii) passenger questionnaires. Crew interviews were conducted to identify issues associated with whale encounter management and monitoring data collection, including methods to improve the quality and quantity of such data.
4. Key Informant Stakeholders were interviewed to evaluate a range of key issues and desired outcomes for future management of the SWW activity. Management processes and outcomes (drawn primarily from stakeholder workshops held over 2006–2008) were assessed and critical elements for successful long-term monitoring and sustainable management of the activity are synthesised into a Swimming-with-Whales Adaptive Management Model (SWAMM).

Data collected (2006–2008):

1. Interviews:
   - 16 Key Stakeholders (including representatives from 7 of the 9 SWW-endorsed operators, as well as Reef managers, scientists, and wildlife conservation NGO representatives)
   - 16 experienced crew (from 7 of the 9 permitted operators)
2. Passenger questionnaires:
   - n=2,171 from eight SWW-endorsed vessels (5 x live-aboards n=1,592; 3 x day boats n=579)
3. Whale Sighting Sheets:
   - n=1,016 (2006-2008)
4. Industry 'effort' data:
   - Vessel Movement Logs (voluntary completed by skippers of SWW-endorsed vessels); n = 524 vessel days at sea.
   - Researcher Log Sheets (completed by MWP researchers and volunteers); n = 349 researcher days at sea.
   - 'Logger' automated GPS logs from Undersea Explorer (2006-2008 seasons)
5. Analysis of Stakeholder Workshops:
   - Analyses were made of the minutes taken from seven Minke Whale Tourism Monitoring workshops held over 2006-2008.

PhD study by A. Mangott

Thesis title: Behaviour of dwarf minke whales (*Balaenoptera acutorostrata* subsp.) associated with a swim-with industry in the northern Great Barrier Reef

Research objectives:

1. To provide better understanding of dwarf minke behaviour around tourism vessels and their swimmers with particular regard to:

   (1) classifying the non-acoustical behaviours of dwarf minke whales in form of an ethogram (Study 1; not part of this report)
   (2) investigating the distribution of interacting dwarf minkes around vessels and swimmers (Study 2)
   (3) examining behavioural changes of dwarf minkes over interactions and over season (Study 3)

2. To assess the risk of dwarf minke behaviours to the swimmers and/or the whales (Study 4)

3. To inform operational practice and management decisions for a sustainable industry

Methodology (for each of the above research aims):

Distribution of interacting dwarf minkes around vessels and swimmers

To investigate the distribution of interacting dwarf minke whales around vessels and their swimmers an adaptive scan sampling protocol was used (Altmann, 1974). Three observation areas defined by distance from the vessel were assigned: (1) '*Inner Area*' (0–60 metres), (2) '*Middle Area*' (61–120 metres) and (3) '*Outer Area*' (121–180

metres). Each area was divided in half (i.e. Areas A & B; see Figure 4.1) for observational purposes. The six sub-areas (e.g. *Inner Area A*, *Outer Area B*) were sampled in a random sequence for set periods of time (five minutes for *Inner Areas* and one minute for each of the *Middle* and *Outer Areas*) followed by a one minute break. For each observation of a whale in the assigned sub-area, the time, the distance to the vessel and the location (sector) every time a whale broke the water surface were recorded. The location (sector) of the ropes was recorded at the start of each area observation. This protocol was followed for the duration of each in-water interaction. Data were standardised per unit effort and unit area.
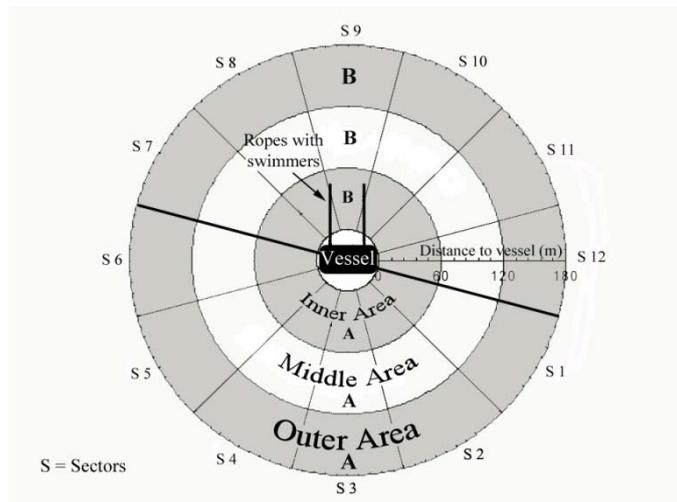
Figure 2: Assigned areas (defined by distance from vessel: *Inner Area A & B* (0–60 metres); *Middle Area A & B* (61–120 metres) and *Outer Area A & B* (121–180 metres) and sectors (based on an imaginary clock face) used for data collection on the distribution of interacting dwarf minke whales around the vessel and swimmers.

The area closest to the vessel (Inner Area) was examined further. The position of the rope varied according to currents and wind direction, thus the data were standardised to the location of the rope and then pooled into four quarters: (1) *'Rope/Swimmer Quarter'*, (2) '*Left Quarter*', (3) '*Right Quarter*' and (4) '*Opposite Quarter*'. A Chi-square goodness-of-fit test was used to investigate if the observed frequencies deviated from expected frequencies assuming equal use of the four quarters. Test assumptions followed Roscoe & Byars (1971) and Zar (1999).

Behavioural changes of dwarf minkes over time

An individual follows protocol (Altmann, 1974) was conducted to investigate how close dwarf minke whales approached swimmers and if this behaviour changes over time. Distance (m) was measured with a hand-held sonar. Both the animal and its closest passing distance were photographed using a Canon G7 with underwater housing or recorded on an underwater slate. The closest passing distance was defined as the minimum distance between a whale and the researcher in a single pass. The sampling protocol was randomised by changing the direction of observation every ten minutes. All animals for which distances were obtained were identified by their individual coloration patterns (Arnold et al., 2005). These identifications were confirmed with help from a parallel photo-ID study. Data were analysed using parametric (Repeated Measure ANOVA's) and non parametric tests (Paired sign test). Parametric

assumptions were explored using residual analysis, and if necessary data were log10 transformed to reduce heteroscedasticity (Zar, 1999).

Assessment of risk of harm to swimmers and/or the whales from dwarf minke whale behaviours

The evaluation of risk of harm to swimmers and/or the whales from dwarf minke whale behaviours was conducted in five steps: (1) identification of dwarf minke behaviours of potential risk; (2) identification of factors contributing to the risk (e.g. closeness); (3) establishment of the frequency of occurrence of the behaviours, (4) evaluation of the risk of harm (consequences) to swimmers and the whales and (5) establishment of the overall risk. The first three steps were conducted using observational data collected over the three years of research, the risk of harm was evaluated with a Key Informant survey and the overall risk was established using a risk assessment matrix, modified from the Australian Workplace Health and Safety (Comcare, 1997).

Over the three year research period (2006–2008), eleven dwarf minke whale behaviours of potential risk to the swimmers and/or the whales were identified. These behaviours were: (1) *slow swim past*; (2) *high speed pass*; (3) *belly presentation*; (4) *bubble release*; (5) *headrise/spyhop*; (6) *pirouetting*; (7) *motorboating*; (8) *gape/gulp*; (9) *breaching*; (10) *sudden speed up* and (11) *sharp veers*. This selection was based on the fact that these behaviours occurred (at least once) within close range (<6m; i.e. within a whale body length) of the swimmers and vessel and that some of those behaviours in other species of cetaceans (e.g. *gape/gulp*, *bubble releases*) are interpreted in the literature as aggressive and/or agonistic.

PhD study by S. Sobtzick

Thesis title: Dwarf minke whales in the northern Great Barrier Reef and implications for the sustainable management of the swim-with industry.

Research objectives:
1. Investigating the potential of non-scientists on 'platforms of opportunity' to contribute to the research by providing well documented photo-identification data
2. Exploring the potential for the whale-watching industry to provide robust and relevant data for long-term monitoring
3. Increasing the biological information about dwarf minke whales in low latitudes
4. Investigating population characteristics of dwarf minke whales involved in swim-with programs in the northern Great Barrier Reef
5. Monitoring potential changes of biological characteristics over time and identifying potential cumulative impacts
6. Exploring implications of the findings for the whale population and for the ecologically sustainable management of the industry.

Methodology:

Photo-identification of dwarf minke whales
During seven weeks in June/July 2006, 2007 and 2008, researchers collected underwater photo-ID data (video and stills) onboard *Undersea Explorer*, a commercial dive-tourism vessel operating in the northern Great Barrier Reef following the methodology described broadly in Birtles *et al.* (2002). General data such as location, total number of whales seen at one time, time of last sighting and duration of the encounter was collected and contributed to a general understanding and overall description of the encounters. The very complex colour patterns of dwarf minke whales, which are unique and in their variability and distinctiveness unmatched amongst baleen whales (Arnold *et al.*, 2005), enable identification of individuals using natural markings only. Once individual whales were identified, they were matched with the photo-ID catalogue.

Objectives 1 and 2

a. *Data quantity*
To maximise the photo-ID data return from the 'platforms of opportunity', a range of multimedia and interpretive materials (including a DVD, posters, flyers and handouts) were developed and distributed among the vessels. During biannual workshops with the permitted industry, researchers updated crew and operators on the photo-ID project and encouraged them to inform their passengers about the value of donating copies of their underwater whale images. Additionally, researchers and trained volunteers were present on various vessels during June/July 2006-2008, encouraging passengers to support the photo-ID study.

b. *Data quality*
The complete 2006 photo-ID data set (researcher plus 'platforms of opportunity' contribution) was scored on a five point scale (1= lowest, 5= highest) for a) picture quality and b) information content for dwarf minke whale photo-identification. Three groups of photographers were classified depending on their skills and knowledge about dwarf minke whale photo-identification: 1) 'Researchers', 2) 'Professionals' and 3) 'Passengers' (including crew).

Objectives 3 and 4

In order to increase the biological knowledge about dwarf minke whales in low latitudes and to investigate population characteristics of dwarf minke whales involved in swim-with programs, this study explored:

a. *Time and locations of dwarf minke whale sightings and site fidelity of individuals*
Questions about spatial and temporal distribution of dwarf minke whales in the Great Barrier Reef were addressed using data collected from the dive live-aboard *Undersea Explorer* and from other 'platforms of opportunity'. Geographical information system (GIS) software was used to present the number of sightings in relation to the location and the time of the sighting. The data were analysed to detect potential spatial and temporal patterns in distribution.

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b. *Association patterns of groups interacting with vessels*
Photo-identification data collected by researchers on board *Undersea Explorer* and from other 'platforms of opportunity' are analysed to determine association patterns between individual dwarf minke whales. Using the software SocProg, association indices between individuals (e.g. Half-Weight-Index) are investigated. An analysis of association patterns of dwarf minke whales interacting with vessels provides insight in their group composition and group stability and therefore informs about the nature of the aggregations.

c. *State of sexual maturity of whales engaged in swim-with programs*
The state of sexual maturity of dwarf minke whales interacting with *Undersea Explorer* was investigated by using underwater videogrammetry to estimate body lengths of the whales. This procedure has been pioneered on humpback whales by Spitz*,* Herman and Pack (2000) and its use on dwarf minke whales is explained in detail in Dunstan, Sobtzick, Birtles and Arnold (2007).

d. *Abundance of dwarf minke whales in the study area*
Dwarf minke whale abundance was investigated using data collected on a standardised platform (*Undersea Explorer*) over the years 2006 and 2007. Sighting histories (within and between years) of individually identified dwarf minke whales were analysed using MARK software and population parameters such as population size, survival rate (i.e. residence time) and capture probabilities were estimated.

Objectives 5 and 6

To monitor potential changes of biological characteristics over time, the results of the population characteristics (Objectives 3 and 4: spatial and temporal distribution of sightings, association patterns, state of sexual maturity and abundance) were analysed and compared over different time intervals, such as (1) over the course of one encounter, (2) over the season and (3) between years. The results were critically evaluated to show possible consequences and explore the implications of the findings for the dwarf minke whale population involved in swim-with programs as well as for the management of the industry.

RESULTS

Analyses of Whale Sighting Sheets 2003–2008

Over the six seasons (2003–2008) a total of 1707 Whale Sighting Sheets (WSS) were returned, 1483 of which reported encounters with dwarf minke whales. Other cetacean species reported included humpback whales (*Megaptera novaeangliae;* n=191 encounters), pilot whales (*Globicephala* spp.; n=2), spinner dolphins (*Stenella longirostris*; n=2); bottlenose dolphins (*Tursiops* spp.; n=1), false killer whales (*Pseudorca crassidens*; n=3); sei whales (*Balaenoptera borealis*; n=1); sperm whales (n=1), and orcas (n=1), Bryde's whales (*Balaenoptera edeni*; n=4 encounters). A further nine WSS were submitted for which the species was not identified, and an additional five WSS were submitted with missing data in this field.

Of the 1483 WSS reporting encounters with dwarf minke whales, 1479 were within the Great Barrier Reef Marine Park, between the latitudes of 14°33' S and 20°34' S. Dwarf minke whale encounters reported outside the Great Barrier Reef Marine Park included one from Marion Reef in the Coral Sea (on 18th May 2008) and three from the south-west coast of Western Australia (between 31st July and 19th August 2005). A total of 1389 (93.9%) of the WSS reporting dwarf minke whale encounters in the Great Barrier Reef Marine Park were submitted by swimming-with-whales (SWW) endorsed operators.

The numbers of WSS reporting dwarf minke whale encounters in the Great Barrier Reef Marine Park each year over the six-year period 2003–2008 are shown below (Figure 3), as well as the number of Whale Sighting Sheets submitted by each SWW-endorsed operator per year (Table 2). Over the six-year period, the number of dwarf minke whale encounters reported in the Great Barrier Reef per year increased by 91%, from 171 to 327 encounters (Table 2 and Fig 3).
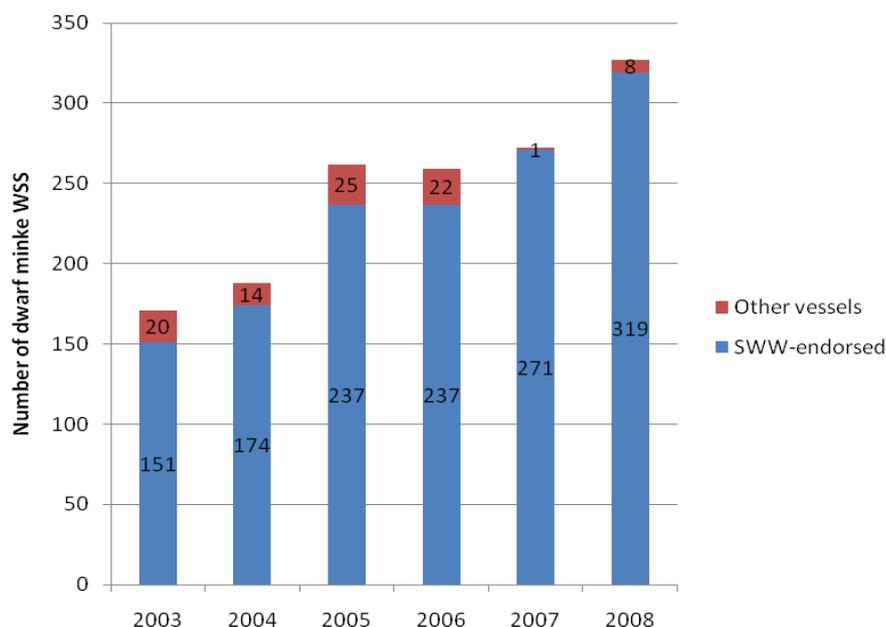
Figure 3: Number of Whale Sighting Sheets reporting encounters with dwarf minke whales in the Great Barrier Reef Marine Park, 2003–2008 (n=1,479; includes WSS submitted by SWW-endorsed operators and WSS submitted by other vessels).

Table 2: Dwarf minke whale encounters reported in the Great Barrier Reef by the swimming-with-whales endorsed vessels, 2003-2008.

SWW-endorsee	2003	2004	2005	2006	2007	2008	TOTAL
Undersea Explorer	62	71	81	80	90	96	**480**
Mike Ball Dive Expeditions	14	18	53	43	65	79	**272**
Nimord Explorer	33	36	47	44	58	42	**260**
Taka Dive	11	24	11	18	31	35	**130**
Poseidon Cruises	8	12	17	7	16	19	**79**
Quicksilver / Silver Series	19	6	12	10	6	12	**65**
Aristocat Reef Cruises	2	0	14	29	1	3	**49**
Eye to Eye Marine Encounters	*Did not operate*	*Did not operate*	*Did not operate*	*Did not operate*	*Did not operate*	31	**31**
Floreat Reef Charter	2	7	2	6	4	2	**23**
Non-SWW-endorsed vessels (combined)	20	14	25	22	1	8	**90**
TOTAL	**171**	**188**	**262**	**259**	**272**	**327**	**1479**

As previously reported to the Great Barrier Reef Marine Park Authority (Birtles *et al.*, 2008b), the number of WSS documenting dwarf minke whale encounters by non-SWW-endorsed operators remains low, however we have received anecdotal reports

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and images donated to the photo-ID study suggesting that such incidental encounters occur regularly in the Great Barrier Reef Marine Park each season. This indicates that a Sightings Network that targeted locations outside the Great Barrier Reef Marine Park along the east and west coasts of Australia to collate dwarf minke whale sightings data on a national scale would be beneficial for the management of this species. The Minke Whale Project research team has identified that continuing to work collaboratively with the other complementary Great Barrier Reef Marine Park Authority-supported reporting systems such as "Eye on the Reef" will maximize the value of all of our data returns.

A wider Sightings Network would greatly enhance the knowledge of the spatial and temporal distribution of dwarf minke whales in Australian waters by engaging and networking existing 'platforms of opportunity' and would facilitate the development of longer-term, broad spatial monitoring for this species which could then form the basis for further exploration of dwarf minke whale sightings in neighbouring South Pacific island nations. Any underwater ID photos that are taken from incidental SWW interactions with dwarf minkes occurring south of the Cairns/Cooktown Management Area of the Great Barrier Reef Marine Park (e.g. in the Townsville/Whitsunday and Mackay/Capricorn Management Areas) may also provide some indication of migration routes if matched with identified whales in our photo-ID catalogue. Establishing a broader 'Sightings Network' has been identified as a research priority and the Minke Whale Project have tried for several years (so far unsuccessfully) to get this funded.

Completion rates for questions on the Whale Sighting Sheets

In general, the completion rates for Whale Sighting Sheets over the six seasons were very high and a consistent improvement was observed in industry completion of key WSS fields each season. Completion rates for key information fields on the WSS (e.g. time of sighting, date, location, species) for the six seasons are presented below (Table 3). Such high completion rates are attributable to ongoing engagement and encouragement of industry personnel by the MWP research team over many years. pre-season workshops played a particularly important role, for distributing data sheets and explaining data requirements to new crew members each season.

Table 3: Whale Sighting Sheet completion rates for key questions, 2003–2008.

Question	Proportion of WSS on which the question was completed Valid % and number of missing cases					
	2003 (n=189)	**2004 (n=217)**	**2005 (n=276)**	**2006 (n=301)**	**2007 (n=313)**	**2008 (n=402)**
Time of initial sighting	95.3 (9 missing)	98.2 (4 missing)	99.3 (2 missing)	99.7 (1 missing)	99.0 (3 missing)	99.3 (3 missing)
Date	99.4 (1 missing)	99.1 (2 missing)	99.6 (1 missing)	99.3 (2 missing)	100	100
Location at start of encounter	81.2 (36 missing)	90.8 (20 missing)	97.8 (6 missing)	98.7 (4 missing)	96.5 (11 missing)	99.3 (3 missing)
Time of last sighting	91.2 (17 missing)	96.8 (7 missing)	93.1 (19 missing)	96.7 (10 missing)	96.8 (10 missing)	95.3 (19 missing)
Vessel name	99.4 (1 missing)	99.1 (2 missing)	100	99.3 (2 missing)	98.7 (4 missing)	99.5 (2 missing)
Type of whale	100	100	99.6 (1 missing)	99.0 (3 missing)	100	98.8 (5 missing)
Number of whales	100	99.1 (2 missing)	98.6 (4 missing)	99.0 (3 missing)	99.0 (3 missing)	98.8 (5 missing)
Recorder name	95.3 (9 missing)	96.3 (8 missing)	98.6 (4 missing)	94.0 (18 missing)	98.1 (6 missing)	98.0 (8 missing)

Temporal distribution of sightings

Over the six year period 2003–2008, 90% (1336/1479) of reported Great Barrier Reef dwarf minke whale encounters occurred during June and July. This temporal distribution of minke whale sightings was consistent across the six years (89% in 2008, 89% in 2007, 88% in 2006, 95% in 2005, 93% in 2004 and 89% in 2003; see Figure 4). The highest number of minke whale encounters reported over a one-week period occurred in 2008, with 57 encounters reported over 1–7 July.
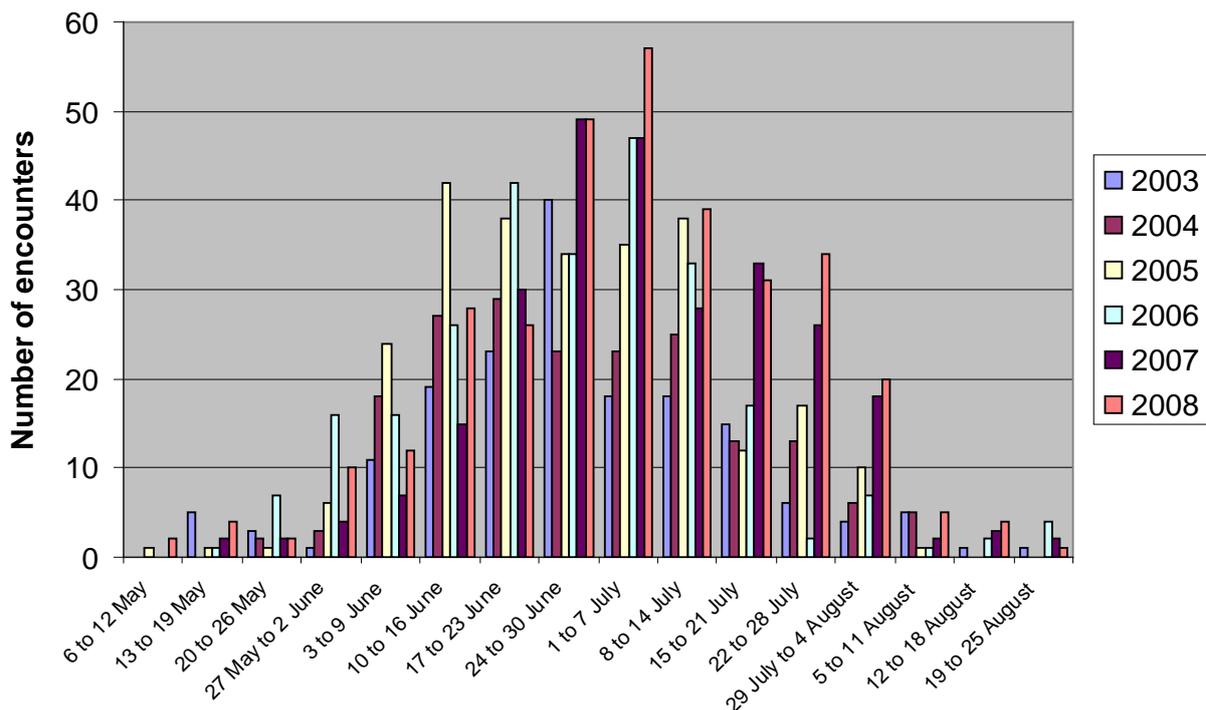
Figure 4: Temporal distribution of reported Great Barrier Reef dwarf minke whale encounters from 2003 to 2008 (n=1466*)
*Figure excludes 13 outlying encounters on: 9/4/2003, 9/9/2004, 6/5/2005, 3/9/2006, 5/10/2006, 5/12/2006, 30/4/2007, 3/5/2007, 26/8/2007, 8/9/2007, 4/5/2008, 5/9/2008 and 25/11/2008.

Number of minke whales encountered

The number of whales reported in dwarf minke whale encounters ranged from 1 to >25 animals (estimated). The mean number of whales per encounter was 2.9 (median = 2). It is important to note that the number of whales reported for many encounters are estimates and that total number of whales reported for each season and each site includes an unknown number of re-sightings of individual whales. Identifying the number of whales involved in an encounter becomes increasingly difficult when more whales are present, and in rough weather conditions. Researcher protocols for estimating the number of whales in such conditions include using a count of the most whales visible at one time as a minimum/lowest estimate for the encounter. Subsequent more accurate estimates of the number of whales present are made when their individual identities have been established from analysis of underwater photographs.

Spatial distribution of sightings

The majority of dwarf minke whale sightings were recorded in three distinct areas within the Cairns/Cooktown Management Area of the Great Barrier Reef Marine Park. A summary of the spatial distribution of dwarf minke whale encounters over the six year period (2003–2008) is shown in Table 4. These include 782 encounters in the vicinity of Ribbon Reefs #9 and #10 (Ribbon 9/10 Area; 14º 39' S to 15º 01' S), 374 encounters in the area between Ribbon Reefs #2 and #5 (Ribbon 2-5 Area; 15º 20' S to 15º 35' S) and 240 encounters in the Offshore Port Douglas Sector (15º 55' S to 16º 20' S). The relative proportion of reported minke whale encounters in these areas was consistent between years (as reported to the Great Barrier Reef Marine Park Authority; e.g. Birtles *et al.*, 2008b).

Table 4: Summary of dwarf minke whale encounters in the Great Barrier Reef by area (2003-2008; n=1,470; *NB. Insufficient location data provided for 9 WSS*).

	Reef Area/Sector (from North to South)	No. of encounters & proportion of total (%)	Total duration (hours)	Mean encounter time (mins)	Mean number of whales per encounter
Ribbon Reefs Sector	**North of Ribbon #10** (Northernmost = 14º33' S)	**26** (1.8%)	37.3	**86** (range 1-498 mins)	**4.6** (range 1-20 whales)
	Ribbon 9/10 Area (14º 39' S to 15º 01' S)	**782** (53.2%)	1,388	**106** (range 1-665 mins)	**3.6** (range 1-25 whales)
	Ribbon 6-8 Area (15º 01' S to 15º 20' S)	**22** (1.5%)	24.1	**66** (range 1-424 mins)	**2.3** (range 1-12 whales)
	Ribbon 2-5 Area (15º 20' S to 15º 35' S)	**374** (25.4%)	472.8	**76** (range 1-473 mins)	**2.3** (range 1-15 whales)
	Southern Ribbon Reefs (15º 35' S to 15º 55' S)	**7** (0.5%)	2.6	**22** (range 10-39 mins)	**1.6** (range 1-3 whales)
	Offshore Port Douglas (15º 55' S to 16º 20' S)	**240** (16.3%)	116.1	**29** (range 1-225 mins)	**1.8** (range 1-14 whales)
	Offshore Cairns (16º 20' S to 17º 00' S)	**8** (0.5%)	9.6	**72** (range 10-240 mins)	**2.9** (range 1-6 whales)
	South of Cairns Planning Area (Southernmost = 20º34' S)	**11** (0.7%)	13.7	**75** (range 1-420 mins)	**1.7** (range 1-4 whales)
	TOTAL	**1,470**	**2,064 hrs**	**84 mins**	**2.9**

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Total interaction time

The total interaction time with dwarf minke whales (i.e. the sum total duration of all dwarf minke whale encounters reported each season) increased substantially over the six-year period, from 237.4 hours in 2003 to 451.6 hours in 2008 (a 90% increase; see Figure 5 below). This growth was found to be primarily in the Ribbon 9/10 and Ribbon 2–5 Areas (Fig. 5), and is consistent with a proportional increase in the total number of encounters in these areas each year. For the Ribbon 9/10 Area, the number of reported encounters more than doubled between 2003 (n=81) and 2008 (n=179; Table 5 & Figure 6 below). However, the *mean duration* of encounters in these areas over the six-year period however show no upwards (or downwards) trend (Table 3.6).

Potential causes of the growth trend observed in the number of encounters and the total interaction time each season were investigated in the PhD study by M. Curnock (2010). Using vessel 'effort' data collected voluntarily by SWW-endorsed operators over three minke whale seasons (2006–2008), the study showed that this growth was a result of increasing industry effort at a number of identified minke whale encounter 'hot spots', involving the same handful of SWW operators. Further details of this study are reported in Section 4 below.
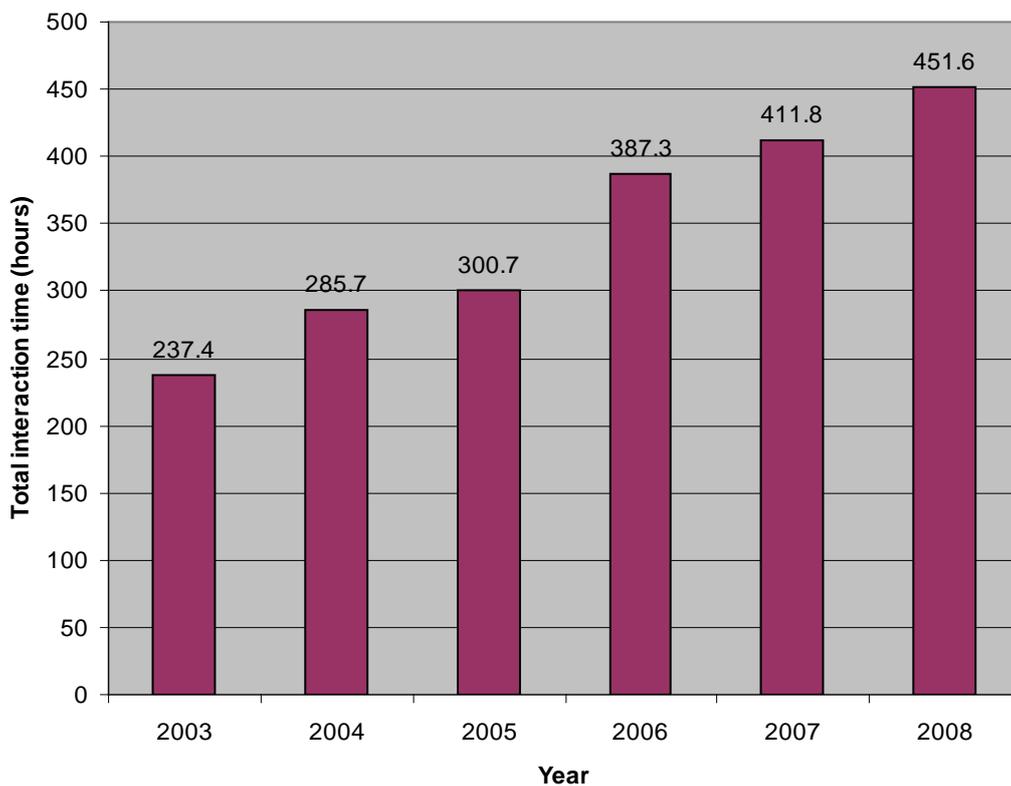
Figure 5: Total reported interaction time with minke whales in the Great Barrier Reef per year (2003-2008; n=1479).
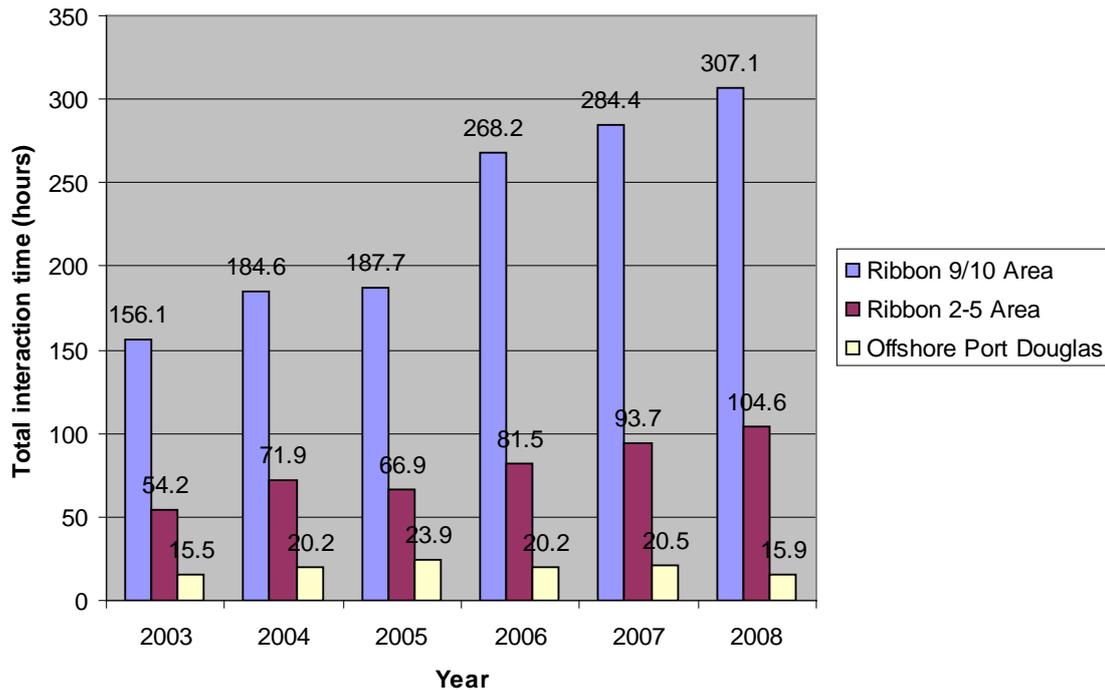
Figure 6: Total reported interaction time with minke whales in three key areas of the Great Barrier Reef Marine Park per year (2003–2008; n=1396).

Table 5: Mean minke whale encounter duration by area over the six-year period 2003-2008 (n=1470*) *Excludes nine encounters for which the location was not recorded.

Reef Area/ Sector (from North to South)	Mean encounter time					
	2003 (n=170)	2004 (n=188)	2005 (n=262)	2006 (n=258)	2007 (n=265)	2008 (n=327)
North of Ribbon #10 (Northernmost = 14º33' S)	48 mins (n=8)	- (n=0)	210 mins (n=1)	170 mins (n=5)	- (n=0)	66 mins (n=12)
Ribbon 9/10 Area (14º 39' S to 15º 01' S)	116 mins (n=81)	119 mins (n=93)	82 mins (n=137)	118 mins (n=136)	109 mins (n=156)	103 mins (n=179)
Ribbon 6-8 Area (15º 01' S to 15º 20' S)	35 mins (n=3)	- (n=0)	80 mins (n=5)	34 mins (n=4)	33 mins (n=8)	272 mins (n=2)
Ribbon 2-5 Area (15º 20' S to 15º 35' S)	76 mins (n=43)	70 mins (n=62)	60 mins (n=67)	91 mins (n=54)	89 mins (n=63)	74 mins (n=85)
Southern Ribbon Reefs (15º 35' S to 15º 55' S)	- (n=0)	20 mins (n=1)	20 mins (n=1)	30 mins (n=1)	18 mins (n=2)	25 mins (n=2)
Offshore Port Douglas (15º 55' S to 16º 20' S)	29 mins (n=32)	43 mins (n=28)	31 mins (n=46)	22 mins (n=55)	34 mins (n=36)	22 mins (n=43)
Offshore Cairns (16º 20' S to 17º 00' S)	- (n=0)	131 mins (n=4)	- (n=0)	13 mins (n=2)	- (n=0)	13 mins (n=2)
South of Cairns Planning Area (Southernmost = 20º34' S)	28 mins (n=3)	- (n=0)	141 mins (n=5)	1 min (n=1)	- (n=0)	16 mins (n=2)

The left side of the table is labelled vertically: **Ribbon Reefs Sector** (spanning the North of Ribbon #10 through Southern Ribbon Reefs rows).

Overall mean	83 mins	91 mins	69 mins	90 mins	91 mins	83 mins

A statistical comparison of the median encounter time between years for all areas (total means shown above in Table 5; a non-parametric Kruskal Wallis test was used) did not yield a significant difference ($p = 0.240$; Table 6). A similar comparison of the median number of whales per encounter also yielded no significant difference between years ($p = 0.059$; Table 6).

Table 6: Kruskal Wallis test for (a) median encounter duration between years and (b) median maximum number of whales per encounter between years, for all areas, 2003–2008 (grouping variable = year).

	Median encounter duration (minutes) 2003–2008 (n=1477)	Median maximum number of whales per encounter 2003–2008 (n=1477)
Chi-Square	6.745	10.632
df	5	5
Asymp. Sig.	.240	.059

A significant difference was found (via a Kruskal Wallis test; $p=0.048$) between years for the median encounter duration in the Ribbon 9/10 Area (Table 7), however this is explained by the lower median encounter time recorded for this area in 2005. No significant difference between the medians for other years was found (see Figure 7).

Table 7: Kruskal Wallis tests for (a) median encounter duration between years and (b) median maximum number of whales per encounter between years, 2003–2008, for (i) the Ribbon 9/10 Area and (ii) the Ribbon 2-5 Area (grouping variable = year).

	Ribbon 9/10 Area		Ribbon 2-5 Area	
	Total encounter duration (minutes) 2003–2008 (n=782)	Median maximum number of whales per encounter 2003–2008 (n=782)	Total encounter duration (minutes) 2003–2008 (n=374)	Median maximum number of whales per encounter 2003–2008 (n=374)
Chi-Square	11.188	7.188	4.495	7.290
df	5	5	5	5
Asymp. Sig.	0.048*	0.207	0.481	0.200

*Significant at $p=0.05$ level
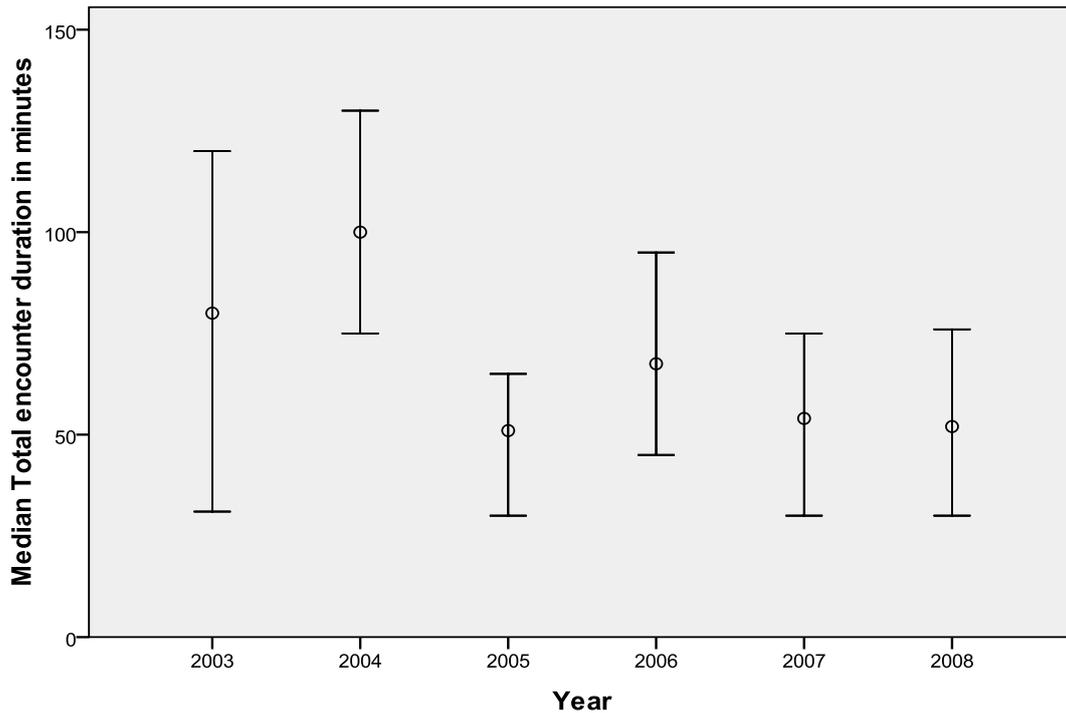
Figure 7: Median total encounter duration (minutes) for the Ribbon 9/10 Area, 2003–2008 (n=782; Error Bars = 95% Confidence Interval).

Minke whale encounters at specific sites

Encounters at Lighthouse Bommie (with the vessel moored or anchored within 100m of the dive site) represented 36.6% of the total reported encounter time for the Great Barrier Reef Marine Park over the six year period (2003–2008). A summary of the top ten specific dive sites for encounters with minke whales over the six years is presented below for comparison (Table 8).

While the number of encounters and total interaction time for Lighthouse Bommie is slightly lower in 2008 than it was in 2007, over the six-year monitoring period there was a clear trend of increasing encounters reported at this site, and correspondingly, the total interaction time and number of whales encountered (see Fig. 8). This is likely to be explained by an increase in vessel effort, i.e. more vessels have visited this site more often in recent years. Anecdotally, this is certainly the case with CHARROA having to roster morning, evening and even night periods of use in recent years and there have been growing numbers of occasions when minor conflicts have occurred between vessels when one has stayed too long, taken the programmed slot of another or just anchored near to the pinnacle and hence reduced the number of minke whales concentrated around the official mooring on the pinnacle. Protocols for managing such situations have been developed by the research team and incorporated into the most recent version of the Code of Practice.

Table 8: Summary of encounter details at top ten specific sites as reported over 2003–2008 (*NB. Vessel reported as moored or anchored within 100m of the site*).

Dive site	No. of minke encounters	Total duration (mins)	Mean encounter time (mins)	Mean number of whales per encounter
Lighthouse Bommie (RR 10; 14º52.5'S; 145º41'E)	266	45,346	170	4.7
Steve's Bommie (RR 3; 15º 30' S; 145º 47' E)	122	12,655	104	2.3
Pixie Reef/Pinnacle (RR 10; 14º 55'S; 145º40.5'E)	109	6,467	59	2.1
Challenger Bay (RR 10; 14º54.9'S; 145º41.4'E)	69	5,325	77	2.6
Ribbon 2 2/3 (15º 30.7'S; 145º 46.6'E)	57	2,994	53	2.1
Clam Gardens (RR 5; 15º 23.8'S; 145º 45.8'E)	46	2,105	46	1.7
Cod Hole (RR10; 14º 39.8'S; 145º39.8'E)	43	1,535	36	2.2
Light Reef (*Offshore Port Douglas*; 16º 01'S; 145º 48'E)	33	776	24	1.6
Two Towers (RR10; 14º 52.3'S; 145º40.5'E)	22	2,598	118	5.1
Andy's Postcard (RR 5; 15º 20.5'S; 145º 44.7'E)	16	1,004	63	2.1
TOTAL FOR THESE SPECIFIC SITES	**783**	**80,805 (1346.8 hrs)**	**103**	**3.1**

The mean encounter time at Lighthouse Bommie was consistently high each season in comparison to other sites (e.g. ranging from 113 minutes in 2005 to a maximum mean of 227 minutes in 2003). A Kruskal Wallis test found a significant difference between years for this variable (p=0.042; Table 9), however there is no apparent trend over the six-year period and this result can be explained by the lower median interaction time in 2005 (see Fig. 9). The mean number of whales per encounter for each season at Lighthouse Bommie was also compared (ranging from a mean of 3.8 whales per encounter in 2005 to a maximum of 6.2 in 2003) however Kruskal Wallis test revealed no significant difference between years for this variable (p=0.077; Table 9).

The increasing trend in the total interaction time and the total number of whales shown for Lighthouse Bommie (Fig. 8) can be explained by the increase in the total number of encounters reported at the site over the six year period. This is attributed to an overall increase in effort by vessels targeting this particular site during the June-July season, as confirmed via analyses of industry site use (i.e. effort) data (Curnock, 2010).
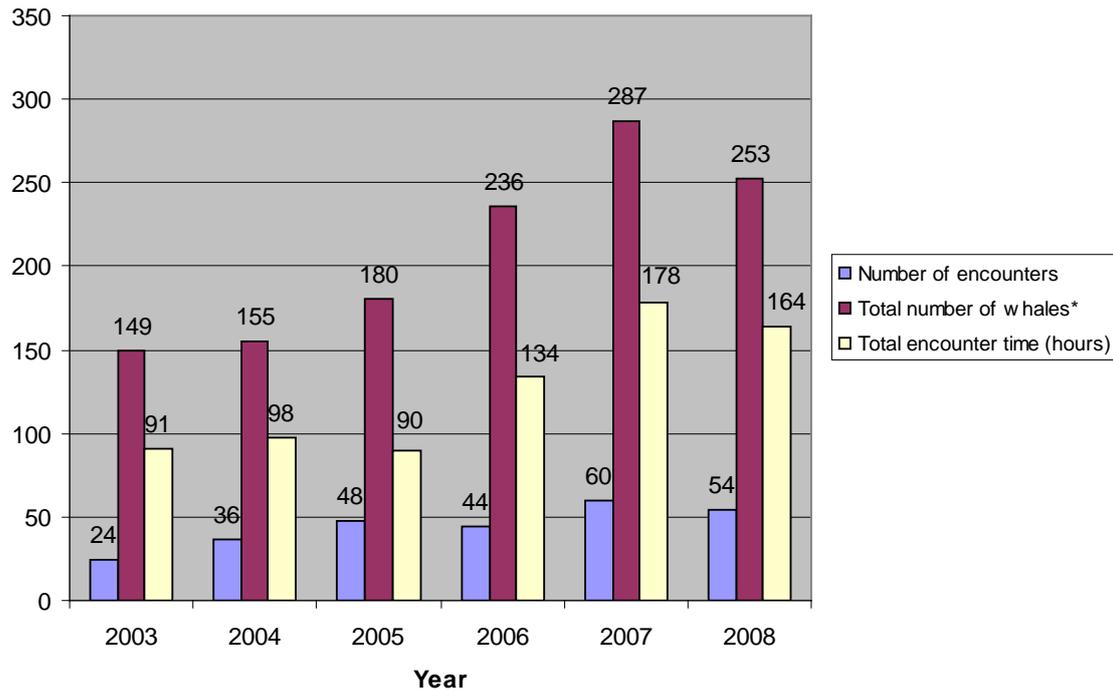
Figure 8: Trends in the number of reported encounters, total number of whales* and total interaction time at Lighthouse Bommie, 2003–2008. (*Figure includes an unknown number of re-sighted animals.)

Table 9: Kruskal Wallis Test for Lighthouse Bommie (2003–2008) for: (a) median encounter duration in minutes and (b) the median number of whales observed during the encounter.

	Median encounter duration (mins)	**Median number of whales observed during encounter**
Chi-Square	11.514	9.954
df	5	5
Asymp. Sig.	0.042*	0.077

*Significant at *p*=0.05 level
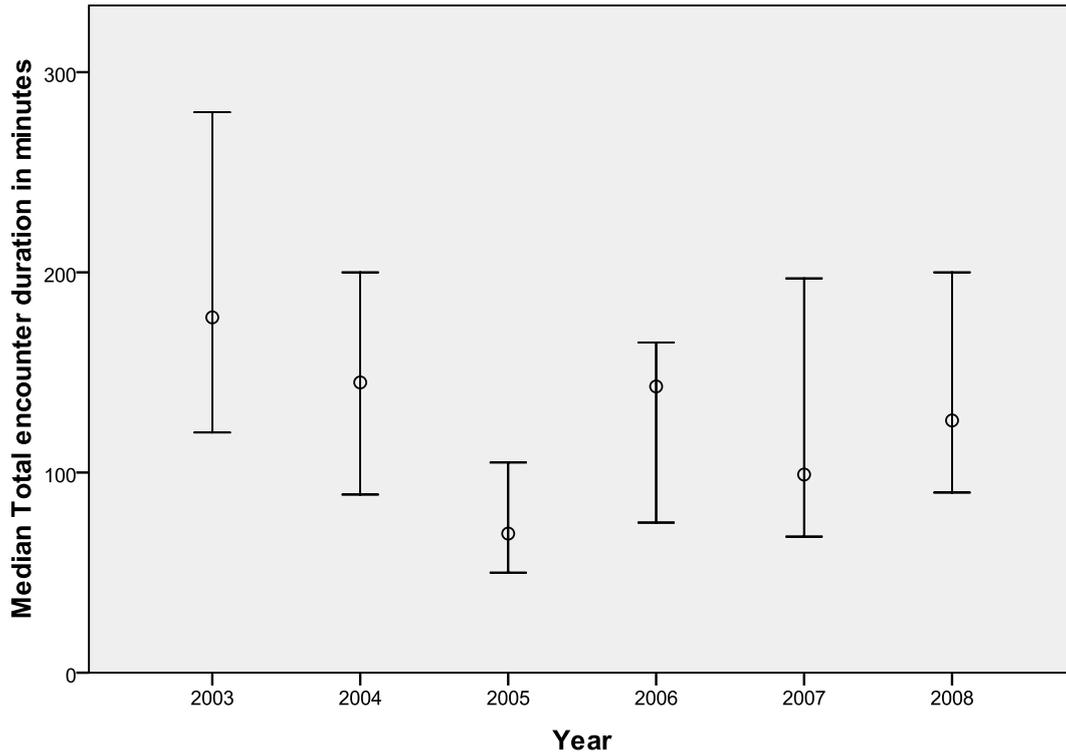
Figure 9: Median total encounter duration (minutes) for Lighthouse Bommie, 2003–2008 (n=266; Error Bars = 95% Confidence Interval).

Status of vessel

These data provide an important indicator of the voluntary nature of approaches to the vessels by whales. While the proportion of time spent searching in open water for whales varies between vessels, for the industry overall the majority of encounters (73.4 %) were initiated with vessels not underway (either anchored or moored; see Table 10). This proportion was relatively consistent between years (Table 10).

Table 10: Status of Great Barrier Reef vessels when dwarf minke whales first sighted, reported in WSS (2003–2008; n=1447).

Year (n)	Moored	Anchored	Drifting	Steaming
2008 (n=324)	198 (61.1%)	30 (9.3%)	5 (1.5%)	91 (28.1%)
2007 (n=270)	188 (69.6%)	30 (11.1%)	7 (2.6%)	45 (16.7%)
2006 (n=249)	144 (57.8%)	37 (14.9%)	7 (2.8%)	61 (24.5%)
2005 (n=257)	162 (63.0%)	27 (10.5%)	11 (4.3%)	57 (22.2%)
2004 (n=184)	105 (57.1%)	29 (15.8%)	13 (7.1%)	37 (20.1%)
2003 (n=163)	89 (54.6%)	23 (14.1%)	9 (5.5%)	42 (25.8%)
TOTAL (n=1447)	**886 (61.2%)**	**176 (12.2%)**	**52 (3.4%)**	**333 (23.0%)**

In-water interactions

The proportion of dwarf minke whale encounters that resulted in an in-water interaction (involving snorkelers and/or scuba divers) varied between years (ranging from 61% of encounters in 2003, to 76% in 2004, 72% in 2005, 63% in 2006, 64% in 2007 and 56% in 2008). This proportion does not necessarily indicate changes in the interactivity of the whales between years, and may be due to variable reporting of sightings of distant whales by different vessels. These results, however, are consistent with WSS collected from *Undersea Explorer* (58% in 2003, 70% in 2004, 70% in 2005, 63% in 2006, 58% in 2007 and 52% in 2008), where researchers conducted a full daylight-hours watch and all sightings (near or distant) were logged. We note that during the 2008 season we were able to place 18 Minke Whale Project volunteer researchers onto eleven different vessels over the season to assist with field data collection (which when combined with members of the MWP research team resulted in 250 researcher days at sea). Members of the MWP research team and volunteers conducted a dedicated surface watch during daylight hours and this increase in 'searching effort' is likely to have contributed to an increased proportion of distant whale sightings being recorded in 2008.

This variable is likely to be an important indicator of potential changes in the 'interactivity' of dwarf minke whales, however it must be standardised for any changes in industry patterns of resource use (i.e. effort) or researcher effort. The PhD study by A. Mangott (2010) conducted a more detailed analysis of dwarf minke whale interactivity over the 2006–2008 seasons and investigated the strong attraction of the whales to vessels and swimmers (See Section 3.3 below).

Numbers of calves seen

Few encounters were reported each season in which dwarf minke whale calves were present (a dwarf minke whale calf is defined as being less than half the length of its mother, in close proximity to her and breathing more often). The number of cow-calf encounters reported each season varied, ranging from 17 in 2003 to 18 in 2004, 10 in 2005, 19 in 2006, 15 in 2007 and 10 in 2008. In 81% of cases (72/89) the cow-calf sighting occurred during an in-water interaction with other whales. In 2008 a new field was added to the WSS to record the duration for which calves were present around the vessel during such encounters. The mean duration for which the calf was present during the interactions was 23 minutes (range 1-56 mins).

Analysis of behaviour

The most frequently recorded behaviours on the WSS were "close approach" (1–3m) to swimmers or the vessel (reported in 431 encounters, 403 of which were in-water interactions), followed by "belly presentation" (393 encounters, 366 of which were in-water interactions). A summary of the most frequently observed behaviours during in-water interactions is presented below (Table 11). Updates to the Whale Sighting Sheet over the monitoring period included the addition of newly described behaviours, some of which had been observed for the first time during these minke seasons (e.g. 'pirouetting' behavioural displays had not been observed prior to the 2005 season). The year in which such behaviours were added to the WSS is indicated in Table 11 below.

Table 11: Reported minke whale behaviours during dwarf minke whale encounters (n=1491) and in-water interactions (n=960) 2003–2008.

Described behaviour	Total number of encounters in which the behaviour was reported	Proportion of total encounters (%)	Number of in-water interactions in which the behaviour was reported	Proportion of in-water interactions (%)
Close approach (less than 3m)	431	28.9	403	42.0
Belly presentation	393	26.4	366	38.1
Spyhop/headrise	265	17.8	240	25.0
Very close approach (less than 1m) [*07]	79	13.0	76	20.9
Motorboating[*07]	71	11.7	64	17.6
Breach	215	11.1	86	9.0
Sudden speed up	159	10.7	151	15.7
Vocalisation[*06]	88	10.1	87	16.5
Bubble release	118	7.9	108	11.3
Sharp veer away	96	6.4	90	9.4
Physical contact[*08]	9	4.9	9	4.9
Pirouetting[*07]	28	4.6	26	7.2
Sudden deep dive	56	3.8	53	5.5
Gulping/jaw gape	30	2.0	28	2.9
Jaw clap	9	0.6	8	0.8

[*06]Indicates new behaviour listed on the WSS from 2006 onwards (n= 867 encounters, 526 in-water interactions).
[*07]Indicates new behaviour listed on the WSS from 2007 onwards (n= 608 encounters, 363 in-water interactions).
[*08]Indicates new behaviour listed on the WSS in 2008 (n= 328 encounters, 182 in-water interactions).

Behaviours of concern

Close and very close approaches are indicative of a high level of interactivity by the whales and when combined with headrises/spyhops, motorboating and pirouetting, such behaviours are regarded as investigative (Mangott, 2010). Very close approaches to swimmers, ropes and/or the vessel may pose a risk to the whales and/or the swimming participants, especially if these approaches are in combination with investigative behaviours such as "headrise/spyhop", "motorboating" and pirouetting, or high impact behaviours such as breaching. Results from the PhD study by A. Mangott suggest that breaching is very rarely displayed in close proximity to the vessel and swimmers and investigative behaviours are most likely exhibited by only a few individual whales. A prime example of this was the whale called 'Pavlova' (as reported in our 2007 Season Report to the Great Barrier Reef Marine Park Authority; Birtles *et al.*, 2008b), a female that was responsible for the majority of very close behavioural displays observed from *Undersea Explorer* in 2007, including 30/34 headrises, 5/5 'motorboating' and 7/7 'pirouetting' displays within 1m of a swimmer (Mangott, 2010). After an incident in 2007 in which a whale became entangled briefly in a surface rope, the WSS was updated in 2008 to include the behaviour "physical contact" to quantify

and monitor the frequency of incidents involving whales touching a rope, other objects or people in the water. In 2008, nine cases of physical contact were reported. The descriptions of these occurrences are as follows (as written on the WSS):

1. "Whale tail hit Tony's flipper" (#8019)
2. "With rope only: whale headrised over rope, then swam completely over surface rope." (#8131)
3. "Rope touch" + *on the reverse side*: "At one stage, one of the minkes spyhopped onto the line, pulled the line down and swam over the top." (#8138)
4. "With mermaid line – whale observed pulling float on end of mermaid line underwater briefly (seen by myself)." *NB. Report by Trip Director.* (#8152)
5. "Whale brushed rope once." *NB. Report by M. Curnock.* (#8165)
6. "Touched snorkeler's fins." (#8185)
7. "Whale touched rope – 'broken dorsal fin' – see pics to ID whale." *NB. Report by M. Curnock.* (#8272)
8. "Yes, while on safety stop 1 whale touched diver & hit with pectoral fin." (#8328)
9. "Whale over rope" + *on the reverse side*: "Minke went over the rope & I saw it." (#8338)

The mean duration of these nine encounters was 325 minutes (ranging from 80 to 489 mins; NB. five of these encounters were >400 mins duration) and the mean maximum number of whales per encounter was 8.8 (range 1 to 15 whales). Findings from the PhD study by A. Mangott (2010) indicate that interacting dwarf minke whales approach closer over time (i.e. over the course of an interaction and over the season).

Two factors significantly influenced approach distance: (1) the whale group size and (2) the familiarity of the whales with the stimulus (vessel/swimmers). The larger the whale group size, and the more familiar these whales are with human interactions (i.e. subsequent encounters with re-sighted individual whales) the closer individual dwarf minke whales approach (Mangott, 2010; Mangott, Birtles & Marsh, 2011). A more detailed analysis of the approach distances of dwarf minke whales to the vessel and swimmers and the associated management implications is reported below (Section 3.3).

A comprehensive risk analysis of specific dwarf minke whale behaviours (including perceptions of the risk of harm of such behaviours from experts in the marine mammal science community as well as from representatives of conservation NGOs and staff of the Great Barrier Reef Marine Park Authority), together with the occurrence probabilities of these behaviours was compiled as part of the PhD study by A. Mangott.

Recording of behaviour

The relatively high proportion of encounters with reported behaviours such as "close approach" and "belly presentation" and the relatively low proportion of encounters with reported behaviours such as "jaw gape/gulping" and "jaw clap" are consistent between years (2003-2008) in the WSS data (Table 12). The behaviour section of the WSS data (2006-2008) was compared with researcher data collected and the evaluation suggests that this monitoring instrument is reliable (Mangott, 2010).

Table 12: Between-year comparison of the proportion of dwarf minke whale encounters for which specific behaviours were reported to occur (WSS 2003–2008; n=1474).

Behaviour	2003 (n=171)	2004 (n=188)	2005 (n=265)	2006 (n=259)	2007 (n=280)	2008 (n=328)
Close approach	33%	38%	30%	23%	28%	26%
Belly presentation	32%	35%	28%	22%	21%	25%
Headrise/Spyhop	26%	23%	16%	17%	14%	18%
Breaching	22%	15%	12%	9%	12%	18%
Bubble release	10%	9%	8%	9%	6%	8%
Sudden speed up	6%	12%	11%	9%	15%	10%
Sharp veer away	2%	7%	3%	6%	10%	8%
Sudden deep dive	2%	3%	2%	3%	5%	6%
Jaw Gape/Gulping	2%	3%	1%	2%	3%	2%
Jaw Clap	2%	0.5%	1%	0.4%	0%	0.3%

Key findings of the PhD study by M. Curnock

Development of sustainability objectives and indicators

Feedback from the 16 Key Informant Stakeholder (KIS) survey and from participants at stakeholder workshops over 2007-2008 contributed to the fine-tuning of a suite of Quadruple-Bottom-Line sustainability objectives (encompassing ecological, social, economic and management goals) for the Great Barrier Reef SWW activity. Over four workshops (16/11/07, 18/4/08, 30/5/08 and 12/12/08) a total of 37 (from a proposed 39) sustainability objectives were formally adopted via unanimous agreement by stakeholder participants (see minutes of the above workshops for specific objectives and discussion points). Feedback from the KIS survey indicated a high level of support for the objectives and for the process followed in their development. Contributing factors to the successful development and adoption of these sustainability objectives by stakeholders include:

- The relatively small industry size (only 9 permitted operators).
- Shared values among different stakeholder groups.
- The nature of the SWW experience.
- Great Barrier Reef Marine Park Authority's six-year commitment to the Dwarf Minke Whale Tourism Monitoring Program (2003–2008) with funding provided for the above workshops and field data collection costs.
- The regular communication of research results and progress to stakeholders (at

the above workshops, via frequent telephone and email communications and with extensive personal contact as part of the Participatory Action Research approach).

- A high level of trust and confidence achieved between the researchers and SWW-endorsed tourism operators (>13 years of collaboration via the Minke Whale Project).
- The transparent and collaborative process in developing the sustainability objectives.

A range of potential sustainability indicators addressing the above objectives were developed and evaluated, drawing on industry and passenger-generated data (e.g. including Whale Sighting Sheets, passenger questionnaires and vessel effort data). The formal implementation of these indicators requires support from all stakeholders and a process by which indicators are periodically reviewed and fine-tuned at stakeholder workshops. A Swimming-with-Whales Adaptive Management Model (SWAMM) was proposed (Curnock, submitted 2010) to assist with long-term monitoring and sustainable management of the Great Barrier Reef SWW activity.

Passenger questionnaire results

The overall response rate for the passenger questionnaire over the three year period (2006-2008) was 44.9% (n=2171/N=4832; NB. *Total passenger numbers on SWW-endorsed vessels during the June-July minke whale season were kindly provided by the operators*). For the total sample (n=2,171) the mean age of respondents was 35 (range 8 to 85). Fifty percent of the sample was female. Respondents came from 50 different countries, with the largest proportions originating from Australia (36.3%), the USA (23.4%), the UK (8.4%), Japan (4.7%) and Germany (4.3%). Respondents from other European countries made up a further 10.6% of the sample.

From the total sample, 71% (1560/2171) indicated that they had seen minke whales on their Reef trip. This proportion differed between the live-aboard and day-boat samples, for which 98% (1560/1592) and 30% (176/579) (respectively) indicated that they had seen minke whales whilst on their trip. From the live-aboard sample, 97% of respondents (1537/1592) indicated that they had experienced an in-water interaction with minke whales, either using SCUBA and/or snorkelling equipment. In contrast, only 17% of the day-boat sample (100/579) indicated that they had experienced an in-water interaction with minke whales on their trip.

Respondents were asked to indicate the most important reasons for their choice of operator for their Reef trip. The opportunity to see and/or swim with minke whales was ranked the second most important reason (15.1%; 296/1961; *question left blank in 210 cases*), after the company reputation/personal recommendation (31.5%; 617/1961). The opportunity to see/swim with minke whales (on a SWW-endorsed vessel) was mentioned more frequently than the cost of the trip (8.7%; 171/1961) as the primary reason for choosing a particular operator.

A significant difference was found between the ratings of 'satisfaction with the minke whale experience' for (i) day boat respondents that had seen whales from the vessel only (n=76) and (ii) day boat respondents that had swum with whales (mean ratings out of 10 were 6.9 and 8.8 respectively; Mann Whitney U Tests: $Z_{1,175}$ = -5.299; p=<0.001). Significant differences were also found between the live-aboard and day boat samples of SWW participants for (a) the total number of whales reported to have been seen by respondents (medians = 6 and 2 respectively; Mann Whitney U Test: $Z_{1,327}$ = -12.042; p=<0.001) and (b) the closest distance to which respondents indicated

they had been approached by a whale (medians = 3m and 5m respectively; Mann Whitney U Test: $Z_{1,175}$ = -5.616; p=<0.001).

The overall mean rating score given by SWW respondents for 'how well their minke whale encounter(s) were managed by the vessel crew' was very high (mean rating out of 10 = 9.44; n=1593; *question left blank in 43 cases*). Several significant differences were found however between individual SWW-endorsed vessels for a number of key variables that have been identified as social and managerial sustainability indicators, including: (i) satisfaction with the minke whale experience, (ii) expectations of the experience and (iii) perceptions of how well minke whale encounters were managed by the vessel crew.

There was a large variation between vessels in the proportion of their passengers who indicated they were not adequately prepared for their minke whale interactions (ranging from 4.3% to 26%), as well as the proportion who indicated that they were not familiar with the Code of Practice (investigated in 2008 only; ranging from 2.7% to 78% of passengers for one vessel). Crew briefings and preparation of passengers emerged as the most important method of managing SWW participants. Note that due to a confidentiality agreement (to ensure the quality and quantity of data), results of the passenger questionnaires have been de-identified and cannot be attributed to any named vessel or operator.

Analyses of vessel effort data

The distribution of minke whale encounters across the northern Great Barrier Reef (n=854) was examined and compared with industry searching effort and site use in this region. It was found that almost three quarters of encounters (74.4%; n=626/841) occurred when vessels were moored at popular Reef dive sites or when at anchor behind reefs (i.e. the whales approached and interacted with stationary vessels). Using vessel effort and the whale sightings data, whale encounter rates and proportions of total encounter time to total vessel effort were calculated for the 40 most frequently visited Reef sites, revealing a small number of encounter 'hot spots' with particularly high encounter rates. A trend over the six-year period 2003–2008 was observed, in which the number of minke whale encounters and the total whale encounter time for the industry increased by approximately 90%. This growth was shown to be a result of increasing industry effort at the identified minke whale encounter hot spots, involving the same handful of SWW-endorsed operators. Despite such growth, considerable latent capacity for further increases in minke whale encounters was found to exist among the nine permitted operators.

Key findings of the PhD study by A. Mangott

Over the three research periods (June/July 2006-2008) a total of 118 days were spent at sea. Overall dwarf minke whales were encountered on 209 occasions of which 101 encounters turned into in-water interactions (Table 13). Behavioural observations were made during 280 hrs of in-water interactions. Whales approached the stationary vessels in 72 cases and on 29 occasions while the vessels were steaming and the boats subsequently drifted with the animals. The mean ($X \pm$ SE) overall interaction time (n=101; 2006-2008) was 171.1 ± 11.43 min with an average ($X \pm$ SE) of 6.4 ± 0.48 animals (see Table 13).

Table 13: Dwarf minke whale encounters and in-water interactions observed during the research period (June/July) from 2006–2008

Year	Days at sea	Total encounters	# In-water interactions						
			N	Length (min)		# Animals		Boat status	
				Mean	SE*	Mean	SE*	S[1]	D[2]
2006	40	68	29	160.8	18.48	6.1	0.89	24	5
2007	39	68	36	160.1	19.03	6.4	0.82	26	10
2008	39	73	36	190.3	21.18	6.5	0.82	22	14
TOTAL	**118**	**209**	**101**	**171.1**	**11.43**	**6.4**	**0.48**	**72**	**29**

[1] S = Stationary; [2] D = Drifting; * Standard Error

Distribution of interacting dwarf minkes around vessels & swimmers

The spatial surfacing patterns of the whales was independent of (1) boat status ($c^2 = 2.529$, df = 2, p = 0.282) and (2) weather conditions ($c^2 = 7.704$, df = 4, p = 0.133). The whales surfaced significantly more often than expected in the '*Inner Area*' and significantly less often in the '*Middle Area*' and the '*Outer Area*' ($c^2 = 729.374$, df = 2, p < 0.001) (Figure 10). Within the area closest to the vessel ('*Inner Area*') the whales surfaced significantly more often than expected in the '*Rope/Swimmer Quarter*' and significantly less often in the '*Left Quarter*' and the '*Opposite Quarter*' ($c^2 = 48.325$, df = 3, p < 0.001; Figure 11). No difference was found in the '*Right Quarter*'. The outcomes indicate that dwarf minke whales interacting with vessels and their swimmers not only clump around the vessel (<60 metres) but aggregate especially around the swimmers.
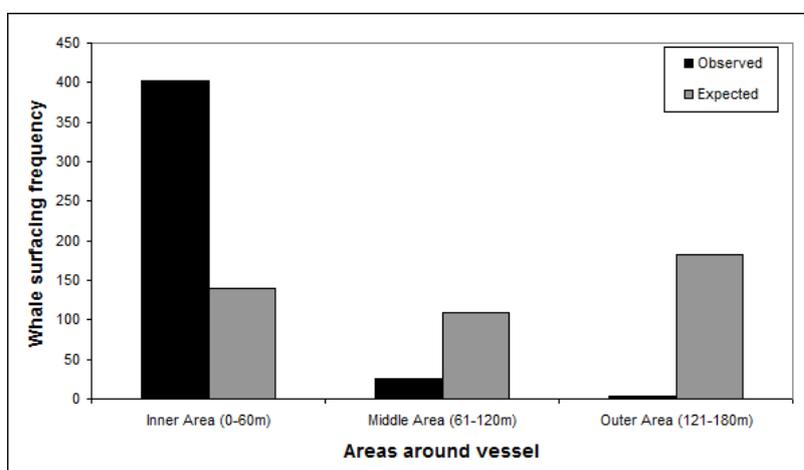
Figure 10:

Observed versus expected frequencies of surfacing dwarf minke whales (per unit effort and unit area) in the three assigned areas (*Inner, Middle* and *Outer Area*) around the vessel from 18 in-water interactions in 2007 (see Figure 2 for Areas).
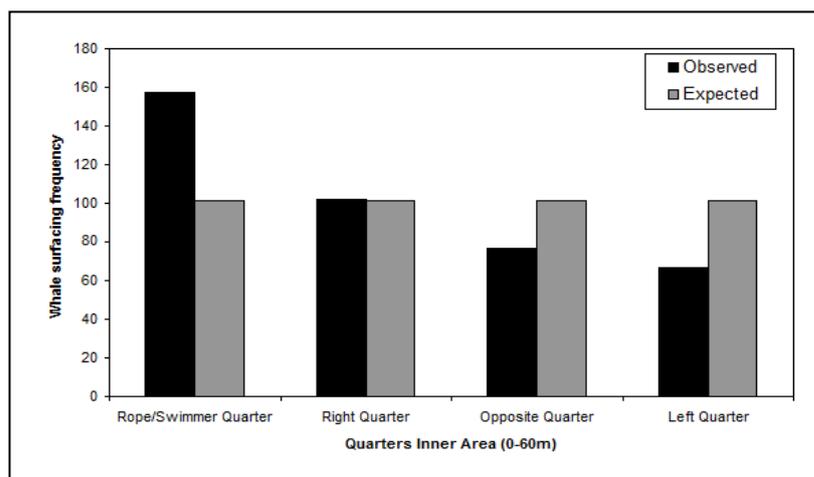
Figure 11: Observed versus expected frequencies of surfacing dwarf minke whales in the four assigned quarters (*Rope/Swimmer Quarter, Left Quarter, Right Quarter* and *Opposite Quarter*) in the area closest to the vessel (*Inner Area*) (n=18 in-water interactions).

Conclusions from this study:

1. Dwarf minke whales in the northern Great Barrier Reef:
2. voluntarily initiate and maintain contact with vessels for prolonged periods,
3. not only show a clumped distribution around vessels (<60 m) but actually aggregate around swimmers.
4. Their voluntary initiation and maintenance of close contact for prolonged periods, contrasts with most wildlife-human interactions.

Behavioural changes of dwarf minke whales over time

Distance measurements on passing dwarf minkes were recorded during 28 different in-water interactions. The number of measurements taken of individual whales was variable with a median of six measurements per whale (range 1-56). The mean passing distance (n=119 whales) to the researcher was ($X \pm SE$) 7.08±0.09 metres. Resighted individuals (n=24) were skewed towards the end of the season ('Beginning Season = 4; 'Middle Season' = 4; 'End Season' = 16 resighted whales).

During an in-water interaction, individual whales came significantly closer to swimmers through time (Repeated Measures ANOVA, within subject effect: $F_{2, 270}= 11.839$; $p = <0.001$).

This behavioural response was significantly more pronounced in whales belonging to a large group, compared to whales belonging to a smaller group (Repeated Measures ANOVA, between subject effect: $F_{2, 135} = 14.208$; P = < 0.001). A Tukey's HSD post-hoc test revealed that individual whales significantly decreased their passing distance to swimmers by a mean of 1.4 m (from 7.1±0.24 m to 5.7±0.22 m) between the categories 'Beginning Interaction' and 'End Interaction' (P = < 0.001), and individual whales among the largest group size category '>6 whales' came significantly closer than animals in the smallest group size class '1–3 animals' (P = < 0.001; Figure 12). Boat status and Wind speed did not significantly influence passing distance.

The passing distances of individual animals in a subsequent independent interaction (resighted) were significantly closer by a mean of 1.5 m than those recorded in their penultimate known interaction (Repeated Measures ANOVA, between subject effect: $F_{1, 45}$ = 34.164; P = < 0.001; Figure 13). There was a significant difference between individual resighted whales (Repeated Measures ANOVA, within subject effect: $F_{1, 45}$ = 34.164; P = < 0.001), however all animals came closer in the subsequent interaction (no interaction effect).
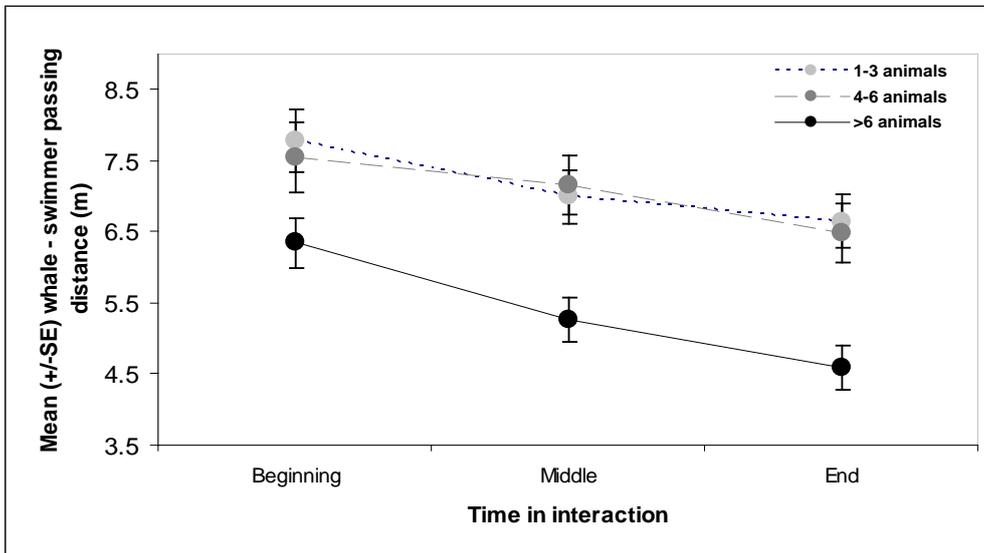
Figure 12: Whale group size dependent changes in mean (±SE) whale-swimmer passing distances (m) of individual whales (N = 20) during the first 90 min of in-water interactions (time based categories: 'Beginning Interaction', 'Middle Interaction', and 'End Interaction')
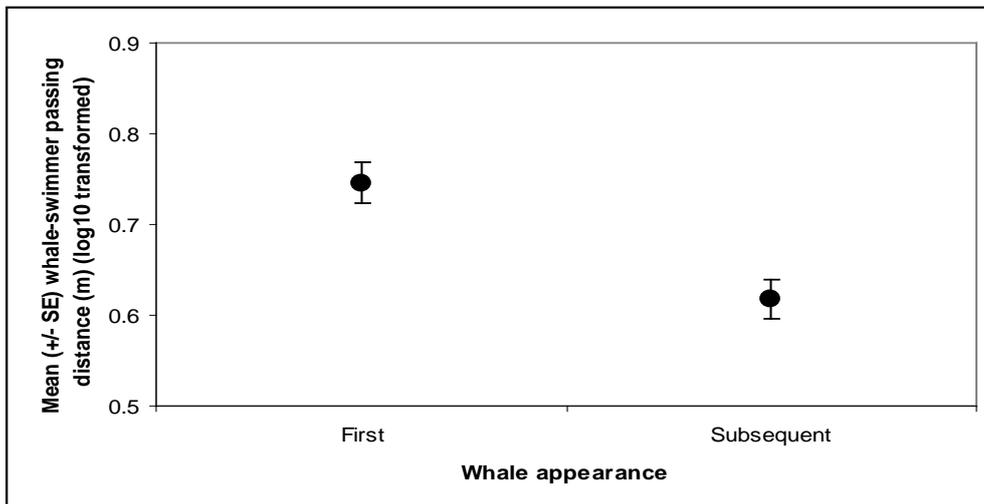
Figure 13: Changes in mean (±SE) passing distance (m; log10 transformed) of individual whales (n=5) from their first to their subsequent interaction

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Resighted animals came significantly closer than unknown individuals by a mean distance of 2.5 m (Paired Sign test: $Z_{1,8}$ = 2.667, P = 0.008; Figure 14). This trend was consistent between all nine encounters. These results suggest that whales familiarise to the presence of swimmers and gain confidence over time.
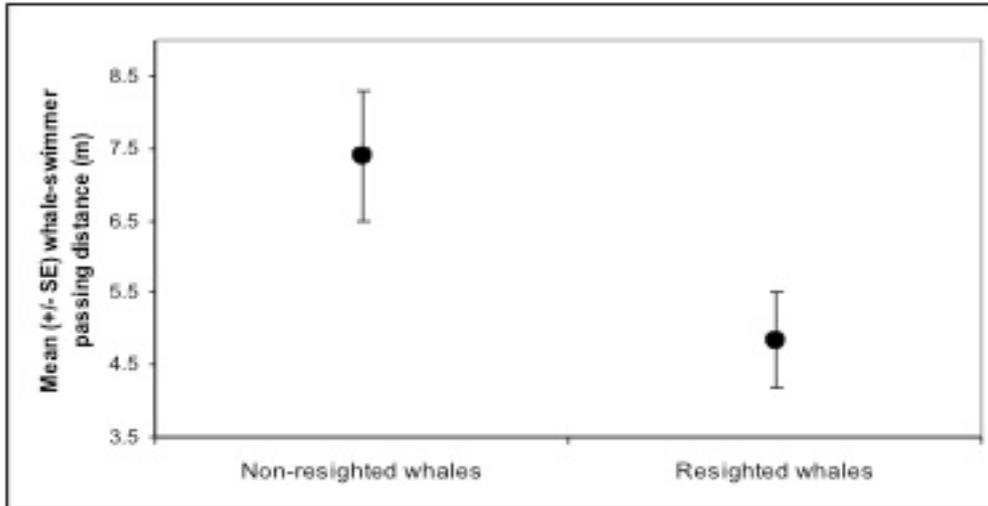
Figure 14: Mean (±SE) passing distances (m) of non-resighted and resighted whales to swimmers during the first hour of in-water interactions (n=9)

Conclusions from this study:

1. Interacting dwarf minke whales changed their behaviour over time
2. These whales show a strong and increasing attraction to the stimulus (vessel and swimmers) which may act as an easily located socialising device for dwarf minkes
3. The more familiar the whales were with the stimulus (i.e. resighted individuals) the more inquisitive the whales became
4. The larger the group of whales the closer individuals approached swimmers
5. Attraction to human activity is likely to increase the risk of harm to both humans and dwarf minke whales.

Assessment of the risk of harm from dwarf minke whale behaviours to swimmers and/or the whales

Key Informants' concerns for the targeted animals

All Key Informants but one (n=20) expressed concerns for the targeted animals in swim-with industries. The most common concerns were that such operations have the potential to harm or harass the target animals (n=6), disrupt critical behavioural states (n=5), negatively influence the time-activity budget (n=4) and cause disturbance, stress and induce aggression (n=4).

Key Informants' concerns for the participants

Most Key Informants (90%) expressed concerns for the swimmers and were mostly worried about the direct harm from cetaceans (n=35) due to for example, potential aggression (n=9), increased risk of accidents because of close contact (n=6) with large and powerful animals (n=5), inappropriate perception of wild animals (n=4) and limited understanding of the animals' behaviour (n=3).

Risk of harm to swimmers

By combining the Key Informants' perceptions of harm to swimmers with the estimated probability of occurrence, the majority of dwarf minke whale behaviours were rated as of low risk of harm to the swimmers. *Breaching* (≤ 6 metres) and *high speed pass* (≤ 1 metre) were perceived to be of high and very high risk of harm respectively, but due to their rare occurrence in interactions, these two behaviours were regarded as only of medium risk of harm to swimmers. No behaviour was therefore regarded as of high risk of harm to the swimmers (Fig. 15).

Risk of harm to dwarf minke whales

The risk of harm from all except one dwarf minke whale behaviour to the whales themselves was regarded as low. Only *breaching* within touching distance to swimmers or the vessel was regarded as of medium risk of harm to the whales due to the perceived high potential of harm to the animals. No behaviour was regarded as of high risk of harm to the whales (Fig. 16).
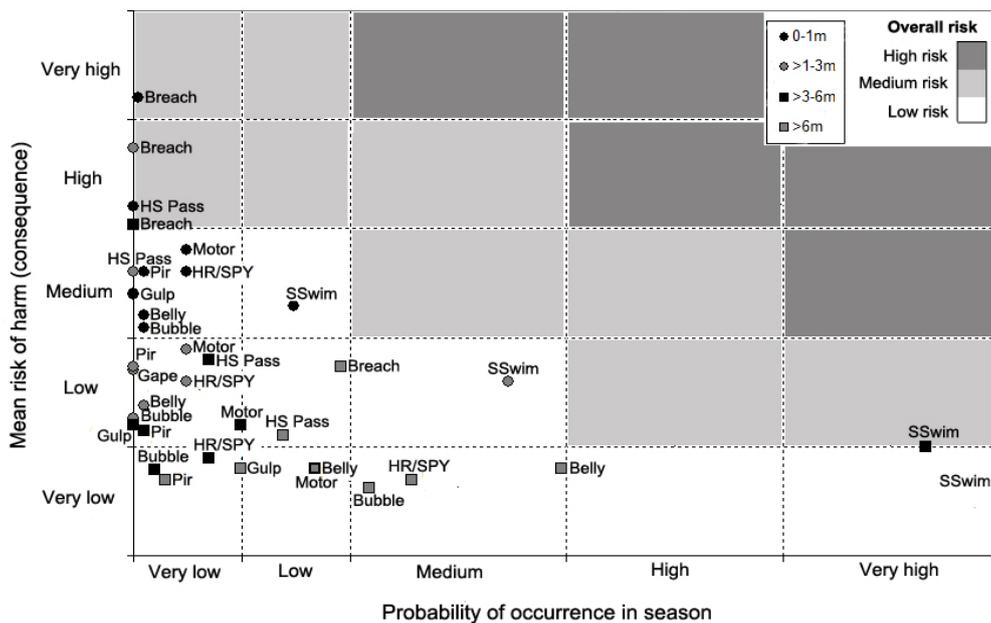
Figure 15: Risk of harm to swimmers from dwarf minke whale behaviours in the assigned distance categories (≤1m; >1-3m; >3-6m; >6m) with respect to the occurrence probability of the behaviour in interactions and the potential for harm (consequences) perceived by Key Informants.
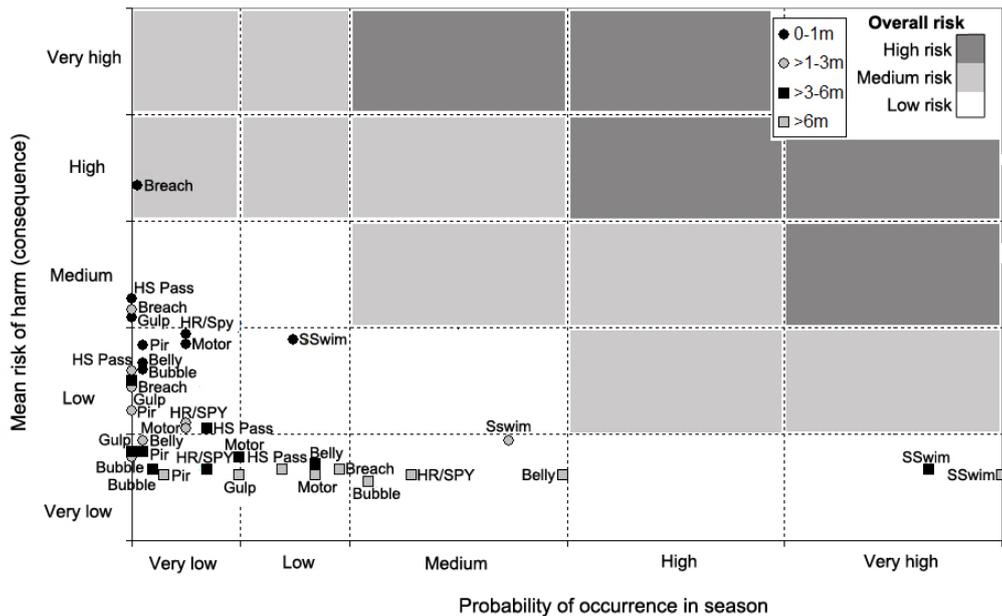
Abbrev: Belly   = Belly presentation   HR/SPY = Headrise/Spyhop   Pir = Pirouetting
         Bubble = Bubble blast   HS Pass = High speed pass   SSwim = Slow swim past
         Gulp   = Gape/Gulp   Motor   = Motorboating

Figure 16: Risk of harm to dwarf minke whales from their behaviours in the assigned distance categories (≤ 1m; >1-3m; >3-6m; >6m), with respect to the occurrence probability of the behaviour in interactions and the potential for harm (consequence) perceived by Key Informants.

Interactions with dwarf minke whale behaviours of greater harm to swimmers and/or whales

Dwarf minke whale behaviours perceived of having a medium or higher potential to harm swimmers occurred in 20 interactions (19.8%) over the research period (2006-2008). These behaviours were *headrise*, *pirouetting*, *motorboating*, *belly presentation*, *slow swim past* within touching distance (≤ 1 m) and *breach* between half and one whale body length (>3-6 m) of a swimmer. Apart from *breaching*, all behaviours are considered to have an investigative function. Most of those behaviours were displayed by only four individual whales. All of these were animals which had been seen more than once, i.e. resighted whales. These four individuals accounted for 92% of *headrises*, 69% of *motorboating*, 59% of slow swim pasts and all *headrises* and *pirouettes*, and were present in only four of the 101 interactions. The only behaviour perceived of having a high potential to harm swimmers was close *breaching* which occurred twice, displayed both times by a calf (Table 14).

Irrespective of the perceived overall low risk of harm to the whales, the curious nature of these whales generates concerns for their own safety. Safety concerns are most apparent for whales familiar with the stimulus (resights) and in particular for animals which have made physical contact with objects such as the dinghy, swimmers and the rope. These concerns were substantiated in 2007 when an unidentified whale got entangled in a thin buoy line attached to the rope which swimmers hold onto while in the water. Fortunately the one person in the water was unharmed and the whale freed itself by breaking the line and hence freeing itself from the buoy and all of its rope.

Table 14: Individual dwarf minke whales exhibiting behaviours of greater risk to harm swimmers

Whale ID (Catalogue #)	Behaviour	N interaction	Frequency of behaviour per interaction	% of total frequency of behaviour	Distance category	Perceived risk of harm S = to swimmer W = to whales
Pavlova (0048)	*Headrise*	1	27	67.5	≤ 1 m	Medium (S) Low (W)
	Slow swim past		10	19.2		
	Pirouetting		7	100		
	Motorboating		4	45		
	Belly presentation		1	100		
'Male Whale' (0109)	*Motorboating*	1	1	11		
	Headrise		6	15		
	Slow swim past		5	9.6		
'Shirley Shark Bite'	*Motorboating*	1	1	11		
	Headrise		5	9.6		
	Slow swim past		13	25		
'Tail Specks' (0004)	*Motorboating*	1	1	11		
	Slow swim past		3	5.8		
?	*Motorboating*	1	2	22		
?	*Headrise*	1	1	2.5		
?	*Slow swim past*	13	21	40.4		
?	*Headrise*	1	1	2.5		
Calf (0217)	*Breach*		1	50	>3-6 m	High (S) Low (W)
Calf ?		1	1	50		

Key Informants current view about the swim-with dwarf minke whale industry in the Great Barrier Reef

All of the respondents (n=21) were aware that dwarf minke whales visit the northern Great Barrier Reef each austral winter. The majority of them (n=60%) had encountered dwarf minkes at least once in their life time, either in the Great Barrier Reef or off the coast of New South Wales or Western Australia. The current view of most of the Key Informants (n=15) about the swim-with dwarf minke whale industry was positive; only two respondents were concerned and four felt they did not know enough about it. Positive responses included the good management measures (e.g. Code of Practice, permits, monitoring) in place (n=8), the significant research and conservation benefits (n=5) and several highlighted the strong association of this industry with research and management (n=4). Respondents however thought that the swim-with dwarf minke whale industry needs continuous monitoring and additional research in order to identify any long-term impacts and to address knowledge gaps (e.g. behavioural budget, interacting population size, migration) for adequate management. Key Informants also expressed concerns about the potential expansion of the activity (i.e. if additional SWW permits were to be issued by the Great Barrier Reef Marine Park Authority) and about the discontinuation of funding for research in 2009.

Conclusions from this study:

1. The immediate overall risk of harm to the swimmers and/or the whales for the majority of the dwarf minke whale behaviours is regarded as low for both the swimmers and the whales.
2. Highly interactive whales are at greater risk of entanglement in the rope, fishing gear or marine debris.
3. The majority of behaviours of risk of harm to swimmers were displayed by only a few known individual whales.
4. The Key Informants were concerned about longer-term impacts on the whales, e.g. disruption of important behavioural states and negative influences on time-activity budgets.
5. The current view of most Key Informants about the conduct of the dwarf minke whale swim-with dwarf minke industry was positive.
6. To ensure that the swim-with dwarf minke whales is managed sustainably, the Key Informants believed the industry needs:
7. continuous monitoring and
8. additional studies to identify any long-term impacts and address key knowledge gaps
9. Key Informants expressed concerns about potential future increases in industry size (i.e. the number of SWW-endorsed operators) and the potential for discontinuation of research and monitoring of the swim-with dwarf minke whale activity if no further funding were made available.

Key findings of the PhD study by S. Sobtzick

Photo-ID images collected by 'platforms of opportunity'

The total number of donated underwater dwarf minke whale images used for photo-identification varied between vessels but increased considerably from 2006–2008 (Table 15). The picture quality of images taken in 2006 varied between the three photographer groups with 'Professionals' providing most images in the highest picture quality category and 'Researchers' providing most of the photos in the highest information content category (Figure 17). In the higher picture quality and information content categories (3–5), 'Passengers' provided 44% (3267 pictures) and 43% (2775 pictures) of all images available, respectively.

Table 15: Number of donated dwarf minke whale underwater images from various vessels in the years 2006, 2007 and 2007 plus number of images taken by researchers

Vessel	# pictures in		
	2006	2007	2008
Undersea Explorer	5,844	4,983	10,568
Spoilsport	1,591	3,472	7,947
Nimrod Explorer	625	1,158	1,600
Phoenix	0	0	1,345
Taka	173	423	1,328
Vivid	0	0	196
Poseidon	0	87	183
Scubapro III	0	0	2
Calypso	0	67	1
Spirit of Freedom	354	0	0
Kalinda	0	306	0
Haba	0	186	0
Aristocat	0	12	0
TOTAL	**8,285**	**10,717**	**23,170**
+Researcher data	**>10,000**	**>15,000**	**>27,000**
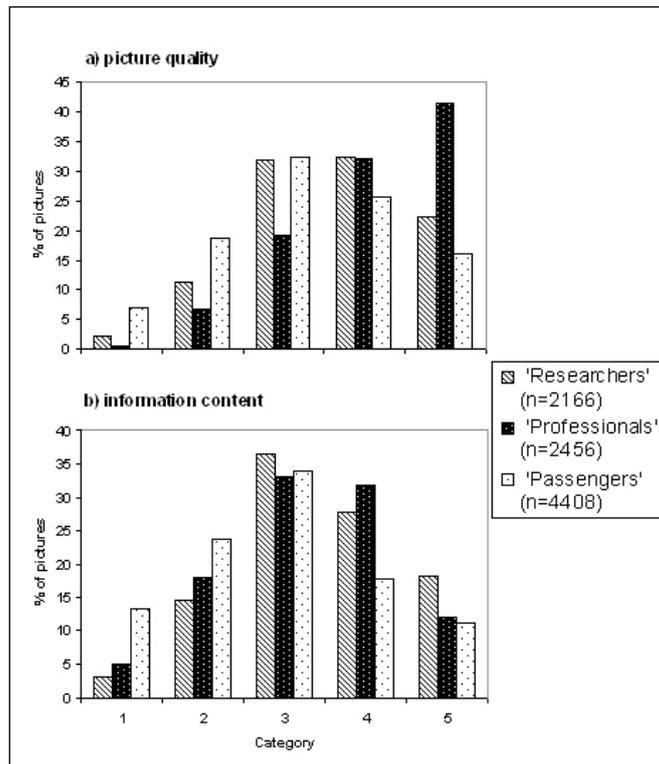
Figure 17: Percentage of pictures in a) quality and b) information content categories one to five for the three photographer classes 'Researchers', 'Professionals' and 'Passengers' in 2006.

Conclusions from this study:

1. Passengers swimming with dwarf minke whales in the Great Barrier Reef provide a large amount of high quality data for photo-ID studies.
2. Data quantity can be increased using educational tools and interpretive material, increased effort of crew, researchers and volunteers.
3. These data enable analysis on spatial and temporal scales that would not be possible with a single research vessel.

Biological data

Dwarf minke whale photo-identification catalogue

A preliminary dwarf minke whale photo-ID catalogue was established by the Minke Whale Project and consists of more than 100 individually identified whales each year from 1999 to 2005. A comprehensive analysis of the 2006 and 2007 photo-ID data sets was conducted as part of the PhD project by S. Sobtzick (2010).

Identified dwarf minke whales in 2006–2007

A summary of the complete 2006 and 2007 photo-ID data sets with regards to the number of complete dwarf minke whale IDs, number of within and between seasons re-sights and time between sightings is presented in Table 16. Analyses of association patterns and abundance are still ongoing.

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Table 16: 2006 and 2007 summary of total number of complete dwarf minke whale photo-identifications obtained; number of between and within season re-sights and maximum/average time between first and last sighting and between two successive sightings.

	2006	2007
Total # of complete MW IDs Of those:	155	141
• New complete IDs	155 (100%)	101 (71.6%)
• Between season re-sights	n/a	40 (28.4%)
Within season re-sights Of those:	56 (36.1%)	56 (39.7%)
• Time btw 1st and last sighting Maximum; average	24 days, 8.13 days	30 days, 10.43 days
• Time btw 2 successive sightings Maximum; average	23 days, 4.84 days	23 days, 5.34 days

Individual whales were encountered up to seven or eight times in 2006 and 2007, respectively, by up to three different vessels. The Sightings Network formed by vessels additional to *Undersea Explorer* (vessel used by researchers) provided 25% (10 whales) of the between 2006/2007 season re-sights and 13% (7 whales) of the within 2006 and 23% (13 whales) of the within 2007 re-sights (Sobtzick, 2010).

Length estimations of dwarf minke whales in 2006 and 2007 (Sobtzick et al., in prep.)

Whales interacting with *Undersea Explorer* in 2006 ranged from 4.03m-7.08m (n=52) and from 3.35m–7.18m in 2007 (n=77). The upper limits of the size ranges are very similar to dwarf minke whale measurements taken during 2003/04 in the Great Barrier Reef by Dunstan *et al.*, 2007 (6.61m in 2003 [n=23] and 7.18m in 2004 [n=56]). The largest dwarf minke whale ever measured was 7.8m from South Africa (Best, 1985). The lower limits (4.03m and 3.35m) represent the smallest dwarf minke whales ever measured alive (smallest animals measured by Dunstan *et al.* (2007) were 4.82m in 2003 and 4.48m in 2004).

In both 2006 and 2007, the majority of interacting whales were smaller than 6m and therefore very likely to be sexually immature (63% in 2006 and 65% in 2007). These figures agree with the findings of Dunstan *et al.* (2007) who reported that 57% and 59% of the interacting whales in 2003 and 2004, respectively, were sexually immature.

Although the closest relatives of dwarf minke whales, the northern hemisphere minke whales, have been reported to segregate by age (e.g. Jonsgård, 1951, Williamson, 1975); the study at hand did not find any segregation of dwarf minke whales by length and therefore age and state of sexual maturity over the course of the season. These findings agree with Dunstan *et al.* (2007).

Conclusions from this study:

1. The high number of within season re-sights indicates that the interacting population is smaller than expected.
2. Low average residence times suggest that the interacting population is open (subject to immigrations and emigrations during the season).
3. High number of within season re-sights and long encounter times result in potentially high cumulative interaction times of individual dwarf minke whales with vessels. This clearly raises concerns about cumulative impacts, especially for highly interactive individuals (e.g. as identified by Mangott, 2010).
4. The wider Sightings Network (more vessels and more encounters and more photographs per vessel) adds valuable biological information about within and between season re-sightings and residence times of individual whales.
5. The majority of dwarf minke whales interacting with *Undersea Explorer* in 2006 and 2007 were sexually immature, although every size class was present over the course of the season.

DISCUSSION

As part of the requirement to assess, using available information, the ecological sustainability of the dwarf minke whale swim-with-whale activity, the authors were asked to address a series of key questions from the Great Barrier Reef Marine Park Authority that are relevant to the potential impacts and management of the activity. These are addressed below:

"Does the dwarf minke whale swimming-with-whales activity result in disturbance to the dwarf minke whales?"

Potential disturbance reactions of dwarf minke whales have been summarised and discussed in Birtles *et al.* (2002), and such behaviours are listed in the current Code of Practice (Birtles *et al.*, 2008a). Some disturbance behaviours of dwarf minke whales were recognised in interactions including *sudden speed ups*, *sharp veers* and *sudden deep dives.* These behaviours are rarely seen in reaction to swimmers and the vessel. Most often *speed ups*, *veers* and *deep dives* were observed in response to conspecifics or other animals, such as for example sea snakes. In all instances, these reactive behaviours were short-lived (e.g. startle response proceeded by gliding) and the animals remained in the close vicinity to the vessel.

For dwarf minke whales as for other baleen whales, unexpected energy demands such as prolonged interactions with vessels and swimmers may have detrimental effects on their fitness. Whales may actively maintain contact with the drifting vessel for several hours, however this may not entail a significant energy burden. Thus far, the observed slow swimming speeds, scarcity of avoidance responses (except for temporary veers or speed ups), prevalence of stroke and glide behaviour, surfing behaviour down the ropes from upwind during open water encounters plus deeper returns upwind (reducing the drag effects of wind driven waves) all suggest low metabolic costs during interactions (Birtles *et al.*, 2002). Baseline data on the energetics of dwarf minkes however, are non-existent. Such data will be needed to evaluate whether or not interactions with tourism vessels draw significantly on the energy budgets of interacting dwarf minke whales. Measuring disturbance in whales requires long-term behavioural monitoring of identified individuals subject to cumulative interactions. In Birtles *et al.* (2008a, p.5) it was reported that "the following behaviours, identified from studies of other cetaceans, may indicate that a dwarf minke whale is disturbed:

- Sudden speed ups / startle responses
- Sudden sharp veers away from swimmers or vessels
- Increased distance of passes
- Changes in breathing patterns (i.e. where they surface around the vessel and/or the intervals between breaths)
- Changes in acoustic behaviour
- Any signs of protective behaviour by other whales when a calf is present (e.g. screening/shepherding or back arching displays)."

Ongoing monitoring of these behaviours will be crucial to detect any changes to the current assessment.

"Do dwarf minke whales control their interactions with vessels and swimmers?"

The proportion of encounters that were reported to have begun whilst the vessel was not under power (i.e. either moored, anchored or drifting) over the 2003–2008 monitoring period was 77.0% (1114/1447) and this proportion was consistent over this six year period. This provides a good indication that the majority of encounters are clearly initiated by the whales. Findings by Mangott (2010; also presented in Mangott *et al.,* 2011) show that dwarf minke whales:

- voluntarily initiate and maintain contact with vessels for prolonged periods;
- show a clumped distribution around vessels (<60 m) and aggregate in particular around swimmers; and
- show an unusual behaviour that contrasts with most other wildlife species involved in interactions with humans (i.e. the whales' maintenance of close contact for prolonged periods is inconsistent with most wildlife-human interactions where the wildlife either tolerate humans and/or show no interest in interacting with people unless there is a tangible benefit, such as food).

"Does the dwarf minke whale swimming-with-whales activity result in dwarf minke whales habituation to vessels and/or swimmers?"

Mangott's (2010) PhD study identified a change in the behaviour of interacting dwarf minke whales which was characterised by closer passing distances to swimmers over the duration of an interaction, as well as significantly closer approaches made by re-sighted individual whales. Longer-term studies of the behaviour of identified dwarf minke whales involved in repeated interactions will be critical to determine the occurrence and extent of any potential habituation. Apart from the issue of habituation (which may be a misleading term for dwarf minke whales; see Bejder *et al.*, 2009), an additional concern is with the attraction of the animals to the vessels and swimmers. Attraction is defined as the strengthening of a positive association with a stimulus (Knight and Temple, 1995) and manifests itself as an increase in an animals' visual, acoustic and/or tactile positive attention (Frohoff, 2004). Attraction of wildlife to human activity has been demonstrated repeatedly to have the potential to be harmful to both the animals and humans. The interactive behaviour of dwarf minke whales (amplified attraction) is highly unusual and is in contrast with the majority of other wildlife species. Thus it is very difficult to determine the trajectory of the effects of these interactions without further studies and careful monitoring. Longer-term monitoring of the whales' behaviour, linked to their photo-identification will be required to establish any such trends.

The risk of harm to both swimmers and the whales, however is amplified if resighted whales and/or calves are present in interactions (Mangott, 2010). It is therefore necessary for the crew to manage interactions much more carefully if and when an individual whale is displaying behaviours of concern in close proximity to swimmers and/or objects. Certainly vessel crew will need to be made aware of such issues for their active management of encounters and the prevention of possible incidents (e.g. entanglements in ropes). Workshops with the industry have an important role to play in refining such management protocols, for example, recommendations for deployment of ropes and monitoring whale behaviour were incorporated into the revised Code of Practice (Birtles *et al.*, 2008a) in the 2008 Code of Practice Workshop, and in raising crews' awareness of such issues. Outcomes of trials by operators using different rope deployments have not yet been fully examined, and no further workshops with the industry and other key stakeholders were funded by Great Barrier Reef Marine Park

Authority after December 2008 to explore and govern the management of these risks. We consider these issues associated with crew management of in-water interactions and associated risks to be of critical importance for the Great Barrier Reef Marine Park Authority's ongoing management of the SWW activity.

"Does the dwarf minke whale swimming-with-whales activity impact on the dwarf minke whales life-history parameters?"

There is currently insufficient information available to adequately address this question. We note that measuring such impacts requires monitoring of a range of key biological indicators over a sufficient time-scale (e.g. population size including in-migration and out-migration, movements, calving rates, mortality rates), and at this stage we are unable to provide a statistically valid answer to this question. The PhD studies by Sobtzick (2010) and Mangott (2010) have contributed essential baseline data which will assist future monitoring of potential changes to such life-history parameters.

"Does the dwarf minke whale swimming-with-whales activity displace dwarf minke whales from their preferred habitat?"

There is currently insufficient information available to adequately address this question. Characteristics of preferred habitat for dwarf minke whales have not yet been established and systematic surveys of dwarf minke whale distribution and abundance (i.e. from a dedicated research platform including vessels and aircraft) will be required. We note the high minke whale encounter rates identified by Curnock (2010) for sites in the vicinity of Ribbon Reef #10 (e.g. Lighthouse Bommie), suggesting a potential preferred habitat within their Great Barrier Reef wintering grounds. It has been hypothesised that the Great Barrier Reef provides an important breeding habitat for this population of dwarf minke whales (e.g. by Gedamke, Costa & Dunstan, 2001; Birtles et al., 2002) and we have observed some behaviours suggestive of courtship, however further research is required to fully establish this.

We have begun collaborating with other researchers studying habitat preferences of northern hemisphere minkes (e.g. M. Tetley, Ocean Sciences, Bangor University; U. Tscherter, ORES Foundation for Marine Environment Research, Switzerland and others) and we will continue to monitor key indicators to address this question in future. Future monitoring data requirements are likely to include photo-identification of individual whales, as well as longer-term analyses of whale encounters and vessel search effort. Again we note that longer-term monitoring of key indicators will be required to provide a statistically valid answer to this question.

"To what extent are dwarf minke whales at risk of physical harm by the dwarf minke whale swimming-with-whales activity?"

The risk of physical harm to dwarf minke whales from the swimming-with-whales activity was first summarised and discussed in Birtles et al. (2002). The authors perceived the whales' direct risk of injury from vessels in the northern Great Barrier Reef is limited, as the whales most frequently approach vessels at dive sites, where the motor is turned off and the vessel is stationary. The risk of striking a whale however becomes greater when vessels are steaming between dive sites, particularly for high speed vessels (e.g. day boats, private yachts) which may travel at speeds of up to 30 knots.

Entanglement in the surface ropes used during the swimming-with-whales activity is another direct risk to the whales, as well as human participants. This concern is most

apparent for known individuals familiar with the stimulus (Mangott, 2010) and was substantiated in 2007 when a whale became entangled in a surface rope but then broke free. This issue was discussed extensively with the industry and managers in workshops in 2007 and 2008 and precautionary measures (e.g. floating devices on the ropes, removal of ropes when not in use) were recommended and incorporated in the new Code of Practice (Birtles *et al.*, 2008a). The field evaluation of such precautionary measures however was not reported by operators due to the cessation of industry workshops prior to the 2009 minke season. The concern for the whales' wellbeing extends beyond the swim-with-whales industry and encompasses potential entanglement in fishing gear and marine debris, both within the Great Barrier Reef Marine Park and along their migration path, which is currently unknown.

Additional concerns for the wellbeing of the whales are the longer-term, cumulative effects of the swimming-with-whales activity on the animals. A high proportion of resighted whales both within and between-season indicates that the interacting dwarf minke whale population is smaller than previously anticipated (Sobtzick, 2010). Cumulative interaction times of individual whales with humans were also addressed in the PhD study by S. Sobtzick (2010). Our current understanding of the biology and behaviour of dwarf minke whales is limited to the interacting population. Moreover, virtually nothing is known about the baseline behaviour of these whales and what they are doing when they are not interacting with humans. It is therefore difficult to determine if and to what degree the potentially prolonged exposure times to vessels and the apparent associated behavioural changes influence the overall behaviour budget of these whales. Addressing these research gaps is crucial to assess the ecological sustainability of the dwarf minke whale swim-with industry.

"What is the current thought on the extent of dwarf minke whales sightings outside the offshore Port Douglas/Ribbon Reef sectors?"

We have addressed issues relevant to this question above (see Section 3.1 of this report) and there are insufficient data to speculate on the extent of dwarf minke whales sightings outside this region, however sporadic sightings of dwarf minke whales have been reported from the Townsville/Whitsunday Management Area of the Great Barrier Reef Marine Park, the Coral Sea (Marion Reef), the NSW coast, Western Australia, Norfolk Island, New Caledonia, Vanuatu and Papua New Guinea. There is a clear need for dedicated studies on the Great Barrier Reef dwarf minke population (not only the whales involved in the swim-with activities) that will require systematic surveys (e.g. aerial surveys and dedicated vessel surveys) in the Great Barrier Reef Marine Park in the near future. We have proposed the development of a Whale Sightings Network that would significantly contribute to a better understanding of this matter.

"To what extent is best practice management applied by the dwarf minke whale swimming-with-whales endorsed operators when conducting the swimming-with-whales activity?"

During the six years reported here it has become clear that the industry has adopted a forward-looking and strongly collaborative approach to ensuring best practice management. Through the twice-yearly workshops the SWW endorsed operators have become strong advocates of a precautionary approach and have worked closely with researchers and managers in establishing voluntary protocols to manage their whale encounters that go far beyond the requirements of national legislation (e.g. Best Practice Vessel Approach Distances Protocol in the Code of Practice: Birtles *et al.*, 2008a, p.5; also reported in Birtles, Valentine, Curnock, Mangott and Sobtzick, 2009). This level of collaboration and initiative has been recognised by representatives of international wildlife conservation NGOs (Whale and Dolphin Conservation Society and

the International Fund for Animal Welfare) as a world-leading approach towards the sustainable management of a whale watching tourism industry. This strong collaboration further provides an excellent foundation for responding to new knowledge about the potential cumulative impacts of the swimming-with-whales activity and for implementing any further protective management practices in a timely manner to help ensure whale and human safety.

The Code of Practice outlines a range of non-regulatory protocols that were voluntarily adopted by the industry in 2002, as best practice measures (given our present knowledge) for managing dwarf minke whale encounters and adequately preparing swimming-with-whales participants for these interactions. Prior to the formal implementation of this Code of Practice a relatively high proportion of passengers indicated in our passenger questionnaires that they did not feel they were adequately prepared for their encounters with minke whales (17.3% in 1999-2000; Birtles *et al*., 2002). Following the introduction of the Code of Practice the proportion of passengers who indicated they were not adequately prepared dropped remarkably and in 2008 was down to 3.6% (Curnock, submitted 2010). This supports the contention that the industry is committed to the implementation of best practices for dwarf minke whale encounter management and has made significant efforts to implement the Code of Practice.

It is our considered view that the Code of Practice has been an extremely valuable tool to enable the improved management noted above and it is clearly a flexible and adaptive tool for managing the SWW activity. One aspect of this is the degree to which the industry has taken part in both developing and implementing the Code of Practice, in partnership with the Great Barrier Reef Marine Park Authority and Minke Whale Project researchers. This has helped develop the sense of ownership and commitment to the Code. The current practices and processes for maintaining and reviewing the Code of Practice should be continued.

As reported by Curnock (Section 3.2 above) the overall mean rating score given by SWW respondents in passenger questionnaires over 2006-2008 for *'how well their minke whale encounter(s) were managed by the vessel crew'* was very high (mean rating out of 10 = 9.44; n=1593), however significant differences between vessels were found for this variable. Of greater concern, for some vessels a substantial proportion of passengers indicated that they were unfamiliar with the Code of Practice (Curnock, 2010). This reinforces that ongoing engagement with the SWW-endorsed operators and the education of new vessel crew (in a high-turnover industry) is required to ensure a high level of compliance with management protocols is maintained. A comprehensive analysis of minke whale encounter management by SWW endorsed operators over 2006-2008 forms part of M. Curnock's PhD thesis (2010).

"Is there a difference in best practice application amongst different operation styles and certification levels?"

As noted above, significant differences were found between operators in passenger questionnaire results for (i) passengers' mean ratings of *how well they thought their minke whale encounters were managed by the vessel crew*, (ii) the proportion of passengers who indicated they *were inadequately prepared for their minke whale encounter* and (iii) the proportion of passengers who indicated that *they were unfamiliar with the Code of Practice* (Curnock, 2010). Note that due to a confidentiality agreement between the researcher and SWW operators, results relating to these questionnaires are de-identified and cannot be attributed to any named vessel or operator. It may be the case that crew participation in annual Pre-Season Workshops strengthens operators' capacity to apply best practice, and Curnock (2010) notes that this industry has considerable crew turn-over rates.

"How has the effort of the dwarf minke whale swimming-with-whales activity changed over the past six years?"

The PhD study by M. Curnock (2010) found that the SWW-endorsed live-aboard operators (n=6) increased the frequency and duration of their visits to sites with high dwarf minke whale encounter rates (e.g. Lighthouse Bommie) over the three year period 2006-2008. Two additional sites in close proximity to Lighthouse Bommie ("Two Towers" and "Acropolis") were rarely used in earlier years and were visited more frequently during the 2007 and 2008 minke seasons, resulting in high encounter success rates (Curnock, 2010). There appears to have been no change in effort among the three Port Douglas-based SWW-endorsed day-boats. The shifting effort of the SWW-endorsed live-aboard vessels over the six-year period 2003-2008 resulted in a near doubling of the total annual minke whale encounter time (90%) over this period. The effects of this increase in the total encounter time on the whales is unknown, however the growth trend itself is cause for some concern and the potential for increased cumulative interaction times for individual whales (and thus the increased potential for changes in their behaviour associated with more/longer interactions) clearly requires further research and ongoing monitoring.

The actual 'searching effort' by the SWW-endorsed operators (with the exception of the primary research vessel *Undersea Explorer*) however, appears to be minimal, with few searches for dwarf minke whales conducted by the SWW-endorsed vessels in open water (Curnock, submitted 2010). This, combined with the existence of SWW-permit holders who did not operate vessels over 2003-2007 and the subsequent ceasing of operations by two SWW permit holders prior to the 2009 season, reveals a latent capacity at the existing scale of the SWW activity (i.e. capped at nine SWW-endorsements), which could be realised if more 'effort' were invested by existing SWW-endorsed operators to conduct such open-water searches (e.g. if Lighthouse Bommie were utilised to its full capacity, which it may have been in 2007 and 2008; Curnock, 2010) and/or if current inactive permits are transferred to new owners.

"Has participation in the dwarf minke whale swimming-with-whales activity changed the economic viability of dwarf minke whale swimming-with-whales endorsed operators?"

This question has not been addressed under the Great Barrier Reef Marine Park Authority Dwarf Minke Whale Tourism Monitoring Program, however members of the MWP research team (Birtles, Valentine, Stoeckl, Mangott and Curnock) have been involved in a Marine and Tropical Science Research Facility funded study investigating the social and economic values of a range of iconic Great Barrier Reef species, including dwarf minke whales. This information is published on the Reef and Rainforest Research Centre website (in our reports to the RRRC) and/or is intended for publication in peer-reviewed journals. Baseline data on the regional economic contribution of the Cairns and Port Douglas live-aboard dive tourism industry (including many of the SWW-endorsed operators) was recently published in *Tourism Economics* (Stoeckl *et al.*, 2010a). Detailed information on the economic value of dwarf minke whale tourism was included in our June 2009 Report to the RRRC (Stoeckl *et al.*, 2010b). We have heard anecdotal reports from the industry that their previous low-visitation period in the austral winter has now become one of their busiest periods.

Due to the seasonality of the SWW activity (with 90% of encounters occurring in June and July), SWW-endorsed operators are unlikely to be able to rely solely on SWW activities for their business. Many Great Barrier Reef tourism operators are also heavily dependent on in-bound tourism visitation and thus are vulnerable to global trends and

impacts that can affect such tourism. We note that in late 2008 and early 2009, two of the SWW-endorsed live-aboard operators ceased trading, with one citing a regional tourism downturn (resulting from the 2008 Global Financial Crisis) as the primary reason for their closure. At the time of writing, we are not aware of the SWW-permits of these two operators being sold or transferred to other operators. These two operators (*Undersea Explorer* and *Explorer Ventures*) had been highly supportive of our research and had contributed substantially to our data collection (in particular *Undersea Explorer*, which had provided several $100k worth of in-kind researcher access over the past 13 years and had been our primary platform for standardized field data collection). We are fortunate to have had increasing support from other SWW-endorsed operators which has allowed us to continue our long-term research and monitoring post-2008.

"Does the high degree of visitation by endorsed operators to Lighthouse Bommie require any specific management actions?"

It is important to note that Lighthouse Bommie is a small site and can only be used by one vessel at a time. Allocation of mooring access to the site is controlled by a roster system, administered by the Cod Hole and Ribbon Reef Operators Association. Findings from the PhD study by M. Curnock (2010) suggest that this site was utilised at or near its maximum capacity in both 2007 and 2008. While the biological significance of this site and surrounding area for dwarf minke whales are unknown, the MWP research team have advocated in previous reports to the Great Barrier Reef Marine Park Authority and in stakeholder workshops that the establishment of a Special Management Area may be appropriate as a precautionary management tool to control and monitor the extent of the SWW activity. We recommend further detailed discussions of issues and implications associated with spatial management of the SWW activity be undertaken with industry, researchers and other key stakeholders in a workshop environment.

CONCLUSIONS AND RECOMMENDATIONS

The Dwarf Minke Whale Tourism Monitoring Program and ongoing research by the Minke Whale Project (including the three recent PhD studies) have significantly enhanced our knowledge of this still undescribed subspecies of minke whale, for which the Great Barrier Reef provides habitat for their only known predictable aggregation in the world. The significance of this aggregation (potentially for breeding purposes however this has not yet been established with sufficient evidence) remains unknown, as do many key parameters of their biology, population and life history.

With the exception of the brief entanglement incident reported in 2007 (leading to amendments to the Code of Practice in 2008) we have observed no immediate impacts or harm to dwarf minke whales or swim-with participants in our 16 years of field observations. While it is clear that ongoing careful management and monitoring of in-water interactions will be required to minimize risks of potential harm to both whales and swimmers, a continuing concern also exists for the cumulative effects of repeat encounters (i.e. cumulative interaction times) and the potential for longer-term impacts on the whales through the apparent strong attraction (and potential habituation) to humans. The PhD study by Mangott (2010) has established that dwarf minke whales exhibit a significant short-term behavioural change in response to swim-with interactions. Further behaviour studies, linked with the photo-identification of individual animals, will be required to determine any longer-term behavioural trends.

The size of the Great Barrier Reef dwarf minke whale population (and hence their potential vulnerability) remains unknown. While the PhD study by Sobtzick (2010) provides a preliminary indication of the number of interacting whales in the Offshore Port Douglas and Ribbon Reefs Sectors of the Great Barrier Reef Marine Park, systematic population surveys from dedicated research platforms are needed to address this fundamental knowledge gap. Likewise, research to determine the currently unknown migration paths and feeding grounds for this population (i.e. where the whales spend the remaining 9-10 months of each year) is considered to be a high priority for the conservation and management of this species.

Recommendations for management and monitoring

To assist the sustainable management of the Great Barrier Reef SWW activity, the Minke Whale Project research team makes the following recommendations:

a. Based on the management successes achieved since the introduction of permits to limit the scale of the SWW activity in the Great Barrier Reef Marine Park, and the potential risks associated with unmanaged, non-endorsed interactions, we recommend that the SWW activity continue to be regulated and managed via Marine Parks permits and SWW endorsements, with minimum conditions that SWW-endorsed operators comply with the Code of Practice and contribute to monitoring of the SWW activity. Additionally, the SWW-endorsements should not be too readily or immediately transferable between operators (e.g. in the case of the sale of a business) to ensure that SWW interactions are managed to a high standard (i.e. vessel crew must be familiar with management protocols and be responsible for supervising in-water interactions) and that monitoring data collection obligations are met to an adequate standard. Due to the high turnover of crew among several SWW-endorsed operators identified by Curnock (2010), the requirement for special

crew training and/or accreditation as a further condition of the SWW endorsements should be evaluated.

b. As the long-term and cumulative impacts of the SWW interactions on the whales have not yet been fully established, we strongly recommend ongoing monitoring of the SWW activity. The Minke Whale Project has established methodologies for the collection and analyses of such data for long-term monitoring (e.g. Whale Sighting Sheets, Vessel Movement Logs, passenger questionnaires) and is committed to the ongoing evaluation of the sustainability of the swimming-with-whales activity. The PhD study by M Curnock (2010) was successful in involving key stakeholders in the development of Quadruple-Bottom-Line sustainability objectives, and the three PhD studies have contributed substantially to the evaluation of a suite of sustainability indicators to address these objectives. Implementation of these sustainability indicators will require the support and involvement of all key stakeholders. Over the last 15 years, we have established a highly successful collaboration with the SWW-endorsed operators that has facilitated improvements every year in their voluntary collection of a wide range of monitoring data (in terms of both quantity and quality). Continuing this collaboration with such 'platforms of opportunity' represents the most cost-effective means of studying dwarf minke whales in the Great Barrier Reef and monitoring potential impacts of the SWW activity, as well as for achieving high levels of compliance with management protocols.

c. Based on the finding of a near doubling of the total annual encounter time over the six-year monitoring period, and the PhD study by M. Curnock (2010) attributing this growth to shifting patterns in industry effort, we recommend that industry effort data be incorporated into standardized monitoring of dwarf minke whale encounters involving SWW-endorsed vessels to assess changing patterns of industry use and encounter rates at key sites for minke whale interactions (e.g. Lighthouse Bommie).

d. To ensure a high standard of monitoring data quality and good compliance with management regulations and the Code of Practice, we recommend that annual workshops involving industry, managers, researchers and other key stakeholders be continued. Pre-minke season workshops held in Cairns during the Dwarf Minke Whale Tourism Monitoring Program provided an excellent opportunity to inform and update SWW-endorsed operators on monitoring data requirements and on management protocols (e.g. for the benefit of new crew; *NB. The PhD study by M. Curnock found a high turnover of crew in this industry*). Over the monitoring program, a steady improvement was recorded each year in the industry's total monitoring and research data returns.

e. As part of an adaptive management approach, we recommend that the Code of Practice continue to be reviewed and revised as necessary with the involvement of the industry, researchers, managers and other key stakeholders in workshops, as new findings from research and monitoring come forth. The model established via the Dwarf Minke Whale Tourism Monitoring Program has been recognised as a world-leading approach toward sustainable management by numerous stakeholders (including representatives of international wildlife conservation NGOs) and has resulted in strong industry support for the current Code of Practice.

f. New and updated interpretative material is needed to assist crew management of SWW interactions and passenger compliance with the Code of Practice. During the Dwarf Minke Whale Tourism Monitoring Program, the Minke Whale Project research team provided annual updates to SWW-endorsed vessels'

interpretive tools (including developing an interpretive DVD), however some of these are now outdated (e.g. the CRC Reef brochure: "*Dwarf Minke Whales in the Great Barrier Reef – Current State of Knowledge 2002*") and supplies of such materials have run out. These interpretive tools have been shown to be valuable resources for vessel crews (especially new crew members) and provide explanations of the reasons for specific management protocols in the Code of Practice.

g. Based on the PhD findings of A. Mangott (2010), risk management procedures (e.g. in the form of a handbook) should be developed and implemented to minimize the risk of potential harm to swimmers and whales during in-water interactions with highly interactive individual whales (i.e. those that display behaviours of concern in very close proximity to swimmers, the vessel and/or objects in the water including ropes) and with cow-calf pairs. Crew and passengers on SWW-endorsed vessels must be made aware of the risks involved in swimming with dwarf minke whales, and be able to recognise potentially high-risk situations and act accordingly (e.g. exit the water and remove ropes if necessary). Periodic assessments of risks associated with behaviours of concern are recommended as the longer-term effects of the SWW interactions on the whales are better understood.

h. As noted above in our response to the Great Barrier Reef Marine Park Authority's question 4.12 "*Does the high degree of visitation by endorsed operators to Lighthouse Bommie require any specific management actions*", we reiterate that the establishment of a Special Management Area in this vicinity may be appropriate as a precautionary management tool to control and monitor the extent of the SWW activity. Further detailed discussions of issues and implications associated with such spatial management must involve industry stakeholders, researchers and other key stakeholders in a transparent process to achieve an agreeable and workable outcome.

Recommendations for future research

As part of the Great Barrier Reef Marine Park Authority's commitment to improving the protection and management of protected and migratory species in the Great Barrier Reef World Heritage Area, we recommend that the Great Barrier Reef Marine Park Authority support new research proposals and funding applications that aim to enhance knowledge of the Great Barrier Reef dwarf minke whale population. Research objectives that we consider are key priorities for this population include:

a. The expansion of the current Minke Whale Project Whale Sightings Network, by encompassing areas outside the range of the endorsed SWW operators, to examine the extent of dwarf minke whale interactions with humans elsewhere in the Great Barrier Reef Marine Park and assess the full extent of potential impacts and cumulative effects.

b. The continuation of long-term population studies using photo-identification. Such data will be needed to assess longer-term behavioural changes of individual whales, as well as survivorship within the interacting population and cumulative interaction times of individuals.

c. Habitat modeling of eastern Australian waters and the south-west Pacific to investigate potential correlations between dwarf minke whale distribution in the northern Great Barrier Reef and the environmental variables of the adjacent region in order to predict currently unknown habitats and potential feeding grounds outside the northern Great Barrier Reef (e.g. around sea mounts in the south-west Pacific).

d. Migration and movement studies (including the potential use of satellite tags), to contribute to more complete assessments of risks and threats to dwarf minke whales both within and beyond the Great Barrier Reef Marine Park.

e. Systematic surveys of dwarf minke whale distribution and abundance in the Great Barrier Reef Marine Park (i.e. from dedicated research platforms including vessels and aircraft).

f. Behavioural studies of the whales' activity budgets when in the Great Barrier Reef Marine Park (via remote sensing and observation from dedicated platforms) and changes associated with the SWW activity.

g. Genetic studies of key biological and population parameters (e.g. including stock structure, potential variation and phylogeography of sub-populations).

Considering the achievements and successes in our collaborative efforts to ensure the sustainable management of the Great Barrier Reef SWW activity during the Dwarf Minke Whale Tourism Monitoring Program, the Minke Whale Project research team commends the Great Barrier Reef Marine Park Authority for their commitment to these adaptive management processes. Given the high-profile nature of this activity and interest shown by leading cetacean scientists and wildlife conservation NGOs, the management of this activity will continue to be observed and evaluated at an international level (e.g. Carlson, 2009). The Great Barrier Reef Marine Park Authority's ongoing commitment to the sustainable management of the Great Barrier Reef SWW activity is therefore crucial.

The results and outcomes of the Dwarf Minke Whale Tourism Monitoring Program and the synthesis of the three PhD studies presented in this report provide a valuable baseline to which future data may be compared. The ongoing engagement and consultation of key stakeholders that were involved through the six years of the Monitoring Program, the 16 years of the overall Minke Whale Project and indeed the >20 years since the late Dr Peter Arnold first began collecting data about these whales from the dive industry in 1990 (Arnold 1997), will also be critically important for the successful implementation of any changes to the management of the Great Barrier Reef SWW activity. There is an excellent opportunity to continue this successful partnership that considers not only the minimization of impacts on the whales, but also the continued enhancement of the tourist experience and the wider promotion of the conservation values of these whales as part of a sustainably managed SWW tourism industry.

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