Dolphin – human interactions in Australian waters

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ABSTRACT

The interaction between humans and cetaceans (dolphins and whales) is a multi-million dollar tourism industry with ever increasing popularity in Australia. This form of tourism allows unique opportunities for people to interact with animals in their natural environment. These interactions may involve observing dolphins and whales from land and boats, as well as swimming with or feeding them in controlled situations. However, while there are obvious benefits of cetacean ecotourism to local communities, there may be associated costs to the animals and their environment. Research is being undertaken in an effort to understand these costs and has indicated that interactions with cetaceans can cause short-term changes in the behaviour of animals, such as alterations to foraging strategies or reduced maternal care. These changes can ultimately lead to long-term effects to individuals and populations, for example, displacement from preferred habitats or reduced reproductive success. Further research and adaptive management will be crucial in ensuring the long-term sustainability of cetacean populations, their environment and this industry.

Key words: dolphin, whale, cetacean, whale-watching, management, tourism

Introduction

Whales, dolphins and porpoises are known as cetaceans, from the Latin *cetus* (a large sea animal) and the Greek *ketos* (sea monster) (Carwardine 1995). These 'charismatic megafauna' have captured people's attention and curiosity for centuries. This interest has led to extensive research over the years as we endeavour to discover more about their complex social structure and behaviour. Research on cetaceans, particularly odontocetes (toothed whales), may offer insight into ecological influences on mammalian social systems in general (Conner *et al.* 1998). Research to date has been largely focussed on the distribution and abundance of cetaceans, their feeding ecology and habitat use, group composition, genetic relationships, acoustic communication and, more recently, investigating the possible effect of anthropogenic activities.

Worldwide, there are 79 species of cetaceans (order Cetacea), with approximately 45 species known to inhabit Australasian waters, including the Subantarctic Territories and the Australian Antarctic Territory (Baker 1990). Cetaceans are subdivided into two suborders, Mysticeti, the baleen whales and suborder Odontoceti, the toothed whales and dolphins. Although commercial whaling ceased in Australia in the 1970s, cetaceans have continued to be susceptible to the influence of human activities; particularly where migration paths, breeding and birthing areas are relatively close to shore and therefore, to urban centres. This paper primarily addresses dolphin tourism in Australian waters, which may involve swimming or feeding cetaceans or observing animals from land or boats; and the possible impacts of these anthropogenic activities. Separate case studies will be discussed that will focus on the short- and long-term implications of tourism activities on dolphins; in particular, assessing the potential impact of boat-based dolphin watching.

Cetacean Tourism in Australia

People *want* to observe dolphins and whales in the wild. The demand for these 'up close and personal' experiences with dolphins and whales is an ever expanding industry worldwide. In Australian waters, cetacean-based tourism has sustained massive growth (Hoyt 2001; IFAW 2004). During 2003, more than 1.6 million people indulged in cetacean watching; more than double the previous estimate of visits in 1998 (IFAW 2004), contributing more than $270 million to the Australian economy (IFAW 2005). The Sydney whale watch industry for example, which primarily targets humpback whales during their northern migration from June to August each year, increased more than 600% in boat-based whale watchers from 2003 to 2004 (IFAW 2005).

Australia is one of the most diverse regions in the world to experience cetaceans, from the sub-Antarctic to the tropics, with over half of the world's 79 or so species represented. However, of the 45 species found in Australian waters; only a minority are the subject of dedicated commercial tourism, including bottlenose dolphins *Tursiops* sp., humpback whales *Megaptera novaeangliae* and the southern right whale *Eubalena australis* (Table 1). These species are targeted by the industry because they may be observed in accessible areas and are reliably found at specific locations due to their migratory nature or residence in a coastal environment. There are a number of other species that are opportunistically sighted during cetacean watching expeditions, although their presence is far less predictable and they are rarely the focus of expeditions. These species include common dolphins *Delphinus delphis*, Indo-Pacific humpback dolphins *Sousa chinensis*, false killer whales *Pseudorca crassidens*, pilot whales

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Globicephala sp., killer whales *Orcinus orca*, sperm whales and the blue whale or more likely, the pygmy blue whale *Balaenoptera musculus*.

Cetaceans are protected by law from human activities in several countries, including Australia (Commonwealth's *Environment Protection and Biodiversity Conservation Act* 1999), New Zealand (*Marine Mammals Protection Act* 1978) and the United States (U.S. *Marine Mammal Protection Act* 1972). The management of dolphin and whale tourism however, is inconsistent between different States and across international waters; ranging from no monitoring or management of species, to voluntary 'codes' usually adapted by local operators, through to controlled regulations managed by government agencies (Garrod and Fennell 2004).

A number of different platforms and types of dolphin and whale interactions are available in Australia, including viewing animals from land, sea or air. The most common platform for observation are commercial cetacean-watching vessels or smaller 'recreational' powerboats. This tourism however, involves repeated and continuous 'up close' encounters with specific cetacean communities, placing greater pressure on these species. New opportunities are constantly arising where a pattern of behaviour expressed by a population may be exploited for tourism as is the case with the recent interest in diving with dwarf minke whales *Balaenoptera acutorostrata* in the Great Barrier Reef Marine Park (Birtles *et al.* 2002).

Feeding

Commercial tourist operations with cetaceans first commenced in Australia in Monkey Mia, Western Australia during the 1960's, where a small number of bottlenose dolphins learnt to accept fish from the local fishers and occasional physical contact from people (Connor and Smolker 1985). Monkey Mia is one of the most popular places worldwide to view wild bottlenose dolphins and is one of the longest scientifically researched populations (Figure 1). Feeding the resident dolphins has become one of the major tourist attractions of the area and it is the longest-running provisioning site in the world. Currently, there are four adult female bottlenose dolphins and their offspring still being provisioned by rangers from the Department of Environment and Conservation (DEC). This activity is regulated and managed by the DEC under state legislation and management plans. Since 1989, restrictions on the amount of fish given each day have been in place. Feeding of marine mammals is prohibited in Australian waters under the *Environment Protection and Biodiversity Conservation Act* 1999 and under most States legislation, although provisioning dolphins also occurs in Bunbury, Western Australia, Tangalooma and Tin Can Bay in Queensland; all of which are managed under the observation of State government agencies and associated parties.

Research has demonstrated that provisioning of free-ranging animals may result in changes to group composition, reproduction, ranging patterns, individual behaviour, survival or growth rate (for review, see Mann and Kemps 2003). In dolphins, problems may occur where animals become habituated to accepting food from humans and thus may become more aggressive in an attempt to obtain food. Furthermore, as a result of the increased focus on humans for obtaining food, there is the potential decrease in maternal care given by dolphins during these provisioning periods (*e.g.* dolphins in Monkey Mia; Mann and Kemps 2003), which has led to increased juvenile mortality and significant changes in behaviour. Research into the possible impacts of provisioning regimes in Australia, and elsewhere, has suggested that dolphins may become dependent on these 'human handouts' (Wilson 1994). As a result, animals may become increasingly aggressive towards humans or endure abuse by humans (Wilson 1994; Orams *et al.* 1996).

Swimming

Swimming with free-ranging cetaceans has increased in popularity and demand, particularly over the last decade (Hoyt 2001). In the southern hemisphere, there are at least 46 different sites, which focus on 11 species of cetaceans (Samuels *et al.* 2003). In Australia, it is illegal to approach within 50 metres of a dolphin in the water unless licensed, and this licensed swimming occurs

Table 1. Some examples of the types of viewing opportunities for dolphins and whales around Australia.

Bottlenose dolphins	Bottlenose dolphins may be observed from **boat-based tours** throughout the year in Jervis Bay, Port Stephens, Byron Bay and Coffs Harbour, New South Wales; Port Phillip Bay, Victoria and Adelaide, South Australia.
	Swimming with bottlenose dolphins occurs in Adelaide, South Australia; Port Phillip Bay, Victoria; and Coffs Harbour, New South Wales.
	Feeding bottlenose dolphins at Monkey Mia and Bunbury, Western Australia; and Tangalooma, Queensland.
Humpback whales	Humpback whales may be sighted during their annual northern and southern migration from commercial **tour boats** or many land-based vantage points along the coasts of New South Wales, Queensland and Western Australia.
Southern right whales	Watching southern right whales in their breeding and resting areas from the land-based areas and from **tour boats** in Victoria and Southern Australia, including areas off the Great Australian Bight.
Dwarf minke whales	**Swimming** with dwarf minke whales in areas of the Great Barrier Reef.

Figure 1. Tourists touching dolphins outside the official feeding time in Monkey Mia, Western Australia. Photo, S. Allen.

primarily in Victoria, although now swim-with programs are undertaken in most other states. These encounters have been operational since the early 1990's and have generally focused on bottlenose dolphins. More recently however, controlled free-swimming with dwarf minke whales occurs in the northern Great Barrier Reef Marine Park (Birtles *et al.* 2002). The impact of these activities on the animals however, is not well understood.

Generally, there are four categories of in-water encounters between cetaceans and humans (from Samuels *et al.* 2003):

- dolphins that are generally solitary and seek human company,
- dolphins that are habituated to in-water interactions through food provisioning by humans,
- cetaceans that are habituated or seek human swimmers for sustained interactions on a regular basis (not including food-provisioned or solitary dolphins), or
- cetaceans *not* habituated to swimmers.

Swimming with lone or solitary dolphins, although rare in Australia, may provide the greatest degree of contact for humans, but it still remains a mystery as to why these dolphins seek people contact. Nonetheless, any interaction between humans and free-ranging dolphins may result in adverse consequences for both people and dolphins. Many dolphins have had periods of misdemeanours with people, which may include misdirected sexual behaviour towards humans or vessels, damage to property, aggression towards humans, short- and long-term avoidance of swimmers and fatality (*e.g.* de O Santos 1997; Bejder *et al.* 1999; Constantine 2001). Conversely, as a result of their close proximity to humans, and therefore urban communities, disruption of the dolphins' behaviour may occur or the animals may sustain potentially life threatening injuries such as entanglements, vessel collisions, physical abuse by people (*e.g.* Samuels *et al.* 2003; Samuels and Bejder 2004). Samuels and colleagues (2003) discuss in detail a review on literature pertaining to in-water encounters with cetaceans focusing on the southern hemisphere. Data on potentially impacted individuals and populations is sparse in Australia, and what is known has relied primarily on anecdotal or descriptive information, leaving many gaps in the literature that is essential for the appropriate management of these interactions.

Vessel-based Viewing

Boat-based cetacean watching commenced on the east coast of Australia in 1987 (Hervey Bay, Queensland) and off the West Australian coast in 1989 (Coughran and Crawford 1996) and focused on the migratory humpback whale (Anderson *et al.* 1996). Since this time, watching dolphins and whales has increased considerably in diverse locations around Australia. Port Stephens, on the east coast of Australia, for example, is considered the 'dolphin watching capital of Australia', with at times more than ten commercial dolphin watch vessels operating on a daily basis, and as many as 250,000 people watching cetaceans in 2003 alone (IFAW 2004).

As a result of frequent exposure to boats, changes in the behaviour of cetaceans have been identified. The impact of cetacean-human interactions may involve direct effects such as vessel strike or entanglements or indirect effects, including changes to vocal and non-vocal behaviour, respiration rates, movement patterns or habitat use (*e.g.* Allen and Read 2000; Scarpaci *et al.* 2000; Allen *et al.* 2003; Constantine *et al.* 2004; Lemon *et al.* 2006) or long-term shifts in behavioural budgets or reproductive success (*e.g.* Lusseau 2004, Bejder *et al.* 2006a; Bejder *et al.* 2006b).

Figure 2. Whale watching platform, Cape Solander, NSW Photo, S. Gibbs.

The Effect of Anthropogenic Activity on Cetaceans

Over the last decade, there has been increasing concern over the impacts of human activities on cetacean populations. Aside from the obvious dangers resulting from the bioaccumulation of toxins from pollution and entanglements in fishing gear, there are still many unanswered questions regarding the less obvious activities such as the effects of shipping, military operations, seismic surveys, ocean acoustic studies or aircraft overflight. However, in areas close to urban centres, inshore delphinids may be predominantly impacted by recreational boats or commercial ecotourism

including cetacean-watching, feeding or swimming. For example, resident dolphins living in a protected bay such as Port Stephens, on the NSW coast, share their environment with 100s of recreational and commercial vessels, many of which attempt to get very close to the dolphins.

The effect of human disturbance is frequently measured in terms of an animal's change in observed behaviour (Beale and Monaghan 2004), and the extent of these changes is often used as a measure of a species' susceptibility to disturbance (Gill *et al.* 2001; Blumstein *et al.* 2003). The animals' reaction to disturbance, or degree of risk, may vary as a result of a number of factors including the type of interaction or previous experience to the stimuli, the sex or reproductive state of the animal or their surface behaviour during the exposure period. Variation may also differ between different species, populations or with geographical location.

The increased pressure from anthropogenic activities may result in short- or long-term impacts. The short-term behavioural response of small cetaceans to small motorised vessels for example, may vary considerably from attraction to flight, or in some cases, indifference (*e.g.* Avecedo 1991; Janik and Thompson 1996; Gregory and Rowden 2001; Lemon *et al.* 2006). The response of these animals may be a reaction to noise, rather than to visual cues. Hector's dolphins *Cephalorhynchus hectori* in New Zealand for example, react to approaching vessels at a distance of more than 2 km, exceeding the area's water visibility (Bejder *et al.* 1999). However, in other instances, the response of small cetaceans to anthropogenic activity may be a combination of both acoustic and visual cues (Richardson *et al.* 1995; Lesage *et al.* 1999; David 2002).

Short-term responses have been widely noted; including changes or disruption to acoustic behaviour; changes in behaviour and activity patterns, *e.g.* foraging or resting; changes in respiratory patterns; changes in dive patterns, group size, formation or cohesion. It has been suggested that disruption of group cohesion in species such as bottlenose dolphins may have significant consequences as they rely strongly on long-term bonds between individuals (Bejder *et al.* 2006a). Short-term investigations on the response of wildlife to disturbance however, make it difficult to deduce any long-term biological significance on the population, for example on their habitat use, reproduction or population size, or to develop the most appropriate management plans to minimise impact and maintain industry needs. The short-term behavioural response of cetaceans to disturbance may have long-term behavioural or physiological consequences, particularly if animals are continuously exposed, or endure cumulative affects of activity. However, minimal research has been undertaken on the long-term effect of anthropogenic disturbance on cetaceans; as it requires baseline information on the population prior to exposure to impact and long-term monitoring. Furthermore, this potential long-term effect is difficult to quantify as these animals are long-lived with low reproductive rates. Recently however, in a long-term study undertaken in Shark Bay Western Australia, resident bottlenose dolphins exposed to an increase in commercial boating activity led to a long-term decline in dolphin abundance in these areas (Bejder *et al.* 2006b; Case Study 3). In reinterpreting the results of this study however, Bejder and colleagues concluded that these short-term behavioural responses to the impact may *not* be sufficient indicators of anthropogenic disturbance on wildlife. A study on bottlenose dolphins impacted by tourism in New Zealand however, has shown that at current levels of boat-dolphin interactions, the viability of the dolphin population is threatened and may potentially become extinct over the next 50 years if the amount of repeated interactions continue (Lusseau *et al.* 2006).

The effect of longer-term repeated exposure to human activities may result in reduced fecundity and ultimately, overall population fitness. Adverse reactions may lead to:

- displacement from critical areas, *e.g.* feeding, calving or breeding areas;
- changes in distribution or migratory patterns which may increase risk of predation or energetic requirements;
- masking of important calls from conspecifics and other significant sounds in their environment, such as from predators and prey;
- noise-induced physiological stress;
- temporary or permanent hearing impairment;
- fatalities, *e.g.* ship strikes.

Cetacean ecotourism has obvious benefits to the local community and the tourism industry, including economic benefits, educational purposes to the public and scientific research (Bejder and Samuels 2003). However, with such a rapid industry growth, there has been significant community and government concern for the appropriate management of cetaceans, particularly those animals that are resident to specific areas, with the main goal being their conservation. A secondary incentive is to ensure the sustainability of the growing ecotourism industry. As a result of this extensive nation-wide growth, there are also potential costs, which may be detrimental to the animals. This may be as a result of direct impacts such as vessel strike or indirect harm through disruption to normal behaviour, displacement from critical habitats and noise trauma (Richardson *et al.* 1995). As examples, three case studies are presented below, which discuss the short- and long-term impact associated with vessel-based dolphin watching on resident populations of bottlenose dolphins.

Figure 3. Dolphin watching, Port Stephens, NSW. Photo, S. Allen

Case Studies

Case Study 1 - Effects of Recreational Boats on Dolphins – Short-Term Impact

Lemon *et al.* (2006) conducted research on the *short-term* impact of approaching powerboats on the vocal and non-vocal behaviour of travelling inshore bottlenose dolphins *Tursiops aduncus* in Jervis Bay, southeastern Australia. Investigations of disturbance on coastal delphinids have generally focused on surface responses, with little research examining both vocal and non-vocal behaviour. Moreover, much of the research has been observational rather than experimental, making it difficult to ascertain if the behavioural change is a result of the boat presence or naturally occurring.

All motorised vessels, ranging from small recreational boats through to large supertankers, create oceanic noise. With over 90% of world trade achieved by sea transportation, vessel noise represents a significant source of anthropogenic noise in the ocean (Richardson *et al.* 1995). Disturbance of cetaceans by ships and boats is likely to be significant as vessels are abundant, widely distributed, mobile and are capable of generating substantial levels of noise. In coastal areas of the NSW coast, bottlenose dolphins inhabit some of the nation's busiest waterways. One such population (approximately 60 residents) of *Tursiops aduncus* inhabits Jervis Bay on the southeast coast of NSW (about 200 km south of Sydney); this area is a popular site for recreational boating, with up to 200 small motorised vessels operating in the bay during peak periods (T. Lynch, pers. comm.). This research aimed to assess short-term changes in the vocal and non-vocal behaviour of travelling bottlenose dolphins in response to approaches by a 'recreational type' powerboat (*i.e.* not commercially used for dolphin observation) (Lemon *et al.* 2006).

The vocal and non-vocal behaviour of travelling dolphins was recorded continuously from an independent vessel before, during and after powerboat approaches (n=12), interspersed with control observations (n=12) in experimental trials between 2001 and 2003. Each trial consisted of 'no boat' (pre-exposure), 'boat' (exposure) and 'no-boat' (post-exposure) periods. Changes in surface behaviour, travelling direction and calling rates were evaluated for each sampling period. This was assessed in the context of broader studies of vocalisations and relation to behaviour of the same population in the absence of anthropogenic activities.

Significant changes in the direction of travel and surface behaviour (from travelling to milling; termed a 'transition' behaviour) of dolphins were evident between the treatment and control periods (Figure 4). In contrast, there were no changes in dolphin call rates when approached. Previous research on the call rates of this dolphin population however, has identified that travelling animals do not produce a great deal of sound (Lemon 2006). It is probable that dolphins resident to an area are more aware of their environment, for example, the location of piers or rocky outcrops, and as such, are able to minimise the use of phonations, possibly relying on visual and tactile perception to maintain contact with conspecifics.

The dolphin population of Jervis Bay has been fairly stable since the mid 1990s, coexisting with increasing proximal anthropogenic activities, such as interactions with recreational boats. Despite the dolphins' long-term exposure to these activities, significant changes in surface behaviour of travelling dolphins were short-term responses to an approaching powerboat. These changes in behaviour occurred at a distance of 100 metres, outside the minimum suggested approach distance of 50 metres recently proposed by the NSW Department of Environment and Climate Change (National Parks and Wildlife Amendment (Marine Mammals) Regulation 2006, under the *National Parks and Wildlife Act 1974*). In this study, a single anthropogenic event caused a short-term disruption to dolphin behaviour which may suggest that cumulative effects of repeated disruptions could lead to longer-term change; this is however, difficult to ascertain. The dolphin population of Jervis

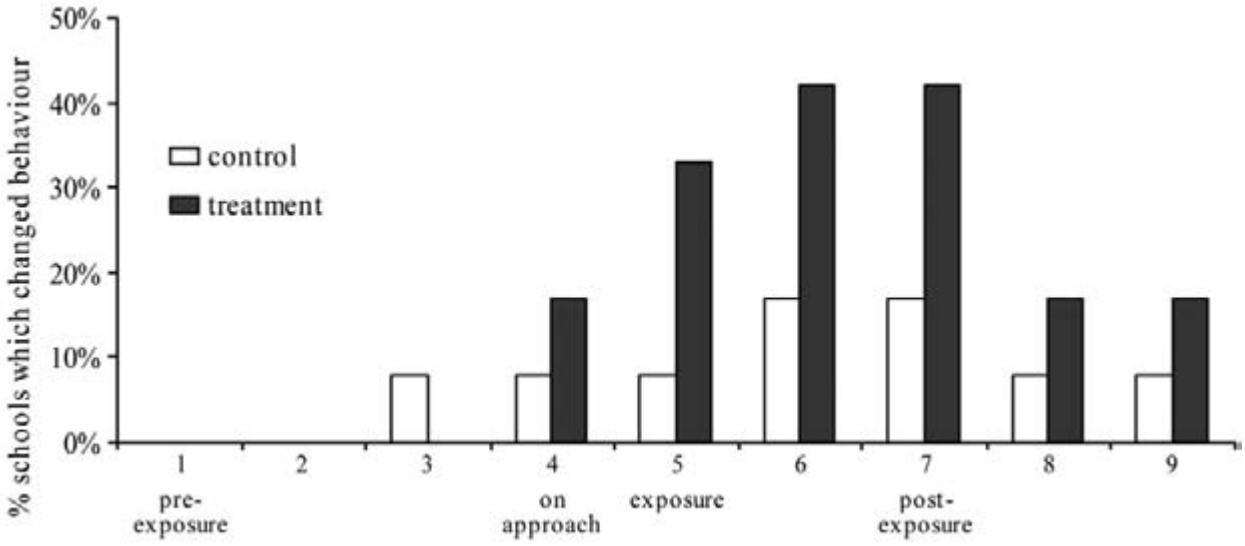

Figure 4a. Percentage of dolphin groups that changed their surface behaviour from travelling to non-travelling behaviour during the experimental approaches by a powerboat. Reprinted with permission from Figure 1, Lemon *et al., Biological Conservation* 127: 367 (2006). Copyright 2007 Elsevier Limited.

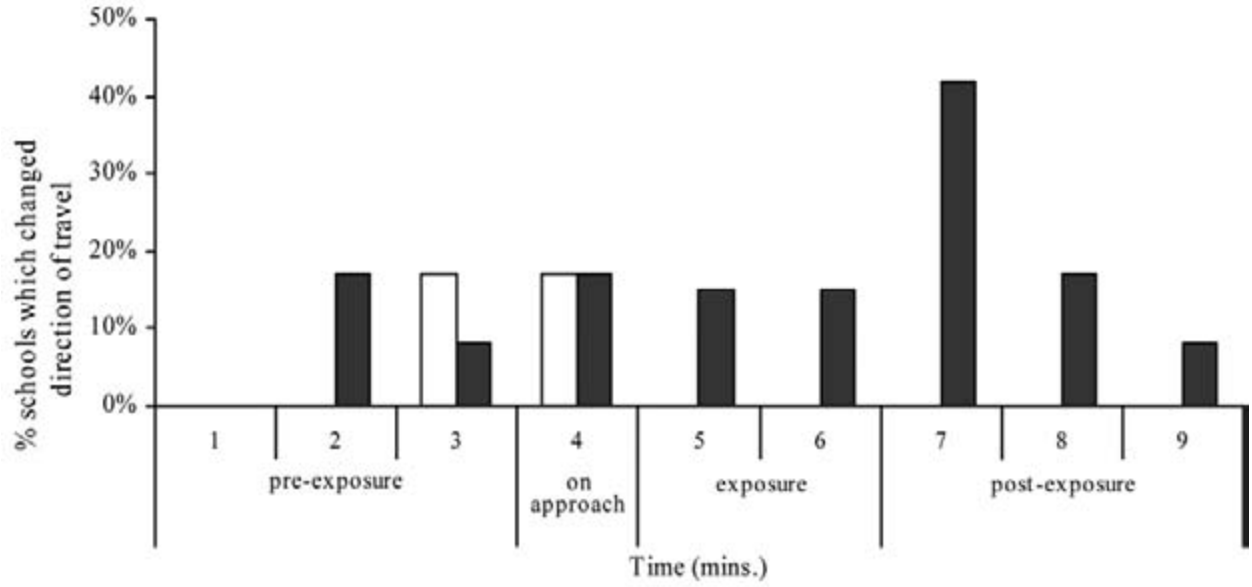

Figure 4b. Percentage of dolphin groups that changed their direction of travel during the experimental approaches by a powerboat. Reprinted with permission from Figure 1, Lemon et al., Biological Conservation 127: 367 (2006). Copyright 2007 Elsevier Limited.

Bay coexist with escalating anthropogenic activities. Longer-term monitoring of both the vocal and non-vocal behaviour, as well has monitoring population abundance, is required to further assess the effect of disturbance in coastal waters.

Figure 5. Approaching dolphins, Port Stephens, NSW. Photo. S. Allen.

Case study 2 - Effect of Commercial Tour Boats on Dolphins – *short-term impacts*

Allen and colleagues (in press) tested the hypothesis that commercial dolphin-watch vessels influence the *short-term* behaviour, spread and school stability of inshore bottlenose dolphins *Tursiops aduncus* in Port Stephens, NSW (Figure 6). The dolphin population of Port Stephens (approximately 90 resident animals) is the focus of the most intensive commercial and recreational cetacean-based tourism in Australia. In the early 1990's, dolphin-watch tourism commenced in this area with two vessels; now over a decade later, a multi-million dollar industry is booming, with at least nine boats operating on a daily basis (Allen *et al.* 2003). As well as the extensive dolphin watch industry in Port Stephens, there are also numerous dive and fishing charter boats and over 48,000 recreational boats are registered in the area (NSW Waterways, pers. comm. 2006). This combination of dolphin-watching and the increased popularity of recreational boating in Port Stephens makes the area perhaps the most concentrated boating activity around dolphins in Australia (Allen 2005). This population of dolphins are unique in that recent genetic analysis has indicated that they are genetically differentiated to those animals inhabiting waters outside this bay (Wiszniewski 2004), highlighting the importance of investigating potential impacts from human disturbance on this closed population of dolphins.

The response of the dolphins to commercial vessels was assessed using shore-basing visual tracking of dolphins and vessels, using a theodolite from a known height. When using a theodolite and the height of data collection is known, accurate positioning of vessel and dolphin movements and behaviour can be determined. Dolphin behaviour, position within a set sampling area, group size and the inter-animal distance or spread of the group, was determined in the presence and absence of commercial tour boats during a field season in 2003.

Dolphin behaviour was significantly different when tour boats were within 100 metres of the groups in Port Stephens ($\chi^2 = 25.661$, d.f. $= 4$, exact $P < 0.001$; Allen *et al.* in press). When boats were interacting with groups, dolphins spent more time travelling (84%), and there was a significant decrease in dolphins foraging or socialising with conspecifics. Furthermore, dolphins were *never* observing resting when commercial tour vessels were within 100 metres of the groups. Focal group follows indicated that dolphins were more likely to split into smaller groups in the presence of these vessels. In addition, fewer groups were observed during peak dolphin-watching periods, indicating possibly short-term movement away from areas of intensive boating activity.

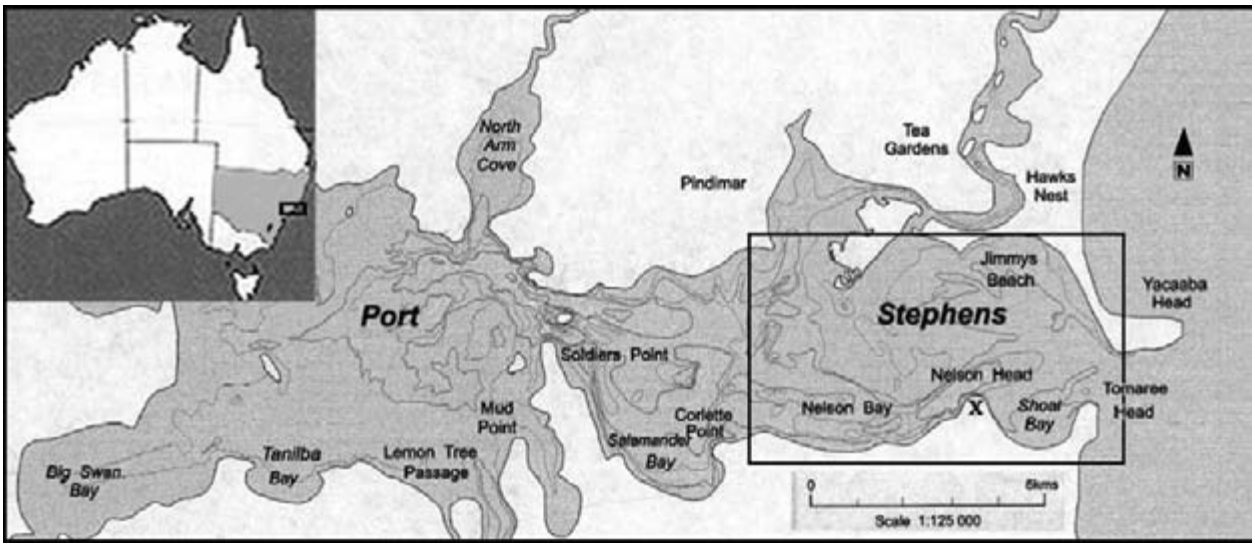

Figure 6. Study area within Port Stephens, approximately 200 km north of Sydney on the NSW coast. Box shows observation area and the observation platform (x) off Nelson Head. Reprinted with permission from Figure 1, Allen *et al*., Journal of Cetacean Research and Management (in press). Copyright 2007, International Whaling Commission, Cambridge, UK.

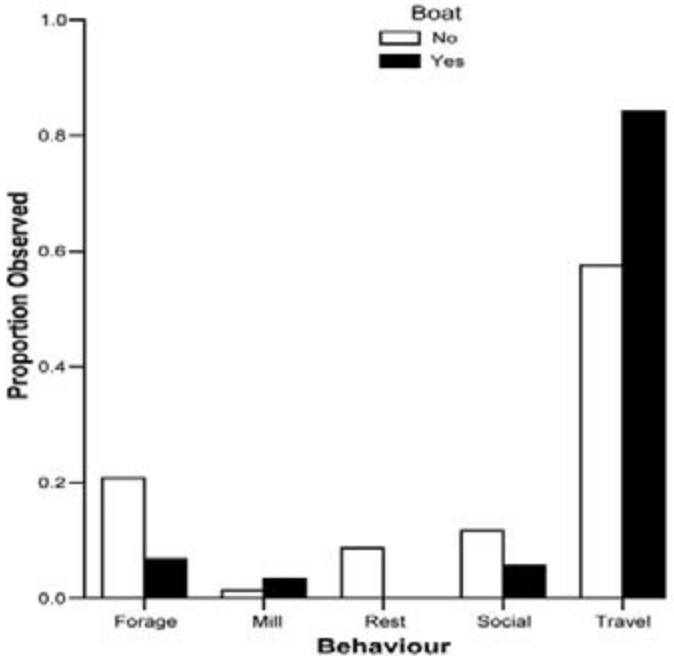

Figure 7. Proportion of dolphin behaviours observed in the presence and absence of commercial dolphin-watch vessels in Port Stephens NSW, during a field season in 2003.

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Dolphin watching on the east coast of Australia is an ever expanding industry, with Port Stephens possibly the main hub of activity. Yet, this study was the first to investigate the short-term effect of dolphin-watching activities on the surface behaviour of these dolphins. Watching resident dolphins targets the same animals repeatedly, it occurs year-round and as such, dolphins may be continuously compensating by altering their behaviour, potentially increasing stress on these animals. While these activities may cause a short-term effect on dolphin behaviour, by causing dolphins to forage less and travel more, it is difficult to assess the biological significance on the population without long-term monitoring and research (refer to Case Study 3). Even more pertinent, is the fact that these dolphins form a small, resident population that is genetically differentiated from those in waters outside Port Stephens, *i.e.* there is little mixing with individuals that inhabit the coastal waters offshore from this area. Even though population estimates have remained fairly stable over the last 10 years, without appropriate management and long-term research, the cumulative impact of continuous tour boat interactions may potentially compromise the long-term viability of this dolphin population.

Case Study 3 – Effect of Commercial Vessels – *long-term impact*

This study is based on long-term, individually specific data which compared the abundance of bottlenose dolphins *Tursiops* sp. in two neighbouring sites which were exposed to differing amounts of boating activity, in Shark Bay, Western Australia (Bejder *et al.* 2006b). Shark Bay, situated mid way up the west coast of Australia, is home to approximately 2,700 Indo-Pacific bottlenose dolphins (Preen *et al.* 1997). Dolphin tourism in this area commenced in the 1960's where resident dolphins were being provisioned by local fishers and tourists. The first commercial dolphin-watch operator began in 1993, with the second boat arriving in 1998; offering around eight trips a day. The resident dolphins are part of the longest scientifically researched population in Australia, with research dating back to 1984. A long-term database, collected during focal animal boat surveys, has identified over 800 individuals (using photo identification of unique dorsal fin characteristics), and has gathered data on their age, sex and distribution (refer to Bejder *et al*., 2006b for reference to these studies).

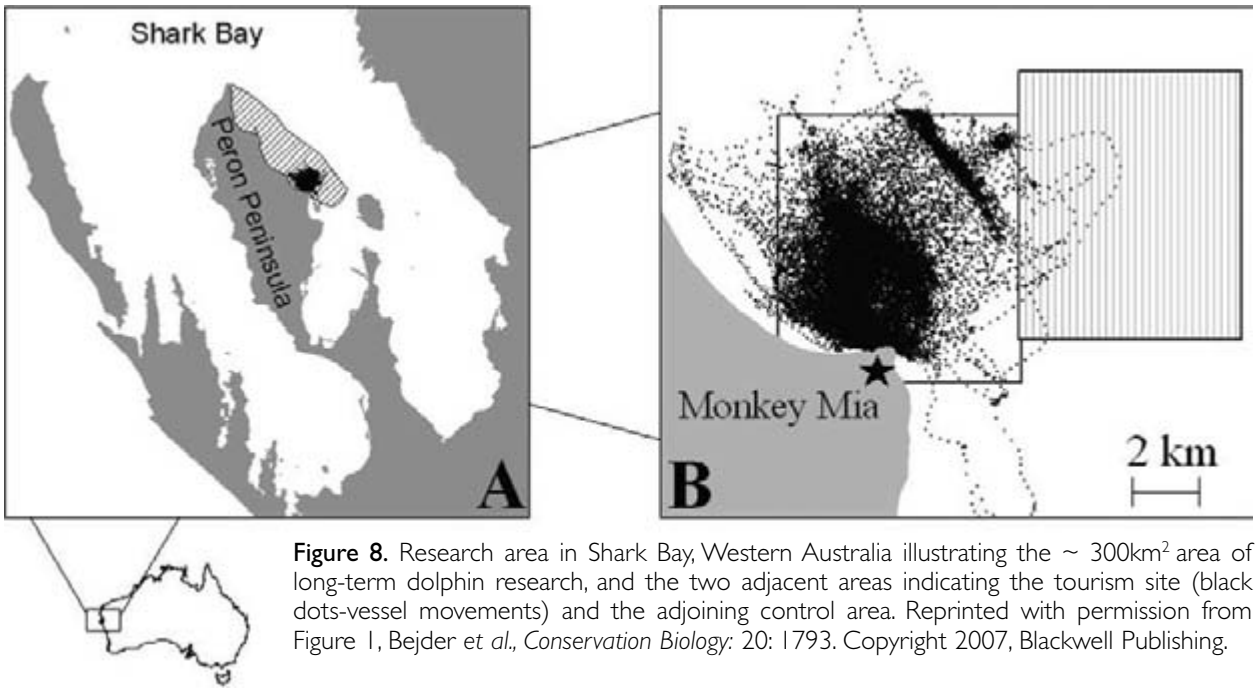

Figure 8. Research area in Shark Bay, Western Australia illustrating the ~ 300km^2 area of long-term dolphin research, and the two adjacent areas indicating the tourism site (black dots-vessel movements) and the adjoining control area. Reprinted with permission from Figure 1, Bejder *et al., Conservation Biology:* 20: 1793. Copyright 2007, Blackwell Publishing.

Bejder and colleagues aimed to document the *long-term* response of dolphins to commercial dolphin-watching tourism. The abundance of animals and the amount these dolphins were exposed to tourism vessels was compared in two adjacent sites: 'impacted' and 'control' regions, over a 4½ year period (Figure 8). During this time, the research vessel activity remained comparatively constant, however, the commercial dolphin-watch activity increased from no boats (T0), to one (T1), to two commercial operators (T2).

The time spent with the dolphins by tour operators increased substantially during the 4½ year study area when going from one to two dolphin-watch vessels (i.e. it doubled). During the period when there where two operators, tour vessels spent 140% more time than the researchers with dolphins in the study area (Figure 9).

There was no difference in dolphin abundance when comparing the period prior to tourism and when only one dolphin-watch boat was present; however, there was a significant decline (14.9%) in dolphin abundance

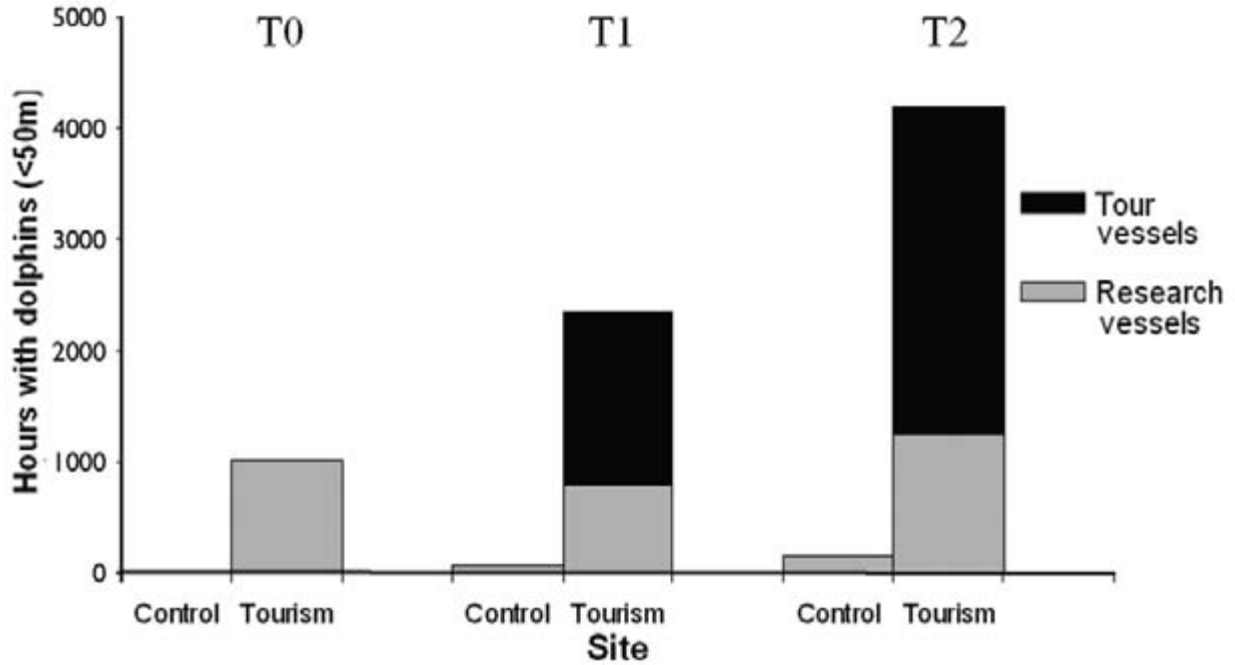

Figure 9. The total time spent with the dolphins (within 50 m) by dolphin-watch operators and the research vessels in the two adjacent study areas (tourism vs. control) during pre-tourism periods (T0), one operator (T1) and when two boats were operating (T2). Reprinted with permission from Figure 3, Bejder *et al*., *Conservation Biology*: 20: 1793. Copyright 2007, Blackwell Publishing.

when increasing from one to two operators. This equates to a decline of approximately one dolphin in every seven individuals. Bejder and colleagues suggested that this decline in local dolphin abundance was due to the presence and proximity of the tour vessels to the animals. Furthermore, this decline was not necessarily an overall population decline, as an opposite trend occurred in the adjacent control area. It was suggested that the local decline may have been due to displacement of the more sensitive animals away from the disturbance area. Their findings suggest a long-term shift in the habitat use of these dolphins, from an area utilised by only two dolphin-watch operators to areas of lower boat traffic.

Animals reacting to disturbance may exhibit short-term responses, such as changes in surface behaviour or direction of travel; however, how these changes equate in the long-term and how to determine the biological significance of this response, is of concern and one that needs to be further addressed. The study by Bejder *et al*. (2006b) has illustrated that by increasing commercial dolphin-watch boat traffic, from one to only two, in an area occupied by a local dolphin population, a displacement of animals to areas with lower boat exposure has occurred. This comes at a potential cost to the animal. Where is the new habitat? Is it is suitable? Where do they find their prey? And mates? Bottlenose dolphins form long-term individual social relationships; changes to these bonds may be detrimental to the individuals, and therefore, the overall population. As a result of this study, it was proposed that there should be a reduction in the exposure of this local population of dolphins in Shark Bay to tourism vessels. As a result, the Western Australian Department of Environment and Conservation reduced the number of operators by half.

Concluding Remarks

There are obvious economic and social benefits for observing and conserving 'charismatic megafauna'; whether it is the resident bottlenose dolphins inhabiting the waters of Jervis Bay or the humpback whale that swims slowly past the coast of many populated areas of Australia. There are, however, potential costs to the animals, which require appropriate management and scientific research, and for sustaining an ever expanding ecotourism industry.

Cetaceans inhabiting areas that are close to urban centres will be influenced by human activities. Interactions between cetaceans and humans are wide and varied, and may be direct or indirect. This paper has illustrated that a single anthropogenic event, such as the approach of a powerboat, may cause a short-term disruption in dolphin behaviour. It has also been demonstrated that an accumulation of these effects can lead to long-term changes to local populations, such as habitat displacement. The research undertaken by Bejder *et al*. (2006b) showed that the presence of only two commercial dolphin-watch operators resulted in a displacement of individuals to areas with lower boat traffic. The authors suggested that this decline in dolphin abundance in tourism areas may not cause a long-term effect on the entire population, which is large and genetically diverse (Krützen *et al.* 2004). However, what is the situation with smaller, genetically isolated populations like the resident animals inhabiting Port Stephens, where there are often more than ten boats operating on a daily basis? The long-term biological impact of intensive boating activity on this dolphin population may have quite detrimental effects, unless appropriate mitigation and management is undertaken in the short-term.

Management and scientific research is essential in determining the longer-term implications from anthropogenic activities; particularly targeted animals that are long-lived species, such as bottlenose dolphins that rely on long-term individually specific bonds. It is important to establish baseline and long-term datasets in order to assess if changes occur in cetacean behaviour as a result of human impact.

Long-term monitoring and research on the behaviour, population abundance, distribution and habitat use of different populations is necessary to assess potential impacts of both interactive and non-interactive activities, and to be able to determine methods for minimising potentially detrimental interactions, particularly resulting from the cumulative effect.

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References

Allen, M.C. and Read, A.J. 2000. Habitat selection of foraging bottlenose dolphins in relation to boat density near Clearwater, Florida. *Marine Mammal Science* 16 815-824.

Allen, S., Constantine, R., Bejder, L., Waples, K. and Harcourt, R. in press. 'Can't sleep, can't eat -let's split': Indo-Pacific bottlenose dolphin responses to tour boats in Port Stephens, Australia. *Journal of Cetacean Research and Management*.

Allen, S., Harcourt, R.G. and Waples, K. 2003. Short-term responses of dolphins to boat approach, Port Stephens, NSW. Unpublished report to New South Wales National Parks and Wildlife Service & Port Stephens Commercial Dolphin Watch Association Inc.

Allen, S.J. 2005. Management of bottlenose dolphins exposed to tourism in Port Stephens, NSW, Australia. Masters Thesis, Graduate School of the Environment. Macquarie University, Sydney, Australia.

Anderson, G.R.V., Forbes, M.A. and Pirzl, R.M. 1996. A national overview of the development of whale watching in Australia. Pp 5-16 in *Proceedings of Encounters with Whales*, edited by K. Colgan, S. Prasser and A. Jeffery. Australian Nature Conservation Agency, Canberra.

Avecedo, A. 1991. Interactions between boats and bottlenose dolphins, *Tursiops truncatus*, in the entrance to Ensenada De La Paz, Mexico. *Aquatic Mammals* 17 120-124.

Baker, A.N. 1990. *Whales and Dolphins of Australia and New Zealand: An Identification Guide*. Allen and Unwin, New Zealand.

Beale, C.M. and Monaghan, P. 2004. Behavioural responses to human disturbance: a matter of choice? *Animal Behaviour* 68 1065-1069.

Bejder, L., Dawson, S.M. and Harraway, J.A. 1999. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. *Marine Mammal Science* 15 738-750.

Bejder, L., Samuels, A., Whitehead, H. and Gales, N. 2006a. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour* 72 1149-1158.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Conner, R., Heithaus, M., Watson-Capps, J., Flaherty, C. and Krützen, M. 2006b. Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology* 20 1791-1798.

Birtles, R.A., Arnold, P.W. and Dunstan, A. 2002. Commercial swim programs with dwarf minke whales on the northern Great Barrier Reef, Australia: Some characteristics of the encounters with management implications. *Australian Mammalogy* 24 23-38.

Blumstein, D.T., Anthony, L.L., Harcourt, R.G. and Ross, G. 2003. Testing a key assumption of wildlife buffer zones: is flight initiation distance a species-specific trait? *Biological Conservation* 110 97-100.

Carwardine, M. 1995. *Whales, Dolphins and Porpoises.* Harper Collins, Sydney.

Conner, R.C., Mann, J., Tyack, P.L. and Whitehead, H. 1998. Social evolution in toothed whales. *Trends in Evolution and Ecology* 13 228-232.

Connor, R.C. and Smolker, R. 1985. Habituated dolphins (*Tursiops* sp.) in Western Australia. *Journal of Mammalogy* 66 398-400.

Constantine, R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatus*) due to long-term exposure to swim-with-dolphin tourism. *Marine Mammal Science* 17 689-702.

Constantine, R., Brunton, D.H. and Dennis, T. 2004. Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. *Biological Conservation* 117 299-307.

Coughran, D. and Crawford, S. 1996. Marine mammal interaction: an overview of the whale watching industry in Western Australia 1989-1994. p 5-16 in *Proceedings of Encounters with Whales*, edited by K. Colgan, S. Prasser and A. Jeffery. Australian Nature Conservation Agency, Canberra.

David, L. 2002. Disturbance to Mediterranean cetaceans caused by vessel traffic. In: Cetaceans of the Mediterranean and Black Seas: state of knowledge and conservation strategies. G. Notarbartolo di Sciara (Ed.). A report to the ACCOBAMS Secretariat, Section 11, Monaco.

de O Santos, M.C. 1997. Lone sociable bottlenose dolphin in Brazil: human fatality and management. *Marine Mammal Science* 13 355-356.

Garrod, B. and Fennell, D.A. 2004. An analysis of whalewatching codes of conduct. *Annals of Tourism Research* 31 334-352.

Gill, J.A., Norris, K. and Sutherland, W.J. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation* 97 265-268.

Gregory, P.R. and Rowden, A.A. 2001. Behaviour patterns of bottlenose dolphins (*Tursiops truncatus*) relative to tidal state, time-of-day, and boat traffic in Cardigan Bay, West Wales. *Aquatic Mammals* 27 105-113.

Hoyt, E. 2001. Whale watching 2001: Worldwide tourism numbers, expenditures, and expanding socioeconomic benefits. International Fund for Animal Welfare, Yarmouth, MA.

IFAW. 2004. The Growth of Whale Watching Tourism in Australia. The International Fund for Animal Welfare, Sydney, Australia.

IFAW. 2005. The Growth of Whale Watching in Sydney 2003-2004 Economic Perspectives. The International Fund for Animal Welfare, Sydney, Australia.

Janik, V.M. and Thompson, P.M. 1996. Changes in surfacing patterns of bottlenose dolphins in response to boat traffic. *Marine Mammal Science* 12 597-602.

Krützen, M., Sherwin, W.B., Berggren, P. and Gales, N. 2004. Population structure in an inshore cetacean revealed by microsatellite and mtDNA analysis: bottlenose dolphins (*Tursiops* sp.) in Shark Bay, Western Australia. *Marine Mammal Science* 20 28-47.

Lemon, M. 2006. The Acoustic Behaviour of Bottlenose Dolphins in Southeastern Australia and the Effects of Anthropogenic Disturbance. Page 300. PhD Thesis, Graduate School of the Environment. Macquarie University, Sydney, Australia.

Lemon, M., Lynch, T.P., Cato, D.H. and Harcourt, R. 2006. Response of bottlenose dolphins (*Tursiops aduncus*) to powerboat approaches in Jervis Bay, New South Wales, Australia. *Biological Conservation* 127 363-372.

Lesage, V., Barrette, C., Kingsley, M.C.S. and Sjare, B. 1999. The effect of vessel noise on the vocal behaviour of belguas in the St. Lawrence river estuary, Canada. *Marine Mammal Science* 15 65-84.

Lusseau, D. 2004. The hidden cost of tourism: detecting long-term effects of tourism using behavioral information. *Ecology and Society* 9 2.

Lusseau, D., Slooten, L. and Currey, R.J.C. 2006. Unsustainable dolphin-watching tourism in Fiordland, New Zealand. *Tourism in Marine Environments* 3 173-178.

Mann, J. and Kemps, C. 2003. Evaluating the effects of nature-based tourism on cetaceans. p 304-317 in *Marine Mammals: Fisheries, Tourism and Management Issues*, edited by N. Gales, M. Hindell and R. Kirkwood. CSIRO Publishing, Victoria.

Orams, M.B., Hill, G.J.E. and Baglioni Jr., A.J. 1996. "Pushy" behaviour in a wild dolphin feeding program at Tangalooma, Australia. *Marine Mammal Science* 12 107-117.

Preen, A.R., Marsh, H., Lawler, I.R., Prince, R.I.T. and Shepherd, R. 1997. Distribution and abundance of dugongs, turtles, dolphins and other megafauna in Shark Bay, Ningaloo Reef and Exmouth Gulf, Western Australia. *Wildlife Research* 24 185-208.

Richardson, W.J., Greene Jr., C.R., Malme, C.I. and Thomson, D.H. 1995. *Marine Mammals and Noise*. Academic Press, San Diego, California.

Samuels, A. and Bejder, L. 2004. Chronic interaction between humans and free-ranging bottlenose dolphins near Panama City Beach, Florida, USA. *Journal of Cetacean Research and Management* 6 69-77.

Samuels, A., Bejder, L., Constantine, R. and Heinrich, S. 2003. Swimming with wild cetaceans, with a special focus on the Southern Hemisphere. p 277-303 in *Marine Mammals: Fisheries, Tourism and Management Issues*, edited by N. Gales, M. Hindell and R. Kirkwood. CSIRO Publishing, Victoria.

Scarpaci, C., Bigger, S.W., Corkeron, P.J. and Nugegoda, D. 2000. Bottlenose dolphins (*Tursiops truncatus*) increase whistling in the presence 'swim-with-dolphin' tour operations. *Journal of Cetacean Research and Management* 2 183-185.

Wilson, B. 1994. Review of Dolphin Management at Monkey Mia. submitted to Executive Director, Department of Conservation and Land Management, Western Australia.

Wiszniewski, J. 2004. Fine-scale genetic structure in inshore bottlenose dolphins (*Tursiops aduncus*) of the Hunter Region, NSW. Page 50. Marine Science Honours Degree, Department of Biological Sciences. Macquarie University, Sydney.

APPENDIX I

Field equipment used for underwater recording of dolphins.

Photo, M. Lemon.

Dolphin watch vessel in Port Stephens, 'Advance II' with dolphins.

Photo, S. Allen.

Inshore bottlenose dolphin *Tursiops aduncus*.

Photo, R. Harcourt.

Brigid Krug during dolphin acoustic field work in Port Stephens.

Photo, M. Blewitt (Lemon).

APPENDIX I

Humpback whale and naval vessel, Jervis Bay.

Photo. Dolphin Watch Cruises, Jervis Bay.

Dolphin acoustic field work Jervis Bay, Jennifer Spencer and Michelle Lemon.

Photo, M. (Lemon) Blewitt.

Michelle (Lemon) Blewitt during field work, Jervis Bay.

Photo, S. Sheehan.

Dolphin begging in Monkey Mia outside provisioning time (supervised).

Photo, S. Allen.

APPENDIX I

Feeding and touching of dolphins in Monkey Mia outside provisioning time and area.

Photo, S. Allen.

Dolphin provisioning area, Monkey Mia.

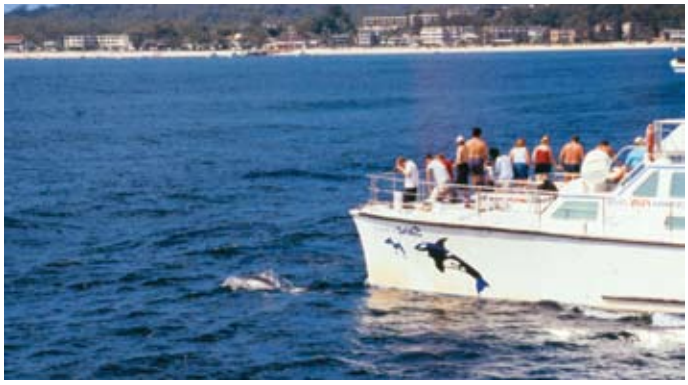
Photo, S. Allen.

Dolphin watch vessel with dolphins in Port Stephens.

Photo, S. Allen.

Many boats involved in dolphin watching, Port Stephens.

Photo, S. Allen.



Close encounter with dolphins and commercial vessels, Port Stephens.

Photo, S. Allen

APPENDIX I

Jet ski rapidly approaching dolphins in Port Stephens.

Photo, S. Allen.

Recreational boat rapidly approaching dolphins in Port Stephens.

Photo, S. Allen.

Dolphin watch vessel and dolphins in Port Stephens.

Photo, S. Allen.

Acoustic recording from vessels.

Photo, S. Sheehan