Department of Environment, Water and Natural Resources

Adelaide Dolphin Sanctuary

Reference Paper 1: Dolphins

This document is a companion to the Adelaide Dolphin Sanctuary Management Plan and provides background information for the development of the Plan.

Government of South Australia

ADELAIDE Dolphin SANCTUARY

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1 Scope and purpose

In 2005 the South Australian Government established the Adelaide Dolphin Sanctuary (ADS) by proclaiming the *Adelaide Dolphin Sanctuary Act 2005*. The purpose of the ADS is to protect the dolphins and their habitat in the Port Adelaide River and Barker Inlet.

The Sanctuary is 118 square kilometres located along the eastern shore of Gulf St Vincent. It includes the Port River and Barker Inlet and from there stretches north around Outer Harbor to North Haven Marina and up the coast to the Port Gawler Conservation Park (see Attachment 1 – Map of the ADS).

The area is environmentally important and includes mangroves, seagrass, saltmarsh, tidal flats, tidal creeks and estuarine rivers all combining to provide the necessary habitat for the ADS dolphins and for their food sources.

The Adelaide Dolphin Sanctuary Act requires the preparation of a Management Plan. The Management Plan must address the priorities for the achievement of the objects and six objectives of the Act.

The objects of the Act are in section 7:

(a) to protect the dolphin population of the Port River estuary and Barker Inlet: and

(b) to protect the natural habitat of that population.

This Reference Paper identifies existing information relating to the first objective in the Act – Section 8(1)(a):

> *The protection of the dolphin population of the Port Adelaide River estuary and Barker Inlet from direct physical harm is to be maintained and improved.*

For the purpose of this paper, the following definitions are used.

Dolphin population – all dolphins resident or visiting the area.

Direct physical harm – actions that result in immediate change for the worse to a dolphin. Such actions include intentional physical harm caused by a person and intentional or unintentional physical harm caused by a vessel strike, or entanglement in marine debris.

vessel (as defined in the *Harbors and Navigation Act 1993*) – *a ship, boat or vessel used in navigation; or an air-cushion vehicle, or other similar craft, used wholly or primarily in transporting passengers or goods by water; or a surf board, wind surf board, motorised jet ski, water skis or other similar device on which a person rides through water; or a structure that is designed to float in water and is used for commercial, industrial or scientific purposes, but does* *not include a structure of a class excluded by regulation from the ambit of this definition.*

This is one of a series of Reference Papers compiling information to support the development and implementation of the ADS Management Plan. The other papers supply information about ADS key habitat features and water quality. While each paper focuses on one specific subject, topics in each overlap. To gain a full understanding of the issues to consider for management of the area, the papers are best considered together.

1.1 Methodology

This paper summarises national and international research about dolphins and describes what is specifically known about ADS dolphins. It should be noted that to date, very little has been published about the dolphins in the Sanctuary. As new research becomes available, this paper may be updated. All Reference Papers and any updates will be available on the ADS website. See: www.adelaidedolphinsanctuary.sa.gov.au

This information is intended to provide guidance for management actions and suggestions for future research opportunities to increase our understanding of the ADS dolphins and their requirements.

Because of the limits in our knowledge, the paper raises as many questions as it answers. Future studies in the Adelaide Dolphin Sanctuary have the potential to contribute to world knowledge about these animals.

1.2 Background

To be able to protect the dolphins and their habitat, we need to know some crucial information. We need to have a basic understanding of how the dolphins use the area – the numbers of residents and visitors - and the characteristics of the residents. Examples of questions to consider include:

- How many individuals rely on the Sanctuary habitat?
- What characteristics in the Sanctuary habitat are necessary for the dolphins to remain in this area?
- What is the composition of the population including age ranges, paternity of residents, birth rates, immigration from outside populations, and emigration to outside populations?
- How many mothers with calves are commonly resident?
- Is the resident population growing, declining or stable?
- What are the birth and death rates in the resident population and what are the causes of the deaths?

This information will support an assessment of the overall status of the ADS dolphins and help decision making to support the on-going sustainability of the population and the habitat.

Equally, we need information about how the dolphins fulfil their basic requirements. We need to know their requirements for food, shelter, and water quality as a start. We know generally it is necessary to maintain food sources and the required habitats (especially sea grass and mangroves) of their prey, and also to maintain good water quality.

What we don't know are the specifics of what these dolphins require. Understanding their requirements more precisely will enable us to take any necessary action to make sure they are protected.

1.3 Physical safety

To maintain population health, the dolphins have some fundamental requirements similar to other animal species. Clean air and water are required. Dolphins rely on clean air to breathe just as land animals do. They need clean water to support their immediate habitat, to make sure toxins are not absorbed through their skins and they rely on underwater vision for some activities. The water also directly supports their food supply.

Dolphins need safety from predators, mainly sharks in South Australian waters, and safety from any humans who might cause them intentional harm. In addition, they need safety from human activities that might unintentionally cause harm such as marine debris causing entanglements and vessels striking them. Although security is an intangible attribute, animals need to feel safe in an environment to live healthily. An environment with too many stressors may eventually cause the animals to move away. If for some reason, they are unable to leave the stressful area, their health may diminish.

1.4 Indo-Pacific Bottlenose Dolphins, *Tursiops aduncus*

The bottlenose dolphin is the species commonly present in the ADS. There are two types of bottlenose dolphins – the common bottlenose (*Tursiops truncatus*) and the Indo-Pacific bottlenose (*Tursiops aduncus*). The common bottlenose tends to inhabit deeper, near offshore waters or open ocean coasts while the Indo-Pacific usually lives in more shallow, inshore waters and protected bays. Physically the two species are similar, and it is possible that there is genetic mixing between them.

The Indo-Pacific bottlenose is typically resident in the ADS while the common bottlenose may occasionally visit the Adelaide coast.

According to the "Review of the Conservation Status of Australia's Smaller Whales and Dolphins" (Ross 2006), there is not enough information known about numbers and locations of populations of bottlenose dolphins to assign them a category describing their survival status. The Review classifies Indo-Pacific bottlenose as NCA(a) – no category assigned because of insufficient information. The World Conservation Union (IUCN) also believes there is not enough known to determine their status (Reeves *et al.* 2003). Anecdotal reports around the world do suggest that numbers of bottlenose dolphins generally have decreased over the last several hundred years, but unfortunately, lack of reliable data means these reports are unconfirmed.

Indo-pacific bottlenose dolphins occur in many locations around the world, including South Africa, the Red Sea, the Arabian Gulf, India, China and Japan and south to Indonesia, New Guinea and New Caledonia. These dolphins are found around the entire Australian coast, including Tasmania (Ross 2006). However, there may be some local populations at risk. Indo-Pacific bottlenose populations have the potential to be more at risk in some locations than do the common bottlenose, since they are resident inshore and these habitats are generally more impacted by human behaviours.

Mortalities of Indo-Pacific bottlenose dolphins are commonly recorded in the Gulf St Vincent, suggesting that the species is reasonably abundant (Kemper *et al.* submitted, 2006).

Coastal areas in Australia and around the world are currently targets of substantial development attention. Marinas, tourism, residential developments, industry, and aquaculture are all proposed coastal developments in South Australia. Inshore dolphin communities could be at some risk if these sorts of proposals are developed without full consideration of their impacts on marine mammals and their habitat.

The Commonwealth "Review of the Conservation Status of Australia's Smaller Whales and Dolphins" (Ross 2006) identifies research into the bottlenose dolphin as a national priority. The Report states,

> *"Management of this species is likely to become increasingly important. It bears the brunt of human impacts on the coastal environment, including habitat degradation and consequent diminishment of local food resources. Burgeoning coastal development and associated issues, including boat traffic, will all impact on this species"* (Ross 2006, p. 16).

The Adelaide Dolphin Sanctuary is well placed to address these issues of concern.

2 Characteristics of bottlenose dolphins

Unless otherwise specified, the following is general information about bottlenose dolphins with specifics about Indo-Pacific bottlenose dolphins where known. Some of this information may not be fully accurate or relevant for the dolphins found in the ADS, but it is recorded here in the absence of specific knowledge to serve as a starting point for consideration of general issues. The immediate aim is to use existing information about other dolphin populations to provide guidance for management actions and research directions for the ADS dolphins when specific information about ADS dolphins is not known.

2.1 Physical overview

The maximum size for Indo-Pacific bottlenose dolphins in South Australia is 2.5 metres and 170 kilograms at maturity. Females may be slightly smaller than males at maturity. Bottlenose dolphin calves are around one metre long at birth and weigh around 14 kilograms (Bannister *et al.* 1996; Ross 2006).

Male bottlenose are sexually mature by 14 years of age. Females are generally sexually mature at 9 to 11 years of age, although births have been observed in females as young as seven years. The maximum age for animals elsewhere is 42 years. These parameters may vary according to the specific population (Bannister *et al.* 1996; Reynolds *et al.* 2000).

<u>ADS dolphins</u>

Specifics unknown.

2.2 Reproduction

The gestation period for bottlenose dolphins is 12 months. In some parts of the world, mating and births occur year around with peaks in summer and early autumn (Ross 2006). As in many mammals, timing is based on favourable climatic conditions to allow for maximum survival of young (Wells and Scott 1999). If a mother loses a very young calf, and conditions are suitable, she may quickly become pregnant again which would move back the timing of any subsequent births. Usually only one calf is born at a time. Newborns must be able to swim, breathe and dive at birth.

On average, calving intervals are three to six years (Bannister *et al*. 1996). Calves usually stay and suckle from their mothers at least until another calf is born. This happens, on average, when they are 18 months to three years of age although calves have been observed suckling up to seven years of age.

The average female may give birth to a total of six to eight calves, and it is thought that females are capable of having calves throughout their entire lifespan (Reynolds *et al.* 2000). However, it appears some common dolphins (*Delphinus delphis*) do stop reproducing as they age, so it is possible this happens in bottlenose dolphins as well. Calves, especially female calves, sometimes stay close with their mothers for an additional three to five years after they are weaned, when it is thought that their mothers offer protection from predators, additional social development and group integration (Reynolds 2000). This may occur even after a new calf is born.

Results of a study of a population of around 80 dolphins at Port Phillip Bay found that the annual loss of two females more than what would be considered the natural mortality rate, gives a greater than 50% probability that the population will become extinct within 25 years (Hale 2002). This has clear implications for population viability of the ADS dolphins.

<u>ADS dolphins</u>

Observations reveal that infants were seen all year around with the majority of sightings between December and May with most of these sightings in March and April (Bossley *et al.* 2006 pers. comm.).

Observations have been recorded of mother, juvenile and calf groupings within the ADS.

2.3 Survival of young

Studies around the world indicate that survival rates for calves vary in different populations. These rates are difficult to determine with certainty, as, even in monitored populations, it is not usually known when females are pregnant, or when they are due to give birth.

Mortality rates for calves in their first year in Shark Bay Western Australia are 24%. This is similar to calf losses in studies in Sarasota, Florida (19%) and for dolphins of a different dolphin species (*Stenella frontalis*) in the Bahamas (24%). Researchers believe these percentages may be lower than actual reality as some infants may have died before being observed (Mann *et al.* 2000).

Deaths are due to a variety of factors including predation, natural causes and human induced events including boat strikes, entanglements and possible exposure to pollutants. There are indications that females impart much of their contaminant load to their firstborn calf (Schwacke *et al.* 2002). Fat soluble toxins are known to be transferred from the mother through her milk and placenta in some populations, and may contribute to illness, disability or death.

Survival rates for calves of young mothers may be lower than the rates for older, more experienced mothers due to other factors. Young mothers may be smaller and more vulnerable to predation and less able to provide ample milk for the infant. They may also be inexperienced and lack adequate parenting skills.

In Sarasota Bay, Florida, there were poor survival rates of calves from first time mothers, with 40% surviving the first year and just 12% surviving the first three years or until separation. Calf survival rates from experienced mothers (those who had reared a calf previously) were considerably higher, with more than

70% surviving the first year and more than 60% surviving the first three years or until separation (Wells *et al*. 2003).

ADS dolphins

Dolphins may live in the ADS in part to receive some shelter from predators, especially for calves. It is possible that calf survival may be more successful for mothers who give birth and raise their calves in the shallow waters, which along with protection from predators, provides important habitat elements and sufficient food supply (Mann *et al.* 2000). These factors may contribute to higher successful birth rates in the ADS than elsewhere in the region, but this remains to be confirmed.

In addition, anecdotal information suggests that it is possible that dolphins resident outside the ADS may give birth or bring newborn calves into the protected ADS waters.

Unpublished information suggests that out of 38 observed births since 1991, 9 calves died or disappeared in their first year of life. One death was from a propeller strike. This is a loss rate of 24% of observed births over this interval (Bossley *et al*. 2006 pers. comm.).

2.4 Population definition and size

The definition of what constitutes a resident animal population, the establishment of a reliable way to consistently identify residents, and the establishment of monitoring techniques to identify who is resident over time all offer significant challenges to researchers. The most appropriate research techniques may vary according to the type of habitat and population under study.

Studies of Australian bottlenose dolphin populations have found minimum population estimates of: at Moreton Bay – 334; inshore waters off Stradbroke Island – 321; open coastal waters off Stradbroke Island – 581 (700 to 1000 in winter); at south eastern Shark Bay – around 400; Cockburn Sound, Western Australia – at least 150; and metropolitan Adelaide - at least 140 (Ross 2006).

Some studies have shown that isolated populations of inshore bottlenose dolphins exist (Möller *et al.* 2001). It may be possible that the population mostly resident in the ADS is isolated from other dolphins, or it may be that some individuals are resident while a number of other individuals visit with varying frequencies.

In some populations, females stay close to their birthplaces throughout their lives. This may make these populations susceptible to eventual extinction if threatening conditions develop, such as "severe habitat destruction or limited food resources" (Ross 2006, p. 63).

To gain an understanding of the composition and overall health of a population, one method includes mark/recapture. This involves closely observing the animals, identifying them by distinguishing marks on their bodies and compiling a photographic catalogue of the animals and their marks. While some dolphins are easily identifiable due to distinctive scars on their fins and bodies, others with unmarked bodies are not. In Sarasota, Florida where the inshore dolphin community has been studied for thirty years, it is estimated that only around 60% of the residents are identifiable from natural markings. In addition, the older an animal is, the more likely it will have marks. This means that a greater number of older animals might be identified by markings than younger ones, so getting accurate counts of younger animals may be more difficult than older ones (Wells and Scott 1999).

Techniques based on capturing the dolphins to both mark them for identification for future monitoring, and also to perform physical examinations and take blood and tissue samples are employed by some scientists. This enables identification of the animals by age and sex, provides genetic information and provides information about diseases and pollutants in the animals' bodies. This offers the most comprehensive information possible, but such methods are invasive to the animal and some scientists oppose them on ethical grounds.

Less invasive methods have been used in South Australia and other Australian states to assess stock structure by genetic identification. Mark/recapture DNA studies can be used to assess population (Gibbs 2006 pers. comm.). No such studies have been conducted specifically on ADS dolphins.

Another aspect of population monitoring to consider is that the smaller the number of individuals in a specific population, the more difficult it becomes to accurately assess numbers, because there is little room for error in conducting monitoring. Further, as the population size decreases, so does our ability to detect the decrease (Taylor and Gerrodette 1993). The smaller the population, the more thorough the monitoring must be to ensure accurate information and any trend in numbers is obtained.

<u>ADS dolphins</u>

It is not known for certain how many dolphins are resident in the 118 square kilometre ADS. It is possible there is more than one community of dolphins living within the boundaries. Estimates of resident numbers range from 30 to 60 individuals.

The number of visiting dolphins usually resident elsewhere is also not known. If it is discovered that resident dolphins are breeding with visiting dolphins, these visiting animals may need to be considered as part of the management of the ADS community.

Dolphins are top order predators in the ADS ecosystem. This ecosystem has been significantly changed by diverse, long-term human activities, and the optimal number of dolphins for the ADS area is difficult to determine. It is a complex issue to identify whether the current resident number is appropriate, too small or too large for the existing ecosystem and the population is steady, in decline or is growing.

For example, if there are presently too many dolphins for the existing environment to support, it is possible that a decrease in the current number may be appropriate. It is also possible that population numbers need to increase to ensure population stability. On-going monitoring to improve understanding about the composition of this population will be important.

2.5 Mortalities

It is difficult to accurately measure mortality rates in populations of wild dolphins. First, a specific population must be identified and then accurate, long-term identification of its membership must follow. For a death to be recorded, the body of the animal must be observed. It is difficult to be certain all deaths are recorded, as bodies can be subject to predation or decomposition, and not be found. They may also wash up in inaccessible areas and never be discovered.

In addition, just because a dolphin is no longer observed in a population, the assumption cannot be made that it has died. Animals do not necessarily stay in the same community for their entire lives. Populations are subject to varying amounts of emigration and immigration which impact on total numbers.

Studies indicate that calves in their first year and sub-adult males have higher mortality rates than other sectors of the population (Wells and Scott 1999; Reynolds *et al.* 2000).

A summary of dolphin mortalities of both bottlenose species and common dolphins in Gulf St Vincent waters from 1988 to 2004 reveals a mean annual mortality rate of 4.76. Since under reporting was likely in the early years, the mean since 1998 of 6.25 may be more accurate. There are peaks in March and July that may be related to the calving peak for Indo-Pacific bottlenose in summer and early autumn. Younger animals made up 72% of the total mortalities (Kemper *et al.*, submitted 2006).

<u>ADS dolphins</u>

Scientists at the South Australian Museum have been studying the biology and causes of death of South Australian marine mammals for around 15 years. A specific Dolphin Trauma Group was established in 2003 as a result of community concerns about the deaths of dolphins in the ADS area. Members of this Group include scientists from the SA Museum, forensic scientists, veterinarians, marine mammal biologists, pathologists and representatives of government and non-government organisations. Each contributes expertise where needed to learn as much as possible from post mortems of retrieved dolphin carcasses (Kemper 2003).

When a carcass is discovered, it is collected and placed in either a refrigerator or freezer, depending on its condition and the availability of members to conduct a post mortem. If the animal is in good condition or if a disease or infection is suspected, all efforts are made to undertake the investigation without freezing it, as disease causing agents such as bacteria and viruses may be lost if frozen.

Cetacean records held by the South Australian Museum document the work of these post mortems and the following mortalities and causes of death for dolphins found in the vicinity of the ADS area.

1998 Seven *Tursiops* sp. recovered.

- Three from intentional human actions. One adult male and one adult female shot and the calf of the female subsequently died. Mother and calf thought to be residents.
- One female calf, congenital heart defect.
- A sub adult/adult male, abscessed lymph node in the area of the abdominal cavity.
- Adult female and incomplete carcass, causes of deaths unknown.

1999 Two *Tursiops* sp. recovered.

- One sub adult male apparently intentionally killed (stabbed).
- One adult/sub adult female caused by disease – blockage of ureter resulting in large abscess.

2000 One *Tursiops* sp. recovered.

- Sub adult male, probable cause - infection due to fishing gear lodged in his mouth.

2001 Two *Tursiops* sp. recovered.

- One newborn male, cause of death unknown, unlikely to have breathed. Thought to be resident.
- One sub adult female, cause of death unknown.

2002 One *Tursiops* sp. recovered,

- Sub adult female, cause of death unknown.

2003 Three *Tursiops sp*. recovered.

- One adult caused by disease – severe arthritis, bladder infection. Thought to be resident.
- One newborn calf caused by propeller strike. Thought to be resident.
- One calf, cause of death unknown.
- Two juvenile/sub adult common dolphins (*Delphinus delphis*) found in North Haven Marina on consecutive days. Causes of deaths unknown.

2004 Two *Tursiops sp.* recovered.

- One juvenile female, cause of death unknown.
- One adult male, cause of death unknown.

2005 Three *Tursiops sp.* recovered.

- One adult male with a viral growth around its blowhole, impeding breathing. Thought to be resident.
- One male juvenile thought to have been diseased with chronic, infected wound. Some nematodes in lungs.
- One adult female, also diseased.

2006 Two *Tursiops sp.* recovered (as of 14 August 2006).

- One new born calf, cause of death unknown, possible birthing problems.
- One juvenile female found off Lower Light coast, sudden death cause unknown, no sign of entanglement.

To monitor the health of any population, it is important to know its mortality rates and causes of death. This will provide guidance to determine if there are management actions to be taken to help prevent future deaths.

2.6 Behaviours of bottlenose dolphins

2.6.1 Habitat requirements

It appears inshore species of bottlenose dolphins have habitat requirements different to the offshore species. Inshore species appear to stay more closely in their birthplace area (Möller *et al.* 2001).

Demographic factors may also play a significant role in determining habitat requirements. A study of bottlenose dolphins in Italy found mothers with calves showed a preference for an area in-shore which experiences relatively little human disturbance (Pulcini *et al.* 2001). At Cockburn Sound, Western Australia another study found females with calves less than two years of age spent a greater amount of time in an area of relatively shallow water (10 -15 metres) than females with older calves, and other individuals. It was suggested that the reason may not only be due to protection from predators, but also protection from oceanic swell and greater availability of prey species (Finn 2005).

Large marine areas include a range of different habitat types. Currents and water temperatures vary. Underwater terrain ranges from thick to sparse seagrass coverage, to rocky outcrops, to sandy bottoms, to mud flats. These all affect the distribution of fish and other animal life. It is possible that dolphins may prefer particular types of habitats as feeding grounds, for social activities or for resting - all activities essential for maintenance of healthy individuals and communities.

<u>ADS dolphins</u>

A significant portion of the Sanctuary is shallow and in protected waters. There are regular sightings of mothers and calves. It is possible that the ADS may be a nursery area for dolphins not usually resident in Sanctuary waters. This hypothesis needs further investigation to confirm its validity.

Observations from a long term study of the ADS dolphins indicate that there are no preferred areas for specific behaviours (Bossley *et al.* 2006 pers. comm.).

2.6.2 Feeding behaviour

Bottlenose dolphins eat a wide range of marine animals including cephalopods (cuttlefish, squid and octopus), sharks, rays, fish and crustaceans (Bannister *et al.* 1996). Inshore dolphins tend to eat what is locally available. Captive adult dolphins consume around seven to fifteen kilograms of food per day, although wild animals may have quite different food and energy requirements. Captive dolphins near Perth were observed to increase their intake rates from autumn to spring, suggesting that their energy demands increase with lower water temperature (Cheal and Gales 1992 in Finn 2005).

A study of bottlenose dolphins in Jervis Bay, New South Wales by Harcourt and Moller (1998) suggested seasonal changes in habitat use and feeding activities were related to energy requirements. It indicated that dolphins increase feeding during cooler months in response to higher energy needs to keep warm.

Typically, lactating mothers need more energy than any other sector of a mammal population. A study of captive dolphins in South Africa showed a 58% to 97% increase in food consumption during lactation, but little increase during pregnancy (Gannon and Waples 2004). In one study, adult females with calves spent approximately 50% of their daytime activity foraging for fish (Finn 2005).

A study of coastal bottlenose dolphins found that habitat (open ocean or inshore) made a significant difference in dietary composition. Also, species available for consumption vary according to seasonal conditions and breeding patterns of prey species (Gannon and Waples 2004). Different dolphin communities in particular habitats may establish hunting behaviours especially for their situation.

Another study of the stomach contents of 685 toothed whales collected in Scotland and northern Spain, including 54 bottlenose dolphins. It found that these dolphins consume a wide range of relatively large organisms using pincer-like jaw movements as well as suction-feeding (MacLeod *et al.* 2006).

Dolphins sometimes fish in groups and herd schooling fish against a barrier where they then may feed in turns. Dolphins have been seen hitting fish or water near the fish with their tails. This may serve to stun the prey for easier eating or may be a form of play (Reynolds *et al.* 2000). Dolphins in the Bahamas have been observed digging in the ocean floor to find their prey (Rossbach and Herzing 1997).

A technique known only in Shark Bay, Western Australia involves the dolphin placing a sponge on its beak and then foraging along the sea bed. It is not known exactly how or why the sponge is used, but does demonstrate the dolphins' capacity to use tools and to learn behaviours (Krutzen *et al.* 2005).

The sounds a fish makes may help the dolphins locate their prey. Some studies have found that more noisy fish are more often found to be part of a dolphin's diet than quieter fish that are similarly abundant (Reynolds *et al.* 2000).

Some dolphins have learned to interact with human fishing activities to feed opportunistically. They follow fishing boats and prey on cast offs or direct feeding from fishers.

Dolphins as young as three weeks of age have been seen playing with seaweed and other objects, perhaps as one means of learning to hunt. Young dolphins may also prey on smaller, easier to catch species or individuals compared to adults, which may make their diet less varied. However, young dolphins supplement their hunting with milk from their mother (Gannon and Waples 2004).

Typically the size of prey ranges between 60 and 200 mm to a maximum of 370 mm. Dolphins do not chew their food, so prey is eaten head first to allow the animal to slip down without impediment (Byard *et al.* 2003).

Dolphins and desert dwelling animals have something in common. They both have adapted to limited availability of fresh water. These animals must minimise water loss as much as possible. It is possible that dolphin kidneys may have the capacity to filter sea water to allow dolphins to be able to drink this salty water. However, to date, research has not provided a conclusive answer to this. It is also possible that dolphins obtain freshwater from on-going metabolic processes (for example, oxidising glucose) and also from some of their food sources (Reynolds *et al.* 2000).

Information about wild dolphins' diets is obtained by various methods including analysing the stomach contents of recovered dolphin carcasses. This type of study can be time consuming and costly as it involves the analysis of the hard remains from prey species such as bones, spines, otoliths (accretions in fish ears) and cephalopod beaks that have accumulated in the stomachs. Accurate identification of these remnants is very time consuming and requires comprehensive expert knowledge across a diverse range of marine species.

It is also possible to identify prey food sources by analysing faecal material, fatty acids, and DNA, but these are also time consuming, expensive and rely on some invasive procedures.

Furthermore, causes of death for collected dolphins vary. Some deaths will have been caused by disease and other physical ailments, all of which could alter the normal diets of the animals. This means that a significant number of stomachs must be analysed for the results to be meaningful to ensure an understanding is gained for animals in varying states of health and to represent the full demographic range.

A South Australian Museum study analysed the stomach contents of dolphin carcasses recovered at Port Lincoln, South Australia. Many of these animals died during or shortly after they were feeding, so stomach contents are relatively indicative of a healthy dolphin's normal diet. However, they were found feeding around fish cages which may influence prey availability. The study suggests that these South Australian bottlenose consumed more cephalopods than fish, along with small amounts of crustaceans. Cephalopod species included octopus, cuttlefish and southern calamari. Fish species (from greatest to smallest quantity) included mackerel, trevally, silverbelly, cod, pilchards, sprat, mullet, and bullseye (Kemper and Gibbs 1997). This study must be qualified by noting that the percentage of parts of each species retained in the stomach is not known and may vary according to prey type.

<u>ADS dolphins</u>

No specific study has been undertaken on ADS dolphins' stomach contents. To find out more about ADS dolphins' feeding, specific studies would need to be conducted on stomach contents already stored at the SA Museum and on any new ADS dolphins collected. It is likely that ADS dolphins will feed on the range of fish and cephalopods found in the ADS. Certainly, dolphins are regularly observed feeding throughout Sanctuary waters. Feeding activities may correlate with areas of interest to recreational fishing. This shared interest increases the opportunity for human and dolphin interaction.

2.6.3 Normal behaviours

Dolphins can swim on average from five to ten kilometres per hour but can reach speeds up to 30 to 35 kilometres per hour. Inshore bottlenose dolphins dive underwater for up to three to four minutes.

Scientists have divided dolphin behaviours into five categories to help understand and categorise their behavioural observations (Lusseau and Higham 2003).

1. Travelling – animals move steadily in a constant direction.

2. Milling – animals are moving in no constant direction with irregular dive intervals. The purpose of this behaviour is not known.

3. Diving – individuals singly or in groups dive together for long intervals. Dives can be steep to increase diving speed. In some studies this could include feeding activities and is described as feeding in some studies.

4. Socialising – many behaviours exhibited including body contacts, hitting with the tail and pouncing. Dive intervals vary.

5. Resting – an animal moves slowly in a constant direction with short, coordinated dive intervals. If in a group, (which often happens) animals move closely together. Resting is not a separate category in all studies.

Bow riding, leaps, surfing, breaching, fluke slaps, head slaps, and interactions between individuals have all been observed.

Dolphin behaviours can be observed to work out time budgets – the amounts of time allocated to each behaviour. Different communities seem to allow different amounts of time for each type of activity. Variations are caused by type of habitat, availability of food, season, time of day and variations in observers' interpretations. In some instances, specific behaviours may be linked to specific habitat types.

It is not clear how behaviours are altered by human disturbances, for example, boats, noises, or changes in onshore activities, and therefore it is also not clear if any alterations have long-term harmful impacts. Behaviour changes could be positive, negative or neutral in their consequences. It is possible some dolphin activities are more sensitive to external disturbances than others. For example, a resting animal may be more sensitive to sound than a socialising animal and levels of sensitivity may vary between individuals.

<u>ADS dolphins</u>

Specifics unknown. Some studies have been undertaken, but the results are not yet publicly available.

Over the long term, it will be useful to gain an understanding of the behaviour patterns of ADS dolphins. This is important to enable us to assess if human activities are causing any negative impacts to the dolphins by changing their behaviours. It may also enable us to recognise if any behaviours are linked to specific ADS habitats or locations, and perhaps provide some direction for the locations of future human activities in the ADS.

2.6.4 Sleeping

Dolphins may spend approximately one third of their time sleeping. They are conscious breathers and their sleep behaviour is adapted to allow them to both breathe and swim while sleeping. When they sleep, it is thought that one half of their brain rests and the other half is more active. One eye remains open, and the other closed. This happens for up to two hours and then the opposite side takes its turn for a rest. It is thought sleeping often, but not always, occurs at night (Hecker 1998). An animal may rest alone or sleep near other individuals.

ADS dolphins

Specifics unknown.

2.6.5 Sensory communication

Sounds

Sound is the most important mode of communication for bottlenose dolphins. They use echolocation and produce a variety of sounds including clicks, whistles, low frequency, narrow band sounds and rasps, grates, mews, barks and yelps. It is thought that individuals may have their own signature whistle, kept the same throughout their lives, which identifies them to other members of their community (Reynolds 2000).

Sight

Dolphins have quite good eyesight, both underwater and in the air. Because of the position of their eyes, they have a wide field of vision, including to the sides, in front, below and even to the rear. This field of vision works together with echolocation to enable dolphins to locate predators and interact with other dolphins (Reynolds 2000).

Other senses

Dolphins may be able to distinguish between different tastes and they do have taste buds on their tongues. However, they do not appear to use a sense of smell and olfactory bulbs have not been found in the brain. Observations of dolphins' behaviours indicate they do have tactile sensations as they are frequently observed rubbing against each other. In addition, tests have revealed special sensitivity on the head and it is possible they are especially sensitive to water pressures and movements (Reynolds 2000).

ADS dolphins

Specifics unknown.

2.6.6 Social structure of communities

A number of studies have been conducted about how communities of bottlenose dolphins function. It may be that different communities establish different social structures, depending on factors such as habitat and location of the community. However, it does appear that societal structures are fluid with temporary alliances formed between individuals and small groups (Krutzen *et al.* 2003; Connor *et al.* 2001)

There are some common, relatively stable groupings. Mothers and calves stay together, usually at least until the mother has a new calf. A sub-adult may sometimes stay with her mother and the new sibling. (Mann *et al*. 2000)

In addition, nursery groups are sometimes formed which contain females who share home ranges and are pregnant or have calves of similar ages. This may be because they have similar requirements for food and for protection from males and predators (Gero *et al.* 2005).

Another grouping involves males forming stable alliances in groups of two to five. This may give them a reproductive advantage for gaining access to females and also possibly protection from predators (Krutzen *et al.* 2004).

One method used to increase understanding of dolphin interactions, is to conduct focal follows by following either individuals or groups of dolphins regularly over extended time periods and recording all behaviours observed. These studies have revealed that different habitats seem to support different types of interactions. Often, dolphins remain in their alliances as described above for feeding and foraging and tend to gather in larger groups for activities such as socialising and resting. These larger groups often do not remain constant. Dolphins living in open, deeper waters may tend to interact in larger groups more often than those living in sheltered, more shallow waters (Bearzi 2005).

A study of a bottlenose dolphin population in New Zealand indicated a complex social network, where some individuals, particularly the older females, had more of an interactive role than others. The study also found that if there was a loss of a key individual important to the population's communications, the communications were unaffected, as there were adequate communication lines available through other individuals to compensate (Lusseau 2003).

It is not known if dolphins born in an area remain there throughout their lives. Female mammals often stay in the regions where they are born, and males often move to other areas. Research in some dolphin populations has found both sexes remained in their birth areas, while other studies of inshore bottlenose dolphins have suggested that males often, but not always, stay in their birth areas. Genetic studies of dolphins in Port Stephens and Jervis Bay New South Wales suggest that females in these populations do tend to stay around their birthplaces while males tend to leave (Möller and Beheregaray 2004).

<u>ADS dolphins</u>

Anecdotal evidence suggests that there appears to be mother and calf groupings in the ADS, in addition to mother, calf and older sibling groups. Male alliances have also been observed. Dolphins are often observed singly, and groups of up to 8 to 12 individuals have been sighted during feeding and socialising activities.

It is possible that the ADS dolphins may have some individuals largely resident in the Sanctuary and there may be others who visit with greater and lesser degrees of regularity. Both may be important for maintenance of the population (Bossley *et al*. 2006 pers. comm.).

Given the inconclusive findings of male and female dispersal behaviours of inshore bottlenose dolphin populations, it is difficult to be certain about what happens in the ADS population.

Gaining greater understanding of the genetic make up of the population structure would contribute to answering questions about the relationships of resident ADS dolphins and about how much interaction there is with dolphins outside the ADS. While observation alone can reveal the likely mother of a calf, it is not possible to accurately establish paternity for a bottlenose dolphin without genetic testing.

This understanding would aid in the assessment of the on-going viability of the resident population and also would provide an indication of the importance of dolphins not resident to the maintenance of the resident population.

2.6.7 Intelligence

Defining a methodology to define and measure human intelligence is a subjective and controversial process. Defining intelligence in animals is even more difficult. Questions arise such as: Are bees super intelligent because of their complex social structure? Are dogs more intelligent than cats because they more readily obey human commands? How do we distinguish between instinctual and learned behaviours? Determining a ratio of brain to body weight may be an indicator of intellectual capacity.

On average, the bottlenose dolphin brain weight is 1500 to 1600 grams and the average adult human brain weight is 1100 to 1500 grams. When examined as a comparison of brain weight to body size, humans have the largest proportion of brain weight to body size of any species. On many scales of measurement, bottlenose dolphins are, however, second only to humans in this ratio (Klinowska 1994; Reynolds 2000).

It is thought that a significant proportion of a dolphin's brain supports its echolocation functions. The complexity of these activities may necessitate a large brain for this species (Reynolds 2000).

Other factors to do with structure and composition of the brain also play a part in the intellectual capacity of a species. However, when a wide range of species is examined, there are enough inconsistencies to make it impossible to reach any final conclusions about using the structure and size of the brain as a determinant of individual or species intelligence.

We do know that dolphins in captivity and in the wild learn behaviours, sometimes seek human interaction and even appear to act cooperatively with humans. Some people believe they have experienced emotional and spiritual communications with dolphins. Until we have much more conclusive information, scientists will not be able to make definitive statements about the intellectual capacity of dolphins.

ADS dolphins

Specifics unknown.

2.7 Interactions with dolphins from the greater Gulf St Vincent

Considering the relatively small number of individuals believed to be resident in the ADS, it is likely there is some interaction between ADS dolphins and those in greater Gulf St Vincent. However, the extent of this interaction and its importance to the sustainability of the resident population is not known. Until we know more about these levels of interaction, consideration must be given to the security of the population in the Gulf to ensure the security of the ADS dolphins.

Evidence of this potential is highlighted in a study of bottlenose dolphins in Moray Firth, Scotland. The study reports that the range of animals there has significantly expanded over a ten year time period to include not only the original core area, but also a much larger range. It is thought this is due to a search for prey, as it is not believed that the population has increased in numbers over this time. The study concludes that it is necessary to monitor a population outside of its known range to discover any changes in range over time. This will ensure adequate protection is offered to all individuals (Wilson *et al.* 2004).

3 Threats to the physical safety of the dolphin population

Threats to individuals and groups of animals are caused by both natural and human actions. It is important to understand what happens naturally to prioritise and manage human caused threats.

3.1 Natural threats

3.1.1 Predators

Sharks and killer whales attack and consume dolphins. Sharks are the main predator and calves are particularly vulnerable. Not all attacks are fatal and many dolphins carry scars from shark attacks. Scars from shark attacks on dolphins were found in 36.6% of the Moreton Bay, Queensland population, on 21.9% of live, non-calf dolphins in the Sarasota, Florida area and 10.3% of bottlenose recovered from gill nets at Natal, South Africa had scars from shark attacks. The locations of the scars indicate sharks often attack from behind or below (Wells 1999). Dolphin remains have also been recovered in shark stomachs. Of 6000 sharks examined in Natal, 1.2% had dolphin remains in their stomachs, predominantly from younger dolphins (Wells 1999). The differences in numbers of attacks could be due to a variety of factors, including density and species of the local shark population, learned behaviours of the dolphin population, and quality of observations.

Stingray wounds, both external and from ingestion have also caused deaths from trauma, infection and poisoning (Wells *et al.* 2003).

<u>ADS dolphins</u>

There is no specific information available about scarring on ADS dolphins. It is possible that dolphins originally located in the ADS, in part, to avoid attacks by predators since large sharks are not usually seen in the area. Also, since the ADS waters are relatively shallow, it is less likely a shark can attack a dolphin from below.

3.1.2 Bottlenose dolphins

Many mammals have the capacity for aggressive or violent interactions with individuals of their own species, community or even family. Dolphins are no exception to this. They do fight with each other and can cause each other injury. Fights may occur between males to access females or to gain access to food sources (Parsons *et al.* 2003). At Moray Firth, Scotland and off the east coast of the US in Virginia, calves who died from dolphin inflicted injuries have been discovered. Although the perpetrator of the injuries is not known the possibility of infanticide exists (Mann *et al.* 2000). Again this behaviour happens in other mammals, and may be an attempt to increase reproductive opportunities for males (Reynolds *et al.* 2000).

<u>ADS dolphins</u>

Specifics unknown.

3.1.3 Disease, biotoxins and parasites

The understanding of naturally occurring diseases, biotoxins and parasites in bottlenose dolphins is very limited. Diseases known to infect dolphins include bacterial pneumonia, pox and other viruses, hepatitis and pancreatitis.

Parasites are also common and may contribute to illness or the death of an individual by weakening its overall condition. (Reynolds *et al.* 2000; Kemper 1998 - 2005)

Little is known about the rates and causes of naturally occurring deaths. Current knowledge is gained from carcasses that are washed up on populated shores, successfully retrieved and scientifically studied. Naturally, many carcasses are never retrieved. An additional complication is that reliable baseline studies done on populations not impacted by human activities have not been undertaken.

It is also possible that exposure to chemical pollutants may weaken animals making them more susceptible to disease and parasites. For example, an individual dolphin with an immune system weakened by exposure to PCBs may not have enough resistance to successfully overcome a specific disease or parasite which it otherwise may have been able to resist (Jepson *et al.* 2005; Schwacke *et al.* 2002).

South Australian dolphins generally have been found with heart diseases, cancers, pneumonia, hepatitis, and unidentified infections.

<u>ADS dolphins</u>

Parasites have been discovered in a number of post mortems, but these are not necessarily the cause of death of the animal. In addition, three post mortems revealed some unexpected information. Unusually, a *Corynebacterium ulcerans* infection was identified from deep sores in a Port River dolphin. This infection is usually associated with bovine mastitis and had not been previously recorded as a cetacean infection.

Second, a young adult male dolphin was found dead in the ADS area. The dolphin's cause of death was found to be from choking on a 660 mm cobbler carpet shark. (Normal prey size is usually 60 to 200mm.) The death may have been caused by over enthusiastic feeding. However, the possibility of a neurological disorder exists, the cause of which is unknown (Byard *et al.* 2003).

Finally, an adult male was found near Garden Island with an obstruction in his blowhole. Tests revealed that the obstruction was caused by the *papilloma* virus. It is not known how the animal was infected by the virus or how, in this instance, it was able to cause its death.

Consideration should be given to the possibility of viruses, bacteria, pathogens and any other disease causing agents being discharged into the water. For example, *E. coli* has been known to contaminate mud cockles in the ADS area.

3.2 Human caused threats

3.2.1 Pollution

Types of toxins from pollution that may impact on dolphins include heavy metals and PCBs. These toxins can affect dolphin populations in two significant ways. They can damage habitat by impacting on water quality, vegetation and/or prey species that are required components of the dolphins' environment. They can also directly affect dolphins by contributing to diseases, genetic disorders, exacerbation of chronic conditions and even possibly deaths.

The IUCN Conservation Action Plan for Cetaceans states that,

> "Although the evidence for links between chemical pollutants and the health of cetaceans remains largely circumstantial and inferential, there is growing concern that exposure to contaminants can increase susceptibility to disease and affect reproductive performance" (Reeves *et al.* 2003).

The Plan further states that PCBs are of particular concern, due to their capacity to interfere with the hormonal and immune systems of other mammals.

Toxins can be absorbed from the water through the skin, from the air through the lungs when the animals breathe, or from the animals the dolphins eat. It is likely dolphins obtain the greatest quantity of toxins from their food (Butterfield and Gaylard 2005).

Bottlenose dolphins feeding in shallow water on bottom dwelling prey such as octopus may be more susceptible to ingestion of toxins from their food, especially those that may be found in sediments (Gibbs 2006 pers. comm.).

Heavy metals

Heavy metals commonly found in the environment include cadmium, lead, mercury and zinc. Cadmium, lead and mercury have no known biological function. Cadmium is known to cause skeletal deformities, kidney failure and cancer in mammals. Lead can cause brain damage; liver and kidney disease; behavioural and growth problems; and birth defects. Mercury has been linked to liver disease, liver and kidney failure and brain disorders in marine mammals (National Pollutant Inventory 2004).

In trace amounts, zinc is essential for all living organisms. Too much or too little zinc can be harmful to an organism. Too much zinc can cause nausea and vomiting, interfere with the absorption of other essential minerals and skin diseases.

These heavy metals occur naturally and are released by the weathering of rocks, gassing from soils, forest fires, geothermal emissions and volcanoes. They can also be released as a result of human activities including mining, smelting and refining metals, discharges from sewage treatment works, vehicle emissions, burning fossil fuels and run off of fertilisers and pesticides (Butterfield and Gaylard 2005).

Heavy metals can accumulate in dolphins in several ways. They can be obtained through the diet of the animal, over the length of its lifespan (the longer the life, generally the greater the opportunity for accumulation), input from natural habitat sources, and accumulation from human inputs into the environment. It is also thought that the mammary gland plays an important role in the transfer of trace metals such as cadmium, lead and zinc to the calf (Frodello *et al*. 2002).

A study of harbour porpoises found around the North Sea examined metal concentrations and the general health of both stranded porpoises and porpoises collected as a result of fishing by-catch. Two specific health indicators were examined – the emaciation status of the individual and the presence of lesions in the respiratory system. It found that elevated levels of zinc, iron and selenium were clearly linked to emaciation and lesions (Das *et al*. 2004). These metals may or may not affect bottlenose dolphins in the ADS in similar ways.

Polychlorinated biphenyls (PCBs)

PCBs are a group of chemicals that contain 209 separate chlorinated compounds. They do not occur naturally and so there is no "normal" level of accumulation for them. PCBs were widely used in industry from the 1930s but were banned in a number of countries in the1970s. In Australia, PCBs were never used in Australian manufactured goods. However, they were widely used in imported goods as heat transfer fluids, hydraulic fluids and fluids in capacitors and transformers (Richardson 1995). They bind well with sediments, organic particles and soils. However, they can still be released from waste sites if improperly stored and remain persistent in the environment for a long time. Old electrical appliances that still contain PCBs may emit them into the air and release them from waste dumps (Agency for Toxic Substances and Disease Registry 2000 and 2001).

As provided by the *Environment Protection Act 1993*, South Australia's *Environment Protection (Water Quality Policy) 2003* requires that no discharge of PCBs in marine waters should increase the level of substances in the water by the amount of 0.000004 milligrams per litre. This indicates that there is no safe level of these substances for our marine environment.

PCBs can be taken up in water by small organisms and fish. They have been linked to cancers in both animals and humans and to toxic effects on immune, reproductive, nervous and endocrine systems. Problems caused in one system may impact on the operations of other systems. The types of PCBs which bio-accumulate in fish and sediments are thought to be the most carcinogenic mixtures (Agency for Toxic Substances and Disease Registry 2000 and 2001).

International studies consistently indicate that, as they age, dolphin males accumulate more PCBs than do females. It is thought this occurs because females off load their accumulations to their young. For example, a South African study found that first born calves received up to 80% of their mother's toxic contaminants by ingesting milk and possibly through placental transfer (Wells and Scott 1999).

A risk assessment of the effects of PCBs on reproduction in three bottlenose dolphin communities in the United States found, "a high likelihood that reproductive success, primarily in primiparous (females pregnant for the first time or with only one calf) females is being severely impaired by chronic exposure to PCBs" (Schwacke *et al*. 2002).

In addition, a number of marine mammal studies have been conducted to investigate the relationship of disease to PCB contamination. No definite conclusions can be reached, but the possibility of a correlation between the presence of PCBs in an animal and its subsequent susceptibility to disease cannot be excluded.

In all of these studies, there are many variables to consider and obstacles to overcome, including a lack of baseline data and difficulties in conducting field studies. For example, animals exposed to PCBs are also likely to have been exposed to a wide variety of other human induced stresses including habitat loss, other contaminants, noise, and changes in food sources. Often, it is not possible to identify a single cause of a disease or death because a number of factors combine to create a fatal condition.

<u>ADS dolphins</u>

There are a number of sources of heavy metals within and in the vicinity of the ADS. Sources of introduced heavy metals in the Gulf St Vincent are SA Water Corporation waste water treatment plants at Bolivar, Glenelg and Christies Beach, the Torrens Island and Pelican Point power stations and the closed Mobil Oil Refinery (Butterfield and Gaylard 2005). Other sources include stormwater run off, industrial effluent, motor vehicles, commercial shipping and boating, and atmospheric sources. The ADS hosts the Bolivar waste treatment plant and both power stations.

Two studies have been undertaken examining pollutants in dolphins collected from the Sanctuary area and in the wider waters of South Australia. The EPA conducted a study in 2000, "Special Survey of the Port River – Heavy Metals in Dolphins, Sediment and Fish." To follow on from this, the Environment Protection Authority recently released, "The Heavy Metal Status of Dolphins in South Australia" (Butterfield and Gaylard 2005). This report documents levels of cadmium, lead, mercury, zinc and selenium in dolphin carcasses collected in South Australian waters by analysing 83 dolphin livers and bones from 62 dolphins. The metals studied tend to accumulate in the liver and historical accumulations of lead are found in bones, although recent lead exposures could also be found in the liver.

The 2005 study also looked at differences in accumulations in three species of dolphins living in the Gulf St Vincent, Spencer Gulf and the Southern Ocean. They looked at the two species of bottlenose dolphins and also common dolphins, *Delphinus delphis*. It is important to remember that the locations are identified by where the animal's carcass was collected. This may or may not be the location where the animal lived or was exposed to the toxicant.

The study shows higher levels of metals in the inshore bottlenose species *Tursiops aduncus* than in *Tursiops truncatus* (common bottlenose) and *Delphinus delphis* (common dolphin), probably due to differences in diet and habitat use. *Tursiops sp.* are also generally longer lived than *D. delphis*. The report compares the South Australian findings with those from elsewhere in the world to determine if local findings are comparatively high or low. These international studies are still in their initial stages.

Findings for specific metals are as follows:

Cadmium – Overall, cadmium levels were low. Bottlenose dolphins from the Southern Ocean had the highest levels in the study. Concentrations in the Spencer Gulf were higher than those in Gulf St Vincent. One *T. aduncus* in Spencer Gulf had a high level. Animals with moderate levels were found around Port Lincoln, Yorke Peninsula and Kangaroo Island.

The effects of cadmium on dolphins are not known. Since the animals with moderate levels were found in less settled areas, it is possible that there are natural background levels of cadmium in South Australian waters.

Lead – In dolphins, recent lead exposures collect in the liver and long term concentrations are found in the bones. The study analysed samples from both locations where possible. Overall, concentrations in livers were classified as low. Lead levels found in bones of Gulf St Vincent *T. aduncus* were categorised as moderate. Levels in *T. aduncus*, the inshore species were significantly higher than those of *D. delphis.*

Butterfield and Gaylard hypothesise that the moderate levels of lead found in the bones of Gulf St Vincent dolphins is possibly a result of historical exposure from motor vehicles using leaded petrol. The report suggests that a follow up study undertaken in five years may help to determine if levels decrease as a result of the phase out of leaded petrol.

Mercury - Overall, mercury was classified as high in *T. aduncus* in Spencer Gulf and Gulf St Vincent, and moderate in *T. truncatus* in the Southern Ocean. Generally mercury levels in all species were significantly higher in both Gulfs than in the Southern Ocean. Concentrations were also significantly higher in *T. aduncus* than in the other two species. The report suggests that the mercury is from natural geological sources rather than introduced human sources. There are high natural levels of mercury in South Australian waters and not very many known discharge point sources of mercury according to the National Pollutant inventory.

The high levels of mercury in *T. aduncus* were the highest median levels of any published study. Mercury and selenium bind together in marine mammals, seemingly protecting the animals from the toxic effects of the mercury (Butterfield and Gaylard 2005). Selenium was found in most of the animals at close to a one to one ratio with mercury. The report states that, "…mercury concentrations had minimal impact on dolphin health" (Butterfield and Gaylard 2005, p. 38).

Zinc – Overall, zinc levels were classified as low for all species in the three regions. However, there was one *T. aduncus* in Gulf St Vincent and three from Spencer Gulf with high levels.

Given that overall levels of zinc were low for all three species of dolphins, it is not thought levels of zinc are a concern. Since zinc is a naturally occurring element in animals, it is possible that the animals with higher levels may have a problem with their liver in the regulation of levels in their own bodies.

The EPA also conducted a previous study in 2000, the "Monitoring Report - Special Survey of the Port River – Heavy metals and PCBs in Dolphins, Sediment and Fish" (EPA 2000). Twenty-one fish were tested for lead, mercury and cadmium and all were found to be within safe limits and were at similar levels to fish from other South Australian waters (EPA 2000).

Testing was done on 26 sediment samples for mercury, cadmium, chromium, lead, zinc, copper, nickel and PCBs. High levels of mercury were found at five sites. It was not clear if these were a result of historical or recent contamination. No site showed high levels of cadmium or chromium.

Seventeen sites had high levels of lead, zinc or both. Twelve of these sites were storm water drains where higher levels of lead might be anticipated from road runoff. The EPA indicates that more needs to be done to stop the runoff entering the river and estuary environment. Lead and zinc are used in boat construction and sites with high levels were also located near shipyards (EPA 2000).

Five sites had high copper levels and one had high nickel. Three of these were near boatyards, one was near an effluent discharge site where copper from piping would be expected, and one was near a major stormwater drain. Nickel does not appear to accumulate in plants, fish or animals used for food (EPA 2000 and the Commonwealth Department of the Environment and heritage 2004).

There is not enough information to fully understand the implications of moderate to high levels of metals in dolphins. It may be that the presence of the metals is having an effect on dolphins' health or reproductive capacity. It may be that they affect only a certain percentage of individuals. Larger numbers of animals would need to be studied to determine any trends in contaminants and to correlate findings with causes of death to see if there are any relationships. To date, the findings are not definitive enough to be certain of any correlations between heavy metal contaminants and their effects on the dolphins.

PCBs

The EPA's (2000) Survey analysed tissue samples from 15 dolphins, sediments from 26 sites, and 11 black bream and 10 yellow eye mullet for PCBs (Arochlor 1260) and heavy metals. Dolphin tissues from dolphins found in both the ADS and wider South Australian waters were tested.

Dolphins found in the vicinity of the ADS had "substantially higher" PCB levels (Arochlor 1260) than other South Australian dolphins (EPA 2000). However, the EPA reports that these levels were still below dolphins studied elsewhere in the world such as South Africa and the Mediterranean Sea where levels were especially high.

According to ANZECC (2000) water quality standards criteria, Arochlor 1260 was found at unsafe levels at four of the sites. Two of these were probably recent contaminations.

It is possible that different PCBs combine to produce different toxic effects and they also may contribute to a total cumulative effect when combined with other types of toxins in mammals generally.

3.2.2 Habitat loss

Habitat loss and degradation is a primary threat to many species, both on land and at sea. Habitat is lost in a number of ways, including by physical removal of the habitat, by pollutants and nutrients released into the air and water, by invasion of pest plants and animals, and by effects of turbidity and sedimentation.

Coastal areas are a focus for residential and industrial development world wide, and South Australia is no exception to this trend. More than 90% of South Australians live at, or near, the coast. Declines in sea grass and mangroves have been documented as developmental pressure along the South Australian coast continues to increase (Department of Environment, Water and Natural Resources 2004).

<u>ADS dolphins</u>

The ADS is an inshore environment and land based developments can have significant direct impacts on it. A number of development proposals exist for infrastructure and industry initiatives in the ADS area. Careful consideration must be given to their impacts on the dolphins and their habitat along with consideration of the economic benefits of the projects.

In addition, the ADS waters currently support a diverse range of current users. Losses of native vegetation in and around the ADS including mangroves, salt marsh and sea grasses have previously occurred which may have already impacted on the dolphins' habitat requirements and food supplies. Consideration must be given to the cumulative impact of current and proposed activities. Impacts and threats on habitat and water quality are separately discussed in Reference Papers 2 and 3.

3.2.3 Noise impacts

Although it is clear that dolphins use sounds and echolocation to communicate, feed and to navigate, it is not so clear what effect the additional noise activities of others have on them. Some types of noises may interfere with dolphins' transmission of these communications.

Observations suggest that some marine mammals avoid noisy situations and others investigate them. It is possible that, other than in extreme events, the response could be dependent on an individual animal's sensitivity. In addition, when dolphins are occupied in specific behaviours, their responses to noise may vary. A resting dolphin may respond to a noise differently than it would if it had been travelling or socialising (Lemon *et al.* 2005). It is possible that noises could alter behaviours and this change could be damaging to a population as a whole. It is possible that noise could have an indirect impact on dolphins by impacting other species on which they rely, for food for example.

Studies on hearing capacities have been undertaken for around 22 of the approximately 125 marine mammal species. Many of these studies are limited by their sample sizes, often to just one individual. Toothed whales (a category including bottlenose dolphins) are thought to have good hearing across a broad range of mid to high frequencies (Southall 2005). It is possible that in busy port areas, such as the ADS, resident animals could experience hearing loss as a result of regular exposure to vessel and industrial noises. A likely effect of specific noise events, such as vessel noise, is that the noise may mask the normal marine environment sounds such as the sounds of prey species. This may make it more difficult for dolphins to hunt or cause them to move to another area where noise is not a barrier to hunting activities (Southall 2005).

In *Marine Mammals: Fisheries, Tourism and Management Issues* (McCauley and Cato in Gales *et al*. 2003) the issue of noise impacts is addressed. In part this work states, "In general, there have been relatively few scientific studies on the effects of noise on marine mammals and knowledge is quite limited." (p. 353) It continues, "Aside from observations of apparent acoustic trauma in stranded Cuvier's beaked whales, and experiments aimed at determining hearing threshold changes, there have been no experiments which have looked for lethal or sub-lethal pathological effects of noise on marine mammals, largely due to ethical constraints." (p. 353)

<u>ADS dolphins</u>

The lack of understanding about how human generated noises impact on bottlenose dolphins means that, at this time, it is not possible to make definitive statements about impacts of specific noise activities such as dredging or construction taking place in the ADS.

Anecdotal reports suggest that during regular Port River maintenance dredging, dolphins are attracted to the dredging operation possibly due to increased numbers of fish congregating in the area. However, during construction activities at North Haven Marina, it appeared that dolphins left the area, and then returned on completion of the operations.

3.2.4 Fishing activities – commercial and recreational

In fisheries around the world, both commercial and recreational fishing activities can affect marine mammals. In some locations, fish stocks are depleted from unsustainable fishing practices. This has wider impacts on the entire ecosystem and can affect the food supply of the dolphins and other marine mammals.

Other potential impacts from commercial and recreational fishing include entanglements in nets when dolphins are accidentally captured in fishing activities aimed at other species, and incidental deaths due to entanglements in derelict fishing gear – ghost nets, single filament line rope, plastic bags and general debris from fishing efforts. Also, there are reports of possible intentional killings when fishers see dolphins as competition for fish stocks or use dolphins as bait.

A report was received about one entangled humpback whale near Nova Scotia Canada which had 57 lobster traps, 8 anchors, 6000 feet of line, 10 bladder balloons and 6 cork buoys attached to it. It was disentangled and apparently survived the ordeal (Pendlebury 2004 pers. comm.).

<u>ADS dolphins</u>

Commercial fishing activity is not significant in ADS waters. It is known that some effort is targeted at blue crabs and mud cockles (Padula *et al.* 2003). In addition, bait digging is undertaken both for personal use and for selling in bait shops. The wider Gulf St Vincent supports a significant amount of commercial fishing effort and the impact this may have on the fish stocks in the ADS is not clear.

Recreational fishers target a range of species available in ADS waters including: yellow eyed mullet; snapper; bream; yellow fin, weedy and King George whiting; garfish; tommy rough; leather jackets; flat head; snook; squid; mulloway; and blue swimmer and sand crabs. Since a significant proportion of ADS waters are breeding and nursery areas for a number of fish species, trends in fish numbers need to be assessed to ensure the viability of these populations to maintain ample food supplies for the dolphins.

There are also fishing impacts directly on the dolphins. A study of cetacean mortalities in all South Australian waters examined records held at the South Australian Museum. Of particular relevance is the information based on post mortems of cetaceans conducted from 1985 to 2000. Entanglements and probable entanglements account for 17% of cetacean deaths in this period. This percentage represents the largest number of deaths directly caused by humans, and includes entanglements in nets, aquaculture operations, long lines and free floating debris (Kemper *et al*. 2005).

ADS dolphins

Entanglement in discarded fishing gear is a threat to ADS dolphins. Since 1998, there is one known death to an ADS dolphin from fishing gear lodged in the animal causing an infection. There have also been fifteen non-fatal reports of entanglements since 1988, both confirmed and unconfirmed. Some of these animals were disentangled by humans and some apparently disentangled themselves (Bossley *et al.* 2006 pers. comm.).

3.2.5 Vessel strikes

Vessel strikes are a threat to marine mammals around the world. Risks may be highest in open waters where large vessels move at higher speeds. Larger, slow moving mammals may be more vulnerable to strike than smaller mammals.

Collisions with vessels can injure or kill dolphins. Precise figures on these incidences are difficult to obtain. A dead animal floating on the water could subsequently be struck, making it difficult to reliably determine the timing of the strike. A dolphin injured or killed at sea is also subject to predation and subsequent strikes by additional vessels, often making it impossible to determine the initial cause of injury.

Observations from all over the world indicate that dolphins seek out vessels, apparently to investigate the vessel or to bow ride. From this behaviour it appears that vessels may not necessarily be considered threatening to the animals. However, this behaviour does expose the animals to more risks.

Younger, ill or stressed animals may be more vulnerable to vessel strikes due to inexperience and less capacity to avoid the vessel. Dolphins may have difficulty with vessels with erratic movements. One study observed that the more boats move unpredictably and erratically, the more the dolphins tried to evade them (Lusseau and Higham 2003).

ADS dolphins

It is not known how many ADS dolphins have been injured by vessel strikes. It is possible that dolphins may be more vulnerable to strike from smaller vessels because they tend to move more quickly and erratically, preventing the dolphin from accurately anticipating the vessel's movements.

According to Flinders Ports, in 2005 there were 1,111 vessel calls to Adelaide, excluding the Australian Navy (Flinders Ports 2005). The SA Museum records show one known death of a calf due to vessel strike in 2003 and a possible death of an adult male in 2004 (Kemper 1998 - 2005).

3.2.6 Aquaculture

ADS dolphins

There are no aquaculture operations currently within the Sanctuary and no proposals are currently expected. If a proposal should arise, the *Aquaculture Act 2001* requires the Aquaculture Minister to seek to further the objects and objectives of the Adelaide Dolphin Sanctuary Act. In addition, the Minister for the ADS must also agree to the proposal.

3.2.7 Mineral exploration and operations

Depending on the type and scope of the undertaking, mineral operations can have significant impact on habitat and on species reliant on the habitat.

ADS dolphins

Currently Cheetham Salt Limited (formerly Penrice) holds a number of mineral licenses for its salt mining operations along the eastern perimeter of the ADS. Salt extraction operations have been undertaken in the Dry Creek area since the 1930s, and now annually produce 650,000 tonnes from the 4,500 hectares of salt fields (Ridley Corp. 2005).

There are no additional mineral activities currently proposed for the ADS. The area is not highly prospective. However, if any are proposed, the Mining Minister must have regard to the ADS objectives and the agreement of the Minister of the Sanctuary is required for any licences to be granted.

3.2.8 Petroleum exploration and operations

Petroleum activities can impact marine ecosystems in both the exploration and extraction phases. Sounds from techniques used during exploration can continue for months at a time and travel tens of kilometres (McCauley and Cato in Gales *et al.* 2003). Particular risk areas are acoustic impacts from exploration and oil spills.

ADS dolphins

In October 2006, Petroleum Exploration Licence PEL 120 was granted to SAPEX Ltd. The PEL covers approximately 9601 square kilometres on land and its southern boundary is approximately one kilometre from the ADS boundary. SAPEX Ltd will be targeting shallow coal-gas plays around known Tertiary-age brown coal deposits (Holloway 2006). Again, the agreement of the Minister for the ADS is required for any new petroleum activities to proceed that are within or adjacent to the ADS and the Minister responsible for petroleum activities must have regard to the ADS objectives.

In addition, the Moomba - Adelaide gas pipeline, PL (Pipeline Licence) 1, and the SEAGas pipeline, PL13, transect the ADS at seven different locations. These pipelines are a strategic component of South Australia's energy infrastructure, providing natural gas to the Torrens Island, Pelican Point, Osborne and Quarantine power stations. The pipelines are production operations under the *Petroleum Act 2000*.

3.2.9 Intentional harm

Intentional killings may occur for reasons such as sport, for use of the carcass for bait or to reduce competition for commercial and recreational fishing effort. It is difficult to accurately document these deaths.

<u>ADS dolphins</u>

In 1998, two dolphins were shot in the ADS and the calf of one of them subsequently died. In 1999 an ADS dolphin was stabbed and killed (Kemper 1998 – 2005). While efforts were made to identify the perpetrators, no charges have been laid.

3.2.10 Tourism

It is estimated that world wide, cetacean based tourism is a US$1 billion annual industry and still growing (Reeves *et al.* 2003).

A number of studies suggest that vessel based tour operations do affect dolphin behaviour with decreases in some behaviour observed (Lusseau and Higham 2003; Mattson *et al.* 2005; Hale 2002). Short term behaviour changes in response to power boat approaches were observed at a distance of approximately 100 metres (Lemon *et al.* 2005). However, long-term impacts of these changes remain to be determined.

The dolphins' ability to adapt to interactions with tourism activities is not known. It is possible that damaging interaction levels vary in different populations and for different individuals (Constantine and Baker 1997).

<u>ADS dolphins</u>

Most of the current tourism activity in the ADS does not seek direct personal interaction with the dolphins. Types of existing activities include canoe and kayaking tours, large vessel tours, and boardwalk viewing from Garden Island and the St Kilda Mangrove Trail. However, types of tourism activities may change as the ADS increases its public profile and with the growing number of residents and other users of the area. It will be important to assess the cumulative effect of tourism activities on dolphin behaviour and also assess this in combination with the impacts of other types of activities.

The *Responsible Nature-based Tourism Strategy 2004 – 2009* is a joint initiative of the South Australian Tourism Commission and the Department for Environment, Water and Natural Resources and provides high level direction for nature based tourism experiences.

In addition, the Department of Environment, Water and Natural Resources is currently finalising new Marine Mammal Tourism Guidelines and, when completed, these will be used to provide a framework to apply to tourism operations within the ADS. These guidelines may result in amendments to the *National Parks and Wildlife 1972- Whale and Dolphin Regulations 2010*.

4 Conclusion

This paper provides information about one component of the Adelaide Dolphin Sanctuary. The topics raised here must be considered along with issues about protecting the dolphins' habitat and food sources, and maintaining and improving water quality. In addition, existing and historical relationships in the area must continue to be acknowledged and respected.

The Adelaide Dolphin Sanctuary environment is complex and diverse. Despite the human activities impacting the dolphins, the area retains considerable environmental importance. The dolphins in the ADS are widely appreciated, and it is clear most community members want them to remain in ADS waters.

The challenge for all of those who use and value the area in so many different ways is to make sure on-going activities do not cause further damage, and, to make sure that future activities improve the existing habitat, water quality and safety of the dolphins.

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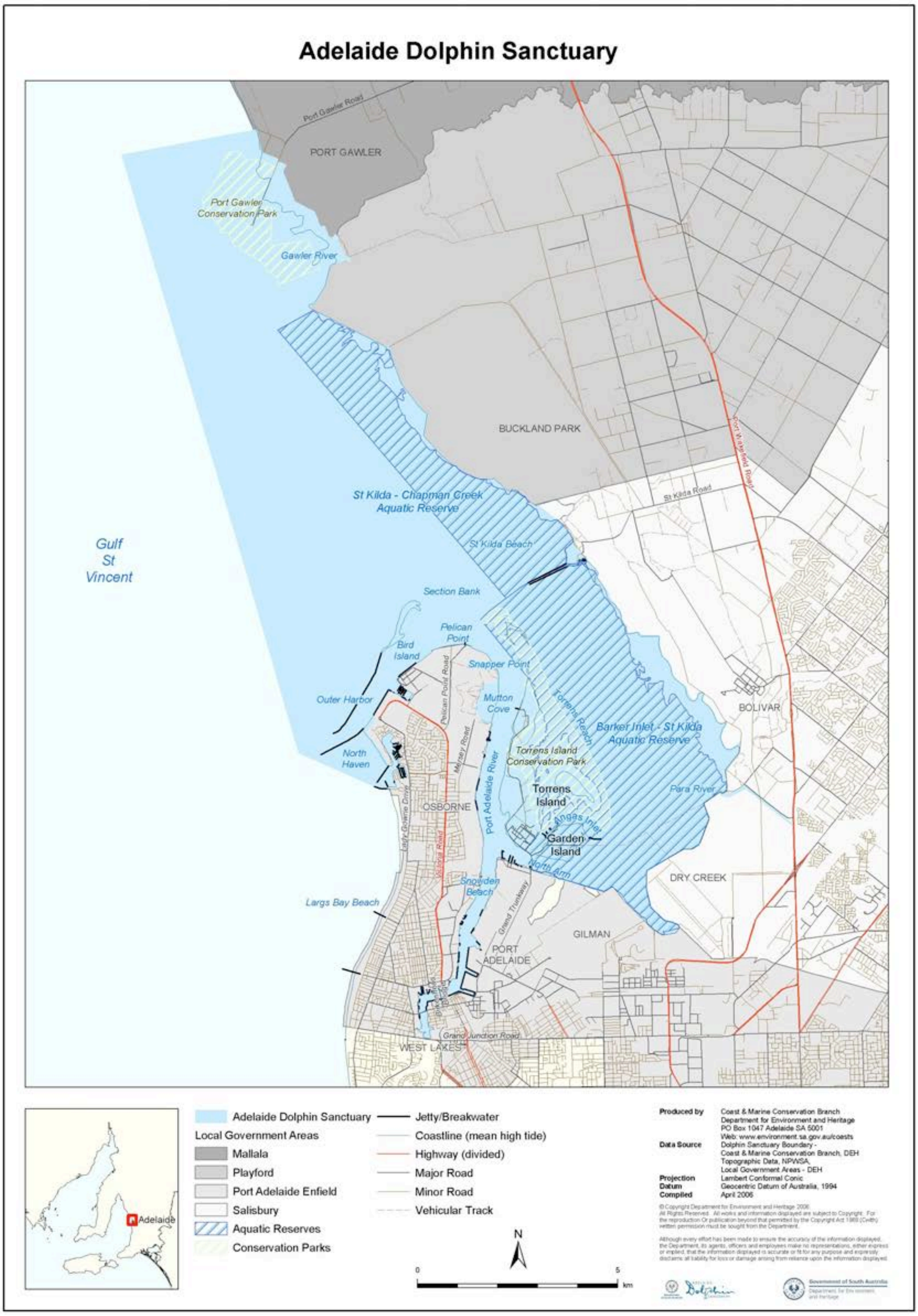
6 Attachment 1 – Map of the Adelaide Dolphin Sanctuary



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