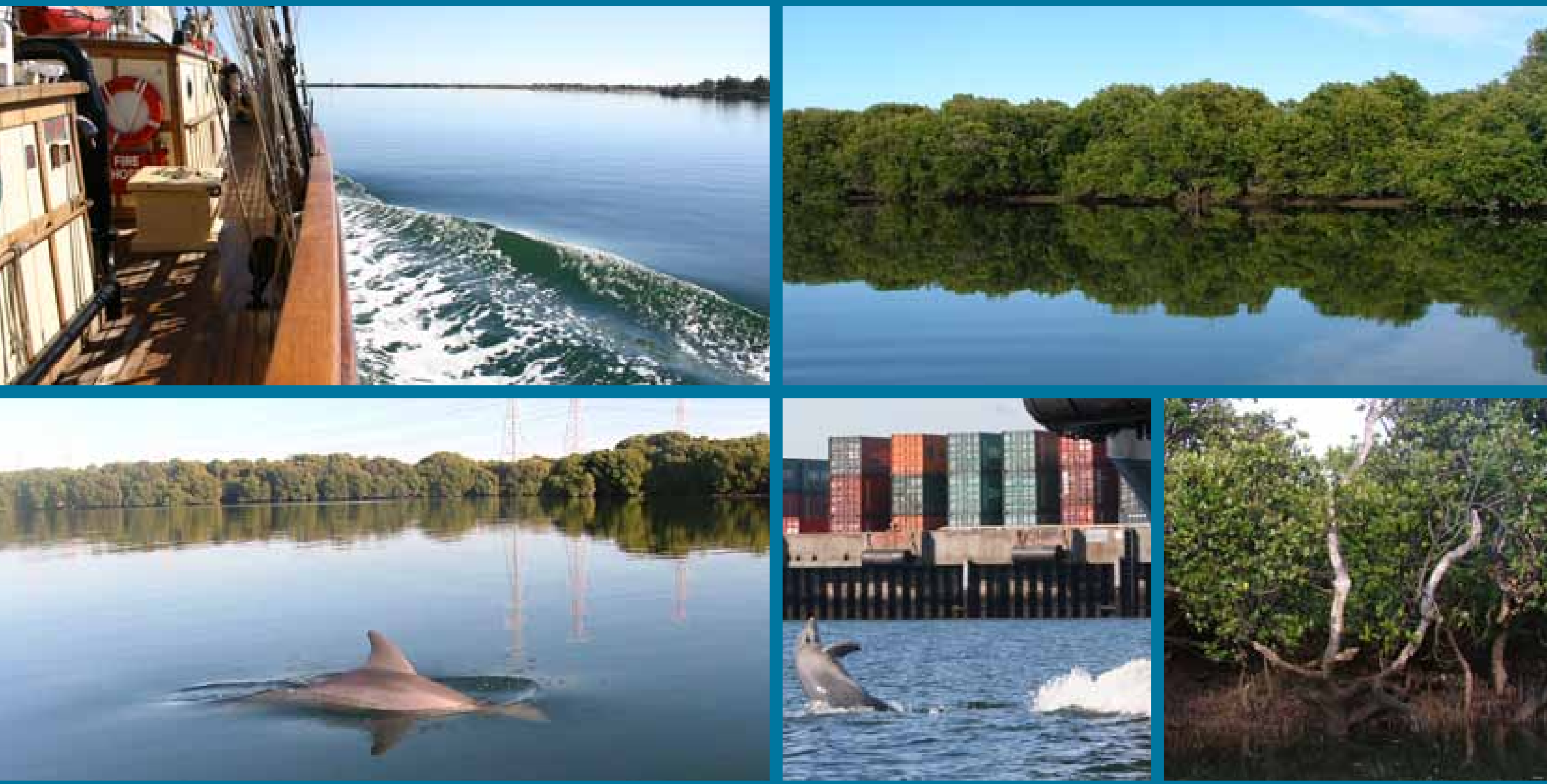
Department of Environment, Water and Natural Resources

Adelaide Dolphin Sanctuary



Reference Paper 2: Key habitat features necessary to sustain the dolphin population

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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This paper is available on the ADS website: www.adelaidedolphinsanctuary.sa.gov.au

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 resources.

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 second objective in the Act - Clause 8(1)(b):

> *The key habitat features in the Port Adelaide River estuary and Barker Inlet that are necessary to sustain the dolphin population are to be maintained, protected and restored* (Government of South Australia 2005).

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

- **Key** - essential**.**
- **Essential** - biodiversity, habitats and ecological processes without which the functioning capacity or integrity of systems would be severely impaired.
- **Habitat** - the physical place or type of site where an organism, species or population naturally occurs together with the characteristics and conditions which render it suitable to meet the lifecycle needs of that organism, species or population.

1.1 Methodology

This paper has been collated from a study of Australian and international research. It describes specific habitat features and characteristics, defines the status and any particulars known about the feature within the Sanctuary, and finally describes the feature's importance to the dolphins.

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 dolphins 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.

It is believed that three species of dolphins regularly frequent South Australian waters – the common dolphin (*Delphinus delphis*), the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and the common bottlenose dolphin (*Tursiops truncatus*). The Indo-Pacific bottlenose is the species most commonly found in ADS waters. Estimates of the number of dolphins resident in the ADS range from 30 to 60. Information quoted in this paper relates to both *Tursiops* species generally, unless otherwise stated.

While it is difficult to be certain which habitat features are essential to support the dolphin population, it is probable that dolphins will remain in the Sanctuary as long as there is:

1. Sufficient food;
2. A functioning ecosystem; and
3. Physical safety.

1.2 Sufficient food

The Sanctuary area is recognised as a significant nursery and breeding area for fish and other marine animals including squid and crustaceans. The presence of these animals means that dolphins in the ADS have food supplies readily available.

1.3 A functioning ecosystem

A functioning ecosystem is essential to support the on-going growth and development of both the dolphins and the animals on which they feed. Key components of the ecosystem include vegetation such as mangroves and seagrasses and a wide variety of animals from invertebrates, to fish, crustaceans and cephalopods, to the dolphins themselves. All of these organisms rely on adequate water quality to maintain ecosystem health.

1.4 Physical safety

It is likely that dolphins also favour the Sanctuary due to its safe and sheltered waters, which are generally free from their natural predators, particularly sharks. The shelter provided by this environment may be especially valuable for mothers and calves.

1.5 Interconnectedness

This paper discusses ADS habitat features individually as a way to understand them. The separation of these elements may lead to the false assumption that each can be managed in isolation from the others. It is important to acknowledge the difficulty in separately describing individual elements of the ecosystem without understanding the complex relationship and interdependence of all of the elements together.

Understanding this ecosystem interdependence is similar to understanding how a human body functions. For example, if we were trying to understand how a human body works, we wouldn't know much from just looking at the heart in isolation from the blood or the skeleton or the brain. All of the organs are essential to maintain human health and they can't work independently of one another. Natural ecosystems are equally connected. Just as damage to one of the human body's organs can have irreversible consequences for the whole individual, damage to one element of the ecosystem may have detrimental impacts for the entire environment.

When reading this paper it is important to remember the interconnectedness of all of the habitat elements discussed. The elements function together and are inherently linked.

1.6 Cumulative impacts

Cumulative impacts are those created by successive minor to major impacts taking place over a period of time. Cumulative impact is a major issue in the ADS due to the many and varied influences on the system, including industrial, recreational, commercial and residential activities.

The continued development of coastal areas, if allowed to proceed unchecked and without consideration of the long term and cumulative impact on the environment, will irreversibly affect the nature of South Australia's coastline and lead to significant damage that may be difficult and costly to repair (EPA 2003).

Some of the individual impacts in the Port River and Barker Inlet system can combine together to create more significant collective impacts. For example, excess nutrients in the system may cause increased growth of native algae, which in turn, can affect the growth of mangrove seedlings. Extra nutrients may also increase the rate of growth of introduced species causing broad impacts on seagrasses and the fish and other species that rely on them.

Bottlenose dolphins are particularly vulnerable to cumulative long-term impacts as they have an average life span of around 40 years, take a number of years to reach sexual maturity, have few offspring, and typically have two to three years or longer between breeding seasons. Therefore, population declines may take many years to become evident, by which time it may be too late to address the impacts causing the decline. This makes it important to look at the full range of activities together to really understand on-going ecosystem impacts. While the system may be able to absorb the impacts of a single given activity, it may not be able to absorb the impacts of this activity multiplied or combined with other actions.

2 Food supply – Follow the fish

The ready availability of food is an important aspect of maintaining habitat for the ADS dolphins.

The Barker Inlet, adjoining mangrove creeks, tidal flats, and sea grass and sand habitats all serve as important nursery areas for a number of fish, cephalopod (octopus, squid and cuttlefish) and crustacean species. The Barker Inlet system has been described as the most significant fish and crustacean nursery and feeding area in Gulf St Vincent, and is also a significant spawning area for some fish species (Baker 2004).

Fish from the Barker Inlet system travel to fishing areas as far as Cape Jervis, Stansbury, and Port Vincent (Jones 1984). Tagging studies have shown that yellow fin whiting from the estuary are found in metropolitan coastal waters, where they make up a significant portion of the recreational fish catch (Jones 1980). This shows the ecological significance of the area, not only for the dolphins, but also for other marine species and commercial and recreational fishing throughout the state.

The following species are found in ADS waters and are likely prey species for dolphins in the Sanctuary:

- Yellow fin whiting
- Snapper
- King George whiting
- Black bream
- Southern sea garfish
- Flathead species
- Western river garfish
- Mulloway
- Yellow eye mullet
- Australian salmon
- Jumping mullet
- Squid
- Striped trumpeter
- Tommy rough
- Flounder species
- Striped trumpeter

(Jones 1984; Connolly 1994).

Research on the distribution of fish species within the ADS has found that the greatest abundance of species is located in seagrass and mangrove habitats (Bloomfield and Gillanders 2005; Berens and Gannon 2003).

2.1 Bottlenose dolphin diet requirements

Several studies on the distribution of bottlenose dolphins have found a link between where they live and where they look for food (Hastie *et al.* 2003; Berens and Gannon 2003; Shane 2004; Miller 2003). This is supported by studies on the environmental factors influencing the presence and seasonal distribution of bottlenose dolphins along the Dorset Coast, England conducted by Sykes (2002). This study found that once local prey resources became depleted, dolphins relocated in search of better feeding conditions. This suggests that to keep the ADS dolphin population within Sanctuary waters, it will be necessary to conserve particular habitat areas that support prey species.

It is difficult to study the diets of wild dolphins to determine both the quantity and full range of species they eat. However, bottlenose dolphins are known to eat a wide variety of species, largely dependent on what is available (Reynolds *et al.* 2000).

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.

Reference Paper 1 - *Dolphins* provides further information on dolphin feeding activity.

2.1.1 ADS dolphins

Dolphins have been regularly observed feeding in Sanctuary waters. Although no specific research has been undertaken on prey species of ADS dolphins, it is thought that the dolphins feed on fish and squid regularly found in ADS waters.

South Australian Museum research analysing the stomach contents of bottlenose dolphin carcasses recovered at Port Lincoln, South Australia suggests that these South Australian *Tursiops* spp. consumed more cephalopods than fish (Kemper and Gibbs 1997). Prey species recorded include fish such as white trevally, yellow eye mullet, mulloway and whiting and cephalopods such as octopus, squid and cuttlefish.

Information about wild dolphins' diets is usually obtained by analysing the stomach contents of recovered dolphin carcasses. To find out more about ADS dolphins' diets, specific studies would need to be conducted on stomach contents already stored at the Museum and on any new ADS dolphin carcasses collected. This type of study is time consuming as it involves the analysis of the hard remains from prey species such as bones, spines, otoliths (accretions in fish ears sometimes known as fish ear bones) and cephalopod beaks that have accumulated in the stomachs. Accurate identification of these remnants is very exacting and requires comprehensive expert knowledge across a diverse range of marine species. It is also possible to identify 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 healthy 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.

2.2 Potential threats to food supply

Activities threatening the food supply may be directed both to prey species and to the habitat that supports these species. Direct threats to prey species are discussed below. Further threats to the broader habitat which may also impact the food supply are also discussed in section 4 - Productive Ecosystems, and section 5 - Broad Ecosystem Threats.

2.2.1 Fishing

Fishing activity both within and outside the ADS may impact on numbers of prey available for dolphins to eat. Impacts come from the direct removal of individuals within the ADS and removal of adult fish outside of the ADS that may have come into the ADS to breed, thus reducing the number of available individuals both in the ADS and in the wider ecosystem.

Recent efforts by PIRSA – Fisheries to manage fish stocks such as closures of areas, the licence amalgamation scheme, the net buy back and changes to size limits have all contributed to achieving sustainable fisheries.

Commercial fishing

Commercial fishing activity is not significant in ADS waters. It is known that some effort is targeted at blue crabs and mud cockles (Padula 2003). In addition, bait digging is undertaken both for personal use and for selling in bait shops. However, because of the breeding and nursery significance of the area, what happens to species caught outside of ADS waters can impact on animal numbers within the ADS. Existing data on fish species refers mainly to the economically valuable species caught commercially. These data have largely been collected by PIRSA and SARDI.

Data exclusively for fish catches in ADS waters is not available. Stock assessments for probable prey species vary from overfished, to fished to capacity, to under utilised. PIRSA – Fisheries is working to ensure all stocks are managed sustainably.

Fishery statistics for the full range of economically valuable species are produced by the South Australian Research and Development Institute (SARDI) and available online at:
http://www.sardi.sa.gov.au/dhtml/ss/section.php?sectID=273&tempID

Recreational fishing

Recreational fishing is a popular pursuit involving a significant number of South Australians every year and the ADS is an important location for this activity. Recreational fishers often consider that they contribute little to overall take, as individual catches are generally low. However, recent surveys have shown that the cumulative impact of all the individual catches is a significant draw on the resource (McGlennon and Kinloch 1997).

Of those species that are economically important, for example King George whiting and snapper, the recreational fishing quota accounts for 58% of total King George whiting caught and 40% of total snapper caught annually (EPA 2003). The 2003 EPA report goes on to say that for snapper, stock levels in Gulf St Vincent remain poor.

To ensure enough prey species for the dolphins remain in the ADS, on-going assessment of their populations is necessary, including those species that are not economically important.

2.2.2 Thermal pollution

The Torrens Island Power Station discharges cooling water into the Angas Inlet that is up to 10 degrees warmer than the normal water. Other power stations and industries also discharge warm water. It appears that this discharge may cause localised effects on congregations of species in the Angas Inlet. A study on the effects of cooling water discharge on the intertidal fauna in the Port River estuary conducted from 1972 to 1985 found changes in molluscs and worm species (Thomas *et al.* 1986). A second study in 1996 on the effects of warm water discharges on the community structure and distribution of fish also reports that thermal pollution has affected species composition in the inner estuary causing a decrease in native species (Jones *et al.* 1996).

The 1996 study also found that fish species diversity decreased as proximity to the discharge pipe increased. Further, the study found that some species were attracted to the warmer water and others were repelled. Some species avoid the area in warmer months and others are attracted to the area in winter months. This could lead to changes in distribution and species diversity in the area.

Connolly (1994) suggests that water temperature could influence the distribution of fish and the presence of seagrass. Indirect effects on fish species may also be caused by changes to habitat.

2.2.3 Other possible impacts

While little specific research has been conducted it is possible other activities may directly impact on prey species in the ADS. For example, it is possible that the wide variety of sounds in the ADS may have an impact on fish activities. Some fish use sounds to communicate and human noises may interfere with this. Noise may also prevent dolphins from detecting some prey species by masking the normal noises made by the fish.

Studies on the effects of climate change are beginning to reveal the possibility of impacts on the full range of marine and coastal plants and animals and the ADS is no exception to this. See section 5.2 – Effects of climate change.

3 Productive ecosystems

Functioning, productive ecosystems are required to sustain the ADS dolphin population and are essential to:

- Ensure there is sufficient food for the dolphin population;
- Provide adequate water quality for the dolphins and their prey;
- Ensure there is sufficient vegetation to support all species in the ecosystem with food and shelter.

Within the ADS, mangrove and seagrass communities are important to the health and productivity of the ecosystem. However, these elements do not function in isolation, as they are supported by the processes of other habitat types, such as saltmarsh and tidal flats.

The following section first provides an overview of two key ecosystem elements - mangroves and seagrass. The second part describes other habitat elements including saltmarsh, tidal flats, tidal creeks, estuarine river and unvegetated habitats that together support the entire ecosystem. These habitats are discussed in *An Inventory of Important Coastal Fisheries Habitats in South Australia* (Bryars 2003). See Attachment 2 for a map showing habitats in the ADS.

3.1 Key ecosystem features - Mangroves

Mangrove trees are flowering plants that live on the edge of the coast in the intertidal zone between the land and sea (Edyvane 1995). The grey mangrove (*Avicennia marina*) is the only species of mangrove found in South Australia. It grows from 3.5 to 5 metres in height and forms forests with mostly uninterrupted canopy cover (Bloomfield and Gillanders 2005). These trees have light green leaves with silvery-grey under surfaces and tubular shaped aerial roots called pneumatophores. Since mangroves occur in anaerobic soils (soils without oxygen), pneumatophores project vertically from the surface from the tree's root system to access the oxygen required for the plant's respiration.

Mangroves have small pale orange flowers that bloom from mid to late summer. Almond sized, green and slightly furry fruits are then produced (Edyvane 1995). These fruits are high in tannins and are not generally considered edible by humans.

The distribution of mangroves within an estuary is dependent on physical and chemical factors such as tidal height, the degree of wave exposure, the availability of suitable soils, and salinity levels.

3.1.1 Habitat significance

Mangrove forests are very productive areas that provide important habitats for many juvenile and adult marine species that are probable food sources for the dolphins. The mangroves play an important role in trapping sediment, acting as nursery areas for a wide range of fish and invertebrates, and protecting the fragile and important saltmarsh habitats from wave action (Cheshire *et al.* 2002). Mangrove pneumatophores act to stabilise the mangrove tree, and also play a significant role in stabilising surrounding sediment by helping to reduce wave action and providing an environment for sediments to settle (Edyvane 1995).

Mangroves also provide nutrients and organic material to the food web in the form of litter (leaves, twigs, bark, fruit and flowers). Some animals eat the energy rich mangrove leaves, while others eat decomposed leaves. The decomposition of leaves is facilitated by fungi and mud bacteria. This decomposing leaf material is called detritus, which acts as the bottom level of the mangrove food chain and is eaten by worms, crabs, shrimps and snails (Edyvane 1995). Marine species that are likely dolphin prey species use mangrove forests for a variety of habitat functions, including spawning and for shelter and are listed in Table 1.

Table 1: Marine species that are probable dolphin food sources and their uses of mangrove habitat.

Species	Spawning area	Nursery area	Feeding area
King George whiting (*Sillaginodes punctatus*)		***	
Yellow fin whiting (*Sillago schomburgkii*)	*	**	*
Garfish (*Hyporhampus melanochir*)	*	**	*
Yellow eye mullet (*Aldrichetta forsteri*)	*	**	*
Bream (*Acanthopagrus butcheri*)	*	*	*
Jumper mullet (*Liza argentea*)	*		*
Mulloway (*Argyrosomus hololepidotus*)			*
Snapper (*Chryosphrys auratus*)			*
Australian salmon (*Arripis trutta esper*)			*

*Known to occur commonly in the area
**Important area for this activity within Gulf St Vincent
***Major area for this activity within Gulf St Vincent
Source: Edyvane 1995.

A study of mangroves in Belize and Mexico found that mangroves are unexpectedly important to the survival of young fish. One significant species became locally extinct when mangroves were removed from an area. The study suggests that mangroves may provide both a refuge from predators and plentiful food which supports the juvenile survival rates. It also suggests that tropical coastal ecosystems are functionally linked and that sound conservation management should protect large areas of connected habitats rather than representative areas of specific types of habitat (Mumby *et al*. 2004).

3.1.2 Mangroves in the ADS

Significant mangroves in the ADS occur along North Arm and the Barker Inlet to the northern edge of the Sanctuary and are also found on Torrens and Garden Islands and at Mutton Cove and Mangrove Cove. The mangroves of the Torrens Reach and the Barker Inlet, north to Port Gawler Conservation Park represent the largest expanse of mangroves in Gulf St. Vincent and are the most significant nursery area for fish species in the Gulf (Edyvane 1991).

A study using aerial photographs from 1935 to 1982 examined mangroves in the ADS area (Burton 1982). It found three key areas of mangrove development. North of the ADS in the Light River Delta area, mangrove coverage moved seaward over an existing mud bank and also moved seaward around Middle Beach. From Port Gawler to St Kilda, the mangroves did not significantly expand or contract, and from St Kilda to the Swan Alley Creek area from 1935 to 1981, mangroves moved inland at an annual rate of approximately 17 metres (Burton 1982).

A subsequent study looked at changes in mangroves and samphire at North Arm Creek (Coleman 1998). It found that there is landward growth of mangroves in the southern Barker Inlet with a reduction of samphires in the area as a result. In addition, the mangroves are also moving seaward and covering a larger area in the southern Barker Inlet, with a maximum advance of 25 to 30 metres between 1979 and 1993.

On average mangroves on Torrens Island have advanced 1.8 metres per year. In total, mangroves are over growing salt marsh communities on Torrens Island at approximately five hectares per year (Fotheringham 1994).

On a rating system ranking management protection from extinct, nil, poor, moderate, reasonable and excellent, the mangroves in the Port Adelaide area are moderately protected and those on Torrens Island are reasonably protected (Kraehenbuehl 1996).

3.1.3 Threats to ADS mangroves

However, despite growth in some areas there are also some localised losses of mangroves within the ADS caused by a number of human-related activities and threats to the remaining mangroves still exist.

Mangroves have often been thought of as environmental wastelands, and because of this attitude, mangrove forests have been used as sites for sewerage outfalls and as illegal dumping grounds.

In addition, sediment movements related to wave action are reported to be a significant contributor to mangrove loss within the ADS (Mifsud *et al.* 2004). For example, it is suggested that offshore wave energy has increased within the ADS in the areas where seagrass loss has occurred, resulting in altered sediments and exposure to water. As mangrove pneumatophores are very sensitive to changes in sediment, changes in water depth and water exposure and/or a significant increase or decrease in wave activity can result in mangrove loss.

However, it is not certain if the increases in wave energy are a result of ongoing loss of sub-tidal seagrass or from other factors such as climate change or boat-generated wave action or a combination of factors.

Marina and boating waste discharges (black and grey water) have been identified as direct sources of nutrients to the Port River and Barker Inlet. The EPA's *Draft Code of Practice for Vessel and Facility Management: Marine and Inland Waters* (EPA 2005) includes the requirement of zero black water (sewage) discharges and the future requirement for zero grey water discharges. Vessel and industrial nutrient discharges can accelerate algal growth of species such as sea cabbage (*Ulva lactuca* and *Ulva rigida)* and cause seagrass loss. Seagrass litter and sea cabbage have been reported to smother mangrove pneumatophores and prevent or retard the establishment and growth of young mangrove seedlings (Edyvane 1991; Kirkman 1995).

Physical disturbance caused by boat-generated wave action (ship-wash), bait-digging, human trampling and illegal rubbish disposal may damage both mangroves and pneumatophores. For example, a section of mangroves near Mutton Cove has been identified as badly affected by boat-generated wave action (Cook and Coleman 2003).

Sediments within the ADS that support mangroves have the capacity to accumulate any material discharged to the near shore marine environment, particularly heavy metals and also polychlorinated biphenyls (PCBs) and organochlorines (Edwards *et al.* 2001). One study found that the inherent characteristics of mangrove muds – their fine particles, organic matter and sulphide production – provide an enhanced capacity for metal accumulation (Harbison 1986).

Analysis of sediments has shown that mangrove substrates in the Barker Inlet contain elevated levels of copper, lead and zinc (Edwards *et al.* 2001). These contaminants can come from industrial discharges, stormwater run off and/or from marinas and vessels. The effects of this accumulation on mangroves and other ecosystem elements are not understood.

Mangroves in the ADS are protected under the *Native Vegetation Act 1991* and the *Fisheries Act 1982*. Any action to clear this vegetation is potentially subject to a clearance application under the Native Vegetation Act or under the requirements of the Fisheries Act which prohibits removal or interference with aquatic or benthic flora, including mangroves within aquatic reserves. Amendments by the ADS Act mean that when administering the Native Vegetation Act, the Native Vegetation Council must now consider if clearance would cause significant harm to the ADS. The Council must also consult with the Minister for the ADS and comply with any directions given in regard to the clearance of mangroves.

3.1.4 Consequences of mangrove loss in the ADS

Any loss of mangroves may impact on the productivity and health of the overall ADS ecosystem. Mangrove loss could eventually lead to a reduction in prey species for the dolphins, potentially causing the dolphins to move elsewhere to search for food.

3.1.5 Rehabilitation of mangroves

Mangrove rehabilitation is taking place within the ADS. At Mutton Cove, tidal flooding regimes have been reinstated which will encourage the regrowth of mangroves along the creeks. A continued management program will be in place to monitor the progress of this project over the next 20 years (Cook and Coleman 2003).

The Port Adelaide Enfield Council manages a series of constructed wetlands including the Barker Inlet, Range and Magazine Creek Wetlands. The City of Salisbury manages the Greenfields and Connector Wetlands. Over 50 species of plants have been planted in the 337 hectares, including mangroves.

These wetlands provide a range of environmental benefits from bird habitat, to tidal areas for mangrove growth, saltmarsh regeneration and the provision of habitat for aquatic invertebrates, fish and crustaceans.

At Mangrove Cove, members of the local community and students at the Portside Christian School have actively re-planted mangroves and the plants are successfully recolonising tidal areas there.

Any rehabilitation efforts must be carefully planned. In some areas, mangroves are taking over other vegetation, especially saltmarsh, sometimes causing significant ecosystem alteration.

3.2 Key ecosystem features - Seagrasses

There are around 60 species of seagrass worldwide. Southern Australia is a centre of diversity for seagrass, as one third of the 60 species are found in Australian waters, including at least 14 that occur nowhere else (Edgar 2001).

Seagrasses are flowering plants that grow in soft sediments of marine and estuarine environments (Dieter *et al.* 2004; Kirkman 1997). They possess leaves, veins and roots, and reproduce from seeds by producing flowers fertilised from pollen. Seagrass meadows usually grow in estuaries, the lee of islands and sheltered bays around Australia. A recent study found that seagrass coverage was denser in summer months than in winter (Bloomfield and Gillanders 2005). The three physical factors believed to most affect the distribution of seagrass species on soft sediments are depth, turbidity and water movement (Edgar 2001).

3.2.1 Habitat significance

Seagrasses have a number of important roles in the functioning of marine ecosystems. They oxygenate water, recycle nutrients, stabilise sediment, expand the base of the food chain, support further seagrass production, and provide an important habitat for many fish and crustacean species, including those that are probable food sources for the dolphins (Bell and Pollard 1998; Coast Protection Board undated; Connolly 1994; Kirkman 1997).

A study on fish and invertebrate assemblages in Barker Inlet and their supporting habitats (Bloomfield and Gillanders 2005) found that seagrass habitat had the highest numbers of fish and invertebrates, followed by unvegetated habitats, mangroves and saltmarsh. It is thought that the diversity and abundance of fish associated with seagrass habitat is affected by the proximity of other habitats, with evidence suggesting that seagrasses near tidal creeks and mangroves receive species from these habitats (Bell and Pollard 1998).

The time fish spend in seagrass varies according to species. Some species are permanent residents, while other species use seagrass seasonally or for specific life stages (Bell and Pollard 1998). A study in Botany Bay, New South

Wales found that fish species use *Zostera* spp. as a nursery and *Posidonia* spp. later in life (Bell and Pollard 1998). Both of these seagrass species occur within the ADS.

Seagrass meadows provide significant nursery grounds for juvenile fish species by providing a good source of shelter, protection against predators, and food sources (Connolly 1994; Kirkman 1997). Studies of seagrass habitat in Australia have recorded that approximately 65% of species found in seagrass habitat were juveniles (Bell and Pollard 1998).

Seagrass habitat also provides an important source of shelter and food for adult fish and crustacean species. While few species of fish consume seagrass or the algae that grows on it, they do feed on small to microscopic plants and animals found within the habitat (Bell and Pollard 1998).

In addition, seagrass meadows host a diverse range of small organisms called epiphytes (plants and algae physically attached to the sea grass) and epifauna (small animals) living in microhabitats and grazing on the leaves, stems and root systems (Connolly *et al.* 2005).

3.2.2 Seagrass in the ADS

Seagrass habitats occur within the ADS from the northern boundary to the southern breakwater at Outer Harbor (Bryars 2003). Seagrass meadows in the Barker Inlet usually occur within 15 to 20 metres of the edge of mangrove forest, with a band of unvegetated area between them (Bloomfield and Gillanders 2005).

Seagrass species found within the ADS include *Zostera muelleri, Heterozestera tasmanica, Posidoniaceae, Amphibolis Antarctica* (Coastal CRC undated; Barker Inlet Port Estuary Committee 2004) and estuarine and intertidal mud flat species - *Ruppia* spp and *Lepilaena* spp (Coleman 2006 pers. comm.). Seagrass habitats around Torrens Island are dominated by *Zostera muelleri* (Bryars 2003).

Losses of *Heterozostera* began shortly after operation of the Bolivar waste treatment plant began in 1967 (Larkum *et al.* 1989). After this, losses of nearby *Posidonia* meadows followed, mostly between 1973 and 1976. Leaf densities, lengths and widths declined while growth of epiphytes increased, most likely as a result of the increase in nutrients from the waste treatment plant. Once initial stands of seagrass died, sediments from exposed areas covered remaining beds and losses continued.

The *Inventory of Important Coastal Fisheries Habitats in South Australia* confirms reports of long-term losses of *Posidonia* and *Amphibolis* seagrass species have occurred around Port Gawler, St Kilda and seaward of Port Adelaide (Bryars (2003). Near the Bolivar waste treatment works, the total cover of *Posidonia* decreased from 26.3% to 6.2% between 1949 and 1993 (Kinhill *et al.* 1995 In Edyvane 1999).

A study comparing fish assemblages from seagrass and unvegetated areas of reports that eelgrass (mainly *Zostera muelleri)* is a relatively fast-growing colonising plant that has persisted in many parts of the estuary, despite high levels of human modification including dredging, construction of wharves and shore reclamation (Connolly 1994). However, since the beginning of operations at the Bolivar waste treatment plant, 600 hectares of intertidal eelgrass have been lost adjacent to the outfall (Shepherd *et al.* 1989).

Within the ADS, seagrass meadows provide critical habitat for many fish and crustacean species. These include blue swimmer crab, razorfish, southern calamary, king and queen scallop, King George whiting, snapper, western Australian salmon, tommy ruff, southern sea garfish, red mullet, flathead, trevally, leatherjacket, snook and whaler shark. The loss of seagrass in the ADS would have a negative impact for these species (Connolly 1995), and potentially reduce available food for the dolphins.

Although it is not within ADS boundaries, survey work done at the Port Adelaide Waste Treatment sludge outfall may be useful in understanding seagrass recolonisation capacity. In 1978 a pipeline began discharging sludge 4.5 kilometres into Gulf St Vincent. By 1984, 365 hectares around the outfall was cleared of seagrass. The pipeline was decommissioned in 1993. In 2001, a survey showed a 32.6% cover of the bare area including species *Halophilia australis* and *Posidonia*. It is likely these plants have grown from seeds from a relatively distant source, considering the large area of clearance (Bryars and Neverauskas 2002).

3.2.3 Threats to ADS seagrass

While natural impacts such as storms and floods contribute to the loss of seagrass, there are a number of human activities that have accelerated seagrass loss within the ADS.

Both nutrients and pollutants can damage seagrass. Point source industrial discharges, stormwater, marinas and vessels discharging grey and black water and road run off are all contributors to the ongoing loss of seagrass.

In *Section Bank, Outer Harbor South Australia – Baseline Monitoring Program to Assess the Potential Impacts on Seagrass and Mangrove Communities from the Proposed Sand Dredging,* Mifsud *et al.* state,

> "Without doubt, by far the greatest threat to the long-term health and survival of the seagrass communities in the vicinity of Section Bank is … the on-going discharge of the high load of nutrients form the Bolivar WWTP and the Port River. Unless these inputs are reduced it appears inevitable that virtually all the seagrass communities in the vicinity of Section Bank will be lost within decades." (Mifsud *et al.* 2004)

See Reference Paper 3 – Water Quality for more information about nutrients in ADS waters.

The effects of PCBs, other organochlorines and heavy metals on the normal functioning of seagrass plants are poorly understood (Larkum *et al.* 1989). Studies have shown that there is a relationship between the presence of metals and species diversity. It appears that more contaminated sites may support fewer species than less contaminated sites. Metals can accumulate in surface sediments and might affect seagrass through root and rhizome absorption (Bell and Pollard 1998). These contaminants can come from industrial discharges, stormwater run off and from marinas and vessels.

Like any plant, seagrass requires light for photosynthesis. Increased sediment in water reduces access to essential light. Marinas and other structures may also obstruct the passage of light.

Physical disturbance from anchors and propellers, moorings and dredging can disturb seagrass beds and damage seagrass meadows (Kirkman 1997).

Seagrass is protected under the *Native Vegetation Act 1991*. Any action to clear this vegetation is potentially subject to a clearance application under Native Vegetation Act. Amendments by the ADS Act mean that the Native Vegetation Council must now consider if any such clearance would cause significant harm to the ADS.

3.2.4 Consequences of seagrass loss in the ADS

Seagrass is critical to maintaining the health of the ADS ecosystem. As fish rely on seagrass habitats for a variety of different functions, it can be suggested that the loss of seagrass habitat will eventually lead to the loss of prey species for dolphins. While some studies suggest that fish and crustacean species are able to persist in areas of seagrass loss, (Bell and Pollard 1998) this is only feasible if alternative sources of shelter and food are available. Because fish need a range of different seagrass species, it is important to maintain the full range of seagrass biodiversity.

A local scientist has observed that as a result of seagrass loss, a wide band of mangroves has died near the Bolivar outfall. The dead seagrass washed into the front line of mangroves, preventing drainage of the creeks and pools further inland and causing the inner mangroves to drown. Now the bare area of sand offshore has no seagrass softening the water flows, and as a result, the front line of relatively healthy mangroves is being eroded. Erosion causes their pneumatophores to retreat towards the trunk until the entire tree is balanced on a little island about a meter across. Several fall over in storms each year and no mangrove shoots can establish in the fast flow (Coleman 2005 pers. comm.).

This is an example of ecosystem interdependence within the ADS. The loss of seagrass causes a loss of mangroves, which in turn, may accelerate the loss of fish and other species reliant on this vegetation. To repair the mangroves, seagrass needs to be re-established across the area offshore from the Bolivar outfall. It is not known if the loss of seagrass habitat has altered fish assemblages or other ecosystem functions within the ADS.

3.2.5 Rehabilitation of seagrass in the ADS

To manage seagrass meadows properly, baseline measurements are needed to document their location and condition. A monitoring program is necessary to detect the effects of disturbance and distinguish those effects from natural variation (Kirkman 1997). In a seagrass community, the main parameters that can indicate change are biomass of above ground parts of the plant, density and productivity (Kirkman 1995).

A pilot project to restore seagrass meadows off the South Australian coast is currently being run by the Department of Environment, Water and Natural Resources and South Australian Research and Development Institute (SARDI) (Hill 2005). This project aims to provide a cost-effective method of restoring degraded seagrass meadows. However, even when successful rehabilitation techniques are found, it will still be necessary to ensure that the activities causing the original degradation are addressed before rehabilitation can proceed.

To address some of the causes of degradation, the EPA is developing a Water Quality Improvement Program (WQIP) for nutrients in the Port River and Barker Inlet in partnership with stakeholders in the area, such as SA Water and Penrice, to reduce nutrients discharged into ADS waters. See Reference Paper 3 – Water Quality for more information. This is predicted to significantly improve future water quality and reduce the growth of algae and epiphytes, which will create conditions more conducive to seagrass growth and survival.

Managing the health of seagrass meadows is not restricted to the meadows themselves, but includes the total management of everything that enters the seagrass habitat (Kirkman 1997).

3.3 Supporting ecosystem features - Saltmarsh

Saltmarshes are communities of low-growing herbs, shrubs and grasses that are tolerant of high salinity and poorly aerated soils (Dieter *et al.* 2004). They occur in areas where tidal inundation is regular but infrequent (intertidal zones), usually behind a stand of mangroves (Bloomfield and Gillanders 2005).

3.3.1 Habitat function

Saltmarsh is considered to be a valuable coastal habitat, creating a critical buffer zone between the mangrove community and land, regulating freshwater run-off and providing new habitat for colonising mangroves (Bass *et al* 1997). Saltmarsh habitats provide food for foraging fish at high tide, nutrients for adjacent food webs, and shelter for a range of marine animals, especially juvenile fish and crabs when inundated at high tide (Morrisey 2000).

A study of fish and invertebrates in various habitats found that saltmarsh habitat generally had significantly fewer fish and invertebrates than seagrass, unvegetated areas and mangrove habitats (Bloomfield and Gillanders 2005). Saltmarsh does provide habitat for other marine and terrestrial organisms such as invertebrates and birds, which are important to the functions of the whole estuary (Edyvane 1999).

Fish species' use of saltmarsh is likely to be seasonal with peak times for use at spring high tides (Coleman 2006 pers. comm.). Sampling of fish is extremely difficult in higher marshes inundated only for short periods on high tides. Although few species occur there, the higher marshes act as nursery areas for larval and juvenile fish. However, a study in the ADS caught no early juveniles of King George whiting in the saltmarsh, even though they were abundant in adjacent seagrass beds (Connolly *et al.* 1997). Further research is required to understand direct use of saltmarsh habitat by fish species (Bryars 2003).

Saltmarsh habitats are important roosting places for shorebirds and a diversity of habitat types (mangroves, saltmarsh and seagrass) are important to support fish stocks (Saintilan and Rogers 2002).

3.3.2 Saltmarsh in the ADS

Saltmarsh habitat occurs within the ADS parallel to the shoreline between Port Gawler Conservation Park and St Kilda; along the eastern shoreline of the Barker Inlet between St Kilda and Magazine Creek; on Torrens Island; on the south end of Garden Island, and in Mutton Cove (Bryars 2003; Baker 2004). Saltmarsh habitat currently makes up approximately 376 hectares or 13% of the Port River Barker Inlet Estuary area (Baker 2004).

Coastal saltmarsh overall distribution in Australia appears to be following the global trend and is declining (Howe and Rodriguez 2005) and South Australia is following this trend (Bryars 2003). During the twentieth century, the area of samphire saltmarsh in north-eastern Gulf St Vincent was greatly reduced by a combination of industrial and urban developments, including salt evaporation pans and waste disposal sites. In some metropolitan areas near the ADS, there have been 100% losses.

3.3.3 Threats to ADS saltmarsh

Key activities threatening saltmarsh communities within the ADS include industrial activity, development, tidal restrictions, coastal acid sulfate soils, sea level rise, increased sedimentation, off-road vehicle users, weed invasion, land reclamation, foot traffic, illegal rubbish dumping, freshwater flooding, and especially mangrove encroachment (Cook and Coleman 2003; Baker 2004).

Mangrove encroachment occurs under natural conditions when saltmarsh moves inland as favourable sites are created by land ward moving tidal patterns. This allows mangroves to spread onto the areas formerly occupied by saltmarsh. However, when some coastal developments occur, for example levee banks, there is no available land for the saltmarsh to colonise even though conditions have altered (Baker 2004). These altered conditions may then support mangroves more than saltmarsh.

3.3.4 Consequences of saltmarsh loss

The impact of saltmarsh loss in the ADS is not well understood. There is currently a lack of information about the fisheries habitat saltmarsh supplies in South Australia (Bryars (2003).

3.3.5 Saltmarsh rehabilitation

Alteration of water inundation patterns in Mutton Cove will certainly cause alterations in saltmarsh species in the area. Monitoring programs are in place to find out more about how the changes take place.

The possibility for saltmarsh rehabilitation experiments to be undertaken in Mangrove Cove is still under consideration. If this project proceeds, it could provide valuable information about rehabilitating saltmarsh elsewhere in the ADS and in other places.

3.4 Supporting ecosystem features - Tidal flats

3.4.1 Tidal flats

Tidal flats include vegetated or unvegetated mud flats, sand flats and intertidal seagrass meadows. Tidal flats are formed over a long period of time from deposits of fine silt and clay particles eroded from catchments, (Dieter *et al.* 2004) but generally have not been well studied in Australia.

Tidal flats are poorly drained environments and remain saturated with water at low tide. Few animals are able to survive in these oxygen deficient conditions, so most are found in the top few centimetres of sediment where oxygen is more available.

3.4.2 Habitat function

Tidal flats are an important habitat and feeding area for a number of species including blue swimmer crab, mud cockle, razorfish, baitworm, yellow fin whiting, western Australian salmon, tommy ruff, southern sea garfish, yellow eye mullet, flathead, flounder and black bream (Bryars 2003).

3.4.3 Tidal flats in the ADS

Tidal flats occur almost continuously between the southern boundary of the ADS to the St Kilda boat channel, (Bryars 2003). Tidal flats also occur around large parts of the Port River and Barker Inlet system, including the Section Banks (Bryars 2003).

3.4.4 Threats to tidal flats

Bait digging is undertaken on tidal flats. This activity removes the targeted invertebrate species from the ecosystem and may also incidentally damage other species. It also can cause physical impacts including damage to tidal flat areas. The impact bait digging may have on dolphin habitat is not understood.

3.5 Supporting ecosystem features - Tidal creeks

Tidal creek habitats are characterised by channels between low and high tide levels and often consist of a main channel with several other smaller branching channels.

Tidal creeks receive little or no freshwater input from the land and are regularly flushed by tidal movements (Bryars 2003). They may cut through mangrove forests and/or saltmarsh and usually retain some water at low tide. They often provide a vital link between intertidal habitats and the open ocean. If water movement along these creeks is cut off, the habitats that they supply with water become seriously degraded.

3.5.1 Habitat function

Tidal creeks provide habitat for a number of species, including blue swimmer crab, King George whiting, yellow fin whiting, Western Australian salmon, tommy ruff, southern sea garfish, yellow eye mullet, black bream, mulloway, flathead, flounder, razorfish, snapper and western river garfish (Bryars 2003). This is supported by Connolly *et al.* (1997), who found that tidal creeks are known to have greater abundances of fish than flooded saltmarsh.

3.5.2 Tidal creeks in the ADS

Several tidal creek habitats occur in the ADS between the boat channel at St Kilda, Gawler River delta creeks and Chapman Creek (Bryars 2003). Tidal creeks also occur adjacent to the Port River/Barker Inlet system south of St Kilda to the end of Barker Inlet.

3.6 Supporting ecosystem features - Estuarine river habitats

Estuarine river habitats are characterised by channels created from land-based freshwater flows. Estuaries receive sediment from both river and marine sources and are influenced by tide, wave and river processes (National Land and Water Resources Audit 2002).

3.6.1 Habitat function

Estuarine rivers provide habitat for a number of species, including blue swimmer crab, razorfish, King George whiting, yellow fin whiting, snapper, Western Australian salmon, tommy ruff, southern sea garfish, western river garfish, yellow eye mullet, black bream, mulloway, flathead, yellow tail kingfish, flounder, western king prawn, school whiting, flounder and whaler shark (Bryars 2003).

3.6.2 Estuarine river habitats in the ADS

Estuarine river habitats occur within the ADS at the Port Adelaide River, Barker Inlet, Angas Inlet, North Arm, Magazine Creek, North Arm Creek, Broad Creek, and Swan Alley Creek (Bryars 2003). Their importance as habitat for the dolphins and their prey species is not well understood.

3.7 Supporting ecosystem features - Unvegetated habitats

Unvegetated habitats include stretches of sand or mud, and may include areas of sparse vegetation or no vegetation at all. They are predominantly located between mangrove forests and seagrass meadows (Bloomfield and Gillanders 2005).

3.7.1 Habitat function

Animals found in unvegetated areas are largely adults of large, mobile fish species protected by schooling behaviour or by camouflage when viewed against sediments (Connolly 1994).

Unvegetated habitats support a number of species, including blue swimmer crab, western king prawn, razorfish, southern calamary, king scallop, queen scallop, King George whiting, yellow fin whiting, school whiting, snapper, Western, Australian salmon, tommy ruff, southern sea garfish, yellow eye mullet, red mullet, mulloway, flathead, snook, flounder and whaler shark (Bryars 2003).

Unvegetated areas adjacent to seagrass meadows have different fish assemblages, usually with fewer fish and fish species than seagrass meadows (Connolly 1994). Several studies suggest unvegetated habitats within the Barker Inlet are often dominated by schooling fish species such as *Atherinosoma microstoma* (small mouth hardyhead) (Bloomfield and Gillanders (2005), Jenkins *et al.* (1997), Rozas and Minello (1998). One study found that the difference in fish assemblages between seagrass and unvegetated habitat depended on the distance between the two (Ferrell and Bell 1991).

3.7.2 Unvegetated habitats in the ADS

Unvegetated habitats occur throughout the ADS. Their importance to the ADS ecosystem is not well understood.

3.8 Fauna

Many species of animals live in the diverse ecosystem of the Sanctuary. These species share the dolphins' environment and are linked to the habitat and food sources of the dolphins.

3.8.1 Birds

The ADS area provides important feeding, roosting, sheltering and breeding areas for fifty-seven recorded species of wading, coastal and sea birds (Baker 2004). These species include the Australian pelican, pied cormorant, black cormorant , oystercatchers, caspian tern, little egret , rufous night heron, silver gull, red capped plovers and crested tern.

Breeding waterfowl including the Australian shelduck, chestnut teal and pied oystercatchers nest on the sandy beaches and spits of Torrens Island and Outer Harbor. Black-winged stilts also commonly breed on samphire flats (Baker 2004).

A number of uncommon migratory birds also visit the Barker Inlet, including Torrens Island, during summer. These species include terek sandpiper, bar-tailed godwit, whimbrel and lesser golden plover (Baker 2004). The Barker Inlet and Port River estuary region is considered critical to the continued existence of the migratory pathways for birds that travel from Siberia and Mongolia, via Japan and the southern archipelago to southern Australia (Johnston and Harbison 2005).

Bird species found in the area listed as vulnerable under *National Parks and Wildlife Act 1972* (Schedule 8) include white-bellied sea eagle and little egret.

Samphire-dwelling bird species may be particularly vulnerable in the area due to the encroachment by mangroves on samphire habitat (Baker 2004).

3.8.2 Marine mammals

In addition to dolphins, New Zealand fur seals and Australian seal lions have also been observed in the Sanctuary by rangers patrolling the ADS (Morcom and Pendlebury, 2005 pers. comm.).

3.9 Pest species

Marine pest species are plants, animals and algae that have been introduced to an area where they do not naturally occur. Native species can also become pests when a change in natural conditions caused by human activity results in unnatural growth patterns of the naturally occurring species.

Pest species have been introduced to the ADS in a variety of ways, including via ballast water and from being attached to outside of ships coming into the Port from interstate and international waters. The Australian Government has recently signed an international agreement on the management of ships' ballast water to minimise, and to prevent where possible, the impact of pest marine species in Australian ports.

Some introduced marine pest species include dinoflagellates, sabellid fan worm, European shore crab, New Zealand greenlip mussel (Edyvane 1999) and the bryozoan *Zoobotryon verticillatum* (Coleman 2006 pers. *comm.)*.

Little is known about the distribution and potential impacts of these species to the ADS and to the dolphins. However, there are two additional introduced species of particular concern – *Caulerpa taxifolia* and *Caulerpa racemosa*.

Caulerpa taxifolia

The Invasive Species Specialist Group is part of the World Conservation Union and consists of 146 scientific and policy experts on pest species from 41 countries (Invasive Species Specialist Group 2005). The group lists *Caulerpa taxifolia* as one of the world's 100 worst pests. *C. taxifolia* was discovered in the Port River at the same time as the West Lakes infestation in 2002 and has since spread down river to near the old Quarantine Station, around Garden Island and into Eastern Passage, North Arm and the southern end of Barker Inlet, despite concerted eradication efforts using salt, chlorine and suction (PIRSA 2005).

When *C. taxifolia* invades, it pushes out native seagrasses replacing habitats for fish, especially nursery habitats. Organisms do not generally eat *C. taxifolia* because it contains a toxin that makes it distasteful (PIRSA 2005). It is suggested that this toxin may interfere with the eggs of some marine mammals as well as killing off many microscopic organisms (Makowka 2000). Large meadows of *C. taxifolia* have vastly reduced native species diversity and fish habitat (NIMPIS 2002).

The conditions in the Port River and Barker Inlet are particularly suitable for the rapid growth of *C. taxifolia* due to the combination of the artificially high level of nutrients in the water and warm water temperatures compared to the wider surroundings. If a small section of *C. taxifolia* is broken from the main body, it can colonise a new area, and if it remains damp, it can survive out of water for up to 10 days.

Actions to control the spread of *C. taxifolia* are currently being undertaken. For example PIRSA Biosecurity administered salt smothering treatment to sections of *C. taxifolia* around Jervois Bridge in 2005. In addition, patches are being manually removed by suction from particular areas and black plastic has been used to smother the pest.

Caulerpa racemosa

Caulerpa racemosa is native to Western Australia and is similar in growth habits and general appearance to *C. taxifolia*. Its potential impacts on the ADS habitat are uncertain. It appears to grow very quickly in ADS waters and it is possible that *C. racemosa,* may also push out local plants and impact on fish habitat, especially nursery habitats within the ADS.

However, little work has been undertaken to understand the impacts of *C. racemosa* on seagrass and fish in these waters and it is also possible that it is colonising degraded areas with elevated nutrients and will not have significant impacts elsewhere.

Sea Cabbage (*Ulva rigida*)

Sea cabbage is an algae native to South Australian waters. It is known to grow in Mediterranean type climates, and thrive in low oxygen waters, especially those with high nutrient loads and shallow, semi-enclosed systems with low water flow (Viarolio *et al.* 2005). Sea cabbage is opportunistic, grows quickly, and has a rapid uptake of nutrients, which aids in its fast spread throughout a marine system (Viarolio *et al.* 2005). The marine environment of the ADS with its elevated nutrient level maintains ideal conditions for this species.

Decomposing sea cabbage has also been implicated in directly lowering dissolved oxygen levels, which can lead to fish kills, particularly at night when oxygen levels are lowest (Viarolio *et al.* 2005). Sea cabbage can wash up onto mangroves and their pneumatophores causing direct impact to these plants and to other plants and animals in their immediate environment (Larkum *et al.* 1999).

4 Broad ecosystem threats

There are several threatening activities that broadly impact across all ecosystem elements.

4.1 Acid sulfate soils

Acid sulfate soils are naturally occurring soils or sediments that contain iron sulfide (Coast Protection Board 2003). Under oxygen-depleted conditions, iron present within soils combines with sulfur to form iron sulfides. When these sulfides are exposed to air, oxidation occurs and sulfuric acid is produced.

Prolonged exposure of acid sulfate soils to air can release acid and metal ions into the environment and cause a number of environmental impacts. These include physical, chemical and biological changes to soil, creation of acid water that can result in fish kills, physical damage to fish, and fish infections. Plant communities can be damaged when some species die, and acid tolerant species may become more dominant. Both of these effects can impact on prey species of the dolphins.

The Port River/Barker Inlet system contains approximately 12 km^2 of potential acid sulfate soils and 2.5 km^2 of actual acid sulfate soils (Davies *et al*. 2002; GeoScience Australia 2001). It is reported that acidic soils and sediments are a significant problem in the St Kilda Bay area (Baker 2004) as a result of previous swamp drainage.

The Coast Protection Board has developed a strategy to minimise any adverse effect to the coastal ecosystems from coastal development and potential acid sulfate soils and actual acid sulfate soils.

4.2 Effects of climate change

Coastal wetlands, such as those in the ADS, are expected to be very sensitive and respond rapidly to climate change (Meynecke 2005). According to the Intergovernmental Panel on Climate Change, the global average surface air temperature is projected to warm 1.4 ^{o}C to 5.8 ^{o}C by 2100 relative to 1990. Globally averaged sea levels are projected to rise 0.09 to 0.88 metres by 2100 (McCarthy *et al.* 2001). A study conducted into the relationship between the degree of mangrove encroachment landward and relative sea-level rise in eastern Australia concluded that continued mangrove encroachment is a likely outcome of greenhouse-related sea-level transgression (Rogers and Saintilan 2005).

Some studies have also reported changes in the distribution of fish species in response to climate change, with certain species moving to cooler water (Towie 2005).

In conjunction with federal and state governments, the Port Adelaide Enfield Council is undertaking a flood management study for the LeFevre Peninsula area. The aim of the study is to assess the combined effects of projected climate change (particularly sea level rise), development-related increased stormwater generation, and potential storm surges on the coastal areas.

The flood management study also intends to identify the best mix of strategies to manage and mitigate these impacts. Management strategies will include consideration of the impact of any proposed strategies on the ecosystems of the marine environment of the Barker Inlet, including the ADS area (Sanders 2006 pers. comm.).

4.3 Acoustic pollution

The study of the effects of acoustic pollution on marine ecosystems is a growing field. Oceans are not the silent places they may first appear to be, and a range of marine species use sound to communicate. The cumulative impacts of human introduced noise from, for example, vessels, seismic testing, drilling, dredging and military exercises are only beginning to be considered. There are a number of human caused noises generated within the ADS and the cumulative effects on the dolphins specifically, or on the habitat as a whole, are not currently understood.

4.4 The Port of Adelaide

The Port of Adelaide is South Australia's major port facility with approximately 2000 large vessel movements per year. It is a key export facility for South Australian products, including grains, wine, motor vehicles and automotive components and mining products. In 2004/5 9.8 million tonnes of cargo were moved through the Port (Flinders Ports 2006a). Continuous vessel movements occur throughout the year during both the day and night (Reardon pers. comm.).

These vessel movements have the potential to impact the habitat by normal and accidental discharges and by introducing pest species.

Flinders Ports operates the Port Adelaide facility and is responsible for dredging, reclamation, land contamination, stormwater management, and sewage and trade waste systems (Flinders Ports 2006b). Australian Quarantine and Inspection Service (AQIS) is responsible for managing ballast water on international ships. Management arrangements for domestic sourced ballast water are currently under development and voluntary codes of practice are expected to come into effect in the middle of 2007 with regulatory capacity in the following year.

4.4.1 Dredging and turbidity

In February 2006, a major dredging project was completed, which deepened the Port Adelaide shipping channel by two metres, extended the channel by three kilometres into Gulf St Vincent, and widened parts of the channel, to allow larger container ships to enter the Port (Government of South Australia 2006). The dredging was undertaken to secure the Port's future to allow the entry of larger container ships.

It is recognised that dredging operations have the potential to impact the ADS environment. Dredging may cause impacts by significantly increasing turbidity, causing sediments to smother marine fauna and flora, reducing light availability for photosynthesis, as well as the direct removal of flora and fauna.

5 Conclusion

This paper provides information about one component of the Adelaide Dolphin Sanctuary. The topics raised here must be considered along with issues about the dolphins' physical safety, 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 habitat damage already caused by human activity, 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 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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Personal Communications

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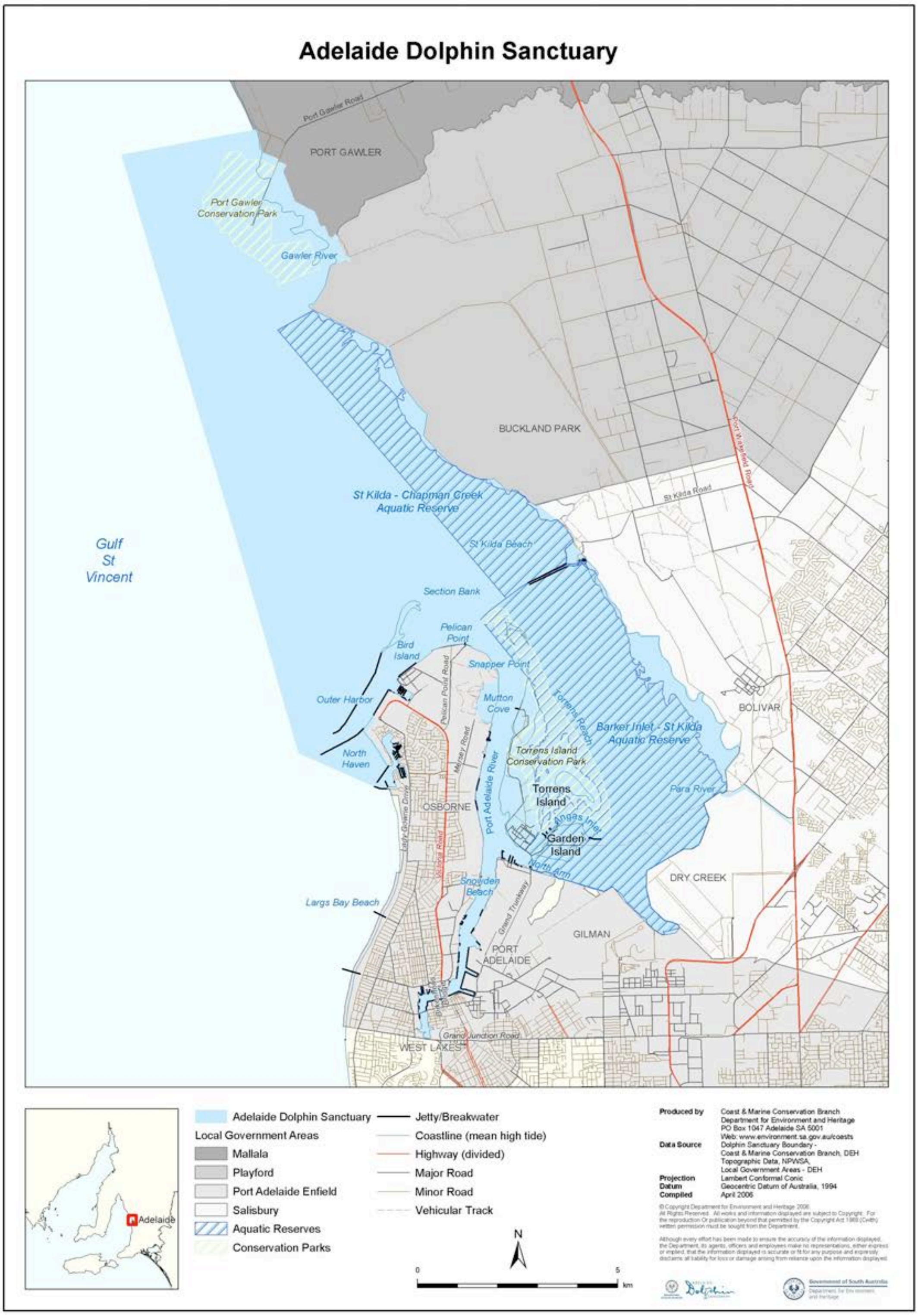
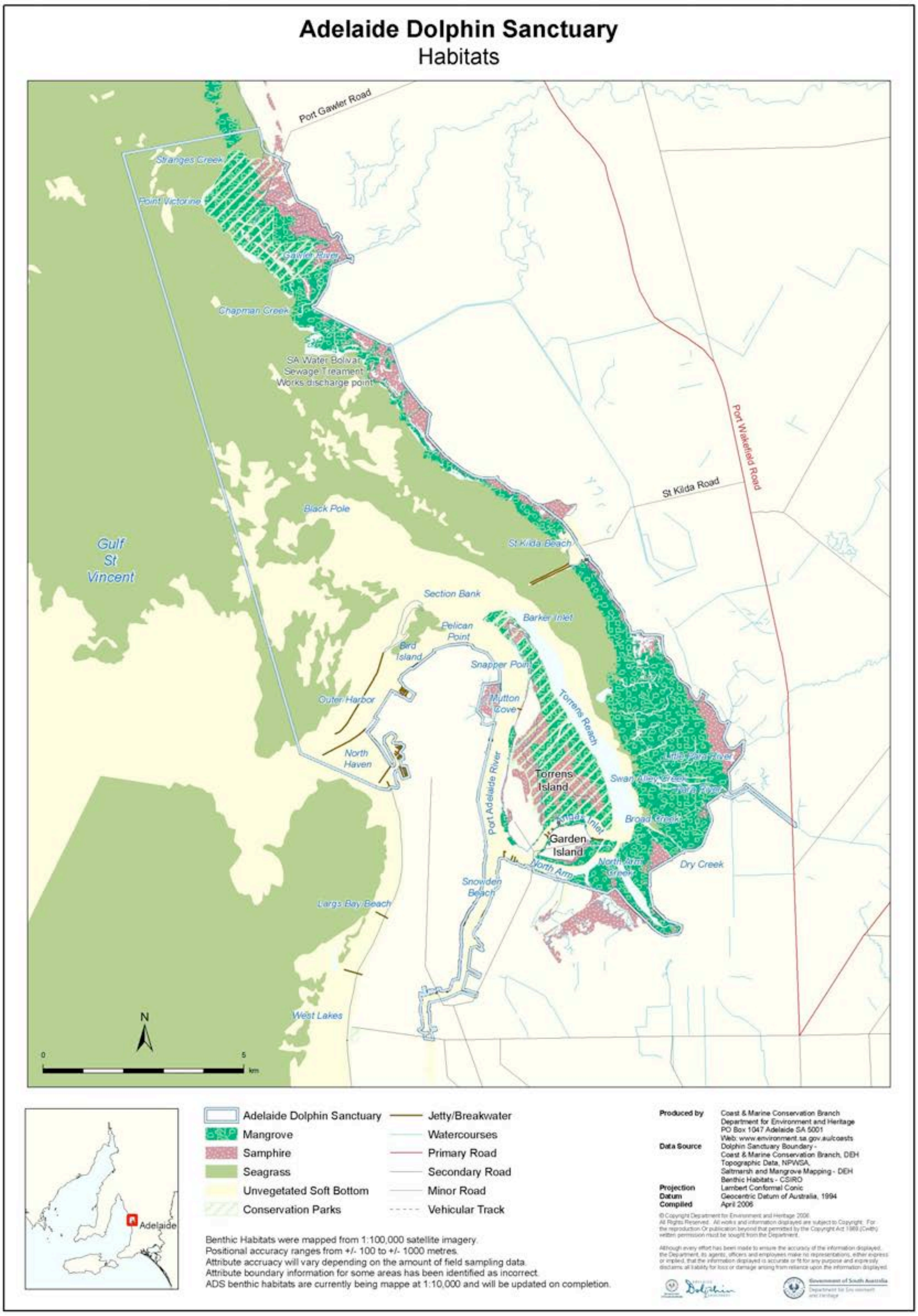
6 Attachment 1 – Map of the Adelaide Dolphin Sanctuary



7 Attachment 2 – Map of Adelaide Dolphin Sanctuary – Habitats



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Department of Environment, Water and Natural Resources
Phone Information Line (08) 8204 1910,
or see SA White Pages for your local
Department of Environment, Water and Natural Resources office.

Online information available at:
http://www.adelaidedolphinsanctuary.sa.gov.au

Photographs: Department of Environment, Water and Natural Resources
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