LOCAL ACTION PLAN FOR THE

COORONG FAIRY TERN *Sternula nereis*

SOUTH AUSTRALIA

David Baker-Gabb and Clare Manning

Cover Page: Adult Fairy Tern, Coorong National Park. P. Gower 2011 ©

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Coorong Fairy Tern *Sternula nereis*

South Australia

David Baker-Gabb[1] and Clare Manning[2]

[1] *Elanus Pty Ltd, PO BOX 131, St. Andrews VICTORIA 3761, Australia*

[2] *Department of Environment and Natural Resources, PO BOC 314, Goolwa, SOUTH AUSTRALIA 5214, Australia*

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Executive Summary

The Local Action Plan for the Coorong fairy tern (the Plan) has been written in a way that, with a minimum of revision, may inform a National and State fairy tern Recovery Plan. The fairy tern is currently listed as *Vulnerable* under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Implementation of the Plan is urgent. The Coorong forms part of the Coorong and Lake Alexandrina and Lake Albert Wetland of International Importance and is a stronghold for the species. The Coorong fairy tern population has declined markedly (Paton 2003; Paton and Rogers 2009a) with a current population 169 individuals (D Paton 2011 *pers. comm.*), an almost 89 % decline since 1984-1985. Without urgent and effective management to ensure successful recruitment in the next three years, there is a real risk that this specie will become locally extinct.

Fairy terns that successfully bred in the Coorong, nested on islands (Paton 2003). Paton (2003) concluded that fairy terns in the Coorong did not appear to be limited by food or predation because breeding success was moderately high in terms of numbers of nesting attempts that led to fledged chicks. Since 2006 however, island nesting sites secure from mammalian predators face a new threat of an inadequate supply of small fish, in particular the small-mouth hardyhead *Atherinosoma microstoma* (Paton and Rogers 2009b,c). The decline of freshwater fish is the result of a significant increase in salinity levels, which exceed their salinity tolerance. The increase in salinity levels is strongly linked to escalating demands for water and over-allocation of water resources in the Murray-Darling Basin, combined with severe drought.

In recent years, fairy terns in the Coorong have shifted northwards to breed on the Younghusband Peninsula near the Murray River mouth (the Murray Mouth). While a reliable source of suitable-sized fish are available in close proximity to nesting sites at the Murray Mouth, the nesting sites are suboptimal with greater susceptibility to mammalian predators, human disturbance and water inundation (Paton and Rogers 2009b; DENR 2011). Consequently, fairy terns that have bred on the Younghusband Peninsula have successfully produced very few fledglings (Paton and Rogers 2009b; C Manning 2011, *pers. comm.*).

For fairy terns and other waterbird populations to remain stable there must be adequate and suitably timed flows from the Murray-Darling Basin. To recover and maintain the Coorong's ecological and cultural character, appropriate integrated management of water resources at Basin level that recognises conservation values of downstream ecosystems is fundamental. In the event that adequate and suitably timed flows are not secured for downstream ecosystems, alternative actions such as intensive nesting site management, creating dredge spoil islands and/or creating nesting pontoons may provide some security for the fairy tern, but at a high financial cost. Such management tools have been successful in the recovery of other species of tern in Victoria (Reside 1996) and New South Wales (NSW NPWS 2003). Eight management options have been explored, of which intensive management of nesting sites is the minimum and essential management option.

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1.0 Introduction

1.1 Current Conservation Status

The fairy tern *(Sternula nereis nereis)* (herein the fairy tern) is currently listed as *Vulnerable* under the *IUCN Red List of Threaten Species* (BirdLife International 2009) and under *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The fairy tern is also listed as *Vulnerable* under the Tasmanian *Threatened Species Protection Act 1995*, *Endangered* under the South Australian *National Parks and Wildlife Act 1972* and threatened under the Victorian *Flora and Fauna Guarantee Act 1988*.

Sternula nereis davisae in New Zealand with an estimated 35-40 pairs (Hansen 2005; Wilson and Hansen 2005), and *Sternula nereis exsul* in New Caledonia with an estimated 100 pairs (BirdLife International 2000) are both considered *Nationally Critical*, equivalent to the IUCN category of *Critically Endangered* Hitchmough (2002) (cited Hansen 2005, p. 6).

1.2. Description

1.2.1 Taxonomic Description

Three subspecies of fairy tern, differing mainly in size, are recognised: one from south-eastern and western Australia *Sternula nereis*, and one each from New Zealand (*davisae*) and New Caledonia (*exsul*). Geographical variation within nominate *nereis* of Australia is negligible, although populations from Western Australia were once considered a separate subspecies: *horni* (Higgins and Davies 1996). Until recently the scientific name, *Sterna nereis nereis* was applied to the fairy tern (Christidis and Bowles 2008) however under the EPBC Act (1999) the fairy tern in Australia is listed as *Sternula nereis neris*.

The fairy tern and little tern *(Sternula albifrons*) have been recorded interbreeding (Cox and Close 1976; Garnett and Crowley 2000), but this has had minimal impact on either species to date (Birds Australia 2009).

1.3. Characteristic Description

The fairy tern is a small (ca. 25cm in length and 70g in weight) (Hitchcock 1959) piscivorous bird, although small gastropods and crustaceans have been reported in gut contents (Hitchcock 1959). The fairy tern is generally restricted to shallow coastal wetlands and estuaries (Higgins and Davies 1996). The fairy tern is much smaller than all other Australian terns except the slightly smaller little tern (ca. 20-28 cm in length) (Hitchcock 1959; NSW NPWS 2003). Both sexes are similar in plumage; adults in breeding plumage are distinguished from the closely-related little tern by their completely bright yellow-orange bill and diagnostic black and white head pattern. When not breeding their fore-crown is streaked black and white and their dull orange bill has a black tip and base. Juvenile and immature birds look similar to non-breeding adults, but have narrower black head bands and duller bill and leg colours (Higgins and Davies 1996). Distinguishing features of a breeding adult and juvenile fairy tern are shown in Plate 1.

1.4. Distribution

The fairy tern is found in coastal Australia (sub-species *nereis)*, New Caledonia (*exsul*) and northern New Zealand (*davisae*) (Plate 2). In Australia, the fairy tern is found in Western Australia, South Australia, Victoria, Tasmania and New South Wales, an area of occupancy estimated to be 1150km^2 (Conservation Advice 2011).

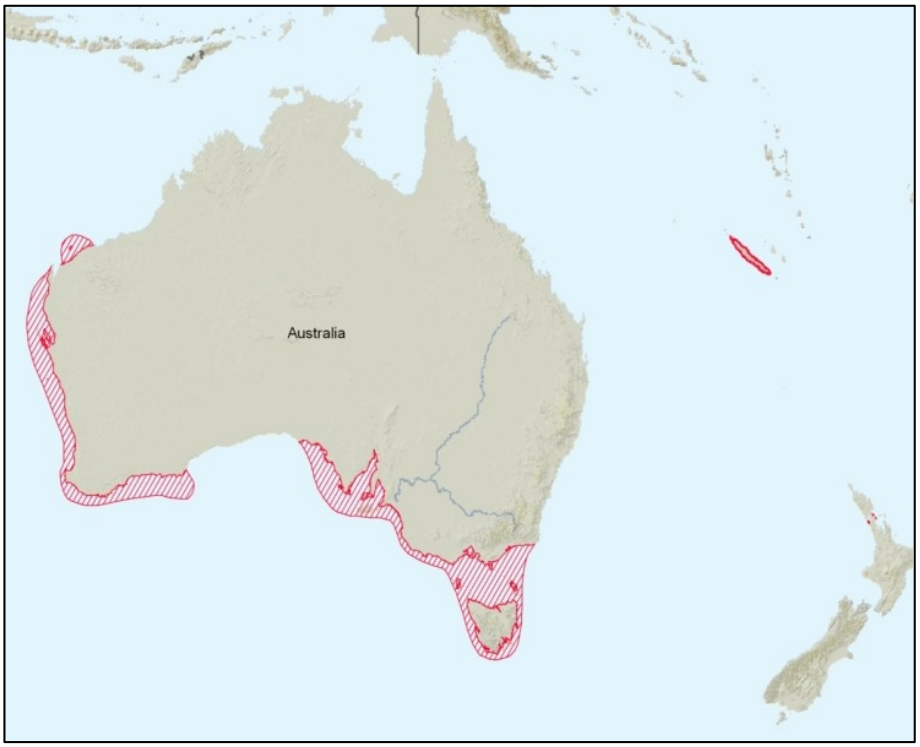
In South Australia, the fairy tern is primarily located in two regions 1) south-east of South Australia including the Coorong and 2) the coastline of Eyre Peninsula including a number of neighbouring offshore islands (Hitchcock 1959, Blakers *et al*. 1984) (Plate 3).

Plate 1. Breeding adult (A) and juvenile fairy tern (B).

Breeding adult fairy tern, Coorong National Park. S. Bourne 2011 ©

Banded juvenile fairy tern, Coorong National Park. K. Bartley 2011 ©

Plate 2. The current global distribution of fairy tern (IUCN 2011).



Fairy terns have been recorded between Port MacDonnell and Fowlers Bay, with records between the Fleurieu and Eyre Peninsulas, including Paisley and Casuarina Islets on Kangaroo Island (Blakers *et. al* 1984; Bransbury 1992; Copley 1996). In the last decade however, the fairy tern appears to have declined on Kangaroo Island (Paton *et al.* 2002) although observations were noted in 2010-11 at Busby Inlet Conservation Park near Kingscote and Cape Rouge (C Baxter 2011 *pers. comm.*). There are observations of fairy tern breeding on the Eyre Peninsulas including offshore islands within the Nuyts Archipelago Conservation Park and Kirby Langdon and Stickney Island on Sir Joseph Banks archipelago (J Van Weenen 2011, *pers. comm.*, J Cooper 2011, *pers. comm*). Sightings have also been noted on Waldegrave and Lilliput Island (Shaughnessy 2007; Shaughnessy *et al.* 2008) as well as areas on the mainland including Sceale Bay Conservation Park and at Lake Hamilton (J Cooper 2011, *pers. comm.*). Sightings of fairy tern from the Nullarbor coast in western South Australia have also been recorded (J Cooper 2011, *pers. comm*). With the exception of Franklin Harbour, there appear to be few sightings on the eastern coastline of Eyre Peninsula (E Smith 2011, *pers. comm*).

Historically, the fairy tern has been observed on Yorke and Fleurieu Peninsula. Further south on the Fleurieu Peninsula, colonies of fairy terns have been recorded at Encounter Bay, but there have been no breeding records since the late 1970s and birds have rarely been sighted in recent years (Copley 1996, D Paton 2011, *pers. comm.*). East of Encounter Bay, in the Coorong National Park, up to twelve breeding sites are known (Plate 4). The majority of these sites are islands located in the Coorong South Lagoon (Appendix 1). South-east of the Coorong National Park the fairy tern has been reported at Beachport and Port MacDonnell. Fairy terns have been recorded at Lake George in particular Rooney, Woolley and Cockies Point (M Christie 2011, *pers. comm.*), and on Cowrie Island near Beachport with records of fairy terns at Robe and Nora Creina Bay (Bransbury 1992).

In Western Australia, the fairy tern is widespread along the coast and on nearby islands (Hitchcock 1959) from the Dampier Archipelago south to Israelite Bay (Plate 2) and some historical records from the Kimberly region (Higgins and Davies 1996). In New South Wales, the fairy tern is a rare visitor and the first confirmed nesting record was in 1994/95 at Wallagoot Lake (NSW NPWS 2003).

There are a few records of fairy terns from eastern Victoria however the specie appears more widespread near Corner and Shallow Inlets and between Westernport Bay and Port Phillip Bay, notably on French Island (Higgins and Davies 1996). In recent years, fairy terns have been reported at Anderson's Inlet at Inver (C Minton 2011, *per. comms*.). In Tasmania the fairy tern is widespread on islands in the Bass Strait including King Island and the mainland (Brothers *et. al* 1996; Woehler 2009). Known nesting sites on King Island include Yellow Rock Beach, Christmas Island, Lavinia Point, and the coast between Sea Elephant River and Cowper Point (Woehler 2009). King Island has been reported the most important breeding site in Tasmania (Woehler 2009).

1.5 Population Trends

According to Strathalbyn Naturalist Club (SNC) (2000) up to 200 fairy terns were recorded at Mosquito Point along the northern shore of Lake Alexandrina between 1967-68 and almost 300 fairy terns were recorded near Tolderol Game Reserve, <3km south of Mosquito Point in 1968. Both of these sites are near (<30km) to the Coorong. Breeding has been recorded on Bird Island, in the Coorong North Lagoon (SNC 2000), with 30 nests being counted in 1969 however no fairy terns have been recorded there since. In 1984-85, the Coorong supported a fairy tern population of c.1, 500 individuals (Paton 2010). In 2000, between 680 and 700 birds was estimated, since then there has been a rapid decline. In January 2011 the estimated Coorong fairy tern population was 169 individuals (D Paton 2011, *pers. comm*.), a decline of almost 89%. In addition, no concurrent increases have been reported elsewhere in South Australia, or inter-state.

Since 2000, at least two chicks banded in 2006 have been successfully recruited into the Coorong breeding population (D Paton 2011, *pers. comm*.). In 2010-11, 7 banded chicks were observed to have fledged but whether these individuals have been successfully recruited into the Coorong breeding population remains unknown. Nesting failures and the current age of fairy tern in the Coorong e.g. 10-years (the maximum longevity recorded to date is 14 years) (Paton and Roger, 2009b) indicate that without a successful breeding event in the next 1-2 years the fairy tern faces imminent local extinction. Fairy terns are still reported further south-east of the Coorong, however breeding success appears to be very low (D Paton 2011, *pers. comm.*; J Campbell 2011, *pers. comm.*).

In South Australia, there are several records of fairy terns breeding on the West Coast of the Eyre Peninsula including a colony of 60 nesting on a low lying sand spit within the Nuyts Archipelago Conservation Park (J Van Weenen 2011, *pers. comm*.). In 2010-11, up to 37 breeding pairs with chicks were reported at Sceale Bay Conservation Park and 60 adults with c.30 incubating at Lake Hamilton (J Cooper 2011, *pers. comm*.). Up to 300 breeding pairs at Ward Spit north of Port Pirie were once recorded on Yorke Peninsula (Wilson 2000). Less than 20 pairs have since been periodically reported with no successful breeding recorded in recent years (D Paton 2011, *pers. comm*). On the Fleurieu Peninsula a colony of 50-100 pairs formerly bred on islands near Encounter Bay (Copley 1996). At Port Adelaide however about 35 pairs attempted to breed in late 2010, but due to water inundation breeding was unsuccessful (G Johnston 2011, *pers. comm*.). Until the early 1990s, colonies of 40-60 pairs of fairy terns were reported breeding on Kangaroo Island at Paisley and Casuarina Islets, with other pairs nesting on sheltered sandy beaches at Busby Inlet Conservation Park and Cape Rouge (C Baxter 2011, *pers. comm.*). In 2006, a flock of about 100 individuals were observed at Casuarina Islet (C Baxter 2011, *pers. comm.*), but no breeding was observed.

Western Australia remains the stronghold of the fairy tern with over two-thirds of the global population considered stable (Garnett and Crowley 2000; Birds Australia 2009; BirdLife International 2009), and South Australia has the second largest population. The apparent decline in Victoria has been observed between Westernport and Port Phillip Bays (Menkhorst *et. al* 1988), although a new sandbank at Andersons Inlet at Inverloch is reported to have provided suitable nesting habitat resulting in successful breeding events of at least 50 pairs between 2009-11 (C Minton 2011, *pers. comm.*). At one colony in south-eastern New South Wales numbers have increased from 3–4 individuals in 2005 to 70 individuals in 2009 (Dunn and Harris, 2009). In Tasmania, approximately 180 pairs of fairy tern nest and about two-thirds of the population breed on King Island, making King Island the most important breeding site for the fairy tern in Tasmania (Woehler 2009). All other

colonies of fairy tern on the Tasmanian coast are typically between 2 and 25 pairs, with the larger colonies at Sea Elephant River.

Cowper Point and Lavinia Point are significant breeding localities for Tasmania and Australia. Known nesting sites on King Island include Yellow Rock Beach, Christmas Island, Lavinia Point, and the coast between Sea Elephant River and Cowper Point. Surveys and monitoring of these sites in the 2006 to 2009 breeding seasons suggest a combined total of approximately 120 to 140 pairs nest on King Island (Woehler 2009).

The total population of mature fairy terns is approximately 5,000 birds (BirdLife International 2009). The fairy tern however has undergone a substantial decline of about 24% over the last 33 years. This decline is expected to continue at a substantial rate over the next few decades, as there is no evidence that the threats affecting this species are abating (Threatened Species Scientific Committee (TSSC) 2010).

1.6 Breeding

In the Coorong region about 50% of 100 or more nests successfully fledged young in both 1999 and 2000 (Paton 2003). Breeding success has however declined markedly in the Coorong with <5% of birds counted between 2003 and 2007 being juveniles (D Paton 2011, *per. comms*.). No successful breeding was recorded in 2008-09 (Paton and Rogers 2009b). Seven juveniles fledged from a colony with c.60 breeding pairs in 2010-11 (C Manning 2011, *per. comms*.).

In southern Australia nesting occurs between October and March, the height of breeding being December-January (Bransbury 1992), although egg laying may not be synchronous within colonies (D Paton 2011, *per. comms*.). Rarely more than 1-2 eggs are laid in a shallow scrape. Incubation, by both sexes, lasts 21-23 days (Wilson and Hansen 2005). Generally, one egg from two-egg clutches fails to hatch (Le Soeuf 1902). The chicks are brooded for up to six days by which time the chicks are sufficiently mobile to move several hundred metres from their scrape. The larger of two chicks is usually fed first and more frequently. By day 23 the chicks are able to fly up to 100 m (Higgins and Davies 1996). If the initial breeding attempt fails, fairy terns may attempt to breed a second or even third time within the breeding season (Bryant 1932, Ferreira *et al.* 2005). After nest failures, individually marked birds have been recorded to move up to 9 km between colonies in the same breeding season (Paton 2003). The fairy tern has only one successful breeding event per year (Higgins and Davies 1996, Ferreira *et al.* 2005).

Fairy terns in New Zealand, have an estimated 63% of fledglings survive per annum, and most individuals attempt to breed when 2-3 years old (Ferreira *et al.* 2005). Similarly, little terns have been recorded to breed at two years of age, but generally breeding will occur at three or more years old (NSW NPWS 2003).

1.7. Longevity and Movements

The recovery of a fairy tern banded in the Coorong was sighted alive 4 July 2011 at Western Treatment Plant at Werribee in Victoria (ABBBS 2011). The bird was originally banded on 19 February 2010 at West Cattle Island. The time between banding and recovery was 1 year 4 months and the bird had moved a distance of 510km (ABBBS 2011).

In South Australia, a chick banded at Beachport was recovered 12 years later and 260 km west in Victoria (Higgins and Davies 1996), while another from the same locality was recovered 190 km east in the Coorong, 11 years later (Paton and Rogers 2009b). These records strengthen an argument that the Coorong is a stronghold for the fairy tern population in south eastern Australia (D Paton 2011, *per. comms*.). The oldest record of a fairy tern from the Coorong is of a chick recaptured 14 years later and 21 km from its banding site (Paton and Rogers 2009b).

Plate 3. Distribution of fairy terns in South Australia based on South Australian Biological Surveys Database 1900-2010.

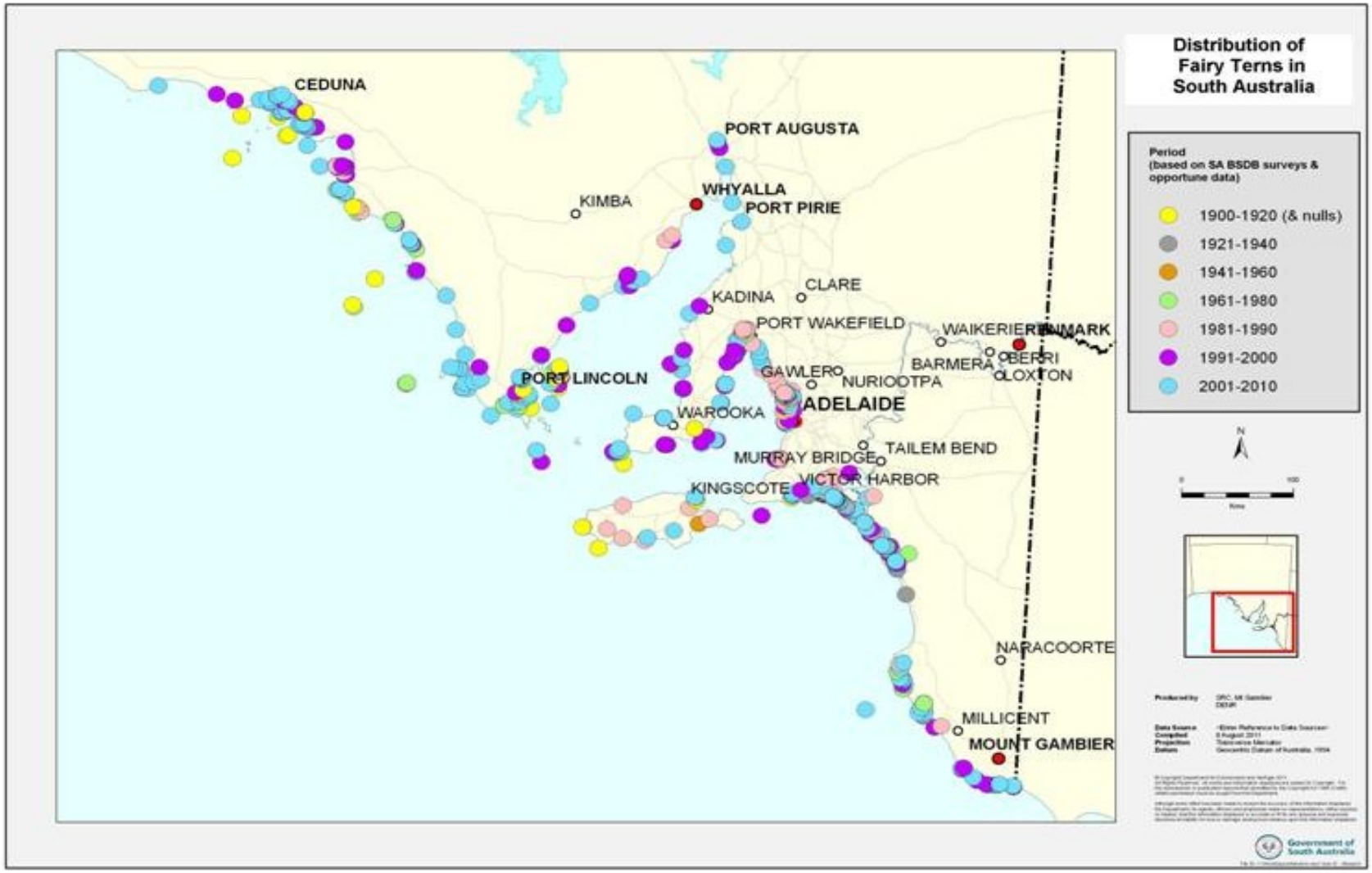


Plate 4. Distribution of fairy terns in the Coorong National Park (marked with white and blue cross) based on South Australian Biological Surveys Database 2000-11.

Terns are reported to live between 25-30 years (Birds Australia 2009). Tasmanian fairy tern populations are thought to migrate to the mainland and those in southern Western Australia may migrate to the Kimberly coast in northern Western Australia (Higgins and Davies 1996). Banding records in Western Australia have shown a single fairy tern to have migrated at least 260 km, >17 years after being banded (Higgins and Davies 1996). Chicks banded in Victoria have been recovered >15 years and >13 years later and 29 km and 13 km respectively.

1.8 Habitat Requirements

The fairy tern nests near to estuaries or on coastal beaches, and feeds in nearby waters. Fairy tern nesting sites are generally reported on sand-spits, sand and/or coral islands or beaches within or adjacent to the estuaries of rivers, creeks and coastal lakes (Hansen 2005; Baling *et al.,* 2009; Paton 2010), and at or near the mouth of the estuary on ocean beaches (C Manning 2011, *per. comms*.). Occasionally fairy terns are found feeding and nesting along inland rivers (Hansen 2005).

The nest is a simple scrape, usually bare, although occasionally lined with shell fragments, tiny pebbles or other material, similar to the little tern (Hansen 2005). Nests are normally located on flat or gently sloping ground, on a loose, sandy substrate with abundant surface shell-grit or pebbles, and bare or almost bare of vegetation (Hill *et al.,* 1988). As with the little tern, the fairy tern appears to select sites with good visibility all around for incubating birds, and with good camouflage for the mottled eggs and chicks (Plate 5).

The fairy tern will generally forage within 2 km of the nest site (Paton and Rogers 2009b), however nests are usually located close to the water, mostly within 150 m of, and less than 1.5 m above the high water mark, probably because the bird hunts by flying to and fro 3-10m above shallow water in sheltered coasts, bays and estuaries and plunging <5m to catch small individual fish, which comprise almost their entire diet (Peter 1994; Higgins and Davies 1996). Hence, a locally abundant source of small fish is critical for the persistence of a fairy tern colony and their breeding success. Many nests however are washed away by high tides or rough seas as a consequence of being located on low-lying areas close to the high water mark (C Manning 2011, *pers. comm*.). NSW NPWS (2003) note that unstable conditions may help to prevent vegetation encroachment and while higher nesting sites provide greater security from flooding, these sites tend to become rapidly overgrown and unsuitable.

In general, terns tend to avoid vegetated areas and will abandon a traditional nesting site if it becomes too overgrown (Golder *et al* 2008). Clumps of vegetation, driftwood and other beach debris however provide shelter and shade for the chicks once they leave the nest. For example, chicks on the Younghusband Peninsula in South Australia moved a distance of 100 m from their nest site to shelter on the foredune where *Spinifex sericeus* was used by the colony as a crèche (C Manning 2011, *pers. comm*.).

Suitable nesting habitat can be created artificially (Rodgers and Smith, 1995; Golder *et al* 2008). Species of terns readily nest on newly deposited dredge-spoil and similar artificial sites, with numerous examples worldwide including Australia (NSW NPWS 2003). Under suitable conditions, these sites may support large and highly successful colonies of terns (NSW NPWS 2003; Guilfoyle and Fischer 2006). The Plan will seek to identify and evaluate opportunities for the incidental creation and/or enhancement of nesting habitat in the Coorong (see Objective 2).

1.9 Cultural Significance

The Ngarrindjeri are the Traditional Owners of the *Kurangk* (the Coorong). The Ngarrindjeri people have occupied, enjoyed, managed and used their inherited lands and waters since the Creation (Ngarrindjeri Nation 2006). Creation stories and oral traditions have been passed down from generation to generation and with them a detailed knowledge of *Yarluwar-Ruwe* (Sea Country).

The Ngarrindjeri people have a unique philosophy regarding the connectivity of country, body and spirit. Ngarrindjeri Ruwe/Ruwar (Country/Body/Spirit) concerns Ngarrindjeri rights and responsibilities as Traditional Owners to care for their country and consideration that all things are

connected. The land and waters must be healthy for the Ngarrindjeri people to be healthy (Hemming *et al* 2002; NN 2006; Birckhead *et al.* 2008).

The preservation of the fairy tern is culturally important for the Ngarrindjeri people because all living things are part of the living body of Ngarrindjeri lands and waters and thus a part of the body of Ngarrindjeri. This species like other bird species are *ngartjis* of the Ngarrindjeri people and therefore close relations. Ngarrindjeri hold a great body of traditional knowledge regarding the *Kurangk* and their *ngartjis* and have cultural responsibilities to conserve and manage these species.

In New Zealand, the Iwi call the fairy tern, *tara-it*, and in some communities the birds are valued as an important part of their area, and are concerned for the species' protection (Hansen 2005).

Plate 5. The nest is often a simple scrape with shell fragments located on flat or gently sloping ground, on a loose, sandy substrate with abundant surface shell-grit providing good camouflage for the mottled eggs.

A fairy tern scrape with two eggs, Coorong National Park. C. Manning 2011 ©

2.0 Threats and Reasons for Decline

According to the Australian Bureau of Statistics (ABS) (2003) 85% of Australia's 21 million people live within 50 km of the coast, placing enormous pressure on the country's dynamic and fragile shorelines. Many species of shorebirds that live in coastal areas as either residents or seasonal migrants are at risk from habitat loss and disturbance at feeding, roosting and breeding sites. Breeding and ground nesting birds in particular are highly susceptible to disturbance due to human-induced threats, introduced and native predators and the effects of extreme weather (Baker-Gabb and Weston 2006; NSW NPWS 2003; Maguire 2008). Fairy terns are subject to these threats (Hill *et al.* 1988; Hansen 2005; Paton and Roger 2009b; Campbell and Christie 2009).

Threats to the fairy tern are reported to have an impact on their reproductive success rather than on flying birds (Hill *et al.* 1988; Hansen 2005; Paton and Roger 2009b). Fairy terns are subject to high levels of predation in exposed sites close to water and prone to frequent natural disturbance from tidal inundation and adverse weather events (Hansen 2005; Paton and Roger 2009b), and consequently is in the balance between nesting success and failure even under completely natural conditions.

2.1 Threats to Breeding Success in the Coorong

2.1.1 Murray Darling Basin Water Resource Management

The Murray-Darling Basin covers approximately 1, 059 000 square kilometres or 14 per cent of Australia's land area. Two million people (10 per cent of Australia's population) live in the Murray-Darling Basin and depend on it for drinking water, including 1.1 million residents in Adelaide. Water resources in the Murray-Darling Basin are managed through the Murray-Darling Basin Agreement (the Agreement). The Agreement sets out the arrangements for sharing water between New South Wales, Victoria and South Australia. Part of the Agreement regulates the sharing of the waters of the upper Murray River (water upstream of the South Australia/Victoria border) the waters of the Murray River tributaries below Albury. The waters for the Darling River and its tributaries upstream of Menindee Lakes remain under the control of the relevant state, although only when below an agreed level for the Menindee Lakes.

Due to escalating demands and over-allocation of water in the Murray-Darling Basin, combined with drought, changes to the magnitude and the timing of Murray River inflows to the region have changed significantly since European settlement (Brooks *et al* 2009). During the period 2001-08, the Murray-Darling Basin experienced severe rainfall deficiencies. The period from September 2001 to August 2008 was the second driest seven-year period on record. This rainfall deficiency, particularly in the alpine areas, has been the main cause for the record low inflows to the Murray River, and these changes have led to severe impacts on the Coorong and Lakes Alexandrina and Albert (Kingsford *et al*. 2009; Kingsford *et al*. 2011). Over the period from 1894-1993, the annual discharge at the mouth of the Murray-Darling Basin ranged from 1626GL to 54 168GL (Rural and Regional Affairs and Transport Standing Committee (RRAT) 2008). Changes to the flow regime of the Murray River have resulted in significant changes to the region's ecological character. Although the Murray River inflow during March 2010 was 150 GL, which was much higher than the 40 GL received in March 2009, the inflows were less than the long-term March average of about 190 GL. Salt carried along the Murray River from upstream is naturally washed out to sea at the Murray Mouth. With less water flowing down the Murray River however, only a very small amount of water flowed through to the sea between 2005 and 2010. With a much-reduced volume of water entering the lakes and high evaporative losses during those years, a build up of salt occurred. One effect of this is that salinity levels increased throughout the Coorong and Lakes Alexandrina and Albert, but in particular the Coorong South Lagoon (Paton 2005).

Salinity is one of two key abiotic drivers of ecosystem health in the Coorong (Brookes *et al*. 2009), the other being water level. Until recently, salinity has increased in the Coorong, in particular since 2002 (DEH 2010a), corresponding with a period of greatly reduced flows from the Murray River into the Coorong at the barrages. The target salinity range for the Coorong South Lagoon to maintain a

healthy ecosystem is a maximum of 139, 000 EC (100 g/l) in summer and a minimum of 87,000 EC (60 g/l) in winter (Lester *et al* 2009). This salinity range best supports an ecosystem characterised by the aquatic plant *Ruppia tuberosa,* chironomid larvae as the dominant benthic macroinvertebrate, and the small-mouth hardyhead *Atherinosoma microstoma* fish, the latter an important prey species for the fairy tern (Paton and Rogers 2009b). Since 2002 the target maximum salinity in the Coorong South Lagoon has generally been exceeded throughout the entire year, and salinities occasionally peaked at close to double the target level (DEH 2010a). For example, in 2007-08, salinity in the Coorong South Lagoon exceed that of seawater by a factor of four or more (Brooks *et al* 2009), thus exceeding the salinity tolerance of key fish species (Paton 2005; Wedderburn *et al.* 2008). Among affected waterbirds of significance are long-distance migratory shorebirds, but also Australian endemic species for some of which the Coorong forms a critical drought refuge. Changes to the Coorong's hydrology have resulted in declines in the quality of waterbird habitat (Paton 2005; Paton *et al.* 2009; Paton and Rogers 2009a and c; Wedderburn and Barnes 2009; Kingsford *et al.* 2009), including critical habitat for the fairy tern (Paton and Rogers 2009c; Paton 2010). Increased barrage and Upper South East flows in 2010-11 provided limited hydrological and ecological improvements to the Coorong and after over a decade of salt accumulation, increased flows have not been sufficient to reduce salinity to suitable levels in the Coorong South Lagoon. In addition, the 2010-11 inflows, significantly increased water levels in the Coorong, not only reducing mudflat areas, which are important feeding habitat for migratory waders but reduced ideal nesting habitat availability for fairy terns. Water levels, exceeded the intertidal zone and encroached into the terrestrial zone on key breeding islands (C Manning 2011, *pers. comm.*), thus high water levels had modified habitat (see Section 2.2.5).

Prior to 1996, Paton (2003) concluded that the fairy tern did not appear to be limited by food or predation in the Coorong, because nest success was moderate in terms of numbers of nesting attempts that lead to fledged chicks. Due to increased salinity levels after 1996, an adequate source of fish in close proximity to nesting islands was poor (Paton and Rogers 2009b). In response, fairy terns in the Coorong shifted north to breed on the Younghusband Peninsula where there is a reliable source of suitable-sized fish, but the nesting sites are susceptible to mammalian predators, human disturbance and water inundation (Paton and Rogers 2009a; DENR 2011), and had limited breeding success (Paton and Rogers 2009b) with only seven fledglings in 2011 (C Manning 2011, *pers. comm.*). Consequently, the proximate threats listed below are only significant now because of the historic and ongoing impacts of water resource management in the Murray Darling Basin.

2.1.2 Climate Change

A combination of sea level rise and increase intensity and frequency of adverse weather events are predicted to increase along the coast of south east South Australia (Matthews 2008), and pose a risk to ground nesting birds including fairy terns. At times of high tides combined with storm events, water inundation is a known cause of unsuccessful breeding (C Manning 2011, *per., comms.*). Sandy coasts such as the Younghusband Peninsula are eroding (Matthews 2008), which may reduce the nesting habitat availability.

A rise in sea level may be accompanied by a rise in the minimum-maximum water level range that the Coorong experiences (Matthews 2008), which may have implications for the islands that exist in the Coorong. The use of dredge spoil material to temporarily create, restore and maintain pre-existing low lying nesting sites that can provide secure nesting habitat has been investigated although not implemented in the Coorong (DENR 2011).

2.1.3 Predation

Introduced predators such as the fox *Vulpes vulpes*, feral cat *Felis catus* and domestic dog *Canis lupus* are responsible for significant losses at many fairy fern nesting sites (Vincent 1983, Hill *et al.* 1988, Wilson and Hansen 2005; DEH 2008, Paton and Rogers 2009b, Birds Australia 2009, DENR 2011).

Despite a biannual fox-baiting program, the fox is the most frequently recorded introduced predator in the Coorong and has been a major cause of breeding failures and desertion of colonies (Paton and Rogers 2009b; DENR 2011). In 2010-11, an extensive fox baiting program was undertaken by SA

National Parks and Wildlife in the Coorong including on the Younghusband Peninsula. On the Younghusband Peninsula, the rate of uptake was 35-50% (DENR 2011). Despite this baiting effort, immediately prior to an active colony of approximately 60 breeding pairs with a total of 84 eggs about to hatch and 51 chicks about to fledge, a single fox disturbed the colony, which abandoned the site and failed to attempt to breed again that season (DENR 2011). This failed breeding attempt was highly significant for the Coorong as it was considered to have been the largest breeding attempt reported in almost four years (C Manning 2011 *pers. comm*.).

Little ravens *Corvus mellori* are the second most reported predator of nesting shorebirds (Reside 1994; NSW NPWS 2003) and are likely to be an avian predator at fairy tern colonies in the Coorong (D Paton 2011, *per. comms*.), although little ravens were not observed in the 2010-11 breeding season (C Manning 2011, *pers. comm*.).

Except for the Ocean Beach, domestic dogs are not permitted in the Coorong National Park. Both leashed and unleashed dogs have been observed on the Ocean Beach, in particular in December-January (C Manning 2011, *per. comms*.), which coincides with the peak breeding season for the fairy tern, albeit dogs have not been observed nor reported to have disturbed shorebirds there (C Manning 2011, *per. comms*.). An unleashed dog on the Ocean Beach within the Coorong is at contravention of the *National Parks and Wildlife (National Parks Regulations) 2001* and expiation *notices* are issued by SA National Parks and Wildlife. It is widely acknowledge that unleashed dogs can be highly disturbing to shorebirds (Weston and Elgar 2006). Given the status of the Coorong and Lake Alexandrina and Lake Albert Wetland of International Importance (Phillips and Muller 2006) it would be desirable to align the Ocean Beach with the entire Coorong National Park and subject to Regulation 27(1) which states that "***…****a person who has control of an animal must not, without the permission of the relevant authority, bring it into a reserve or permit it to enter a reserve" (Maximum penalty $1000 or $135 by expiation notice).*

2.1.4 Human Disturbance

The Coorong is renowned for its beautiful coastline, and the beaches support a variety of beach-nesting resident shorebirds and provides important habitat for migratory shorebirds. Visitors to the Coorong increase between spring and summer, which coincides with the fairy tern breeding season. Off-road recreational driving on the Younghusband Peninsula is among a number of recreational activities that visitors come to the Coorong to enjoy. Buick and Paton (1989) reported that 81% of artificial Hooded Plover *Thinornis rubricollis* nests are run over by off-road recreational vehicles. Chicks were reported to shelter in wheel ruts and the number of wheel ruts on the Younghusband Peninsula indicated that up to 30% of chicks could be crushed (Buick and Paton 1989). As a result of this study, the Younghusband Peninsula has an annual beach closure to all vehicles from 24 October to 24 December, primarily to protect the Hooded Plover (SA Government 1993). All shorebirds including fairy terns have benefited from this management action (DENR 2011). A small number of commercial fishery vehicles however are exempt from the beach closure.

Local tour operators operate in the Coorong. Currently, cruise boats can carry up to 75 people and take visitors around the Coorong North Lagoon and on guided walks across the Younghusband Peninsula to the Great Southern Ocean. At times these tours are in >50m proximity of active fairy tern colonies. For minimising visitor disturbance Carney and Sydeman (1999) recommend 100-180m distance from breeding terns.

To help minimise the threat from human disturbance, active fairy tern colonies have been fenced off with at least a 40m buffer zone and informative and instructional signage have been installed. Monthly updates on nesting activity and associated threats have been provided directly to tour operators by SA National Parks and Wildlife Service. This has increased support for management actions and led to individual tour operators wishing to assist with monitoring activities (DENR 2011).

2.1.5 Communication Tools

Increasing awareness about the fairy tern remains largely in its infancy. Oral presentations including media and special events both locally and state-wide have been implemented in South Australia. Newsletters and interpretive signs have been used with some success. This was reflected in the number of community volunteers offering support in protecting active colonies and no reported evidence of recreational vehicles disturbing active colonies in areas that recreational drivers have traditionally accessed (C Manning 2011, *pers. comm.*).

There is however scope to build and maintain ongoing communication tools in particular relating to a wide variety of policies and laws affecting the protection of important habitat in the coastal zone. For example, policies related to dog access to the Coorong National Park, may in future present a threat to nesting fairy terns and/or other beach nesting birds.

2.1.6 Research Gaps

Monitoring of the Coorong fairy tern population has provided valuable information on population trends, local movements within and between breeding seasons, breeding success, and movements between foraging sites (e.g. Paton 2003, Paton and Rogers 2009b). At present data are poorly captured in an easily accessible centralised system and this situation may hinder current and future management decisions.

Research priorities in the Coorong that would inform national, regional and local priority actions include:

- Building and maintaining positive working relationships with local universities and research institutes, overseas researchers, consultants and volunteers to ensure open dialogue and the sharing and exchanging of information
- Seeking opportunities for linking information between partners and stakeholders

2.2 Threats to Breeding Success at International and National Level

2.2.1 Climate Change

> *"Coastal regions are vulnerable to sea level rise, increased sea surface temperature, increased storm intensity and frequency, ocean acidification and changes to rainfall, run-off, wave size and direction and ocean currents."*
> *(National Climate Change Adaptation Framework, COAG, April, 2007)*

Climate science predicts that south eastern Australia, which includes the Murray-Darling Basin, will become drier and hotter in the future due to anthropogenic climate change. Since 1950, Australia's average temperature has risen by 0.9ºC and in South Australia the average temperature has increased by 1.2ºC (CSIRO 2007) slightly faster than the national trend with 2005 recorded as the warmest year on record in South Australia. Since 1950 rainfall in south eastern Australia and in south west Western Australia has declined markedly and this has had a major affect on the Murray-Darling Basin (see Section 2.1.2). Trends in South Australia annual rainfall are generally weaker than other parts of the continent while most of the north-western part of the State has experienced an increasing rainfall trend, while southern coastal regions have experienced a slight drying trend.

Sea level change is one of the main factors in stimulating coastal change, and in the long term it has been controlled by changes in the volume of landlocked ice sheets. If sea level rises, the coasts must be able to change dynamically to keep up or drown. The response of different types of coastal systems to sea level change is often very specific to the given system. Global sea level rose 17cm from 1900 to 2000. From 1950 to 1993 the average rise was 1.8mm/year; since 1993 the rise has been 3mm/year National Tidal Centre of the Bureau of Metrology (cited Caton *et al*., 2011: 178). According to the Intergovernmental Panel on Climate Change (IPCC) (2007) current model projections indicate substantial variability in future sea levels in different locations. Some locations

could experience sea level rise higher than the global average projection, while others could have a fall in sea level. A sea level rise may lead to the landward migration of a mobile shoreline or the submergence and drowning of a stationary shoreline. In contrast a sea level fall may lead to the emergence of a shoreline. Global sea level rise is projected by the IPCC to be 18-59 cm by 2100 (IPCC 2007).

Adverse weather events such as storms are likely to become more intense, produce stronger peak winds, and produce increased rainfall over some areas due to warming sea surface temperatures, which can energize these storms (IPCC 2007). A combination of sea level rise and increase intensity and frequency of adverse weather events such as storms pose a real risk to ground nesting birds, in particular at the coast where low lying areas may become inundated with water and blown sand may cause the loss of active bird colonies (McGarvie and Templeton 1974, Murlis 1989; NSW NPWSS 2003; Maguire 2008) including fairy terns (Hill *et al.* 1988; Hansen 2005; Campbell and Christie 2009). In South Australia, two pairs of fairy terns attempted to breed at Danger Point near Carpenter Rocks in the lower south east but both nests, which had two eggs present when discovered, were later washed away by a high tide event (Campbell and Christie 2009). An active fairy tern colony nesting on a low lying sand spit at Port Adelaide was lost and later totally abandoned following a storm event (G Johnston 2011 *per. comms*.). To help minimise this known threat, fairy tern nests have been protected with sand bags and, at times, chicks and eggs have been successfully moved to avoid a predicted water inundation (NSW NPWS 2003).

2.2.2 Oil Spills

Oil spills have the potential to have major impacts on shorebirds, causing mortality, reduced foraging and growth rates and displacement from preferred habitat Weston (2008, cited Maguire 2008: 67). In Victoria, oil spills have been identified as a key threat to fairy terns due to the close proximity of oil facilities to the species' breeding habitat (Conservation Advice 2011).

2.2.3 Predation

Under Schedule 3 of the *Endangered Species Protection Act 1992* (ESP Act), predation by the red fox was listed as a key threatening process to biodiversity. Hence, the ESP Act required the preparation and implementation of a threat abatement plan to coordinate nationally the management of the impact of fox predation on native wildlife in conjunction with the Commonwealth Fox Threat Abatement Plan (DEWHA 2008).

Several native animals prey on eggs and chicks, with avian predators the most significant in terns of losses. Raven attacks on bird colonies can result in a high mortality of nestlings and fledglings (Tella *et al* 1995). *Corvus* spp., are the second most reported native predator of nesting shorebirds (Reside 1994; NSW NPWS 2003). On Towra Spit Island in NSW, Australian ravens *Corvus coronoides* were responsible for 67 little tern egg losses over four seasons between 1992 and 1995. Of these, 37 eggs were lost in one season alone (Priddel and Ross 1996). Other avian predators including silver gulls *Larus novaehollandiae* and raptors also target nesting sites and areas, and may even cause the loss and abandonment of entire breeding colonies. Silver gulls are the most frequently reported native predator at fairy tern and little tern colonies (Reside 1994; NSW NPWS 2003; Hansen 2005). In Victoria, a colony of fairy terns on Mud Island declined when silver gull numbers increased and subsequently the colony established on the mainland nearby (Lane 1981). Silver gulls have increased in parallel with the increase in the human population and the additional food resource that this has provided for Silver Gulls (NSW NPWS 2003).

Feral cats and domestic dogs are occasionally implicated in losses of eggs or chicks. Domestic dogs accompanying people or straying from nearby houses may cause frequent disturbance to nesting fairy terns. Unleashed dogs especially can be highly disturbing to shorebirds (Weston and Elgar 2006), probably because the dog will tend to move more rapidly across the beach perpendicular to the water's edge, sometimes in pursuit of shorebirds. In South Australia there have been few records of predation by domestic dogs at colonies of fairy terns (C Manning 2011, *per. comms*.).

The fox is the most frequently recorded introduced predator at tern colonies (Reside 1994, NSW NPWS 2003, Paton and Rogers 2009b; DENR 2011) where eggs and chicks are often eaten and cause breeding failures and desertion of colonies (DENR 2011). Despite fox-baiting programs, foxes have caused the failure of fairy tern colonies (Paton and Rogers 2009b; DENR 2011). Control campaigns can improve nesting success of nesting shorebirds. For example, 2% of hooded plover nests were destroyed by foxes in an area where control programs had been implemented, and up to 27% of nests where foxes were not controlled (Weston 2003), although there is little evidence for long-term changes in the numbers of adult hooded plovers (D Paton 2011, *pers. comm.*). In South Australia, the fox is not present on Kangaroo Island yet the fairy terns appear to have declined to near extinction (Paton *et al.* 2002). Wild dogs, including dingoes, are responsible for losses in remote coastal areas.

In NSW, tree goannas *Varanus varius*, black rats *Rattus rattus* and even long-nosed bandicoot *Perameles nasuta* have all been recorded taking tern eggs or chicks at various sites (NSW NPWS 2003; Hansen 2005; DECC NSW 2008). The threat from predators can be assess from direct observation and by the presence of tracks in the sand.

2.2.4 Human Disturbance

Breeding fairy terns are often disturbed by visitors, albeit unintentionally (Hill *et al.* 1988; Higgins and Davies 1996; Dowling and Weston 1999; Garnett and Crowley 2000, NSW NPWS 2003; Maguire 2008).

Fairy tern colonies may become agitated when people are nearby with repeated disturbance often resulting in desertion of a colony (Higgins and Davies 1996). Members of the breeding colony may circle overhead calling until some minutes after the disturbance is over (Bryant 1932; Higgins and Davies 1996). The birds' habit of leaving the nest and not returning until the disturbance has subsided can have an influence on breeding success.

While the parent birds are absent the eggs or chicks are vulnerable to predators and high temperatures (Hill *et al.* 1988; Weston 2000). The incubation temperature of most avian species is between 35°C and 38°C, which is close to the upper lethal temperature tolerate of 42-48°C, depending on the age of the embryo (Drent 1975). Drent (1970) found that on a sunny 18°C day the internal temperature of an abandoned herring gull *Larus argentatus* egg reached 44°C within two hours and exceeded the lethal limit. Where air temperatures are above 38°C, the risk to the embryo is far greater, and the time to reach the lethal limit is much shorter (Drent 1975).

Vehicles driving along beaches can have a major impact on breeding success of nesting shorebirds, particularly in South Australia where recreational driving is permitted on most of the coastline (Buick and Paton 1989, Garnett 1992). The growing number of off-road vehicles has resulted in increased recreational driving on isolated stretches of coastline where beach-nesting birds previously lived undisturbed (Schulz and Bamford 1987). Vehicles have destroyed nests of fairy terns (BirdLife International 2009) and little terns (NSW NPWS 2003). Vehicles on dunes and beaches are thought to have caused colonies of fairy tern to decline in eastern Tasmania (Birds Australia 2009; Threatened Species Section 2010) and the Eyre Peninsula (DEH 2008).

2.2.5 Habitat Modification

Small terns prefer early succession habitats consisting of bare sand or sand and shell substrates with sparse (<15% percent cover) vegetation (Golder *et al.* 2008; C Minton 2011, *pers. comm.*). Vegetation encroachment on nesting sites may prevent fairy terns nesting (Hill *et al.* 1988; Garnett and Crowley, 2000). In Victoria, fairy tern colonies are reported to have abandoned nesting sites when vegetation encroached onto the nesting habitat. Following subsequent clearing and replacement of shell-grit to enhance nesting habitat fairy terns returned to the areas to breed in later years (Lane 1981, Minton 1988). Ongoing maintenance of sites by clearing vegetation remains a challenge (C Minton 2011, *pers. comm.*). Similarly, little tern breeding success improved markedly when nesting birds relocated onto an estuarine dredge-spoil island clear of vegetation (Hill *et al.* 1988).

2.2.6 Communication Tools

Publicity materials and other promotion tools are essential for raising awareness about the issues that shorebird conservation managers are addressing, and for education and advocacy, but sometimes the wording and presentation of educational material can be misleading. Gaps in the distribution network of information remains, and together with poorly developed educational and interpretative material can also result in misunderstandings and add to management issues. Additionally, the variation in occurrence and impact of threats means that managers face complicated decisions about what threats to manage, where to manage them and what communication messages to broadcast in a particular area.

Publicity materials and other promotion are essential for many reasons, including:

- Raising awareness among stakeholders and encouraging their participation;
- Changing peoples' thinking and behaviour in relation to a particular issues (e.g. threatened shorebirds;
- Informing people about shorebird conservation and its achievements and any change in management activities;
- Raising awareness about shorebird conservation at regional, national and international levels to strength linkages;
- Assisting with fundraising.

Oral presentations including media and special events, brochures, posters, leaflets, newsletters, display boards and exhibitions, website, cards, interpretive signs and merchandise have been used to raise awareness about shore nesting birds (Weston 2003, Dodge *et al*. 2005, Antos *et al*. 2006).

In Australia, shorebird conservation projects vary in their success at increasing environmental education and awareness (Antos *et al.* 2006). A combination of communication approaches and management strategies has been effective in highly visited areas (Weston and Dowling 1999) however despite clear messages about the need to keep dogs on a lead visitors may often not comply with the advice and/or direction.

A careful 'communication strategy' should form part of a management plan. It should define target audiences, the types of materials and products most suitable, the issues to be addressed and the time scale. Conservation International has developed a strategic planning tool, the 4-Ps, which can be used to identify the Problems, Public, Products and Plan that are needed for effective awareness raising and communication (Conservation International 2003). An overarching objective of any shorebird management program should be to 'share the shoreline'. This message promotes positive, low impact beach usage that ensures the birds thrive while allowing people to enjoy and learn about the area (DECC 2008). The Plan will seek to identify opportunities for increasing awareness of the fairy tern (see Objective 3).

2.2.7 Research Gaps

Appropriate research, on both biological and socio-economic issues, is essential for long-term effective management of the fairy tern. The natural sciences are vital to understanding ecosystems function and change in which fairy terns inhabits, and the social sciences are essential for identifying the sources of human-induced threats to the fairy tern.

It is rare for a management agency to be able to fund all the necessary studies, and outside assistance will be required. This may come from a range of sources: local universities and research institutes, overseas researchers, students working on projects or further degrees or consultants and volunteers. Developing a good partnership with academic institutions and universities is vitally important. As is the sharing, exchange and/or centralisation of information on population trends, movements within and between breeding seasons, breeding success, and movements between foraging sites to inform management decisions.

Research priorities that would inform future national, regional and local priority actions include:

- Design and implement a monitoring program or, if appropriate, support and enhance existing programs.
- Undertake survey work in suitable habitat and potential habitat to locate any additional populations.
- More precisely assess population size, distribution, ecological requirements and the relative impacts of threatening processes.
- Improve understanding of the interactions between different populations, particularly populations in the south-east, Coorong and Eyre Peninsula

The Plan will seek to identify opportunities for contributing to each of these areas (see Objective 2).

3.0 Management Issues of a Local Action Plan

3.1 Biodiversity Benefits

From an ecological point of view, if the fundamental issues associated with water resource management within the Murray-Darling Basin are addressed, the benefits to biodiversity will be widespread and significant both geographically from the lower Murray River to upstream areas. Migratory shorebirds listed under the Japan Australia Migratory Bird Agreement and the China Australia Migratory Bird Agreement such as sanderlings *Calidris alba* would also benefit.

3.2 Strategic Alignment

Owing to recent declines over much of its breeding range, predation by introduced species, disturbance and inappropriate water level management that are thought to have contributed most to the birds decline. As a species listed under the *EPBC Act 1999,* a requirement to develop a National Recovery Plan for the sub-species is one of the outcomes of this listing. The Plan will inform and contribution to the development of a National Recovery Plan.

Management actions will have a direct contribution to the Department of Environment and Natural Resources Corporate Plan 2010-14. In particular, Goal 1: T*he environment is conserved and natural resource managements are used sustainably* and Priority 1a: Implement *No Species Loss Strategy,* by assisting in the recovery of a threatened species. Volunteer community engagement will be pivotal to the success of management actions and thus contribute to Goal 2: *The environment is valued and enjoyed,* by running events and activities that increase interest in the environment and natural resource management. Management actions will also contribute to Goal 3: T*he environment is integral to development decision* by the provision of accessible and comprehensive environmental information to help government and communities make well-informed decisions, for example, determine the current distribution and abundance of fairy terns in South Australia.

The Coorong National Park Management Plan and the Coorong and Lower Lakes Ramsar Management Plan state special protection will be given to vulnerable and endangered species in the Park through habitat management.

3.3 Monitoring and Evaluation

Monitoring and evaluation is an essential component of any successful management activity. Managers need the information generated to improve their management and funding sponsors and stakeholders need results to ensure accountability. The principle reasons for developing a monitoring and evaluation program are to: (1) assess the status of key values such as the biodiversity and socio–economic aspects of the Plan and, (2) determine whether management is having its intended impact and is effective and thus funds are spent wisely. Monitoring and evaluation therefore allows the Plan to be adjusted according to an adaptive management approach.

Monitoring – a continuous systematic process of collecting and analysing information though the use of indicators such as breeding success

Evaluation – an activity repeated regularly that assesses how well the objectives of the Plan are being met.

Not all the activities described in the Plan may be monitored and evaluated as resources and capacity maybe limited (see Section 3.3). Specific monitoring and evaluation requirements e.g. from funding bodies will however need to be a high priority. Beyond that, a careful balance is needed between investing resources in management activities and in assessing their impact. Secondly, appropriate indicators that are units of information that when measured over time will document change, must be selected as it is not possible to monitor every process of the Plan. Selection of indicators must be based on:

1. A careful analysis of the objectives and the types of change anticipated, as well as how progress might be measured
2. An analysis of available human, technical and financial recourses

Given the complexity of a monitoring and evaluation program, a general plan should be developed and comprised of:

- Timetable for the main activities and components
- Indicators and data collection methods
- Responsibilities for each component
- Reporting requirements including formats, review frequency of the Plan, sponsors and other authorities
- Budget

The monitoring and evaluation program is best carried out by or with full involvement of the key personnel and relevant stakeholders, notably the Recovery Team. It may also be necessary, and often beneficial, to use external consultants or researchers. Progress will be monitored and evaluated by members of the Recovery Team through an annual review. The monitoring process should include:

- Compiling information and data, assessing progress made for all actions with the criteria and objectives of the Plan in mind.
- An external review after three years of Plan implementation.

3.4 Social and Economic Consequences

The nesting sites currently used by fairy terns in the Coorong are all located in the Coorong National Parks administered by the Department of Environment and Natural Resources (DENR). To date, no known sites in the Coorong are in private ownership.

With the exception of two known nesting sites in the vicinity of the Murray Mouth, nesting, resting and fledgling feeding sites are excluded from popular summer recreational areas. In the event that the fairy tern breeds at sites near to popular summer recreational areas actions would need to be implemented to minimize the disturbance e.g. restricting people and off-road recreational vehicles. Nesting areas near to human disturbance are small (<3ha), the breeding season relatively short (see Section 1.6) and in the context of the Younghusband Peninsula coastline, would represent only a minor (<1%) imposition on recreational amenity.

The restriction of people and off-road recreational vehicles from the vicinity of active nesting sites will limit the aspirations of a few people who have undertaken these activities in the past. The concerns of people however can be reduced by consultation with relevant community groups especially off-road vehicle clubs, distribution of information material, the installation of well

informed and instructional signage and organising and training volunteer wardens. In Victoria, these initiatives have been implemented at Mornington Peninsula National Park but enhanced law enforcement played a significant role.

Experience has shown that with education, most people visiting the Coorong respect the need to protect threaten species and their contact with management programs enhances rather than detracts from their recreational experience (DENR 2011). To the fairy tern's advantage, off-road recreational access to the Murray Mouth along the Younghusband Peninsula was hampered in 2010-11 by an eroding coastline and adverse weather conditions (C Manning 2011, *pers. comm*). Experience has shown that restricting access to parts of a beach in order to protect threaten species can enhance the tourist values of a particular area (Dowling and Weston 1999; DENR 2011). Tour operators within the Coorong have noted that in cooperating with SA National Parks and Wildlife staff and obeying regulations, their clients reported that their experiences with fairy tern colonies had enriched their visit (B Carl 2011, *pers. comm*.). Similar observations have been reported for the conservation of the little tern (NSW NPWS 2003) and hooded plover (Schulz 1992; Dowling and Weston 1999; Dodge *et al.* 2005).

The actions in the Plan have community involvement and will continue to raise community awareness about the fairy tern and the importance of integrated water resource management in the Murray-Darling Basin. To date, voluntary assistance from various academic research institutes in particular the University of Adelaide, community groups and individuals has provided support in monitoring and data collection. In 2010-11, the use of volunteers in the Coorong was beneficial for expanding the management program beyond its financial and staff restraints, identifying the primary cause of nest failure, breeding success rates and also provided a valuable opportunity for the volunteers to enhance their ecological knowledge and assist in the management of a threatened species. The broader community also benefited from the general education campaign through oral presentations. The Plan will therefore seek to continue community involvement in the recovery of the Coorong fairy tern (see Objective 3).

The fairy terns is culturally important to the Ngarrindjeri (see Section 1.9), who should be consulted to clarify the level of their participation and involvement in all stages of the Plan, in particular the implementation phase. This would be equally important to ensure Work Area Clearance requirements are met.

The success of the Coorong Fairy Tern Recovery Program will be underpinned by the financial and human resources that need to be committed to the program over the lifespan of the Plan if the remaining Coorong breeding population of the fairy tern is to successfully breed and avoid imminent localized extinction.

3.5 Assumptions and Constraints

The following assumptions are made:

- That the Plan can be achieved within the proposed timeframe.
- That DENR have human, infrastructure and financial resources to implement the Plan
- That a suitably qualified and experienced Project Officer can be identified and engaged
- Understanding of issues and response to management are adequate

The following constraints are predicted:

- Secure funding availability from government, non-government agencies and/or other funding bodies
- The insecure nature of current nesting and breeding sites

- Geographic nature of South Australia – offshore islands (e.g. Nuyts Archipelago CP) and remote coastal peninsulas (e.g. Younghusband Peninsula) experience adverse weather conditions that reduce safe access to monitor fairy terns in South Australia
- That the implementation of actions may depend on substantial input from community groups and volunteers

3.6 Partners and Stakeholders

List of potential partners and stakeholders but not limited too:

3.6.1 Partners

- Traditional Owners
- Australian Government Department of Environment, Water, Heritage and the Arts
- Murray Darling Basin Authority
- SA Department for Environment and Natural Resources
- SA Department for Water
- SA Water
- Local Government
- Research intuitions including SARDI, CSIRO, PIRSA and academic
- Local Action Plan (LAP) groups
- Other non-government organisations

3.6.2 Stakeholders

- Bird groups such as the Australasian Wader Study Group, SA Ornithologists Association, BirdLife Australia and BirdLife International
- Local businesses including tour operators
- Local communities
- 4WD clubs

4.0 Recovery Information

4.1 Current Management in the Coorong

The University of Adelaide has undertaken considerable research in the Coorong including the study of the fairy tern (Paton 2003; Paton 2005; Paton and Rogers 2009b; Paton 2010). In response to the University of Adelaide research, the SA National Parks and Wildlife Service have increased monitoring and habitat management of fairy tern nesting sites since 2009. In summary the following key activities have been undertaken and include but not limited to:

- Ongoing study of the breeding ecology (Paton 2003; Paton and Rogers 2009b; Paton 2010) (University of Adelaide).
- Beach closures along the Ocean Beach Younghusband Peninsula between 24 October and 24 December endorsed (DENR).
- Annual surveillance of all known breeding sites in the Coorong since 2009 (DENR).
- The use of dredged material substrate to elevate and secure a single priority fairy tern nesting site investigated through extensive literature review; local to international support and guidance on creating artificial bird nesting habitat, geo-textile reinforcement; dredge operations and structural material and design; topographical and bathymetry surveys in 2010-11 (DENR).
- Part time Project Officer engaged in 2010-11 (DENR).

- Intensive monitoring and management of a single priority fairy tern nesting site through repeated and comparable measurement of variables of interest. Monitoring of abundance and fledging production. Design and install accurate, concise, colourful (eye-catching) signage bearing clear messages with a purpose at boat ramps, and the start of beach access paths nearest to breeding sites. Poly-pipe fence to provide a visual cue to people about the area the signs refer to 2010-11 (DENR and volunteer wardens).
- A manual for volunteer wardens developed to ensure continuity of effort and techniques, and provide a basis for training volunteer wardens in 2010-11 (DENR).
- Targeted predation control programs intensified along the Ocean Beach Younghusband Peninsula 2010-11. Baits were placed 300m apart for up to 30km from a priority nesting site. Stations monitored every 2-3 days, with the rate of uptake noted and baits replaced accordingly (DENR).

4.2 Management Strategies

For the recovery of the Coorong fairy tern several management options are offered:

a) No management

b) Integrated water management of the Murray-Darling Basin

c) Restore the Coorong: medium-term strategies to manage the hydrology and ecology of the Coorong

d) Intensive protection of priority nesting sites

e) Attract the breeding population to 'safe' nesting habitat

f) Create and manage floating pontoon islands

g) Create and manage dredge spoil islands

h) Maximise productivity by egg and chick manipulation

The risks associated with each of the above management strategies are explored below.

4.2.1 No management

Experience has shown that intensive management of nesting colonies leads to breeding success through an increase in recruitment of juveniles, which contribute significantly to the adult population. Without this recruitment the population goes into decline as a result of ageing. Given the current age of the Coorong fairy tern population, without successful recruitment within the next 1-2 years there is risk of localised extinction at a stronghold for the species (Paton and Rogers 2009b).

A localized extinction would fail to meet Australia's obligations under national legislation and international agreements (see Section 1.1). Under the Convention on Wetlands, Australia has an international obligation to maintain the ecological character of the Coorong and Lake Alexandrina and Lake Albert Wetland of International Importance, which supports a number of waterbird species, and some individual species including the fairy tern make up more than 1% of their global populations (Paton and Rogers 2009c).

There is a wide variety of policies and laws affecting the protection of this subspecies' habitat in the coastal zone. For example, policies related to dog access to beaches vary widely across Australia. Furthermore, the fairy tern is an *ngartjis* of the Ngarrindjeri people and therefore a close relation. Ngarrindjeri hold a great body of traditional knowledge regarding the *Kurangk* and their *ngartjis* and have cultural responsibilities to conserve and manage these species.

Overall Response: in the absence of intervention there is a significant risk of local extinction, with the consequences of failure to meet obligations under national legislation and international agreements, and placing the species globally at increased risk of extinction. No management is inadequate for the recovery of this species.

4.2.2 Integrated water management of the Murray-Darling Basin

The Murray-Darling Basin has been, and continues to be under enormous stress as a result of water-allocation decisions, prolonged drought, natural climate variability and emerging climate change. These stresses have had a profound impact on both the aquatic and terrestrial environment (see Section 2.2.2). A healthy Murray-Darling Basin is not only vital for wetland ecosystems, but is also vital for a healthy economy and healthy communities. A high-level plan is urgently required to ensure that the water resources of the Murray-Darling Basin are managed in an integrated and sustainable way.

Lessons learnt from past droughts and floods can underpin strategies that include management practices, infrastructure and environmental flows that together provide security of access to water and an environment that is resilient to change. Working with the Murray-Darling Basin states and communities, the Murray-Darling Basin Authority (the Authority) is preparing the Basin Plan, as required by the *Water Act 2007.* The Basin Plan aims to provide an agreed Basin-wide framework to manage the water resources of the Murray–Darling Basin. Working within the Basin Plan framework states, communities and industry will be able to work towards a common goal, but in ways that suit their particular situations best, and where flexibility, innovation and local solutions can operate. The Basin Plan aims to identify, and seek to protect and restore, key environmental assets, which are essential to the life of the rivers, their surrounding landscapes and the cultural values of the communities that depend on those water resources. The Basin Plan aims also take into account the impact of this protection and restoration on individual communities, industries, regions and the wider economy (MDBA 2011).

Content that must be in the Basin Plan includes:

- limits on the amount of surface water and groundwater that can be taken from the Basin on a sustainable basis
- identification of risks to Basin water resources, such as climate change, and strategies to manage those risks
- the requirement that state water resource plans must comply with for them to be accredited or adopted under the Act
- an environmental watering plan to optimise environmental outcomes for the Basin
- a water quality and salinity management plan
- rules about trading of water rights in relation to Basin water resources

The Authority will release the proposed Basin Plan and supporting documents for public consultation in late-2011. Following public consultation, the revised proposed Basin Plan will be given to the Murray–Darling Basin Ministerial Council for comment. After the Ministerial Council, the Authority will give the Basin Plan to the Minister for Sustainability, Environment, Water, Population and Communities for adoption and tabling in Parliament (MDBA 2011).

The Basin Plan is due to be implemented in 2012 (MDBA 2011), and must achieve security of environmental flows to underpin the health of the environment and the communities which rely on it (MDBA 2011). According to the MDBA (2011), “the security of environmental flows however may take time to eventuate”, and therefore the Basin Plan may have little effect on the survivorship of the Coorong fairy tern in the next 1-2years.

Overall Response: a high-level plan to ensure that water resources of the Basin are managed in an integrated and sustainable way is urgently required, but an environmental watering plan to optimise environmental outcomes for the Basin is unlikely to be implemented and take affect within 1-2years.

Agencies and organisations should strongly advocate for environmental flows that meet the long-term ecological requirements of the Coorong and the fairy tern. This advocacy can be supported by our obligations under the Ramsar Convention, which also places the Coorong, Lower Lakes and Murray Mouth as a Matter of National Significance under the EPBC Act, with the fairy tern having a separate listing under the *EPBC Act 1999*. An appropriately designed Basin Plan that meets these requirements is the only viable long-term solution for the maintenance of wetland ecosystems of the Basin, and their component flora and fauna.

4.2.3 Restore the Coorong

The difficulty of the task of returning the salinity gradients in the Coorong to acceptable levels cannot be underestimated (see Section 2.2.2). In the long-term, this can only be achieved sustainably through the implementation of an adequately designed Basin Plan (4.2.1). However, a total of $186 million from combined State and Federal Government contributions has been allocated to CLLMM recovery programs including an allocation of up to $46 million to reduce salinity levels in the Coorong South Lagoon and reintroducing the aquatic plant *Ruppia tuberosa* to the Coorong to boost the region's ecology.

Following an initial investigation phase (DEH 2010a), State Government determined that the following management actions as having merit for mitigating salinity build up and accelerating ecological recovery:

- South Lagoon Salinity Reduction Scheme
- South East Flows Restoration
- Rupppia Restoration Project.

These preliminary assessments also concluded that maintaining an open Murray Mouth was essential for the Coorong.

In summary, the South Lagoon Salinity Reduction Scheme was an options analysis that investigated several proposals for reducing the salt load in the Coorong South Lagoon. The preferred short term solution was the South Lagoon Pumping proposal. This is an engineering intervention aimed at reducing the salinity in the Coorong, in particular the Coorong South Lagoon, by pumping salt out of the system, via pipes over the Younghusband Peninsula, to an ocean outfall (DEH 2010a).

The South East Flows Restoration (the South East Flows) is proposed as a longer term management action that aims to reduce salinity in the Coorong South Lagoon during future periods of low or no barrage flows. The scheme is currently at the feasibility stage. It aims to divert water from south east South Australia towards the Coorong South Lagoon (DEH 2010b), by using a combination of natural watercourses, an engineered floodway system and existing drains.

The South Lagoon Pumping proposal is considered by the South Australian government as a ‘reset’ for the Coorong South Lagoon ecosystem in anticipation of additional flows from the South East Flows and/or natural flows via the barrages. The third project in the Restoring the Coorong management action, *Ruppia* Translocation, is contingent on reduced Coorong South Lagoon salinity (G Ricketts 2011, *pers. comm.*). Transplanting of *Ruppia* spp is aimed at restoring and providing habitat and food for the many biological components of the ecosystem (DEH 2009).

The benefits of the South Lagoon Pumping were assessed at the end of the last drought in 2009-10. Pumping would have reduced salinity in both the Coorong North and South Lagoon. Lower salinities were required for the ecological recovery of the Coorong South Lagoon. Target levels were determined for keystone species such as *Ruppia* and small-mouthed hardyhead. At peak salinity levels, however, modelling suggested that to reduce salinity concentrations to the target levels, pumping would have taken up to two years (G Ricketts 2011, *pers. comm.*). Since late in 2010, significant barrage flows have diluted the salt levels and may have reduced the salt load. Further work is underway in order to understand the relationship between barrage flows, salt concentrations

and salt load. This management action has high capital costs, high annual operating and maintenance costs and high demobilisation costs (G Ricketts 2011, *pers. comm*.). The South Australian government is actively monitoring the hydrology and ecology of the Coorong to determine if this management action is required. Consequently, the South Lagoon Pumping proposal is currently on hold whilst the Department of Environment and Natural Resources (DENR) assesses the effects of recent barrage flows. This decision also provides time for DENR to further investigate the South East Flow proposal (G Ricketts 2011, *pers. comm*.).

The benefits of the South East Flows include reducing salinity by the supply of up to 54GL per annum (Montazeri *et al* 2011) of water from the South East of South Australia to the Coorong South Lagoon. The supply of up to 54GL per annum includes the predicted contribution from the existing drainage network that is forecasted to deliver an average of 26GL per annum. Other studies have shown that under drought conditions with no barrage flows a target flow from the south east would be an average of 60GL per annum. The provision of augmenting flows into the Coorong could enhance ecosystem resilience, especially during low Murray River inflows. There is also the potential to restore, improve and provide long-term support to a considerable area of wetland habitat within the south east of South Australia, and this action has been shown to be technically feasible (DEH 2009).

Currently the South East Flows is at the concept design phase and would not provide additional flows to the Coorong for at least two years (G Ricketts 2011, *pers. comm*.). This assumes however that the ongoing cost benefit analysis concludes the South East Flows proposal should progress to construction. Prior to any delivery of additional flows from the south east, appropriate precipitation within the catchment is required after two years, and hence there is a considerable time lag associated with the South East Flows proposal (G Ricketts 2011, *pers. comm*.).

Ruppia translocation is heavily reliant on appropriate hydrology and salinity levels that could occur as a result of the South Lagoon Pumping, the South East flows and/or integrated water resource management in the Murray-Darling Basin. Successful transplanting of *Ruppia* spp will help support the re-establishment of aquatic vegetation communities and increase habitat coverage and complexity for macro invertebrates and migratory and residential birds including the fairy tern.

Overall Response: due to the time lags associated with 'Restoring the Coorong' management actions to take effect, the associated management actions would not deliver the environmental conditions required for fairy terns in a timely manner. For this reason, other management actions for conserving the fairy tern are important and urgently required, and should occur independently of large scale actions under the Restore the Coorong proposals. These solutions are short-medium term measures, and will only provide a long-term benefit if done in conjunction with the implementation of an appropriately designed Basin Plan.

4.2.4 Intensive protection of priority nesting sites

The fairy tern is vulnerable to predation by introduced mammalian predators, water inundation and adverse weather events, disturbance from humans and habitat degradation. These factors need to be managed to maintain and increase the population. If management is stopped the Coorong population is likely to decline to extinction.

Experience has shown that intensive management of active colonies can lead to improved breeding success and an increase in recruitment of juveniles (Hill *et al*. 1988, NSW NPWS 2003). Intensive management would include threat abatement and once a colony had established include a search for all signs of predators in the locality, as this can help identify potential predators, and can also identify the presence of large animals that can accidentally trample nests. Unfortunately, the threat from predation is often not realised until it occurs. If losses do occur, it is important to assess the evidence (prints around nest, shell remains) to attempt to determine the predator responsible so further losses may be mitigated. Intensive protection would also include the erection of suitable fencing, monitoring, compliance, community engagement activities using volunteer wardens as well as education and advocacy activities. Consequently, intensive protection of priority nesting sites, that is

the majority of the known breeding population, would require substantial management commitment and therefore a designated Project Officer.

The broad tasks of the Project Officer would include but not limited to:

- development of and assisting with the implementation of a threat abatement plan for the red fox
- actively manage and protect all known breeding areas, including new breeding sites
- actively manage and protect priority active colonies to achieve an increase of >10% levels of productivity per year (i.e. >18 chicks per annum)
- increase public awareness

While a designated part-time Project Officer has an estimated cost of $50,000-70,000 per year (including on costs), the Project Officer would also be supported by additional 'in kind' contributions from government and non-governmental agencies and in particular community volunteers such as volunteer wardens (DENR 2011). Technical, practical and financial involvement and support must also be sought in partnership with the Traditional Owners.

Intensive protection of priority nesting sites would also require an operational budget of $30,000-50,000 per year. This is based on the average cost of different types of electric fencing ranging from $7,000 to $10,000 per km (a single colony is unlikely to exceed 1km in perimeter) and the average cost of threat abatement. A fox abatement control program focused in areas of fairy tern sites in the Coorong is an estimated cost of $5,000 per year. Intensive protection of priority nesting sites would also require monitoring activities, community engagement activities and education and advocacy activities as per similar management activities undertaken in the Coorong 2010-11 (DENR 2011). Sand bagging activities that may help protect nests against predicted water inundation may seem cheap to purchase and but can be expensive to use. Sandbagging requires physical labour, although volunteers may assist, and associated equipment and materials. On average a single sandbag cost is approximately $0.25 each, sand $20.00 per bag, shovels $20 each and trucking $70-80 per hour (Geocell System 2011).

A particular difficulty with intensive protection of potential priority nesting sites in the Coorong is that all known nesting sites are >20mins from the nearest emergency medical treatment, and access remains a constant challenge. Under adverse weather conditions access can be impossible (C Manning 2011, *pers. comm*.).

Overall Response: this is the minimum and essential management option in Years 1-3, to ensure the maintenance of the fairy tern population while longer term solutions are being implemented (4.2.2, 4.2.3).

4.2.5 Attract the breeding population to 'safer' nesting habitat

Using decoys to attract birds to nest in protected areas is a potential management tool that has had some success (Marchant and Higgins 1990), including with fairy terns (Jefferies and Brunton 2001). Whether the attraction of fairy terns to decoys will encourage them to nest in the area remains to be seen. For example, in a single study fairy terns were attracted to decoys in a specific area, however the decoy's degree of resemblance to real fairy terns, type of call played, and the posture of decoy requires further investigation (Jefferies and Brunton 2001). Furthermore, one limitation of this study is that the sample size of fairy terns was very small: four individuals.

The general cost of developing decoys varies between $100-1,000 and is reported to have a lead time of 6-8 weeks. Given that fairy tern decoys would not be available on the market the development of a fairy tern decoy could be in access of $500 per decoy and is likely have a greater lead time for final production.

Although the effectiveness of using decoys to attract the breeding population of fairy terns to 'safe' nesting habitat has remained limited, the implementation of decoys would provide opportunity for further complimentary research building on work of Jefferies and Brunton (2001). In using decoys to attract breeding terns to safer nesting habitat, decoy experiments may explore responses of fairy terns during the breeding season and the effects of greater numbers of decoys. In doing so, knowledge gaps are narrowed.

Overall Response: to be investigated and implemented in Years 1-3 as a complimentary management strategy to intensive protection of priority nesting sites.

4.2.6 Create and manage floating pontoon islands

A pair of common terns *Sternula hirundo* were attracted with decoys to nest on a pontoon in Spain in a country where the bird is very rare (P Copley 2011, *pers. comm*.). In Victoria, seabirds such as the Australasian gannet *Morus serrator* have taken opportunistically bred on floating artificial structures that are anchored in Port Phillip Bay (Marchant and Higgins 1990). Like islands, these structures provide a more secure nesting area as disturbance from humans and mammalian predators is often very low.

Floating pontoon islands that are artificially covered with sand and shell grit to mimic the preferred fairy tern nesting habitat have not been specifically trialled and consequently would required ecological and engineering investigation (but see the common tern example cited above). The structure would need to withstand a wide range of water level changes in the Coorong as well as endure storm events. Careful consideration of the substrate type including material, structure size, elevation and shape would be necessary, as would the associated risks such as loss of chicks due to falls from floating pontoon islands. The development of floating pontoon islands may however have the advantage of mobility and could be anchored in favourable locations in close proximity to adequate prey species in the Coorong, and thus provide a more secure nesting site compared to mainland nesting sites.

Attracting fairy terns to floating pontoon 'safe' nesting habitat would also be required, perhaps in conjunction with the use of decoys (see Section 5.2.4). Equally, floating pontoons may become a magnet for other birds that interfere with breeding fairy terns.

The succession and useful life of floating pontoon islands requires consideration as it is likely these manmade features would undergo a predictable pattern of plant succession, which largely determines the habitat available for nesting fairy terns, as is similar for dredge spoil islands (Golder *et al* 2008). For example, habitat management for dredge spoil islands is often required after 3-7 years to maintain a site with <15% vegetation cover, which is recommended for most specie of terns (Golder *et al* 2008). The most effective and longest lasting means of maintaining early successional habitat is by periodic nourishment with a fresh deposit of sand and shell grit, which could be feasible given the mobility of floating pontoon islands. This action may in the long term become costly. On the other hand, other methods of vegetation management can be used to maintain early successional habitat including removal of vegetation by hand, machinery, or chemicals; or covering vegetation with landscape fabric. These methods however are temporary and usually last for only one season (Golder *et al* 2008).

While floating pontoon islands would most likely be located in remote areas of the Coorong and only accessible by boat, there may be the added risk that such sites become popular areas for passive and active recreational activities, especially if located near population centers. These activities often peak during the warmer months of the year, which typically coincide with nesting activity by fairy terns. Floating pontoon islands would therefore require ongoing management and regular monitoring to prevent or discourage human disturbances. This has the potential to place additional responsibility on the appropriate agency human resources within the Coorong.

The financial cost of development of floating pontoons islands is unknown, however the ongoing management, monitoring and maintenance required after installation would be likely to be considerable in terms of human resources and thus to create and manage floating pontoons islands could be a high cost option, especially in the long term.

With each floating pontoon island potentially supporting nesting fairy terns, a management, monitoring, and maintenance plan should also be developed and implemented by an appropriate agency and/or non-governmental organization with demonstrated experience in waterbird management.

Overall Response: In the event that intensive protection of priority nesting sites fails to produce >10% fledglings in Years 1 and 2, investigate and evaluate secure floating pontoon islands that will provide additional nesting, resting and fledgling feeding habitat for the fairy tern at a range of sites in the Coorong in Year 3 with consideration for implementation after the life span of the Plan.

4.2.7 Create and manage dredge spoil islands

The use of dredged spoil (material) by nesting waterbirds has been documented for decades, but it was not until the last few decades that the overall importance of dredged material sites to nesting waterbirds was realized. For example, Parnell and Soots (1979) (cited in Golder *et al* 2008: 2) found that 76% of all ground-nesting waterbird colonies including species of terns, skimmers, pelicans, and gulls were on dredged material sites in North Carolina, USA. Dredge spoil islands have also been a key action facilitating little tern recovery in Victoria (Reside 1994) and New South Wales (NSW NPWS 2003).

Golder *et al* (2008:2) note that, "one of the greatest benefits to terns from dredging is the creation and maintenance of nesting habitats on islands. Islands created with dredged material can mimic their natural counterparts and provide excellent habitat for most tern species." Dredge spoil islands can improve nesting conditions, as the creation of dredge spoil islands are generally remote and lack mammalian predators, and are typically only accessible by boat which reduces, but does not eliminate, the potential for human disturbances. A key advantage of dredge spoil islands is that islands are often higher in elevation than natural islands, which reduces the chances of flooding during severe weather events.

There are also potential disadvantages of dredge spoil islands. Dredge spoil islands require periodic deposits of sand, typically every 3–7 years (Golder *et al* 2008; Bailey 2005) to maintain their size and appropriate vegetation in an early successional stage. This is especially true for sites for most tern species (Golder et al 2008). Islands constructed in open water where an island or emergent shoal did not previously exist can experience rapid erosion, shortening the useful life of the site. The process of dredging and disposal of dredged material can also cause localized increases in turbidity, re-suspend contaminants in sediments, degrade or eliminate submerged aquatic vegetation, cover shellfish, impact finfish spawning sites and other fishery habitat, and cover or remove intertidal habitats that are important for migrating and wintering shorebirds. These potential impacts would be detrimental for the Coorong renowned for its waterbird communities and fish nursery habitats.

Another potential disadvantage and important consideration is that creating man-made islands could be viewed as a mitigation tool for practices that destroy or degrade stable, natural habitats. This could result in more loss of natural habitats over time, especially early successional habitats, unless these habitats are permanently protected, actively managed, and periodically replenished to maintain suitable conditions for nesting terns (see Section 5.2.5). Furthermore, budgetary constraints and increased pressure to place sand on barrier beaches for beach widening and the protection of real estate (the same sand that once went to islands for the benefit of birds) could jeopardize the future of dredge spoil nesting sites that have historically supported significant populations of terns. Nevertheless, dredge spoil islands can and do provide excellent habitat for terns, and have been shown to be essential to terns (Erwin et al. 2003).

In planning for the creation or improvement of tern nesting sites with dredge spoil, the following must be considered: location, possible need for a dike, size, elevation, shape, substrate, and the implementation of a long-term maintenance, management, and monitoring plan (Golder *et al*; DENR 2011).

The Department of Environment and Natural Resources evaluated opportunities for the enhancement of bird nesting habitat including the fairy tern using dredge spoil in the Coorong North Lagoon, specifically at the Murray Mouth (DENR 2010 and 2011). Utilizing a pre-existing and low-lying (<2m) emergent shoal and a pre-existing *in-situ* dredge operation the use of dredge spoil and geotextile bags were investigated from an ecological, engineering and logistical perspective and shown to be feasible at a cost of approximately $70,000 plus in-kind contribution of approximately $80,000 (DENR 2011). Had a pre-existing dredge operation not been *in-situ*, the infrastructural, logistical and operational cost might have exceeded $200,000 (C Manning 2011, pers. *comm*.). An Agreement between the SA Government and the Ngarrindjeri Regional Authority that represent the Traditional Owners requires that any works associated with the movement or disturbance of earth requires a Work Area Clearance Survey. This Agreement process between the SA Government and the Ngarrindjeri Regional Authority exceeded the strict timeframe and a dredge spoil island was not built (DENR 2011).

Despite undertaking a detailed scope of works, had the proposal dredge spoil island been implemented, the site would have likely been undercut and eroded as unexpected flood water entered the Murray-Darling Basin (C Manning 2011, pers. *comm*.). In January 2011, flow to South Australia averaged at 56,000 ML/day and water was released from the barrage to pass the higher flows and to lower the water level in the Lakes for improved salinity outcomes (DfW 2011a). Subject to river operations and weather conditions, high flow conditions remained with the range of 65,000 ML/day to 85,000 ML/day during February (DfW 2011b) with the majority of barrage gates (402 out of 593) opened. It was during this period, that almost 80% of the site of the proposal dredge spoil island eroded (C Manning 2011, *pers. comm*.). It was also during this period, notably the peak breeding season, that an active colony, believed to have been the majority of the Coorong fairy tern breeding population, established on the Ocean Beach Younghusband Peninsula, a nesting site not previously recorded (C Manning 2011, *pers. comm*.). Whether the birds would have established a colony at this new site despite of flood waters is unknown.

With the increased inflows, the need to manually maintain an open Murray Mouth by use of dredging was surplus to requirements. Consequently, the Murray Mouth Sand Pumping Project has since ceased operations until: a) integrated water management in the Murray-Darling Basin is appropriate and ensures adequate and suitably timed environmental flows or, b) the risk of the Murray Mouth closing becomes apparent.

Overall Response: dredge spoil islands provide a useful management tool for nesting birds but without an *in situ* dredge operation this management option would most likely be constrained by high costs. Given the lessons learnt by DENR (2011), further investigation into the structure of such islands under different flow conditions is required. Dredge spoil islands constructed in open water where an island or emergent shoal did not previously exist can experience rapid erosion, shortening the useful life of the site. In the Coorong North Lagoon, few pre-existing islands or emergent shoals exist however due to the locality of such areas within the Coorong North Lagoon, a dredge operation at these sites would likely present major logistical, operational and access issues. In addition, these sites are important nesting sites for a variety of waterbirds including fairy terns and therefore the risks associated with a dredge operations disturbance would also require investigation.

In the event that intensive protection of priority nesting sites fail to produce >10% fledglings in Years 1 and 2 this option should however be further investigated in Year 3 with consideration for implementation after the life span of the Plan. Intensive protection of the site and attracting the remaining breeding population to the site using decoys would also form part of this management option. A budgetary requirement would need to be investigated.

4.2.8 Maximise productivity by egg and chick manipulation

In New Zealand, the fairy tern has a high proportion of infertile eggs (c. 33%) and an average 6–7 year life-span. For their survival and recovery it is vital that the maximum number of chicks is produced each breeding season to compensate for population fluctuations and the natural events (storms and high tides) that they are vulnerable to (Hansen 2005). For the equivalent of one chick to be reared per breeding pair each season, all eggs are candled to determine their fertility, and abandoned eggs are rescued for artificial incubation (Hansen 2005; Ferreira *et al* 2005). Eggs are cross-fostered or returned to parents after about 20 days of artificial incubation. Chicks are also cross-fostered to maximise productivity. The long-term success of this level of intervention has yet to be demonstrated.

Even if it was possible to adopt a similar program in the Coorong it would involve a substantial increase in the intensity of management and require a full-time Project Officer and dedicated infrastructure and a budgetary requirement would need to be fully investigated.

Overall Response: in the event intensive protection of priority nesting sites fail to produce >10% fledglings in Years 1 and 2, maximising productivity by egg and chick manipulation should be further investigated in Year 3 with consideration for implementation post the life span of the Plan. Intensive protection of nesting sites and attracting the remaining breeding population to 'safer' sites using decoys would also form part of this management option. A budgetary requirement would need to be investigated.

4.3. Goal and Objective

The overall goal of the Plan is *to ensure their long-term survival by increasing the Coorong fairy tern population by >75% within three years.*

4.3.1 Objectives for the Term of the Plan

The Plan has a three year life span of 2011-14 and has four core objectives under which actions are required.

Objective 1.0 Managing the population

Objective 2.0 Research

Objective 3.0 Partner and Community Involvements and Coordination

Objective 4.0 Planning, Monitoring and Evaluation

4.3.2 Managing the Population

Actively managing and protecting the Coorong fairy tern population by reducing known threats in order to achieve an increase in the population by >10% within three years.

4.3.3 Research

Identifying the research needs that will contribute to the protection of the fairy tern, and developing and implementing research programs in partnerships between government and non-government research organisations.

4.3.4 Partner and Community Involvements and Coordination

Raising public awareness through accurate and regular media outputs and increasing partner and community involvement in the bird's protection.

4.3.5 Planning, Monitoring and Evaluation

Ensuring the Plan is implemented through the engagement of a Project Officer to gather information for local planning and management decisions and implementing, monitoring and evaluating the effectiveness of the Plan.

Table 1 outlines the objectives and actions for the term of the Plan.

Table 1. Plan objectives and actions 2011-14.

Key

Essentaial	Highly Desirable	Desirable	Not Applicable

To ensure their long-term survival by increasing the Coorong fairy tern population by >75% within three years.				
Objective 1.0 Managing population				
	Action(s)	**2011-12**	**2012-13**	**2013-14**
1.1 Reducing Threats	1.1.1 Discourage birds from nesting in low lying areas prone to water inundation by crisscrossing the area with bunting attached to stardroppers			
	1.1.2 If birds nest where water inundation is inevitable, and where possible, protect individual nests with raised sand bags and/or move nests to higher ground. Nests may be raised by picking up the eggs, forming a ring with sandbags, filling the ring with sand and placing the eggs back on top of the mound. Alternatively, the eggs may be gradually moved to higher ground at a rate of 1-2 m per day (Hansen 2005)			
	1.1.3 Attract birds to 'safer' nesting sites by using bird decoys			
	1.1.4 Develop and implement a threat abatement plan for the fox that is effective in minimizing the impacts of fox predation on the target species. Electric fencing should be used where possible in conjunction with baiting			
	1.1.5 Monitor and, if required, control avian predators by shooting, baiting or trapping depending on the timing of events in relation to the fairy tern breeding season			

1.1 Reducing Threats	1.1.6 Control human disturbance by erecting temporary or permanent fences and signs around nesting sites warning of the presence of nesting fairy terns.			
	1.1.7 Enforce the annual beach closure to off-road recreational vehicles from 24 October to 24 December by compliance activities and liaise closely with commercial fisheries whose vehicles are exempt from the annual beach closure			
	1.1.8 Exclude off-road recreational vehicles from the vicinity of active nesting sites by compliance activities. Where feasible, access should be blocked with physical barriers			
	1.1.9 Control encroaching vegetation and/or remove vegetation at times of high water levels at known breeding sites in August-September. There should be <15% vegetation cover on nesting areas; however patches of low vegetation should be retained around the fringes of the area to provide valuable shelter for chicks.			
	1.1.10 Consult with agencies and organisations and strongly advocate for the ban of domestic Dogs in the Coorong National Park using the fairy tern and other threatened birds and their listing under the EPBC Act 1999 as a lever.			
	1.1.11 Consult with agencies and organisations and strongly advocate to the Federal and State Government for environmental flows within the Murray-Darling Basin using the fairy tern and its listing under the EPBC Act 1999 as a lever.			
Performance Criterion	*Increase trend in the Coorong fairy tern population*			
Objective 2.0 Research				
2.1 Improved understanding of the demographics of the Coorong fairy tern population	2.1.1 Collate historic data of Coorong fairy tern demography. These data are currently held by the University of Adelaide in the form of a long-term mark-recapture study of the population.			
	2.1.2 Use collated data to develop a demographic model of the Coorong fairy tern population, in order to predict population viability in response to alternative management regimes			
	2.1.3 Identify information gaps from a demographic model. Develop and implement research projects to fill information gaps. Ensure monitoring programs are designed to			

	detect changes in key demographic processes			
2.2 Improved understanding of the ecological requirements of the Coorong fairy tern	2.2.1 Collate existing information of ecological (biotic and abiotic) requirements of the Coorong fairy tern. These data currently come in a range of forms, including waterbird surveys, other relevant ecological survey data (fish, *Ruppia*), hydrological data, spatial (e.g. elevation) data and expert models.			
	2.2.2 Develop a mechanistic model (using e.g. Bayesian networks) that incorporates the biotic and abiotic ecological requirements of the Coorong fairy tern, in order to predict changes in distribution of suitable habitat at key life-history stages (e.g. breeding, non-breeding) in response to alternative management regimes			
	2.2.3 Identify information gaps from the model. Develop and implement research projects to fill information gaps. Ensure monitoring programs are designed to detect change in key ecological components and processes (e.g. fish, *Ruppia*, hydrology)			
2.3 Improved understanding of the relationship of the Coorong fairy tern population with other Australian fairy tern populations	2.3.1 Determine the current distribution and abundance of fairy terns in South Australia by coordinating and collaborating with relevant agencies, organisations and community groups			
	2.3.2 Liaise with interstate organisations to determine the national status and trend of the fairy tern. Input to the development of national monitoring protocols for the fairy tern			
	2.3.3 Develop research programs designed to determine the role that the Coorong fairy tern population plays in the metapopulation dynamics of fairy terns, particularly in south-eastern Australia. Such investigations may focus on a combination of mark-recapture studies, movement studies and genetic studies.			
2.4 Design and implement a monitoring and evaluation plan	2.4.1 Design and implement a monitoring and evaluation plan that: i) evaluates if intervention measures have been implemented; ii) evaluates the response of the Coorong fairy tern population to intervention measures (in the context of "unmanaged" environmental change); iii) improves the predictive power of demographic models (2.1) and "habitat" models (2.2)			
2.5 Creation and management of floating pontoon islands	2.5.1 Investigate and evaluate secure floating pontoon islands that will provide additional nesting, resting and fledgling feeding habitat for the fairy tern at a range of sites in the Coorong by consulting with the Traditional Owners, land managers,			

	engineers, hydrologist, researchers and ornithologists			
	2.5.2 Investigate and evaluate the budgetary requirements for the creation and management of floating pontoon islands by consulting with the Traditional Owners, land managers, engineers, hydrologist, researchers and ornithologists			
2.6 Creation and management of dredge spoil islands	2.6.1 Investigate and evaluate the use of dredge spoil islands under different flow conditions in the Coorong by consulting with the Traditional Owners, land managers, engineers, hydrologist, researchers and ornithologists			
	2.6.2 Investigate and evaluate the use of dredge spoil islands at pre-existing islands or emergent shoals within the Coorong by consulting with the Traditional Owners, land managers, engineers, hydrologist, researchers and ornithologists			
	2.6.3 Investigate and evaluate the budgetary requirements for the use of dredge spoil islands at pre-existing islands or emergent shoals within the Coorong by consulting with the Traditional Owners, land managers, engineers, hydrologist, researchers and ornithologists			
2.7 Maximise productivity	2.7.1 Investigate and evaluate the viability of maximising productivity by egg and chick manipulation by consulting with the Traditional Owners, land managers, researchers and ornithologists			
	2.7.2 Investigate and evaluate the budgetary requirements for maximising productivity by egg and chick manipulation by consulting with the Traditional Owners, land managers, researchers and ornithologists			
Performance Criterion	*Improved understanding of the ecology of Coorong fairy tern, the response of Coorong fairy tern to management, and the efficacy of potential management options*			
Objective 3.0 Partner and Community Involvements and Coordination				
3.1 Public education and awareness and publicity	3.1.1 Develop a species profile to provide information about the conservation status and management issues affecting the fairy tern			
	3.1.2 Distribute a species profile to target groups including 4WD clubs, tour operators,			

	visitors and local communities			
	3.1.3 Develop other forms of educational material about the conservation status and management issues affecting the fairy tern such as newsletters, news articles, posters, radio, public seminars			
3.2 Cultural involvement	3.2.1 Seek partnerships with the Traditional Owners in technical, practical and/or financial involvement and support in Plan implementation			
3.3 Increase volunteer wardens	3.3.1 Provide opportunities for community volunteer wardens to assist in the protection of Coorong fairy tern nesting sites by providing training			
	3.3.2 Develop and produce a field manual for volunteer wardens to advise on field based activities			
3.4 Recovery effort	3.4.1 To assist in data validation and community contribution ensure feedback from volunteer wardens is captured.			
	3.4.2 Ensure in kind community contributions are accurately recorded and acknowledged			
Performance Criterion	*Support for the protection of the Coorong fairy tern increased*			
Objective 4.0 Planning, Monitoring and Evaluation				
4.1 Human Resources	4.1.1 Engage a Project Officer			
4.2 Monitoring and Evaluation	4.2.1 Identify issues, assess management success and review the Plan by a coordinated Local Fairy Tern Recovery Team			
	4.2.2 Identify and establish a Local Fairy Tern Recovery Team to ensure a participatory process at every stage of decision making by selection of appropriate individuals that include representative of the Traditional Owners, land managers, hydrologist, researchers, ornithologists and community members			
	4.2.3 Develop Terms of Reference for evaluations and review of the Local Fairy Tern			

	Recovery Team			
Performance Criterion	*Project Officer engaged and supported by the Recovery Team that assesses or evaluates management effectiveness by measuring the degrees to which the Plan is achieving its objectives, and how successfully the Plan is designed, planned and managed.*			

4.4 Timeframe and Budget

An annual funding schedule for the Plan is provided in Table 2. Figures quoted are the approximate costs associated with undertaking the actions. The primary cost is attributed to an ongoing Project Officer and ongoing intensive management and monitoring of fairy tern colonies in the Coorong.

Table 2. Budget forecast for the term of the Plan.

Objective	Abbreviated Action(s)	Estimated Annual Cost ($)			
		2011-12	**2012-13**	**2013-14**	**Project Cost**
Objective 1.0 Managing population					
1.1 Reducing Threats	1.1.1 Discourage birds from nesting in low areas	300.	300.	300.	**900.**
	1.1.2 Protect individual nests with sand bags	2,500	0	0	**2,500.**
	1.1.3 Use bird decoys	2,000.	0	0	**2,000.**
	1.1.4 Threat abatement plan and control	5,000.	5,000.	5,000.	**15,000.**
	1.1.5 Control avian predators	1,000.	1,000.	1,000.	**3,000.**
	1.1.6 Control human disturbance	1,000.	1,000.	1,000.	**3,000.**
	1.1.7 Enforce the annual beach closure	✓	✓	✓	✓
	1.1.8 Exclude off-road recreational vehicles from active nesting sites	✓	✓	✓	✓
	1.1.9 Control encroaching vegetation	✓	✓	✓	✓
	1.1.10 Advocate for a ban on domestic dogs	*	*	*	*

	1.1.11 Advocate for environmental flows within the Murray-Darling Basin	*	*	*	*
Objective 2.0 Research					
2.1 Improved understanding of the demographics of the Coorong fairy tern population	2.1.1 Collate historic Coorong fairy tern demography	*	*	*	*
	2.1.2 Develop a demographic model of the Coorong fairy tern population	†	†	†	†
	2.1.3 Identify information gaps in a demographic model and develop monitoring programs	†	†	†	†
2.2 Improved understanding of the ecological requirements of the Coorong fairy tern	2.2.1 Collate existing information of ecological requirements of the Coorong fairy tern.	*	*	*	*
	2.2.2 Develop a mechanistic model	†	†	†	†
	2.2.3 Identify information gaps from the mechanistic model and narrow information gaps	†	†	†	†
2.3 Improved understanding of the relationship of the Coorong fairy tern population with other Australian fairy tern populations	2.3.1 Statewide fairy tern census	18,000.	0	0	**18,000.**
	2.3.2 Determine the national status and trend of fairy tern. Input to national monitoring protocols	*	*	*	*
	2.3.3 Determine the role that the Coorong fairy tern population plays in the metapopulation dynamics of fairy terns	†	†	†	†

2.4 Design and implement a monitoring and evaluation plan	2.4.1 Design and implement a monitoring and evaluation plan	*	*	*	*
2.5 Creation and management of floating pontoon islands	2.5.1 Investigate and evaluate secure floating pontoon islands	0	0	†	†
	2.5.2 Investigate and evaluate the budgetary requirements for the creation and management of floating pontoon islands	0	0	*	*
2.6 Creation and management of dredge spoil islands	2.6.1 Investigate and evaluate the use of dredge spoil islands under different flow conditions in the Coorong	0	0	†	†
	2.6.2 Investigate and evaluate the use of dredge spoil islands at pre-existing islands or emergent shoals within the Coorong	0	0	†	†
	2.6.3 Investigate and evaluate the budgetary requirements for the use of dredge spoil islands	0	0	*	†
2.7 Maximise productivity	2.7.1 Investigate and evaluate the viability of maximising productivity by egg and chick manipulation	0	0	*	†
	2.7.2 Investigate and evaluate the budgetary requirements for maximising productivity	0	0	*	†
Objective 3.0 Partner and Community Involvements and Coordination					
3.1 Public education and	3.1.1 Develop a species profile	5,000	0	0	**5,000**

awareness and publicity	3.1.2 Distribute a species profile to target groups	2,000.	1,000.	1,000.	**4,000.**
	3.1.3 Develop and distribute other forms of educational material	3,000	3,000.	3,000.	**9,000.**
3.2 Cultural involvement	3.2.1 Seek partnerships and opportunities for involvement and support with the Traditional Owners	1,000.	1,000.	1,000.	**3,000.**
3.3 Increase volunteer wardens	3.3.1 Provide opportunities for community volunteer wardens	1,000.	1,000.	1,000.	**3,000.**
	3.3.2 Develop a field manual	500.	0	0	**500.**
3.4 Recovery effort	3.4.1 Data validation and community contribution	500.	500.	500.	**1,500.**
	3.4.2 Community contribution acknowledged	500.	500.	500.	**1,500.**
Objective 4.0 Planning, Monitoring and Evaluation					
4.1 Human resources	2.1 Project Officer	70,000.	70,000.	70,000.	**210,000.**
4.2 Monitoring and Evaluation	4.2.1 Identify issues, assess management success and review the Plan	1,000.	1,000.	1,000.	**3,000.**
	4.2.2 Identify and establish a Local Fairy Tern Recovery Team	1,000.	1,000.	1,000.	**3,000.**
	4.2.3 Develop Terms of Reference	500.	0	0	**500.**

✓ Indicates that the cost of the action is included as part of core functions of SA NPWSS and as such is not included as part of the budget forecast.

† Indicates that the cost of the actions is not known at this time.

* Indicates that the cost of the action is included as part of core functions of the Project Officer and as such is not included as part of the budget forecast.

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Appendix 1

The location of known fairy tern colonies in the Coorong National Park as at June 2011.

Nesting Site	Region of Coorong	Map	Datum	Easting	Northing	Source
Murray Mouth	Murray River Estuary	54	WGS84	0308000	6063250	Paton and Roger 2009b
Dredge Outlet Ocean Beach	Younghusband Peninsula	54	WGS84	0308750	6062448	C. Manning *pers.comms*
Goat Island	North Lagoon	54	WGS84	0350700	6031800	Paton and Roger 2009b
Island 300m south of Seagull Island	South Lagoon	54	WGS84	0373250	6005500	Paton and Roger 2009b
Reef north of Wild Dog Island	South Lagoon	54	WGS84	0376071	6001967	C. Manning *pers.comms*
Reef north of Cattle Island	South Lagoon	54	WGS84	0368100	6013750	Paton and Roger 2009b
Cow Island	South Lagoon	54	WGS84	0360250	6022500	Paton and Roger 2009b
West Cattle Island	South Lagoon	54	WGS84	0365100	6013750	Paton and Roger 2009b
Teal Island	South Lagoon	54	WGS84	0370100	6011000	Paton and Roger 2009b
Mellor Island	South Lagoon	54	WGS84	0371650	6007550	Paton and Roger 2009b
South Reef	South Lagoon	54	WGS84	0372200	6007300	Paton and Roger 2009b
Drain Outlet Salt Creek	South Lagoon	54	WGS84	0377700	6001600	Paton and Roger 2009b

Appendix 2

Under technical guidance and support, Volunteer Wardens are appointed to assist in protecting and monitoring active fairy tern colonies. The main tasks may include:

- Putting up temporary fences and signs around the nest sites to discourage people from approaching active colonies
- Observing and recording potential threats e.g. number of vehicles, dogs, people and potential predators
- Monitoring egg laying, hatching and fledging of chicks
- Recording details about egg and chick failures
- Recording tide and weather conditions
- Assisting with protection measures such as sand-bagging and nest relocation and removing eggs or chicks from nests at risk
- Recording fairy tern behaviour and interaction
- Increasing public awareness of the species and recovery program