Shorebird Population Monitoring in Gulf St Vincent: 2016-17 Annual report

Prepared by Chris Purnell on behalf of BirdLife Australia for
Natural Resources, Adelaide and Mount Lofty Ranges

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BirdLife Australia

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Cover photos:
Workshop attendees viewing shorebirds, Thompsons Beach north – Chris Purnell
Curlew Sandpiper at Bakers Creek, Webb Beach– Chris Purnell

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EXECUTIVE SUMMARY

Populations of shorebirds (also known as 'waders') are declining throughout the world. Their long-term survival will require managers and planners to identify and protect their habitats, identify and reduce the impacts of threats to their fitness, and identify population declines sufficiently early to limit their severity through sympathetic management. Shorebirds conservation has been recognised as a *matter of national environmental significance* in Australia's *Environment Protection and Biodiversity Conservation Act* (1999), and also in several international conservation agreements to which Australia is a signatory.

Gulf St Vincent has long been recognised as a nationally and internationally significant area for shorebirds. The area currently hosts an average of over 29,000 shorebirds each year including 14,000 migrants of 13 species. With the cumulative effects of threats throughout the East Asian—Australian Flyway driving regional declines in migratory shorebirds in the region (Table 1), the conservation and appropriate management of key terminal migration habitats in Gulf St Vincent will be crucial to the national conservation effort.

Table 1. GSV migratory shorebird populations from 3 periods; 1979-1985 (estimates from Close 2008), 2000-2008 (estimates from Close 2008) and 2009-2017 (BirdLife S2020 data) *.
***Average taken from top 5 counts per species over the project period.**

Species	PERIOD 1 1979-85	PERIOD 2 2000-2008	PERIOD 3 2009-2017	% change PERIOD 1-2	**% change PERIOD 1-3**
Bar-tailed Godwit	960	213	212	-78	**-78**
Black-tailed Godwit	84	0	14	-100	**-84**
Common Greenshank	1149	786	368	-32	**-68**
Curlew Sandpiper	8695	2541	400	-71	**-95**
Eastern Curlew	171	156	48	-9	**-72**
Great Knot	443	237	264	-47	**-40**
Grey Plover	1167	564	161	-52	**-86**
Grey-tailed Tattler	61	1	2	-98	**-96**
Marsh Sandpiper	55	77	16	40	**-71**
Red Knot	1167	1036	1395	-11	**20**
Red-necked Stint	28912	18382	8855	-36	**-69**
Ruddy Turnstone	289	513	85	78	**-70**
Sharp-tailed Sandpiper	16469	4864	2095	-70	**-87**

The South Australian Government, Department of Environment, Water and Natural Resources and Natural Resources, Adelaide and Mt Lofty Ranges in conjunction with local councils should be commended in their efforts to secure shorebird habitat values through a large portfolio of works culminating in the declaration of the formulation of the *Adelaide International Bird Sanctuary National Park- Winaityinaityi Pangkara* and the successful listing of the site as an *East Asian Australasian Flyway Network Site of significance*.

As a result of further fieldwork, literature reviews, a review of development proposals, and managers' and stakeholders' workshops, it seems clear to BirdLife Australia that:

a) Disturbance and habitat loss/degradation are the two greatest threats to shorebirds in the region;
b) Intensifying anthropogenic disturbance on the intertidal zone of Samphire Coast's northern Beaches (Pt Prime- Parham) is having a deleterious effect on important shorebird habitat of international significance. Immediate intervention (DEWNR, PIRSA) is necessary.
c) Highly threatened, internationally significant intertidal areas adjacent to Thompson Beach township should be included in the Adelaide International Bird Sanctuary National Park boundary.
d) The increased severity and regularity of climate change induced storm events has highlighted the necessity for conservation of key intertidal retreat zones throughout the samphire coast.

e) The artificial wetlands of the Dry Creek Saltfields have supported the greatest abundance of shorebirds in the region (15,000 on average) and add resilience to the regional population that is irreplaceable. Informed adaptive management of these habitats will be required to maintain shorebird populations now that salt production has ceased;
f) The Dry Creek Saltfields site can provide unparalleled ecological community and tourism opportunities.
g) Significant refuge habitat on Section Bank/Bird Island should be included in the Adelaide International Bird Sanctuary National Park boundary and optimised by ongoing pest control and managing recreational visitation;
h) The Northern Connector Southern Gateway Project has had a deleterious effect on shorebird habitat in the Barker Inlet Wetlands. Consultation and inclusion of comments on design changes throughout the Lendlease design and implementation phase were inadequate.
i) Planning and design for Northern Connector offset habitat should consult closely with BirdLife Australia, Birds SA, NR AMLR and DEWNR.
j) The Adelaide International Bird Sanctuary has significantly increased shorebirds conservation awareness in the community, improved cross-sector and department collaboration and increased recognition of Gulf St Vincent as a significant shorebird site nationally and internationally.
k) Working groups administering the Adelaide International Bird Sanctuary and the rehabilitation plan for the Dry Creek Saltfields should continue to consult the abundance of literature and expertise made available by experts in the development of future strategic planning for shorebird conservation.

This report: (a) repeats an overview of shorebirds, habitats and threats; (b) provides details of the 2016–17 counts (A total of 103 counts were submitted by 25 counters, equating to approximately 720 hours contributed by citizen scientists.); (c) reports on training and awareness events conducted in 2016-17 (d) provides information that is relevant to the management of shorebirds and the threats they face in Gulf St Vincent.

We look forward to another year in which we can further inform on how to optimise shorebird monitoring and conservation effort in Gulf St Vincent

1 *INTRODUCTION*

Gulf St Vincent has long been recognised as an internationally significant area for shorebirds (Close 1983, Lane 1987, Wilson 2000, Close 2008, Bamford *et al.* 2008) and over the last 25 years, counts of migratory shorebirds throughout wetlands of the region have been conducted by volunteer counters from organisations including the Australasian Wader Studies Group and Birds South Australia.

The Gulf is known to be one of the most species diverse shorebird areas in Australia with 52 species of shorebird documented in the region. Currently the gulf regularly plays host an average of over 29,000 shorebirds each year including 14,000 migrants of 13 species.

The importance of migratory shorebird conservation is widely documented, and as indicators of wetland health, shorebirds are considered to be good flagship species for wetland habitats, both nationally and internationally. There has been an increased need for shorebird conservation in recent years, with evidence that migratory shorebird populations are declining throughout the world (Morrison *et al*. 2001; IWSG 2003; Olsen *et al*. 2003; CHSM 2004; van de Kam *et al*. 2004), including a growing body of evidence that suggests populations are declining in Australia (Gosbell & Clemens 2006; Nebel *et al*. 2008; BirdLife Australia unpublished data). With this in mind, the Adelaide and Mount Lofty Ranges Natural Resources Management Board (NRM) provided funding to BirdLife Australia to coordinate a complete count of the shorebirds within Gulf St Vincent, including supplementary surveys of poorly known shorebird habitat. Commencing in 2009, the project aimed to reinvigorate shorebird population monitoring and identify important shorebird habitats in the region. The resulting reports and associated GIS layers provide an inventory of shorebird habitats and highlight the distribution and abundance of shorebirds in Gulf St Vincent, as well as identifying current and potential threats to shorebirds in the region. Work also included conducting shorebird training workshops to recruit, train and inform counters. Additional funding from the Adelaide and Mount Lofty Ranges NRM Board will allow this work to continue until 2018.

This report highlights the results to July 2017. Work between July 2009 and June 2017 has increased the number of active, trained volunteers required to carry out shorebird surveys in Gulf St Vincent, increased the spatial resolution of mapping and identified priority shorebird habitats and the threats affecting them in Gulf St Vincent. Associated work in 2015–16 also included the coordination of four simultaneous counts of shorebirds in Gulf St Vincent, workshops to recruit and train counters, further banding expeditions, by Friends of Shorebirds SE and Victorian Wader Study Group, to increase our knowledge of bird movements. We have also increased our understanding of the threats to shorebirds in Gulf St Vincent as well as the types of management required to ensure long-term shorebird conservation. Data was also incorporated into a flyway wide review of shorebird population estimates. The project also contributed data to assist with the South Australian government's proclamation of the Adelaide International Bird Sanctuary as well as the successful East Asian Australasian Flyway Site nomination of Gulf St Vincent.

The reinvigoration of shorebird monitoring in Gulf St Vincent has provided valuable information to BirdLife Australia's Shorebirds 2020 program, which coordinates national shorebird population monitoring. Shorebirds 2020 was initiated in 2007 in response to growing concern over declining shorebird populations in Australia and the need to reliably determine population trends for the various species of shorebirds. The aim of Shorebirds 2020 is to collect data on the populations of shorebirds, and this can be used to aid their conservation and management. Specifically, the aim is to understand national (and, where possible, site-based) population trends, and explore the potential causes of change through increasing our understanding of the relationship between habitat, habitat quality and threats, and how they interact to affect the distribution and abundance of shorebirds in Australia.

Recent work has identified a need to conduct annual surveys at over 150 sites throughout Australia to detect the national population trends of migratory and resident species of shorebirds. Gulf St Vincent is considered the second-most important shorebird area in South Australia due to its abundance and diversity of species of shorebirds, and it is crucial in terms of areas that must be surveyed to determine national population trends.

With projected growth estimates predicting that Adelaide's population will increase to 560,000 people (including 160,000 in the northern Adelaide region) in the next 30 years, it is vital to inform managers and planners about how to ensure the long-term conservation of shorebirds in Gulf St Vincent. This project has delivered some of the first steps required to achieve that long-term aim. Gulf St Vincent's shorebird habitats have been identified, mapped at fine scale and described with regard to the relative importance for shorebirds in each area. This should allow improved planning and threat minimisation. Awareness of the need for shorebird conservation has been raised within the birdwatching community and stakeholders involved in the management of shorebird habitat through workshops. These workshops, together with work by Birds South Australia, have also increased the number of skilled shorebird counters.

Shorebird monitoring has been reinvigorated within Gulf St Vincent and steps are being taken to optimise that monitoring to inform on adaptive management of shorebird habitats. Results from recent analyses suggest current monitoring is sufficient to detect national shorebird trends, but significantly more counts would be required to identify anything other than a catastrophic (>70%) decline of shorebirds within Gulf St Vincent over 20 years. Fieldwork, literature reviews and stakeholder discussions have increased our understanding of the specific threats to shorebirds in Gulf St Vincent and highlighted some of the management and conservation measures required to limit the impact of those threats. These threats are growing and it is clear that some key areas, such as the northern beaches, will need to be protected, while other areas will require active management to maintain shorebird populations. This report highlights the progress towards these required steps for long-term shorebird conservation in Gulf St Vincent, but ultimately shorebird conservation in the region will depend on the role that local planners and managers adopt.

Whilst previous work has focused on coastal areas north of Adelaide, natural resource managers are also aware of the need to conserve and manage other shorebird habitats in the region. Recent work and survey count effort has also focussed on shorebird habitats in the Willunga Basin, such as the Onkaparinga Estuary and Washpool Lagoon.

Section 1.01 Background information on shorebirds, habitats and threats

(a) What are shorebirds?

Shorebirds (also known as 'waders') in Gulf St Vincent include sandpipers, plovers, stints, oystercatchers, godwits, curlews, knots and greenshanks. As a somewhat arbitrary group within the order Charadriiformes, shorebirds are not defined by any agreed taxonomic or morphological definition, they are however characterised by their general dependence on wetland habitats. The conservation of any one shorebird species is contingent on their life history and can be influenced by changes to these habitats at several spatial and temporal scales. In Australia, shorebirds are categorised as either:

- Flyway migrants- 37 species regularly spend their non-breeding season in Australia
- resident breeding species - 18 species of breed in Australia, remaining here throughout the year (Geering *et al*. 2007)

Each strategy has its own associated conservation issues; however, it is the conservation of flyway migrants that poses the most significant management challenge. These species undertake one of the most spectacular annual migrations in the animal kingdom, enabling them to breed in highly productive tundras and steppes of the northern palearctic in the boreal summer and then disperse widely across the abundant wetlands and coastlines of Oceania and southern Asia for the remainder of the year. This annual migration route follows what is known as the East Asian Australasian Flyway (EAAF) and encompasses a wide variety of landscapes spanning many administrative boundaries and potential threats.

(i) The East Asian Australasian Flyway

A flyway represents the collective migration routes of waterbirds, including shorebirds, between their breeding and non-breeding areas. The EAAF is one of the world's nine major flyways for migratory waterbirds, extending from northern Russia and Alaska (USA) to south-east Asia and Australasia, encompassing 21 countries. It supports 155 migratory waterbird species that depend on intertidal and associated coastal habitats, including over five million migratory shorebirds of 71 species; more than any of other flyway (Barter 2002, Bamford 2008, MacKinnon *et al.* 2012). Thirty-seven of these shorebird species occur annually in Australia, and travel 12,000-14,000 km to reach the boreal and arctic areas of Russia, Alaska, Mongolia and northern China where they breed during the northern hemisphere summer (Jackson 2017). The Australian Government identifies these species as *Matters of Environmental Significance* under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The two million migratory shorebirds that visit Australia each year breed in the arctic tundra of Russia and Alaska, in meadows within the belt of boreal forests in the Northern Hemisphere, or in the rugged deserts and steppes of the middle-northern latitudes, in places such as Mongolia and northern China. Many shorebirds hatch into the care of a male and female which travel to breed in the same place, year after year. Others hatch in areas where food was plentiful at that time, where either the male or the female may mate with many partners, leaving the parental care to their many mates. A few hatch into families where the male takes care of one clutch of eggs while the female cares for a second. No matter where they were born, or the type of family they come from, all grow quickly before they embark on a remarkable journey (Figure 1).

Almost as soon as a shorebird hatches it is able to walk and forage on its own. Parental care consists mostly of distracting predators, such as Arctic Foxes, Jaegers or skuas and Snowy Owls, and leading young to patches of food. When the chicks are only six weeks old, the mother often leaves on her migration to the Southern Hemisphere, and the father often follows about a week later.

The chicks are fully grown just eight weeks after hatching, and they must fly south without their parents or else they risk freezing in the coming snows. In a physiological frenzy, the young birds may increase their mass by up to 80 per cent until their body mass comprises 55 per cent fat, their weight increasing by 2–5 per cent each day. Just before they leave on migration, the young birds' feeding organs shrink, their heart expands and their blood thickens. Then they set off south, burning their accumulated fat at a rate of up to 1 gram each hour, flapping constantly as their body, heart and muscles atrophy. Avoiding aerial predators and poor weather along the way, the most difficult aspect of the journey is navigating distances of up to 13,000 kilometres by instinct, as there are no older birds to guide them. They fly non-stop for days at time, and most are only able to last about half the journey before they need to stop to feed so that they can again increase their body mass to provide sufficient energy to complete the journey. The areas they stop at must be rich intertidal ecosystems with abundant food sources.

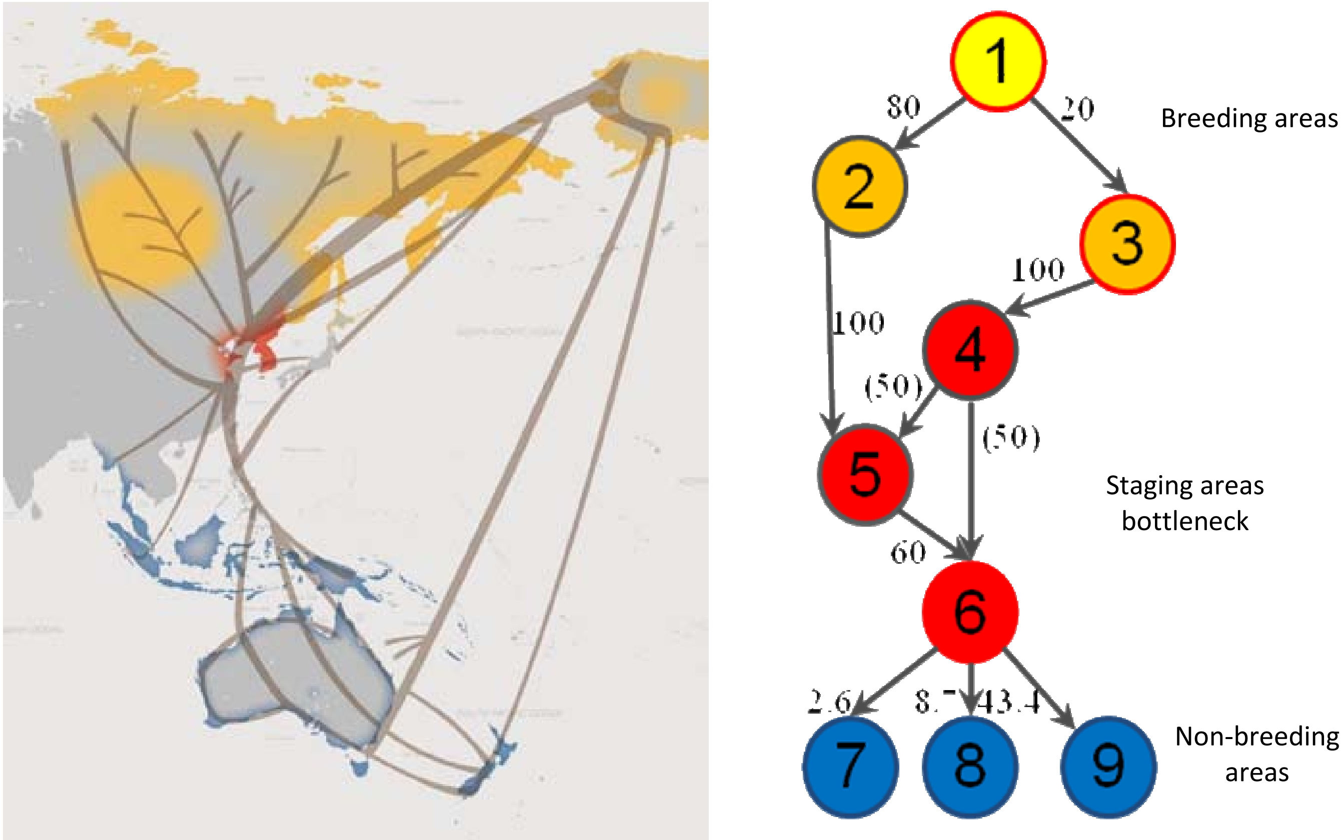


Figure 1. a) Every year more than 2 million shorebirds travel back and forth between their Arctic breeding grounds (yellow) and their Australasian non-breeding areas (blue), travelling along migration routes (dark grey). Over 3 million shorebirds stage in the Yellow Sea (red).
b) These routes are complex and numerous, and any one population may rely on a number of staging and wintering sites. A theoretical migratory species flyway, modelled as a graph consisting of nodes and edges. A node represents a geographical group of internationally important wetland sites that are used as a single unit by the birds. An edge connects two nodes and has direction and weight, representing the proportional flow of birds between nodes (Adapted from Iwamura et al 2013).

A few shorebirds have been shown to complete their flight in one hop. Some Bar-tailed Godwits were tracked flying directly from Alaska to New Zealand over nine days, comprising a non-stop 11,000-kilometre trip across the Pacific Ocean. On such long flights, there is evidence which suggests that: these birds can rest different parts of their brains independently; they can see lines of polarity in the sky (like seeing a compass); they can sense low-frequency, long-distance travelling sounds called infrasound (a sound made by crashing waves, among other things); and they can navigate by the position of the sun and moon and the movement of the stars.

The Samphire Coast Icon Project has supported recent satellite tracking of Grey Plovers migrating from Thompson Beach to the arctic. These birds undertake a non-stop flight of over 7,000 kilometres over some 6 days to mainland China and Taiwan, before making their way to the Siberian coast and islands.

After completing their first migration by the time they are 3–4 months old, juvenile birds inhabit the tidal flats and wetlands of Australia, where they may remain for up to five years before migrating north again to breed. Meanwhile, adults migrate back and forth each year, building up their weight before each migration, and most appear to stop over to feed along the way. An extra refuelling stop on the northward migration may be necessary because their destinations in the high latitudes of the Northern Hemisphere are still cold when the birds arrive, and they need to have sufficient energy to breed successfully.

Unfortunately, these critical stop-over sites are being destroyed at an alarming rate, and this appears to be driving both long and short-term population declines in migratory shorebirds (Section 1.01(c)).

Given the size of the area that migratory shorebirds rely on to survive each year, their conservation is not simple. It requires a level of international cooperation to maintain the vital habitats that occur from Siberia to Australia on which shorebirds rely to survive. However, Australia is uniquely placed to use good science to understand how shorebird populations may be changing. Without such knowledge it is difficult to make the case for the protection of shorebird habitats, to discover what is driving some of these declines, and what can be done to ensure shorebird populations can persist into the future.

(ii) Australia

Australia represents the largest terminal, non-breeding habitat for migratory waders in the EAAFP. The extensive coastline is indented by several major gulfs, bays, inlets and estuaries and is surrounded by over 8,000 islands. These areas support the largest extent of intertidal habitat in the flyway by country (Table 2). Intertidal wetlands are complimented by extensive near coastal wetlands and ephemeral inland wetland systems and floodplains.

Inland wetlands can provide massive areas of high value habitat for shorebirds but are not predictable in their hydrology. Australia's pulses in the availability of water make it unique in the scale at which wetlands appear and disappear, with vast parts of the continent full of wetlands one year, only to return to near empty deserts in following years (Kingsford et al., 2010, Clemens 2016).

Australia's coastal and freshwater wetlands provide important habitat for these birds to rest and feed, enabling them to build the energy reserves they need to travel the long distance (up to 13 000 kilometres) back to their breeding grounds. In the month or two before migrating, migratory shorebirds need to increase their body mass by up to 70 per cent to sustain their journey. After their first southward migration, juvenile birds often remain in Australia until they reach approximately two years old before embarking on their first northward migration (Clemens 2016).

On southward migration, shorebirds that migrate from the northern hemisphere reach 'staging areas', such as Roebuck Bay and Eighty-mile Beach in north-west Western Australia and the Gulf of Carpentaria in Queensland, by August. From these staging areas, the birds disperse across Australia, reaching the south-eastern states by October (Figure 1). Smaller flocks—cumulatively numbering thousands of birds—take advantage of ephemeral wetlands across inland Australia, while others spread along the coastline. Migratory shorebirds are often gregarious, gathering in mixed flocks, but also occur in single-species flocks or feed and roost with resident shorebird species such as stilts, avocets, oystercatchers and plovers. By March, the birds that have previously dispersed across the country begin to gather at staging areas, once again forming large flocks and feeding virtually round the clock to accumulate the energy reserves that are required for their northward migration.

Currently, national or international site importance for migratory shorebirds is determined in multiple ways including:

- a site meets or exceeds flyway population thresholds (Table 5);
- a site supports more than 2,000 or 20,000 shorebirds (national and international significance respectively); or,
- a site regularly supports more than 15 species of migratory shorebirds (Commonwealth of Australia 2015a).

Table 2. Net area of intertidal habitats across EAAFP range states (adapted from Murray et al 2012, 2014)

Country	Area of potential intertidal habitat with 5km of coastline (km^2)
Australia	**9,851**
China	3,558
Indonesia - East	2,844
Indonesia - Sumatra	2,831
Philippines	2,612
Indonesia - Java Borneo	1,990
Myanmar	1,452
Malaysia	1,295
Korea Ro	1,207
Vietnam	1,177
New Zealand	1,138
Papua New Guinea	1,127
Thailand	968
Bangladesh	736
Korea DPR	410
Japan	379
Cambodia	144
Chinese Taipei	99
Singapore	54
Brunei	52
Timor-Leste	17

(iii) South Australia

South Australia has the fourth largest extent of intertidal habitat of any state (Table 3). Low energy coastlines found in large bays (Coffin Bay, Venus Bay, Smoky Bay and Ceduna), and gulfs (Spencer Gulf and Gulf St Vincent) accumulate vast amounts of sediment which form the basis of extensive tidal flats.

The large gulfs function as reverse estuaries, fine sediment mobilised towards the south deposits along the coast and ultimately at the head of each gulf creating large areas of shallow water which in turn creates a gradient in both temperature and salinity south to north. The mosaic of habitats created provides variable ecological conditions for a wide variety of shorebirds which feed in the intertidal zone.

In addition to extensive intertidal habitat South Australia contains large networks of coastal lagoon, floodplain and ephemeral wetlands.

South Australia's south east is characterised by a number of internationally significant near coastal wetlands, including the Robe Lakes and the Coorong and lower lakes complex. The Coorong is South Australia's most significant shorebird habitat supporting up around 38,000 shorebirds annually. In years of privation drought can forces several more tens of thousands of birds to move into the drought refugia. However, the Coorong itself is subject to large salinity variation dependant on upstream flows delivered by via the Murray Darling system. This dependency can result in drastic declines in shorebird habitat condition and local carrying capacity, as was observed during the millennium drought.

The ephemeral wetlands of the Lake Eyre Basin and Channel country are known for their episodic booms in productivity during and after flood events. These areas are not only critical for arid dependant breeders like the iconic Banded Stilt but are thought to be important staging areas and indeed preferential habitat for marsh species like Sharp-tailed Sandpiper and Curlew Sandpiper when conditions are appropriate (Clemens 2016).

Figure 2. Thousands of shorebirds. Flying over vast intertidal sandflats in Gulf St Vincent, SA. Photo: Aleisa Lamanna.

South Australia is estimated to support over 110,000 shorebirds annually. The areas mentioned above are known to be terminal non-breeding habitats for birds on migration. That is, unlike several sites on the north and east coast, South Australian habitats are the final destination for birds seeking to refuel over the spring and summer before returning to arctic breeding grounds in March and April.

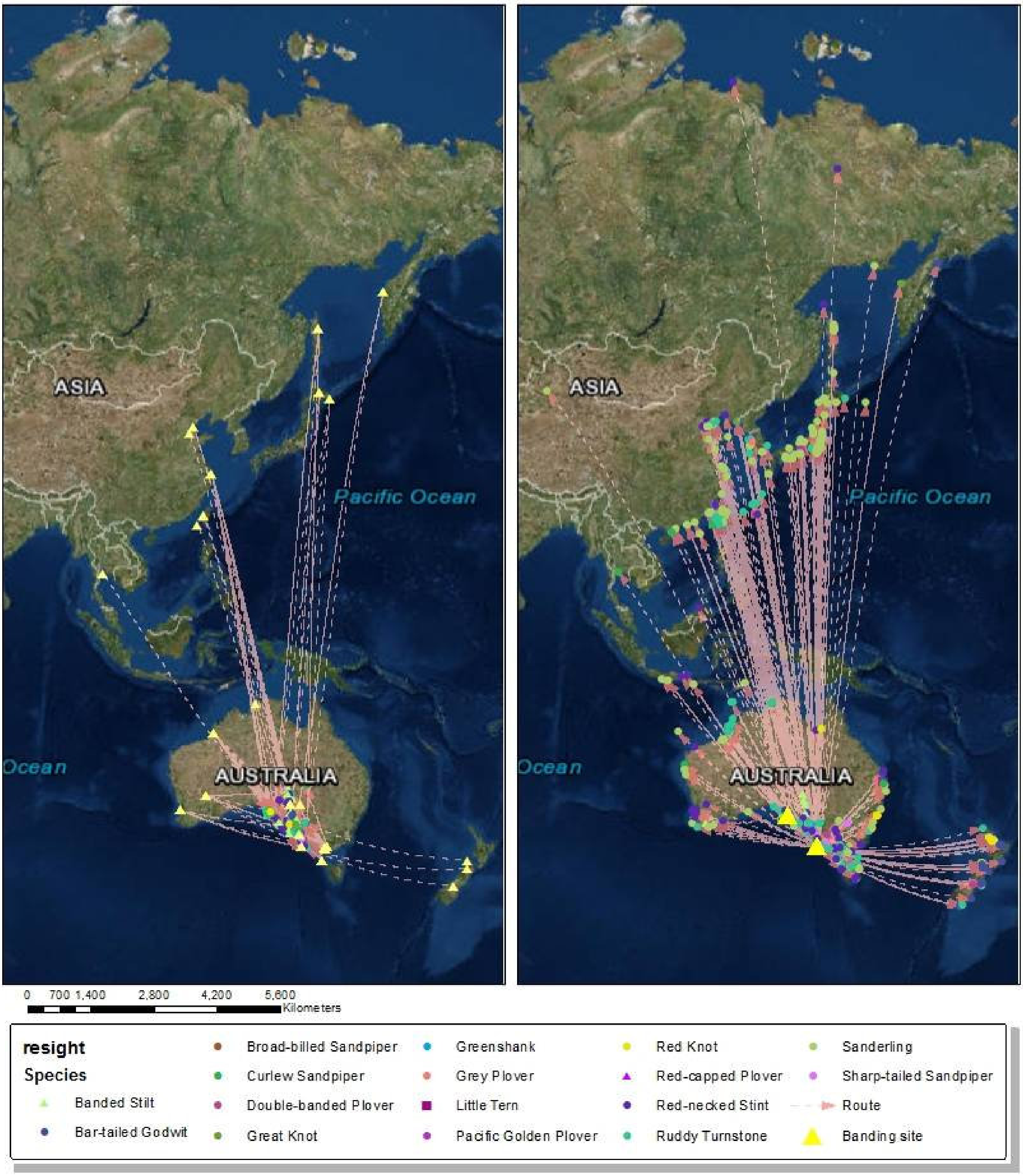
As a mid-point along Australia's fertile south coast South Australia appears to be a mixing site for subspecies of shorebirds that have been traditionally known to either use east or west coast habitats (Map 1). Notably both subspecies of Bar-tailed Godwit (*menzbieri* and *baueri*) are observed in mixed flocks in both gulfs. Although not confirmed, it is also suspected that both subspecies of Red Knot (*piersmai* and *rogersi*) also occur in Gulf St Vincent. Red Knot banded in Victoria and Western Australia are regularly recorded in the area. Although the phenology of the subspecies are not fully understood Rogers et al 2010 found a higher proportion of Victorian banded birds were *Rogersi*, compared to northern West Australian birds which were *piersmai.*

Recent flagging work in Gulf St Vincent by the by the Victorian Wader Study Group and Friends of Shorebirds SE has revealed movement of Red Knot between the Gulf and New Zealand. A catch of Red Knot at Thomson Beach, South Australia, is revealing some interesting trans-Tasman connections. An adult Knot was recaptured at Thompson Beach which was flagged in New Zealand NZ and a juvenile Red Knot (Orange DM over yellow) caught at Thompson Beach has been sighted at Miranda in New Zealand. There are some earlier 2006 Red Knot observations from the South East of South Australia of a banded juvenile overwintering with a small group of a dozen juvenile Red Knot in the lower SE in June 2006, which was resighted in October 2006 in NZ. Earlier analysis of resights of Knot in Australian and New Zealand indicates that many red knot spend their first year or more in Australia, and overwintering at various locations before moving on to New Zealand sites (pers comm T Flaherty).

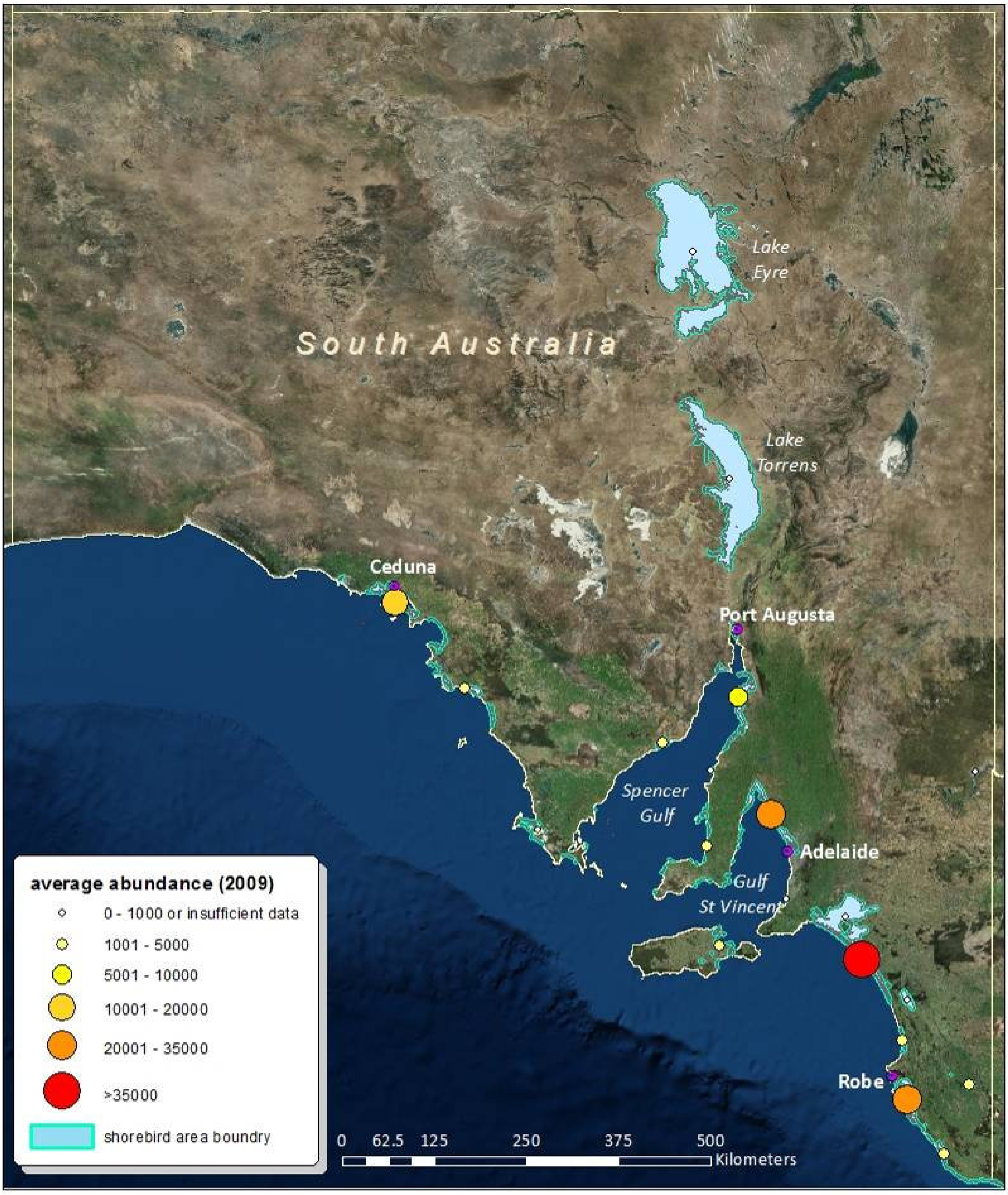
Work in New Zealand has revealed that non-breeding knots use an extensive network of sites there and appear to frequently move between them (see Riegen et al. 2005; Battley et al 2011). Small groups of migrant knot appear to arrive in New Zealand across spring and summer with the peak of arrivals from December to January (Williams et al 2006). It appears that few birds return to Australia once they have finally reached New Zealand, (the NZ Red Knot caught at Thompson Beach last November being an exception), and so they probably become regular migrants between New Zealand and the Arctic. (Clive Minton, pers. comm. in Riegen, A.C., 1999). Bar-tailed godwit appear to have some similar movement patterns to the knots between Australia and New Zealand.

Table 3. Net area of intertidal habitats and monitoring coverage across Australia (adapted from Murray et al 2012, 2014 and Hansen et al 2016)

Region	Area of mapped intertidal habitat region (km^2)	Area of counted intertidal habitat region (km^2)	Proportion of mapped intertidal habitat that is counted
NSW	96	56	0.58
NT	2,214	693	0.31
QLD (East coast)	1,617	1,006	0.62
QLD (Gulf of Carpentaria)	1,076	410	0.38
SA	**936**	**510**	**0.55**
TAS	87	26	0.29
VIC	228	221	0.97
WA	3,597	999	0.28



Map 1. Band resightings from the Australasian Wader Study Group database from shorebirds resighted in SA (left) banded in South Australia (right).



Map 2. Average total abundance of all shorebirds from shorebirds 2020 stilt summary data up to and including 2009. Nb: Due to insufficient knowledge about shorebird movements within the Ceduna, Western Eyre and South East SA regions data has been consolidated from several count sites into estimated "shorebird areas". Shorebirds are thought to move within but not between shorebird areas and are thereby considered relatively closed systems for the peak non-breeding census period

(iv) Gulf St Vincent

Gulf St Vincent (GSV) is a highly productive and ecologically significant ecosystem. The mosaic of marine, coastal, inland and man-made habitats provides important feeding and roosting areas for migratory waterbirds, particularly shorebirds. These habitats include: expansive tidal flats, tidal creeks and estuaries, mangrove forests, seagrass meadows, tidal saltmarshes, tidal and supratidal claypans (sabkahs). These natural wetlands are supplemented by significant areas of artificial habitat including two large commercial saltfields

(Price and Dry Creek), artificial stormwater detention wetlands, effluent water treatment ponds and an man-made ephemeral, freshwater lake.

The gulf functions as reverse estuary; fine sediment mobilised towards the south deposits along the coast and ultimately at the head of the gulf creating large areas of shallow water and expansive mudflats on the coast adjacent to Clinton Conservation Park. This variation in turn creates a gradient in both temperature and salinity south to north. The mosaic of intertidal habitats between Ardrossan in the north west and Barker Inlet in the south east provides variable ecological conditions for a wide variety of shorebirds which feed in the intertidal zone. Habitat types and site profiles are detailed in (Section 1.02 & Section 2.02).

The area has been identified nationally and internationally for its significance for shorebirds and waterbirds (Table 4). Gulf St Vincent supports nationally and internationally significant numbers of migratory and resident shorebirds surpassing all three afore mentioned criteria for recognition as a wetland of international significance ((Section 1.01(a)(ii)). At least 52 shorebird species, including 37 migratory species, have been recorded in Gulf St Vincent. The area regularly supports over 25,000 shorebirds of 36 species including 25 migratory species. Three migratory species regularly occur in internationally significant numbers.

In addition to its value to shorebirds, the Gulf St Vincent is important habitat for many other coastal birds and seabirds, including the Samphire Thornbill (also Known as Slender-billed Thornbill (*Acanthiza iredalei rosinae)*, Elegant Parrot (*Neophema elegans*), Rock Parrot (*Neophema petrophila*), Little Egret (*Egretta garzetta*) and Fairy Tern (*Sternula nereis*). The Gulf St Vincent is part of the EPBC-listed (*Environment Protection and Biodiversity Conservation Act 1999)* subtropical and temperate coastal saltmarsh threatened ecological community and contains the largest area of critical habitat for the nationally vulnerable Bead Samphire (*Tecticornia flabelliformis*). It also supports many regionally significant species, including coastal-dependent reptiles and significant butterflies (Flyway nomination 2016).

Table 4. Documented recognition of the significance of the GSV shorebird population.

Publication/ Network	Site level recognition	recognition		
		State	National	Interntl
Migratory Shorebirds of the East Asian Australasian Flyway – Population Estimates and Internationally significant sites (Bamford et al 2008)	• Penrice Saltfields (47) • Port Wakefield-Webb Beach (99) • Price Saltfields/Clinton Cons.Park (13)		X	X
East Asian Australasian Flyway Site Network	• Adelaide's International Bird Sanctuary (EAAF 131)	X	X	X
Wetlands of National Importance	• Barker Inlet & St Kilda (SA005) • Clinton (SA007) • Port Gawler & Buckland Park Lake (SA015) • Wills Creek (SA019) • Onkaparinga estuary (SA033)		X	
Key Biodiversity Area (BirdLife International)	• Gulf St Vincent			X
South Australian National Park	• Adelaide International Bird Sanctuary- Winaityinaityi Pangkara	X		

(b) Global and national recognition of the importance of shorebirds

Recognising that the long-term conservation of viable populations of the world's species requires the identification, protection and management of their habitats, many governments have initiated conservation measures and signed international conservation agreements. The international agreements pertaining to Australian shorebird populations include the Ramsar Convention, the World Heritage Convention, the Bonn Convention, the Convention of Biological Diversity, the Asia–Pacific Migratory Waterbird Conservation Strategy and the East Asian–Australasian Shorebird Reserve Network. There are also several bilateral agreements, including the China–Australia Migratory Birds Agreement (CAMBA), the Japan–Australia Migratory Birds Agreement (JAMBA) and, most recently, the Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA).

Australia's Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) protects threatened species and recognises migratory shorebirds as species of *National Environmental Significance* (NES). The Act provides a legal framework to protect and manage species and their environments, in doing so providing implementation of the agreements listed above.

The Australian Government's *Wildlife Conservation Action Plan for Migratory Shorebirds* (2014) outlines a national framework identifying research and management actions to protect migratory shorebirds in Australia.

In recognition of the ongoing decline in many migratory shorebird species and the complexity of effective conservation actions, BirdLife Australia has sought to improve coordination between stakeholders in Australia and, to some extent, across the flyway, through the conservation action planning approach.

The *Migratory Shorebird Conservation Action Plan* (MS CAP) has been developed by a broad range of stakeholders from all across the country and internationally working in shorebird conservation and management across the East Asian-Australasian Flyway (EAAF). Led by BirdLife Australia, the MS CAP is intended to improve coordination and collaboration on conservation actions for the 37 species of migratory shorebirds that regularly visit Australia across the range of stakeholders that contribute to migratory shorebird conservation, management and research.

The first iteration of the MS CAP seeks to operationalise some of the *High* and *Very High* priority actions in the Australian Government's Wildlife Conservation Plan for Migratory Shorebirds across the four objectives:

1. Protection of important habitats for migratory shorebirds has occurred throughout the EAAF.
2. Wetland habitats in Australia, on which migratory shorebirds depend, are protected and conserved.
3. Anthropogenic threats to migratory shorebirds in Australia are minimised, or where possible, eliminated.
4. Knowledge gaps in migratory shorebird ecology in Australia are identified to inform decision makers, land managers and the public.

Across a series of workshops, stakeholders developed detailed plans for each strategy and begun identifying key delivery partners and resourcing opportunities and challenges.

The implementation of the MS CAP will be overseen by a Steering Committee with representation from Federal and State Environment Departments, research institutions and conservation organisations.

The first iteration of the MS CAP was finalised in October 2017. The MS CAP Steering Committee have identified a number of high priority projects for early 2018.

The Project Coordinators are also currently seeking opportunities to work with community groups, local governments, NRMs, government agencies and other relevant stakeholders around Australia to identify opportunities and partnerships to deliver priority conservation actions at a national, state and local scale.

The MS CAP will inform the direction of BirdLife Australia's Migratory Shorebirds Program for the next five years and seek to coordinate the delivery of high priority actions for shorebird conservation in Australia. The Plan also identifies opportunities for Australian stakeholders to improve the protection and management of shorebird habitat across the EAAF. Under the MS CAP, S2020 will continue as Australia's national monitoring program. This monitoring program will play a critical role in evaluating the effectiveness of conservation actions undertaken as part of the MS CAP.

In South Australia the MS CAP has been adopted by the *South Australian Shorebird Alliance* as a framework for prioritising shorebird conservation management actions across the NRM regions. The Alliance, formed in 2017 and led by DEWNR, is currently developing terms of reference.

In South Australia the National Parks and Wildlife Act 1972 (NPW Act) provides for the conservation of wildlife and ecosystems. The criteria used to define threatened species in South Australia are generally based on categories and definitions from the IUCN Red List Categories and Criteria. The current categories and order of the schedules under the NPW Act are:

- Schedule 7: Endangered species (including critically endangered and extinct species)
- Schedule 8: Vulnerable species
- Schedule 9: Rare species[1]

(c) Global shorebird population trends

Throughout the world, many populations of shorebirds appear to be declining (Wilson 2000; Morrison et al. 2001; IWSG 2003; Olsen et al. 2003; CHSM 2004; van de Kam et al. 2004; Murray et al. 2013, Studds et al 2016). In 2003, trend estimates were available for 41 per cent of the 499 populations of shorebirds around the world. Of these, 44 per cent appeared to be declining, 13 per cent were increasing, 39 per cent were stable and 4 per cent had become extinct (Delaney 2003; IWSG 2003).

The population declines that were detected coincide with accelerating loss and degradation of shorebird habitat (UNEP 2006; Rogers et al. 2009; Murray et al. 2013, 2014, Studds et al 2016). In the East Asian–Australasian Flyway, a disproportionately high number of shorebird species have been classified as threatened, and many are under increasing threat from habitat destruction (IWSG 2003; Murray et al. 2013, McKinnon 2012, Studds et l 2016).

The Red List Index (RLI), which uses information from the IUCN Red List to track trends in the projected overall extinction risk of sets of species, is among the indicators adopted by the world's governments to assess performance under the Convention on Biological Diversity (CBD) and the United Nations Millennium Development Goals. Of the 49 Australian bird species which had deteriorated in status in the last 20 years, over half were migratory shorebirds or seabirds (Szabo et al. 2012). Population-trend analysis of the BirdLife Australia Shorebird 2020 database shows strong evidence of declines in the Australian populations of 12 species of migratory shorebirds, and evidence of declines evident in another eight species (Clemens et al 2016, Studds et al 2016). These continent-wide trends would suggest that the major drivers of decline are occurring outside of Australia.

[1] The Rare category is not recognised in the IUCN structure and criteria have been created for a Rare category to be utilised in South Australia. The Rare category criteria are consistent with current IUCN definitions for the 'Near threatened' category and encompass species in decline and those that naturally have a limited presence.

Recent analysis undertaken by the University of Queensland utilising BirdLife Australia Shorebird 2020 data (11,000 of the 93,000 counts from 153 shorebird areas across Australia, spanning the years from 1973 to 2014), revealed decreases in abundance in 12 of 19 migratory shorebirds which were analysed (Clemens et al 2016). The seven most significant declines in shorebirds that winter in Australia were found in species which are heavily reliant on the Yellow Sea for staging including the Far Eastern Curlew (declining at 6% per year) and Great Knot (5% per year) (Stubbs 2016). Six of these species regularly occur in Gulf St Vincent and five have been observed in internationally significant numbers (>1% EAA flyway population) (Section 1.01(a)), however with rates of decline as high as 8 per cent per annum (Figure 3) numbers in the region have declined proportionately.

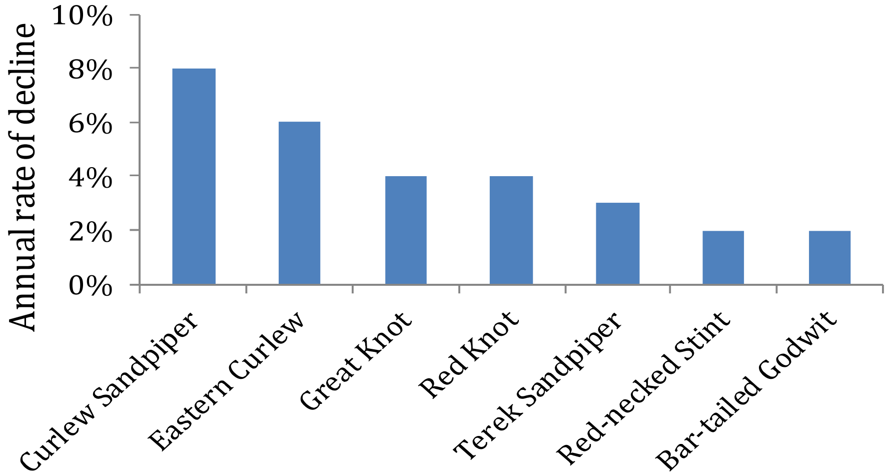


Figure 3. Rates of population decline of seven species of shorebirds in the East Asian–Australian Flyway (R. Fuller, unpublished data).

In alignment with these identified trends of decline, the following migratory shorebird species were listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Critically endangered

- *Limosa lapponica menzbieri* (Bar-tailed Godwit (spp *menzbieri*)
- *Calidris tenuirostris* (Great Knot)
- *Calidris ferruginea (Curlew Sandpiper)*
- *Numenius madagascariensis* Eastern Curlew)

Endangered

- *Calidris canutus* (Red Knot)
- *Charadrius mongolus* (Lesser Sand Plover)

Vulnerable

- *Limosa lapponica baueri* (Bar-tailed Godwit (spp *baueri*)
- *Charadrius leschenaultii* (Greater sand Plover)

These species remain listed ‘migratory’ and ‘marine’ under the EPBC Act.

Of the species that are resident in Australia, the species of most concern is the Hooded Plover (Vulnerable EPBC), populations of which appear to be declining, due mainly to human disturbance during their nesting period, as well as degradation of their habitats (Weston 2003). In the Adelaide and Mt Lofty Ranges region, this species is found along the southern Adelaide and Fleurieu Coast. Conservation monitoring and management for this species on the Fleurieu has been underway since 2008 in collaboration with BirdLife Australia, Adelaide and Mt Lofty Ranges NRM Board, local councils and volunteers. Some decline is evident nationally for a further four resident species which occur in Gulf St Vincent.

For other resident shorebirds, rates of decline were greater at non-tidal wetlands threatened by inappropriate water levels, while local threats do not appear to explain rates of decline in migrants. Results are consistent with other studies indicating wetland degradation in Australia has impacted resident shorebirds, but migrants have been impacted most by factors outside Australia. Heterogeneous trends in migrants do suggest, however, places where habitat management in Australia might have the largest positive impact (Clemens 2016).

Recent site based analysis of shorebird data in Australia revealed that the areas that appear to be losing large numbers of multiple shorebird species most rapidly were: the Mackay area, Queensland; Richmond River Estuary, New South Wales; Gulf of St Vincent, South Australia; Moolap Saltworks, Victoria; the Hunter River Estuary, New South Wales; the Tweed River Estuary, New South Wales; The Coorong and Kangaroo Island, South Australia; Shoalhaven River Estuary, New South Wales; Port Stevens, New South Wales; and Corner Inlet, Victoria (Clemens 2016).

Review of shorebird population declines in Australia highlights that careful management of Australian wetlands is crucial to maintain their suitability for shorebirds (Clemens 2016).

Scientific Name	Common Name	WPE5 estimate	1% EAAFP	Conservation status	State Listing
Pluvialis fulva †	Pacific Golden Plover	135,000-150,000	1,350		RARE
Pluvialis squatarola	Grey Plover	104,000	1,040	NT	
Charadrius bicinctus	Double-banded Plover	50,000	500		
Charadrius mongolus †	Lesser Sand Plover	188,500-218,500	1,885	E	RARE
Charadrius leschenaultia	Greater Sand Plover	79,000	790	V	RARE
Gallinago hardwickii	Latham's Snipe	25,000-1,000,000	250		RARE
Limosa limosa	Black-tailed Godwit	139,000	1,390	V	RARE
***Limosa lapponica* †**	**Bar-tailed Godwit**	**279,000**	**2,790**	**CE * / V**	**RARE**
Numenius phaeopus	Whimbrel	55,000	550	NT	RARE
Numenius madagascariensis	**(Far) Eastern Curlew**	**32,000**	**320**	**CE**	**VUL**
Xenus cinereus	Terek Sandpiper	50,000-55,000	500		RARE
Actitis hypoleucos	Common Sandpiper	50,000	500		RARE
Tringa brevipes	Grey-tailed Tattler	44,000	440	NT	RARE
Tringa nebularia	Common Greenshank	100,000	1,000		
Tringa stagnatilis	Marsh Sandpiper	100,000-1,000,000	1,000		
Tringa glareola	Wood Sandpiper	100,000	1,000		RARE
Arenaria interpres	Ruddy Turnstone	28,500	285	NT	RARE
Calidris tenuirostris	**Great Knot**	**290,000**	**2,900**	**CE**	**RARE**
***Calidris canutus* †**	**Red Knot**	**99,000-122,000**	**1,100**	**E**	
Calidris ruficollis	Red-necked Stint	315,000	3,200		
Calidris subminuta	Long-toed Stint	25,000	250		RARE
Calidris melanotos	Pectoral Sandpiper	1,220,000-1,930,000	12,200		RARE
Calidris acuminate	Sharp-tailed Sandpiper	160,000	1,600		
Calidris ferruginea	**Curlew Sandpiper**	**135,000**	**1,350**	**CE**	
Calidris pugnax	Ruff	25,000-100,000	250		RARE

Table 5. List of East Asian-Australasian Flyway migratory shorebird species that visit Gulf St Vincent.
WPE5 estimate is the current global population estimates summed across relevant subspecies for the EAAF (Wetlands International 2016).

Conservation status refers to IUCN status listed in Garnett et al. (2010), except for bolded species which are listed in the Environment Protection and Biodiversity Conservation Act 1999 (***EPBC*** Act) (Department of the Environment 2016).

† These species have two or more subspecies which are recognised in the EAAF. Population estimates and thus, 1% population criterion, differ between subspecies and hence, the 1% criterion for each species is not presented here. See Waterbird Population Estimates (2016) for the most recent values.
* Bar-tailed Godwit subspecies menzbieri listed as Critically Endangered and subspecies baueri listed as Vulnerable under recent (5 May 2016) EPBC Act changes.

(d) Shorebird trends in Gulf St Vincent

The number of counts available in the dataset for Gulf St Vincent differs strongly between sites. Therefore, trend estimates for the entire population using data across all sites is coarse (as 2010 power analysis predicted). However, when compared with the national network of shorebird sites with long term data Gulf St Vincent appears to be losing large numbers of multiple shorebird species most rapidly, along with Moolap Saltworks (VIC), the Hunter Estuary (NSW), the Coorong (SA), and Corner Inlet (VIC) (Clemens 2016). All but one of these sites are highly modified systems where, along with additional threats mentioned in Section 1.03, habitat loss/alteration and disturbance are likely to be high.

Total shorebird estimates have decreased by over 75% in Gulf St Vincent since the 1980's. Close (2006, 2008) recorded maximum average totals of 79,610 shorebirds in the 1979-1985 period this consisted of 59,851 migratory species and 18,759 residents. By the 2000-2008 period this estimate had reduced to 46,459 (29,929 migrants 16,530 residents). Including the current 2016/17 count maximum average total counts for the project period (2009-2017), based on simultaneous counts show a marked decline in migratory species. 24,791 shorebirds are regularly observed presently. Whereas resident populations remain reasonably stable (14,467), on average only 10,324 of these are migratory species.

A coarse assessment of species max averages across the three time periods (using only the highest five totals from simultaneous counts for 2009-2017) reveals that 12 of 13 regular recorded migratory shorebirds have suffered declines (Table 6).

Table 6. GSV migratory shorebird populations from 3 periods; 1979-1985 (estimates from Close 2008), 2000-2008 (estimates from Close 2008) and 2009-2017 (BirdLife S2020 data) *.
***Average taken from top 5 counts per species over the project period.**

Species	PERIOD 1 1979-85	PERIOD 2 2000-2008	PERIOD 3 2009-2017	% change PERIOD 1-2	% change PERIOD 2-3	**% change PERIOD 1-3**
Bar-tailed Godwit	960	213	212	-78	-1	**-78**
Black-tailed Godwit	84	0	14	-100	↑	**-84**
Common Greenshank	1149	786	368	-32	-53	**-68**
Curlew Sandpiper	8695	2541	400	-71	-84	**-95**
Eastern Curlew	171	156	48	-9	-69	**-72**
Great Knot	443	237	264	-47	11	**-40**
Grey Plover	1167	564	161	-52	-72	**-86**
Grey-tailed Tattler	61	1	2	-98	133	**-96**
Marsh Sandpiper	55	77	16	40	-79	**-71**
Red Knot	1167	1036	1395	-11	35	**20**
Red-necked Stint	28912	18382	8855	-36	-52	**-69**
Ruddy Turnstone	289	513	85	78	-83	**-70**
Sharp-tailed Sandpiper	16469	4864	2095	-70	-57	**-87**

Long term counts of Gulf St Vincent's Dry Creek Saltfields provide a larger dataset and smaller number of missing values than that of the greater region and can therefore be used to derive a reliable trend analysis, albeit on a smaller scale (Purnell 2012). Given the Dry Creek Saltfields dataset is not only more consistent than that of any other site but also includes an additional 11-year period of data (1979-1990), it was decided that this site alone would provide the best chance of identifying trends. Trend analysis using more sites in Gulf St Vincent will be attempted in 2018.

Table 7. GSV resident shorebird populations from 3 periods; 1979-1985 (estimates from Close 2008), 2000-2008 (estimates from Close 2008) and 2009-2017 (BirdLife S2020 data) *.

Species	PERIOD 1 1979-85	PERIOD 2 2000-2008	PERIOD 3 2009-2017	% change PERIOD 1-2	% change PERIOD 2-3	**% change PERIOD 1-3**
Banded Lapwing	155	0	14	-100	↑	**-91**
Banded Stilt	12592	13936	11914	11	-15	**-5**
Black-winged Stilt	590	306	590	-48	93	**0**
Masked Lapwing	269	191	134	-29	-30	**-50**
Pied Oystercatcher	21	130	87	519	-33	**315**
Red-capped Plover	3810	1731	1930	-55	12	**-49**
Red-kneed Dotterel	103	38	94	-63	148	**-8**
Red-necked Avocet	1100	41	406	-96	891	**-63**
Sooty Oystercatcher	19	146	80	-87	-45	**323**

Trend analysis completed by BirdLife Australia in 2012 revealed that six migratory species have undergone significant declines in the Dry Creek Saltfields since 1979 (Purnell 2012). It is presumed that these declines reflect declines in the greater region, given simultaneous counts over the last six years have identified that an average of over 48 per cent of the shorebird population in Gulf St Vincent occurred in the Saltfields. The majority of the declines (between 55 to 88 per cent) occurred between 1979 and 1990. It is probable that these declines are primarily connected to overall threats throughout the Flyway, but significant declines in two resident species- Red-capped Plover, 88 per cent, and Black-winged Stilt, 68 per cent (Purnell 2012) can only be attributed to local influences on saltfield habitats and surrounds (i.e Buckland Park Lake (Section 2.02(f)). Although not as severe, declines in Red-capped Plover are reflected throughout the gulf (-49%). These threats are discussed in more detail in Section 1.03 of this report.

(e) Shorebird requirements in Gulf St Vincent

Gulf St Vincent provides a diverse range of shorebird habitats that are vital for shorebirds to survive and reproduce. All shorebird habitats must provide a combination of feeding areas that are rich in available food and nearby roosting areas that allow shorebirds to rest without losing too much energy due to disturbance. Further, shorebird habitat must minimise the risk of predation by providing sufficiently open areas to allow shorebirds to detect and avoid predators. An ecosystem should provide a mosaic of suitable roosting and feeding habitats should one or more preferential sites become compromised. In a general sense shorebird feeding sites require:

- Readily accessible and abundant prey.
- Appropriate substrate resistance.
- Variety in prey type (between sp. & temporally).
- Large areas of shallow water (<20cm in depth).
- If tidal, low energy tidal influence (low gradient in tidal zone).
- If supratidal, maximum surface area of shoreline.
- Open uninterrupted views.
- Close proximity to appropriate roosting area.
- Close proximity to alternate feeding sites.

While roost sites require:

- Open uninterrupted views.
- Available throughout the tide cycle (including king tides).
- Sheltered from wind.
- Free of dense vegetation >10cm in height.
- Close proximity to appropriate feeding area.

- Close proximity to other roost sites.

For resident shorebirds, the wetlands of Gulf St Vincent must also provide sufficient suitable habitat for successful breeding.

Shorebird habitat types and preferences among species are further discussed in Section 1.02.

Figure 4. Red-necked Stints roost on levees at Price Saltfields. Photo: Chris Purnell.

(f) Conservation status of shorebird habitat in Gulf St Vincent

South Australia is committed to conservation and protection of shorebirds.

Much of the identified shorebird habitat and adjacent areas in Gulf St Vincent are now legally protected within the reserve system that is administered by the Department of Environment, Water and Natural Resources (DEWNR), occur within protected Australian Defence Force land or, until recently, commercial saltfields (Map 3). The classified conservation areas include Clinton Conservation Park, Torrens Island Conservation Park, Mutton Cove (crown land), Port Gawler Conservation Park, Barker Inlet Aquatic Reserve, St Kilda–Chapman Creek Aquatic Reserve, Adelaide Dolphin Sanctuary, Upper Gulf St Vincent Marine Park (UGSV MP), Lower Yorke Peninsula Marine Park and the newly gazetted Adelaide International Bird Sanctuary. Around 1,600[2] Hectares remains on freehold land. Much of this habitat occurs within the Dry Creek Saltfields. Future management of the saltfields are subject to an ongoing management planning process and are

[2] This figure discounts significant shorebird habitat in the Price Saltfields which have not been mapped as part of this project.

discussed further in Section 1.03. A literature study investigating potential options for future conservation management options for shorebirds is included in the 2014-15 report.

(i) Adelaide International Bird Sanctuary National Park - Winaityinaityi Pangkara

Management Authority: DEWNR

The creation of the *Adelaide International Bird Sanctuary* was a 2014 election commitment by the then South Australian Government. The land, originally, comprising a returned mining lease, existing Crown land and 2,300 hectares of State Government purchased freehold land and incorporated much of the significant terrestrial shorebird habitat along the Samphire Coast.

It was proposed that land identified as suitable for inclusion in the sanctuary, was to be proclaimed as a conservation park under the National Parks and Wildlife Act 1972. Additional lands identified in 2014-15, totalling 1,955 hectares, increased connectivity and shorebird/samphire buffer areas within the proposed sanctuary to 9,461 hectares. However, in 2015-16, recognising limitations of protection that can be achieved over the Dry Creek Saltfields, and nearby waste/stormwater treatment wetlands, these areas were removed from the Adelaide International Bird Sanctuary National Park boundaries (Table 8, Map 3).

The overall extent of AIBS was increased, largely by the addition of important areas of tidal flats (to the low tide mark), however the exclusion of saltfield salinas and stormwater wetlands increases the threat that shorebird values of these areas may be jeopardised[3] (Section 1.01(a)). These areas are recognised for the role they play in supporting shorebird populations and potential for future inclusion.

The first stages of the national park were proclaimed in 2016 and 2017 and are managed as a protected area consistent with the objectives of the National Parks and Wildlife Act 1972.

The national park, named *Winaityinaityi Pangkara* (‘a country for all birds’ in the local Kaurna language) is 14,633 hectares, making it the largest park in the Adelaide and Mount Lofty Ranges region. Over time, future additions of other lands will be incorporated into the park and these areas will be managed in line with the AIBs management plan.

The initiative is being delivered by the Department of Environment, Water and Natural Resources (DEWNR), providing facilitation of resources to community groups and stakeholders to form sustainable leadership of the Adelaide International Bird Sanctuary.

To establish and manage the Adelaide International Bird Sanctuary:

- A community and stakeholder leadership group ‘The Collective’ have been convened to represent local interests and ensure the protection of shorebirds and the Adelaide International Bird Sanctuary is in partnership with adjacent landowners, developments and opportunities. The framework being used for partnerships is the Collective Impact model. Taskforce groups have been convened to action the four focus areas as outlined by The Collective (Protecting Shorebirds, Stimulating Economy, Enhancing Wellbeing and Expanding Global Flyway Conservation)[4].
- A management plan for the Adelaide International Bird Sanctuary is being developed through the collaborative process of Collective Impact and will be finalised in 2018.

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[3] It should be noted that Barker Inlet Wetland was formerly included in the original AIBs proposal but removed in the restructure. Works associated with the Northern Connector Project have negatively impacted the site and significantly reduced its value for shorebirds (Section 1.01(a)(ii)).

[4] BirdLife are represented on *The Collective* and a number of taskforce groups alongside a diverse range of stakeholders.

- Social media, education, events and promotions have formed a large part of the community engagement and outreach to the general public and specially the birding community since 2016.
- An annual festival is held at the Adelaide International Bird Sanctuary in celebration of the return of migratory shorebirds.

Table 8. Shorebird habitat protected in the original AIBS proposal (2015) compared to recent amendments featured in the draft management plan (2018).

YEAR	Protected areas extent (ha)	AIBS extent (ha)	% habitat protected total	% habitat protected by AIBS	% habitat solely protected AIBS	% unprotected
2015	122,614	9,453	90.50%	7.70%	5.40%	9.50%
2018	122,145	14,720	89.70%	10.60%	4.90%	11.30%

Much of the Sanctuary area lies adjacent to, or within, the Upper Gulf St Vincent Marine Park and Adelaide Dolphin Sanctuary, protecting connected habitats from the coast into the sea. These marine sanctuaries are particularly important in the conservation of extensive intertidal feeding areas for shorebirds. It should be noted that highly threatened, internationally significant areas of intertidal habitat adjacent to the Thompson Beach Township have been omitted from the park boundaries. Given the well-recognised shorebird population in the area and the increasing negative affect of disturbance (Section 1.01(b)) this appears to be a lost opportunity to allocate national park staff to work with a highly-motivated local community to address an extrinsically driven threat.

(ii) Upper Gulf St Vincent Marine Park

Management Authority: DEWNR

Protection within the UGSV MP varies depending on zoning. Shorebird habitat exists within *Restricted Access Zone* (RAZ), *Sanctuary Zone* (SZ) and *Habitat Protection Zone* (HPZ) (Appendix 1).

RAZ- The area of coast and intertidal adjacent to the Port Wakefield Proof and Experimental Range is off limits to the public. No aquaculture, coastal development, fishing/collecting, harbours navigation and transport, recreation, wastewater disposal/discharge, extractive process or production are permitted.

SZ- Shorebird habitat in the southern section of Light beach are included in the Light River Delta SZ. Intertidal habitat 2km north of Port Wakefield west to Port Clinton are included in the Clinton Wetlands SZ. No aquaculture, coastal development, recreation, wastewater disposal/discharge, extractive process or production are permitted.
Aboriginal fishing/collecting is permitted. Domestic animals are permitted. Recreational activities are permitted. Boating is permitted with a permit

HPZ- Intertidal shorebird habitat from northern Light Beach to the border of the PWPEE, at Bald Hill and from Clinton south to Tiddy Widdy Beach are include in the HPZ. Most activities including many disturbance inducing activities (fishing, boating, dog walking etc) are permitted as are activities likely to impact habitat condition (dredging and deposition of dredge materials, discharge from terrestrial sources and vessels).

Resource extraction, collecting of seagrass and trawling are not permitted.

(iii) Adelaide Dolphin Sanctuary

Management Authority: DEWNR

The ADS is an area of 118 square kilometres, located along the eastern shore of Gulf St Vincent. It includes the Port Adelaide River and Barker Inlet and from there it stretches around to North Haven Marina, then north around Outer Harbor and up the coast to the Port Gawler Conservation Park. The ADS is home to an estimated 30 or more resident Indo-Pacific bottlenose dolphins, with some 300 more dolphins thought to visit or have visited the area.

Established in 2005 to protect and maintain a resident population of dolphins' habitat and food sources within the Port River, Barker inlet and the adjoining section of Gulf St Vincent. The ADS management Plan (2008) is supported by three reference papers which compile information around the main environmental objectives: Dolphins, key habitat features and water quality while annual implementation programs set specific annual targets and actions.

Beyond the monitoring and maintenance of healthy aquatic environments, ADS objectives have little implication for shorebird populations. Several privately-run tourism operations currently use the Adelaide International Bird Sanctuary for their tour options.

(iv) Existing Conservation Reserves

Management Authority: DEWNR

Wills Creek CP and Clinton CP are located in the Northern &Yorke NRM region and listed under the Department for Environment and Heritage Management Plan for Mainland Conservation Parks of Yorke Peninsula (2009)

Wills Creek Conservation Park (2,130 hectares; proclaimed in 2006) is situated at Mangrove Point on the north-western shores of Gulf St Vincent and is a significant coastal wetland/estuary area supporting mangroves and intertidal habitats. The park extends south from the township of Port Clinton to the town of Price. Wills Creek Conservation Park consists of mangrove and samphire habitats along the coastal fringe. Wills and Shag Creeks are known fish nursery areas and as an important habitat for seabirds. To the north, the mangrove woodland is somewhat atypical, being backed by eroding limestone cliffs topped with Mallee and dryland tea-tree vegetation. Wills Creek Conservation Park is subject to active mining leases (DEWNR 2009).

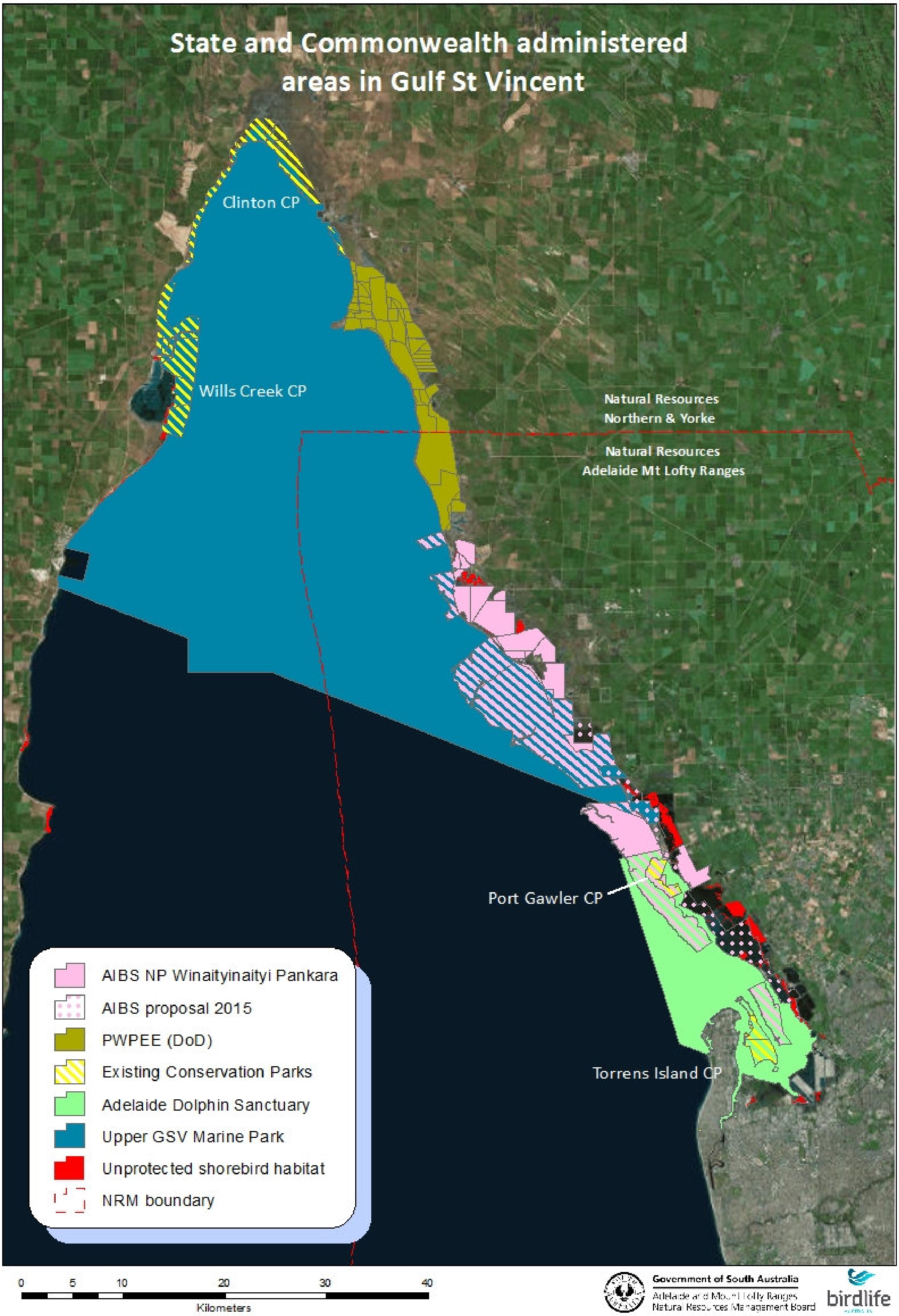
Clinton Conservation Park (1,923 hectares; constituted by statute in 1972) is a boomerang-shaped reserve situated at the northern extremity of Gulf St Vincent. The park has had several land additions following its proclamation. This coastal park extends from north of the township of Port Clinton, around the western side and head of the gulf, to the town of Port Wakefield. It then runs south again along the eastern coast to Sandy Point. The park comprises an expanse of mainly low-lying, coastal-fringe habitats, with mangroves and samphire communities, and extensive tracts of intertidal mudflats. The head of gulf wetland and Wakefield River estuary are important as a fish nursery and a significant site for migratory wading birds (DEWNR 2009).

Torrens Island, Port Gawler Conservation Parks and Mutton Cove Conservation Reserve are located in the Adelaide Mt Lofty Ranges NRM region and do not yet have associated management plans.

Torrens Island Conservation Park (637 hectares; proclaimed in 2014) is a protected area located on Torrens Island in the Barker Inlet about 3.9 kilometres (2.4 mi) north-northeast of Port Adelaide. The conservation park covers the majority of Torrens Island down to the low water mark with exception to the land associated with the former quarantine station and the Torrens Island Power Station. The east side of the conservation park immediately adjoins the Barker Inlet Aquatic Reserve. The conservation park is reported as protecting areas of mangrove forest, samphire shrubland and sand dune systems home to vulnerable and threatened species

Port Gawler Conservation Park (419 hectares; constituted by statute in 1972) lies adjacent to Dry Creek Saltfields and the Port Gawler Off-road Park. Port Gawler's intertidal area is buffered to the west by mangroves and is fed by two intertidal creeks. The Two Wells District Council and Trade Association has, in association with the WWF, identified the area as being important for shorebirds.

Mutton Cove Conservation Reserve (Crown Land) (48 hectares unalienated Crown land – Allotment 22 Hundred of Adelaide (Deposited Plan 76309), held under a Crown Record to Minister for Environment. This areas' status as a crown land reserve has not been formalised. The land is referred to by stakeholders as a conservation park, and formally sign posted, has an active Friends of Group, but is un-alienated Crown land. There has been long standing intent for the land to be dedicated to the Minister for Environment and Conservation as a Conservation Park Reserve when issues involving adjoining land were resolved. Mutton Cove is the last remaining biodiverse samphire and mangrove area on the LeFevre Peninsula. This habitat is dependent upon the integrity of the levee banks, which have recently breached. The walls allowed controlled tidal inundation of the waterways within the cove.



Map 3. The current extent of State and Commonwealth administered areas which overlap with shorebird habitat in Gulf St Vincent.

Section 1.02 Key shorebird habitats in Gulf St Vincent

The coastal wetlands of Gulf St Vincent consist of a mosaic of artificial and natural shorebird habitats. The suitability and selection of roosting or feeding habitat by shorebirds is temporally heterogeneous, and is governed by ambient factors including; environmental, human, structural and abiotic features (Purnell et al 2010). It is important to determine the extent to which these factors affect the use of various habitats and the associated implications for shorebird habitat protection, so that conservation strategies and informed management of human recreational use of these habitats can be formulated (Peters & Otis 2007; Oldland *et al*. 2008).

Six broad categories of habitat type have been identified as being of priority conservation value for the protection of shorebirds in Gulf St Vincent and mapped (see Purnell *et al*. 2012). They are: tidal flats; sandy shores; saltmarsh; saltpans; commercial saltfields and freshwater wetlands. These sites are used according to temporal variations in prey abundance, tide conditions, local weather and hydrology, human interference and the diversity and abundance of the shorebirds themselves. The availability and proximity of these feeding and roosting habitats to each other is another limiting factor to use and can contribute immensely on the final fitness of a bird upon departure. It has been calculated that for every extra kilometre that a bird has to commute between roosting and feeding sites energy expenditure increases 1.3% (van de Kam et al 2004).

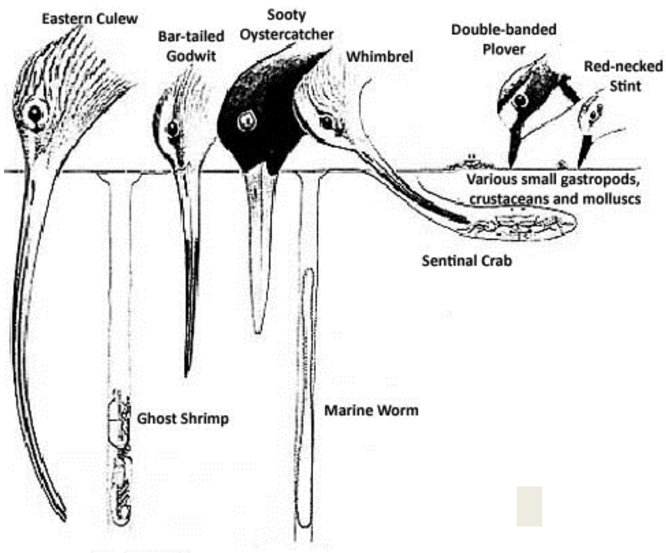


Figure 5. Shorebird bill adaptations to feeding in substrate (Illustration by Jeff Davies from Lane & Davies, 1987).

When considering shorebird conservation there are a number of habitat requirements which dictate where birds feed, roost and, in the case of residents, breed (Section 1.01(e) Purnell et al 2010). Habitat requirements, tolerances and preferences vary between species and can be dependent on water depth, salinity, substrate and food source (Purnell et al 2015). Some species like the Sharp-tailed Sandpiper can be found in most wetland habitats, while others like Red Knot have very specific requirements. These requirements seek to maximise energy intake and minimise unnecessary energy use. A detailed matrix of habitat preferences for shorebird species occurring in Gulf St Vincent can be found in BirdLife Australia 2014 - *Dry Creek Saltfields Shorebirds Values Matrix*. Habitat requirements of threatened species are also discussed in Section 3.04.

Detailed mapping of shorebird habitats to each documenting spatially explicit detail on habitat types and use in Gulf St Vincent, will be provided in association with this report. Although polygons in the shorebird habitat mapping layer give no weighting to abundance or diversity of shorebird species when overlayed with habitat and ecosystem mapping detailed in Coleman 2009, certain patterns in shorebird distribution and habitat use are evident (Figure 6). Site by site profile of shorebird habitat type and use in Gulf St Vincent can be found in (Section 2.02)

Excluding the transitioning habitats of the Dry Creek Saltfields (Section 1.01(l)), mapping identifies that the mudflats (primarily those between Light Beach and Ardrossan) provide the most feeding habitat. Sabkhas

(Section 1.02d) are utilised throughout the tide cycle for both feeding and roosting and embankments are used exclusively for roosting. It is important to note that there is varying value in habitat both between habitat types and within habitat types. For example, not all tidal flats provide productive foraging and when they do only a handful of species may utilise them and a smaller subset of these species may roost in the shallow waters when the tide is up. The relative value and prioritisation of these sites is documented and will be provided in an annotated guide which will supplement this report. Summaries of the broad habitat types and how they are used by shorebirds are explored in this below.

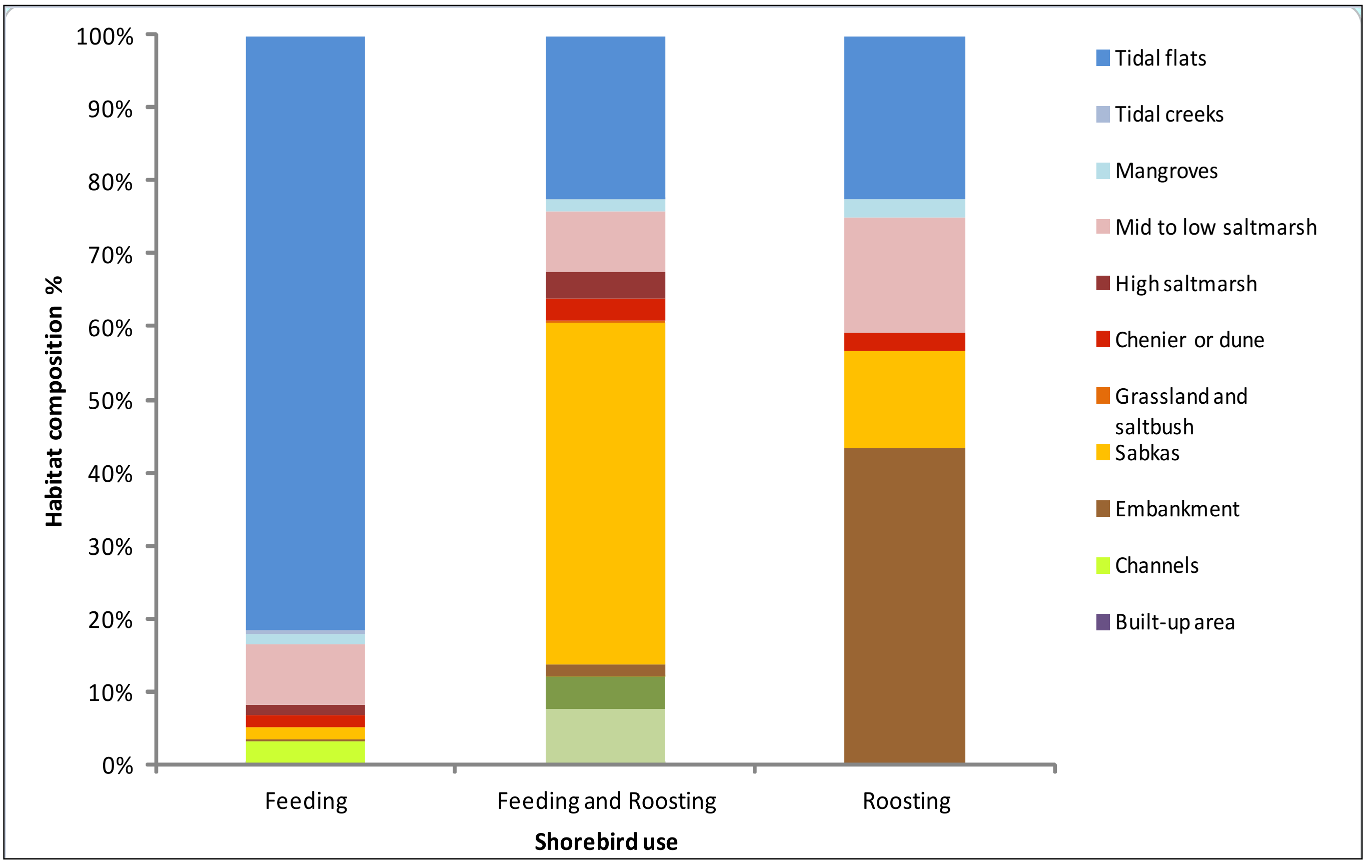


Figure 6. Proportions of habitat type use by shorebird in Gulf St Vincent derived from the overlap of shorebird distribution (BirdLife 2016) and habitat layers (Coleman 2009). Given continuing changes in habitat (salinity, structure etc) at the Dry Creek Saltfields since 2013 salina habitats have been excluded from this summary.

(g) Tidal flats and creeks

A combination of sediments, currents, low relief and tidal range can produce large areas of tidal flats. In Gulf St Vincent, these factors have combined to form large expansive areas of tidal flats, such as those between Barker Inlet and Clinton Conservation Park, where the tidal flats stretch for nearly 100 kilometres, some of them are more than 250 metres wide.

The sand flats and mudflats which occur along Australia's coastline are inhabited by abundant and diverse small burrowing invertebrates. These benthic bivalves, worms, snails and crustaceans can be difficult to find, let alone catch, but shorebirds are expert at obtaining them (Figure 5). Accordingly, they are the most commonly seen birds on tidal flat systems around Australia.

In Australia, fourteen of the most regularly occurring shorebirds, including species such as Red Knot, Bar-tailed Godwit and Eastern Curlew, specialise in feeding on tidal flats. These species, all of which occur in Gulf St Vincent, have evolved to exploit different food sources within tidal flats and feed almost exclusively in those habitats during the non-breeding period. Due to the vertical stratification of benthic invertebrates found in intertidal substrates, large densities of several species can coexist in the same area without competing for prey. This resource partitioning is mirrored in several tidal and supratidal habitats mentioned throughout this section.

Significant areas of tidal flats in Gulf St Vincent support an array of invertebrates that are regularly eaten by shorebirds. Studies investigating intertidal benthic fauna at four sites on the eastern shoreline of Gulf St Vincent (Section Bank/Bird Island, Thompson Beach, Middle Beach and Port Gawler) revealed high species diversity across the board. Molluscs, annelids and crustaceans accounted for the majority of the 90 taxa found with the highest diversities occurring at Section Bank (Dittmann *et al*. 2012). However, abundance of benthic invertebrates was low and varied significantly depending on the site, taxa and season. Pronounced variance in large and small-scale spatial and temporal distribution patterns throughout the sites highlights the importance of maintaining a network of potential shorebird feeding sites.

(h) Tidal Flat Wrack Islands

Figure 7. Over 2,000 shorebirds including 977 Red Knot (EN) 48 Bar-tailed Godwit (CE/VUL) and 23 Curlew Sandpiper (CE) were counted roosting on tidal wrack at Pt Prime in the January 2016 count. Photo: Chris Purnell

Figure 8. The island of wrack at Pt Prime. Neamap

North of Light beach accumulations of tidal wrack form islands which can stretch up to a kilometre into the mudflat and can remain accessible for feeding and roosting throughout the tide cycle. The largest such accumulation, found at Pt Prime, covers over 165ha and can provide novel, secure habitat for several thousand shorebirds[5] (Figure 7, Figure 8). Due to the softness of the underlying sediment and the ability of the mats to float these extensive areas are inaccessible to most terrestrial predators and remain free from the disturbance caused by crabbers and other recreational use in areas of coastline to the north. Smaller wrack islands intermittently from in nearshore areas of of Thompson Beach and other locations.

(i) Sandy shores

Much of Australia's coastline comprises beaches, consisting of predominantly sandy shores of varying steepness and width. Beaches often occur on high-energy shorelines, and they may support fewer burrowing invertebrates than tidal flats. Nevertheless, they provide a diversity of prey for a few species of shorebirds that specialise in foraging in these habitats. For example, species such as Ruddy Turnstones and Red-capped Plovers are adept at picking invertebrates from the tidal wrack of decomposing seaweed that is washed up on some beaches.

In general, shorebirds occur in low densities in these habitats, with the exception of high-tide roosts where large flocks of shorebirds sometimes congregate. Such large flocks usually occur when the expansive flats are covered by the high tide, forcing birds to rest in open areas (with unobstructed views) that have not been inundated.

Some species of shorebirds, such as the Hooded Plover and Red-capped Plover, are true ocean-beach specialists, foraging and nesting on beaches. They are less numerous than many other species of shorebirds, and a beach supporting only a few pairs may be of considerable conservation importance.

Sandy beaches often experience intensive recreational use, with some coastal parks hosting millions of visitors each year. However, few Australians consider beaches to be important habitat for wildlife and, as a result, the impacts that coastal development, exploitation, modification and recreation have on shorebirds on beaches are often overlooked. If this trend continues unabated, many areas that are currently considered good habitat for shorebirds could be rendered unsuitable.

Although vast stands of mangroves line the coast between Barker Inlet and Light Beach, most of Section Bank/Bird Island consists of sandy shores. Sandy shores occur from Light Beach north to Bald Hill, where they form the dominant intertidal buffer between tidal flats and saltmarsh. They are often covered in thick layers

[5] Counts of the Port Prime wrack island can only be completed from the shore. Due the size, undulating topography and colour/texture of the wrack island it is considered that official counts may underestimate the total population of shorebirds using the area.

of beachcast sea grass (wrack). Novel feeding opportunities for small surface feeding waders, such as plovers and Turnstones, occur in these areas.

(j) Saltmarsh

Characterised as a mostly treeless plant community comprising a mosaic of low succulent shrubs and herbs, salt-tolerant grasses and sedges, saltmarsh is considered by some to be a lifeless wasteland. As a result, many saltmarshes have been in-filled, used as rubbish tips and places for recreational off-road vehicles (DECC 2008). Ignorance of the ecological value of saltmarsh has been reflected in the relative lack of protection afforded to the habitat when compared with most other ecosystems. Until recently, saltmarsh was the least studied of all of Australian marine habitats, even though the habitat occupies up to 16,000 km2 of the Australian coastline and supports more than three times the number of vascular plant species than occur in mangrove forests (Saintilan & Williams 2000). There are 1,270 km^2 of coastal saltmarsh in Gulf St Vincent, comprising 600 km^2 along the eastern side, 200 km^2 at the head of the Gulf and 470 km^2 along the western shoreline.

Figure 9. Sharp-tailed Sandpipers roosting amongst samphire in the tidal creek areas adjacent to Dry Creek salinas. Photo Chris Purnell.

Migratory and resident shorebirds feed and roost in saltmarshes, and in the absence of freshwater wetlands they are the preferred habitat of species such as the Common Greenshank, Marsh Sandpiper, Black-winged Stilt and Pacific Golden Plover. These sites are especially crucial during spring tides and other periods of high tidal inundation, when regular feeding and roosting sites are rendered unsuitable for most shorebirds. The birds are forced inland to feed or roost in saltmarshes and saltpans, such as those at Third Creek. Thus, with the threat of rising sea levels, these sites are valuable for shorebird conservation.

As with tidal flats, saltmarshes provide wide, open spaces which allow shorebirds uninterrupted views that provide increased surveillance for predators, enabling more time to be spent feeding. Some tidal creeks and runnels which criss-cross saltmarsh open up into large saltpans which may support large flocks of feeding or roosting shorebirds. Similarly, small, shallow pools and streams may also provide areas where shorebirds can feed while roosting.

Much of the destruction of coastal saltmarsh in Australia has occurred through reclamation for agricultural, industrial, transport and residential development (Kratochvil et al. 1972; Finlayson & Rea 1999). Significant alterations to the hydrology of saltmarshes have followed the construction of levees, culverts and floodgates, leading to the loss of ecological function and alteration of the floristic composition. The discharge of storm-water in coastal areas also alters regimes of salinity, increases nutrient levels and facilitates the spread of invasive weeds as well as the expansion of mangrove communities (Saintilan & Williams 1999). Similarly, unrestricted access into saltmarsh by walkers, cyclists, off-road vehicles and grazing animals also adversely affects saltmarsh communities. For example, wheel ruts from off-road vehicles and trail bikes persist for many years in saltmarsh, even after vehicles have been excluded (DECC 2008; see Threats to shorebirds in Gulf St Vincent, below).

Gulf St Vincent supports some of the most diverse saltmarsh communities in Australia and is part of the key remaining range of the threatened Bead Samphire *Tecticornia flabelliformis*, listed as Vulnerable in the Environment Protection and Biodiversity Conservation Act (1999) (EPBC Act) and National Parks and Wildlife Act (1972) (South Australia).

Subtropical and Temperate Coastal Saltmarsh was listed as a vulnerable threatened ecological communities under section 181 of the Environment Protection and Biodiversity Conservation Act 1999 in August 2013 (EC118) (05/08/2013) (TSSC, 2013). The Conservation Advice related to this listing includes a range of key priority conservation actions:

- Avoid native vegetation clearance and destruction of the ecological community and its buffer zones; including protecting potential areas of natural retreat.
- Collate effective policies and management actions already in progress (including development controls) to support and widely disseminate best practice and lessons learnt.
- Undertake surveys to identify areas where natural retreat of Coastal Saltmarsh may be possible and actively manage them to enable natural retreat in the future.
- Undertake effective community engagement and education to promote the value of the ecological community (e.g. it is not 'wasteland' as some perceive); also to highlight the importance of minimising disturbance (e.g. during recreational activities) and of minimising pollution and littering (e.g. via signage).
- Liaise with planning authorities to promote the inclusion of Coastal Saltmarsh protection and projected tidal inundation zones in their plans/responses to climate change and sea level rise and in coastal zone management generally.

The TEC Conservation Advice also includes a range of research priorities.

The listing recognises adequate protection and appropriate land use practices are important to ensure the ecological community persists to benefit future generations. The listing under the EPBC Act does not prevent land managers from continuing land practices which were started before the EPBC Act came into effect, providing that the activity is lawful and not significantly intensified. However, national protection means new or intensified activities that may have a significant impact on the listed ecological community should be referred to the Australian Government Minister for the Environment for assessment.

The eastern coast of Gulf St Vincent supports fragmented patches of low-lying saltmarsh which are used by shorebirds. Further north, mangroves dominate the shoreline, and saltmarsh and saltpans of varying size and condition are bound by either mangroves or sandy shores on the seaward side, and, on the landward side, by higher land, ridges or development (Coleman & Cook 2009).

(k) Claypans and sabkhas

Claypans are characteristically open and free of tall vegetation, and, like saltmarsh, they also remain vastly under-studied and under-protected in Australia. Formed in supratidal areas of low-lying, dry regions, they are seldom inundated by water (Coleman & Cook 2009). However, when they become covered with water, biofilms of cyanobacteria are able to grow, forming the basis of a food web in which shorebirds are the top predators. Recent studies of the feeding ecology of small sandpipers have revealed that some species, like the Sharp-tailed Sandpiper, may acquire a large proportion of their diet by feeding directly on biofilm (Kuwae 2010; Figure 10).

Figure 10. Sharp-tailed Sandpiper and Red-necked Stints feed on the wet cyanobacterial mats formed in the sabkhas north of Thompson Beach. Photo Dan Weller.

In Gulf St Vincent large areas of claypans from Dry Creek to Price provide valuable shorebird habitat. North of the Light River Delta claypans provide the predominant supratidal habitat for shorebirds. Although these areas are largely independent of tide and are only rarely inundated by rain events or spring tides, many regularly receive water through evaporative pumping. These habitats, known as sabkhas, form along arid coastlines when sea water filters through porous near coastal sediment and is brought to the surface through evaporation.

As with saltmarshes, the lack of tall vegetation and largely supratidal nature of claypans provide ideal roosting, feeding and breeding habitat and should be considered as a crucial refuge with the threat of sea-level rise (Figure 12).

Figure 11. Grey Plovers flocking in the supratidal claypans at Bald Hill. Photo - Chris Purnell.

Figure 12. The satellite track of a Grey Plover tagged at Thompson Beach by VWSG and Friends of Shorebirds SE for the AMLR NRM Board showing usage of inland roost sites.

(l) Commercial saltfields

Though many migratory shorebirds inhabit intertidal habitats while they are in Australia, during their non-breeding season, their use of claypans indicates that supratidal habitats can also provide suitable habitat for wintering shorebirds.

In Gulf St Vincent, some of the most significant supratidal habitats are artificial ones. Of these, the salt evaporation ponds in the Dry Creek Saltfields has historically provided the greatest amount of shorebird habitat. Shorebirds commonly dispersed throughout 3,204 of the 4,307 hectares of ponds in Sections 2, 3 and 4 prior to decommissioning. Of these marine to high hypersaline ponds only shallow areas (<20cm) such as exposed banks, islands and levees were utilised for feeding and roosting[6]. This represents less than 15% of the total area of the operation.

Fine scale habitat mapping of the saltfields (Purnell 2011) has not been updated since decommission, due to the variation in habitat being lost and created, as result of the transition between active operation and holding pattern (further discussed in Section 1.03).

The presence of supratidal habitats can increase the number of shorebirds that a region can sustain or reduce the detrimental impacts of the loss of intertidal habitats (Velasquez & Hockey 1992; Masero 2003; Dias 2009). A reduction in the area of intertidal foraging sites often results in an increase in the density of shorebirds in the remaining areas, which, in turn, leads to an increase in both the impact on shorebird food supplies and interference between foraging birds (Velasquez 1992).

The presence of supratidal habitats which resemble intertidal habitats, such as the Dry Creek Saltfields (Figure 14), can provide alternative foraging areas for shorebirds and other species of waterbirds (Weber & Haig 1996). Several studies have suggested that the availability of high-tide foraging areas contribute significantly to the maintenance of both high foraging densities of shorebirds on intertidal mudflats and overall stability of non-breeding populations (Velasquez & Hockey 1992).

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[6] Two common resident species, Banded Stilt and Red-necked Avocet are the exception to this statement as they regularly swim into deeper water to feed on invertebrates in the water column.

Commercial saltworks are supratidal habitats managed for the production of salt. By the predictable manipulation of water depth and salinity used for salt production, these areas attract many species of shorebirds, as the fluctuations in water depth and salinity provide a variety of foraging habitats, each of which suits a particular guild of shorebirds. Because these artificial supratidal areas have salinity, fluvial dynamics and benthic substrates that differ from tidal communities, they support distinct invertebrate communities. Consequently, these habitats can provide both supplemental high-tide and preferential feeding habitats for different species of shorebirds (Masero *et al.* 2000).

Figure 13.Shorebirds and waterbirds congregate on pond XC3 at Dry Creek Saltfields. Photo Chris Purnell.

Figure 14. Several species of shorebirds thrive on the high densities of invertebrates, including clouds of Brine Flies *Ephydridae,* which occur in the hypersaline ponds of the Dry Creek Saltfields. Photo Chris Purnell.

Figure 15. Brine Shrimp *Artemia sp* and Fairy Shrimp *Parartemia sp* accumulated at the windward of a levee in high hyperdsaline pond XB8. Photo Chris Purnell.

Shorebirds represent about 25 per cent of the more than 200 species of birds recorded in and around the Dry Creek Saltfields. Since 1976, 52 species of shorebirds have been recorded in the region (including nine of them in numbers considered to be of international significance). Together with the Price Saltfields, these artificial supratidal habitats are a major factor in Gulf St Vincent being an important shorebird area in South Australia, second in importance only to the Coorong.

Importantly, these habitats are not readily accessible to the public and remain largely undisturbed, apart from occasional operational staff, contractors, researchers or birdwatchers (both of whom are usually aware of the implications of disturbance).

While shorebirds occur at varying densities across the salinity gradient, medium-high hypersaline ponds of Dry Creek Saltfields have traditionally supported the highest abundance and diversity (Day 2002, Purnell et al 2010, 201, 2012, 2013, Brett Lane & Associates 2014). A similar pattern occurs in San Francisco Bay where densities of diving ducks decreased with increasing salinity while those of shorebirds increased (Stralberg et al 2003). Medium-high hypersaline (80–150 g l-1) ponds may be particularly valuable for many shorebirds and other species because of high densities of saline-tolerant invertebrates they support (Masero, 2003; Takekawa et al., 2006; Takekawa et al., 2009). As salinity increases species richness often decreases (Britton and Johnson 1987; Williams et al 1990) however overall biomass can increase up to high hypersaline conditions (Warnock 2013). In Dry Creek saltfields medium-high hypersaline ponds, introduced Brine Shrimp *Artemia franciscana* Fairy Shrimp *Parartemia* zietzania (Figure 15), Brine Fly larvae and pupa *Ephydridae* sp and Chironomid larvae *Tanytarsus barbitarsis* represent an important food resource for species that exploit this type of prey. As in similar systems elsewhere (Takekawa et al., 2006), biomass in these ponds can exceed the combined macroinvertebrate biomass of other ponds by several orders of magnitude (Brett Lane &

Associates 2014). Given abundance and their location (either suspended in the water column, on the water surface or accumulated on the shoreline) these prey items can often be consumed by birds at a high rate with little search time (Masero et al., 2000). However, Ephydra are likely to be preyed upon by many more species of waterbirds than are Artemia (Anderson, 1970; Takekawa et al., 2009). Fly larvae, pupa and adults are particularly accessible to shorebirds when prevailing winds accumulate them on the windward side of salinas.

(m) Freshwater wetlands

Other supratidal habitats used by shorebirds include low-intensity aquaculture ponds, waste water treatment plants, stormwater detention ponds and natural ephemeral wetlands. In the Adelaide Mt Lofty NRM region the Greenfields Wetland complex, Buckland Park Lake and several mixed-use wetlands throughout the Onkaparinga region have been identified as the priority shorebird habitats.

The wetlands in the region have mostly been constructed to assist in flood management and water treatment, are part of waste water treatment areas or are part of the Dry Creek salt fields. Most are present at areas which historically contained wetlands, especially floodplain communities, samphire shrublands and other saline wetlands. The Greenfields wetland complex, Barker Inlet wetlands and various detention basins adjacent to Port Wakefield Road and the Little Para River provide suitable habitat for a number of bird and aquatic species. Smith Creek, Dry Creek and some of the larger drains, such as Whites Road drain, contain smaller areas of habitat suited to some bird, frog, reptile and aquatic species. The water treatment lagoons, native vegetation and revegetation on SA Water land at Bolivar provide habitat for a relatively high diversity of species (Anderson 2009).

In late 2015 SA Water inundated two decommissioned ponds within the former Dry Creek Saltfield with treated wastewater. The formerly hypersaline ponds PA 9 and 10 (46 and 14 ha respectively) (Figure 16) were filled with freshwater creating a slightly brackish habitat immediately utilised by waterbirds and several shorebird species[7].

Figure 16. Ponds PA9 and 10. Dry 31/12/2014 (left) and inundated 17/1/2016. Google earth

In addition to providing ecosystem and anthropogenic services such as flood mitigation and nutrient filtration, these areas provide unique foraging, roosting and often breeding opportunities for shorebirds. As with saltfields, time spent in these habitats is not restricted by tidal fluctuation, allowing shorebirds to spend

[7] One shorebird count of Bolivar ponds was conducted in coordination with Dry Creek counts (Section Section 3.03). Additional waterbird counts were conducted monthly by G. Carpenter between 10/12/2015 and 21/4/2016

longer periods foraging (Velasquez & Hockey 1992; Weber & Haig 1996). These wetlands also provide an open, shallow freshwater habitat for shorebirds such as Wood Sandpipers and the Australian Painted Snipe (Endangered EPBC), which prefer feeding and roosting in freshwater or brackish conditions. North of Adelaide, stormwater wetlands (Barker Inlet Wetlands, Greenfields, Whites Rd Wetlands), the above mentioned SA Water wastewater ponds and the ephemeral Buckland Park Lake, represent the only semi-regular fresh-water sources in the coastal area.

Although prone to larger scale temporal fluctuations in freshwater availability these areas can support high densities of shorebirds and a variable continuum of available foraging habitat as water levels draw down (Purnell et al 2015).

Section 1.03 Conservation & threats to shorebirds in gulf St Vincent

Listed migratory species are a matter of national environmental significance under the EPBC Act. As such, any action that has, will have, or is likely to have a 'significant impact' on a matter of national environmental significance will require approval. Substantial penalties apply for taking such actions without approval.

In Australia and the EAAF, many of the current threats are linked to the changing availability of wintering, stop-over and breeding habitats (MacKinnon et al. 2012). The loss of key locations at any point on the migratory pathway will have significant consequences for a number of species (Commonwealth of Australia 2015). While it is theorised that habitat loss in the Yellow Sea is the most significant driver of declining shorebird populations, there are a number of local threats which may be contributing to decrease fitness in non-breeding birds.

The Commonwealth of Australia's *Wildlife Conservation Plan for Migratory Shorebirds* identifies eleven threats that are likely to significantly affect shorebird populations adversely. These threats and their relative consequences and likelihood are listed in the threat matrix below.

Likelihood of	**Consequences**				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain		• Harvesting of shorebird prey	• Coastal development in Australia		• Coastal development, particularly in the Yellow Sea*
Likely		• Hunting* • Fisheries by-catch*	• Anthropogenic disturbance • Altered hydrological regimes • Invasive species	• Climate variability and change	
Possible					
Unlikely		• Chronic pollution			
Rare or Unknown		• Acute pollution			

Table 9. Migratory Shorebird Population Residual Risk Matrix listed in the Commonwealth of Australia's *Wildlife Conservation Plan for Migratory Shorebirds*. http://www.environment.gov.au/system/files/resources/9995c620-45c9-4574-af8e-a7cfb9571deb/files/widlife-conservation-plan-migratory-shorebirds.pdf

* threat occurs mostly outside Australia.

Threats to shorebird populations and their habitats in Gulf St Vincent can be classified under five categories:

- Human-induced habitat loss or degradation (including coastal development, altered hydrological regimes and climate change variability and change).
- Human disturbance.
- Invasive species.
- Human-induced mortality or breeding failure.
- Pollution.

The relative consequence of these threats depends on the scale and cumulative effect of human actions throughout the area, and the degree to which shorebird populations are currently limited in the area. Previous reviews of wader populations in Gulf St Vincent have been limited by data gaps and are therefore subject to some sampling error, and probable declines in shorebird numbers may also be attributed largely to factors independent of the Gulf (Close 2008). These conclusions are based on a 50 per cent decline in numbers (from 59,851 to 29,929) of Northern Hemisphere (or Palaearctic) breeding species recorded in Gulf St Vincent between 1979 and 2008. In contrast, resident species declined overall by only 12 per cent. However, within the category of residents, the number of Red-necked Avocets declined by 96 per cent, and numbers of Black-winged Stilts, Red-kneed Dotterels, Red-capped Plovers, Masked Lapwings and Banded Lapwings also declined greatly (Close 2008). The Shorebird Population Monitoring Program has recognised declines in both resident and migratory birds throughout south-eastern Australia (Gosbell & Clemens 2006; R. Fuller, unpublished data), and recommends that threats to local shorebird habitats must be identified and managed.

The threats listed above are not mutually exclusive, rather shorebird population declines are considered to be driven by the cumulative impact of these threats. For the purposes of identifying of site based threats and management priorities, the Shorebirds 2020 program requests observers to document threats using a technique developed by the Western Hemisphere Shorebird Reserve Network (Table 10. Each "count area" is scored as a discreet site and the "scope of threat" is only based on what is considered to be average shorebird population utilising that site. The following section lists known and potential threats to shorebirds and shorebird habitat in Gulf St Vincent at a site-based level. The maximum threat score from the five categories was reported, along with the sum of the five threat scores for each area. While this technique is subjective, and results varied between counters, it allows comparisons between potential threats (Clemens *et al*. 2007a).

- Management of marine pest species – Biosecurity SA, Australian Government (National System for the Prevention and Management of Marine Pest Incursions).Management of Crown Lands and Conservation Parks, Protected Species – DEWNR
- Conservation of marine biodiversity - DEWNR and PIRSA
- Commercial and recreational fishing regulation – PIRSA Fisheries, Australian Government (joint managed fisheries and fisheries export assessment)
- Vessel management – Department of Planning, Transport and Infrastructure (DPTI) Marine Safety, Australian Marine Safety Authority
- Evaluation of new coastal developments – DEWNR (for Coast Protection Board), EPA, relevant planning authorities with strategic support from (DPTI), State Planning Commission, Local Councils
- Improvement of water quality – EPA, Local Councils, Stormwater Management Authority,
- Catchment management and protection of native vegetation – DEWNR (Native Vegetation Council, and for Adelaide and NRM Mount Lofty Ranges and NRM Northern & Yorke).

Map 4. Shorebird Count Areas in Gulf St Vincent

Table 10. Description of threats to shorebird areas and how threats were scored.

Types of Threats Identified and their Scores:	
Human-induced habitat loss and degradation	
Human-induced disturbance	
Invasive species/habitat loss or degradation due to natural causes (e.g. vegetation encroachment)	
Pollution (oil spills, runoff, or anything that changes soil texture, elevation, acidity, toxicity, turbidity, etc.)	
Accidental mortality (not including oil spills; primarily refers to direct or indirect mortality during breeding, such as crushing of nests by vehicles, people, etc.)	
Scoring:	
Likelihood of threat:	Timing Threat Score
Happening now/ Almost Certain	3
Likely	2
Possible	1
Unlikely	0
Scope of threat:	Scope Threat Score
Entire area/population (>90%)	3
Most of area/population (50–90%)	2
Some of area (10–49%)	1
Small area	0
Unknown	1
Severity of threat:	Severity Threat Score
Severe/very rapid deterioration (>30% over 10 years)	3
Rapid to moderate deterioration (10–30% over 10 years)	2
Slow but significant deterioration (1–9% over 10 years) or large fluctuations	1
No or imperceptible deterioration (<1% over 10 years)	0
Unknown	1
Overall impact of threat:	
Add threat scores for timing, scope and severity to get an overall score of the impact of each kind of threat	
Impact score for each threat: 8–9=high, 6–7=medium, 2–5=low, 0–1=negligible	

(a) Habitat loss or degradation

Table 11. Shorebird count area threat scores; Habitat loss or degradation.

Count area	liklehood	scope	severity	Total	source of habitat impact
Whicker Rd Wetlands	1	1	2	**4**	uncertainty of sufficient freshwater input
Barker Inlet Wetlands	3	2	3	**8**	Northern Expressway
Magazine Rd	2	2	3	**7**	uncertainty of sufficient freshwater input
Bolivaar	2	3	2	**7**	uncertainty of sufficient freshwater input
White's Rd Wetlands	2	3	1	**6**	uncertainty of sufficient freshwater input
Saint Kilda	3	2	2	**7**	hard levees leave no room for habitat retreat
Section Banks	2	1	1	**4**	mangrove succession and sea level rise
Dry Creek Saltfields	3	2	3	**8**	altered hydrology
Port Gawler	3	2	1	**6**	habitat damage by ORV, mangrove succession
Middle Beach	2	1	1	**4**	habitat damage by ORV &boat launch
Light Beach	2	0	1	**3**	sabkah ORV damage
Port Prime	2	0	1	**3**	sabkah ORV damage
Thompson Beach S	2	0	1	**3**	sabkah ORV damage
Thompson Beach N	2	0	1	**3**	sabkah ORV damage
Webb Beach	1	0	1	**2**	sabkah ORV damage
Port Parham	1	0	1	**2**	sabkah ORV damage
Bald Hill	0	0	0	**0**	NA
Port Arthur	0	0	0	**0**	NA
Clinton CP	0	0	0	**0**	NA
Port Clinton	2	2	1	**5**	hard levees leave no room for habitat retreat
Price Saltfields	1	1	3	**5**	contingent on continued commercial operation
Price coast (Mac's Beach)	0	0	0	**0**	NA

Habitat loss and degradation is the prime long-term threat to migratory and resident shorebird populations in Gulf St Vincent. The urbanised stretch of coast south of Adelaide has historically supported healthy numbers of shorebirds, including breeding Hooded Plovers, but since extensive development, increasingly intensive use by people and altered hydrology and numbers of shorebirds in the area have plummeted (Close 2008) and beach-nesting birds, especially Hooded Plovers, have become increasingly uncommon.

This is the scenario now facing shorebird habitats north of Adelaide, with the projected population growth of the northern Adelaide region tipped to exceed 160,000 over the next 30 years. Apart from direct loss of habitat, it is the cumulative indirect effects that population growth has on shorebirds which will threaten populations in Gulf St Vincent. For example, large areas of tidal mudflats at St Kilda have been reclaimed and built upon, including a boat launch and marina. This has not only removed historic feeding and roosting sites and degraded surrounding habitats (Coleman & Cook 2003) but has also increased levels of disturbance from boat traffic, the occurrence of exotic predators and competitors, the potential for pollution and the introduction of coastal weeds.

When considering habitat loss or degradation on its own, there are three major management areas to consider:

- the Dry Creek Saltfields,
- Barker Inlet Wetlands,
- the Samphire Coast,

- Freshwater habitats (Buckland Park Lake and Greenfields complex).

(i) Dry Creek Saltfields (Section 2.02(f))

The habitats that the Dry Creek Saltfields created as an active operation supported an average population of nearly 15,000 shorebirds.

Modified salt pan habitats have been available for shorebirds for over sixty years since the Dry Creek salt pans were established with Imperial Chemical Industries (ICI) commencement of salt production at Dry Creek in 1940.

In his 1966 book, *Birds of a Salt-field*, Roy Cooper noted that "These saltfields, which were proclaimed a sanctuary, have not only increased enormously the area which is attractive to many birds, but they have provided an alternative habitats which has greatly enlarged the number of species which regularly and also occasionally occur in the area under review".

A “closed area” in the region of the Dry Creek salt fields was proclaimed in 1938 under the Animals and Birds Protection Act 1919, with further portions proclaimed in 1959 (Pers Comm Edwards, T.). With each change in the Act covering fauna protection, ICI applied to have the Sanctuary re-declared (Coleman., P. pers. comm). A Sanctuary was created over various Leases in the Saltfields under the "Fauna Conservation Act, 1964". The Fauna Sanctuary provisions protected animals and birds in a prohibited area, fauna reserve or sanctuary, were able to control entry, prevent the use of firearms and restrict entry of dogs and cats into sanctuary areas.
The Sanctuary status was revoked by the implementation of the NPW Act 1972 (this act did not ratify any existing sanctuaries). Some Fisheries Act provisions remained

In 2001 Application was made by Penrice Soda Pty Ltd for the creation of a sanctuary over salt field land. However although received by the Ministers office at the time, there is no evidence it was approved or implemented, as such no sanctuary status currently exists in the saltfields and has not existed since the enactment of the National Parks and Wildlife Act 1972. (Pers Comm Tammie Edwards).

The current National Parks and Wildlife Act 1972 allows for dedication of Sanctuaries over public land and private lands, with consent of the owner or land manger, if the Minister is of the opinion that it is desirable to conserve the animals or plants for which any land is a natural habitat or environment. Sanctuary provisions provide for fines for take of native fauna and plants.

The primary aim of the Saltfields was to supply brine for the manufacture of sodium carbonate and sodium bicarbonate on LeFevre Peninsula. Since the sale to Penrice Soda Products in 1989, the operation was sold to Ridley Corporation Limited in 2005, operated by Ridley’s subsidiary, Cheetham Salt. More recently land has been sold on to Adelaide Resource Recovery / Buckland Dry Creek Pty Ltd (Hough 2008).

Maintenance of habitat condition at Dry Creek was contingent on continuous, active management of site water levels, however recent steps toward decommissioning the site have drastically altered the established salinity gradient and the shorebird prey communities which rely on it (Purnell 2014). The decommissioning process presents both risks (habitat loss or degradation) and opportunities (habitat creation or optimisation) for shorebird conservation. These are identified in a 2013 board funded *Risks and Opportunities* briefing paper (Coleman 2013) and their varying potential effects on shorebirds are further investigated in the discussion section of this report. The following summarises the decommissioning process to date and its effect on shorebird habitat.

As with several other sites in Australia, the Dry Creek Saltfields were managed for the production of salt by Ridley Corporation on a mixture of freehold and crown land under a 100-year mining lease. However, in a statement from the Australian Stock Exchange (November 2012), Ridley Corporation announced the sale of “non-development potential saltfields” plus the Cheetham brand-name to a Chinese operator, CK Life Sciences. Ridley Corporation retained the saltfields at Dry Creek to service contracts with Penrice Soda plus several non-operational saltfields interstate. Ridley Corporation stated that it will actively pursue other development opportunities for the land north of the Dry Creek operations which are not utilised for salt production (Flaherty 2013).

A break of contract with Penrice Soda in June 2013 (ceasing the necessity for salt production and thus continued flow management) confirmed that Ridley Corporation would announce plans for decommissioning of the operation.

In this case The *Mining Act* (1971) dictates that mining lease land does not have to be returned to pre-lease conditions; rather, it must be returned in a state that is *fit for the proposed purpose of use*. The company’s proposed use of freehold land will set any rehabilitation targets, however the

Before decommissioning, the saltfield operator is compelled to provide a Program for Environmental Protection Rehabilitation (PEPR) in compliance with conditions outlined by the *Mining Act* (1971). This document will detail the final closure outcomes to be agreed upon by the landowner, including rehabilitation standards and criteria as well as acceptance of any residual risks which may be implicit.

Given the Dry Creek Saltfields supports important habitat for birds listed as threatened and/or migratory species under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC) the ultimate management of that in the interim, PEPR development stage should seek to have no detrimental impact on these Matters of National Significance (MNES).

To this end Ridley developed a proposal for a “holding pattern” which was initiated in August 2013 however not approved by DIMTRE until March 2014. As discussed in the Purnell 2014 report, this period was preceded by several months where, having ceased pumping, no new water was entering the system (April- October 2013). The ensuing months of evaporation caused drastic changes in the salinity of ponds throughout high value conservation value areas in Sections 3 and remained at abnormal salinities until January 2014 when water (entrained months earlier) was able to replenish the ponds (Brett Lane & Assoc 2015, Coleman pers com, Purnell 2014). The salinity fluctuations in these ponds exceeded the ranges experienced during historic operations (Brett Lane & Assoc 2015) and were too great to sustain the established in-pond invertebrate communities (Coleman pers com).

During this period (August-November 2013) ponds on freehold land, namely XF2, XE4, XC1, XC2 and XC2S were dried. Active pumping and passive evaporation reduced pond levels and, particularly during the tail of the drying period, provided additional shorebird habitat as dead and dying, marine-adapted invertebrates became concentrated and more readily accessible. This increase in the available foraging area was however only temporary as residual moisture evaporated, substrate hardened and any infauna that was capable of surviving the hypersaline conditions became desiccated and perished.

Unseasonal rains in February 2014 promoted growth of cyanobacterial mats in XF2 and XE4 which attracted shorebird foraging in those ponds. These conditions remained throughout winter and maximums of 1,087 shorebirds (including 78 critically endangered Curlew Sandpiper) were observed on XE4 in September 2014 (Figure 17) until the ponds dried again in October 2014 (Figure 18).

Figure 17. Shorebirds feeding in standing surface water on dried pond XE4 in September 2014. Photo Chris Purnell.

Figure 18. Transitional stages of change in pond XE4: a) Inundated- July 2013 b) Almost completely dry January 2014 c) Surface water collected after high amounts of rain February 2014 d) Dry October 2014 (NearMAP imaging).

The transitional phases of drying as part of the progression into an established holding pattern have continue to provide temporary habitat for shorebirds as pond levels drop and sandy banks are exposed. Pond by pond scale data collected by EBS on behalf of Ridley Corporation as part of ongoing investigations demonstrates how shorebirds are adapting spatially and temporarily to these alterations.

Whether intended or incidental these drying patterns have been advantageous to shorebirds however cannot be taken as evidence of sustaining in-pond quality in previously high value areas or relied upon as habitat in the future. By summer 2014/15 all the ponds that had been drained in late 2013 were devoid of shorebirds and waterbirds, however by this time XF1 (drained over a 4 month period in late 2014) provided additional temporary habitat and in February 2014, 311 waders recorded. These including Banded Lapwing and breeding Red-capped Plovers in and around damp substrate on the margins of water remaining in the levee borrows. Once dry and in the absence of summer rain events these ponds become functionally useless for shorebirds. Similarly, several ponds in Section 3 (XA3, XC3, PA3-5) have been subject to fluctuating water and salinity. In the case of XA3 and XC3 (Figure 19) this has resulted in increases in suitable habitat however increases in salinity in pond PA4-5 may be responsible for declines in shorebird usage in those ponds.

As part of previous Ridley Corporation[8] investigations, variables influencing pond ecology were being recorded howver are not currently being undertaken. These included:

- Pond by pond bird count data
- Observations of bird behaviour (i.e. foraging or roosting).

[8] Investigations innovated by Ridley Corporation have now been taken on by new managers Buckland Dry Creek Pty Ltd (a subsidiary of Adelaide Resource Recovery).

- Food source information for selected ponds in selected months.
- Pond depth
- Pond chemistry including dissolved oxygen and salinity

The ongoing data will feed into an Adaptive (Risk) Management Plan to address unforeseen impacts the holding pattern may be having on natural values, soil and water condition. A report in preparation will assess the impacts of the holding pattern against the expectations presented in the 2013 EPBC Self-Assessment.

Figure 19. Reduced water levels in pond XC3 provide an increase in shallow, complex shorelines for 1,429 Red-necked Stint February 2015. Photo Chris Purnell.

In early 2016 local company Adelaide Resource Recovery (ARR) acquired 5,500ha of the saltfield from Ridley Corporation. The company who own 120ha in neighbouring Wingfield conduct comprehensive recycling of construction & demolition materials into valuable resources and are operating the saltfield under the name Buckland Dry Creek (BDC) Pty Ltd. All relevant obligations applying to the original PEPR outlined during Ridley Corporation lease period have now been transferred to BDC. DEWNR Dry Creek closure project managers are engaged in discussions with BDC about future use, however beyond a note on a commercial feasibility into running a reduced saltfield in sections 3 & 4 have not proposed any future works. BDC have allowed necessary continuation of relevant research to continue and continue to manage the site satisfactorily.

Figure 20. Pond C2 south ("Wader alley") (a) January 2012 (b) June 2014 (c) January 2016. Photos Chris Purnell.

As discussed, the maintenance of habitat values for migratory and threatened species at the Dry Creek Saltfields are contingent on seasonal, active management of water levels on site, therefore decommissioning without appropriate environmental planning will significantly decrease the quality of the habitat and have an impact on species listed under the *EPBC Act*. Any change in operation thereby triggers the requirement for a referral to Department of Environment for assessment under the *EPBC Act* before any action is undertaken.

The salt fields are regulated by the Department of the Premier and Cabinet (DPC) Mineral Resources Division under the Mining Act 1971. This regulation includes a requirement for a program for environment protection and rehabilitation (PEPR). Buckland Dry Creek Pty Ltd is also licensed by the EPA under the Environment Protection Act 1993, this licencing is focused on managing discharges of saline water.

Planning for the Dry Creek Saltfields to maintain shorebird populations will rely on critical decisions on how to adaptively manage existing ponds to meet multiple ecological goals within the given financial parameters and a larger strategic framework. The Dry Creek saltfield closure is being overseen by a State Government steering group of agency heads, chaired by DEWNR, involving Department of State Development, Department of Planning Transport and Infrastructure, Environment Protection Authority, Primary Industries and Regions SA, SA Water, Renewal SA, the saltfield owners and local councils. Project coordination is managed by DEWNR and this is supported by a Strategy / Technical Advisory Group including managers from these agencies and organizations.

A discussion paper on ***Risk and opportunities: A briefing paper on coastal habitat and shorebird conservation in the light of potential closure of the Ridley Dry Creek salt fields*** commissioned by the Adelaide and Mount Lofty Ranges Natural Resources Management Board (Coleman 2013), investigated possible outcomes and associated risks of several management scenarios for the Dry Creek Saltfields after closure. Some of the options presented include retaining ponds as detention and polishing ponds or for use in aquaculture, or remediation of the pondage area to tidal wetlands.

In 2014, DEWNR released a *Saltfields* document which outlined *Creating the Adelaide International Bird Sanctuary. This outlined the opportunities provided by the closure of the Dry Creek saltfields in conserving the Adelaide hub of the international migratory bird flyway; enhancing water quality in Gulf St Vincent; creating a more liveable and sustainable city; offering exclusive eco-tourism experiences and facilitating indigenous involvement.*

BirdLife Australia advocates that management of optimised ponds for the conservation of shorebirds should continue in concert with some level of tidal remediation and optimised polishing ponds, thus meeting a variety of ecological goals (shorebird, waterbird, samphire, intertidal and fish). The advantages and disadvantages of varying levels of the aforementioned solutions were further investigated in Purnell 2015.

As discussed (Section 1.01(m)) an option for utilisation of ponds for treatment of wastewater has already been initiated by SA Water as a trial with immediate benefit. Tidal remediation trials have also been initiated on one of the seaward ponds. The University of Adelaide (UoA) and Department of Environment, Water and Natural Resources (DEWNR) undertook preliminary desktop and laboratory-based research on this option that suggested it could be feasible without creating unacceptable environmental risks.

Figure 21. The tidal gate controlling inundation of XB8A. Photo: Chris Purnell

Administered by CSIRO and UoA's Adelaide Research & Innovation Pty Ltd and supported through the AMLR NRM Board's and BirdLife Australia's Samphire Coast Icon Project, the trial aims to restore tidal cycling to pond XB8A by the installation of a tidal weir. The changes in the sediment/subaqueous Acid Sulfate Soils (ASS), water quality, and hydrology in the pond will be assessed. These changes will be linked to additional assessment of vegetation and benthic invertebrate recolonization and ultimately vegetation and shorebird populations (University of Adelaide 2016). Given pond floor topography- levee borrows, a major remnant creekline and associated dendrital creeklines, care must be taken that water not be exclusively restricted to these areas. Failure to regularly inundate large areas of open pond floor will result in colonisation by vegetation and an overall reduction in shorebird value[9] (Figure 20, Figure 25).

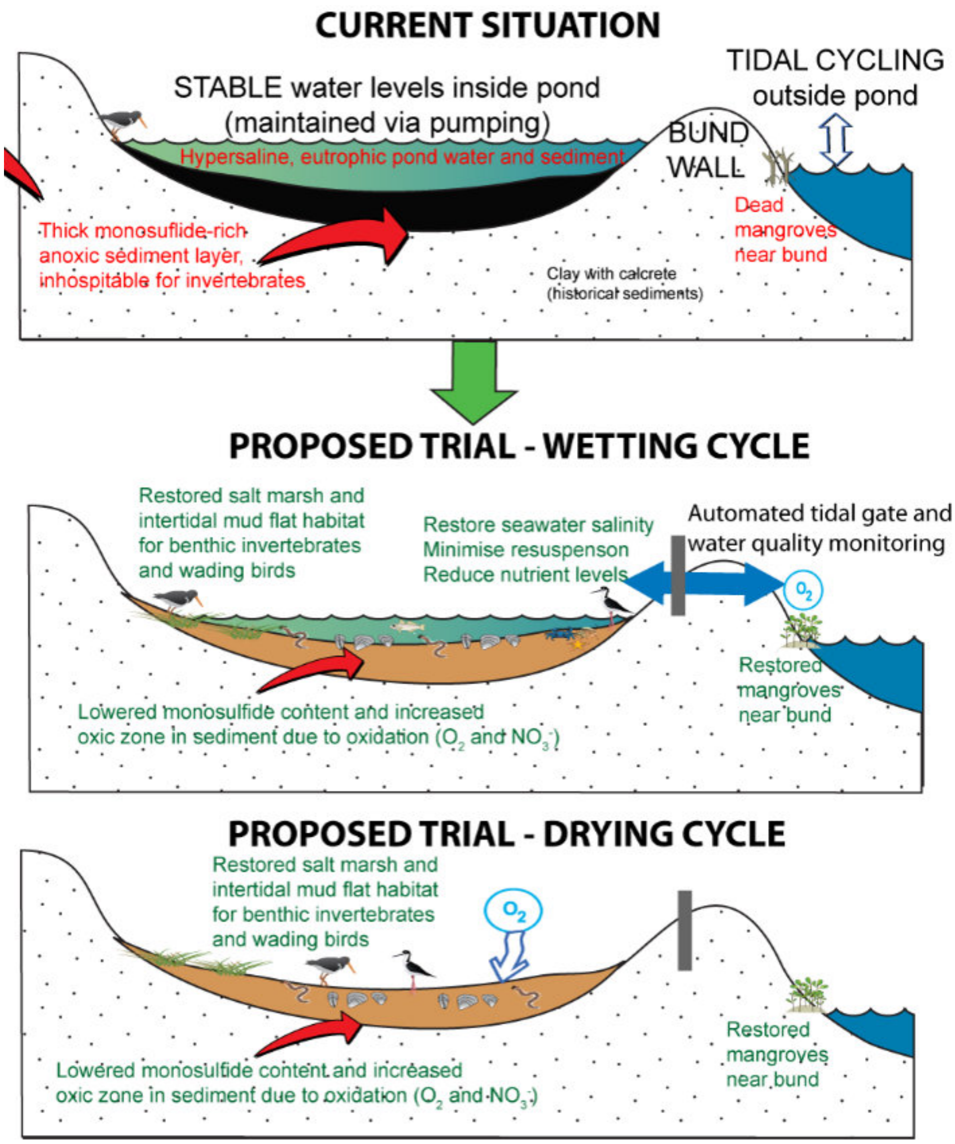

Figure 22. A conceptual model of the tidal inundation trial project showing hypothesised outcomes of the lower monosulfide concentration and benthic invertebrate and vegetation re-colonisation while minimising external environmental impacts (UoA proposal to DEWNR 2016)

[9] Further information on tidal inundation trials associated with shorebird habitats can be found in Purnell 2015

Understanding the current benefits of maintaining supratidal habitats in the context of climate change induced sea-level rise roost sites in and associated with the saltfields should be a maintained and optimised. With access to repurposed spoil, BDC are in a unique place to assist in the trial creation of artificial roost creation in the saltfield ponds.

Figure 23. Pond XB8A pre-inundation, 1/6/2017 (left) and post inundation 22/11/2017.

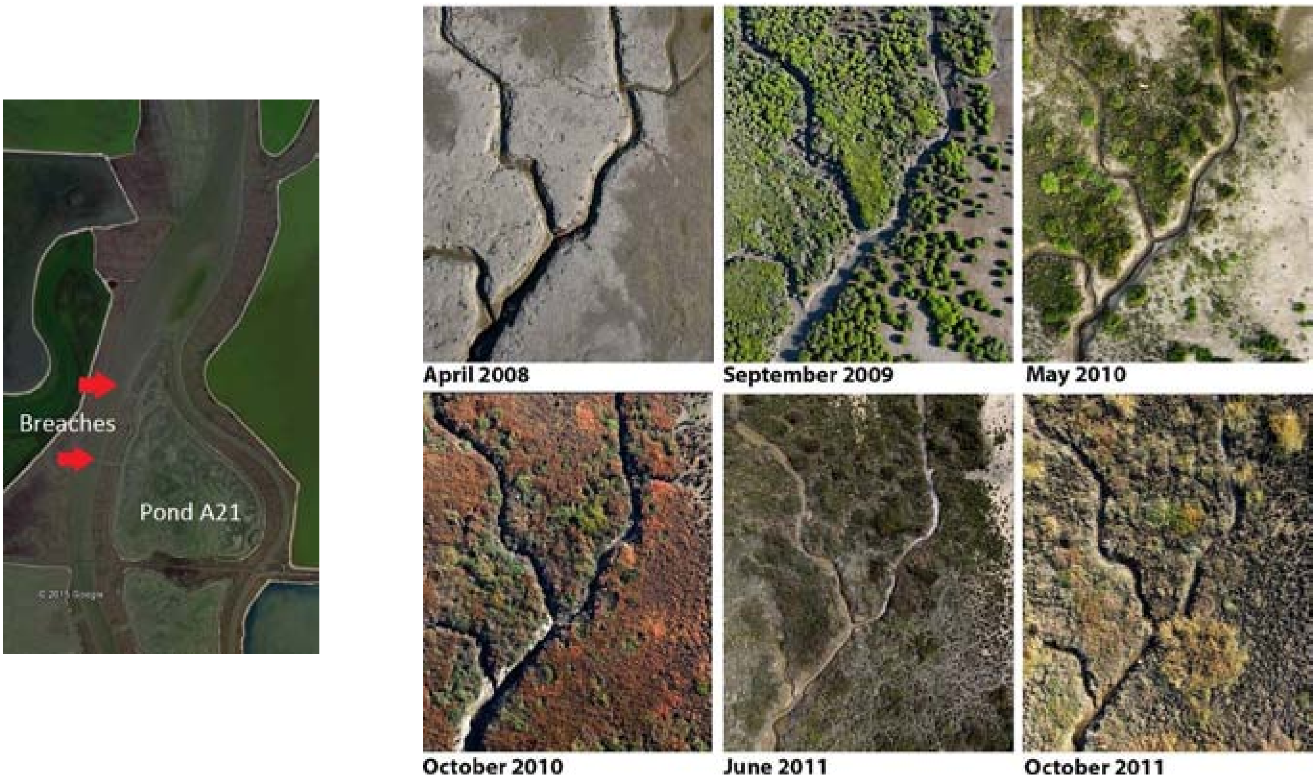

Figure 25. Aerial views of Salt Pond A21 in San Francisco Bay's South Bay Salt Pond Restoration Project transitioning to mature saltmarsh after being breached in 2008. Photos satellite image Google Earth (left) Kite aerials Cris Benton (right)

(ii) Barker Inlet Wetlands (Section 2.02(d)).

The northern basin of the Barker Inlet Wetlands (north of Salisbury Highway), managed by Pt Adelaide Enfield Council, comprise the final stages of stormwater treatment before being debouched into tidally influenced ponds which are connected through a single weir to the mangrove forest dominated estuary of North Arm Creek. The large terminal pond in the north east of the system provides the most abundant and valuable foraging habitat for shorebirds and is densely populated on falling and rising tides (Section 2.02(d)).

The surrounding saltmarsh and tidal creeks support lower densities of marsh species throughout the tide cycle and are home to breeding Red-capped Plovers. The freshwater section of the wetlands provide novel habitat for freshwater and marsh species at low densities including breeding Red-capped Plovers, Black-fronted Dotterels and Black-winged Stilt.

The Barker Inlet Wetlands is the only notable shorebird habitat which has been affected by the footprint of the Northern Expressway development. At the southern end of the Northern Connector, the project has modified the Barker Inlet Wetlands to allow for the Southern Interchange, which incorporates on and off ramps and bridge abutments. The original footprint for Southern Interchange proposed by the Department of Planning Transport and Infrastructure significantly impacted the wetlands (Figure 26, Figure 80, Appendix 2).

Although subsequent changes in project management have altered the proposed footprint to reduce the amount of wetland habitat impacted, and the current tender plans do make more accommodation for the intertidal pond in the north east, there has inevitably been a net loss of available habitat (Figure 27, Appendix Figure 81). In addition to the physical loss of habitat, project works have temporarily impacted an area greater than the footprint of the final infrastructure. Additional impacts include; temporary hydrological changes, increased disturbance and dust pollution.

Figure 26. The original proposed footprint of the Northern Expressway. Image adapted from the Department of Planning, Transport and Infrastructure South Australia proposal 2015 (now superseded by Lend Lease proposed plan, August 2016).

Project managers, Lendlease, have engaged in initial consultation with stakeholders including BirdLife Australia, DEWNR NRM, and local councils by forming a Wetland Working Group to discuss the wetland aspects of the project to ensure the best biodiversity outcomes for redesigned aspects of the wetland.

Works on site began in 2017 and plans for the redesign are currently at 95%.

An offset wetland has been nominated for optimisation to compensate for the net loss of habitat at Barker Inlet Wetlands. The selected site, a former borrow pit associated with Dry Creek Section 1, will be managed for shorebird and mangrove, samphire community values. The proposed inundation of the pond should seek to mimic trial in pond XB8A including measures to maximise regular tidal presence while precluding colonisation by neighbouring mangroves (Section 1.01(e)).

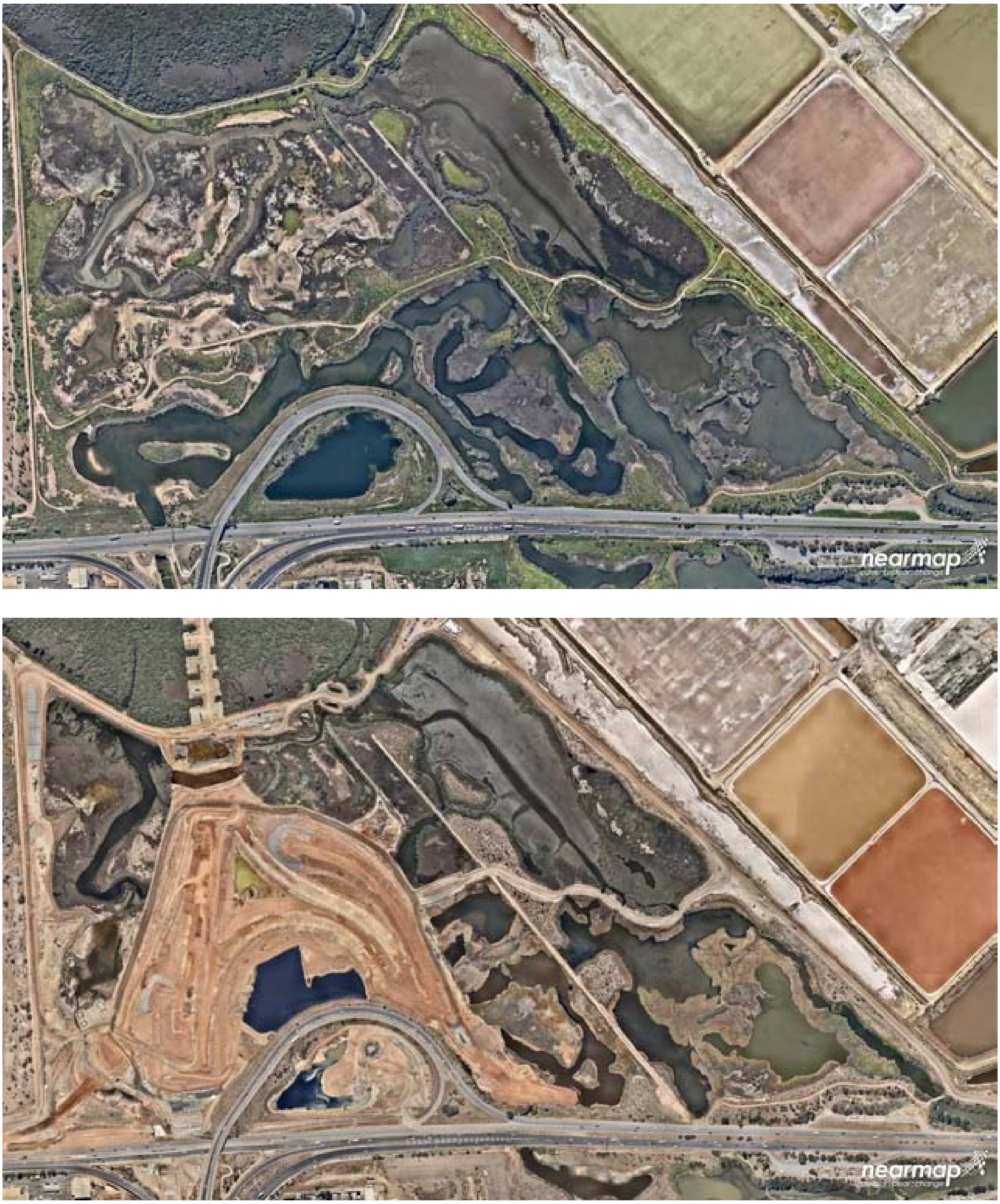

Figure 27. Barker Inlet Wetlands pre-commencement of the Norther Connector, 31/8/2015 (top) and currently 2/2/2018 (bottom). Nearmap

(iii) The Samphire Coast

Other notable shorebird areas along the Samphire Coast are susceptible to pressure from habitat loss or degradation. As previously discussed much of the priority shorebird habitat in this region has been included within the boundaries of the *Adelaide International Bird Sanctuary* and is thereby exempt from threat of habitat loss through development or inappropriate land use however an influx of off-road vehicles accessing areas of saltmarsh, intertidal flats and claypans, from Port Gawler to Port Parham, threatens to reduce the value of the habitats as feeding areas. Off-road vehicles can compact sediment and the benthic macrofauna contained within (Schlacher *et al*. 2008), drastically reducing the availability of prey for shorebirds. When driven in saltmarsh, four-wheel drives and motorbikes can also destroy the samphire flora and change the structure of the habitat (Section 1.01(b)(iii)).

Significant loss of intertidal habitat is also likely to occur through the effects of climate change and sea level rise. Since the early 1990s, southern Australia has experienced sea level rises of 2–7 millimetres per year (Edyvane 1999; Harris 2011) and it is expected that a further rise of more than 10 centimetres can be expected by 2030 (Clarke & Simpson 2010). Recent studies into the effects of climate change on shorebird habitat suggest that in the 21st century, sea-level rise will lead to the loss of a quarter of the habitat area used by waders, but will cause the overall population to decline by about two-thirds across 10 taxa because of the way the migration networks are structured (R. Fuller, unpublished data).

In Gulf St Vincent, this will cause beaches to recede by between 5 and 30 metres by 2050 (variation is determined by beach topography, supply of sand and movement of littoral sediment). Supratidal communities will be displaced by intertidal communities, and those that fail to migrate upslope will be lost (Caton et al 2009). The extent of potential loss of shorebird habitat and potential measure to mitigate against such losses are investigated in Coleman and Cook 2009, Clarke and Simpson 2010 and Purnell et al 2012. An increase in water temperature and the regularity of storm surges and turbidity resultant effects on sediment deposition and benthic communities are also likely to negatively impact the abundance and distribution of shorebird foraging habitat.

Dune systems and intertidal habitat in the low lying northern beaches were significantly modified by storm surges in the 2016-17 season. Several creek mouths were gouged, accumulations of wrack formerly on the tidal flat were deposited in intertidal claypans and a large supratidal claypan in Thompson Beach was connected to tidal inundation when the dune was breached.

Understanding the necessity of maintaining supratidal roost sites in the context of climate change induced sea-level rise, the conservation and maintenance of sabkha and claypan habitats should be prioritised, allowing for coastal retreat[10].

(iv) Freshwater habitats

As mentioned (Section 1.02 ((m)) the Greenfields wetlands complex provide unique and favourable conditions for a number of freshwater marsh species. As it stands, plans for the Northern Connector will directly impact on the adjacent Barker Inlet Wetlands and may have implications for White's Rd wetlands. This may increase reliance on the Magazine Rd Wetlands for shorebirds and waterbirds.

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[10] BirdLife in association with NR AMLR and DEWNR are seeking to trial floating roost sites at a number of locations in GSV in 2018/19 (Purnell in prep). If successful, the application of floating roost sites will increase resilience of coastal habitats to sea-level rise by creating low impact artificial roosts which are immune to the effects of tide and sea-level rise. The application of these roosts will be particularly pertinent to areas (including the Yellow Sea) which have undergone significant reductions in available roosting areas through by damning, dredging and large-scale land reclamation.

Given the site's reliance on stormwater flows and available surface water runoff to provide adequate shorebird habitat, successive dry summers have precluded many species of shorebirds from using the ponds for months at a time during the October to March periods. When wet, the shallow ephemeral sections of the wetlands in the North West of Magazine Rd Wetlands are used by the highest densities and diversity of shorebirds however the same feature means they have a very low capacity to retain water (Figure 28). Providing an emergency allocation of water over a prolonged period (rather than a single large allocation) to these sites in October and again in January would ensure sufficient habitat in dry years. Such staged draw-downs are utilised at several non-tidal conservation ponds around Australia (Rogers et al 2014) to extend the period in which shorebirds can forage and reduce the likelihood that pond floors are colonised by vegetation (Purnell 2015).

Figure 28. Satellite imagery documenting the rapid drawdown of shallow ponds utilised by shorebirds at Magazine Rd Wetlands (top left). November 2014 (a), to January 2015 (b) and March 2015 (c).

The Washpool Lagoon, located south of the Aldinga Scrub Conservation Park at Aldinga Beach, is one of the last remaining coastal lagoons in metropolitan Adelaide. It is a seasonal coastal wetland lagoon that has been highly modified as a result of artificial changes to water levels and drainage patterns.

As with the wader ponds in Magazine Rd the shallow depth of the Washpool Lagoon means it has a low capacity to retain water but fills rapidly with direct rainfall. The Washpool Lagoon wetland would be enhanced by damping the current peaks in flow. Reducing the size and prolonging the duration of inflows would reduce the probability of dry periods in winter and spring and increase the probability of flooding persisting into November and December. Any changes in water regime must allow the system to dry out in summer and autumn to maintain the vegetation structure and salinity balance of the current ecosystem (Ecological Associates, 2003). A Silver Sands Catchment Stormwater Management Plan is being developed by the City of Onkaparinga. This will outline environmental flow proposals and costing for actions to manage water in the Washpool and Aldinga Scrub.

If revegetation is to occur, consideration should be made to allow for planting design that can optimise waterfowl and shorebird use especially maintaining open roost areas, maintaining distances of any overstory or tall shrub layers away from lagoon and lagoon edges and establishing conditions and undertaking treatments that will encouraging saltmarsh restoration which is a low lying habitat which can be utilised by shorebirds should be integrated into landscape design (Ecological Associates, 2003).

BIRDLIFE AUSTRALIA RECOMMENDATIONS

1. Continue BirdLife involvement in strategic discussions with the Major Projects Working Group, the Dry Creek Task Force, Buckland Dry Creek Pty Ltd and other potential stakeholders to ensure provisions for the shorebird population at Dry Creek.
2. Ensure new and revised management plans for protected areas incorporate measures to effectively maintain or improve shorebird habitat values.

3. Ensure offset habitats selected by the Northern Connector project are equal to or greater in ecosystem value to the areas being impacted by ensuring BirdLife, DEWNR and councils have adequate opportunity and time to comment on plans throughout the development process.

4. Continue DEWNR monitoring of transitioning Dry Creek Saltfields habitats including trial areas XB8A and PA9/10.

5. Work with Flinders Ports and The Department of Planning, Transport and Infrastructure to secure Section Banks (Bird Island) as a protected area within the *Adelaide International Bird Sanctuary* network.

6. Ensure that any changes to the Dry Creek holding pattern and any changes proposed for future use of all or part of the Dry Creek site undergoes appropriate impact assessments and is subject to an official EPBC referral.

7. Encourage Buckland Dry Creek Pty Ltd as custodians of the Dry Creek site to provide a mix of shorebird habitats site and optimise as much habitat as possible for shorebirds within the scope of the lands purpose (options further investigated in Purnell 2015). This may include a combination of the following:
   1) Reconnection of tidal prism to saltponds.
   2) Retaining a managed salt gradient in tidally independent salt ponds.
   3) Storm or waste water polishing and detention ponds

8. Investigate further options for decommissioned ponds in Sections 2, 3 & 4 Ponds of Dry Creek saltfields to be converted to freshwater wetlands (stormwater/wastewater treatment) or alternatively restore tidal influence.

9. Protect existing samphire retreat zones by using planning or other measures and provide additional, adequate areas for samphire retreat (Coleman & Cook 2009: Action 2.5, 2.7).

10. Complete any proposed infrastructure works in months April to September to reduce impacts on migratory shorebirds, breeding resident species and EPBC listed threatened species (Australasian Bittern)

11. Where development is approved in near-coastal areas and an allowance for floodwater to escape to the sea is required, allow additional width for the flood-escape routes, over that required to handle the 1:100 year ARI flood event, to provide area for shorebird habitat and a path for landward migration of saltmarsh (Coleman & Cook 2009: Action 2.7).

12. Work with councils and planners to ensure storm-water wetlands are managed in a manner sympathetic to shorebirds' needs, taking into account the necessity for open, unvegetated areas for feeding and roosting and a dynamic regime of inundation.

13. Encourage strategies that facilitate the cooperative, cross-jurisdictional planning which is required to limit the likely cumulative impacts of increasing urban growth in the region through the newly established *Shorebird Alliance*.

14. Incorporate shorebird spatial layers and attributes into existing planning layers, such as environmental significance overlays, so that shorebirds can easily be incorporated into the planning process.

15. Ensure that a rigorous EPBC assessment is conducted for any planned activity or development that is likely to impact within 200 metres of important shorebird areas (including secondary impacts).

16. Investigate options for the feasibility of shorebird- and waterbird-based eco-tourism to increase the economic and community value of conservation actions. Develop national and international partnerships with established initiative locally and internationally (case studies detailed in Purnell et al 2013 and 2015).

17. Trial floating roost sites at a number of tidally variable sites throughout the Gulf in 2018-19.

(b) Disturbance

The largest ongoing threat to the survival of migratory shorebirds in Gulf St Vincent is disturbance.
As Adelaide grows, increasing numbers of people are likely to visit the coastal and wetland habitats used by shorebirds particularly during the summer months. This threat is likely to escalate if thoughtful, adaptive management of recreation is not applied.

Table 12. Shorebird count area threat scores; Disturbance.

Count area	liklehood	scope	severity	Total	source of habitat impact
Whicker Rd Wetlands	2	1	2	**5**	recreational use, dogs
Barker Inlet Wetlands	3	2	3	**8**	construction activities
Magazine Rd	2	1	1	**4**	recreational use, dogs
Bolivaar	0	0	0	**0**	NA
White's Rd Wetlands	2	2	1	**5**	recreational use, dogs
Saint Kilda	3	2	3	**8**	recreational use, dogs
Section Banks	2	1	0	**3**	recreational use, dogs
Dry Creek Saltfields	1	1	1	**3**	potential for future visitor access
Port Gawler	3	3	3	**9**	recreational use, ORV, bait collecting, dogs,
Middle Beach	3	2	1	**6**	recreational use, ORV, bait collecting, dogs,
Light Beach	1	1	1	**3**	unauthorised access by ORV, rec fisherman
Port Prime	3	2	2	**7**	recreational use, ORV, bait collecting, fishing, dogs.
Thompson Beach S	3	3	3	**9**	recreational use, ORV, bait collecting, fishing, dogs.
Thompson Beach N	3	3	3	**9**	recreational use, ORV, bait collecting, fishing, dogs.
Webb Beach	3	2	2	**7**	recreational use, ORV, bait collecting, fishing, dogs.
Port Parham	3	2	2	**7**	recreational use, ORV, bait collecting, fishing, dogs.
Bald Hill	1	1	1	**3**	recreational use, ORV, bait collecting, fishing, dogs.
Port Arthur	1	1	1	**3**	recreational use, bait collecting, fishing, dogs.
Clinton CP	0	0	0	**0**	NA
Port Clinton	2	2	1	**5**	recreational use, dogs
Price Saltfields	0	0	0	**0**	NA
Price coast (Mac's Beach)	1	1	1	**3**	recreational use, bait collecting, fishing, dogs.

Figure 29. Red-necked Stint (left) roost and Banded Stilt feed on the intertidal mudflats of Thompson Beach South as Crabbers patrol the edge of the tide. Photo: Chris Purnell

Studies have shown that human disturbance of roosting shorebirds is related to declines on local populations (Pfister et al. 1992; Tubbs et al. 1992; Burger et al. 2004), lowered body condition (Durell et al. 2005), regional habitat shifts (Burton et al. 1996) and local avoidance behaviour (Kirby et al. 1993). Species with high roost-site fidelity and minimal movement between roosts are most at risk from human disturbance and require particular attention (Rehfisch et al. 1996).

Occasional disturbance to shorebirds — such as those caused by the appearance of a raptor — are common, but generally there tends to be a balance between the energy lost during these natural periodic disturbances and the ability to offset those losses by foraging for longer or on supplemental prey. Globally, an increasing number of areas, however, human disturbance appears to be too great to be offset by supplemental feeding (West *et al*. 2002, Blumstein 2006, Glover et al 2011). Modelling suggests that some patterns of disturbance can result in net energetic losses in habitats that remain occupied, and in some cases these energetic losses are greater than would have occurred if the habitat had been lost entirely (West *et al*. 2002; Rogers *et al*. 2006; Gill 2007). These energetic losses can potentially affect species at the population level, and the relationship between disturbance and population declines in non-breeding areas have been shown overseas in populations of the Pink-footed Goose (Tombre *et al*. 2005; Gill 2007). The level of knowledge required to determine conclusively to what degree disturbance may impact on shorebird populations is far from being met.

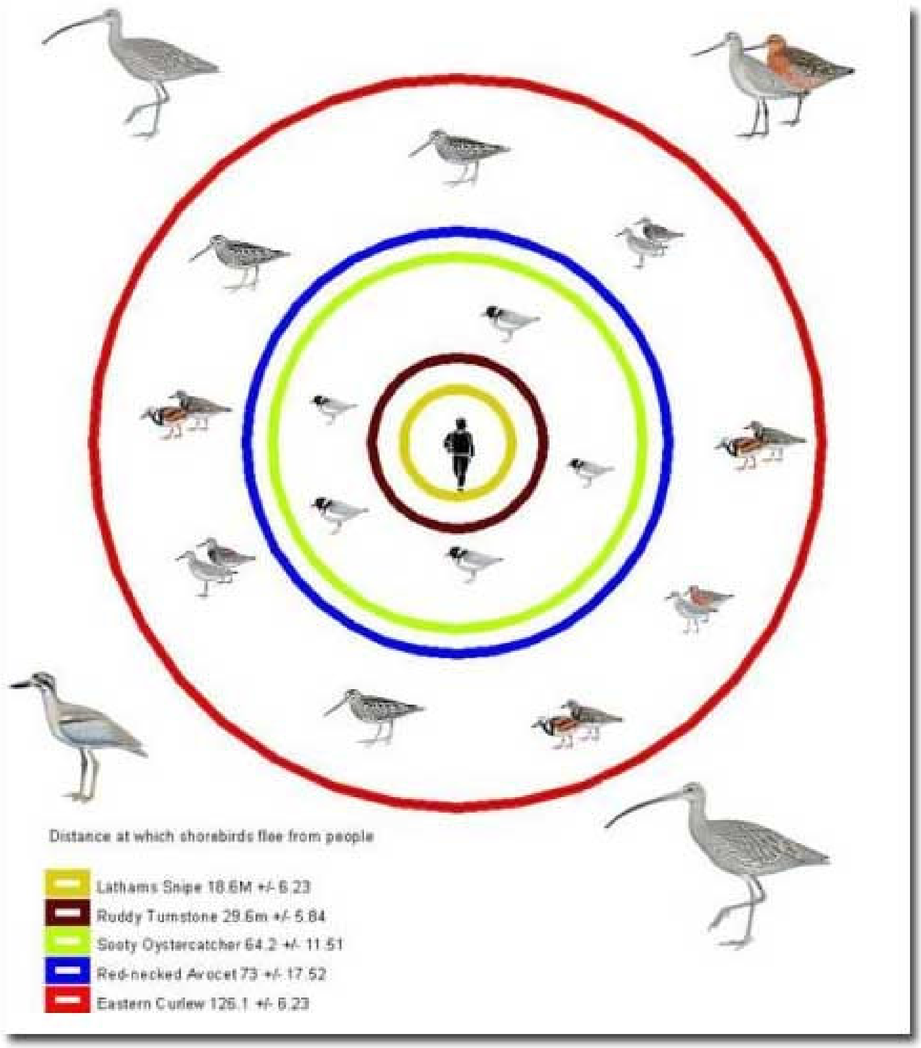


Figure 30. Each species of shorebird has its own tolerance to disturbance to human approaches. Distances given are from preliminary data, but further study may reveal larger buffers are required. (Illustration Jeff Davies).

A major complication in determining the impact of disturbance is the difficulty in determining the energetic cost of the wide variety of disturbances that may occur. Much work has been done to determine the distance at which different bird species flush when confronted with different kinds of disturbance, and results vary from 50 metres to 250 metres, with Eastern Curlews more likely to fly off at greater distances (Figure 30); most birds respond at greater distances to unleashed dogs or noisy and fast watercraft (Paton *et al*. 2000; Blumstein 2003; Yasué 2005; Gill 2007; Glover 2009). Unfortunately, this intuitive measure of disturbance probably underestimates the true energetic impacts of disturbance. Global reviews of research, including in Australia, of recreation and ecotourism impacts on birds conclude that non-motorised recreation activities have a range of negative effects on birds, (Steven et al 2011).

The shorebird habitat in and around much-visited Samphire Coast has been identified as the habitat most effected by disturbance. The frequency of disturbance necessary to cause shorebirds to abandon an area is unclear. It is clear, however, that disturbance has energetic costs that could potentially reduce a shorebird's chances of survival or its ability to reproduce. Pine Point, on the western shore of Gulf St Vincent, provides a good example. At this site, boats are continually launched by being towed by a tractor across shorebird feeding areas on the rocky reef and mudflat. The remaining edges of the tide line are patrolled by people catching crabs, many of whom are accompanied by dogs which constantly disturb feeding birds. It is difficult to gauge the effect of increased human activity on shorebirds over time without historic counts for these areas, but a comparison with similar undisturbed rocky reef or mudflat habitats at Black Point, 5 kilometres further south, shows a drastic difference. Although it receives limited disturbance, the small reef at Black Point boast one of the highest shorebird diversities in the Gulf, despite its remoteness in relation to other feeding and roosting areas.

(i) Non-vehicular recreational activities

The most readily identified cause of disturbance to feeding and/or roosting shorebirds in Gulf St Vincent arises from non-vehicular recreational activities. These activities can be static (e.g. fishing, sunbaking, picnicking) or mobile (e.g. walking, jogging, crabbing, walking dogs).

Static activities may not initiate flight but can cause habitat avoidance and increased surveillance behaviour among feeding and roosting shorebirds. Alternatively, mobile activities are of lower temporal impact but have greater likelihood of initiating flight. Of these activities, dog walking, especially of unleashed dogs, causes the greatest levels of disturbance (see 'Dogs', below).

A steady increase in fishing, crabbing and collection of cockles is also contributing to high levels of disturbance as well as the destruction of habitat around Gulf St Vincent (Fitzpatrick & Bouchez 1998). The upper sections of the Gulf provide important breeding and nursery areas for a number of key marine species, including King George Whiting *Sillaginodes punctata* and Blue Swimmer Crab *Portunus pelagicus*, both of which are fished recreationally and commercially.

1) Crabbing

In South Australia, the majority of Blue Swimmer stocks inhabit the warmer shallow waters of Gulf St Vincent and Spencer Gulf in algal and seagrass bottoms, and on sandy and muddy substrata, from the intertidal zone to at least 50m depth. Blue Swimmer Crabs are typically targeted in the shallow waters of both gulfs (PIRSA 2015).

Crabbing season coincides with the arrival of thousands of migratory shorebirds in Gulf St Vincent. The Blue Swimmer Crab season begins in September and runs through summer as the crabs congregate in inshore areas to breed, peaking in February; they then disperse back into deeper water by April.

One popular crabbing technique, raking (known locally as "dabbing"), involves patrolling the tide line of shallow sandy beaches or mudflats. This overlap with shorebird habitat causes continual interaction and disturbance of feeding and roosting shorebirds. The alarming increase in the amount of crabbers visiting priority shorebird areas such as Thompsons Beach, in the last 5 years, has the added side effect of attracting an increase in dog and vehicle based disturbance and habitat destruction.

The 2007-08 *South Australian Recreational Fishing Survey* estimated the recreational catch of Blue Swimmer Crabs at more than 283t per year, which accounted for approximately 29% of the total State-wide harvest (Jones 2009). Based on the results of the 2011-12 Blue Crab Fishery stock assessment report, which indicated sustainability concerns in Gulf St Vincent (Dixon et al. 2013), the Total Allowable Commercial Catch (TACC) in Gulf St Vincent was subsequently reduced by 20% to 196.1 t for 2013-14. By 2015 PIRSA reported a significant increase (31%) in statewide Swimmer Crabs. Increases are also supported by recreational fisheries surveys (Beckmann & Hooper 2017) with the acknowledgement that there is uncertainty in the survey effort across periods and there is limited understanding of the impacts ecosystem change has on crab stocks, predator prey relationships and trophic level change.

Recreational fishers are subject to some restrictions including minimum legal size, bag limit and protection of females with eggs, however closed seasons do not apply to recreational fishers despite accounting for nearly one third of the total harvest.

Table 13. Summary of current management arrangements for the South Australian Recreational Blue Crab Fishery (adapted from PIRSA 2015).

Management arrangements	Details
Recreational gear	> Hoop and Drop net > Hand net > Hand spear > Crab rake
Recreational gear restrictions	Number of drop nets or hoop nets
Minimum legal size limit	11 cm carapace width
Recreational bag and boat limits	20 per day 60 per day
Protected species	No retention of females with external eggs
Spatial closures	No
Temporal closures	No
Possession limit	No

Crabbing has been a culturally important pastime for communities in the region for over half a century, however several factors have facilitated a recent, rapid and unsustainable increase in novice crabbers visiting the area. Dabbing requires very little skill, no prior knowledge or accreditation, involves the use of cheap and accessible tools and can be commonly undertaken at a number of readily accessible sites along the coast. For these reasons the pass-time has become very popular among certain communities who share tips and promote sites on social media. In many cases new recreational crabbers are not aware of responsible use of beaches or the standing restrictions listed in (Table 13) and regularly contravene size and bag limits[11] (Falkenberg, Buckley, Barnes pers comms).

Time lapse footage taken by one crabber at Thompson Beach in October 2014 documents beach use in a 20m stretch adjacent to the southern boat ramp over an approximately 3 hour period (Table 14). Although October is not peak crabbing period, the footage documents significant foot traffic on the beach and tidal flat

[11] Bag limits have halved from 40 per day in the 2014-15 season to 20 per day in 2017 and are listed on PIRSA recreational fishing website and in targeted brochures, however capacity for enforcing limits is low and bag limits are regularly exceeded by up to 500%.

(Figure 31). At least 161 people were observed accessing the tidal flats in the 3 hours period after high tide. 152 of these individuals were observed in just a 1.5 hour window.

Table 14. Activity summary of potential disturbance cues for shorebirds observed on time lapse footage access through https://www.youtube.com/watch?v=meGAOa6Pmjk

activity / area	stationary	walker/ crabber	dog	vehicle
beach	4	2	2	17
tidal flat	0	161	4	0
Total	**4**	**163**	**6**	**17**

Figure 31. Crabbers depart cars parked on the foreshore adjacent to the Thompsons Beach southern carpark (top). A crabber (left) returns to 2 unleashed dogs. A family waits under an umbrella for crabbers to return.

This volume of crabbers may remain dispersed along the tide line for up to 6 hours[12] around low tide. During the peak crabbing periods December - February a constant stream of crabbers can be observed coming and going from the tide line along the entire 6.5 km extent of Thompsons Beach. As competition between crabbers for crabs and carparks has increased at Thompson Beach so does the extent of beach and tidal flat they exploit. Given the temporal and spatial extent of the disturbance in these habitats this behaviour is likely

[12] Some crabbers remain on the tide line for long periods, filling large eskies or periodically sending buckets of crabs back to vehicles. However, many novice, recreational crabbers spend around 1-2 hours at a time, as one party leaves they are often replaced.

to have effects on the population level if not addressed.

2) Collection of Cockles and bait digging

Several bivalve species common to the intertidal zone of southern Australia can be found in Gulf St Vincent. Duck Clam *Mactra* sp., Tellin shells *Tellina sp*, *Paphies cuneate* or Mud Cockle *Katelysia sp* are patchily distributed throughout intertidal shorebird habitat in the region (Dittman 2012). Several of these species are collected at low tide for use as bait or food. Unlike crabbing, cockle collection can occur across the extent of an exposed tidal flat increasing potential interactions with shorebirds.

Bait digging also occurs throughout intertidal habitats in Gulf St Vincent and is one of the major recreational uses of Mutton Cove (Cook & Coleman 2003). Target species are mainly polychaete worms. There are two commonly utilised collection methods. The first, is to dig large holes with a shovel picking the worms up with your hands or sieving them out using a colander. This method leaves large piles of mud and holes behind the digger.

The other method of extracting worms is to walk along the surface looking for holes. A device very like a bicycle pump is then placed over the hole, and the worm sucked out using an upward motion. This gives the diggers a considerably lower yield of worms per man-hour but leaves a less visible scar on environment (Cook & Coleman 2003).

Shorebirds and their habits may be affected by this activity in a number of ways:

- Disturbance of feeding or roosting birds
- Direct competition for resources
- damage to intertidal aquatic macrophyte beds Benthic community
- increased rates of erosion from the disturbed areas

(ii) Boating

Boating traffic is a major source of disturbance to shorebirds, and it has been linked to long-term abandonment of roosts (Burton *et al*. 1996). Red Knots, which occur in great abundance in Gulf St Vincent, have been recorded avoiding roosts in areas where high boating activity occurs within 1 kilometre (Peters & Otis 2007). Apart from feeding and roosting sites situated on sandbars adjacent to boating channels (Section Bank/Bird Island, Middle Beach and Port Wakefield), most shorebird areas in the Gulf do not currently receive high levels of boating traffic, but if the level was to increase it would reduce the number of coastal sites available for roosting by some species.

(iii) Off-road vehicles

Off-road vehicle (ORV) use in the Samphire Coast occurs throughout saltmarsh, claypan and intertidal habitats. In addition to recreational driving of four-wheeled drives and motorbikes, ORV use is often associated with fishing/crabbing and illegal dumping activities as continuous stretches of sandy coastline allow access to remote areas and fishing sites (Figure 32). This disturbs roosting and feeding shorebirds, and potentially causes resident shorebirds to abandon their nests (Figure 43). The disturbance caused by four-wheel drives and dirt-bikes in roosting and feeding areas can have the same effects on shorebirds as habit loss, if levels of disturbance reach the point where the energy costs of surveillance behaviour and disturbance flights outweigh the energy gained from the habitat (West *et al*. 2002; Goss-Custard *et al*. 2006; Rogers *et al*. 2006; Peters & Otis 2007). If disturbance is sustained, shorebirds may abandon even the most productive of habitats, both within and across seasons (West *et al*. 2002; Goss-Custard *et al*. 2006). The use of off-road vehicles also has an impact on macrobenthic assemblages on sandy beaches (Schlacher *et al*. 2008).

Figure 32. Three primary activities linked to offroad vehicle use on shorebird habitat in Gulf St Vincent. a) recreational off-road driving (Pt Gawler), b) access to fishing (Bakers Creek), or c) crabbing sites (Port Prime), site-seeing (Pt Prime). Photos Chris Purnell.

A related issue is regular stranding of both conventional and 4 wheel drive vehicle. These can cause localised pollution and additional disturbance during retrieval. Venturing off track, challenging driving conditions and quickly changing tides catch many drivers unawares.

Figure 33. Abandoned ORV at Port Prime, Photos Tony Flaherty

The closure of the Port Gawler Off-road Vehicle Park in late 2006 resulted in an increase in the number of off-road vehicles using shorebird habitat. In particular, dirt-bike riders regularly gain access to protected areas by flattening fences (Figure 35). These activities not only destroy habitat but also have create disturbance at inland roosts. Recently, the Off-road Park was reopened, attracting considerable attention from the dirt-bike and four-wheel drive community: a Facebook page run by the managers has attracted over 1,300 members. However, with a $40 entry price, limited opening hours (Saturday and Sunday), and no four-wheel drive facilities, there is still a large number of drivers using adjacent shorebird habitat in saltmarsh, most notably the Port Gawler intertidal foreshore. Off-road-vehicle drivers cause repeated disturbances, impacting on habitat quality and potentially causing accidental mortality to the two species of beach-nesting shorebirds that use the site. Research into the use of four-wheel drives in shorebird areas shows that only a small proportion (15 per cent) of off-road drivers heed signs asking them to avoid these sensitive areas (McGrath 2006). This problem has escalated due to the increasing affordability and accessibility of off-road vehicles. It should be noted that the increasing use of off road vehicles and related environmental impacts was raised in a 1977 Australian Government House of Representatives inquiry, yet little has progressed nationally to better manage these impacts (Australian Government 1977).

Figure 34. Damage caused by ORV to the intertidal flat at Pt Gawler. Photos Chris Purnell.

In March 2009, the South Australian LGA Executive Committee passed a motion requesting the LGA Secretariat organise a strategic workshop of key stakeholders on off road vehicle use. As a result of this motion, the LGA hosted a state-wide forum in July 2009. The key theme for this forum was to examine the differing roles and involvement of respective organisations in assisting Councils in the management of vehicles on land under the care and control of Local Government (Sargent et al 2012).

A Local Government Land Access working group was established after the forum to address ORV access. The group consisted of Council representatives, South Australia Police, Department of Environment and Natural Resources, Natural Resources Management Boards, user groups and the Local Government Mutual Liability Scheme. A discussion paper was drafted in early 2012 to consider land access management and the legislative framework governing vehicles on public land. While the paper identified issues arising from off-road access, it also identified issues relating to overlapping jurisdictions making it difficult to establish any single solution that Local Government could adopt (Sargent et al 2012).

The paper noted that access of 'off road vehicle use' might be managed in 3 key ways:

- Prohibition of all vehicle access;
- Uncontrolled vehicle access; and
- Controlled vehicle access.

Suggested enforcement options include:
Establishment of Codes of Practice through community and representative user organisations;
Enactment of Council By-laws to enforce breaches of the Code of Practice (including appointment of authorised officers which might also include persons from representative jurisdictions); and
Enactment of State Government legislation to prohibit and/or control identified activities on Council land.

Following workshops on off-road vehicles at the 2010 National Coast to Coast Conference in Adelaide, the AMLR NRM Board’s Coast, Estuary and Marine Advisory Committee endorsed support for a workshop or forum to address collaborative national approaches to coastal vehicle management issues with the aim to allow discussion and networking to progress a coordinated national approach to the issue. A discussion paper and workshop was held at Coast to Coast 2012 Conference.

The AMLRNRM Board’s (now defunct) Coast, Estuary and Marine Advisory Committee should be commended for championing national investigations into collaborative approaches to coastal vehicle management issues however need further support at the state level to effectively implement social change.

In many areas of conservation value in the study area, activities have been undertaken to restrict ORV access to defined routes/ exclude them from sensitive areas. These include fencing, bollards, signage and vegetation. To date these measures have had varying success, however it is anticipated that there will be an increase in visitation to shorebird areas by recreational ORV users as the necessity to travel further in search of isolation increases.

ORV management on beaches are a complex, multi-jurisdictional problem. To address this, there are several examples of “Vehicle Action Groups” (or similar collaborative partnerships) that have been formed to work towards shared goals of ecological protection, human safety and increasing education of ORV users.

Figure 35. Dirt bike riders regularly damage fencing to access claypan areas, Pt Prime. Photo: Chris Purnell

(iv) Other sources of disturbance

Other recreational activities in the Gulf, such as land-yachting jet skis, flyboarding and para-surfing, can all discourage shorebird feeding and roosting. These activities have caused multiple disturbances at many sites, including Port Parham, Port Gawler, Light Beach and throughout the Samphire Coast, especially Thompson Beach and the saltpan at Third Creek.

The evidence of increased disturbance can be more tangibly measured in resident beach-nesting shorebirds than on migratory shorebirds. Preventable sources of breeding failure or mortality arise from people, vehicles or dogs on the beach; all of these can disturb birds to the point that they are unable to incubate eggs or brood their chicks to maintain a suitable temperature or to ensure they are fed. Populations of Hooded Plovers (listed as Vulnerable under the *National Parks and Wildlife Act* [1972]) breed on the beaches of the southern Fleurieu Peninsula, from Sellicks Beach to Port Willunga. They and the more widespread Red-capped Plover and Masked Lapwing are threatened by human-induced breeding failure or mortality, and other pressures such as predation by foxes (Dowling & Weston 1999; Weston 2000).

Some form of disturbance occurs in most shorebird areas, but their effects are not fully understood, as birds may be able to find refuge in nearby habitat. Observations suggest that disturbance often occurs in many areas throughout Gulf St Vincent, forcing shorebirds to continually move, thus compounding the effect of each disturbance. This is likely to increase as coastal development expands. It is, therefore, important to set buffers to disturbance around these important shorebird areas now, before more areas become adversely affected.

In 2009, the Australian Government's House Standing Committee on Climate Change, Water, Environment and the Arts presented its report into climate change and environmental impacts on coastal communities. Committee Recommendation 32 states that the Australian Government must work through the Natural Resource Management Ministerial Council and in consultation with Birds Australia (now BirdLife Australia) and other stakeholders to implement a National Shorebirds Protection Strategy. The strategy should focus on tightening restrictions on beach driving and access to bird breeding habitat, preserving habitat, identifying suitable buffer zones for migration of coastal bird habitat, managing pest animals and increased public education.

In July 2011, the Natural Resources Committee of the Parliament of South Australia undertook a fact-finding visit in the northern area of the Natural Resources, Adelaide and Mount Lofty Ranges Region. The Committee noted the significance of the remnant samphire habitats and the importance of the area for migratory shorebirds. They also noted the threats to migratory shorebirds and habitat from "*encroaching housing and industry, uncontrolled access by off-road vehicles, vandalism*" and sea level rise. Recognising the work already being undertaken by the NRM Board and local councils, the Committee recommended that the Gawler Conservation Park be expanded to include more of the samphire flats and that a campaign be developed to promote the importance of this critical coastal habitat (Parliament of South Australia 2011).

Actions to increase awareness were part of the Samphire Coast Icon Project, (however Australian Government funding for this project ceases in June 2017). Additionally, the Department of Environment, Water and Natural Resources, with financial support from non-government organisations, has acquired the southern portion of Buckland Park Lake, with the intention of incorporating this portion of land (along with the northern portion of the lake) into the Gawler River Conservation Park.

BIRDLIFE AUSTRALIA RECOMMENDATIONS

18. Seek to continue important integrated management works undertaken as part of the ***Samphire Coast Icon Project and the NRM Levy funded coastal programme.***

19. Investigate establishing a Northern Beaches *Habitat Protection Zone* between Light Beach and Parham under the Upper Gulf St Vincent Marine Park or AIBS.

20. Introduce and enforce restrictions on off-lead dogs in priority shorebird areas during migration/breeding season (September–March).

21. Work with PIRSA to better monitor the effects of crabbers and cockle collection on coastal ecology:

    - Assess beach use at Port Prime, Thompson Beach and Webb to deduce the interaction/disturbance rates caused by recreational crabbers.

    - Regularly Assess fishery stock of mud cockle and Blue Swimmer Crab in the Gulf St Vincent.

22. Investigate feasibility of spatial and temporal restrictions on recreational fishing in high priority shorebird areas during sensitive periods. This could include measures such as temporal/spatial bans on crabbing at high priority shorebird areas.

23. Enforce catch and size limits on recreational crabbing and cockle collecting.

24. Investigate legislative approaches (such as the Western Australian Control of Vehicles [Off Road Areas] Act and the Victorian Land Conservation [Vehicle Control] Act 1972) that can provide effective mechanisms for local government to manage off road vehicle issues Legislative approaches need to be combined with planning and community awareness support for local jurisdictions.

25. Set initial buffer distances for development around identified habitats at 250 metres to limit the impacts of disturbance and use active monitoring to explore how to adjust those buffers with the understanding that buffers less than 250 metres may be sufficient in some areas, or for some forms of potential disturbance.

26. Continue to address systemic compliance and disturbance issues surrounding use of off-road vehicles and shorebird disturbance through public engagement (signs, brochures, meetings, media) and encourage responsible off-road driving.

27. Investigate integrated social change initiatives targeting off-road vehicle users.

28. Provide community engagement and/or environmental mentors for off-road enthusiasts.

29. Work with off-road vehicle groups and stakeholders to provide safe, cost effective and easily accessible alternatives for off-road enthusiasts in areas not likely to impact upon conservation values.

(c) Domestic and introduced fauna

In natural ecosystems, there is a co-evolution between predator and prey species, with prey species evolving evasive or defensive behaviour in concert with evolving prey-capturing behaviour by predators. However, when exotic predators are introduced into an ecosystem, they often thrive in these environments, reaching high population densities. Because native species of prey have not evolved to cope with the strategies of these predators, their impacts can be severe (Maguire 2008).

Introduced animals pose a readily identifiable threat to shorebirds in Gulf St Vincent. Rats, dogs, foxes and cats have all been observed in shorebird habitat during the study period, and are likely to pose a threat to resident shorebirds in the Gulf. These exotic predators give rise to increased disturbance and surveillance behaviour among all shorebirds, and this is ultimately manifested in reduced feeding rates, increased energy expenditure and reduced breeding success.

Established in 1995 under The Dog and Cat Management Act 1995, the Dog and Cat Management Board (the Board) is the only statutory board of its kind in Australia and offers a unique perspective in reporting on the status of dog and cat management in South Australia.

The Board works closely with key partner organisations and State Government to improve dog and cat management in South Australia. Using its research and expertise the Board has ensured that South Australia's regulatory and legislative framework has been reviewed and amended to improve the management of dogs and cats in South Australia.

The Board's 2017-20 strategic objectives are:
•Improved dog management through responsible dog ownership and community collaboration.
•Improved cat management through responsible cat ownership and community collaboration.
•Connecting Councils, community, professionals and agencies interested in and responsible for dog and cat management.
•Leadership in dog and cat management and effective administration of the Dog and Cat Management Act 1995.

The strategic plan does not directly address wildlife impacts or disturbance.

(i) Foxes

There is considerable variation in the impact of foxes on shorebirds. It is thought that even though urban development can encourage population densities of foxes that are three or more times greater than in rural areas (Coman *et al*. 1991; Marks & Short 1996), it is in relatively pristine areas that foxes become the dominant local threat to shorebirds, particularly beach-nesting birds. On the Victorian coast, for example, rates of nest failure of Hooded Plovers of 17–27 per cent were attributed to predation by foxes (Weston 2003; G. Maguire, unpublished data). Elsewhere, in Western Australia, the contents of one fox's stomach contained the remains of 38 Red-capped Plovers (Geering *et al*. 2007).

Mapping of active fox dens adjacent to high-value shorebird habitats between Port Gawler to Port Parham was undertaken in 2010–11 through the Adelaide and Mount Lofty Ranges Natural Resources Management Board and identified six fox dens (Greening Australia 2011). Ongoing control is planned throughout the region.

Eradication across large urban and agricultural landscapes can be a difficult ongoing process, as new individuals regularly move into newly vacated territories. Additionally, the risk to domestic dogs and perceived risk of litigation that may occur if poisoning occurs, can dissuade agencies and land managers from control. However, quick gains can be made in isolated areas such as islands. Section Bank/Bird Island has been identified as a significant area for several shorebird species and also supports regular breeding populations of four resident shorebirds as well as several species of waterbirds and terns. Given the reduced opportunities for colonisation by terrestrial predators — mainly through low-tide land bridges — Section Bank/Bird Island could easily be secured as a fox-free refuge for these ground-nesting species with minimal management input.

A memorandum of Understanding has been undertaken with the ministers for Environment and Transport and the Port Authority to better enable conservation management, including pest management control on the island.

Figure 36. A fox at Barker Inlet Wetlands. Photo Chris Purnell.

(ii) Dogs

Domestic dogs are not only the greatest source of disturbance to shorebirds (Figure 37) but they have also been recorded preying on both eggs and birds (Buick & Paton 1989). However, even when leashed, dogs are recognised as a greater cause of major disturbance to shorebirds than people. This is due to the unpredictable behaviour and non-linear paths that dogs walk, as well as their obvious similarities to traditional shorebird predators. In a study of the Western Snowy Plover in North America, people with dogs were found to cause flushing of birds 100 per cent of the time once they were within 50 metres, and 52 per cent of the time when they were within 100 metres (Page *et al*. 1977). NR AMLR and BirdLife Australia have been providing advice to councils on local dog by law reform as these regulations are reviewed, particularly with regards to beach-nesting bird conservation in the Fleurieu.

Figure 37. Unleashed dogs disturb feeding shorebirds and gulls at St Kilda. Photo: Peri Coleman

The linkage of roosting bird and nesting bird signage to provisions under local council by laws and National Park regulations should be explored. This may provide a more adaptive response to managing recreational disturbance than seasonally closed areas if important shorebird roost areas regularly change. In the beach-nesting bird conservation, a network of NR AMLR, council and volunteers regularly monitor sites for nesting activity. When present a response is determined with managers through beach response plans which outline land manager and volunteer roles and responsibilities, (usually this is local councils for Hooded Plover in the Fleurieu), this may include temporary fencing and signage requesting dogs to be leashed. The deployment of signs in some council areas is now linked directly to local council animal by-laws requiring dogs to be leashed in the signage area.

(iii) Rats

The impact of exotic rats on seabirds and other ground nesting birds and island biodiversity, has been widely documented (Jones et al 2008). Black Rats (*Rattus rattus*) are known to have caused extinctions on islands overseas and exotic rats have caused or contributed to the extinction of a number of Australian native bird species by preying on their eggs and young chicks. There is considerable concern over the impact of exotic rats on Australian native species through predation. They may also have an indirect impact on the abundance of other native predators, through competition (TSSC 2006).

Black Rats feed on refuse around seabird nesting colonies and may also prey on the eggs and chicks of ground nesting birds, and so are likely to be affecting the breeding of ground nesting birds on Bird Island. On Bird Island, rat populations undergo an annual flux related to the timing of bird breeding on the Island – with peak numbers following the principal bird breeding time during winter, and with a population crash in the summer months (Milne and Telfer, 2014).

In 2006, the Australian Government listed exotic rodents on islands as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and developed a threat abatement plan for rats and mice on islands less than 100 000 ha in area.

An analysis of penguin breeding success on Granite Island since 1990 (Colombelli-Négrel and Kleindorfer,2014), showed that rat predation particularly influenced the number of fledglings produced per pair, confirming the results found by Bool et al. (2007) that predation pressure mainly occurred on chicks but not on eggs. In addition, the recent study showed that predation rates at penguin burrows significantly decreased following extensive rat baiting.

Rat control is being undertaken by NR AMLR on Granite Island off the Fleurieu Peninsula and more recently Bird Island off of Outer Harbor. Current Bird Island rat control is being monitored, as well as Silver Gull numbers, as one risk identified is that it may result in increased silver gull numbers which themselves have potential to predate other native seabird and shorebird eggs and chicks.

(iv) Marine pests

Introduced marine pests have the potential to seriously impact the region's native marine species, habitats, food chains and ecosystems. They can also pose a serious risk to human health and social and economic benefits provided by the marine environment including aquaculture, recreational, commercial fishing, and domestic and international shipping, and tourism. Marine pests plants and animals can be introduced through ballast water (e.g. toxic dinoflagellates and larvae), the hulls of ships (e.g. European fan worm), the and through the escape of aquaculture species (pacific oyster) or release of aquarium species (e.g. aquarium Caulerpa). The rate of invasion by marine pests in Australian waters is increasing, and the risks to Australia's unique marine ecosystems and multi-billion dollar marine industries from introduced marine pests are compounding (Flaherty & Sampson 2005). There are a range of international pest species not yet recorded in Australian waters which are of concern.

The two introduced macroalgal species *Caulerpa taxifolia* and *C. racemosa* var*. cylindracea,* have the potential to change the fundamental characteristics of subtidal soft-bottom habitats such as seagrass meadows and unvegetated soft sediments. Both species are established in the Port River-Barker Inlet system, however it is possible that due to environmental limitations, the threat of further spread may be minimal (Bryars 2013).

The European green crab*, Carcinus maenas*, has established persistent populations on eastern Gulf St Vincent. Monitoring along the Adelaide coastline since 2012 has found variation in numbers of the crabs with large increases and decreases (Dittman et al 2015,2017) across years and seasons. The studies have found more evidence that *C. maenas* prefers soft-shelled mussels as prey compared to harder shelled cockles, but there is also evidence that they feed on other native macroinvertebrates. Along northern Adelaide beaches the crab there is more evidence that the crab prefers mangrove habitats (Dittman 2015). This medium sized crab species may have ecological and economic impacts effects on habitats and fisheries communities, including causing decline of native species through predation, severe impacts on commercial shellfish production, and indirect effects on shorebird feeding rates as a result of high levels of predation on native fauna (Cmwth Aust 2015, NIMPIS 2002).

Another national marine pest species of concern, not yet found in South Australian Waters but which have spread form outbreaks in Tasmania to Victoria is the northern Pacific sea star (Asterias amurensis). This species has potential to impact on native shellfish populations, and in areas such as the Tasmania's Derwent River Estuary has become the dominant invertebrate predator. There is strong evidence that predation by the seastar is responsible for the decline and subsequent rarity of bivalve species that live just below or on the sediment surface in the Derwent Estuary (Johnson et al 2007, Ross 2001). Of concern would be the presence of both Shore Crab and the Pacific Sea Star, as both predators can have a major effect on the abundance of bivalves. The combined effect on bivalves of both predators may be significant because combined distribution is likely to cover a broader range of habitats (Ross et al 2004).

Additionally the New Zealand screw shell *Maoricolpus roseus* may also be a species of concern if established in state waters. The New Zealand screw shell has become established in extensive beds in northern Bass Strait and off the coasts of eastern Tasmania, Victoria and New South Wales. Its abundance in some areas has altered benthic habitats from fine sand or mud to one with a dense cover of live and dead shells NIMPIS (2002).

Some introduced marine pests pose a previously unperceived threat to the ecosystem nutrient cycling processes which breakdown excess nitrogenous nutrients (denitrification). Disruption of this process could result in algal blooms, eutrophication and other pollution problems. Pests may disrupt the denitrification process through predation or displacement of native species (Keogh 2006).

BIRDLIFE AUSTRALIA RECOMMENDATIONS

30. Seek to include specific objectives, strategies and actions in the Dog and Cat Management Board's Strategic Plan to address dog and cat owner education with regards to wildlife disturbance, including provision of resources for dog owners upon registration and at vet clinics regarding responsible use of beaches.

31. Utilise council by-laws to facilitate temporary instllation of signage for leashing dogs during key shorebird roosting periods (high tide, September – March) and beach-nesting bird nesting in areas of shorebird habitat adjacent to the Thompson Beach township.

32. Build upon an integrated, adaptive management fox control program throughout the Metropolitan, Wakefield, Adelaide Plains and Light Regional Councils.

33. Undertake regular fox den mapping in the Samphire Coast including major likely source populations on private or leased lands (agricultural properties, the Dry Creek saltfields, Buckland Park, SA Water properties, Globe Derby equine farcicalities.)

34. Build feral mammal control toolkits for landholders, detailing best practice measures to deter pest species.

35. Initiate regular fox control measures to secure Section Bank/Bird Island as a shorebird refuge. Prohibit dogs from Section Banks during the migration/breeding season (September–March). Explore possibilities of Canid Pest Ejectors (CPE) during these periods.

36. Remove refuse/vegetation (e.g. dense boxthorn) which is likely to provide fox harbour.

37. Provide training to residents and volunteers on how to monitor fox behaviour and contribute to control.

38. Introduce and enforce restrictions on off-lead dogs in priority shorebird areas during migration/breeding season (September–March).

39. Prohibit dogs from Section Banks / Bird Island

40. Continue to monitor rat numbers on Bird Island and undertake control when necessary.

(d) Invasive plants

Coastal sand dunes and surrounding habitat are under threat from environmental weeds. This threat is recognised by local councils and control measures are in place. Rice or Cord Grass *Spartina spps.*, Marram Grass *Ammophila arenaria*, Pyp Grass *Ehrharta villosa*, Sea Wheat Grass *Elymus farctus,* Sea Spurge *Euphorbia paralias*, African Boxthorn *Lycium ferrocissimum* (and Tree Mallow *Lavatera arborea* on the Fleurieu Islands) are hardy, opportunistic colonisers which threaten to choke shorebird and seabird habitats.

Spartina is a potential threat to the coastal wetlands of Gulf St Vincent. It is considered a threat to waders due to its impacts on mudflat habitats. A sterile variety of *Spartina* was planted at Port Gawler in the 1930s by the Waite Institute. It infested the edge of the mangroves, though it covered less than a hectare in 1997. The species appears to have been successfully eradicated at Port Gawler in 2006 through herbicide and manual removal (D. Fotheringham, pers. comm.)

Marram Grass was introduced from Europe in the 19th century to stabilise mobile sand dunes, and it has successfully colonised areas of open substrate throughout Gulf St Vincent, where it has displaced indigenous vegetation. Chosen for its strong vertical growth and capacity to hold a large volume of sand, Marram Grass has changed the morphology of foredune systems from low, terraced dunes to higher dunes with steeper sides. Lower-terraced dunes are preferred by resident shorebirds such as Hooded Plovers and Red-capped Plovers, as are sparse native grasses which provide incubating birds with uninterrupted surveillance (Park 1994). Marram Grass is most common on beaches south of Outer Harbour, where it dominates, and has probably contributed to the decline of shorebirds in that area. Ongoing vigilance and awareness on recognising this plant is necessary.

Sea Spurge, a native of the Mediterranean coasts, occurs on free-draining sandy beaches, around estuaries, on dunes and in other associated coastal habitats (Wilcock 1997). It is widespread throughout the Gulf, especially north of Middle Beach. Infestation by this plant may impact on beach-nesting birds such as terns, Hooded Plovers and Red-capped Plovers (Park 1994; Rudman 2003) and may result in steep dunes that are susceptible to wave erosion. Sea Spurge has received much attention on the southern beaches, and the Seacliff to Brighton Beach Sand Dune Restoration Project has targeted the aggressive spread of the weed with a routine of spraying and hand weeding.

African Boxthorn and Tree Mallow are woody weeds that occur on ridges and dunes. Although more confined to urban beaches, they threaten to proliferate along coasts throughout Gulf St Vincent and have already had an impact on areas surrounding Middle Beach, Thompson Beach, Dry Creek Saltfields and Buckland Park Lake (Jensen 2004; Carpenter 2008). Infestations of these plants have blanketed bare sites favoured by nesting terns on Section Bank/Bird Island. They have also caused significant problems in coastal habitats elsewhere, including the loss of valuable shorebird areas on Mud Islands in Victoria and West and Encounter Islands in South Australia (Veitch & Clout 2002; Carpenter 2008), and internationally, the displacement of nesting puffins in the Northern Hemisphere (McKie 2005). When mature, these plants also provide preferred nesting habitat for Silver Gulls *Chroicocephalus novaehollandiae* (Carpenter 2008) and cover for introduced predators such as foxes and feral cats. It is important to note however that these plants have in fact added structure to the otherwise low-lying vegetation which is now utilised by nesting Australian White Ibis *Threskiornis moluccus* and Eastern Great Egret *Ardea alba modesta*.

Significant pest plant control and restoration planning on 18 project sites has been undertaken as part of the Samphire Coast Icon Project, supported by the Australian Government in parallel with NRM Levy investment. In 2014-15 these works resulted in 108 hectares of weed control across eight sites, including significant African Boxthorn control and restoration planning in the Light River, and 19 hectares of revegetation across 11 sites. Approximately 11,000 seedlings were planted and 27 kilograms of seed used for direct seeding.

BIRDLIFE AUSTRALIA RECOMMENDATIONS

41. Continue to control and remove invasive Sea Spurge from affected areas, and search for and eradicate any Sea Spurge, Tree Mallow, Marram Grass or African Boxthorn that appears in new areas. These invasive species spread rapidly and are difficult to control once established.

(e) Encroachment into habitat by native vegetation

Some native plants also pose a threat to shorebird habitat in Gulf St Vincent, with incursion of intertidal vegetation communities occurring in many coastal areas. Mangrove and saltmarsh habitats are seral — that is, their boundaries do not stay the same over time, but change to reflect factors such as changes in sea level and supply of sediment. In some parts of the Gulf, areas vegetated with Grey Mangrove *Avicennia marina* are expanding at an unprecedented rate (Saintilan & Williams 1999; Harris 2011), and many young mangroves are sprouting among the saltmarsh plants (Figure 41). This is especially prevalent in Barker Inlet, where mangroves migrated at a rate of 5ha per year from 1979 ton 1993 (Harty 2004). In its current state, small patches of saltmarsh are confined to an area between the mangroves and the seawalls.

There are many possible explanations for this trend of mangrove expansion. It has been suggested that the increased annual rainfall in the area since 1945 may have diluted salt levels within saltmarsh soils to the extent that mangrove colonisation was enhanced (Saintilan & Williams 1999). Mangrove seedlings require the right environmental conditions to establish and thrive. Often seedlings establish where sediment levels have increased, often resulting from nearby land disturbances such as either works and or hydrological impediments (e.g. bridges, causeways, seawalls or breakwaters). Increased nutrient levels and sedimentation from agriculture and large-scale vegetation removal in catchements are also considered a possible cause of increased colonisation by mangroves (Hughes 2003; Straw & Saintilan 2006).

The expansion of mangroves can limit the availability of the open spaces that shorebirds use for roosting and feeding. Shorebirds prefer the security of open spaces with high visibility for the easy detection of approaching predators (Straw & Saintilan 2006). To illustrate shorebirds’ preference for open areas, in a survey of 63 intertidal mudflats in nine estuaries in New South Wales, 90 per cent of ground-roosting sites used by shorebirds were more than 10 metres from 2-metre-tall trees and shrubs, and 83 per cent were at least 30 metres from 5-metre-tall trees (Lawler 1996).

The expansion of the Grey Mangrove in south-eastern Australia and New Zealand is viewed by some as unnatural.

Table 15. Changes in intertidal communities in south-eastern Australia (adapted from Hart 2004).

Site	Time period	% change in mangrove	% change in saltmarsh
Brisbane Water, NSW	1954 - 1996	3.8	-78
Botany Bay, NSW	1956 – 1999	32.8	-78.7
Rhyll Inlet, VIC	1939 - 1999	55	-19
North Arm Creek, Barker Inlet SA	1979 - 1993	16	-62.3

Pressure is currently being exerted by residential, coastal development, planning and management authorities to remove and destroy mangroves, partly to protect and reinstate other impacted habitats such as saltmarsh and mudflats. Estuary management planning is a useful tool that can integrate and balance policy directions for mangroves and other estuarine habitats in a strategic manner. Options for management intervention, such as the controlled removal of mangrove seedlings and saplings from key shorebird feeding grounds, as well as the restoration and creation of mudflats and saltmarsh, are being undertaken to conserve shorebird habitat in Hong Kong (Straw & Saintilan 2006) and Auckland.

In the NSW Hunter Wetlands National Park, permits for mangrove removal for shorebird habitat at Ash Island have been issued. Removal of seedling can be difficult and keeping pace with mangrove seedling rates may require repeat treatment, depending on wind patterns and tides. To help protect the annual investment in removing mangrove seedlings, several Mangrove Propagule Exclusion Devises (MPEDs) have been installed at key locations. The purpose of the MPEDs is to restrict the flow of mangrove seeds without affecting fish passage.
In Auckland, Coastal Plan policy has been amended to enable people to control mangrove spread by allowing the hand removal of seedling (<60cm tall) outside of ecologically sensitive areas (Auckland Regional Council 2010). Studies in Taiwan of partial removal of mangroves to restore shorebird-roosting mudflats indicate that transformation of a vegetated area into an open mudflat appeared to benefit shorebirds by providing roosting habitat. The studies also indicated that controlling the spread of estuarine mangrove forests could increase biodiversity that could particularly benefit the migratory shorebird community.

Mangroves should not be considered as 'bad' in isolation, but viewed as part of the mosaic of tidal habitats that are important for estuary function and health. In some areas of Gulf St Vincent, such as Dry Creek Saltfields, natural die-off of mangroves is exceeding their expansion. However overall within the Gulf, there appears to be a net increase in the extent of mangroves. Areas of greatest concern regarding impacts on shorebird habitat are:

- Section Banks
- Pt Gawler intertidal

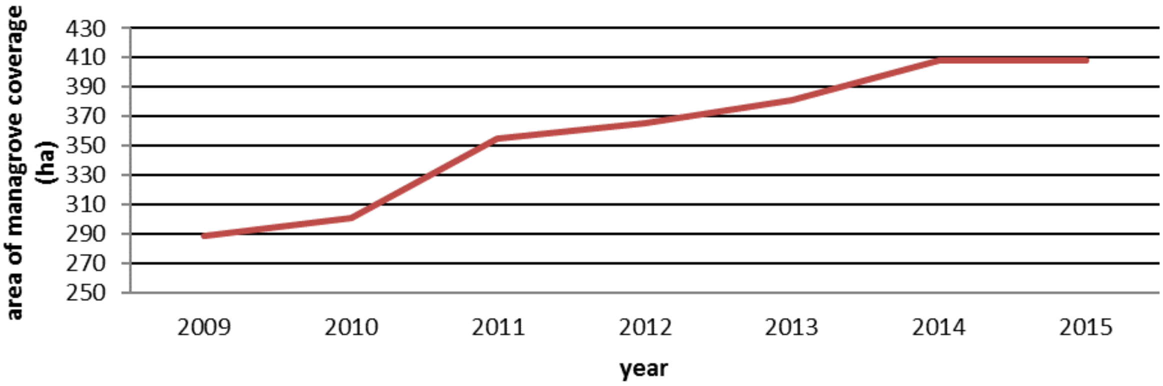


Figure 38. Change in mangrove extent measured from remote satellite imagery over a 5-year period at Port Gawler intertidal.

In 2010, AMLR NRM Board, in liaison with the Native Vegetation Council and PIRSA, removed planted mangroves in the Onkaparinga Estuary. With increased salinity in the estuary during drought conditions, it was considered that the spread of these plants threatened to change the character of the river and potentially cause a flood risk through constricting the river channel. Mangroves stands had not previously been recorded in the Estuary in recent history, and it is thought that the plantings were undertaken by canoeists who had transplanted seedlings from Barker Inlet.

Figure 39. A Grey Mangrove propagule ready to root on open sand on Section Banks. Photo: Chris Purnell

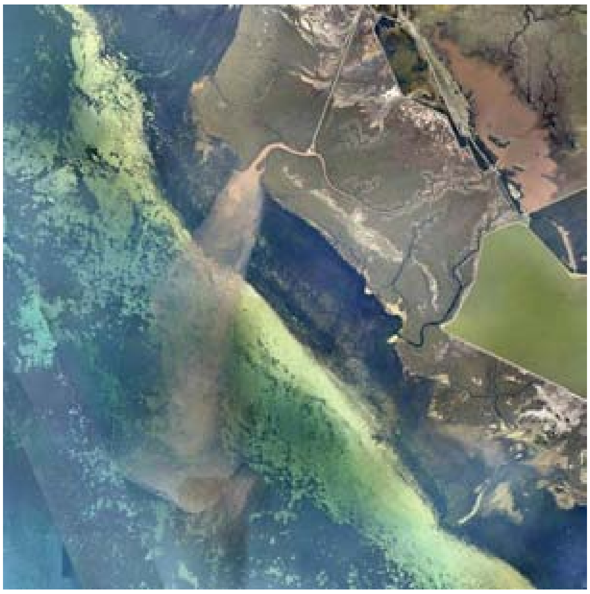


Figure 40. Sediment entering the gulf via Gawler River after extensive winter rain in August 2011. Nearmap.

The most effective long-term method of reducing mangrove spread is to minimise the amount of sediment entering the coast. This requires long term comprehensive measures, such as controls of earthworks and land disturbance activities and riparian restoration planting to reduce sediment entering waterways and the coast.

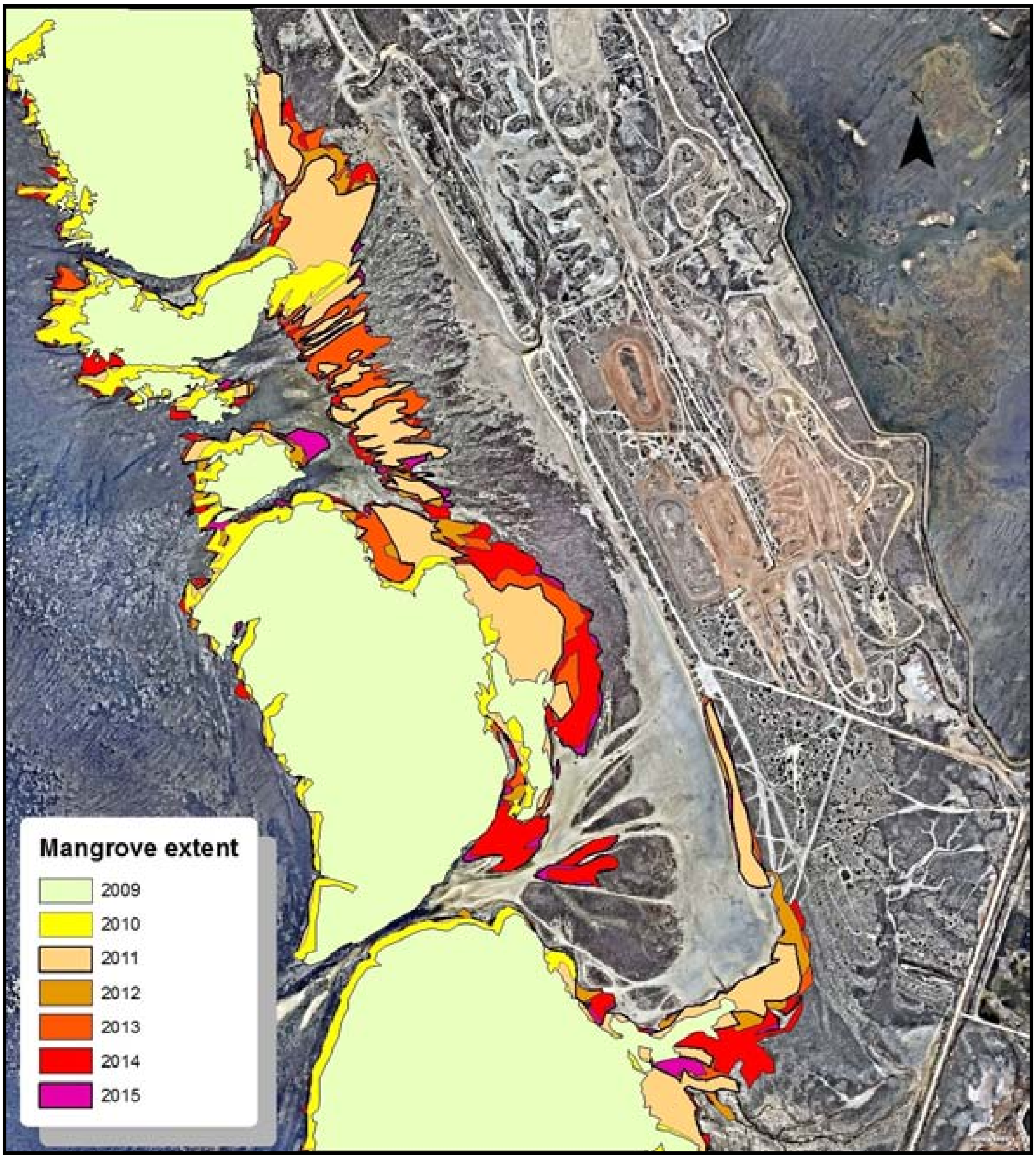


Figure 41. Satellite imagery reveals the extent of mangrove colonisation over a 5 year period in intertidal shorebird habitat at Port Gawler. (Image adapted from Nearmap imagery)

BIRDLIFE AUSTRALIA RECOMMENDATIONS

42. Investigate potential management options for Grey Mangroves to minimise encroachment onto significant shorebird habitat including: Section Banks, Port Gawler, Thompson Beach South.

- Section Banks (Bird Island)
- Port Gawler intertidal
- Low saltmarsh, tidal creeks and claypan adjacent to ponds in Dry Creek saltfields

43. Mitigate the colonisation of mangroves that may occur when reinstating tidal flows to salt ponds (including the Northern Connector offset) through methods such as seedling weir traps.

44. Seek to allow permitted exceptions to native vegetation legislation to allow for hand removal of mangrove seedlings by members of the community to manage available shorebird habitat.

45. Investigate causes of mangrove spread with assistance from EPA and local academic institutions.

(f) Potential impacts of native birds

Locally nesting shorebirds are also under threat from expanding populations of opportunistic native birds. An increase in food resources, such as coastal rubbish tips and urban rubbish bins, may sustain artificially high populations of Little Ravens *Corvus mellori* and Silver Gulls.

(i) Ravens

Ravens, which are also attracted by fruiting events of coastal shrubs, have been identified as the major predator of the eggs of beach-nesting birds and, to a lesser extent, their chicks (Weston & Morrow 2000; Maguire 2008). In New South Wales, Victoria and Tasmania, ravens have been identified as predators of Hooded Plover and oystercatcher chicks, accounting for up to 11 per cent of nest failures (Hanisch 1998; Weston 2000; Weston & Morrow 2000; Berry 2001; Keating & Jarman 2003; Maguire 2008).

(ii) Gulls

Populations of Silver Gulls have increased substantially throughout Australia (Blakers *et al*. 1984; Higgins & Davies 1996; BirdLife Australia Atlas of Australian Birds, unpubl. data), and this has been mirrored in the Gulf over the last 50 years, reflecting the increased availability of food at rubbish tips (Carpenter 2008). Generally, beach-nesting birds are effective at defending their eggs and chicks against Silver Gulls (Weston 2000). However, Silver Gulls are able to approach nests more closely when the attending adults are disturbed and have moved away from the nest. This may suggest that gull predation is more likely to be a factor in highly disturbed areas (Weston 2000; Maguire 2008). Silver Gulls are suspected to have some impact on nesting Red-capped Plovers, Fairy Terns and Crested Terns at several sites in Gulf St Vincent. This can manifest in

- direct predation of eggs or chick,
- disturbance of brooding parents and/or precocial young leading to a decreased likelihood of survival to fledging age or
- competition for nesting sites

The negative impact that Silver Gulls have on nesting shorebirds has, in the past, prompted active gull control in Gulf St Vincent (Baxter 2003). Changes to the management of Wingfield Rubbish Tip since 2005 have reduced the amount of food available to gulls, which has resulted in a reduction of their numbers and restricted their breeding opportunities, but, nevertheless, they still occur in enormous numbers around the Gulf, and the Integrated Waste Services northern landfill site at Dublin provides an attraction near key shorebird areas.

A breeding colony has successfully established in the Port Adelaide/Middle Beach area. In Section Banks 2013/14 the colony had two discrete breeding areas on Section Banks (c >6,000) at the eastern and western extremities of the sand bank. In the 2014/15 season this colony, perhaps displaced by continued works on Section Banks, colonised low saltmarsh covered islands in Section 4 of the Dry Creek Saltfields 2014/15 (c >8,000).

Population control of Silver Gulls has been successful in several parts of Australia however due to the adaptability and mobility of colonies requires a coordinated program consistent program. Given the Gulf St Vincent colonies often exist in habitats which also support non-pest species physical methods of exclusion including scaring, netting and habitat modification will not be appropriate as they are likely to preclude use by other non-target species. Species specific methods of population control include:

- Removal of eggs (every 2 weeks during breeding). This can be labour intensive given birds have several attempts in a season.
- human disturbance at established colonies (Smith and Carlile 1993)

- Egg-pricking or "oiling" (canola oil is 99 to 100% effective in preventing hatching (Martin et al 2006). This is preferable as it induces adults to sit on infertile eggs rather than attempting to lay another clutch (Blockpoel and Hamilton 1989).
- Selective professional culling of adults by shooting or application of Alpha-choralose to food likely to be scavenged by Gulls like bread.

BIRDLIFE AUSTRALIA RECOMMENDATIONS

46. Investigate methods to manage Silver Gull populations

47. Discourage feeding (intentional or incidental) of Silver Gulls by the public by providing interpretive signage encouraging responsible disposal of waste.

48. Work with councils to ensure sites of waste disposal and collection are appropriately covered.

(g) Human-induced mortality or breeding failure

The resident shorebirds that occur on several sandy beaches and claypans around Gulf St Vincent are under threat of accidental human-induced mortality or breeding failure. In these areas the threat is primarily due to shorebirds' well-camouflaged eggs or chicks that are accidentally stepped on or run over by vehicles. Eggs of Australian Pied and Sooty Oystercatchers and Red-capped Plovers are well camouflaged and are laid directly onto the sand, so they are especially susceptible to accidental crushing. Chicks are also easy to overlook and trample.

Figure 42. Red-capped Plovers forage, roost and nest on tracks in Dry Creek Saltfields. The eggs and chicks are vulnerable to being crushed by vehicles. Photo: Chris Purnell

Vehicles have also been identified as a risk for breeding Red-capped Plovers at the Dry Creek and Price Saltfields. Access tracks running between the evaporation ponds in the Dry Creek Saltfields are favoured by Red-capped Plovers as nesting sites, and during vehicle-based monitoring surveys throughout the study period, only vigilant driving prevented many chicks from being run over. Due to the narrow width of these roads, chicks have few escape routes, and some were seen trying to outrun cars. Cheetham Salt's staff have been trained to be aware of wildlife on the tracks and visiting birdwatchers have also been alerted to the threat, however it is unclear whether contractors currently accessing the site are aware of the issue. With an increase in contractors and stakeholders accessing the Dry Creek site during the planning and subsequent decommissioning period there is an equally increased potential for detrimental impacts on breeding shorebirds.

Fencing of priority conservation areas, such as the claypans from Light Beach to Port Parham has had varying success in precluding off-road vehicles.

Figure 43. A Red-capped Plover nest at Thompson Beach, less than 20cm from dirt bike tracks. Photo: Aleisa Lamanna.

BIRDLIFE AUSTRALIA RECOMMENDATIONS

49. Surveys of breeding shorebirds should be encouraged to identify and protect easily impacted breeding areas. BirdLife Australia's Beach-nesting Birds project are working closely with the NR AMLR to improve our knowledge of these populations and engage local communities on how to monitor and conserve them.

50. Include a shorebird awareness component in the Northern Connector and Dry Creek site induction process and ensure future purposes limit vehicle use in remaining roosting and breeding areas.

Figure 44. A Banded Stilt found under disused power lines adjacent to Pond XB3

Figure 45. A Sharp-tailed Sandpiper rendered flightless by a broken wing at Price Saltfields. Photo Chris Purnell

(h) Bird strikes and infrastructure collision risks

Birds are vulnerable to collisions with man-made fixed structures such as buildings transmission towers electricity lines and wind turbines (Erickson et al. 2001, Manville 2005, Rioux et al 2013). Vulnerability to collisions with transmission lines varies across bird groups Bevanger (1998) found that mortality by shorebirds (40%) was the most frequently reported in the US followed by waterfowl (24%). Shorebirds are particularly susceptible to collision with wires for a multitude of possibilities:

- Their tendency to move in flocks
- The altitude of non-migratory flight
- The otherwise low structural nature of shorebird habitat.
- Dawn/dusk and nocturnal movement of shorebirds in accordance to tide conditions

Electrical lines not only cause direct mortality of birds (Figure 44Figure 44) but they can also cripple individuals leaving them susceptible to predation or reducing their fitness to a point that they either starve or reduce their potential fecundity (Figure 45). For migratory species, the chances of recovery and successful migration are sign incredibly low once injured (Ericson et al 2003)

Landscape features will affect the flight path of birds, potentially funnelling them towards powerlines (Bevanger1990, Martin and Shaw 2010, Rioux 2013) which makes line orientation an important feature in planning (APLIC 2012).

In Gulf St Vincent the majority of likely line strike related fatalities and injuries are recorded at the Price saltfields (Pedlar and Treloar pers comms) and Dry Creek Saltfields. These strikes likely occur with lines which run parallel to the coast and therefore create obstacles to birds moving to and from the intertidal zone from the salinas. Banded and Black-winged Stilt make up the majority of the apparent strike fatalities and injuries however Red-necked Stint and Sharp-tailed Sandpiper have also been recorded.

Windfarm developments have previously been proposed in the area adjacent to wetlands. Such proposals should take into consideration the vicinity of nearby shorebird and waterbird roosts and populations to mitigate bird strike. Not only is there a risk to the birds, but collision with larger waterfowl such as swans and pelicans which use these areas could significantly damage infrastructure.

Figure 46. Dead Pelicans observed adjacent to the highway turnpike at the Barker Inlet Wetlands. Photo Chris Purnell

Birds may collide with moving vehicles or infrastructure as they fly over the roads or they may be struck by passing vehicles as they cross. This issue is of particular concern, as a wide range of bird species travel daily between the coastal habitats to the west, and the grassland, woodland and wetland habitats to the east. In particular, large bodied birds, such as Australian White Ibis and Australian Pelican (Figure 46), commonly fly at heights of 15-50 m.

The Northern Connector Project has also identified the construction of light poles associated with the road may increase the incidence of bird strike. It is possible some birds could also nest on the edges of the road/rail track, especially as it had good thermal properties and was sufficiently open. By observation, the most common road kill victims in freshwater wetlands in the region are usually introduced species and some aquatic species such as swamphens, coots and crakes (Cowley 2002). These birds mainly travel on foot so must dodge traffic as they run across the road when moving between wetlands birds are often killed as they cross the existing highway between Barker Inlet Wetlands North and South. The use of culverts and bridges in the wetland system to allow continued water flow may provide safe passage for species and reduce the risk of bird strike for some species. However, gates across culverts and weirs to control water levels would reduce their effectiveness as passageways. (Kellogg and Root 2011).

BIRDLIFE AUSTRALIA RECOMMENDATIONS

51. Remove redundant electrical lines, in coastal areas (particularly in Dry Creek and Price Saltfields)

52. Incorporate likely shorebird flight paths into planning for any new infrastructure to exceed 2m in high for coastal areas.

(i) Pollution

The main sources of pollution in Gulf St Vincent include sewage effluent discharge (organic matter, nutrients, pathogens), storm-water runoff (heavy metals, oils, litter), agricultural runoff (fertilisers, pesticides, suspended solids) and industrial waste (Edyvane 1999). Some contaminants, particularly heavy metals, can persist and become increasingly concentrated in higher trophic level organisms, including birds.

(i) Nutrient pollution

Sewage outfall into marine habitats has been linked to various effects on native flora and fauna. Of particular note, sediments near nutrient-rich sewage discharge points are believed to support high densities of invertebrates, and the species composition of these sites differs from those at sites further away (Poore & Kudenov 1978; Davies & Brown 1995; Rogers *et al*. 2007). As a consequence, this enhanced production may support large numbers of shorebirds and it has been noted that improvements in sewage treatment and disposal may lead to a decline in shorebird numbers (van Impe 1985; Raffaelli & Hawkins 1999).

Recent studies which took into account only shorebird prey have had varying results, with the number of certain species such as polychaetes (common prey of species such as godwits and knots) showing a clear gradient extending out from the sewage outfall, whereas other species show the reverse or no gradients at all (Rogers *et al*. 2007; Alves *et al*. 2011).

While moderate organic enrichment might be seen as having a beneficial effect on shorebird habitat, nutrient enrichment by sewage can also stimulate blooms of opportunistic benthic macroalgae, especially the green *Enteromorpha*, *Cladophora* and *Ulva* (Knox 1986; Rafaelli and Hawkins 1999; Mackenzie 2000). Nutrient enrichment or coastal eutrophication as elsewhere in Australia and the world, has been recognised as the highest priority marine issue in Gulf St Vincent, as it is elsewhere (DELM 1993; Edyvane 1999). The most obvious symptom of eutrophication is the loss and degradation of seagrass (Larkum *et al*. 1989). Such losses are evident at the site of the Bolivar Waste Water Treatment Plant Outlet, where 470 tonnes of nitrogen, 27 tonnes of ammonia and 190 tonnes of phosphorus where discharged into the Gulf in 2007 alone (EPA 2009). These levels represent reductions of 68, 72 and 9 per cent, respectively, in the levels of nitrogen, ammonia and phosphorus discharged since 1999, but still fall well short of the EPA's projected reductions to 318 tonnes by 2010 (EPA 2005).

By 2013, a substantial reduction in emissions from wastewater treatment plants (WWTP) has already been realised, but further reductions require considerable investments. Moreover, the population of Adelaide is expected to grow by up to 45-50% between 2006 and 2036, resulting in higher volumes of wastewater to treat and a larger drained urbanised area (Fernandes et al. 2017).

Nutrients and turbidity caused by the discharge from the Outlet has been linked to a die-off of seagrass communities (most notably *Amphibolis* and *Posidonia*) in a 19-kilometre stretch from St Kilda to Middle Beach (Kinhill *et al*. 1995; Edyvane 1999; Coleman & Cook 2000; Fox *et al*. 2007; P. Coleman, pers. comm.). However more recent mapping data (2013) suggest that further net losses of seagrass has been limited since 2007 and revealed the first signs of seagrass recovery at some sites (Fernandes et al. 2017)

The loss of seagrass equates to a loss of local biodiversity — a 40-fold difference exists between biodiversity in seagrass and bare-sand communities (Fox *et al*. 2007). The absence of seagrass meadows and an increase in nutrients has seen this area of intertidal mudflats now colonised by mats of Sea Lettuce *Ulva lactuca*. Sea Lettuce is well-known nitrogen scavenger, and if dense algal mats are able to become established they can have catastrophic effects on the underlying invertebrate assemblages through deoxygenation of sediment (Raffaelli & Hawkins 1999; Mackenzie 2000). Such a decline in benthic prey species would explain a surprising absence in shorebirds feeding in the intertidal zone between Middle Beach and St Kilda. The greatest rate of loss of seagrass occurred in the early 1970s, about eight years after the maximum rate of population growth in the metropolitan region was recorded (Kinhill *et al*. 1995).

Wastewater discharges from the now closed Penrice soda factory have been substantial, with historical annual nitrogen loads of up to a 1000 Tonnes. The cessation of this significant nitrogen source is likely to have positive benefits for adjacent marine environments in Barker Inlet and the northern coast.

Seagrass restoration trials off the metropolitan coast, being undertaken by SARDI with AMLR NRM Board support, now appear to be having some success, with seagrass regrowth infilling between some restoration plots. The overall reduction of nutrient inputs across the coast will hopefully improve the long-term potential for restoration (Tanner 2016)

Seagrass restoration is a long-term proposition. The work to date builds on collaborative approaches undertaken since 2002 across state agencies and NRM, with now limited resourcing. Continued investment in seagrass restoration methodologies would capitalise on progress made over the last few years.

A study into mudflat condition at four sites from Section Bank to Thompson Beach, funded by the Adelaide and Mount Lofty Ranges Natural Resources Management Board, found that although the intertidal zone in eastern parts of Gulf St Vincent has high species diversity, the overall biomass of invertebrate fauna is low. Contrary to assumptions based on the distribution of shorebird feeding sites, Thompson Beach was found to have markedly lower densities of invertebrates than Port Gawler[13] suggesting that the distribution of feeding and roosting sites for shorebirds may be driven more by abiotic features, such as habitat structure, than availability of prey (Dittman *et al*. 2012).

The EPA's Port Waterways Water Quality Improvement Plan addresses the problem of nutrient discharges into ADS waterways and The Adelaide Coastal Waters Study outlines recommendations to guide future management actions relating to water quality along Adelaide's metropolitan coast.

- Improvement of water quality – EPA
- Catchment management and protection of native vegetation – DWLBC (for NRM AMLR, and for Native Vegetation Council)
- Vessel management – DTEI
- Conservation of marine biodiversity – DEWNR
- Stormwater management – local councils, DWLBC (for Adelaide and Mount Lofty Ranges NRM Board)
- Management of pest marine species – PIRSA Fisheries

[13] The study also reported significant patchiness in distributions of benthic fauna. Given survey effort was limited to two sampling periods on-going monitoring may yield a more complete picture of benthic fauna distributions.

(ii) Agricultural, industrial and storm-water pollution

Run-off from the area's water catchments or storm-water outfalls that are contaminated with phosphorous, nitrogen or other nutrients or chemicals could have a great impact on shorebird feeding areas, and they have already been linked to a die-off in seagrass in the Gulf (Close 2008). In addition, in some areas, increased agricultural run-off with high nitrogen content has been shown to lead to an initial increase in the diversity of invertebrates in the mudflats used by foraging shorebirds, but excess nitrogen leads to eutrophic conditions, which kills the food species (van de Kam *et al*. 2004). Initial seagrass condition monitoring commissioned by the Adelaide and Mount Lofty Ranges NRM Board shows seagrass off the Light River delta to be in good condition, and they do not appear to be degraded due to discharges from the Light River (Tanner et al 2012).

The potential impacts of run-o off from the proposed intake of toxic chemicals and heavy metals at Dublin's Integrated Waste Services northern landfill has been a matter of contention between the local council, residents and Integrated Waste Services. The installation of a high-temperature waste-disposal system would drastically reduce any potential risk of waste held on site leaching into the Gulf and surrounding areas. Thermal pollution, industrial run-off, effluent disposal, ballast water, heavy metals and other toxicants have all been identified as factors that are likely to impact on the Port River–Barker Inlet area, including valuable feeding areas such as Section Bank/Bird Island (Bryars 2003, 2013).

(iii) Munitions

The coastline encompassed by the Port Wakefield Proof Range and Experimental Establishment is exposed to a different suite of potential threats due to its use as a munitions testing ground. Surveys conducted by Sinclair Knight Merz in 2007 uncovered many expended artillery shells on the tidal mudflats and many impact sites where the subsurface material had been exposed. The potential impact of this munitions testing on shorebirds remains unclear, with critical factors being firing regimes and the chemical composition of the munitions.

(iv) Oil Spill

The South Australian Marine Spill Contingency Action Plan has designated Gulf St Vincent as a high-risk area (EPA 2006), with the threat of pollution in the shorebird areas focused around Port Adelaide. With the closure of the Port Stanvac refinery, the number of large oil tankers entering the Gulf has declined. However, fuel is now transported to facilities in Port Adelaide and this has increased the risk in that area. In 2004–05, 103 vessels unloaded over 2 million tonnes of petroleum product at Port Adelaide (CPAE 2012, Flinders Ports 2013).

Whilst there is no active oil production being undertaken in the Gulf, the area has been explored for petroleum and a number of lease areas exist. Petroleum exploration works in the mid-1960s resulted in bare seismic shot-holes scars in seagrass meadows off the metropolitan coast at Grange. However, these scars are no longer visible due to the complete loss of seagrass where they occurred mostly between 1970 and 1977 (Fox 2006). In the 1990's exploration was marred by the collapse of the Mobile Offshore Drilling Unit, 'Maersk Victory' rig in Gulf St Vincent in 1996. Legs of the rig "punched through" a hard layer of sediment approximately 10 m below the seafloor leading to its collapse. The incident occurred before drilling activities had commenced. A Mines and Energy SA investigation*"found evidence that insufficient attention had been paid to evaluating the risks to the rig inherent in undertaking operations in an area where a jack-up rig had not previously been used" (MESA 1996). The footings of the rig were left on site of the main prawn fishing area called The Big Hole, hindering prawn trawling activities* (SECITARC 2000).

Boat traffic in the upper sections of the Gulf is relatively low, but if an oil spill occurred, the effects could be catastrophic, having long-lasting effects on shorebird populations. Further, industrial development or increased capacity for more boats would increase the threat of a spill in these areas (Clemens *et al*. 2007a).

The Inter-Governmental Agreement on the National Plan to Combat Pollution of the Sea by Oil and Other Noxious Substances (2002) includes the process for recovering clean-up costs from the polluter. The State Government is committed to ensuring that all costs from oil spills, including environmental rehabilitation and monitoring, are met by those responsible. The South Australian *Environment Protection (Sea Dumping) Act* was passed by Parliament in 1984 to mirror Commonwealth legislation but was never proclaimed. Therefore, the regulation of sea dumping in coastal waters currently rests with the Commonwealth. The Environment Protection Authority is currently reviewing the South Australian Act to align it — with subsequent modifications — to the Commonwealth's sea-dumping legislation. The State Government will negotiate with the Commonwealth to bring 'coastal waters' within the control of the South Australian Government by demonstrating compliance with the London Protocol (NCHD 2004).

(v) Rubbish

Accumulations of rubbish not only threaten to have detrimental effects on the food chain but also restrict available roosting and nesting areas and increase the likelihood of entanglement (McKinnon et al 2012). Leg entanglements are reasonably frequent among shorebirds, and can cause injury, death or simply impede movement leading to reduced foraging rate or diminished predator avoidance. Although entanglement occasionally occurs with nature objects including seaweed and human hair the most common sources reported are from fishing line plastic bags and other synthetic fibres (Weston et al 2009).

Marine Debris is a matter of environmental significance. 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris' was listed in August 2003 as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act, 1999).
The marine debris monitoring program of the Gulf St Vincent bioregion (Gulf St Vincent Marine Threat Abatement project) established by the AMLRNRM Board in 2010 (with Australian Government funding) aimed to address local impacts of marine debris across broad spatial coastal environments following the objectives of the national Marine Debris Threat Abatement Plan. Several Marine Debris surveys have been undertaken in Gulf St Vincent by the AMLRNRM Board. Around ninety per cent of litter comprised plastic, of which dominant sources consisted hard-polymer fragments, fishing and boating-related rope fragments, and consumer-based products predominantly plastic drink bottle caps, food wrappers and plastic bags.

The majority of debris found around urban sites is most likely terrestrial-based in its origin. This is supported by the higher occurrence and abundances of packaging associated with common use food items and general housing products observed on the beaches of eastern GSV, These beaches comprised 50% of all packaging and 40% of household products, with plastic food wrappers and fast- food plastic drinking straws most commonly encountered debris. The issue of consumer-driven litter confirmed in surveys, emphasises the shared responsibilities of local, regional and state agencies to implement better management for minimisation and reduction of litter. A T'angler Bin fishing line recycling programme has been initiated with a number of local councils to recreational reduce fishing line which poses an entanglement risk for shore and sea birds (Peters & Flaherty 2013)

BIRDLIFE AUSTRALIA RECOMMENDATIONS

53. Investigate measures to optimise use of wastewater and storm-water, with a particular emphasis on re-establishing seagrass beds in the literal zone adjacent to the Bolivar Waste Water Treatment Plant Outlet. Recommendations on rehabilitation of seagrass meadows are included in the Adelaide Coastal Waters Study (Fox et al. 2007) and are being undertaken by SARDI with AMLRNRMB support (Tanner 2016).

54. On-going mudflat condition monitoring and associated adaptive management.

55. Explore feasibility of "drip feeding" sewage outfall over several tidally reconnected salt ponds to reduce concentrations of nutrient at Bolivar outfall (see addendum to this report for more information.)

2 SHOREBIRD MAPPING

Section 2.01 Shorebird habitat and count area mapping

The 2016/17 amendments to shorebird mapping provide the most spatially specific account of habitat in Gulf St Vincent to date. A combination of high resolution satellite imagery provided by Nearmap and Esri, NRM Board funded LiDAR layers, habitat/vegetation layers (Coleman et al 2009, DEWNR 2013) and overlays of existing habitat mapping, supplemented 8 years of field studies. Shorebird habitats identified in the field were sufficiently recognisable from the satellite images and ground-truthed using smart-phone GIS applications which aided in defining boundaries of polygons.

Boundaries of count areas and shorebird habitat were digitised on screen-displayed digital ortho-photos in ArcMap 10.3. The accuracy of these photos was confirmed by the comparison of GPS ground-control points with physical features. Shorebird feeding areas that had been determined in previous years were based mainly on a report which plotted polygons over shorebird areas (Close 2008). These were adjusted with reference to features visible on high-resolution digital ortho-photos, such as beds of seagrass, which provide a good indication of the boundaries of intertidal feeding areas. Due to the variable nature of some features in coastal environments (sand spits, mangroves and seagrass wrack), some of the polygons may not reflect the actual boundaries of shifting habitat features. A complete list of attributes, and further technical details of the GIS layers provided is available in the metadata which is separate to this report.

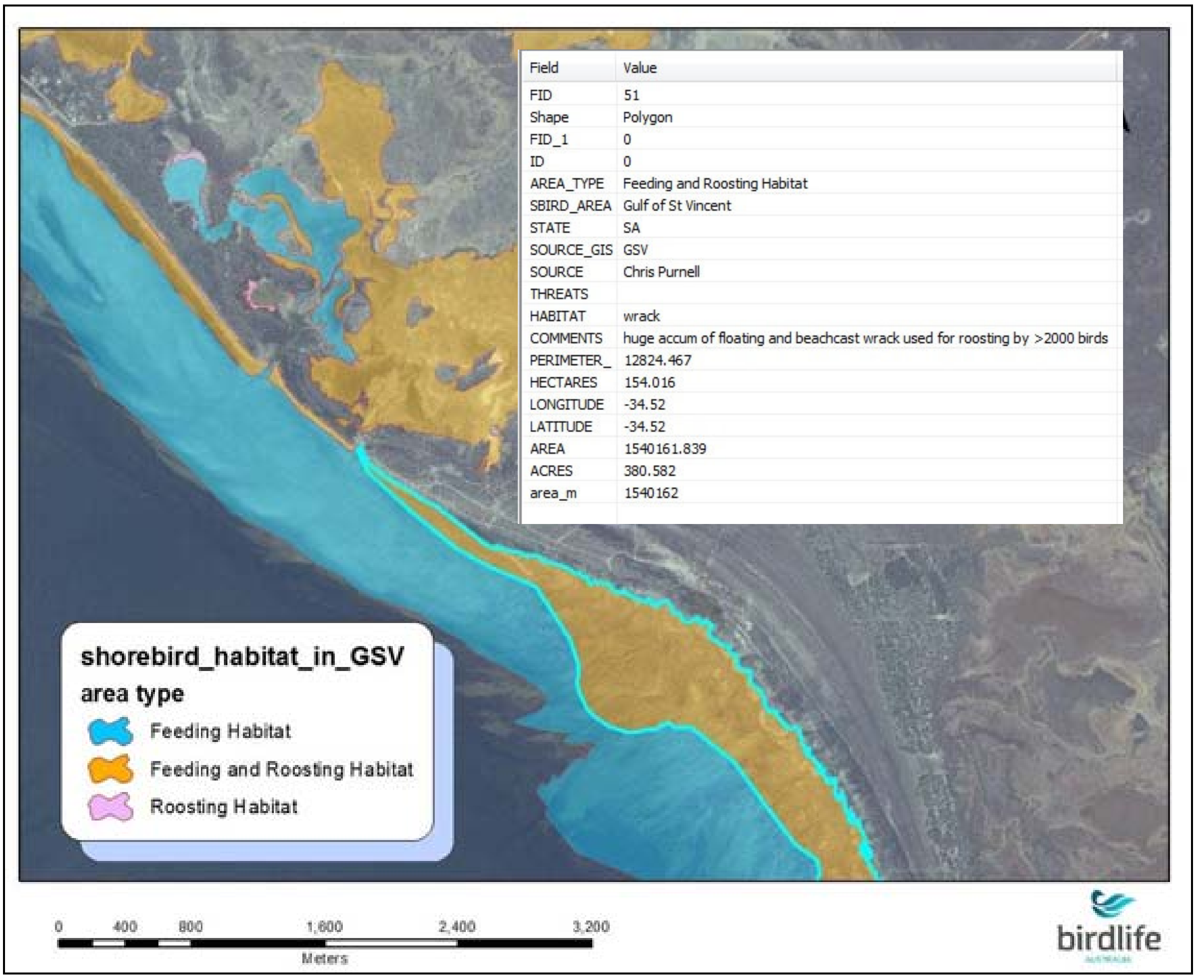
As discussed in Section 1.02; the Shorebird Monitoring project has expanded to include several areas in the Onkaparinga region, Onkaparinga River estuary

- Onkaparinga Oxbow (tidal creek and saltmarsh).
- Noarlunga Downs Wetlands (artificial freshwater wetland).
- Onkaparinga River Recreation Park Wetlands (natural ephemeral wetlands).
- Hart Rd Wetlands (stormwater detention wetland).
- Aldinga Scrub Reserve Wetlands (natural ephemeral wetland).
- Aldinga Washpool (natural coastal lagoon).

Given the majority of these sites are supratidal and condition is subject to available fresh water habitat has been defined simply as “feeding and roosting areas” in the 2014/15 mapping. These sites now appear in the Shorebird 2020 national count area network.

Accuracy of mapping and attributes

Digital ortho-photos were found to be spatially accurate after comparisons with GPS field points. GPS readings fluctuated by only up to 10 metres in the field, but some features such as sandbars or the edge of mudflats may shift over time by over 100 metres. In a few remaining areas, the actual edge of the mapped shorebird habitat was uncertain, and boundaries were poorly defined. In these areas the discrepancy between our boundary and the boundary the birds used may be as off by as much as 50 metres and may depend on conditions of tide. Despite this variation in spatial accuracy of digitised static boundaries, all spatial boundaries are believed to include the core of the important habitat, and an estimate of spatial accuracy which generally applies only to the boundary edges is reported in the attribute table.



Field	Value
FID	51
Shape	Polygon
FID_1	0
ID	0
AREA_TYPE	Feeding and Roosting Habitat
SBIRD_AREA	Gulf of St Vincent
STATE	SA
SOURCE_GIS	GSV
SOURCE	Chris Purnell
THREATS	
HABITAT	wrack
COMMENTS	huge accum of floating and beachcast wrack used for roosting by >2000 birds
PERIMETER_	12824.467
HECTARES	154.016
LONGITUDE	-34.52
LATITUDE	-34.52
AREA	1540161.839
ACRES	380.582
area_m	1540162

Figure 47. Clip of habitat mapping files and attributes provided in association with this report.

For planners and managers requiring greater spatial resolution, some generalisations may assist in future interpretation of important shorebird areas. In general, roosting areas near the mouths of tidal creeks and sand embankments such as Section Banks will continue to shift to wherever exposed sand remains at high tide. Further, they will be lost or diminished in importance as vegetation encroaches on roosting areas. Lastly, boundaries of feeding areas will change depending on where the channels shift to and as the distribution of benthic organisms shift.

Fine scale shorebird habitat mapping of Dry Creek saltfields has not been updated. Due to the variability in habitat being both created and lost as the site transitions from an active operation towards decommissioning it is impossible to quantify the amount of habitat available at any one time (See (a).

Section 2.02 Shorebird Count area profiles

The following section provides site by site summaries of shorebird sites that contribute to the Gulf St Vincent shorebird area and have been the subject of NRM board funded population monitoring project since 2008.

A key to shorebird site profiles.

Habitat type-
Habitat type, extent and proportion (DEWNR 2009) used by shorebirds (BirdLife 2017)

Priority-
1= commonly used
2= secondary use
3= uncommon or low-density use

Protection-
Protected area in which habitat partially or fully falls within.
Section 1.01 (f)

(a) Example Beach

Site management and details

NRM region: NRM ALMR.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council.

Count area map-
Maps identify area described in the
- summary survey route
- landmarks of interest
- Sites referenced in habitat descriptions

Population details-
Summary information using Shorebirds 2020 survey data from 2008-2017.
- Nationally significant (>0.1%EFP)
- Internationally significant (>1% EFP)

Threats-
Detailed sites specific shorebird threat scores, overall scores for each threat and summary information on the most pertinent threats.
More information on threats and threat scoring in Section 1.03

Habitat type	ha	% cover	priority	Protection
Intertidal Seagrass - Patchy	5	5	1	UGSV MP
Supratidal Saline Patch Bare	25	25	1	AIBS
Supratidal Samphire - Intact	70	70	3	AIBS
Grand Total	100	100.00		

Shorebird Diversity:
Avg Abundance:
Max Abundance:
Important shorebird species:
Abundance-
Threatened-
Breeding-
Regionally uncommon-

Table XX. Species list*

Common Name	RR (%)	Max	Avg
Ruddy Turnstone	41.67%	160	18
Great Knot	16.67%	100	2
Red Knot	45.83%	5040	331

Shorebird prey:

Habitat Use:
Low tide -

High tide –

Shorebird prey- based on biodiversity surveys of sites where available (Coleman 2009, Dittman 2012) cross-referenced with Shorebird diet data (BirdLife 2012).

Habitat use-
Summary of how shorebird populations use the site under varying conditions; tide, disturbance, drought etc.

Threats

1.Habitat *2.Disturbance* *3.Invasive fauna* *4.Invasive flora* *5.Native flora* *6.Native fauna* *7.Human induced morality* *8.Bird Strikes* *9.Pollution*

Threat	1	2	3	4	5	6	7	8	9
Liklehood	2	3	3	0	0	0	0	1	1
Scope	0	3	2	0	0	0	0	1	1
Severity	1	3	1	0	0	0	0	1	1
Overall impact	3	9	6	0	0	0	0	3	3

Relative importance- a summary of how the site contributes to the GSV shorebird complex.

Relative importance:
Overall avian diversity:

Other avian values:

Overall avian diversity- # species observed at the site since 2008.
Other Avian value- Species listed as Threatened under the NPW Act 1972 or EPBC Act 1999.

(a) Section Banks (Bird Island).

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Port Adelaide Enfield.
Tenure/Principal manager(s): Department of Planning, Transport and Infrastructure (DPTI), Flinders Ports, DEWNR / NR AMLR.

Map 5. Section Banks shorebirds 2020 count area

Figure 48. Shorebird roosting in the bay and far north eastern spit ② on Section Banks. Photo Chris Purnell

Section Banks (Bird Island) is an artificial island located at the northern end of the Northern Revetment mound (a rock breakwater), about 700 m offshore from Outer Harbour. The island was created from sediments dredged from the Port River in 1976 and is composed of shell-grit, clay and sand. The intertidal and supratidal extent of the island is growing to the north-east as accretion from the northern movement of sand along the coast continues.

Although areas are occasionally flooded or breached by high tides and storms (particularly in sandy sections of the island's central north-west) more permanent sections of dune and chenier have been colonised by coastal vegetation forming areas of; low closed shrubland, mangrove, open shrubland (Ecological Evaluation 2014). The bank is a combination of intertidal flat, saltmarsh and mangrove on finer sediments on the eastern side (Carpenter 2008).

Table 16. Shorebird habitat type within the Section Banks count area.

Habitat type	ha	% cover	priority	Protection
Chenier or dune	16.85	3.31	1	ADS
intertidal saltmarsh	6.51	1.28	1	ADS
Tidal flats	485.24	95.40	1	ADS
Total	508.61			

Shorebird Diversity: 21
Avg Abundance: 1,156
Max Abundance: 4,394
Important shorebird species:
Abundance- Red-necked Stint (>0.01 EFP), Sharp-tailed Sandpiper (>0.01 EFP),
Threatened- Curlew Sandpiper, Eastern Curlew
Regionally uncommon- Whimbrel, Terek Sandpiper.
Breeding- (suspected) Red-capped Plover, Pied Oystercatcher

Table 17. Shorebird species list Section Bank

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	53%	120	35
Sooty Oystercatcher	30%	206	48
Banded Stilt	11%	230	77
Red-necked Avocet	2%	2	0
Black-winged Stilt	9%	5	2.7
Grey Plover	58%	39	19
Pacific Golden Plover	4%	1	0
Red-capped Plover	72%	653	178
Masked Lapwing	70%	8	3.7
Red-kneed Dotterel	4%	3	1.3
Whimbrel	4%	4	1.3
Eastern Curlew	25%	4	2.3
Bar-tailed Godwit	18%	7	0
Red Knot	16%	1	0.3
Sharp-tailed Sandpiper	56%	144	74
Curlew Sandpiper	33%	82	44
Red-necked Stint	72%	2857	664
Terek Sandpiper	2%	1	0
Common Sandpiper	2%	1	0.3
Common Greenshank	70%	6	3.3
Marsh Sandpiper	4%	8	2.7

Shorebird prey Algae, crustaceans, insects, annelids, molluscs, bryozoans, cnidarians, echinoderms and fish.

Habitat Use:
Low tide - Shorebirds forage on the large intertidal flats on the sandy north west of the island and the small seagrass dominated bays on the south east.

High tide –
Grey Plover, medium and small waders roost and feed on the steep-sloping, sandy bank on the islands north west (1).
Eastern Curlew and medium and small waders roost on sandy bay to the spit on the far east of the island (2)
Marsh species (sharp-tailed sandpiper, Common Greenshank, Curlew Sandpiper, Red-necked Stint) and Oystercatcher sp. forage and roost in low saltmarsh o the east of the island (4).

Red-capped Plover, Red-necked Stint roost on open sand on the south west of the island between (3) and (4). Pied Oystercatcher and Red-capped Plover are assumed to breed in this area.

Figure 49. Rat prints on open sand of the dune crest of the island. Photo Chris Purnell

Table 18. Threats Section Bank

Threat									
Liklehood	2	2	3	1	3	0	0	0	0
Scope	1	1	2	1	1	0	0	0	0
Severity	1	0	1	0	1	0	0	0	0
Overall impact	4	3	6	2	5	0	0	0	0

Habitat loss- Sea-level rise
Disturbance- fisherman and bait collectors
Domestic and introduced fauna- Rats, foxes, dogs
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Native vegetation- Mangrove incursion
Native birds- Silver Gull predation of chicks increased by local breeding
Pollution- Potential Oil-spill or pollutant spill from shipping

Relative importance:
Observations of flocks of birds arriving from the east and south east as the tide drops suggest that these areas are used as supplementary feeding sites for shorebirds which otherwise forage at Dry Creek Saltfields, Barker Inlet & Magazine Rd Wetland during high tide.

Overall avian diversity: 83

Other avian values: In addition to resident shorebirds several waterbirds and tern species are known to breed on the island. Black-faced Cormorant, Australian Pelican, Australian White Ibis, Silver Gull, Caspian Tern Crested Tern and Fairy Tern (EN) have established regular colonies and have been subject to a separate monitoring study.

The Pelican colonies on the Island has been recognised as the second largest permeant colony in the state. Although it varies in distribution Pelican, Ibis and Gull rookeries are confined to the vegetated, supratidal, chenier ridge among open shrub.

Tern colonies regularly occur on the sandy beaches to the gulf side of the island. Crested and Caspian Terns nest towards the northern end and Fairy Tern neat between points ① and ③ on the western coast with low density nesting sometimes occurring in the sandy dune in the centre of the island.

The Black-faced Cormorant colony utilises the stony revetment wall and is reported to be the largest in Australia with historically up to 6,000 nests recorded during winter breeding (Johnston and Wiebkin 2008).

Less commonly Royal Spoonbill, Great Egret and Straw-necked Ibis attempt to breed at the site. White-bellied Sea Eagle are thought to breed in the norther shores of Torrens Island and are regularly observed roosting on the channel marker to the island's south.

(b) Mutton Cove

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Port Adelaide Enfield.
Tenure/Principal manager(s): DEWNR

The area of Mutton Cove is one of the few areas along the edges of the LeFevre Peninsula that remains at natural surface level. Although it has been severely degraded since European settlement remains the most biodiverse area of salt marsh and Grey Mangrove woodland on the Peninsula. The saltmarsh is comprised of Beaded Samphire (*Sarcocornia quinqueflora*), Austral Seablite (*Suaeda australis*), Shrubby Glasswort (*Tecticornia arbuscula*) and Grey Samphire (*Tecticornia halocnemoides*) low shrubland and is bisected by Mutton Cove Creek. Management of the site seeks to restore flora and fauna by introducing a controlled tidal influence. The deteriorating levee bank at Mutton Cove breached in 2016 and the area is now subject to much higher tidal levels than previously. This is drowning saltmarsh areas and may increase mangrove distribution.

The creek splits into three main branches. The extent of these branches extended beyond the proposed Mutton Cove area. However, the outer limits of these branches had been blocked with earth levee banks and land fill. Currently no stormwater runoff actually enters Mutton Cove proper.

There is a single council maintained Storm water drain that runs underground along the southern border of the site, within the proposed Recreation and Carpark Reserve. This storm water drain discharges stormwater from the surrounding roads into the Port River (Cook & Coleman 2003).

Habitat mapping not provided.

Shorebird Diversity: 11 (17)
Avg Abundance: NA
Max Abundance: NA
Important shorebird species:

Table 19. Shorebird species list Mutton Cove.

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	70%	49	NA
Sooty Oystercatcher	49%	19	NA
Black-winged Stilt	89%	26	NA
Red-capped Plover	19%	20	NA
Masked Lapwing	92%	9	NA
Red-kneed Dotterel	38%	9	NA
Sharp-tailed Sandpiper	8%	400	NA
Red-necked Stint	43%	227	NA
Common Sandpiper	3%	2	NA
Common Greenshank	19%	12	NA
Marsh Sandpiper	8%	1	NA

Shorebird prey Algae, crustaceans, insects, annelids, molluscs, bryozoans, cnidarians, echinoderms and fish.

Habitat Use:
Low tide - Shorebirds forage on intertidal flats on the sandy bank of the Port River and at the mouth and banks of Mutton Cove Creek.

High tide- Shorebirds forage on muddy banks of tidal creeks or inundated saltmarsh. Large numbers of Sharp-tailed Sandpipers and Stint also roost in the saltmarsh.

Table 20. Threats Mutton Cove.

Threat									
Liklehood	1	1	3	1	1	0	0	1	2
Scope	0	0	2	1	1	0	0	1	1
Severity	1	0	1	0	1	0	0	1	1
Overall impact	2	1	6	2	3	0	0	3	4

Habitat loss- Sea-level rise, levee breach
Domestic and introduced fauna- Rats, foxes, dogs
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Native vegetation- Mangrove incursion
Bird Strikes - electrical wires
Pollution- Oil-spill or pollutant spill from shipping

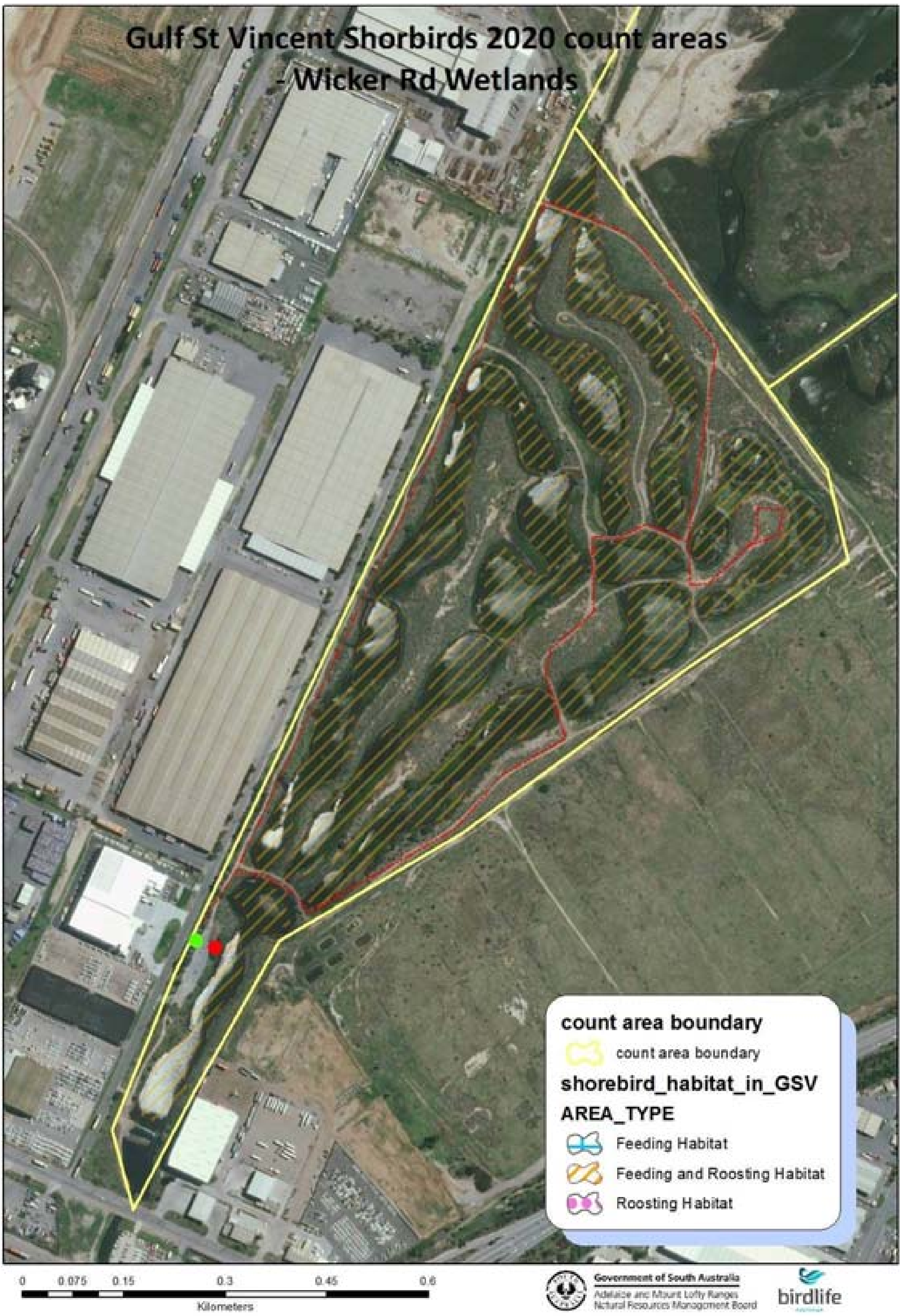
Relative importance:
Observations of flocks of birds arriving from the east and south east as the tide drops suggest that these areas are used as supplementary feeding sites for shorebirds which otherwise forage at Dry Creek Saltfields, Barker Inlet & Magazine Rd Wetland during high tide.

Overall avian diversity: 93

Other avian values: Australasian Shoveler, Peregrine Falcon (NPW Rare), White-bellied Sea Eagle

(c) Whicker Rd Wetlands (Magazine Creek Wetlands)

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Port Adelaide Enfield.
Tenure/Principal manager(s): SA Water



Map 6. Whicker Rd Wetlands shorebirds 2020 count area

The Whicker Rd Wetlands are constructed on reclaimed intertidal saltmarsh which has a very shallow water table fed by Magazine Creek. Considerable excavation and levee building has resulted in a storm water wetland with a series of freshwater ponds with complex, but often steep, shorelines.
Nb: Habitat data not available.

Shorebird Diversity: 14 (15)
Avg Abundance: 57
Max Abundance: NA
Important shorebird species:
Regionally uncommon - Long-toed Stint, Pectoral Sandpiper, Wood Sandpiper, Ruff.

Table 21. Shorebird species list Whicker Rd Wetland

Common Name	RR (%)	Max	Avg
Red-necked Avocet	14%	19	0
Black-winged Stilt	83%	27	20
Red-capped Plover	3%	3	0
Black-fronted Dotterel	45%	4	1
Masked Lapwing	59%	6	2
Red-kneed Dotterel	59%	30	6
Ruff	17%	1	0
Sharp-tailed Sandpiper	34%	50	4
Long-toed Stint	3%	1	0
Red-necked Stint	3%	19	2
Pectoral Sandpiper	24%	2	0
Common Sandpiper	14%	1	0
Common Greenshank	24%	2	0
Wood Sandpiper	14%	2	0

Shorebird prey Algae, crustaceans, insects, annelids, molluscs, bryozoans, cnidarians, echinoderms and fish.

Habitat Use:
Throughout the tide cycle marsh species forage on in shallow waters bordering rocky and vegetated banks. During dryer months water recedes exposing muddy edges in some ponds and channels which are used by smaller shorebirds,

Table 22. Threats Whicker Rd Wetlands

Threat									
Liklehood	1	2	3	1	0	0	0	1	1
Scope	1	1	2	1	0	0	0	1	1
Severity	2	2	1	0	0	0	0	1	1
Overall impact	4	5	6	2	0	0	0	3	3

Threats:
Habitat loss- unsuitable hydrology
Domestic and introduced fauna- Rats, foxes, dogs
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Bird Strikes - electrical wires
Pollution- pollutant run-off and rubbish from neighbouring industrial areas

Relative importance:
One of a small number of freshwater sources in the region.

Overall avian diversity: 90
Other avian values: Blue-billed Duck, Freckled Duck, Australasian Shoveler, Glossy Ibis, Peregrine falcon

(d) Barker Inlet Wetlands

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Port Adelaide Enfield.
Tenure/Principal manager(s): City of Port Adelaide Enfield, SA Water

The Barker Inlet Wetlands are currently undergoing considerable reconfiguration as part of the Northern Connector Project. Habitat extent and condition will be significantly impacted by the Southern Interchange ((a)(ii)).

Prior to modification the northern basin of the Barker Inlet Wetlands (north of Salisbury Highway), managed by Pt Adelaide Enfield Council, comprised the final stages of stormwater treatment before being debouched into tidally influenced ponds which are connected through a single weir to the mangrove forest dominated estuary of North Arm Creek. The southern basin (blue in Figure 27) comprises fresh water lagoons and channels. Ponds vary from deep and heavily vegetated in the south east of the wetlands to shallower with open shorelines in the south west. This water was channelled through a number of one-way weirs into the norther basin where it interacted with tidal waters originating from a tidal weir in the north east. Thus, northern basin resembles an intertidal claypan (north east), and tidal creek system (north west) supporting saltmarsh.

The Northern Connector project has significantly impacted the tidal and fresh water lagoons in the western two thirds of the wetland area. Despite these losses the Pt Adelaide Enfield Council's development plan does have specific environmental objectives for the Barker inlet Wetlands.

When detailing the "desired character" of the areas the plan notes

> *Barker Inlet Wetlands are an integral part of the policy areas character. The wetlands will be conserved and the primary role of these areas is the improvement in the quality of stormwater discharge. The future development of the wetlands seeks to establish a diverse ecosystem through the creation of a range of habitats including marine intertidal (i.e. mangrove forest, samphire, mudflats, and bare grit flats), freshwater wetland (i.e. reeds, sedges and open water), and terrestrial coastal (i.e. woodland, shrub land, grassland, bare soil, and salt scald) (Port Adelaide Einfeld 2018).*

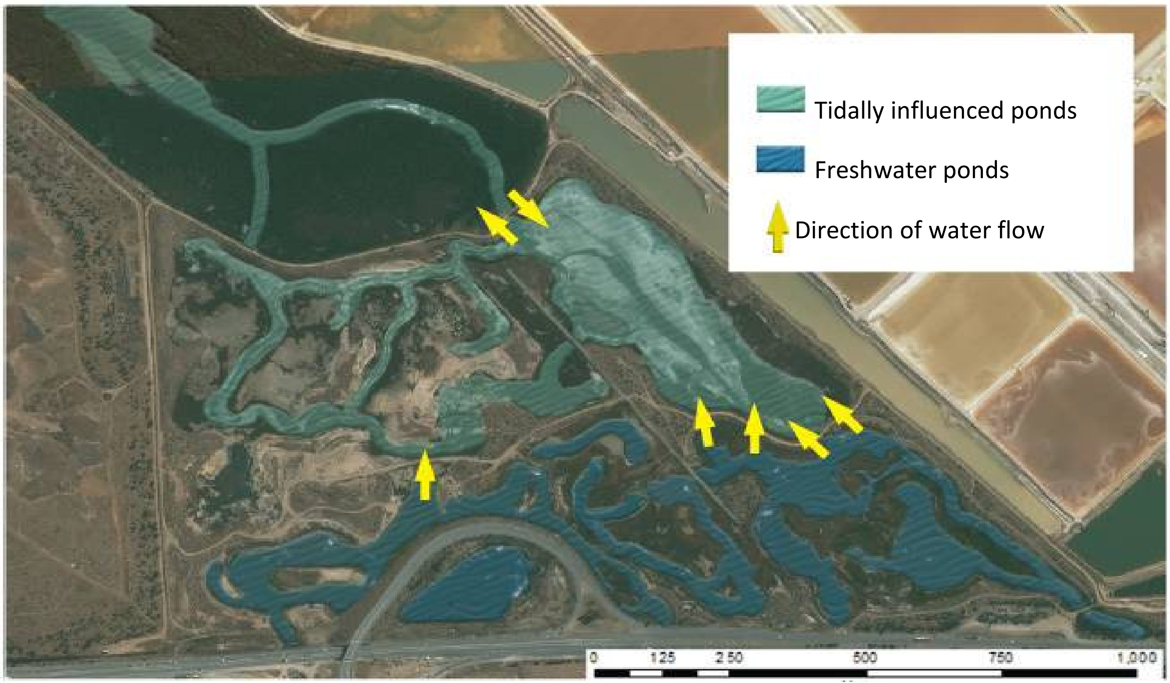


Figure 50. Barker Inlet Wetlands northern basin.

Nb: As an artificially constructed habitat there is no available habitat mapping for the site.
Habitat information presented has been roughly estimated from the Northern Connector impact assessment (Kellogg and Root 2011) and refers to pre-modified conditions.

Table 23. Shorebird habitat type within the Barker Inlet Wetlands count area.
* PAE Development Plan Objectives MOSS Barker Inlet Conservation Policy Area 17

Habitat type	% cover	priority	Protection
Intertidal Shallow marine and freshwater flowpaths	30	1	No protection (AIBS 2015)*
Shallow salt water and intertidal mudflats	30	1	No protection (AIBS 2015)*
Intertidal samphire	20	1	No protection (AIBS 2015)*
Deep freshwater with areas of tall aquatic grassland	15	1	No protection (AIBS 2015)*
Bare ground	5	2	No protection (AIBS 2015)*
total	100		

Shorebird Diversity: 16
Avg Abundance: 275
Max Abundance: 497
Important shorebird species:
Abundance - Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP), Curlew Sandpiper (>0.1% EFP).
Threatened- Curlew Sandpiper, Black-tailed Godwit,

Shorebird prey Algae, crustaceans, insects, spiders, annelids, molluscs, bryozoans, cnidarians, echinoderms and fish

Table 24. Shorebird species list Barker Inlet Wetlands.

Common Name	RR (%)	Max	Avg
Banded Stilt	68%	200	56
Red-necked Avocet	47%	100	26
Black-winged Stilt	95%	150	61
Red-capped Plover	16%	14	5
Black-fronted Dotterel	16%	4	0
Banded Lapwing	5%	1	0
Masked Lapwing	63%	16	4
Red-kneed Dotterel	42%	60	24
Black-tiled Godwit	5%	1	0
Sharp-tailed Sandpiper	47%	160	33
Curlew Sandpiper	5%	200	50
Red-necked Stint	26%	322	81
Common Sandpiper	5%	1	0
Common Greenshank	58%	50	3
Wood Sandpiper	16%	3	1
Marsh Sandpiper	11%	14	1

Habitat Use:
Low tide - The large terminal pond in the north east of the system provides the most abundant and valuable foraging habitat for shorebirds and is densely populated on falling and rising tides as mud is exposed.

High tide – The surrounding saltmarsh and tidal creeks support lower densities of marsh species throughout the tide cycle and are home to breeding Red-capped Plovers (Figure 51).

The central and eastern ponds of southern, freshwater basin of t provide novel habitat for freshwater and marsh species at low densities including breeding Red-capped Plovers, Black-fronted Dotterels and Black-winged Stilt.

Figure 51. A female Red-capped Plover and chick forage on the muddy edges of tidally influenced mudflats at Barker Inlet Wetlands. Photo Chris Purnell.

Table 25. Threats Barker Inlet Wetlands:

Threat									
Liklehood	3	3	3	2	0	3	3	3	2
Scope	2	3	2	2	0	1	2	2	2
Severity	3	2	1	0	0	0	1	1	1
Overall impact	8	8	6	4	0	4	6	6	5

Habitat loss- Northern Connector, southern hub project.
Disturbance- temporary disturbance from construction.
Domestic and introduced fauna- Fox, rat and cat impacts from nearby industrial areas
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Bird Strikes - existing and new elevated infrastructure including roads and electrical wires
Human induced mortality- Crushing and collision by works vehicles and highway traffic.
Pollution- pollutant run-off and rubbish from neighbouring industrial areas

Figure 52. Red-necked Stint, Red-capped Plover, Common Greenshank and Black-winged Stilt feed and roost in the north western intertidal section of Barker Inlet Wetlands. Photo Chris Purnell.

Relative importance: Barker Inlet contributes the mosaic of fresh brackish and intertidal wetlands in the Port Adelaide/ Greenfields area. A mix of tidal and non-tidal wetlands not only allows for variation in feeding guilds and water depth gradients but allows land managers (using weirs and tidal gates) to manipulate habitat condition to optimise shorebird values.

Overall avian diversity: 114

Other avian values: Bittern (EN EPBC), Spotless Crake, Peregrine Falcon, Glossy Ibis, Freckled Duck

(e) Magazine Rd Wetlands

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Salisbury
Tenure/Principal manager(s): SA Water, Salisbury Water.

Map 7. Magazine Rd Wetlands shorebirds 2020 count area

Magazine Rd Wetlands was created as Stage 3 of the Greenfields wetlands complex in 1995.

A storm-water treatment area, these wetlands comprise a system of freshwater channels and lagoons which vary from <10 centimetres deep in the summer to over 1 metre deep after sustained rain or local water allocation from neighbouring stormwater storage areas. The lagoons and channels have shallow edges and complex, often muddy, shorelines vegetated with low sedge, tussocks and saltmarsh. Small stands of dense reedbed occur in the north-eastern basin.

Nb: As an artificially constructed habitat there is no available habitat mapping for the site.

Table 26. Shorebird habitat type within the Magazine Rd Wetlands count area

Habitat type	ha	% cover	priority	Protection
Shallow freshwater wetlands with muddy shoreline and emergent vegetation	NA	80	1	No protection (AIBS 2015)*
Supratidal samphire	NA	15	1	No protection (AIBS 2015)*
Deep freshwater with areas of tall aquatic grassland	NA	3	1	No protection (AIBS 2015)*
Bare ground	NA	2	2	No protection (AIBS 2015)*

<u>Shorebird Diversity</u>:19
<u>Avg Abundance</u>: 180
<u>Max Abundance</u>: 380
<u>Important shorebird species</u>:
Abundance- Sharp-tailed Sandpiper (>0.01 EFP).
Threatened - Australian Painted Snipe (EN)
Regionally uncommon- Ruff, Long-toed Stint

Table 27. Shorebird species list

Common Name	RR (%)	Max	Avg
Banded Stilt	13%	39	7
Red-necked Avocet	13%	6	1
Black-winged Stilt	89%	304	90
Red-capped Plover	32%	14	2.9
Black-fronted Dotterel	30%	7	1.7
Masked Lapwing	64%	8	1.3
Red-kneed Dotterel	73%	50	21
Australian Painted Snipe	2%	11	0
Ruff	4%	1	0
Sharp-tailed Sandpiper	52%	107	32
Curlew Sandpiper	2%	3	0
Long-toed Stint	9%	3	0.3
Red-necked Stint	25%	100	17
Pectoral Sandpiper	11%	3	0.4
Latham's Snipe	4%	2	0.1
Common Sandpiper	18%	1	0.3
Common Greenshank	25%	2	0.9
Wood Sandpiper	50%	9	4.3
Marsh Sandpiper	27%	3	0.7

<u>Habitat Use:</u>
Shorebird habitat availability at the site is heavily dependent on seasonal and annual variation in water availability. When wet, the shallow ephemeral sections of the wetlands in the North West of Magazine Rd Wetlands (1) are used by the highest densities and diversity of shorebirds however the same feature means they have a very low capacity to retain water.

Deeper ponds and channels in the southern half of the complex provide a longer period of habitat availability as shorelines are exposed over a greater evaporation gradient. When full all of these ponds become functionally useless for all but large waders (2).

Low tide - Freshwater species (Dotterels, Wood Sandpiper, Black-winged Stilt) forage on the muddy shorelines and islands throughout the tide cycle. Latham's Snipe forage in sedge, tussock and saltmarsh as well as Reedbed fringes (3).

High tide – At high tide marsh species become more numerous as Sharp-tailed Sandpiper, Common Greenshank and Red-necked Stint arrive from local intertidal feeding areas.

Table 28. Threats Magazine Rd Wetlands

Threat									
Liklehood	2	2	3	1	1	0	0	1	0
Scope	2	1	2	1	1	0	0	1	0
Severity	2	1	1	0	1	0	0	0	0
Overall impact	6	4	6	2	3	0	0	2	0

Threats:
Habitat loss - Unsuitable hydrological input and timing.
Disturbance- walkers and birdwatchers
Domestic and introduced fauna - Cats, dogs, foxes, rats
Bird Strikes - neighbouring highway and electrical wires

Relative importance:
Observations of flocks of birds arriving from the east and south east as the tide drops suggest that these areas are used as supplementary feeding sites for shorebirds which otherwise forage at Dry Creek Saltfields, Barker Inlet & Magazine Rd Wetland during high tide.

Overall avian diversity:

Other avian values:
Australasian Bittern (EN EPBC), Glossy Ibis, Freckled Duck, Blue-billed Duck, Musk Duck, Little Egret

(f) Dry Creek Saltfields

The Dry Creek Saltfields operation has been active on several scales since the 1950s. The modern operation consisted of over 4,300ha of salinas along a roughly north south stretch of coast running 30km from Dry Creek in the south to Pt Gawler in the north. Following the decommissioning of the active saltfield in 2013 a holding pattern was instated to retain habitat values until a final management plan could be agreed upon. Areas outside the ponds were treated as another habitat type “associated areas of saltmarsh, mudflats, and tidal creeks”.

Fine scale habitat mapping of the saltfields (Purnell 2011, 2012) has not been updated since decommission of the managed production flow in 2013. As discussed in Section 1.01(a)(i) the implementation of the holding pattern, preceding periods of inconsistent pumping and subsequent on-going changes to hydrology (planned and otherwise) have resulted in variation in habitat being lost and created. A review of pond scale data collected over the 2013-17 period will be included in the 2017-18 Population Monitoring report. Detailed accounts of pre-decommission, pond-scale habitats can be found in Purnell 2012.

Figure 53.An aerial image of the mosaic of habitats found in and adjacent to Dry Creek Saltfields marine salinity pond XE1 (bottom of image). Neighbouring habitat includes tidal creek-lines, saltmarsh and borrow pits. Photo: Aleisa Lamanna

(i) Dry Creek Saltfields Bolivar Section (Section 2)

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Salisbury
Tenure/Principal manager(s): Buckland Park Ltd Pty (Adelaide Resource Recovery), SA Water, DSD Mineral Resources Division.

Map 8. Creek Saltfields Bolivar Section shorebirds 2020 count area

With the commencement of the 2013 holding pattern high hypersaline ponds PA 6 to 12 were decommissioned. In late 2015 SA Water began using two of these ponds (PA 9 & 10) to process treated wastewater from the adjacent Bolivar Waste Water Treatment. The inundated ponds totalling 60ha have a base crust of mineral deposits which encase potential acid sulphate soils and sulphidic black ooze. The eastern sides of these ponds are shallower and are dominated by large areas of remanent mineral deposits and microbial mats. These mats sometimes grow into balls, accumulating at the edges of ponds and in other areas of shallow water, and often protrude above the water's surface, resembling stromatolites. Gaps between these islands are often filled by sediment and spoil creating small, often vegetated islands.

The freshwater input from Bolivar WWTP combined with remnant salt crusts provides slightly brackish conditions.

Table 29. Shorebird habitat type within the Dry Creek Saltfields Bolivar Section count area.

Habitat type	ha	% cover	priority	Protection
Salina + levee	100.95	41.36	1	
Intertidal Mangrove - Dieback	1.10	0.45	2	
Intertidal Samphire - Degraded	16.20	6.64	2	
Intertidal Samphire - Dieback	5.85	2.40	2	
Intertidal Samphire - Intact	59.56	24.40	2	ADS
Supratidal / Estuarine Sedges - Intact	2.89	1.18	3	
Chenier / Beach Ridge Vegetated - Intact	16.58	6.80	3	
Intertidal Mangrove - Intact	15.39	6.31	3	
Supratidal Samphire - Intact	14.03	5.75	3	
Supratidal Samphire +/- Atriplex +/- Grassland - Intact	11.48	4.71	3	
Total	244.0	100		

Figure 54. Ruff (left) and Sharp-tailed Sandpiper observed feeding on algae coated mineral deposits in pond PA9. Photo Chris Purnell.

Shorebird Diversity: 13
Avg Abundance: 1,866
Max Abundance: 3,685
Important shorebird species:
Abundance - Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP) Common Greenshank (>0.1% EFP).
Threatened- Curlew Sandpiper
Regionally uncommon- *Pectoral Sandpiper, Ruff* (Figure 54)
Breeding- Black-winged Stilt

Shorebird prey: Algae, crustaceans, insects, spiders, annelids.

Table 30. Dry Creek Saltfields Bolivar Section Shorebird species list

Common Name	RR (%)	Max	Avg
Banded Stilt	33%	1335	445
Black-winged Stilt	100%	275	165
Red-capped Plover	50%	60	49
Masked Lapwing	83%	19	16
Red-kneed Dotterel	67%	48	29
Sharp-tailed Sandpiper	50%	483	210
Red-necked Stint	67%	505	288
Common Greenshank	67%	36	25
Ruff	15%	2	0
Marsh Sandpiper	15%	1	0
Curlew Sandpiper	15%	1	0
Long-Toed Stint	15%	1	0
Common Sandpiper	15%	1	0

Habitat Use:
Shorebird use of the PA ponds is dependent on tidal conditions and variations in water levels both within and between seasons.

Carpenter 2016 found lower diversity and abundance in the ponds in 2016-17 than 2015-16. This was likely a response to higher spring summer water levels and reduction in midges and associated larvae (which provide the bulk of the waterbird food in the ponds).

Small waders (Stints and small sandpipers) forage on shallow edges, banks and spit when exposed (Figure 54). Higher abundances are recorded at high tides.

Black-winged Stilt use the ponds year-round and have been recorded breeding on islands within both ponds.

Figure 55. Shallow algae coated shorelines (foreground) support high densities of brine flies in Pond PA 10. Photo Chris Purnell

Table 31. Threats Dry Creek Saltfields Bolivar Section

Threat									
Liklehood	2	0	3	1	1	3	0	3	1
Scope	2	0	2	2	1	1	0	2	1
Severity	3	0	1	0	1	1	0	1	1
Overall impact	7	0	6	2	3	4	0	6	3

Threats:
Habitat loss - Inappropriate water levels. Insufficient draw down period.
Domestic and introduced fauna - Fox, rat and cat impact from nearby industrial areas
Invasive plants - invasive weed incursion from neighbouring unmanaged lands. Vegetation incursions onto roosting and breeding islands.

Native birds- Silver Gull predation of resident chicks increased by local breeding
Bird Strikes - electrical wires
Pollution- Potential effect of acid sulphate soils and sulfidic black ooze

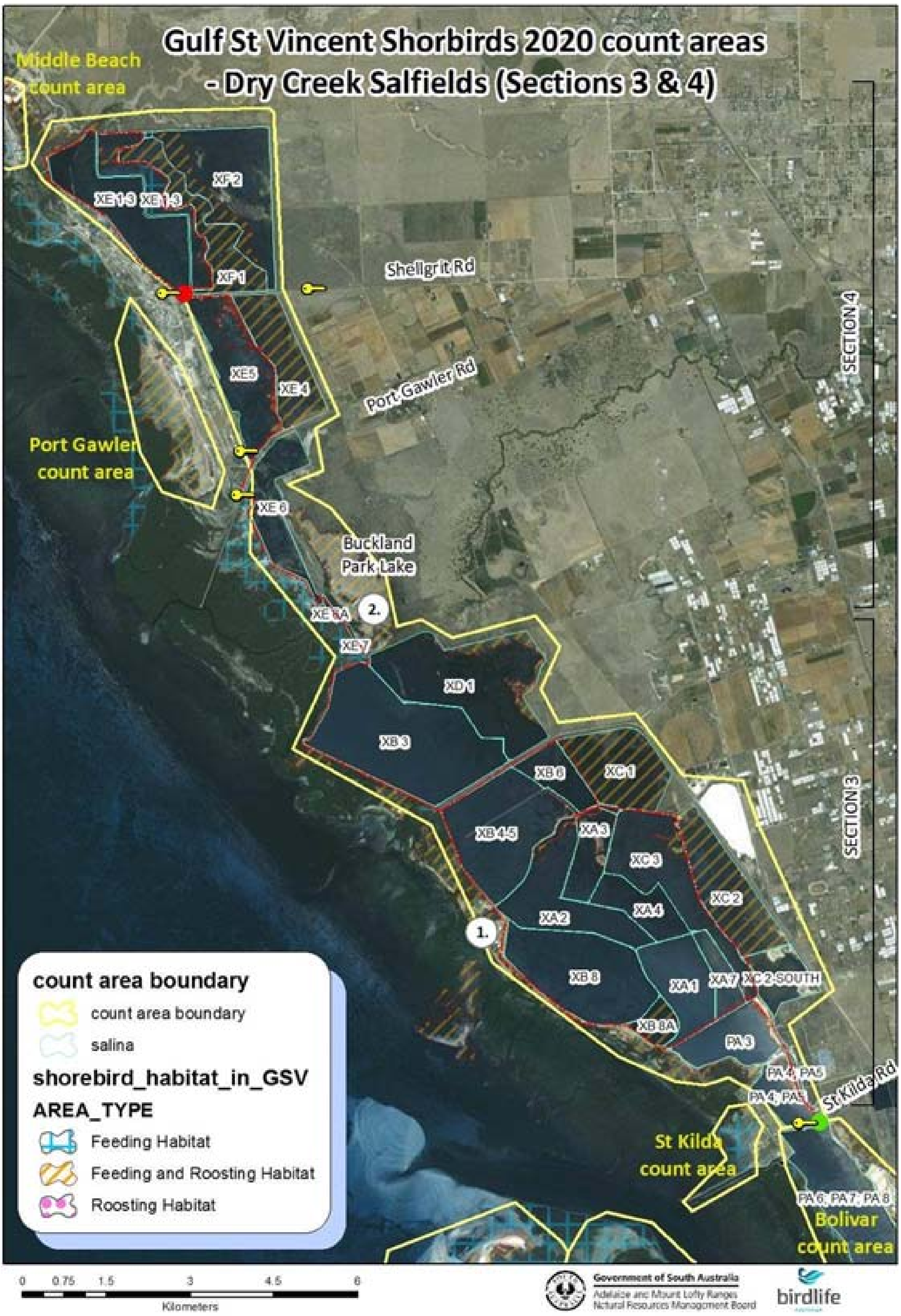
Relative importance: With decommissioning of the Saltfields, loss of wetlands at Barker Inlet Wetlands and irregular freshwater inputs to both Magazine Wetlands and Buckland Park Lake, the Bolivar PA ponds provide a unique opportunity to create high value shorebird habitat in the region. The unique ability for SA Water to manage freshwater inputs over such a large, open, shallow basin allows managers to not only optimise water depth for maximum shorebird feeding area but manage the wetting and drying periods to suppress vegetation and increase invertebrate productivity

Overall avian diversity: 31

Other avian values: Freckled Duck

(ii) Dry Creek Saltfields Sections 3 & 4 (Saint Kilda Rd to Middle Beach)

NRM region: Adelaide & Mt Lofty Ranges.
Council: City of Salisbury, Playford City Council, Adelaide Plains Council
Tenure/Principal manager(s): Buckland Park Ltd Pty (Adelaide Resource Recovery). DEWNR. SA Water, DSD Mineral Resources Division



Map 9. Dry Creek Saltfields Saint Kilda Rd to Middle Beach shorebirds 2020 count area

Prior to decommission Sections 3 & 4 maintained a consistent salinity gradient from marine salinity to medium salinity ponds. In its current condition, the extent of salina containing permanent water has reduced to 2,500ha.

Although their distribution and extent has altered, habitat types can still be classified based on their salinity (Coleman and Cook 2009, Purnell et al 2012), which dictates floral and faunal assemblages. The habitat types identified included:

- marine saltponds (39-65 g/L total dissolved salts [TDS]);
- low hypersaline saltponds (65-110 g/L TDS);
- medium hypersaline saltponds (110-175 g/L TDS)

Given salt is no longer produced at Dry Creek, highly hypersaline saltponds (330 g/L TDS) have not been included in the holding pattern operational plan. By not allowing salt concentrations to exceed medium hypersaline water that has passed through the system can safely be debouched into the gulf in adherence with EPA standards. These ponds held little value for shorebird populations.

Marine saltponds are similar to naturally occurring intertidal wetlands, and thus resemble a marine ecosystem, supporting all or most of the macro- and micro-organisms that usually occur in nearby seawater. Most of these ponds are shallow and sheltered, and they contain seagrass beds and high densities of invertebrates typical of rocky shores (Coleman and Cook 2009). In these ponds shorebirds would likely find and eat gastropods, bivalves, crustaceans, insects, worms, echinoderms and fish.

Low hypersaline saltponds overlap significantly with medium hypersaline saltponds in the Saltfields. Without the strict salinity standards required for commercial salt production it is expected that classification of any one pond may shift with seasonal changes in evaporation and freshwater input. Between the two classifications there are similarities in their salinity, prey assemblages, habitat types (generally non-vegetated levee walls banks and shorelines. Not surprisingly, there is a regular interchange of shorebirds between the two types of saltponds.

As salinity increases, many less-resilient aquatic species, such as fish, occur at lower densities, while other more resilient species become more abundant: i.e. plankton, crustaceans, molluscs and insects (Coleman & Cook 2009). The most hypersaline ponds in this habitat type are often inhabited by brine shrimps, *Artemia franciscana* and *Parartemia zietziana*, along with larvae of brine flies (*Ephydrella*) (Coleman & Cook 2009). Shorebirds feeding in this habitat type would find a wide variety of prey to eat including: gastropods, crustaceans, insects, worms and fish.

Pond XB8A is subject to a managed tidal inundation which seeks to mimic natural intertidal conditions (Section 1.01(a)(i)).

Shorebird Diversity: 31
Avg Abundance: 11,981
Max Abundance: 21,571
Important shorebird species:
Abundance- Sharp-tailed Sandpiper (>1% EFP), Red-necked Stint (>1% EFP), Curlew Sandpiper (>0.1% EFP), Common Greenshank (>0.1% EFP).
Threatened- Eastern Curlew, Curlew, Sandpiper, Black-tailed Godwit, Bar-tailed Godwit. (Historic) Australian Painted Snipe, Red Knot, Great Knot, Lesser Sand Plover.
Regionally uncommon: Ruff, Terek Sandpiper, Latham's Snipe, Pectoral Sandpiper, Black-tailed Godwit.
Vagrants- (historic) Cox's Sandpiper, Baird's Sandpiper, and Little Ringed Plover, American Golden Plover, Hudsonian Godwit, Lesser Yellowlegs, Common Redshank, Oriental Plover, Oriental Pratincole, White-rumped Sandpiper.

Table 32. Dry Creek Saltfields Saint Kilda Rd to Middle Beach Shorebird species list

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	33%	10	1
Banded Stilt	88%	17302	8349
Red-necked Avocet	88%	500	212
Black-winged Stilt	100%	904	253
Grey Plover	38%	44	21
Pacific Golden Plover	3%	2	0
Red-capped Plover	100%	1152	440
Double-banded Plover	3%	2	0
Black-fronted Dotterel	3%	3	0
Banded Lapwing	6%	9	1
Masked Lapwing	100%	94	57
Red-kneed Dotterel	45%	85	26
Whimbrel	16%	1	0
Eastern Curlew	44%	21	10
Bar-tailed Godwit	6%	18	10
Black-tailed Godwit	66%	32	6
Ruff	6%	1	0
Sharp-tailed Sandpiper	77%	1643	339
Curlew Sandpiper	77%	181	77
Red-necked Stint	100%	3713	2058
Pectoral Sandpiper	3%	1	0
Latham's Snipe	3%	1	0
Terek Sandpiper	6%	1	0
Common Sandpiper	33%	1	1
Common Greenshank	88%	216	113
Marsh Sandpiper	88%	18	7

Shorebird prey Algae, crustaceans, insects, spiders, annelids, molluscs, bryozoans, cnidarians, echinoderms and fish.

Habitat Use:
Sections 3 & 4 of the Dry Creek Saltfields historically provided the greatest amount of shorebird habitat for shorebirds in the Gulf St Vincent. Shorebirds commonly dispersed throughout 3,204 of the 4,307 hectares of ponds prior to decommissioning. Of these marine to high hypersaline ponds, only shallow areas (<20cm) such as exposed banks, islands and levees were utilised for feeding and roosting. This represents less than 15% of the total area of the operation.

Shorebirds found in these different habitats vary in species composition and abundance given the marked differences in available prey. However, the abundance of shorebirds using these ponds will not vary solely based on salinity. Simply, shorebirds need low enough water levels to be able to exploit the available prey, and as in any area, also require places to rest (roost). At present relatively, undisturbed roost sites are found in abundance within the ponds, so the distribution of shorebirds in Dry Creek will be largely a function of water depth and salinity.

Low tide surveys conducted by EBS Ecology on behalf of Ridley Corporation found an overall decline in numbers of shorebirds using section 3&4 ponds at low tide. Decreases in pond XA4 were particularly pronounced with a complete departure of birds during low tides.

Table 33. Threats Dry Creek Saltfields Saint Kilda Rd to Middle Beach

Threat									
Liklehood	3	1	3	1	1	3	1	3	1
Scope	2	1	2	2	1	1	1	2	1
Severity	3	1	1	1	2	1	1	1	1
Overall impact	8	3	6	4	4	5	3	6	3

Habitat loss – changing hydrological regime.
Disturbance – small scale temporary from construction.
Domestic and introduced fauna - Fox, rat and cat impacts from nearby agricultural areas
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Native plants- saltmarsh communities colonising feeding areas in dried ponds.
Native birds- Silver Gull predation of resident chicks increased by local breeding.
Bird Strikes- electrical wires.
Human induced mortality- Crushing and collision by works vehicles.
Pollution- Potential effect of acid sulphate soils and sulfidic black ooze.

Relative importance:
The Dry Creek Saltfields is the second most significant for shorebirds in South Australia (behind The Coorong), and one of the most important in Australia. It regularly supports >1% of the population of a number of migratory shorebirds in the East Asian–Australasian Flyway, of ov er 20,000 waterbirds during the summer months.

Around the world commercial saltfields have replaced natural sites as preferred habitat of shorebirds and waterbirds including in France (Hofferman 1958, 1964, Blondel & Isenmann 1974, Britton & Johnson, 1987), Spain (Velasquez & Hockey, 1992; Masero & Pe´rez-Hurtado, 2001; Paracuellos et al., 2002; Sanchez et al., 2006), Portugal (Rufino et al., 1984; Dias, 2009), Italy (Baccetti et al., 1995), Sri Lanka (Bellio et al., 2009), and the United States (Carpelan, 1957; Warnock et al., 2002; Takekawa et al., 2006). In Australia three of the ten most important sites for shorebirds encompass commercial saltfields (Lane & Davies 1987).
The attraction to saltfields for shorebirds includes:

- A mosaic of reliable feeding and roosting habitats within close proximity of one another (Warnock&Takekawa, 1996).
- Habitats are available year after year and throughout the tide cycle thus used as supplemental and preferential habitat (Rufino et al., 1984; Masero et al., 2000 Masero & Pe´rez-Hurtado, 2001; Warnock et al., 2002; Dias, 2009).
- Levees and associated shallow sheltered impoundments provide roosting and nesting opportunities (Ahearn 2012). They also provide shelter from prevailing winds (Warnock 2013).
- The large expanses of water and lack of tall vegetation allow for predator surveillance and avoidance and facilitate flight initiation (Masero et al., 2000 Masero & Pe´rez-Hurtado, 2001).

These conditions have been maintained for 60 years at Dry Creek, which untill recently provided a consistent flow regime through 4,000ha of salt ponds, ensuring a network of ponds with varying depths, topography, fluvial dynamics and salinity, ranging from marine conditions to hypersaline and support relatively simple but productive assemblages of algae and invertebrates (Carpelan, 1957; Lonzarich & Smith, 1997, Coleman 2009, Coleman pers coms). This variation is attractive to different species of shorebirds and waterbirds, each with a slightly different habitat preference predicated by diet, feeding apparatus and behaviour, and thus with different optimal conditions.

Associated areas of saltmarsh, mudflats, and tidal creeks form some of the most important shorebird habitat in the Saltfields. These saltmarsh and tidal creek habitats lie adjacent to the saltponds on the west side, are generally low lying and sheltered on the seaward side by mangroves, and the landward side by the embankments of saltponds. Saltmarshes and tidal creeks run almost the entire 25kilometre length of the western seaward side of the Dry Creek Saltfields. In addition, the northern extremity of the Middle Beach section is also bordered by saltmarsh, as is the area between the northernmost saltpond and Salt Creek. A wide variety of prey for shorebirds is available in these habitats including: gastropods, crustaceans, insects, worms, fish and frogs.

<u>Overall avian diversity:</u> 168

<u>Other avian values:</u>
Pelican, Bittern (EN EPBC), Spotless Crake, Peregrine Falcon, Glossy Ibis, Freckled Duck, White-bellied Sea-eagle, Elegant Parrot, Slender-billed thornbill.

Breeding waterbirds, gulls and terns. After breeding Australian Shellduck take refuge in the saltfields to undertake their annual moult. During this period thousands of vulnerable Shelduck occupy the islands and levees isolated from the threat of terrestrial predators.

(iii) Buckland Park Lake

NRM region: Adelaide & Mt Lofty Ranges.
Council: Playford City Council.
Tenure/Principal manager(s): Buckland Park Ltd Pty (Adelaide Resource Recovery). DEWNR

East of the final Section 4 ponds (XE 6 & 7) lies Buckland Park Lake 2 which was historically formed by damming the deltaic mouth of the Gawler River. The Lake is a shallow, ephemeral freshwater lake and is divided into a southern and northern basin. When full, the Lake consists of a relatively long (2 km) and narrow (0.4 km) stretch of open water. Several channels radiate from the Lake and penetrate into the surrounding lignum swamps on the east and northern boundaries. The southern bank is bordered by salina levees and the western banks are fringed by the Gawler River, which has its source over 40 km to the east, flows through both sites and forms a long, narrow estuary at Port Gawler.

The Lake was formed from the deposition of alluvial sediments from the Gawler River and is the site of a coastal perched aquifer. Floodwater from the Gawler River creates a lens of freshwater over saline groundwater. Here, regular surface water inflows have created a shallow perched freshwater system over a shallow saline water-table that is strongly influenced by the marine environment. The shallow aquifer is saline and not subject to use.

Buckland Park Lake - fills in winter from flows along the Gawler River which enters the lake via a channel from the south east corner. Water depth: Buckland Park Lake is relatively shallow and does not exceed 0.9 m when full; maximum depths in channels exceed 1.5 m. As the water level rises and the Lake overflows, water leaves the Lake via spillways and is channelled through the mangroves and out to sea. Water levels drop during spring (Sept.-Dec.) and rapidly dries up in summer once the Lake is pumped to remove saline water from the southern basin. Water salinity: Buckland Park Lake - 1-4 ppt TDS, in winter after the Lake has filled; 40-60 ppt TDS, in the Lake's southern basin in late summer (Paton et al. 1991).

Figure 56. Waterbird, tern and shorebird roost at Buckland Park Lake, 2011 as viewed from the south bank. Photo Chris Purnell

Shorebird Diversity: 15
Avg Abundance: N/A
Max Abundance: 165
Important shorebird species:
Threatened- Curlew Sandpiper, Black-tailed Godwit (Historic) Australian Painted Snipe
Regionally uncommon - Latham's Snipe, Common Sandpiper. (Historic), Wood Sandpiper, Pectoral Sandpiper, Ruff, Broad–billed Sandpipers Long-toed Stints
Breeding- Red-capped Plover, Black-winged Stilt,
Vagrants- Cox's Sandpiper, Baird's Sandpiper, and Little Ringed Plover.

Table 34. Buckland Park Lake Shorebird species list

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	7%	2	n/a
Banded Stilt	33%	150	n/a
Red-necked Avocet	27%	48	n/a
Black-winged Stilt	60%	37	n/a
Red-capped Plover	47%	44	n/a
Masked Lapwing	80%	17	n/a
Red-kneed Dotterel	27%	35	n/a
Black-tailed Godwit	7%	3	n/a
Sharp-tailed Sandpiper	53%	20	n/a
Curlew Sandpiper	20%	9	n/a
Red-necked Stint	33%	79	n/a
Latham's Snipe	7%	1	n/a
Common Sandpiper	47%	3	n/a
Common Greenshank	67%	5	n/a
Marsh Sandpiper	13%	2	n/a

Table 35. Threats Buckland Park Lake.

Shorebird prey: Crustaceans, insects, spiders, water mites and worms.

Habitat Use:
Shorebird populations in and around the lake depend both on its level and the timing of its inundation (Figure 13). Due to reduced environmental flows and accumulated sediment (among other factors), the lake has changed from being a permanent wetland to being ephemeral (P. Coleman and R. Attwood pers. Comm).

The lake occasionally fills during winter, and by late spring the effects of evaporation and seepage sometimes cause the water level to recede to an attractive depth for shorebirds. Under these conditions, muddy edges suitable for shorebird foraging are revealed, coinciding with an increase in invertebrate abundance and accessibility, just as migratory shorebirds arrive.

The shallow unvegetated banks in the southern basin 2 support the highest accumulations of shorebirds during spring and summer. Low sedge fringed areas of the eastern and northern banks are used by freshwater waders (stilt and avocet) and likely support Latham Snipe which may go undetected.

Threat									
Liklehood	3	0	3	2	2	3	0	3	2
Scope	2	0	2	2	1	1	0	2	2
Severity	3	0	1	0	2	0	0	1	1
Overall impact	8	0	6	4	5	4	0	6	5

Habitat loss – changing hydrological regime.
Domestic and introduced fauna- Fox, rat and cat impacts from nearby agricultural areas
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Native vegetation- Casuarina woodland precludes use of western shoreline by shorebird & creates roost sites for raptors.
Native birds- Silver Gull predation of resident chicks increased by local breeding
Bird Strikes - electrical wires
Pollution- Potential effect of acid sulphate soils and sulfidic black ooze

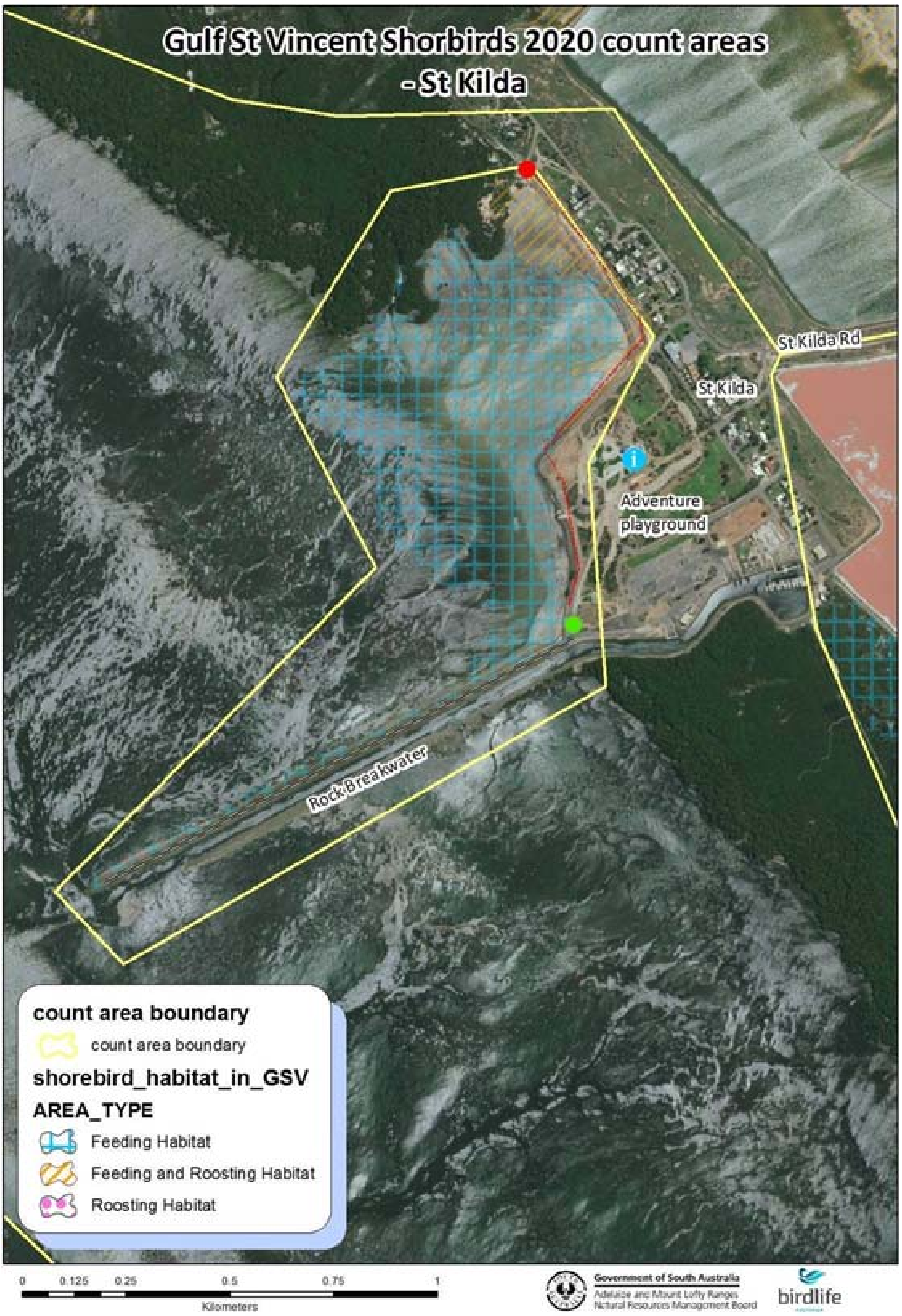
Relative importance:
As the only semi natural freshwater wetland on the Adelaide Plains, Buckland Park Lake provides a unique wetland environment preferred by marsh species (Stilt, Avocet, Snipe, Black-tailed Godwit, and Marsh, Curlew and Sharp-tailed Sandpipers). It is also the largest and most important breeding habitat for waterbirds on the Adelaide Plains (Anderson 2009).
The wetting and drying of the lake creates pulses in productivity and gradual draw-down promotes a temporal mosaic of habitats which benefit several shorebird feeding guilds. Vegetation communities surrounding the lake also provide cover and foraging habitat for Latham's Snipe and Australian Painted Snipe.

Overall avian diversity: 110

Other avian values:
Crested-Shrike Tit, Blue-billed Duck, Freckled Duck, Baillon's Crake, Buff-banded Rail, Glossy Ibis, White-bellied Sea-eagle, Perrine Falcon, Slender-billed thornbill.

(g) St Kilda

NRM region: Adelaide & Mt Lofty Ranges.
Council: Salisbury City Council.
Tenure/Principal manager(s): Buckland Park Ltd Pty (Adelaide Resource Recovery). DEWNR



Map 10. St Kilda shorebirds 2020 count area

St Kilda historically consisted of three low-lying islands that were covered with shell grit and saltmarsh, and were surrounded by mangroves and saltmarsh. However, with the establishment of a coastal township, and associated marina and the adjacent Dry Creek Saltfields, there has been a drastic loss of natural habitat (Coleman and Cook 2003).

The tidal flats of Saint Kilda are bordered by mangroves to the north, the marina breakwater to the south and constrained by the town seawall to the east.

Table 36. Shorebird habitat type within the St Kilda count area.

Habitat type	ha	% cover	priority	Protection
Intertidal Seagrass - Patchy	34.12	94.98	1	ADS
Intertidal Mangrove - Intact	1.11	3.11	2	ADS
Intertidal Mangrove - Dieback	0.09	0.25	1	ADS
Intertidal Samphire - Intact	0.26	0.72	1	ADS
Total	35.58	100		

Figure 57. Banded Stilt feeding on the tidal flat at Saint Kilda seafront. Photo: Chris Purnell

Shorebird Diversity: 20
Avg Abundance: 2,227
Max Abundance: 8,064
Important shorebird species:
Abundance-
Threatened- Curlew Sandpiper, Black-tailed Godwit, Eastern Curlew
Regionally uncommon -Common Sandpiper, Pectoral Sandpiper.
Breeding- Red-capped Plover.

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Table 37. St Kilda Shorebird species list

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	27%	10	3
Sooty Oystercatcher	43%	20	6.71
Banded Stilt	51%	5000	1024
Red-necked Avocet	8%	350	0
Black-winged Stilt	57%	150	49
Grey Plover	5%	28	0
Red-capped Plover	49%	450	139
Banded Lapwing	3%	4	0
Masked Lapwing	78%	60	6
Red-kneed Dotterel	8%	35	0
Eastern Curlew	3%	7	0
Bar-tailed Godwit	5%	12	0
Black-tailed Godwit	3%	12	0
Sharp-tailed Sandpiper	27%	550	93
Curlew Sandpiper	22%	100	14.3
Red-necked Stint	51%	3,000	488
Pectoral Sandpiper	3%	1	0
Common Sandpiper	5%	1	0
Common Greenshank	51%	60	10.7
Marsh Sandpiper	8%	25	6.43

Shorebird prey: Gastropods, crustaceans, insects, worms, bivalves, bryozoans, cnidarians, echinoderms and fish.

Habitat Use:
Low tide - the tidal flats of the Saint Kilda foreshore are often used by high concentrations of shorebirds feeding on the tides edge.

High tide – the town seawall precludes birds from roosting on the foreshore. Small densities of shorebirds may roost on rocks fringing the seawall and breakwater.

Table 38. Threats St Kilda.

Threat									
Liklehood	3	3	3	2	0	1	0	3	1
Scope	2	3	2	2	0	1	0	2	1
Severity	2	2	1	0	0	0	0	1	1
Overall impact	7	8	6	4	0	2	0	6	3

Habitat loss – lack of retreat zone in the event of sea-level rise.
Disturbance- High use recreational area (dog walkers, fisherman, bait collectors, kite flyers, drones.)
Domestic and introduced fauna- Dogs and cats from local community and visitor.
Bird Strikes - electrical wires
Pollution- Runoff from the town. Oil spill or bilge pollution form marina

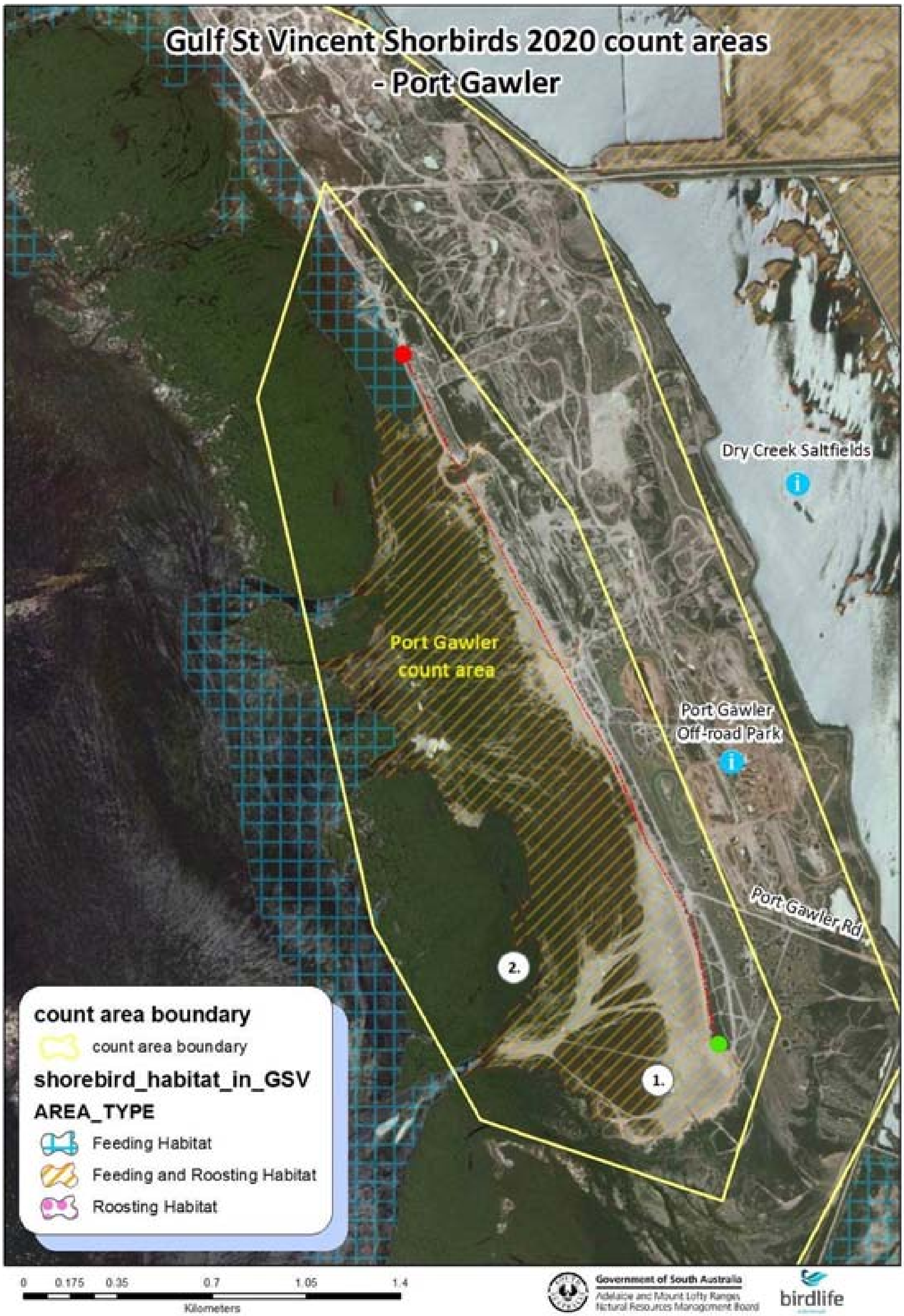
Relative importance:
Although small, the Saint Kilda foreshore is the closest intertidal habitat to high value shorebird habitat in Section 3 of the Dry Creek Saltfields and Section Banks adding to the important mosaic of sites in the Dry Creek region.

Overall avian diversity: 115

Other avian values: Little Egret, Glossy Ibis, Darter, Peregrine Falcon, White-bellied Sea-Eagle, Elegant Parrot, Samphire Thornbill

(h) Port Gawler

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR



Map 11. Pt Gawler shorebirds 2020 count area

North of the Gawler River, west of Section 4 of the Dry Creek Saltfields and the Port Gawler Off-road Park, Port Gawler shorebird habitat area consists of vast sandy tidal flats fringed by prograding mangrove forests that are crossed by a multitude of tidal channels. Shell-grit ridges occur along a well-defined belt within the mangrove forest. The southern channel is extensively used as a boat launch which is access by driving across the tidal flat (between ①&②). 0ver 75% of the tidal flat is now colonised by saltmarsh and/or mangrove saplings (Section 1.01(e).

To the east, within 500 metres of the area, lie extensive shallow salt evaporation ponds. A saltmarsh samphire community occupies the area between the mangroves and the evaporation ponds (Coleman 2014).

The Two Wells District Council and Trade Association have, in association with the WWF, identified the area as being important for shorebirds as part of a national Shorebird project supported by the Australian Government in the early 2000's.

Figure 58. Dirt bike riders disturb Red-necked Stint on Pt Gawler intertidal. Photo Chris Purnell

Table 39. Shorebird habitat type within the Pt Gawler count area.

Habitat type	ha	% cover	priority	Protection
Intertidal Mangrove - Intact	2.06	1.67	3	Pt Gawler CP/UGSV MP/AIBS
Intertidal Mangrove - Prograding	0.85	0.69	3	Pt Gawler CP/UGSV MP/AIBS
Intertidal Samphire - Intact	5.11	4.13	1	Pt Gawler CP/UGSV MP/AIBS
Intertidal Sandflat Bare - Marine	49.2	39.79	1	Pt Gawler CP/UGSV MP/AIBS
Intertidal Seagrass - Patchy	0.88	0.72	1	Pt Gawler CP/UGSV MP/AIBS
Intertidal Seagrass - Uniform	59.64	48.21	1	Pt Gawler CP/UGSV MP/AIBS
Supratidal Samphire - Degraded	0.5916	0.48	3	Pt Gawler CP/UGSV MP/AIBS
Tidal Stream Bare	0.2224	0.18	1	Pt Gawler CP/UGSV MP/AIBS
Grand Total	123.71	100.00		

Shorebird Diversity: 23
Avg Abundance: 441
Max Abundance: 6,964
Important shorebird species:
Abundance- Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP)
Threatened- Eastern Curlew, Curlew, Sandpiper, Bar-tailed Godwit, Red Knot, Great Knot, Lesser Sand Plover.
Regionally uncommon- Whimbrel, Terek Sandpiper, Lesser Sand Plover

Table 40. Pt Gawler Shorebird species list

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	14%	4	1
Banded Stilt	7%	5062	37
Red-necked Avocet	4%	8	0
Black-winged Stilt	7%	72	7
Grey Plover	39%	22	4
Red-capped Plover	79%	279	54
Double-banded Plover	7%	4	0
Lesser Sand Plover	4%	3	0
Black-fronted Dotterel	4%	1	0
Masked Lapwing	71%	29	4
Red-kneed Dotterel	11%	50	7
Whimbrel	4%	2	1
Eastern Curlew	29%	13	6
Bar-tailed Godwit	4%	8	1
Ruddy Turnstone	11%	8	1
Red Knot	14%	4	1
Sharp-tailed Sandpiper	64%	155	11
Curlew Sandpiper	25%	81	1
Red-necked Stint	79%	1450	265
Terek Sandpiper	7%	1	0
Common Sandpiper	7%	3	0
Common Greenshank	57%	41	9
Marsh Sandpiper	4%	6	0

Shorebird prey: Gastropods, crustaceans, insects, worms, bivalves, bryozoans, cnidarians, echinoderms and fish

Habitat Use:
Low tide –
Shorebirds of all sizes feed on the open sandy flats (1) enclosed by the mangrove forest and in low saltmarsh and amongst prograding mangrove shooters (2).

High tide –Shorebirds roosting the saltmarsh or move into the saltfields. Large waders such as Eastern Curlew may remain to roost in the higher sand ridges of the southern beach (1).

Table 41. Threats Pt Gawler.

Threat									
Liklehood	3	3	3	0	3	3	3	0	2
Scope	2	3	2	0	2	1	2	0	2
Severity	3	2	1	0	3	0	1	0	1
Overall impact	8	8	6	0	8	4	6	0	5

Habitat loss - ORV habitat destruction
Disturbance – high intensity ORV presence.
Domestic and introduced fauna – Fox and cat.
Native plants- prograding mangrove forest and saltmarsh community
Human induced mortality- Crushing of Red-capped Plover (chicks and nests) by ORVs.
Pollution- fishing line entanglement, dumping of automotive parts and fluids.

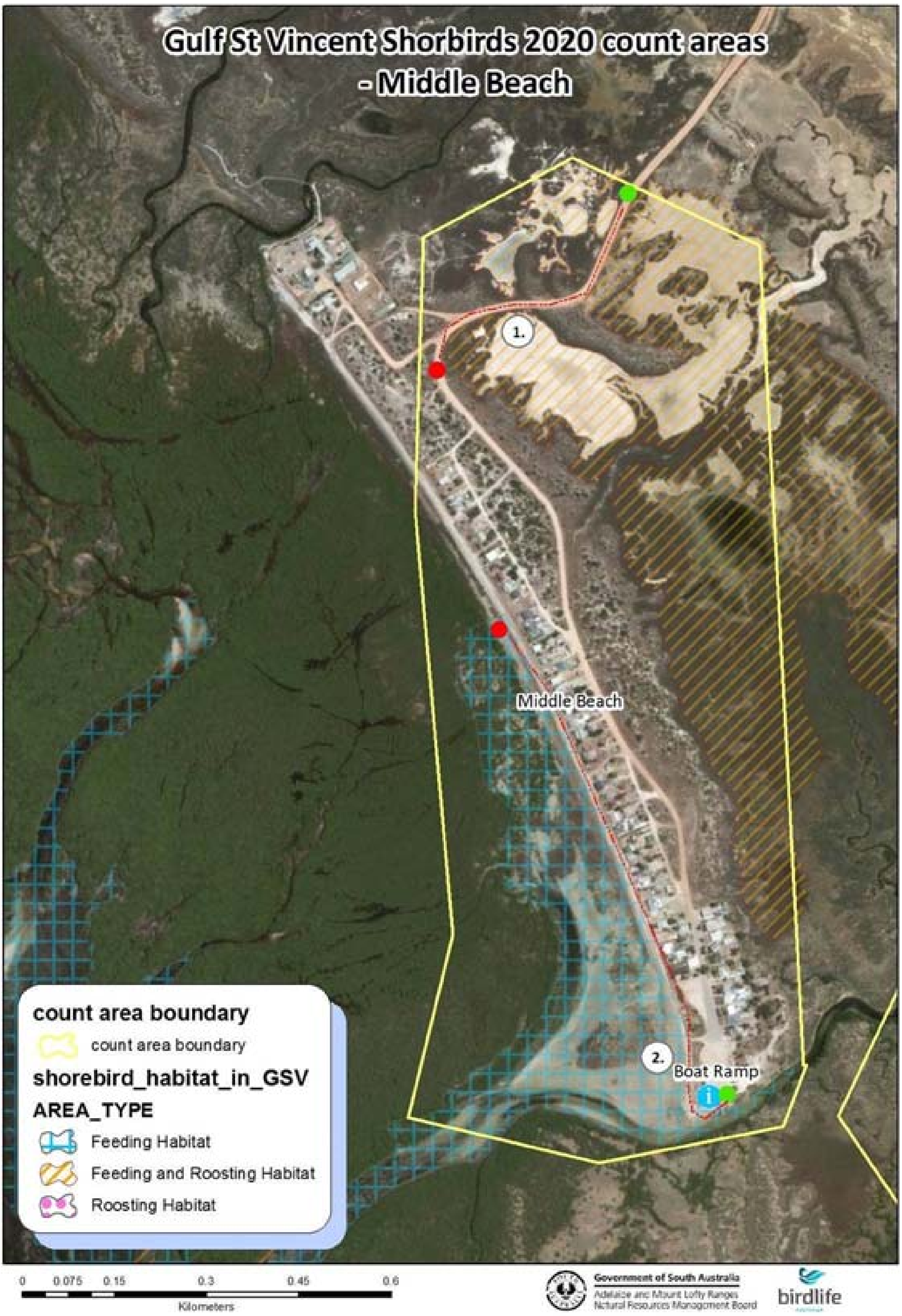
Relative importance:
Port Gawler intertidal area has traditionally been a significant area for shorebirds, providing highly accessible alternate feeding habitat for birds occupying the marine pond of Dry Creek's Section 4 during high tide however an increase in disturbance and vegetation cover in the area has resulted in available habitat and use of what remains.

Overall avian diversity: 85

Other avian values: Intermediate Egret, Little Egret, Elegant Parrot, Samphire Thornbill

(i) Middle Beach

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council,



Map 12. Middle Beach shorebirds 2020 count area

The 1.2 km long beach is enclosed by mangroves except for the mouth of Salt Creek which is used as a boating channel at high tide. Open sandy flats are more prevalent in the south around the creek. Houses are built on the foredune, and some back onto areas of low-lying saltmarsh and saltpans

The small coastal community has a population of 367 residents. Visitation to the area by tourists is quite low due to the encompassing mangroves which separate the small sandy beach from the ocean, though the boat launch is regularly used by visiting fishermen.

Table 42. Shorebird habitat type within the Middle Beach count area.

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Vegetated - Intact	2.7921	2.87	3	AIBS
Intertidal Flat Bare - Terrestrial	4.483	4.61	1	UGSV MP
Intertidal Mangrove - Intact	0.9602	0.99	3	UGSV MP
Intertidal Samphire - Intact	58.2806	59.95	2	UGSV MP
Intertidal Sandflat Bare - Marine	9.1752	9.44	1	UGSV MP
Supratidal Samphire - Intact	20.3736	20.96	2	
Tidal Stream Bare	0.5524	0.57	1	UGSV MP
Grand TOTAL	97.2226	100.00		

Shorebird Diversity: 10
Avg Abundance: 57
Max Abundance: 148
Important shorebird species:
Threatened - (historic) Lesser Sand Plover
Regionally uncommon – Grey-tailed Tattler

.

Table 43. Middle Beach Shorebird species list

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	30%	2	1
Banded Stilt	10%	140	23
Black-winged Stilt	10%	20	3
Red-capped Plover	30%	50	7
Masked Lapwing	60%	6	4
Sharp-tailed Sandpiper	40%	11	1
Red-necked Stint	20%	80	13
Grey-tailed Tattler	10%	1	0
Common Greenshank	80%	19	3
Marsh Sandpiper	10%	1	0

Shorebird prey:
Gastropods, crustaceans, insects, worms, bivalves, bryozoans, cnidarians, echinoderms and fish

Habitat Use:
Low tide –
Shorebirds feed along the shoreline with higher densities occurring on the open tidal flats around the creek opening (2) than the low samphire.

High tide –
Shorebirds that remain roost or continue feeding in the saltmarsh to the north of the intertidal area. When conditions are suitable shorebirds may roost or feed in the claypans to the north east of the township (1).

Table 44. Threats Middle Beach

Threat									
Liklehood	2	3	3	0	1	0	0	0	2
Scope	1	3	2	0	1	0	0	0	1
Severity	1	2	1	0	1	0	0	0	0
Overall impact	4	8	6	0	3	0	0	0	3

Habitat loss – intertidal habitat damage by ORV & boat launching
Disturbance – ORV & boat launching, dog walking
Domestic and introduced fauna - Fox, rat and cat impacts from nearby agricultural areas
Native plants- mangrove incursion
Pollution- boat bilge and fuel spills.

<u>Relative importance:</u>
Middle Beach intertidal provides occasional supplemental habitat in the case preferential habitat is not available.

<u>Overall avian diversity:</u> 84

<u>Other avian values</u>: fairy Tern, Little Egret, Elegant Parrot, Samphire Thornbill.

Figure 59. The Middle Beach tidal flat is used as a popular boat launch. Photo: NRM AMLR

Northern Beaches of the Samphire Coast

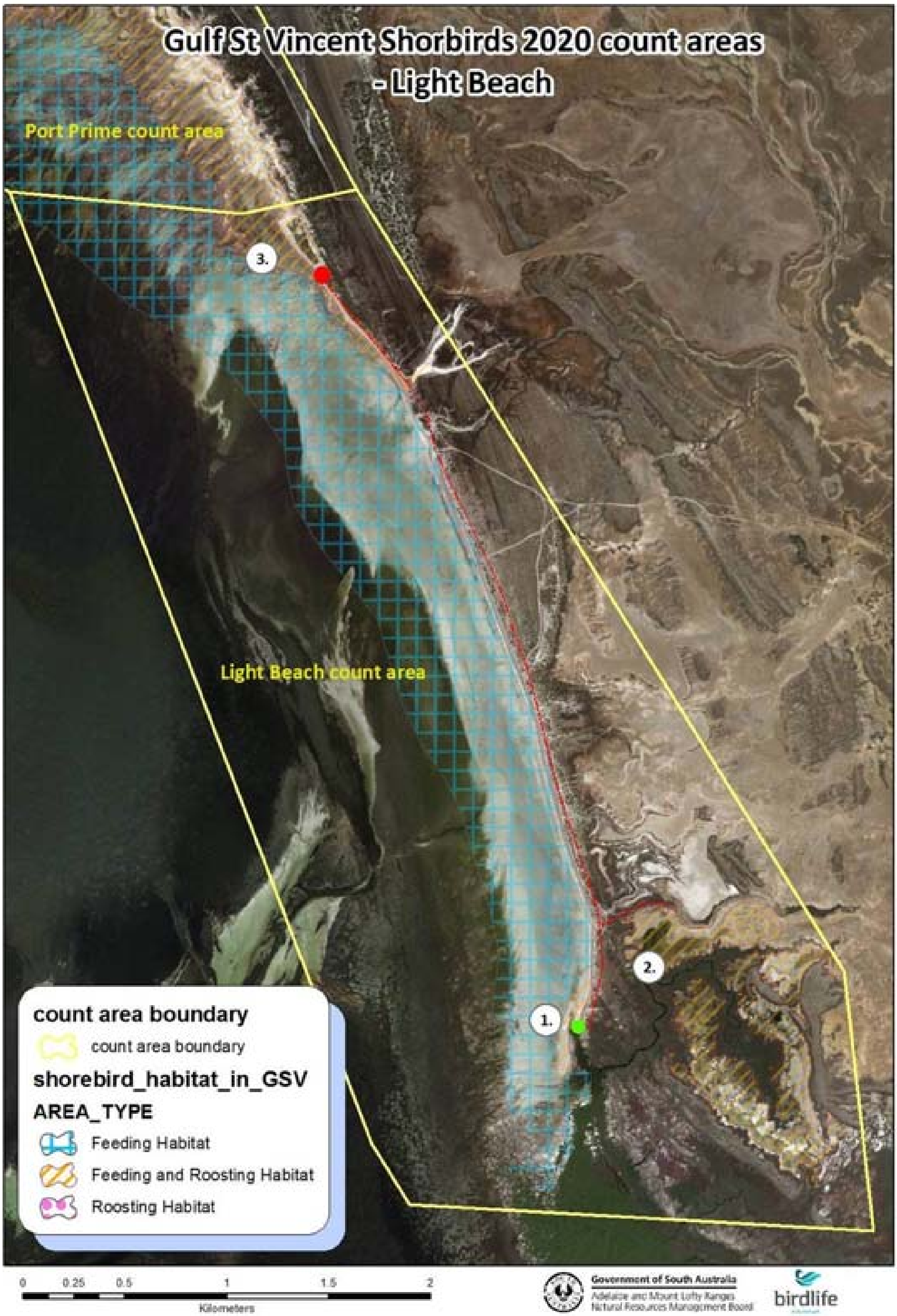
North of Middle Beach, the mangrove-dominated intertidal area gives way to open tidal flats and sandy beaches. Accumulatively; the intertidal habitat found at Light Beach, Port Prime, Thompsons Beach, Webb Beach, Port Parham, the Proof and Experimental Establishment* and Bald Hill represents the most significant unit of natural habitat remaining in Gulf St Vincent. The boundaries of these beaches and associated coastal towns are bookended by a number of tidal creeks which cross-cut low coastal dunes and feed extensive saltmarsh and claypan-lagoon systems. Beyond the reach of the tide large areas of supratidal claypans (Sabkhas) are the dominant habitat used by shorebirds (Section 1.02).

These beaches create a continuous habitat for various species of shorebirds that specialise in foraging in intertidal flats, and they may utilise any of these count areas, resulting in variation in count data[14]. These beaches are unique in that they provide relatively high densities of some shorebird prey species such as shellfish which in turn support the high numbers of bivalve specialists like Red Knot. Other prey species in the area include: gastropods, crustaceans, insects, worms, bryozoans, cnidarians, echinoderms and fish.

[14] Given the regular movement of birds between sites throughout the northern beaches, species abundances quoted for the following sites should not be considered as separate populations, but rather maximums each site may support (e.g., it is assumed that there is one relatively coherent flock of Red Knot using the northern beaches. The flock of < 2,500 birds is readily observed at several sites and management must accommodate their occasional occurrence at any one site within a season. Gulf wide population data is discussed further in Section 3.04.

(j) Light Beach

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council.



Map 13. Light Beach shorebirds 2020 count area

Light Beach is the most southerly stretch of shellgrit sandy beach that remains open to the gulf (not bound by mangrove) on the samphire coast. It is bordered to the south by the dense mature mangrove forests which line the tidal creeks of the Light River delta. Mangroves at the southern end of the beach create a small sheltered bay which is dotted with small islands and sand ridges which extend into the intertidal area ①. Some of these islands are covered in low saltmarsh (Figure 62).

Accumulations of seagrass wrack become denser to the northern end of Light Beach. A large island of wrack which extends over 3km north to Pt Prime blanketing the intertidal 800m from the dune into the tidal flats (Figure 8).

Light Beach's extensive network claypans of southern claypans ② are fed by both evaporative pumping and tidal influence.

Direct access to Light Beach is restricted by a locked gate on Light Beach Rd. however fences and gates may regularly be cut for access by ORV users. Access by the coast, via Pt Prime, is restricted by an impenetrable band of sea wrack.

Table 45. Shorebird habitat type within the Light Beach count area.

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Bare	0.06	0.03	3	AIBS
Chenier / Beach Ridge Vegetated - Degraded	0.77	0.32	3	AIBS
Chenier / Beach Ridge Vegetated - Intact	5.38	2.19	3	AIBS
Intertidal Flat Bare - Terrestrial	0.49	0.20	1	AIBS
Intertidal Mangrove - Intact	2.11	0.86	3	UGSV MP/AIBS
Intertidal Rotten Spot	1.19	0.49	1	AIBS
Intertidal Samphire - Intact	3.73	1.52	1	AIBS
Intertidal Sandflat Bare - Marine	178.83	72.67	1	UGSV MP/AIBS
Intertidal Seagrass - Patchy	2.95	1.20	1	UGSV MP/AIBS
Intertidal Seagrass - Uniform	20.3	8.25	1	UGSV MP/AIBS
Supratidal Rotten Spot	0.54	0.22	1	AIBS
Supratidal Samphire - Intact	27.85	11.32	1	AIBS
Tidal Stream Bare	0.4	0.16	1	UGSV MP/AIBS
Supratidal Flat Bare	1.17	0.48	1	AIBS
Total	246	100		

Figure 60. Pied Oystercatcher feeding at Light Beach. Photo: Chris Purnell

Shorebird Diversity: 18
Avg Abundance: 2,900
Max Abundance: 9,747
Important shorebird species:
Abundance- Red Knot (> 1% EFP), Grey Plover (>0.1% EFP), Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP), Curlew Sandpiper (>0.1% EFP), Common Greenshank (>0.1% EFP).
Threatened- Eastern Curlew, Curlew, Sandpiper, Bar-tailed Godwit, Red Knot, Great Knot, Lesser Sand Plover.
Breeding- Red-capped Plover

Table 46. Shorebird species list for Light Beach

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	91%	32	14
Banded Stilt	77%	6600	1941
Black-winged Stilt	14%	60	9
Pacific Golden Plover	1%	1	0
Grey Plover	45%	121	25
Red-capped Plover	95%	1,000	163
Double-banded Plover	9%	1	0
Banded Lapwing	5%	90	19
Masked Lapwing	73%	25	11
Red-kneed Dotterel	9%	30	0
Eastern Curlew	55%	27	6
Bar-tailed Godwit	5%	25	0
Great Knot	23%	70	7
Red Knot	41%	2500	106
Sharp-tailed Sandpiper	50%	200	43
Curlew Sandpiper	41%	74	6
Red-necked Stint	95%	1860	524
Common Greenshank	95%	80	27

Habitat Use:
Low tide – a large abundance of shorebirds disperse across the extensive, open tidal flats and seagrass beds at low tide.

High tide – Small shorebirds arrive from neighbouring beaches and unknown areas to the south to continue to feed along the tide edge and raised ridges and islands at the southern end of the beach (1).

On larger tides small waders retreat to the large southern claypan (2) to roost or continue feeding. This area receives occasional tidal influence and regular evaporative pumping and supports dense cyanobacterial and algal mats. Medium and Large shorebirds roost in the small bay. Red-capped Plovers breed in the claypans.

Figure 61. Red-necked Stint and Sharp-tailed Sandpiper feed on inundated claypans at Light Beach. Photo Chris Purnell

Table 47. Threats Light Beach.

Threat									
Liklehood	2	1	1	0	0	0	1	0	0
Scope	0	1	1	0	0	0	1	0	0
Severity	1	1	1	0	0	0	1	0	0
Overall impact	3	3	3	0	0	0	3	0	0

Habitat Loss or degradation -ORV damage on sabkhas
Disturbance – recreational ORV drivers, crabbers and bait collectors have accessed the beach by illegally gutting access locks.
Domestic and introduced fauna - Fox, rat and cat impact from nearby agricultural areas
Human induced Mortality- ORV crushing of nesting Red-capped Plover.

Relative importance:
Light Beach is an important section of the northern beaches in maintaining sufficient feeding and roosting opportunities for a high density of birds. Access restrictions to the area ensure that shorebirds remain undisturbed throughout the tide cycle. Large flocks of Knot and Godwit are often observed retreating to Light Beach when subjected to high levels of disturbance on the more populated beaches to the north.

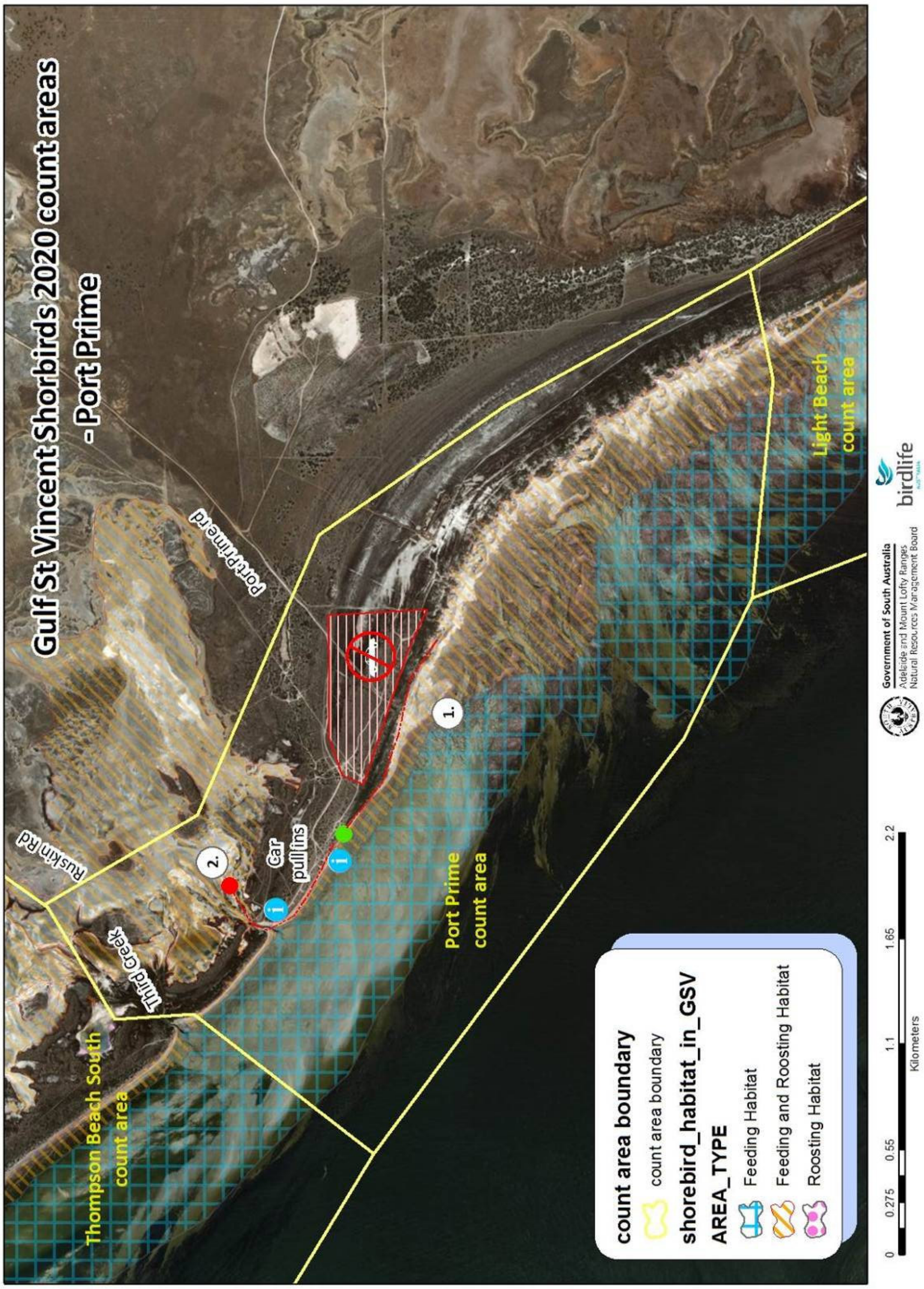
Overall avian diversity: 69

Other avian values: Samphire Thornbill, White-bellied Sea eagle, Peregrine Falcon, Fairy Tern.

Figure 62. Sharp-tailed Sandpiper and Banded Stilt roost on a small samphire cover island at high tide at Light Beach. Photo Chris Purnell

(k) Port Prime

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council.



Map 14. Port Prime shorebirds 2020 count area

Port Prime is a shellgrit sandy beach accessible by gravel road. The extensive tidal flat is a mix of fine sand and muddy substrate. The northern section of the dune is cross-cut by two tidal creeks the northern of which, Third Creek forms the border to Thompson Beach.

The southern section of tidal flat and beach is dominated by a large accumulation of seagrass wrack which forms an island ①. Depending on conditions this island can exceed 6 hectares in extent (Section 1.01(g), Figure 63).

Third Creek, and the unnamed creek 1km to its south, feed an extensive network of tidal claypans ②. Still further claypans (sabkas) are fed by evaporative pumping.

Figure 63. A large flock of Red and Great Knot arrive to feed and roost on the soft mud bordering the Port Prime weed mat. Photo Chris Purnell

Table 48. Shorebird habitat type within the Port Prime count area.

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Vegetated - Degraded	2.54	0.84	3	AIBS
Chenier / Beach Ridge Vegetated - Intact	0.21	0.07	3	AIBS
Intertidal Rotten Spot	2.64	0.88	1	AIBS
Intertidal Saline Patch Bare	2.71	0.90	1	AIBS
Intertidal Samphire - Intact	5.44	1.80	1	AIBS
Intertidal Sandflat Bare - Marine	246.77	81.85	2	UGSV MP/AIBS
Intertidal Seagrass - Uniform	7.40	2.45	1	UGSV MP/AIBS
Supratidal Saline Patch Bare	12.10	4.01	1	AIBS
Supratidal Samphire - Intact	20.90	6.93	3	AIBS
Total	301.48	100.00		

Shorebird Diversity: 17
Avg Abundance: 1,633
Max Abundance: 4,256
Important shorebird species:
Abundance- Great Knot (>0.1% EFP), Red Knot (>0.1% EFP), Grey Plover (>0.1% EFP), Ruddy Turnstone (>0.1% EFP), Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP), Curlew Sandpiper (>0.1% EFP).
Threatened- Eastern Curlew, Curlew, Sandpiper, Bar-tailed Godwit, Red Knot, Great Knot, Greater Sand Plover.
Breeding- Red-capped Plover

Habitat Use:
Low tide – Shorebirds feed throughout low tide on the open tidal flat. Small waders including stint, Red-capped Plover, sandpipers and Ruddy Turnstone may remain feeding close to shore in sheltered channels created between weed accumulations

High tide – Shorebirds roost or continue feeding along the weedy shoreline, on the floating weed (2), or along the sandy banks of Third Creek. Smaller shorebirds my retreat to the adjacent claypans (1) to feed or roost.

Table 49. Port Prime Shorebird species list

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	36%	38	7
Sooty Oystercatcher	4%	1	0
Banded Stilt	16%	1210	292
Grey Plover	76%	80	0
Pacific Golden Plover	4%	1	18
Red-capped Plover	64%	430	104
Greater Sand Plover	4%	1	0
Masked Lapwing	56%	20	2
Eastern Curlew	16%	14	0
Bar-tailed Godwit	44%	275	32
Ruddy Turnstone	60%	30	10
Great Knot	24%	750	290
Red Knot	44%	977	264
Sharp-tailed Sandpiper	40%	300	26
Curlew Sandpiper	48%	500	18
Red-necked Stint	76%	2000	566
Common Greenshank	40%	58	4

Table 50. Threats Port Prime

Threat									
Liklehood	2	3	3	0	0	0	0	1	0
Scope	0	3	2	0	0	0	0	1	0
Severity	1	3	1	0	0	0	0	1	0
Overall impact	3	9	6	0	0	0	0	3	0

Threats
Habitat loss – ORVs; Cars accessing intertidal and beach, motorbikes readily access claypans.
Disturbance – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna – Dogs accompanying recreational visitors. Fox, rat and cat impacts from nearby agricultural areas

Human induced mortality- Crushing of Red-capped Plover chicks by ORVs

Relative importance:
Port Prime is an important section of the northern beaches in maintaining sufficient feeding and roosting opportunities for high densities of birds. Flocks of Bar-tailed Godwit and Red Knot, which are regularly observed on the northern beaches, utilise the floating weed mat as a safe high-tide roosting and feeding site.

Overall avian diversity: 81

Other avian values: Samphire Thornbill, Fairy Tern, White-bellied Sea-Eagle, Little Egret, Intermediate Egret, Elegant Parrot.

(l) Thompson Beach North

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council.

Map 15. Thompson Beach south shorebirds 2020 count area

Thompson Beach is a small coastal town with a semi-permanent population of around 300. The local Progress Association is involved in advocacy, on-ground actions and awareness raising related to shorebird conservation. Thompson Beach is a flagship location for the Adelaide International Bird Sanctuary and is a well-recognised fishing and crabbing destination. The town is accessed by a public paved road.

Thompson Beach is split into 2 count areas for logistical purposes. Thompson Beach South is bordered by Third Creek in the south and Ruskin Road boat ramp in the north. The extensive sandy tidal flats and shellgrit beach are largely open ②, however can be subject to large deposits of seagrass wrack which regularly accumulate around a small stand of mangroves ①. Mangroves in the area are <2m high and sparsely dispersed.

An extensive system of claypans ⑤ receives an intermittent tidal exchange through Third Creek. On neap tides or in dry conditions many of these sabkas remain connected to tidal hydrology via evaporative pumping. Vehicle access to the southern claypans is restricted by maintained fences and bollards funded via NRM.

The southern tidal flats and claypans can be accessed via the Third Creek interpretive trail which has been maintained by the Adelaide Plains City Council in association with AMLR NRM Board and the local Progress Association. The trail area is now incorporated into the AIBS National Park managed by DWENR.

Figure 64. Pied Oystercatchers and thousands of Banded Stilt (background) feed amongst roosting terns and cormorants on the intertidal sand flats north of Third Creek. Photo Chris Purnell

Table 51.Shorebird habitat type within the Thompson Beach south count area.

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Vegetated - Intact	8.24	3.06	3	AIBS
Intertidal Rotten Spot Total	0.08	0.03	1	AIBS
Intertidal Saline Patch Bare Total	25.28	9.38	1	AIBS
Intertidal Samphire - Intact Total	7.85	2.91	2	AIBS
Intertidal Sandflat Bare - Marine Total	70.78	26.26	1	UGSV MP
Intertidal Seagrass - Patchy Total	71.99	26.71	1	UGSV MP
Intertidal Seagrass - Uniform Total	63.44	23.54	1	UGSV MP

Supratidal Samphire - Intact Total	21.86	8.11	3	AIBS
Grand Total	269.53	100.00		

Shorebird Diversity: 24
Avg Abundance: 2120
Max Abundance: 3290
Important shorebird species:
Abundance- Red Knot (>1% EFP), Great Knot (>0.1% EFP), Bar-tailed Godwit (>0.1% EFP), Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP), Common Greenshank (>0.1% EFP).
Threatened- Eastern Curlew, Curlew, Sandpiper, Bar-tailed Godwit, Red Knot, Great Knot, Lesser Sand Plover.
Breeding- Red-capped Plover

Table 52. Thompson Beach south Shorebird species list

Common Name	RR (%)	Max	avg
Pied Oystercatcher	17.24%	17	10
Sooty Oystercatcher	6.90%	6	0
Banded Stilt	32.76%	1000	478
Red-necked Avocet	3.45%	7	0
Black-winged Stilt	1.72%	11	2
Grey Plover	77.59%	30	16.429
Pacific Golden Plover	13.79%	2	1
Red-capped Plover	74.14%	353	90.143
Double-banded Plover	3.45%	2	0
Lesser Sand Plover	15.52%	5	0
Banded Lapwing	1.72%	4	0
Masked Lapwing	53.45%	19	4.5714
Eastern Curlew	3.45%	9	1
Bar-tailed Godwit	53.45%	605	96
Black-tailed Godwit	12.07%	3	0
Ruddy Turnstone	70.69%	24	6
Great Knot	37.93%	800	10
Red Knot	58.62%	1480	609
Sharp-tailed Sandpiper	43.10%	240	60
Curlew Sandpiper	31.03%	86	20
Red-necked Stint	86.21%	3103	539
Common Sandpiper	1.72%	2	0
Common Greenshank	77.59%	196	90
Marsh Sandpiper	1.72%	4	0

Habitat Use:
Low tide - Shorebirds feed throughout low tide on the open tidal flat. High use areas include the sandy flats and spit north of Third Creek (between (2) and (3)) and the around the small stand of mangroves(1). Some species (Common Greenshank and Sandpipers) may remain roosting amongst mangrove roosts throughout the low tide. Small waders including stint, Red-capped Plover, sandpipers and Ruddy Turnstone may remain feeding close to shore, while larger species follow the tide line.

High tide – Bar-tailed Godwit have been observed roosting on the sheltered banks of one lagoon defined as an *intertidal rotten spot* (4)in DEWNR habitat mapping.

Table 53. Threats Thompson Beach south

Threat									
Liklehood	2	3	3	0	0	0	0	1	1
Scope	0	3	2	0	0	0	0	1	1
Severity	1	3	1	0	0	0	0	1	1
Overall impact	3	9	6	0	0	0	0	3	3

Habitat loss – ORVs: Cars accessing intertidal and beach. Motorbikes readily access claypans.
Disturbance – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna – Dogs accompanying recreational visitors. Fox, rat and cat impacts from nearby agricultural areas
Human induced mortality- Crushing of Red-capped Plover chicks by ORVs or birdwatchers
Pollution- entanglement or ingestion of fishing refuse.

Relative importance: Thompson Beach is an important section of the northern beaches in maintaining sufficient feeding and roosting opportunities for high densities of birds. It is a key feeding and roosting area for Red Knot and Grey Plover and Bar-tailed Godwit.

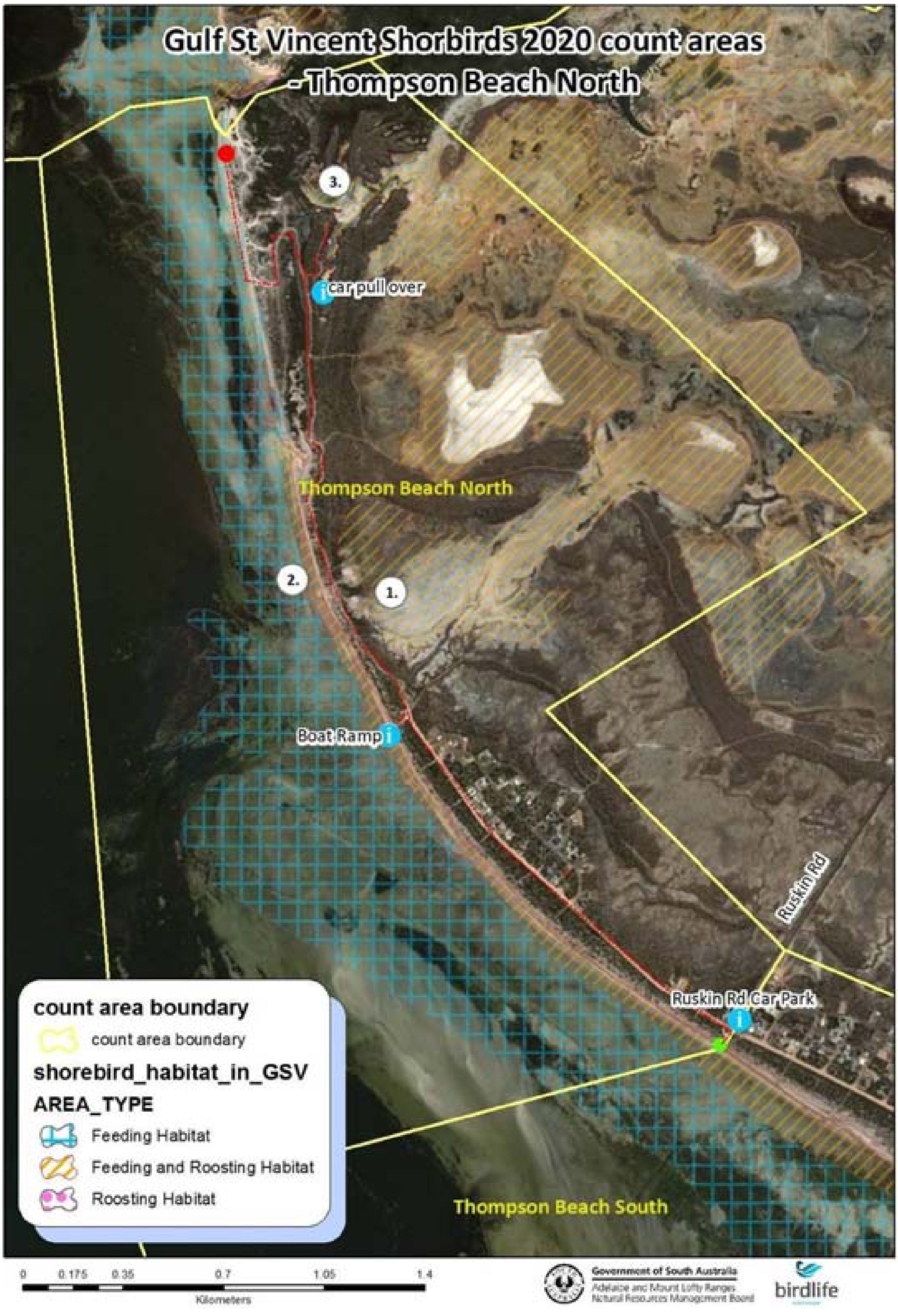
The extensive network of sabkas provides increasingly important high-tide feeding and roosting habitat and retreat habitat in the case of climate change.

Overall avian diversity: 112

Other avian values: Samphire Thornbill, Fairy Tern, White-bellied Sea-Eagle, Little Egret, Intermediate Egret, Elegant Parrot.

(m) Thompson Beach North

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council



Map 16. Thompson Beach north shorebirds 2020 count area

Intertidal and beach substrates at Thompson Beach north are predominantly sandy. Volume and extent of seagrass wrack in the tidal zone are variable dependant on local and regional conditions but does form small islands around tidal creeks and small inlets ②.

An extensive system of claypans receives an intermittent tidal exchange through Baker Creek ③ and a small inlet which is regularly gouged open by spring tides and storm surges ②. On neap tides or in dry conditions many of these sabkas remain connected to tidal hydrology via evaporative pumping.

Figure 65. Red-necked Stint roost on small islands of wrack at high tide. Photo Chris Purnell

Table 54. Shorebird habitat type within the Thompson Beach north count area

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Vegetated - Intact	3.93	2.03	3	AIBS
Intertidal Samphire - Intact	0.13	0.07	2	AIBS
Intertidal Sandflat Bare - Marine	91.58	47.29	1	UGSV MP
Intertidal Seagrass - Patchy	10.01	5.17	1	UGSV MP
Intertidal Seagrass - Uniform	16.26	8.40	1	UGSV MP
Subtidal Channel Seagrass	0.35	0.19	2	UGSV MP
Supratidal Saline Patch Bare	24.76	12.79	1	AIBS
Supratidal Samphire - Intact	46.61	24.07	3	AIBS
Grand Total	193.67	100.00		

Shorebird Diversity: 19
Avg Abundance: 916
Max Abundance: 1592
Important shorebird species:
Abundance- Great Knot (>0.1% EFP), Red Knot (>0.1% EFP), Grey Plover (>0.1% EFP), Ruddy Turnstone (>0.1% EFP), Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP), Curlew Sandpiper (>0.1% EFP).
Threatened- Eastern Curlew, Curlew, Sandpiper, Bar-tailed Godwit, Black-tailed Godwit, Red Knot, Great Knot, Greater Sand Plover.
Breeding- Red-capped Plover

Table 55. Thompson Beach north Shorebird species list*

***Prior to 2013 Thompson Beach was originally counted as one unit. Counts for Thompson Beach are not included in the summary presented here. Greater Sand Plover and Black-tailed Godwit were observed on Thompson Beach North but not since the site split.**

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	35.42%	17	6
Sooty Oystercatcher	6.25%	6	0
Banded Stilt	27.08%	750	126
Black-winged Stilt	4.17%	12	0
Grey Plover	77.08%	35	5.9
Pacific Golden Plover	4.17%	3	0
Red-capped Plover	50.00%	200	15
Lesser Sand Plover	2.08%	8	0
Masked Lapwing	43.75%	9	2.1
Eastern Curlew	16.67%	14	0
Bar-tailed Godwit	41.67%	125	32
Ruddy Turnstone	41.67%	160	18
Great Knot	16.67%	100	2
Red Knot	45.83%	700	331
Sharp-tailed Sandpiper	39.58%	40	9.1
Curlew Sandpiper	41.67%	100	1
Red-necked Stint	85.42%	800	345
Common Greenshank	77.08%	111	25
Marsh Sandpiper	2.08%	1	0

Habitat Use:
Low tide - Shorebirds feed throughout low tide on the open tidal flat.

High tide – Shorebirds roost on small near shore spits and islands associated with the small claypan inlet (2). Several marsh species (sandpipers, stint, Stilt Avocet and Greenshank) and coastal obligates (Grey Plover, Red Knot, Ruddy Turnstone, Bar-tailed Godwit and Pied Oystercatcher) roost or continue feeding in near coastal claypans when wet. Claypans fed by Baker Creek (3) and the inlet (1) support the highest abundances and diversity of shorebirds at high tide and are known to host large numbers of Curlew Sandpiper in the right conditions.

Red-necked Stint and Red-capped plover may also be found feeding and roosting claypans disconnected from tidal influence. Red-capped Plover regularly breed in these claypans.

Figure 66. A Red-capped Plover with two chicks in the vegetation fringing a Thompson Beach north claypan. Photo Chris Purnell

Table 56. Threats Thompson Beach north .

Threat									
Liklehood	2	3	3	0	0	0	0	1	1
Scope	0	3	2	0	0	0	0	1	1
Severity	1	3	1	0	0	0	0	1	1
Overall impact	3	9	6	0	0	0	0	3	3

Threats
Habitat loss – ORVs: Cars accessing intertidal and beach. Motorbikes readily access claypans.
*Disturbanc*e – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna – Dogs accompanying recreational visitors. Fox, rat and cat impact from nearby agricultural areas
Human induced mortality- Crushing of Red-capped Plover chicks by ORVs or birdwatchers
Pollution- entanglement or ingestion of fishing refuse.

Relative importance: Thompson Beach is an important section of the northern beaches in maintaining sufficient feeding and roosting opportunities for high densities of birds. It is a key feeding and roosting area for Red Knot and Grey Plover and Bar-tailed Godwit.

The extensive network of sabkhas provides increasingly important high-tide feeding and roosting habitat and retreat habitat in the case of climate change. The large open areas also provide the surveillance and hydrological predictability preferred by nesting Red-capped Plover

Overall avian diversity: 104

Other avian values: Brown Quail, Fairy Tern, Intermediate Egret, Elegant Parrot, Rock Parrot, Samphire Thornbill.

(n) Webb Beach

NRM region: Adelaide & Mt Lofty Ranges .
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council

Map 17. Webb Beach shorebirds 2020 count area

Webb Beach is a small settlement accessed via Parham which is located to its immediate north. Intertidal and beach substrates at Webb Beach are predominantly sandy. Sand spits are associated with mangrove-lined creeks to the north and south of the town.

Baker Creek feeds a small claypan 3 and an extensive area of low saltmarsh on its northern bank.

An extensive claypan system to the south east of the town is regularly filled with local run-off and can remain full throughout the summer period.

Table 57. Shorebird habitat type within the Webb Beach count area.

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Vegetated - Intact	3.44	1.13	3	AIBS
Intertidal Mangrove - Intact	0.24	0.08	3	UGSV MPA/AIBS
Intertidal Samphire - Intact	4.07	1.33	2	UGSV MPA/AIBS
Intertidal Sandflat Bare - Marine	148.68	48.65	1	UGSV MPA/AIBS
Intertidal Seagrass - Patchy	9.69	3.17	1	UGSV MPA/AIBS
Intertidal Seagrass - Uniform	22.49	7.36	1	UGSV MPA/AIBS
Stranded Tidal Saline Patch Bare	5.89	1.93	1	AIBS
Supratidal Flat Bare	83.37	27.28	1	AIBS
Supratidal Saline Patch Bare	22.64	7.41	1	AIBS
Supratidal Samphire - Intact	4.85	1.59	2	AIBS
Tidal Stream Bare	0.14	0.05	1	AIBS
Grand Total	305.60	100		

Figure 67. Bakers Creek from Webb Beach. Photo: NRM AMLR.

Shorebird Diversity: 17
Avg Abundance: 420
Max Abundance: 816
Important shorebird species:
Abundance- Ruddy Turnstone (>0.1% EFP),
Threatened- Curlew, Sandpiper, Bar-tailed Godwit, Red Knot, Great Knot, Greater Sand Plover.

Table 58. Webb Beach Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	37.50%	16	3
Sooty Oystercatcher	12.50%	2	1
Banded Stilt	6.25%	280	42
Black-winged Stilt	6.25%	7	7
Grey Plover	62.50%	32	1
Pacific Golden Plover	6.25%	2	11
Red-capped Plover	81.25%	129	37
Masked Lapwing	68.75%	25	9
Bar-tailed Godwit	37.50%	20	1
Ruddy Turnstone	50.00%	69	3
Great Knot	12.50%	27	0
Red Knot	25.00%	14	2
Sharp-tailed Sandpiper	62.50%	129	34
Curlew Sandpiper	31.25%	376	3
Red-necked Stint	100.00%	709	209
Common Greenshank	62.50%	50	11
Marsh Sandpiper	6.25%	2	0

Habitat Use:
Low tide - Shorebirds feed throughout low tide on the open tidal flat. The highest abundance and diversity occurs at Bakers Creek ② and the smaller creek to the north ①.

High tide –Bakers Creek is favoured as a roost site for small waders including Curlew Sandpiper; either on the sandy banks or saltmarsh islands ②. Marsh species move inland to continue to feed at low densities in saltmarsh or claypans ③.

Table 59. Threats Webb Beach

Threat									
Liklehood	1	3	3	0	0	0	0	1	1
Scope	0	2	2	0	0	0	0	1	1
Severity	1	2	1	0	0	0	0	1	1
Overall impact	2	7	6	0	0	0	0	3	3

Habitat loss – ORVs: Cars accessing intertidal and beach. Motorbikes readily access claypans.
Disturbance – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna – Dogs accompanying recreational visitors. Fox, rat and cat.
Human induced mortality- Crushing of Red-capped Plover chicks by ORVs or birdwatchers
Pollution- entanglement or ingestion of fishing refuse.

Relative importance:
Webb Beach adds resilience to the chain of beaches that make up the Samphire Coast. Sheltered creek lines and low levels of disturbance allow for shorebirds to take refuge when preferred habitats are impacted.

Overall avian diversity: 85
Other avian values: Samphire Thornbill, Fairy Term, Little Egret, White-bellied Sea-Eagle, Peregrine Falcon, Elegant Parrot.

(o) Port Parham

NRM region: Adelaide & Mt Lofty Ranges.
Council: Adelaide Plains Council.
Tenure/Principal manager(s): DEWNR, Adelaide Plains Council

Map 18. Port Parham shorebirds 2020 count area

Port Parham and Webb beach have a joint population of around 200 residents. Intertidal and beach substrates at Webb Beach are predominantly sandy. Sand spits are associated with mangrove-lined creeks to south. Although there is no physical change in habitat or topography, public access to the north is restricted by the southern border of the Port Wakefield Proof and Experimental Establishment ②.

Table 60. Shorebird habitat type within the Port Parham count area.

Habitat type	ha	% cover	priority	Protection
Tidal Stream Bare	0.12	0.03	1	UGSV MP/AIBS
Intertidal Seagrass - Patchy	8.39	2.15	1	UGSV MP/AIBS
Intertidal Samphire - Intact	3.68	0.94	1	AIBS
Intertidal Sandflat Bare - Marine	241.90	61.88	1	UGSV MP/AIBS
Intertidal Seagrass - Uniform	22.25	5.69	1	UGSV MP/AIBS
Intertidal Saline Patch Bare	12.37	3.16	1	AIBS
Supratidal Samphire - Intact	36.30	9.28	3	AIBS
Chenier / Beach Ridge Vegetated - Intact	1.23	0.31	3	AIBS
Supratidal Saline Patch Bare	58.75	15.03	1	AIBS
Grand Total	390.99	100		

Shorebird Diversity: 13
Avg Abundance: 222
Max Abundance: 1126
Important shorebird species:
Abundance- Red Knot (>0.1% EFP), Red-necked Stint (>0.1% EFP)
Threatened- Bar-tailed Godwit, Red Knot, Great Knot.

Table 61. Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	31.25%	11	3
Sooty Oystercatcher	6.25%	1	0
Banded Stilt	18.75%	30	6
Grey Plover	18.75%	10	2
Red-capped Plover	18.75%	100	4
Masked Lapwing	25.00%	10	2
Bar-tailed Godwit	18.75%	210	19
Great Knot	6.25%	4	1
Red Knot	6.25%	750	0
Sharp-tailed Sandpiper	12.50%	33	2
Red-necked Stint	43.75%	504	181
Common Greenshank	43.75%	16	2
Marsh Sandpiper	6.25%	15	0

Habitat Use:
Shorebirds feed throughout low tide on the open tidal flat. The highest abundance and diversity occurs at the southern creek ①

High tide – Shorebirds roost at creek in low densities; either on the sandy banks of saltmarsh islands ①. Marsh species move inland to continue to feed at low densities in saltmarsh or claypans ③. This area is highly variable and largely undersurveyed.

Table 62. Threats Port Parham.

Threat									
Liklehood	1	3	3	0	0	0	0	1	1
Scope	0	2	2	0	0	0	0	1	1
Severity	1	2	1	0	0	0	0	1	1
Overall impact	2	7	6	0	0	0	0	3	3

Habitat loss – ORVs: Cars accessing intertidal and beach. Motorbikes readily access claypans.
Disturbance – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna – Dogs accompanying recreational visitors. Fox, rat and cat.
Human induced mortality- Crushing of Red-capped Plover chicks by ORVs or birdwatchers
Pollution- entanglement or ingestion of fishing refuse.

Relative importance:
Webb Beach adds resilience to the chain of beaches that make up the Samphire Coast. Sheltered creek lines and low levels of disturbance allow for shorebirds to take refuge when preferred habitats are impacted.

Overall avian diversity: 96

Other avian values: Samphire Thornbill, Brown Quail, Fairy Tern, Little Egret, Elegant Parrot, Rock Parrot,

(p) Port Wakefield Proof and Experimental Establishment (PWPEE)

NRM region: Northern & Yorke ,.
Council: Adelaide Plain's Council, Wakefield Regional Council.
Tenure/Principal manager(s): DEWNR (GSV Marine Park), Australian Government (Department of Defence)

The townships of Parham and Wakefield are separated by a stretch of undeveloped coast, 18.5 kilometres long, which is reserved for the Australian Defence Force Proof Range and Experimental Establishment.

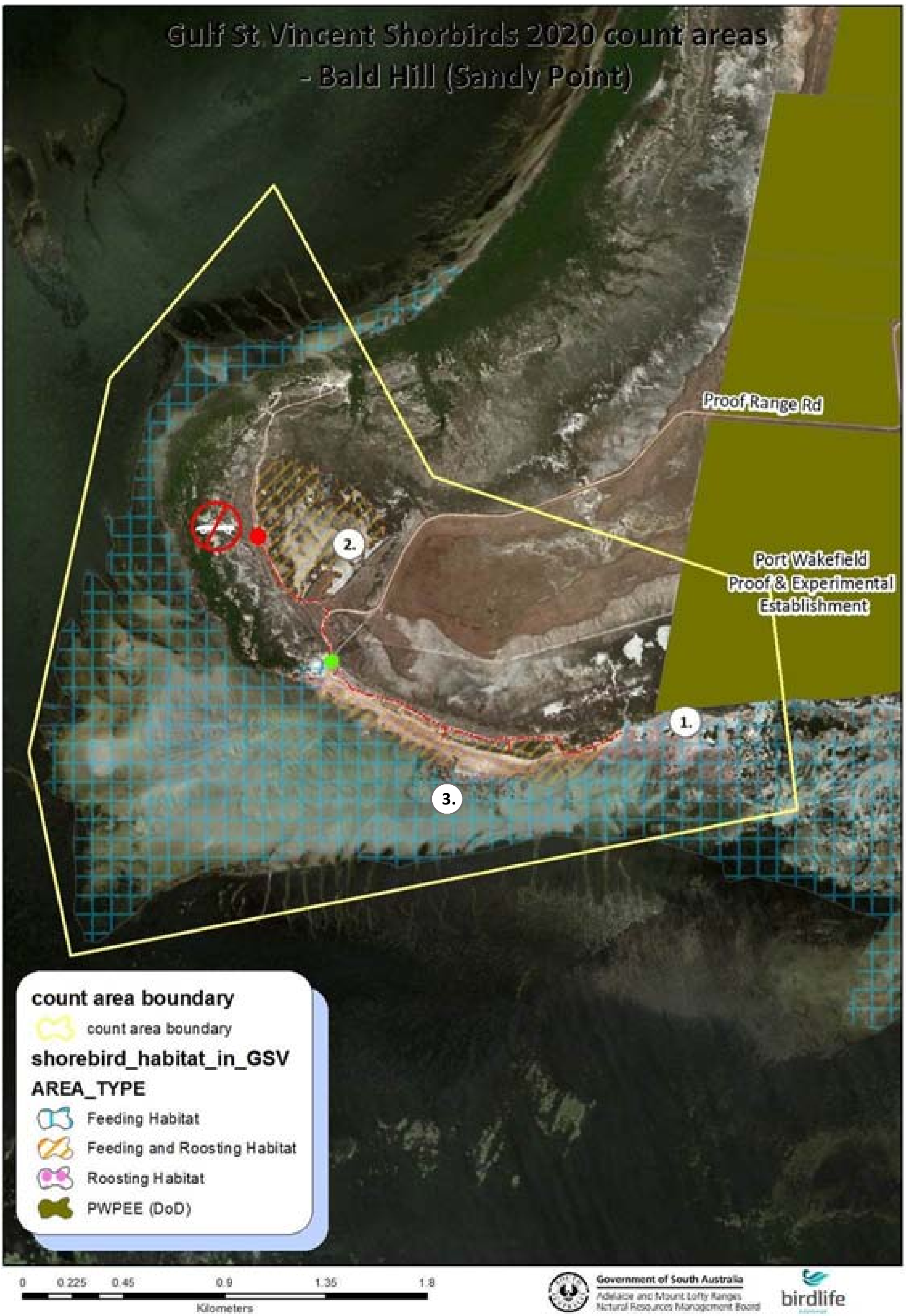
Habitat in this stretch of coastline is largely consistent with that found at Parham with large bare sandy tidal flats 1-1.5km wide backed by an extensive network of claypans and saltmarsh. The coast is uniform throughout with no tidal creeks or channels and is backed by a thin band of vegetated beach ridges (degraded in places), behind which lies stranded samphire and bare flats, extending several km inland. There is one small island of intertidal saltmarsh towards the southern border.

This area has a public exclusion zone which extends beyond the tidal flats into the waters of Gulf St Vincent. Only 2 brief surveys have been conducted at the site since 2009. A surprisingly low density and diversity of shorebirds was observed on both occasions. Regular access has now been permitted to Birds SA observers and a site profile will be included in the 2017-18 report.

The PWPEE area is not included in the Flyway Site Network boundary.

(q) Bald Hill (Sandy Point)

NRM region: Northern & Yorke .
Council: Wakefield Regional Council.
Tenure/Principal manager(s): DEWNR(GSV Marine Park), Australian Government (Department of Defence)



Map 19. Bald Hill shorebirds 2020 count area

Bald Hill is a low energy beach on the southern bank of a large point at the northern border of the Port Wakefield Proof and Experimental Establishment. Vast tidal flats have formed on the southern and western banks of the point where fine sediment has accumulated.

The south facing shellgrit beach is carpeted in seagrass wrack which forms small islands (Figure 68) on the tidal flat. Shellgrit ridges extend into the tidal flat and several have been colonised by low saltmarsh ③. The beach is bordered to the east by a sparse stand of mangrove ① and to the west by a dense forest which extends north to Port Wakefield.

Inland of the mangrove forest a small number of tidally fed claypans are fringed by low saltmarsh and receive an intermittent tidal exchange ②.

Figure 68.Grey Plover, Bar-tailed Godwit (front), Curlew Sandpiper and Sharp-tailed Sandpiper roost on an accumulation of wrack as Red-necked stint feed (foreground). Photo: Chris Purnell

Table 63. Shorebird habitat type within the Bald Hill count area.

Habitat type	ha	% cover	priority	Protection
Chenier / Beach Ridge Vegetated - Intact	2.42	1.37	3	UGSV MP
Intertidal Flat Bare - Terrestrial	1.94	1.10	1	UGSV MP
Intertidal Mangrove - Intact	1.41	0.80	3	UGSV MP
Intertidal Mangrove - Prograding	3.70	2.09	2	UGSV MP
Intertidal Saline Patch Bare	0.52	0.30	1	UGSV MP
Intertidal Samphire - Intact	13.17	7.43	2	UGSV MP
Intertidal Sandflat Bare - Marine	108.93	61.42	1	UGSV MP
Intertidal Seagrass - Patchy	45.00	25.37	1	UGSV MP
Intertidal Seagrass - Uniform	0.20	0.12	1	UGSV MP
Sand Beach	0.02	0.01	1	UGSV MP
Total	177.36	100.00		

Shorebird Diversity: 20
Avg Abundance: 537
Max Abundance: 830
Important shorebird species:
Abundance- Red Knot (>0.1% EFP), Grey Plover (>0.1% EFP), Ruddy Turnstone (>0.1% EFP), Sharp-tailed Sandpiper (>0.1% EFP), Red-necked Stint (>0.1% EFP).
Threatened- Eastern Curlew, Curlew, Sandpiper, Bar-tailed Godwit, Red Knot, Great Knot, Greater Sand Plover.
Breeding- Red-capped Plover, Pied Oystercatcher.

Habitat Use:
Low tide - Shorebirds feed throughout low tide on the open tidal flat, amongst the eastern mangroves 1 and on and amongst accumulations of wrack.

High tide –Shorebirds either continue to feed or roost on small islands of wrack, shellgrit ridges, saltmarsh islands or on the beach. On spring tides wader retreat to the inland claypan to roost 2.

Table 64. Bald Hill Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	77.78%	7	3
Sooty Oystercatcher	7.41%	2	0
Banded Stilt	14.81%	47	11
Grey Plover	70.37%	90	32
Pacific Golden Plover	3.70%	4	1
Red-capped Plover	74.07%	270	21
Double-banded Plover	11.11%	6	0
Greater Sand Plover	3.70%	2	1
Masked Lapwing	44.44%	8	2
Red-kneed Dotterel	7.41%	4	1
Eastern Curlew	29.63%	15	4
Bar-tailed Godwit	48.15%	95	32
Ruddy Turnstone	81.48%	50	13
Great Knot	25.93%	25	10
Red Knot	33.33%	268	53
Sharp-tailed Sandpiper	62.96%	250	70
Curlew Sandpiper	22.22%	30	3
Red-necked Stint	88.89%	500	273
Common Sandpiper	3.70%	1	0
Common Greenshank	48.15%	60	11

Table 65. Threats Bald Hill.

Threat									
Liklehood	0	1	1	0	0	0	0	0	1
Scope	0	1	1	0	0	0	0	0	1
Severity	0	1	1	0	0	0	0	0	1
Overall impact	0	3	3	0	0	0	0	0	3

Disturbance – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna - Fox, rat and cat impact from nearby agricultural areas
Pollution- Unknown effect of ordinance being discharged on.

Relative importance:
At least part (30) of the large flocks of Grey Plover which feed on the adjacent tidal flats from Bald Hill to Price regularly roost on the Bald Hill intertidal 3 or in the adjacent claypan 2. Tracking/tagging of Grey Plover at Thompson Beach has illustrated that individuals on the northern beaches occasionally travel as far north as Bald Hill however a lack of banded birds regularly observed at Bald Hill and amongst large flocks at Clinton Conservation Park suggest there are several flocks in the gulf. This theory is reinforced by observations of Grey Plover at several sites during simultaneous counts.

Observations of Red Knot leaving both Macs Beach and Price saltfield (western gulf) on falling tides note high on a bearing due east. This may suggest that part of the large Knot population travel

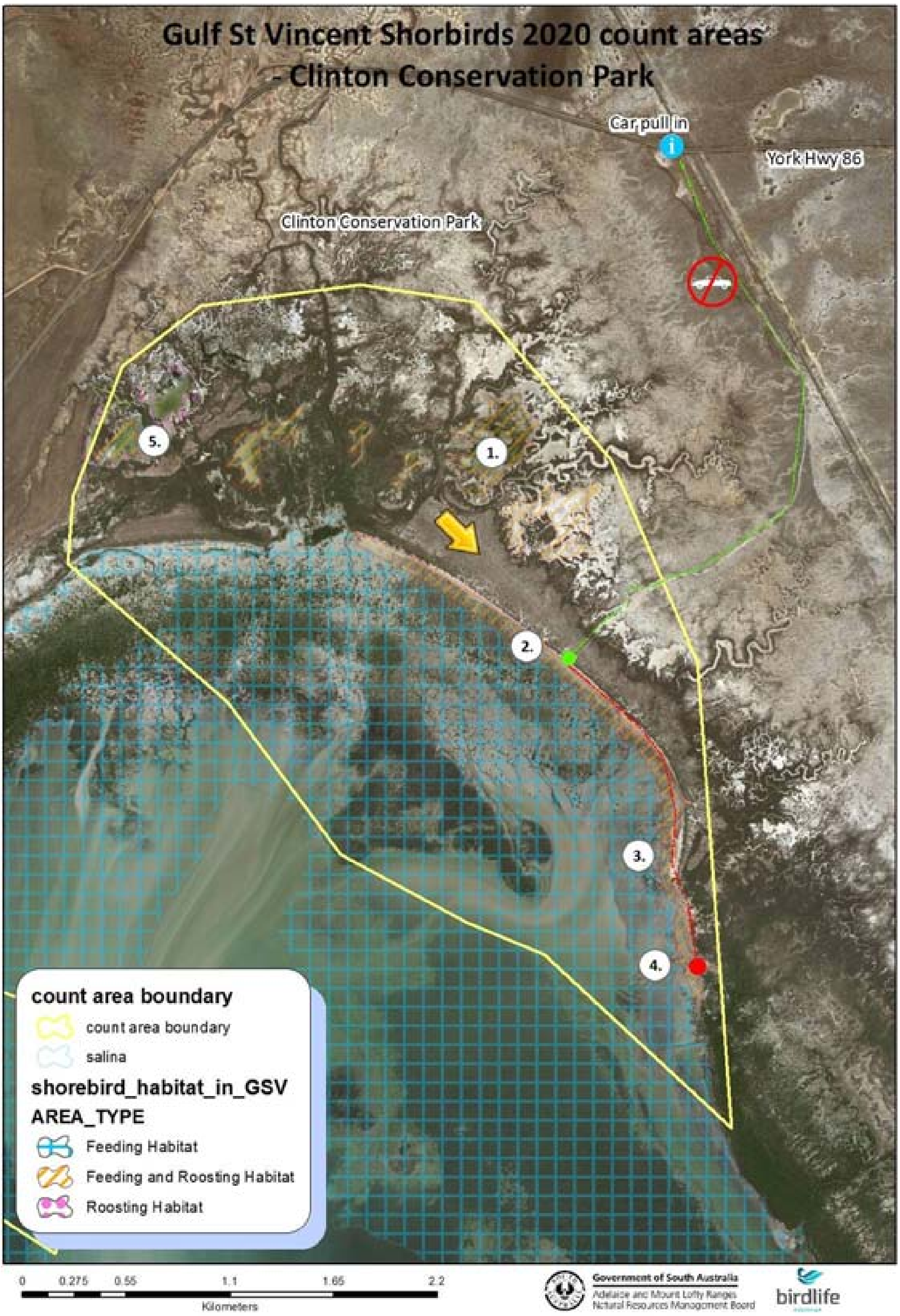
Bald Hill provides a roosting and feeding opportunities where shorebirds will not be subjected to regular disturbance.

Overall avian diversity: 94

Other avian values: Fairy Tern, Little Egret, White-bellied Sea-Eagle, Black Falcon, Peregrine Falcon, Elegant Parrot.

(r) Clinton Conservation Park.

NRM region: Northern & Yorke .
Council: Yorke Peninsula Council, Wakefield Regional Council.
Tenure/Principal manager(s): DEWNR



Map 20. Clinton CP shorebirds 2020 count area.

Figure 69. Small waders feeding and roosting on the falling tide along intertidal bare mudflat with interspersed dead mangrove. Photo Chris Purnell.

Clinton Conservation Park is situated at the head of Gulf St Vincent between Port Wakefield and Clinton. The Park covers over 19 km² of mainly low lying, coastal fringe habitats including mangrove, samphire and chenopod shrublands and borders on intertidal mudflat protected under the Upper Gulf St Vincent Marine Park. The tidal currents of Gulf St Vincent carry fine suspended sediments that settle in the upper reaches creating large expanses of shallow mudflat and seagrass beds at the head of the gulf. The mangrove/samphire estuarine area is cut through by many large tidal channels fringed by mangroves. The River Wakefield is the only major drainage channel in the area and the only major input of freshwater into the tidal flat-Gulf system. The wide mangrove tidal flats are backed by rolling plains or by low scarps. The hinterland consists of alluvial fan deposits which are incised with small creek gullies. These creeks either fan out onto the tidal flats, depositing red clay loam and gravel on the surface, or continue across to the sea

The tidal creeks that connect a network of claypans and sabkhas, up to 1km inland, to potential inundation. Claypans vary in hydrology and (therefor ecology) depending on tidal connectiveness, tidal conditions, surface water availability and evaporative pumping.

Prior to the establishment of AIBS, Clinton CP was the largest reserve in Gulf St Vincent and remains one of the most significant sites in terms of shorebirds (Close & McCrie 1986; Watkins 1993).

Clinton Conservation Park is listed as a wetland of national significance. It is classified in the Directory of Important Wetlands as comprising Marine and Coastal Zone Wetlands types A1, A2, A6, A7, A8 and A9 (Environment Australia, 2001). The criteria for listing were:

1. It is a good example of a wetland type occurring within a biogeographic region.
2. The wetland supports native plant or animal taxa or communities, which are considered endangered or vulnerable at a national level.

Table 66. Shorebird habitat type within the Clinton CP count area.

Habitat type	ha	% cover	priority	Protection
Intertidal Sandflat Bare - Marine	52.33	17.02	1	UGSV MP
Intertidal Seagrass - Patchy	102.07	33.20	1	UGSV MP
Sand Beach	6.74	2.19	1	UGSV MP, Clinton CP
Intertidal Rotten Spot	19.27	6.27	1	UGSV MP, Clinton CP
Intertidal Mangrove - Prograding	118.29	38.47	2	UGSV MP
Intertidal Samphire - Intact	12.12	3.94	2	UGSV MP, Clinton CP

Shorebird Diversity: 17
Avg Abundance: 1,601
Max Abundance: 3,321
Important shorebird species:
Abundance- Red-necked Stint (>0.01 EFP), Common Greenshank (>0.01 EFP), Curlew Sandpiper (>0.01 EFP), Sharp-tailed Sandpiper (>0.01 EFP).
Threatened- Curlew Sandpiper, Eastern Curlew, Red Knot, Great Knot, Lesser Sand plover.
Regionally uncommon- Broad-billed Sandpiper, Terek Sandpiper, Grey-tailed Tattler, Lesser Sand plover.

Shorebird prey Algae, gastropods, crustaceans, insects, worms, bivalves, bryozoans, cnidarians, echinoderms and fish.

Table 67. Clinton CP Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	22%	3	1
Sooty Oystercatcher	22%	23	3
Grey Plover	78%	60	18
Red-capped Plover	89%	1107	87
Lesser Sand Plover	11%	1	0
Masked Lapwing	33%	4	1
Red-kneed Dotterel	11%	43	0
Eastern Curlew	67%	39	19
Great Knot	11%	1	0
Red Knot	11%	1	0
Broad-billed Sandpiper	11%	1	0
Sharp-tailed Sandpiper	100%	948	86
Curlew Sandpiper	56%	307	103
Red-necked Stint	100%	2390	1205
Terek Sandpiper	22%	4	0
Grey-tailed Tattler	11%	1	0
Common Greenshank	100%	117	73

Habitat Use:
Low tide - Shorebirds preference feeding on the open intertidal sandflat and intertidal seagrass mudflat (3) & (4) south-east of the prograding intertidal mangrove (2). Small waders (Curlew Sandpiper, Sharp-tailed Sandpiper, Red-necked Stint, Red-capped Plover) and Common Greenshank may feed in the claypans throughout the tide cycle when they're sufficiently wet, however the majority of these birds move to the coast in their hundreds when the tide falls below 2m (indicated by arrow in map). Red-capped Plover breed in the claypans.

High tide – In tidal conditions above 2m many small waders move from the intertidal to roost and feed in claypans (1) & (5). On high tides below 2m small waders may remain feeding on the mudflat and samphire or roost on the sandy beach or islands of beach cast wrack. Large waders (Eastern Curlew & Grey Plover) may remain roosting on the steeply sloping sandy beach between the point (3) and the mangrove forest to the south (4). On higher tides birds move to roosting sites elsewhere in the gulf (Bald Hill, Port Arthur).

Figure 70. An inundated claypan in the western section of Clinton CP (5).

Table 68. Threats Clinton CP

Threat									
Liklehood	0	1	1	0	0	0	0	0	0
Scope	0	0	1	0	0	0	0	0	0
Severity	0	0	1	0	0	0	0	0	0
Overall impact	0	1	3	0	0	0	0	0	0

Disturbance – ORVs, crabbers, bait collectors and fisherman.
Domestic and introduced fauna - Fox, rat and cat impact from nearby agricultural areas.

Relative importance:
As the largest expanse of tidal flats in the gulf, the mud and sandflats bordering Clinton Conservation Park are capable of supporting high densities of the shorebirds. Although historically popular with fisherman, new restrictions on driving in the park limit visitation to the coast. Given the relative inaccessibility of the coastal zone area and shallow waters birds are capable of feeding without disturbance. Given high rates of disturbance elsewhere in the gulf these mudflats provide reliable supplementary feeding and roosting areas should conditions at other sites become unfavourable and thus contributes significantly to the resilience of the gulfs population.

The large flocks of Eastern Curlew (≈35) and Grey Plover (≈60) which is regularly observed at Clinton conservation Park are the biggest for their species in the gulf. The Eastern Curlew flock is thought to feed on the adjacent tidal flats from Bald Hill to Price and is on occasion seen roosting at Port Arthur on higher tide conditions. This is a separate group than the smaller flock (≈18) observed roosting from Dry Creek Saltfields to Light Beach.

Similarly, the Grey Plover flock appears to be local to the head of the gulf as birds tagged and/or satellite tracked from Thompson Beach/Pt Prime have not been observed in the Clinton CP flocks.

Overall avian diversity: 61 (97)

Other avian values: Clinton Conservation Park is understood to accommodate a large Cormorant (*Phalacrocorax* spp.) rookery on the eastern side of the gulf. The park has been used as a research site for the Samphire-favouring Slender-billed Thornbill. Other birds with conservation ratings recorded from the park include the Blue-winged Parrot (*Neophema chrysotoma*) (SA: V) and White-bellied Sea-Eagle (*Haliaeetus leucogaster*) (SA: E).

(s) Port Arthur

NRM region: Northern & Yorke.
Council: Yorke Peninsula Council.
Tenure/Principal manager(s): DEWNR, Yorke Peninsula Council

Map 21. Port Arthur shorebirds 2020 count area.

Port Arthur is part of the continuous coastal fringe of samphire, mudflats and sandflats the make up the larger Clinton Conservation Park. It is the only break in the intertidal mangrove forest between Port Clinton and the head of the Gulf. Mid and low samphire slope directly into the tidal flat which is fringed by prograding mangroves (Figure 71).

A small claypan 1 collect local run-off.

Table 69. Shorebird habitat type within the Port Arthur count area.

Habitat type	ha	% cover	priority	Protection
Intertidal Seagrass - Uniform	2.19	11.04	1	UGSV MP
Chenier / Beach Ridge Vegetated - Intact	1.78	8.99	3	Clinton CP
Intertidal Samphire - Intact	0.90	4.5	2	Clinton CP
Intertidal Mangrove - Intact	0.37	1.89	3	Clinton CP/UGSV MP
Intertidal Sandflat Bare - Marine	14.57	73.49	1	UGSV MP
Total	19.83			

Shorebird Diversity: 11
Avg Abundance: 93
Max Abundance: 1,377
Important shorebird species:
Abundance- Eastern Curlew (>0.01 EFP), Sharp-tailed Sandpiper (>0.01 EFP).
Threatened- Eastern Curlew.

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Table 70. Port Arthur Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	2.86%	2	0
Sooty Oystercatcher	2.86%	1	0
Red-capped Plover	60.00%	51	6.2
Banded Lapwing	11.43%	18	1
Masked Lapwing	40.00%	4	1.7
Whimbrel	2.86%	2	0
Eastern Curlew	8.57%	43	8
Sharp-tailed Sandpiper	8.57%	99	0.7
Red-necked Stint	68.57%	318	73
Grey-tailed Tattler	2.86%	3	0
Common Greenshank	14.29%	27	2

Habitat Use:
Low tide – Shorebirds typically leave Port Arthur at low tide to feed on the adjacent mudflats at the head of the gulf.

High tide – Small waders may arrive and roost at high densities on the small patch of intertidal saltmarsh between the mangroves. Larger waders (e.g. Eastern Curlew) roost in shallow water on the edge of the tidal flat. Sharp-tailed Sandpiper, Common Greenshank and Grey-tailed Tattler may roost on the mangroves edge amongst samplings or aerial roosts.

Marsh species including Sandpipers, stilt and Lapwings may roost in the small claypan 1.

Table 71. Threats Port Arthur

Threat									
Liklehood	0	3	1	0	0	0	0	0	0
Scope	0	3	1	0	0	0	0	0	0
Severity	0	2	1	0	0	0	0	0	0
Overall impact	0	8	3	0	0	0	0	0	0

Disturbance – given the small area and proximity to the rest stop, birds are particularly susceptible to disturbance.
Domestic and introduced fauna - Fox, rat and cat impact from nearby agricultural areas
Native plants- there is a risk that mangrove may enclose the remaining open intertidal.
Relative importance:
Although only infrequently used, Port Arthur provides an important supplementary high tide roost site for the Eastern Curlew Population at the head of the gulf. It is suspected that the flock of (≈35) Eastern Curlew observed at Port Arthur are the is flock which regularly roost at Clinton Conservation Park

Overall avian diversity: 108

Other avian values: Musk Duck, Fairy Tern, Intermediate Egret, Little Egret, Peregrine Falcon, Blue-winged Parrot

Figure 71. Intertidal sandflat, saltmarsh and prograding mangroves at Port Arthur. Photo: Chris Purnell

(t) Port Clinton

NRM region: Northern & Yorke
Council: Yorke Peninsula Council.
Tenure/Principal manager(s): DEWNR, Yorke Peninsula Council.

Map 22. Port Clinton shorebirds 2020 count area.

Port Clinton is a small coastal settlement between Price and Pt Arthur with a population of around 350, 250 of which are permanent. The towns' foreshore is largely open, bordered by mangroves to the South west and north east. The vast tidal sandflats are only interrupted by a small dense stand of mangroves near the eastern boat ramp. East of the boat ramp intertidal saltmarsh and sparse prograding mangrove dot the sandflat (1) and a small tidal creek feeds a community of shrubby saltmarsh.

Towards the southern end of the town a small point and associated sandpit and rocky reef are partially vegetated by low saltmarsh (2). The coast south of this area is dominated by intertidal saltmarsh and small inlets and lagoons.

Table 72. Shorebird habitat type within the Port Clinton count area.

Habitat type	ha	% cover	priority	Protection
Intertidal Sandflat Bare - Marine Total	119	93	1	UGSV MP
Intertidal Mangrove - Prograding Total	0.08	0.07	1	UGSV MP
Intertidal Mangrove - Intact Total	1.15	0.91	2	UGSV MP
Intertidal Seagrass - Uniform Total	6.09	4.79	1	UGSV MP
Total	127.1097	100.00		

Shorebird Diversity: 21
Avg Abundance: 534
Max Abundance: 1,127
Important shorebird species:
Abundance: Red-necked Stint (>0.1 EFP)
Threatened: Lesser Sand Plover, Eastern Curlew, Bar-tailed Godwit, Black-tailed Godwit, Great Knot, Red Knot, Curlew Sandpiper

Table 73. Port Clinton Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	84.62%	22	4
Sooty Oystercatcher	30.77%	2	0.2
Red-necked Avocet	1.92%	2	0
Black-winged Stilt	1.92%	1	0
Grey Plover	55.77%	72	33
Red-capped Plover	78.85%	140	46
Double-banded Plover	3.85%	2	0
Lesser Sand Plover	1.92%	1	0.2
Banded Lapwing	3.85%	2	0
Masked Lapwing	25.00%	7	2.3
Eastern Curlew	44.23%	37	0.7
Bar-tailed Godwit	36.54%	70	4.5
Black-tailed Godwit	1.92%	26	0
Ruddy Turnstone	59.62%	24	7
Great Knot	11.54%	10	3.8
Red Knot	17.31%	60	5.5
Sharp-tailed Sandpiper	53.85%	70	20
Curlew Sandpiper	36.54%	34	4.7
Red-necked Stint	82.69%	959	373
Grey-tailed Tattler	57.69%	10	4.3
Common Greenshank	82.69%	73	25

Shorebird prey:

Habitat Use:
Low tide – Shorebirds feed on the sandy tidal flats at low densities. Small waders may remain on the town beach feeding throughout the tide cycle. Many disperse further north into the head of the gulf as the tide exposes large fertile flats adjacent to Clinton Conservation Park.

Marsh species may remain feeding at low densities in intertidal saltmarsh and tidal creeks to the north of town.

High tide – Waders arrive from other sites to roost on the saltmarsh and rocky platforms to the south of town. The highest concentration of shorebirds roost on the rocky platform at (2).

Marsh species, Sharp-tailed, Marsh and Curlew Sandpiper and Greenshank roost amongst prograding mangroves and low intertidal saltmarsh (1).

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Table 74. Threats Port Clinton

Threat									
Liklehood	2	3	3	0	0	0	0	1	0
Scope	0	3	2	0	0	0	0	1	0
Severity	1	3	1	0	0	0	0	1	0
Overall impact	3	9	6	0	0	0	0	3	0

Habitat loss – ORVs; Cars accessing intertidal and beach.
*Disturbanc*e – Walkers, Dogs, crabbers, bait collectors and fisherman. Proximity of the Esplanade Rd
Domestic and introduced fauna – Dogs accompanying recreational visitors. Fox, rat and cat impact from nearby agricultural areas
Human induced mortality- Crushing of Red-capped Plover chicks by ORVs or walkers.

<u>Relative importance:</u>
Although subject to varying levels of disturbance, Port Clinton is an important feeding and roosting site for shorebirds on the western side of the gulf. Located between Price and Clinton Conservation Park it is provides added resilience to the network of local sites.

<u>Overall avian diversity:</u> 105

<u>Other avian values</u>: Fairy Tern, Little Egret, Eastern Reef Egret, Glossy Ibis, Blue-winged Parrot, Elegant Parrot. Slender-billed Thornbill

Figure 72. Red Knot, Great Knot, Curlew Sandpiper, Bar-tailed Godwit, Sharp-tailed Godwit and Crested Tern roost on a bank in Price Saltfields. Photo Chris Purnell

(u) Price Saltfield, Macs Beach, Wills Creek.

NRM region: Northern & Yorke Council: Yorke Peninsula Council.
Tenure/Principal manager(s): DEWNR

The Price area (including Wills Creek Conservation Park) supports sandflat and mudflat areas, associated with saltmarsh both above and between the tide line, and intertidal mangroves.

Commercial salt production by solar evaporation of seawater has occurred at Price Saltfields since the Gulf Salt Co. Ltd began production in 1919 with the capture of seawater at high tide by a dam across Willis Creek. In the following decades a number of different owners expanded the field to 1064 hectares of evaporators and crystallisers. A processing plant produces salt for industrial and household use (Hough 2008).

The Price saltfields operation maintains a system of salt evaporation fields and access tracks. Levees preclude tidal inundation to the ponds however adjacent areas are dominated by saltmarsh and dendrital tidal creeks. With ongoing contracts for provision of salt, Price Saltfields will maintain operational hydrology into perpetuity.

The greater Price area is subject to regular inundation by seawater and has two tidal creeks (Wills Creek and Shag Creek) which form shallow estuaries at Mangrove Point. Mangrove forests line the coast and are dissected by numerous small tidal channels, which provide drainage when the tide recedes. Much of the area lies below high tide level, and is therefore subjected to daily inundation (Seager, unpublished, cited by Morelli and de Jong 1995).

The coastline adjacent to the Price Saltfields is dominated by mangrove forest which extend to Port Clinton in the north and Mac's Beach in the south. Mac's Beach is a sandy shellgrit beach with large deposits of seagrass wrack. The intertidal area consists of a rocky reef platform amongst bare sandflat.

Shorebird Diversity: 24
Avg Abundance: 7,465
Max Abundance: 12,425
Important shorebird species:
Abundance: Red-necked Stint (>0.1 EFP), **Ruddy Turnstone** (>0.1 EFP), **Red Knot** (>0.1 EFP), **Sharp-tailed Sandpiper** (>0.1 EFP), **Curlew Sandpiper** (>0.1 EFP), **Red-necked Stint** (>0.1 EFP), **Common Greenshank** (>0.1 EFP)
Threatened: Lesser Sand Plover, Eastern Curlew, Bar-tailed Godwit, Great Knot, Red Knot, Curlew Sandpiper

Table 75. Shorebird species list for

Common Name	RR (%)	Max	Avg
Pied Oystercatcher	89%	10	7
Banded Stilt	100%	11000	5401
Red-necked Avocet	89%	250	187
Black-winged Stilt	100%	29	16
Grey Plover	78%	17	1
Pacific Golden Plover	11%	7	0
Red-capped Plover	100%	344	131
Lesser Sand Plover	22%	9	3
Masked Lapwing	89%	21	8
Red-kneed Dotterel	44%	27	0
Whimbrel	78%	18	2
Eastern Curlew	56%	9	5
Bar-tailed Godwit	89%	297	151
Ruddy Turnstone	100%	86	32
Great Knot	67%	240	34
Red Knot	78%	1089	450
Sharp-tailed Sandpiper	100%	487	287
Curlew Sandpiper	100%	222	155
Red-necked Stint	100%	1129	539
Terek Sandpiper	11%	1	0
Common Sandpiper	78%	3	1
Common Greenshank	100%	183	54
Wood Sandpiper	33%	3	0
Marsh Sandpiper	22%	1	0

Habitat Use:
Low tide - Small waders, Greenshank and Banded Stilt may remain feeding in the salinas throughout the tide cycle. Many medium and large shorebirds (Curlew, Knot, Godwit, Grey Plover) leave the saltfields as the tide drops.

As the tide drops, Knot have been observed flying over the mangroves at Price and landing on the adjacent coastline (Macs's Beach) to feed on the intertidal reef and sandflat.

Thousands of Banded Stilt feed by wading in water <20cm or swimming in water >20cm deep.

High tide – Thousands of shorebirds roost on islands, levees, associated banks and on mineral deposits throughout the operation. Larger species (Stilt, Avocet, Godwit, Grey Plover) also roost in the centre of large shallow ponds.

Greenshank and Small waders including; stint, sandpiper sp, small plovers and dotterels, continue feeding throughout the tide high tide on pond edges, island banks and in adjoining areas of saltmarsh.

Table 76. Threats (v) Price Saltfield, Macs Beach, Wills Creek

Threat									
Liklehood	1	0	3	0	0	0	1	3	0
Scope	1	0	2	0	0	0	1	1	0
Severity	3	0	1	0	0	0	1	2	0
Overall impact	5	0	6	0	0	0	3	6	0

Habitat loss – changing hydrological regime.
Domestic and introduced fauna - Fox, rat and cat impact from nearby agricultural areas
Invasive plants- invasive weed incursion from neighbouring unmanaged lands.
Native plants- saltmarsh communities colonising feeding areas in dried ponds.
Native birds- Silver Gull predation of resident chicks increased by local breeding.
Bird Strikes- electrical wires.
Human induced mortality- Crushing and collision by works vehicles.
Pollution- Potential effect of acid sulphate soils and sulfidic black ooze.

Relative importance:
Like Dry Creek Saltfields, Price plays a crucial role in the gulf for a large number of species which have come to rely on the site as a reliable high tide feeding and roosting area and supplementary/preferential low tide feeding habitat. The consistent salinity gradient maintained within the active operation provides a mosaic of habitats within a small area. The supratidal nature of these habitats ensures that they are not only available throughout the tide cycle but will be exempt from the effect of climate change induced sea-level rise and increases in coastal storm surge.

Price is unique in the region as the only supratidal area that regularly supports large numbers of roosting coastal obligates (Bar-tailed Godwit, Great & Red Knot, Ruddy Turnstone). This is only observed at a handful of other sites nationally.

The Knot, Eastern Curlew, Whimbrel and Bar-tailed Godwit which are commonly observed roosting in Price saltfields are thought to be a separate flock to those observed on the Samphire Coast (Light Beach to Parham). This can be deduced from:

- Simultaneous observations at the two locations
- Varying species composition between the sites (e.g. significantly larger numbers of Great Knot at Price)
- Discreet individuals identified through band details observed exclusively at one site or another within a year.

It is thought the birds feed on the western coastline between Mac's Beach and Clinton Conservation Park. As the tide drops Knot have been observed flying over the mangroves at Price and landing on the adjacent coastline (Macs's Beach) to feed on the intertidal reef and sandflat. On one occasion a large flock of Red Knot was observed flying due east over the gulf presumably to Bald Hill (Treloar pers comm).

Overall avian diversity: 114

Other avian values:
There is a large cormorant breeding colony associated with the mangrove lined Shag Creek. It is suspected that Little Egret may also breed in the mangrove forest.

3 2016–17 SHOREBIRD COUNTS

Section 3.01 Count methods

In 2010, power analysis was undertaken to establish how long it would take to deliver high levels of statistical confidence in shorebird declines in Gulf St Vincent. The results indicated that if the present level of monitoring were to continue for 20 years, a statistically significant change would be likely to be detected only if the population had declined by more than 70 per cent. To improve this, BirdLife Australia recommended two or three simultaneous counts to be conducted each season in Gulf St Vincent (Purnell *et al*. 2010). Following this recommendation, Birds South Australia organised three simultaneous counts each summer (Figure 75). If sustained, this level of monitoring would increase the sensitivity of our trend analysis to a level where declines of 47–64 per cent would be detected within a 20-year period.

Counts are conducted in line with the Shorebirds 2020 count methodology outlined at: www.birdlife.org.au/projects/shorebirds-2020/counter-resources. Counters are encouraged to contribute to simultaneous counts in which every ***count area*** within the ***shorebird area*** is covered within the smallest window of time. Counters are then asked to submit their result either by paper form (Appendix A) or through the new BirdLife Australia birdata portal (Figure 73).

The simultaneous counts during 2016–17 were organised for 19 November 2016, 15 January and 23 of February 2017 (Table 78 to Table 83Error! Reference source not found.). These dates were chosen to identify temporal changes in habitats used by shorebirds. Count coverage across the 19 count areas was incomplete across all dates, but each count covered all the most significant sites where possible. Notable exceptions were:

- Price Saltfields — not covered in November surveys.
- Clinton Conservation Park— not covered in January counts.
- Barker Inlet Wetlands were not covered due to access restrictions.
- Section Banks- not covered in January.
- Light Beach not covered in February.

Unfortunately, variation and gaps in coverage will result in non-representative species abundance and totals for the region. Although areas like Clinton Conservation Park and Price Saltfields are not within the, Adelaide and Mount Lofty Ranges study area, they contribute to the same 'Shorebird Area' and are known to contribute significantly to habitat used by birds on the Samphire Coast. They are therefore critical monitoring sites when trying to identify large-scale trends. The implications of these gaps are addressed in Section 3.04.

The current support provided by Natural Resources, Adelaide Mount Lofty Ranges does incorporate some capacity to monitor upper and western Gulf St Vincent. The need for cross regional action is recognised in a memorandum undertaken by the three NRM Boards across the Gulf for collaboration on managing the Gulf St Vincent.

A shorebird area is the boundary around the total area used by the same group of shorebirds during the peak of the non-breeding season (November–March). Regular bird movement may be observed between habitats within a shorebird area, but birds seldom move in or out of the shorebird area during the peak of the non-breeding season.

A count area is a fixed boundary which defines the area within which a count of all shorebirds is made during any repeated monitoring survey. These areas are predefined and are based on identified roost or feeding habitats. There may be one or many count areas within a shorebird area. Count areas tend to be marked by boundaries of readily identifiable geographic features, and include areas easily surveyed by one counter in less than 4 hours.

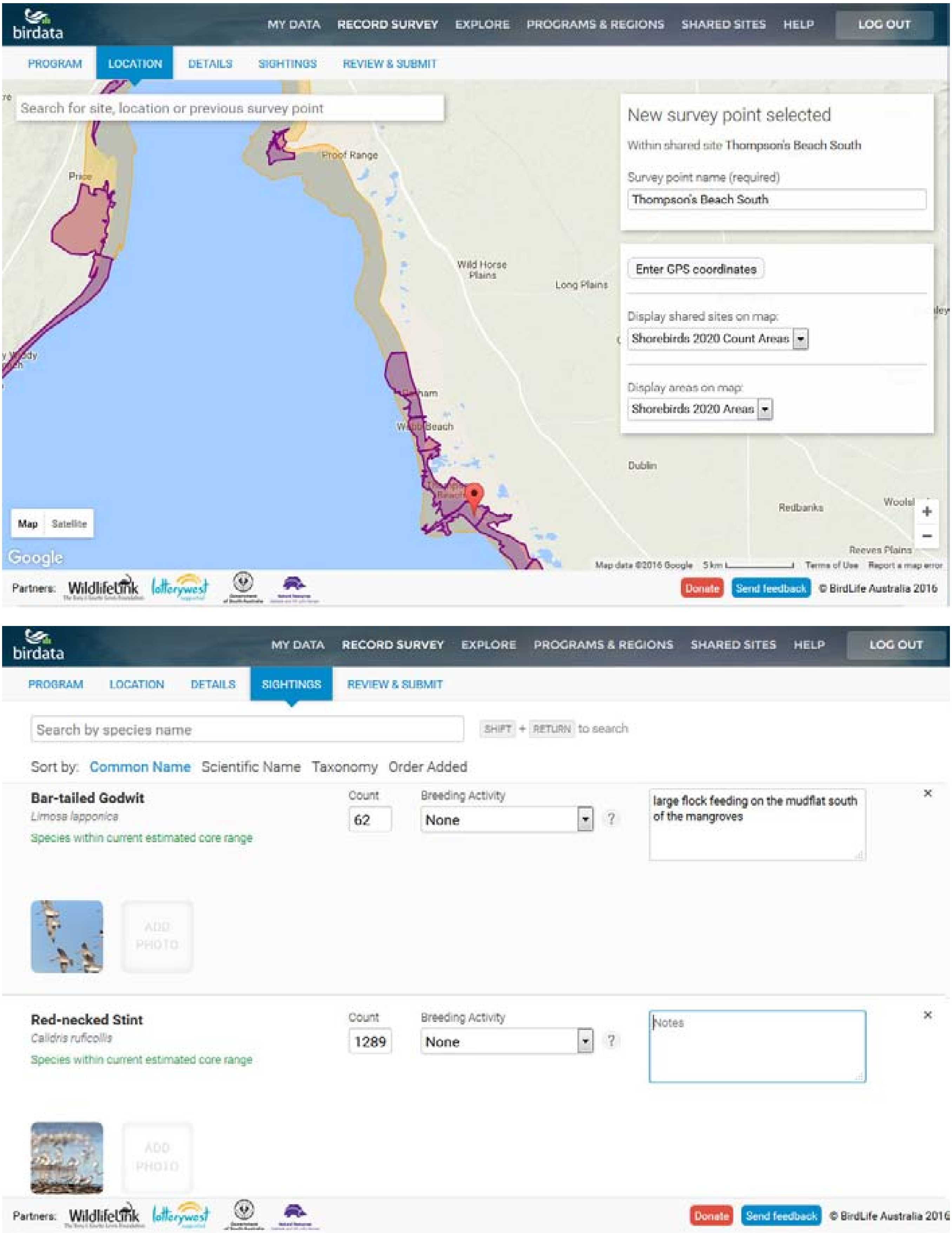


Figure 73. The new BirdLife Australia Birdata portal.

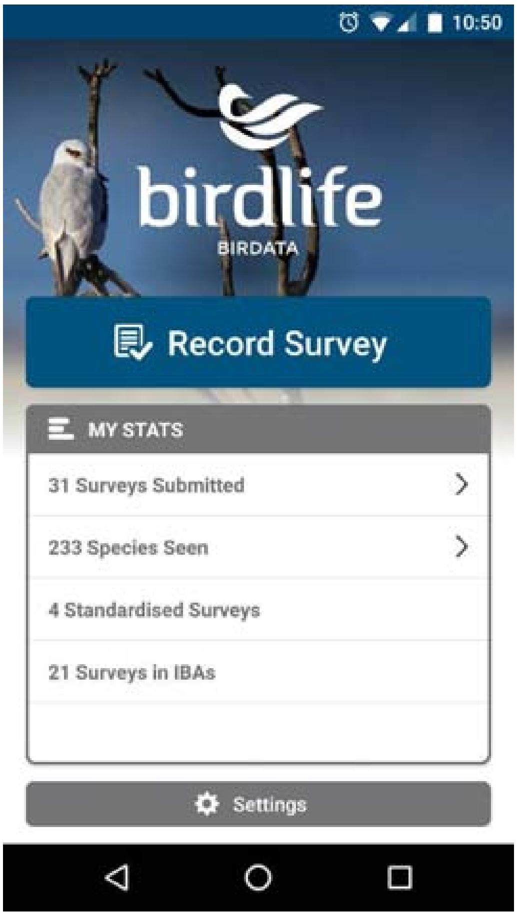


Figure 74. The new BirdLife Australia Birdata app

During the peak of the non-breeding season, shorebirds tend to remain within a defined region, moving between proximate feeding and roosting sites in accordance with variations in habitat conditions, such as tide height. Shorebirds often return to these same areas within and between seasons (Peters & Otis 2007). It has been suggested that there was little movement beyond the boundaries of the shorebird area as mapped in 2009, which extend north from Section Bank/Bird Island and around Gulf St Vincent to a point south of the Price Saltfields (Purnell *et al*. 2009). Shorebird banding and band reporting (described below) supports this theory. The site fidelity observed in most shorebirds suggests that any count conducted in Gulf St Vincent during the peak of the non-breeding season would encounter the same population of birds.

It is critical to conduct a coordinated survey within Gulf St Vincent so that multiple areas can be surveyed simultaneously. Birds are likely to be either missed or double-counted if counts are not conducted simultaneously throughout the Gulf. Further, these counts should be conducted during the peak of the non-breeding period, in the same month as previous summer counts. In terms of national population monitoring, counts conducted outside the November–February window risk a measurement error at a national scale, with entire populations of shorebirds potentially being counted twice or not counted at all (Clemens et al. 2007a).

The volunteers involved in the counts should be commended for their continued commitment and contribution. A total of 129 counts were submitted by 42 counters. When considering survey duration, commute to site and data entry citizen scientist contributed over 389 hours to the project in 2016/17

Figure 75. A Shorebirds 2020 volunteer surveying Thompson Beach. Photo: Chris Purnell

Section 3.02 Historic data

As a recognised area of significance for shorebirds, the Gulf St Vincent population has been the subject of varying levels of biodiversity surveying since the late 70's. At the initiation of the ALMR NRM Board funded monitoring project, all available data from state and known private sources was incorporated into the Shorebirds 2020 database. This included a significant dataset from local shorebird expert David Close. Expert advice and literature had also been sourced from Cheetham Salt (Rix 1978, Cooper 1980) and Frank Day (Day 2004) however it was not until 2014 that Day's extensive dataset was incorporated into BirdLife databases. Given these surveys were not standardised (and are therefore not comparable to Shorebirds 2020 methodology or the results) they were incorporated into the BirdLife Atlas of Australian Birds as incidental records. The data include 1,458 surveys from the study area and 1,150 visits to the Dry Creek Saltfields. Although the data type is insufficient to establish population trends if has been useful in identifying species present and population minimums and (in some cases) maximums (Table 80). This data has been useful in the successful nomination for the Flyway Site Network. It will also be valuable if a nomination of the Gulf as a Ramsar wetlands of international importance is undertaken in the future.

Count Area name	Count area code
Adelaide Mount Lofty Ranges	
Barker Inlet Wetlands	BIW
Whicker Rd Wetlands	WRW
Magazine Rd Wetlands	MRW
Section Banks	SnBa
Torrens Island	ToIs
Bolivar Ponds	BolSW
Saint Kilda	StKi
Port Gawler	PtGa
Dry Creek Saltfields	DCSf
Middle Beach	MiBe
Light Beach	LiBe
Port Prime	PtPr
Thompson Beach South	ThBS
Thompson Beach North	ThBN
Webb Beach	WeBe
Port Parham	PoPa
Northern & York	
Bald Hill	BaHi
Clinton Conservation Park	ClCP
Port Arthur	PoAr
Port Clinton	PoCl
Price Saltfields	PrSf
Macs Beach	MaBe
Black Point	BlPo
Pine Point	PiPo

Table 77. Key to Count Area names in tables 81-83.

Section 3.03 Count results

Species	1% EAA*	0.1%EAA*	Nov-08	Feb-09	Jan-10	Dec-10	Jan-11	Mar-11	Dec-11	Jan-12	Mar-12	Aug-12	Dec-12	Feb-13	Mar-13
Australian Painted Snipe**	12		0	0	0	0	0	0	0	0	0	0	0	0	0
Banded Lapwing**	270		0	90	0	0	65	0	0	0	0	0	0	49	27
Banded Stilt**	2060		12062	3252	2228	110	2	0	19843	11133	10771	0	24647	11425	12856
Bar-tailed Godwit	1460	146	419	575	337	163	70	324	0	8	53	14	152	824	13
Black-fronted Dotterel**	170		25	0	1	0	0	4	0	0	2	2	2	0	2
Black-tailed Godwit	1390	139	0	0	0	0	0	0	0	0	0	0	0	2	6
Black-winged Stilt**	2660		310	99	408	7	47	0	254	218	571	460	202	95	195
Common Greenshank	1000	100	154	703	367	241	36	19	104	169	170	2	173	59	80
Common Sandpiper	500	50	1	4	27	0	1	0	3	1	0	0	2	0	0
Curlew Sandpiper	1350	135	228	535	259	126	3	58	16	0	63	28	476	174	278
Double-banded Plover	500	50	0	4	0	0	0	0	0	0	0	0	0	0	0
Eastern Curlew	320	32	9	36	29	12	0	1	11	6	0	0	19	26	46
Great Knot	2900	290	930	203	6	800	52	750	0	40	0	22	44	70	4
Greater Sand Plover	790	79	2	8	10	8	0	2	0	0	15	0	0	3	0
Grey Plover	1040	125	164	291	122	46	47	25	19	42	73	13	68	152	36
Grey-tailed Tattler	440	44	1	4	0	1	0	9	5	0	4	0	0	5	5
Latham's Snipe	250	25	0	0	0	0	0	0	1	0	0	0	0	0	0
Lesser Sand Plover	1080	108	7	8	0	0	0	0	0	0	0	0	0	5	0
Long-toed Stint	250	25	0	0	1	0	0	0	0	0	0	0	0	0	0
Marsh Sandpiper	1000	100	20	7	3	6	3	0	6	1	3	0	1	7	29
Masked Lapwing**	2870		94	148	124	23	41	15	61	73	104	11	35	101	121
Pacific Golden Plover	1000	100	5	2	1	1	0	0	0	0	0	0	2	17	0
Pectoral Sandpiper	100	10	1	0	0	0	0	0	0	0	0	0	0	0	0
Pied Oystercatcher**	110	0	23	125	118	10	7	6	14	24	22	27	43	28	43
Red Knot	990	99	1150	1637	1103	200	4	1615	0	70	1097	110	1450	1980	87
Red-capped Plover**	950	0	608	4963	2026	80	119	19	1084	616	553	164	566	649	2194
Red-kneed Dotterel**	260	0	152	121	79	0	0	0	108	5	37	4	32	74	88
Red-necked Avocet**	1070	0	555	285	27	23	0	0	424	262	481	0	317	257	48
Red-necked Stint	3150	315	83,91	11791	6749	2324	2927	1372	3169	2820	3123	577	3830	2098	4619
Ruddy Turnstone	440	44	57	91	70	41	7	23	0	40	5	6	55	75	2
Ruff	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
Sharp-tailed Sandpiper	1600	160	1205	3224	3120	74	5	0	752	218	79	0	1059	543	31
Sooty Oystercatcher**	40	0	0	160	61	0	0	3	0	1	0	26	13	5	0
Terek Sandpiper	500	50	0	2	1	1	0	0	0	0	0	0	0	0	0
Whimbrel	5500	550	6	26	4	3	0	0	0	0	0	0	1	0	1
Wood Sandpiper	100	10	2	2	8	0	0	9	0	0	1	0	0	0	0
total			**26580**	**28392**	**17289**	**4299**	**3436**	**4245**	**25869**	**15747**	**17223**	**1466**	**33189**	**18724**	**20811**

Table 78. Simultaneous count totals November 2008 to March 2013

1% EAA = International Significance (threshold of 1% of the estimated population in the East Asian–Australasian Flyway);

Species	1% EAA*	0.1%EAA*	Jul-13	Nov-13	Jan-14	Mar-14	Jun-14	Nov-14	Jan-15	Feb-15	Mar-15	Nov-15	Jan-16	Feb-16	Nov-16	Jan-17	Feb-17
Australian Painted Snipe**	**12**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Banded Lapwing**	**270**		0	0	0	0	0	0	0	9	0	0	2	3	4	0	0
Banded Stilt**	**2060**		35	0	**8055**	**8278**	**8176**	**15901**	1863	**9043**	**7088**	**2406**	**13222**	**21352**	**9342**	**130**	**1943**
Bar-tailed Godwit	**1460**	**146**	0	2	104	12	39	67	118	407	52	90	112	92	2	175	236
Black-fronted Dotterel**	**170**		0	0	0	0	0	0	0	0	0	0	0	0	1	6	4
Black-tailed Godwit	**1390**	**139**	0	0	6	53	0	0	0	2	0	0	1	32	27	0	0
Black-winged Stilt**	**2660**		350	0	180	1299	390	304	119	285	202	128	549	2555	46	234	250
Common Greenshank	**1000**	**100**	0	50	281	113	97	231	227	226	195	168	419	315	373	249	267
Common Sandpiper	**500**	**50**	0	0	1	0	0	0	4	1	0	1	2	2	1	2	1
Curlew Sandpiper	**1350**	**135**	14	0	7	6	196	8	86	261	81	24	77	289	870	523	682
Double-banded Plover	**500**	**50**	0	0	0	1	35	0	0	0	0	0	0	0	0	2	2
Eastern Curlew	**320**	**32**	0	0	12	0	29	33	16	8	5	49	51	40	67	44	30
Great Knot	**2900**	**290**	0	0	2	6	0	4	11	103	2	13	7	17	1	25	276
Greater Sand Plover	**790**	**79**	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Grey Plover	**1040**	**125**	0	31	79	164	28	92	154	92	40	112	152	124	179	177	124
Grey-tailed Tattler	**440**	**44**	0	0	10	0	0	4	4	0	0	7	0	1	3	3	5
Latham's Snipe	**250**	**25**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lesser Sand Plover	**1080**	**108**	0	0	1	0	0	3	8	0	0	0	1	9	0	0	6
Long-toed Stint	**250**	**25**	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Marsh Sandpiper	**1000**	**100**	0	0	3	8	2	8	2	19	25	2	6	2	5	1	1
Masked Lapwing**	**2870**		4	42	96		29	94	82	82	127	54	77	185	54	101	181
Pacific Golden Plover	**1000**	**100**	0	2	4	0	0	0	0	1	0	1	0	0	0	12	2
Pectoral Sandpiper	**100**	**10**	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0
Pied Oystercatcher**	**110**	**0**	14	25	49	44	101	43	55	43	45	39	81	89	50	93	89
Red Knot	**990**	**99**	0	3	80	836	30	63	305	1109	388	77	1727	1301	230	454	824
Red-capped Plover**	**950**	**0**	332	363	349	628	1206	465	527	501	270	423	982	2301	438	344	1225
Red-kneed Dotterel**	**260**	**0**	0	28	71	83	8	57	0	0	0	51	8	0	0	36	91
Red-necked Avocet**	**1070**	**0**	0	0	80	120	1074	80	0	157	24	0	500	324	367	17	72
Red-necked Stint	**3150**	**315**	440	873	1082	3865	3311	3149	4808	6162	6129	1607	7243	7642	9209	6960	10318
Ruddy Turnstone	**440**	**44**	0	15	24	57	7	48	99	27	68	34	48	120	98	293	132
Ruff	**0**	**0**	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
Sharp-tailed Sandpiper	**1600**	**160**	0	145	363	757	51	189	439	545	107	488	1406	1521	170	318	1062
Sooty Oystercatcher**	**40**	**0**	0	0	5	1	0	14	14	27	44				19	14	88
Terek Sandpiper	**500**	**50**	0	0	0	0	0	0	0	0	0	19	10	149	0	0	4
Whimbrel	**5500**	**550**	0	0	0	0	0	0	0	6	0	0	0	4	2	25	14
Wood Sandpiper	**100**	**10**	0	0	3	0	0	3	2	0	0	7	4	1	0	0	0
total			**1197**	**1541**	**10895**	**16427**	**7983**	**20841**	**8943**	**19116**	**14892**	**5801**	**26689**	**38471**	**21559**	**10206**	**17929**

Table 79. Simultaneous count totals July 2013 to February 2017.

Table 80. Species maximums and site they were recorded from known data; historically and in the current project period. Bolded numbers represent significant records at any one counts area; *= nationally significant >0.1% EAA, **= internationally significant >1%

Species	maximum count	Site Name	Data source	year	s2020 project max	Site Name	year
Latham's Snipe	3	Dry Creek Saltfields	David Close	1980	2	Magazine Rd	2014
Black-tailed Godwit	**200***	Dry Creek Saltfields (S 3)	Frank Day	1991	41	Dry Creek Saltfields	2008
Bar-tailed Godwit	**1250***	Price Saltfields	David Close	1984	**605***	Thompson Beach	2013
Hudsonian Godwit	1	Dry Creek Saltfields	Frank Day	1988	-	-	-
Little Curlew	3	Price Saltfields	David Close	1982	-	-	-
Whimbrel	70	Price Saltfields	David Close	1986	18	Price Saltfields	2009
Eastern Curlew (CR)	**120***	Clinton CP	David Close	1983	**40***	Port Arthur	2016
Common Redshank	1	Dry Creek Saltfields (S 3)	Frank Day	1983	-	-	-
Marsh Sandpiper	100	Dry Creek Saltfields (S 3)	Frank Day	1995	25	St Kilda	2015
Lesser Yellowlegs	1	Dry Creek Saltfields (S 3)	Frank Day	1990	-	-	-
Common Greenshank	**594***	Price Saltfields	David Close	1995	**216***	Dry Creek Saltfields	2010
Wood Sandpiper	**30***	Dry Creek Saltfields (S 2)	Frank Day	1991	**12***	Magazine Rd	2010
Terek Sandpiper	7	Dry Creek Saltfields	S2020	2009	7	Dry Creek Saltfields	2009
White-rumped Sandpiper	1	Dry Creek Saltfields (S3)	Frank Day	1988	-	-	-
Common Sandpiper	17	Dry Creek Saltfields	David Close	1979	3	Dry Creek Saltfields	2012
Grey-tailed Tattler	38	Middle Beach	David Close	1981	10	Pt Clinton	2014
Ruddy Turnstone	**451****	Price Saltfields	DEWNR	2001	**62***	Macs Beach	2015
Great Knot	**1908***	Price Saltfields	David Close	1990	**800***	Thompson Beach	2010
Red Knot	**2500****	Light Beach	S2020	2009	**2,500****	Light Beach	2009
Sanderling	6	Dry Creek Saltfields	Atlas data		-	-	-
Little Stint	1	Dry Creek and Price	J Cox, D Close & FDay	1979-92	-	-	-
Red-necked Stint	**29,000****	Dry Creek Saltfields	David Close	1981	**7,000****	Dry Creek Saltfields	2008
Long-toed Stint	20	Dry Creek Saltfields	David Close	1980	3	Magazine Rd	2014
Pectoral Sandpiper	6	Buckland Park Lake	Frank Day	1997	3	Magazine Rd	2014
Sharp-tailed Sandpiper	**9800****	Dry Creek Saltfields	David Close	1980	**3,000****	Dry Creek Saltfields	2008
Cox's Sandpiper	1	Dry Creek Saltfields	John Cox	1982	-	-	-
Curlew Sandpiper (CR)	**6,256****	Dry Creek Saltfields	David Close	1984	**600***	Dry Creek Saltfields	2011
Broad-billed Sandpiper	1	Saltfields &Samphire Coast	Various	1979-2004	-	-	-
Ruff	2	Dry Creek Saltfields	David Close		1	Magazine Rd	2013
Red-necked Phalarope	4	Dry Creek Saltfields	Frank Day	1999	-	-	-
Australian Painted Snipe (EN)	**14****	Magazine Rd Wetlands	S2020	2011	**14****	Magazine Rd Wetlands	2011
Pied Oystercatcher	**120****	Section Banks	S2020	2009	**120****	Section Banks	2009
Sooty Oystercatcher	**206****	Section Banks	S2020	2009	**206****	Section Banks	2009
Black-winged Stilt	840*	Dry Creek Saltfields	David Close	1980	402	Dry Creek Saltfields	2011
Red-necked Avocet	1157	Price Saltfields	David Close	1982	500	Price Saltfields	2008
Banded Stilt	**29,110****	Dry Creek Saltfields	David Close	1986	**19,843****	Dry Creek Saltfields	2011
American Golden Plover	1	Dry Creek Saltfields	Collin Rogers	2007	-	-	-
Pacific Golden Plover	32	Price Saltfields	David Close	1981	17	Macs Beach	2013
Grey Plover	**500***	Clinton CP	David Close	1982	80	Port Prime	2009
Ringed Plover	1	Dry Creek Saltfields	Frank Day	1986	-	-	-
Little Ringed Plover	1	Dry Creek Saltfields	Cecil E Rix	1976	-	-	-
Red-capped Plover	**2,100****	Dry Creek Saltfields	David Close	1979	**1,152****	Dry Creek Saltfields	2013
Double-banded Plover	**100***	Price Saltfields	David Close	1981	39	Thompson's Beach	2011
Lesser Sand Plover	25	Clinton CP	David Close	1982	5	Thompson's Beach S	2013
Greater Sand Plover	20	Thompson's Beach	BirdLIfe Atlas	2008	15	Thompson's Beach N	2012
Oriental Plover	2	Dry Creek Saltfields		1981	-	-	-
Inland Dotterel	30	Clinton CP	David Close	1985	-	-	-
Black-fronted Dotterel	50	Dry Creek Saltfields	Frank Day	2010	31	Magazine Rd	2010
Red-kneed Dotterel	**346****	Dry Creek Saltfields	David Close	1985	83	Dry Creek Saltfields	2013
Banded Lapwing	**500****	Clinton CP	David Close		105	Tiddy Widdy - Price	
Masked Lapwing	300	Dry Creek Salfields (S 3)	David Close	1994	94	Dry Creek Saltfields	2013
Oriental Pratincole	1	Dry Creek Saltfields	Frank Day (ref)	1988	-	-	-
Australian Pratincole	20	Dry Creek Salfields (S 3)	Frank Day	1987	-	- -	

Start Date			23-11-16		26-11-16	18-11-16	22-11-16	18-11-16	18-11-16	22-11-16	18-11-16	22-11-16	19-11-16	19-11-16	20-11-16	22-11-16	Total NRM region	22-11-16	18-11-17	23-11-16	19-11-16		23-11-16	23-11-16	23-11-16	GSV total
Count area	BIW	WRW	MRW	SnBa	ToIs	BolSW	StKi	PtGa	DCSf	MiBe	LiBe	PtPr	ThBS	ThBN	WeBe	PoPa		BaHi	ClCP	PoAr	PoCl	PrSf	MaBe	BlPo	PiPo	
Australian Painted Snipe**																	**0**									**0**
Banded Lapwing							4										**4**									**4**
Banded Stilt							1		9341								**9342**									**9342**
Bar-tailed Godwit																	**0**	2								**2**
Black-fronted Dotterel								1									**1**									**1**
Black-tailed Godwit									27								**27**									**27**
Black-winged Stilt			13			23			7		1				2		**46**									**46**
Broad-billed Sandpiper																	**0**		1							**1**
Common Greenshank						3		19	80	6	35		6	74	13		**236**		75		58				4	**373**
Common Sandpiper																	**0**	1								**1**
Curlew Sandpiper								12	181				42	23	376		**634**		236							**870**
Double-banded Plover																	**0**									**0**
Eastern Curlew									2					14			**16**		18		33					**67**
Great Knot																	**0**		1							**1**
Greater Sand Plover																	**0**									**0**
Grey Plover						36		18					8	4	32		**98**	39	41		1					**179**
Grey-tailed Tattler																	**0**				3					**3**
Latham's Snipe																	**0**									**0**
Lesser Sand Plover																	**0**									**0**
Long-toed Stint																	**0**									**0**
Marsh Sandpiper									5								**5**									**5**
Masked Lapwing			3		4	3			27	3			1	4	1		**46**	4		1	1			2		**54**
Pacific Golden Plover																	**0**									**0**
Pectoral Sandpiper																	**0**									**0**
Pied Oystercatcher								4	10		11			9	4		**38**	4			6			2		**50**
Red Knot												60	20				**80**						150			**230**
Red-capped Plover								30	19		2		90		8		**149**	7	227	4	46		5			**438**
Red-kneed Dotterel																	**0**									**0**
Red-necked Avocet									367								**367**									**367**
Red-necked Stint								400	2284			60	3103	122	49		**6018**	212	2390	30	382		170	7		**9209**
Ruddy Turnstone												2		18	69		**89**	4			4		1			**98**
Ruff																	**0**									**0**
Sharp-tailed Sandpiper								2	5				20	4	2		**33**		137							**170**
Sooty Oystercatcher					6		12										**18**				1					**19**
terek sandpiper																	**0**									**0**
Whimbrel																	**0**			2						**2**
Wood Sandpiper																	**0**									**0**
total	**NA**	**NA**	**16**	**0**	**10**	**65**	**17**	**486**	**12355**	**9**	**49**	**122**	**3290**	**272**	**556**	**0**	**17247**	**273**	**3126**	**37**	**535**	**NA**	**326**	**11**	**4**	**21559**

Table 81. Simultaneous count results November 2016. Highlighted yellow records denote breeding records

Start Date		15/1/17	15/1/17		15/1/17	30/1/17	15/1/17	15/1/17	30/1/17	15/1/17	30/1/17	15/1/17	15/1/17	15/1/17	15/1/17	15/1/17	Total	15/1/17		14/1/17	15/1/17	17/1/17	15/1/17	16/1/17	16/1/17	14/1/17	
	BIW	WRW	MRW	SnBa	ToIs	BolSW	StKi	PtGa	DCSf	MiBe	LiBe	PtPr	ThBS	ThBN	WeBe	PoPa	NRM region	BaHi	ClCP	PoAr	PoCl	PrSf	MaBe	BlPo	PiPo	PoVi	Total GSV
Australian Painted Snipe**																	0										0
Banded Lapwing																	0										0
Banded Stilt									120								120					10					130
Bar-tailed Godwit												29		3			32					96	15				175
Black-fronted Dotterel		4	2														6										6
Black-tailed Godwit																	0										0
Black-winged Stilt		23	12		2	86	2		100		1						226					8					234
Broad-billed Sandpiper																	0										0
Common Greenshank						8	6	9	30	2	13			80	21	7	176	3			35	24	5			6	249
Common Sandpiper		1															1					1					2
Curlew Sandpiper									8		12	300		50			370	30				120	3				523
Double-banded Plover								1			1						2										2
Eastern Curlew								6			18	13					37					6	1				44
Great Knot												15					15					10					25
Greater Sand Plover																	0										0
Grey Plover								1			13	55		9	17		95	39			4	8	31				177
Grey-tailed Tattler																	0				3						3
Latham's Snipe																	0										0
Lesser Sand Plover																	0										0
Long-toed Stint																	0										0
Marsh Sandpiper																	0					1					1
Masked Lapwing			8		2	8	4		47		4			3	8	2	86					10		2	3		101
Pacific Golden Plover																	0					7	5				12
Pectoral Sandpiper																	0										0
Pied Oystercatcher					20				5	1	19	11	5	14			75	2			7	7	2				93
Red Knot											4	50		20			74					80	300				454
Red-capped Plover								31	92		19	40			2		184	2			65	50	7	1	1	34	344
Red-kneed Dotterel						32											32					4					36
Red-necked Avocet									0								0					17					17
Red-necked Stint								375	3413		616	800	6	40	50	23	5323	287			357	800	50		3	140	6960
Ruddy Turnstone												14		160			174	21			7	86	5				293
Ruff																	0										0
Sharp-tailed Sandpiper						66			102		6			40	7		221	34			3	60					318
Sooty Oystercatcher					10												10				1		1		2		14
terek sandpiper																	0										0
Whimbrel																	0					14	11				25
Wood Sandpiper																	0										0
total	NA	28	22	NA	34	200	12	423	3917	3	726	1327	11	419	105	32	7259	418	NA	0	482	1419	436	3	9	180	10206

Table 82. Simultaneous count results January 2017. Highlighted yellow records denote breeding records

Start Date			27/2/17	1/3/17	27/2/17	16/2/17	27/2/17	28/2/17	16/2/17	5/3/17		5/3/17	23/2/17	23/2/17	28/2/17			4/3/17	14/2/17	25/2/17	27/2/17	15/2/17		14/2/17	
Count Area	BlW	WRW	MRW	SnBa	ToIs	BoIsW	StKi	PtGa	DCSf	MiBe	LiBe	PtPr	ThBS	ThBN	WeBe	PoPa	Total NRM region	BaHi	ClCP	PoAr	PoCl	PrSf	MaBe	BlPo	Total GSV
Australian Painted Snipe**																	0								0
Banded Lapwing																	0								0
Banded Stilt									1153								1153					790			1943
Bar-tailed Godwit													120	19			139				23	74			236
Black-fronted Dotterel			4														4								4
Black-tailed Godwit																	0								0
Black-winged Stilt			30			74	22		98								224					26			250
Broad-billed Sandpiper																	0								0
Common Greenshank					9	17	9	10	11				10	50	12		128	5	70		30	32		2	267
Common Sandpiper																	0					1			1
Curlew Sandpiper				5					148					2			155	6	307		6	208			682
Double-banded Plover																	0	2							2
Eastern Curlew				1													1		20			9			30
Great Knot														100			100	5			5	166			276
Greater Sand Plover																	0								0
Grey Plover				2				1						3	17		23	38	45		5	13			124
Grey-tailed Tattler																	0		2		3				5
Latham's Snipe																	0								0
Lesser Sand Plover																	0					6			6
Long-toed Stint																	0								0
Marsh Sandpiper			1														1								1
Masked Lapwing			2	5	6	17	20	6	91	2					9		158	8		2	2	9		2	181
Pacific Golden Plover															2		2								2
Pectoral Sandpiper																	0								0
Pied Oystercatcher				26	2		4	3	3			32	1		2		73	2			6	8			89
Red Knot														400			400	12			6	406			824
Red-capped Plover			14	653		2		72	131	1			1		8		882	44	121		95	61		22	1225
Red-kneed Dotterel			43			48											91								91
Red-necked Avocet									10								10				2	60			72
Red-necked Stint				1500		10		200	4922	55		170	50	150	160		7217	260	1017	3	606	1129		86	10318
Ruddy Turnstone												1		18	16		35	22			12	63			132
Ruff																	0								0
Sharp-tailed Sandpiper			56	8		30		20	128					1	11		254	74	245		2	487			1062
Sooty Oystercatcher				55	6		3						6	6			76		9		1			2	88
terek sandpiper																	0		4						4
Whimbrel																	0					14			14
Wood Sandpiper																	0								0
total	**NA**	**NA**	**150**	**2255**	**23**	**198**	**58**	**312**	**6695**	**58**	**NA**	**203**	**188**	**749**	**237**	**NA**	**11126**	**478**	**1840**	**5**	**804**	**3562**	**NA**	**114**	**17929**

Table 83. Simultaneous count results February 2017.Highlighted yellow records denote breeding records

Section 3.04 Discussion of shorebirds 2020 count results

This is the ninth year in which Birds South Australia and BirdLife Australia's Shorebirds 2020 Program have cooperated to coordinate simultaneous counts of shorebirds in Gulf St Vincent. Simultaneous counts have been an important factor in reinvigorating the monitoring program across the region and have aided in identifying several internationally and nationally significant areas for shorebirds. They have brought the community together, and have enhanced the mentoring program for new or inexperienced shorebird surveyors. With the finalisation of the boundaries of count areas and an increase in the number of experienced counters, a rapid reduction in the variability of counts should be achieved.

Results from the 2016-17 counts reinforce previous data which identify priority habitats on the Gulf St Vincent as containing one or more species in numbers that are internationally or nationally significant. Even as individual discrete sites these areas classify as "important site" by the definition outlined by the Commonwealth (Section 1.03):

- Dry Creek Saltfields
- Price Saltfields
- Section Bank/Bird Island
- Thompson Beach
- Light Beach
- Port Prime

As a larger complex, the mosaic of sites, which contribute to the Gulf St Vincent "shorebird area" (see pg 72 for definition), exceed several criteria for listing as an internationally significant shorebird habitat (Section 1.03). Important migratory shorebird habitat in Australia is specifically protected under the EPBC Act. Under the Act, approval is required for any action that has, will have, or is likely to have, a significant impact on a matter of national environmental significance, which includes migratory species. An 'action' is broadly defined as a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things.

As defined in the EPBC Act Policy Statement 1.1 Significant Impact Guidelines, an action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

For further information on the application of the EPBC act in relation to shorebirds and shorebird habitat refer to *EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and* ***mitigating impacts on EPBC Act listed migratory shorebird species, Commonwealth of Australia 2015.***
https://www.environment.gov.au/system/files/resources/67d7eab4-95a5-4c13-a35e-e74cca47c376/files/shorebirds-guidelines.pdf

Although there is some variation between count totals for simultaneous counts (further discussed below) and totals listed in Table 78 and Table 79 can't account for the entire Gulf St Vincent population, they are very useful in identifying population abundance minimums. From these counts we can assume that the current condition of habitats within the gulf sufficiently provides for around 20,000-40,000 shorebirds. Of note:

- Several natural sites within the Samphire Coast regularly support nationally (>0.1% EAA) or internationally (>1% EAA) significant number of coastal obligates Red Knot Red and Bar-tailed Godwit (individual species accounts in Section 1.01(a). These species are heavily reliant on feeding (intertidal mudflat) and roosting habitat (sandy shores, shellgrit islands and floating accumulations of wrack) between Light Beach and Bald Hill. Given their specific requirements and the finite amount of available intertidal habitat, these populations should be management priorities in the area. Increasingly inconsistent recording of these species at regular roost sites in Port Prime and Thompsons Beach suggest some behavioural shifts. Tendencies for these large flocks to more frequently roost at Bald Hill and the Price Saltfields may be a reaction to increased disturbance at Thompsons Beach from crabbers and other recreational visitors.
- The Dry Creek Saltfields has maintained high abundances of species despite changes to the operational hydrology. As with ephemeral wetlands, the ponds transitioning from wet to dry have provided temporary increases in available feeding and roosting areas (further discussed in Section 1.03 (a)).
- Isolated areas (Section Banks, Samphire Coast claypans, Dry Creek Saltfields) remain priority breeding areas for Red-capped Plovers and Pied Oystercatchers. Section Banks also regularly supports populations of breeding Sacred Ibis, Australian Pelican, Eastern Great Egret, Crested Tern and the 'vulnerable' Fairy Tern. Management of these areas should seek to accommodate the specific needs of these populations.

(a) Species accounts for significant populations

The following accounts of significant populations occurring within Gulf St Vincent.

Using simultaneous count data, band resight data and satellite tracking data habitat use has been theorised for a number of species.

Notes on Listings

The following species accounts refer to the latest available information on conservation status and population size of migratory shorebirds in Australia found in Hansen et al (2016); *Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species. Unpublished report for the Department of the Environment*. BirdLife Australia, Melbourne.

Bar-tailed Godwit *Limosa lapponica*: Both subspecies of Bar-tailed Godwit (*menzbieri* and *baueri*) are known to occur in Gulf St Vincent however there is no detail on what proportions of each. A combined population estimate for both subspecies is referenced in this report.

Red Knot *Calidris canutus*: It is not known which subspecies of Red Knot (*piersmai* or *rogersi*) occurs in Gulf St Vincent. A combined population estimate for both subspecies is referenced in this report.

(I) Group B Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Nine shorebird species listed as threatened under the EPBC have been observed in the Northern Gulf St Vincent. The area regularly supports nationally significant numbers (0.1% EAAFP) of 2 globally Endangered species (IUCN Red List):

- Eastern Curlew *Numenius Madagascariensis*
- Great Knot *Calidris tenuirostris*

2 species found to be regionally Vulnerable (IUCN Red List) in the EAA Flyway (Conklin et al 2014):

- Bar-tailed Godwit *Limosa lapponica*
- Curlew Sandpiper *Calidris leschenaultii*.

The site also regularly supports internationally significant (>1% EAAFP) numbers of 1 regionally Vulnerable (IUCN Red List) in the EAA Flyway (Conklin et al 2014):

- Red Knot *Calidris canutus*

(II) Group B Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

The Northern Gulf St Vincent regularly supports internationally significant populations of two species of migratory waterbird; Red Knot *Calidris canutus* and Red-necked Stint *Calidris ruficollis*.

(i) Red Knot *Calidris canutus*

As discussed it is not clear which subspecies of Red Knot occurs in Gulf St Vincent, the latest combined 1% threshold for the two subspecies is 1,100 birds. This threshold was exceeded in 6 of the last 9 years (Table 84) falling short by just 5 individuals in the 2011/12 summer.

Table 84. Population count data for Red Knot in Gulf St Vincent (2008-2016).

Summer	Max Count	date
2008/09	1637	28/02/2009
2009/10	1103	23/01/2010
2010/11	1615	12/03/2011
2011/12	1095	2/02/2012
2012/13	2055	5/12/2012
2013/14	836	17/03/2014
2014/15	1109	2/02/2015
2015/16	1291	22/02/2016
2016/17	824	22/2/2017

(ii) Red-necked Stint *Calidris ruficollis*

The latest 1% threshold is 4,750 birds. The threshold was exceeded in 5 of the last 8 years (Table 85).

Red-necked Stints regularly occur in internationally significant numbers (>1% EAAFP) at the Dry Creek saltfields. As the largest supratidal area of habitat in Gulf St Vincent Red-necked Stints use the saltfields as a supplementary high-tide feeding and roosting site. Given counts in Gulf St Vincent are predominantly conducted at high-tide roosts they do not completely account for habitat usage at all tide heights and a proportion of the birds that are counted at the saltfields are considered to move to nearby intertidal areas on a falling tide.

Table 85. Population count data for Red-necked Stint in Gulf St Vincent (2008-2016).

Summer	Max Count	date
2008/09	11,791	28/02/2009
2009/10	6,749	23/01/2010
2010/11	2927	12/03/2011
2011/12	3,123	9/11/2011
2012/13	4070	1/12/2012
2013/14	3865	17/03/2014
2014/15	6162	2/02/2015
2015/16	7,834	22/02/2016
2016/17	10,3018	22/02/2017

*NB: A single count of 2,200 Red-necked stints was made on the coastline adjacent to the Port Wakefield Proof and Experimental Range in 2011. This one incidental count exceeded the accumulative count for all other sites on the simultaneous count for that season. Due to access restrictions enforced by the Department on Defence, this area has only been counted twice in the last decade. Counts have been reinstated for the 2017/18 season.

(iii) Sharp-tailed Sandpipers *Calidris acuminata*

Although more variable in their abundance depending on large scale water availability Sharp-tailed Sandpiper regularly occur within the Gulf St Vincent in nationally significant numbers (>85) and have occurred in the site at nationally significant numbers (>850) twice in the last 8 years. These events occurred during the millennium drought and highlight the significance of the Dry Creek Saltfields and the gulfs coastal wetlands as drought refugia.

Table 86. Population count data for Sharp-tailed Sandpiper in Gulf St Vincent (2008-2016)
Population count data for Sharp-tailed Sandpiper in Gulf St Vincent (2008-2016).

Summer	Max Count	date
2008/09	3,224	28/2/2009
2009/10	3,120	23/1/2010
2010/11	0	12/3/2011
2011/12	79	9/11/2011
2012/13	1,103	1/12/2012
2013/14	757	17/3/2014
2014/15	545	21/2/2015
2015/16	1,530	22/2/2016

(b) Count variation

A comparison of results from the simultaneous counts conducted since 2008 provides an insight into the variation one might expect from repeated counts in Gulf St Vincent (Table 1). There are three possible sources of discrepancies: (1) shorebirds' behavioural variation; and (2) count error (3) incomplete coverage.

A high variation in counts, such as that observed in Australian resident species (i.e. those that breed in Australia) including Banded Stilts and Red-necked Avocets, suggests that these shorebirds may move in and out of the study area, which is inconsistent with the concept of a shorebird area in which birds remain over the peak summer months. This is perhaps not surprising considering the life histories of these species.

These shorebirds are generally associated with sudden, episodic increases in the availability of prey in coastal or inland wetlands. Their use of flooded inland habitats is often opportunistic, and sudden inland flooding sometimes results in rapid and dramatic breeding events involving a large proportion of the population. For example, this occurred in winter 2010, when 150,000 Banded Stilts descended on Lake Torrens to breed, with an estimated 200,000 chicks hatching. Many of these birds reportedly remained in nearby pastoral areas, where they bred again seven months later when water generated from Tropical Cyclone 'Yasi' once again inundated Lake Torrens. On this occasion, an estimated 25,000 Banded Stilts were observed at the site. In 2011–12, nearly 20,000 Banded Stilts returned to the eastern shores of Gulf St Vincent.

Similarly, some migratory shorebirds, such as the Sharp-tailed Sandpiper, are thought to utilise episodic flood events which may save them a flight of more than 150 kilometres further south to terminal non-breeding sites on Australia's southern coastline. This event was reflected in a 98 per cent decline in Sharp-tailed Sandpipers recorded in the Gulf between January 2010 and January 2011. Such events may account for some of the natural variation in counts which occurs over short time scales. In the 2014-15 season increased salinities at the Dry Creek saltfields promoted an increased biomass (largely brine fly larvae) in Section 3 ponds.

The second cause of variation in counts stems from incomplete or excessive count coverage. For example, the numbers of Pied and Sooty Oystercatchers recorded in 2008 and 2011 were low and probably did not capture the whole population. This possibly arose because Section Bank/Bird Island, where most oystercatchers were recorded in the intervening surveys, was not surveyed in 2008 and 2011. Similarly, large numbers of Common Greenshanks, Red-capped Plovers, Sharp-tailed Sandpipers and Red-necked Stints were recorded in 2009; these numbers were inflated by a survey which was conducted at low-tide, while birds were feeding on the extensive mudflats of the Clinton Conservation

Park, and may have resulted in double counts of birds that roosted at high tide in nearby count areas, such as Price Saltfields.

Variation in counts of small, common waders, such as Red-capped Plovers, Red-necked Stints and Sharp-tailed Sandpipers, may also be caused by difficulties in surveying areas of high shorebird abundance and diversity, such as Dry Creek Saltfields, where the sheer number of birds makes it difficult to count them. Due to the supratidal nature of such sites, birds may remain feeding throughout the day, and often move throughout the salt ponds to access different feeding and roosting areas. This sometimes results in either double counts or birds not being counted at all. To reduce this problem, counters work in teams, with the counting of a common species delegated to one person who is more able to keep track of movements and overall abundance. In addition, counters are encouraged to collect data which allows the completeness of a count to be assessed.

Total maximum counts of conspicuous species (such as Bar-tailed Godwits and Red Knots), which occur mainly on the northern beaches and Price Saltfields have shown remarkable consistency in the total number observed in each complete survey of Gulf St Vincent to date. These results are encouraging as they demonstrate that with consistent coverage, sufficient counter experience and standardised methods, resulting data will have notably less variation than observed in previous shorebird surveys in Gulf St Vincent.

By considering the average maximum of birds counted at each site across the 9 year study period we can better understand how shorebird populations are using sites and what their requirements are (Section 2.02). Species maps found in Purnell 2016 further reinforce the significance of the northern Samphire Coast (Light Beach to Bald hill), the two saltfields and the Section Banks. These sites not only support the highest diversity and abundances of shorebirds abundance but also provide habitat for threatened migratory species.

Table 87. A summary of site data generated from count data collected in simultaneous counts during the study period. The maximum average count is calculated from the maximum count of each species observed at each site each season averaged over the number of seasons that site was covered. For threatened species records "1" denotes species that are regularly observed at the site "2" denotes irregular visitors. *Bolivar maximums are based on a single season of counts conducted by G. Carpenter in the 2015/16 summer.

				Austrlaian Painted Snipe	Lesser Sand Plover	Greater Sand Plover	Black-tailed Godwit	Bar-tailed Godwit	(Far) Eastern Curlew	Great Knot	Red Knot	Curlew Sandpiper
Count area	**Max Avg total shorebirds**	**shorebird diversity**	**EPBC listed Species**	**E**	**E**	**V**	**V**	**CE * / V**	**CE**	**CE**	**E**	**CE**
Bald Hill	984	20	6			2		1	1	1	1	1
Barker Inlet Wetlands	446	14	1									x
Bolivaar*	1748	13	1									x
Clinton CP	740	10	3		1				1			1
Dry Creek Saltfields	26019	24	4				1	1	1			1
Light Beach	5959	19	5					1	1	1	1	1
Magazine Rd	271	16	1	2								
Middle Beach	73	9	0									
Port Arthur	122	19	5					1	1	2	2	1
Port Clinton	984	21	7		2		1	2	1	2	1	1
Port Gawler	641	4	5		2			2	1		2	1
Port Parham	216	20	5		2			1		2	1	1
Port Prime	2316	15	6			2		1	1	1	1	1
Price Saltfields	7465	21	6		2			1	1	1	1	1
Saint Kilda	3611	21	4				2	2	2			1
Section Banks	1206	18	5					1	1	2	2	1
Thompson's Beach N	1372	25	8		2	2	2	1	1	1	1	1
Thompson's Beach S	3010	23	6		2			1	1	1	1	1
Webb Beach	667	11	6		2	2		1	1		1	1
Black Point	100											
Price coast (Mac's Beach)	29	15	5				2	1		2	1	1
Whicker Rd Wetlands	32	13										
White's Rd Wetlands	15	14	1	2								

Birds South Australia and its volunteers should be commended for their excellent efforts in continuing to undertake shorebird monitoring in Gulf St Vincent. Although the advent of the Shorebirds 2020's online data entry portal will be beneficial in the long run, it has also caused initial coordination confusion as some observers circumnavigate the regional coordinator, which allows less chance for feedback, accountability and retention. BirdLife Australia must continue to work closely with regional coordinators and counters in the future to overcome this shortfall. To further reduce the variation between counts, which would enable researchers to detect population trends more quickly, a number of refinements could be made:

BIRDLIFE AUSTRALIA RECOMMENDATIONS

56. Conduct surveys at the same time of year each year. This ensures that site conditions are similar each time and further increases the chances of counting the same group of birds.

57. Conduct surveys within a tighter time-frame, both within the week and within daily tide cycles, especially at proximate sites where there is a frequent exchange of birds. Provide volunteers with up-to-date maps, marked with the boundaries of count areas, to ensure that the areas being surveyed remain consistent.

58. Foster good count and identification techniques among counters through workshops and mentoring.

59. Continue conducting twice-yearly shorebird workshops to increase awareness of shorebird conservation and to expand the pool of experienced volunteer surveyors.

60. Develop an understanding of how well monitoring informs adaptive management, and optimise monitoring to inform on threats as our understanding of the severity and the distribution of threats increases.

61. Conduct field trips and counts with experienced mentors to foster appropriate count methods and familiarise new counters with shorebird identification and shorebird count areas.

4 EVENTS

Section 4.01 Shorebird training and education

In the 2016–17 season (spring–summer), a number of shorebird events where conducted in collaboration with the AMLR NR Board, the Adelaide International Bird Sanctuary and a banding expedition conducted by the Victorian Wader Study Group (VWSG) and Friends of Shorebirds SE and NR AMLR staff on behalf of AMLR NRM Board. Two workshops were conducted targeting 1) beginners and general public and 2) experienced counters and land managers. The events aimed to educate local communities and land managers about shorebird conservation and equip them with the identification skills and survey methodologies necessary to contribute to the Gulf St Vincent Population Monitoring Project.

Figure 76. Participants in the beginners' workshop observing shorebirds in the Thompson Beach North sabkha. Photo: Chris Purnell.

Topics covered included:

- The responsibilities and achievements of the Adelaide and Mount Lofty Ranges Natural Resources Management Board's coastal team;
- Shorebird ecology (migration, physiology, habitat requirements);
- Shorebird threats and conservation priorities (threats, population trends, mitigating against decline);
- The Shorebirds 2020 program;
- A review of outcomes achieved through the Gulf St Vincent Population Monitoring Project
- An introduction to shorebird ID and effective monitoring techniques;
- The use of optics.

Online survey feedback from previous shorebird workshops had identified that the majority of ‘beginner’ and ‘intermediate’ shorebirders required more time spent on the identification training. With this in mind, much time in each session was dedicated to working through the diagnostic characteristics, behaviour and typical habitat choices of the 30 most common shorebird species that occur in Gulf St Vincent. Presentation materials were also supplemented with shorebird identification booklets and access to the Oz Shorebird app which can be viewed on all smartphones.

BirdLife staff also contributed to the Aldinga Washpool Community Forum, providing a presentation detailing the avian values of the site and the value of citizen science.

Figure 78. BirdLife staff present on the ecological value of Aldinga Washpool at a Community Forum.

Effectiveness of recruitment, coordination and submission of data

The main goals of the workshops were to: (1) increase awareness of shorebird conservation; (2) recruit counters to the shorebird monitoring program; and (3) train them as counters.

When the Gulf St Vincent monitoring program began in 2008, approximately 80 counters were recruited to monitor shorebirds in Gulf St Vincent in the summer of 2009–10. This was a marked increase in the number of counters who participated the previous summer and resulted in the most comprehensive survey coverage in Gulf St Vincent so far. However, volunteer participation in the 2010–13 counts declined drastically. On a coordination level, insufficient follow-up of volunteers in the lead-up to the season probably contributed to the poor levels of participation. Shorebirds 2020’s move towards online data entry has also caused some confusion for coordinators, as counters submit their counts directly to BirdLife Australia. By circumventing contact with the coordinator at the data submission point, it becomes difficult to keep track of which observers have conducted surveys and have submitted their data, and which areas have been covered.

REFERENCES AND ADDITIONAL RESOURCES

African-Eurasian Waterbird Agreement (AEWA) (2009) Analysis of waterbird population trends in the African-Eurasian Flyway, 1983-2007, based on data from the International Waterbird Census (IWC).

Alves, J.A., Sutherland, W.J. and Gill, J.A. (2011) Will improving wastewater treatment impact shorebirds? Effects of sewage discharges on estuarine invertebrates and birds. Animal Conservation 15, 44–52.

Alves, J.A., Sutherland, W.J. & Gill, J.A. (2012). Will improving wastewater treatment impact shorebirds? Effects of sewage discharges on estuarine invertebrates and birds. *Animal Conservation* 15: 44–52.

Anderson, B. (2009) Buckland Park proposal- fauna technical report. Prepared for Walker Corporation.

Anon. (2013) Shorebird festival attracts thousands of birders to Gray Harbor Refuge. News Tribune, 21 April 2013. Accessed online at <http://www.thenewstribune.com/2013/04/21/2566656/shorebird-festival-attracts-thousands.html>.

Athearn, N.D., Takekawa, J.Y. & Shinn, J.M. (2009). Avian response to early tidal salt marsh restoration at former commercial salt evaporation ponds in San Francisco Bay, California, USA. *Natural Resources and Environmental Issues* 15: 77–86.

Athearn, N.D., Takekawa, J.Y., Bluso-Demers, J.D., Shinn, J.M., Brand, L.A., Robinson-Nilsen, C.W. & Strong, C.M. (2012). Variability in habitat value of commercial salt production ponds: implications for waterbird management and tidal marsh restoration planning. *Hydrobiologia* 697: 139–155.

Atkinson, P.W. (2003) Can we recreate or restore intertidal habitats for shorebirds? Wader Study Group Bulletin 100, 67–72.

Atkinson, P.W., Crooks, S., Drewitt, A., Grant, A., Rehfisch, M.M., Sharpe, J. and Tyas, C.J. (2004) Managed realignment in the UK — the first 5 years of colonisation. Ibis 146 (Suppl. 1), 101–110.

Austin, G.E. and Rehfisch, M.M. (2003) The likely impact of sea level rise on waders (Charadrii) wintering on estuaries. Journal for Nature Conservation 11, 43–58.

Australian Government (1977) Off-road vehicles: Impact on the Australian Environment Third Report of the House of Representatives Standing Committee on Environment and Conservation

Australian Nature Conservation Agency (1996) A Directory of Important Wetlands in Australia. Second Edition. ANCA, Canberra.

Auckland Regional Council (2010). Removing mangrove seedlings. Coastal fact sheet www.arc.govt.nz/coastplan

Avian Power Line Interaction Committee (APLIC). 2012. Reducing avian collisions with power lines: the state of the art in 1994. Edison Electric Institute and APLIC, Washington, D.C., USA.

Badley, J. and Allcorn, R.I. (2006) Changes in bird use following the managed realignment of Freiston Shore RSPB Reserve, Lincolnshire, England. Conservation Evidence 3, 102–105.

Baccetti, N., G. Cherubini, A. Magnani & L. Serra, 1995.Homing performances of adult and immature dunlins Calidris alpina (Aves Scolopacidae) displaced from their wintering area. Ethology Ecology &Evolution 7: 257–264.

Bamford, M.J., Watkins, D.G., Bancroft, W., Tischler, G. and Wahl, J. (2008) Migratory Shorebirds of the East Asian-Australasian Flyway: Population Estimates and Important Sites. Wetlands International, Oceania, Canberra.

Battley, P.F.; Schuckard, R.; Melville, D.S. 2011: Movements of bar-tailed godwits and red knots within New Zealand. Science for Conservation 315. Department of Conservation, Wellington. 56 p. http://www.doc.govt.nz/Documents/science-and-technical/sfc315.pdf

Baxter, C.I. (2003) Banded Stilt Cladorhynchus leucocephalus breeding at Lake Eyre North in year 2000. South Australian Ornithologist 34, 33–56.
Beckmann, C. L. and Hooper, G. E. (2017). Blue Crab (*Portunus armatus*) Fishery 2015/16. Fishery Assessment Report to PIRSA Fisheries and Aquaculture. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2007/000729-13. SARDI Research Report Series No. 944. 59pp.)
Beeton, S. (1998). Ecotourism: A Practical Guide for Rural Communities. Landlink Press, Melbourne.
Bellio, M. G., R. T. Kingsford & S.W. Kotagama, 2009. Natural versus artificial wetlands and their waterbirds in Sri Lanka. Biological Conservation 142: 3076–3085.
Berry, L. (2001) Nest predation in Australian woodland and shoreline nesting birds. PhD thesis, Monash University, Melbourne.
Bevanger, K. 1999. Estimating bird mortality caused by collision and electrocution with power lines: a review of methodology. Pages 29–56 in M. Ferrer, and G. F. Janns, editors. Birds and power lines: collision, electrocution, and breeding. Quercus, Madrid, Spain.
Bevanger, K., and H. Brøseth. 2004. Impact of power lines on bird mortality in a subalpine area. Animal Biodiversity and Conservation 27:67–77.
BirdLife Australia Atlas of Australian Birds database. BirdLife Australia.
BirdLife Australia (2014) - Dry Creek Saltfields Shorebirds Values Matrix. Excel spreadsheet report to the Adelaide and Mt Lofty Natural Resources Management Board April 2014.
BirdLife International. 2016. Species factsheets: IUCN Red List for birds. Accessed 11 July 2016 at: www.birdlife.org/datazone/species/search
Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984) The Atlas of Australian Birds. University of Melbourne Press, Melbourne.
Blokpoel H. and Spaans A.L. (1991) Superabundance in gulls: causes, problems and solutions. Introductory remarks. In 'Acta XX Congressus Internationalis Ornithologici'. Wellington pp. 2361-2363. (New Zealand Ornithological Congress Trust Board).Blondel, J. & Isenmann, P. 1973. L'è volution de la structure des peuplements de Laro-limicoles nicheurs de la zone saum â tre de Camargue. Terre et Vie, 27: 62-84.
Blumstein, D.T. (2003) Flight-initiation distance in birds is dependent on intruder starting distance. Journal of Wildlife Management 67, 852–857.
Blumstein, D.T. (2006). Developing an evolutionary ecology of fear: how life history and natural history traits affect disturbance tolerance in birds. Animal Behaviour 71:389-399.
Blumstein, D.T., D.S. Samia, and W.E. Cooper. (2016). Escape behavior: dynamic decisions and a growing consensus. Current Opinion in Behavioral Sciences 12:24-29.
Bool, N. M., Page, B. and Goldsworthy, S. D., (2007). What is causing the decline of little penguins *(Eudyptula minor)* on Granite Island, South Australia? SARDI Research Report Series No. 217. Adelaide.
Botton, M. L. (1979) Effects of sewage sludge on the benthic invertebrate community of the inshore New York Bight. Estuarine and Coastal Marine Science 8, 169–180.
Britton, R. H. & A. R. Johnson, 1987. An ecological account of a Mediterranean Salina: the Salin de Giraud, Camargue (S. France). Biological Conservation 42: 185–230.
Brown, S., Hickey, C., Harrington, B. and Gill, R. (2001) United States Shorebird Conservation Plan. Manomet Center for Conservation Sciences, Manomet, Massachusetts.
Bryars, S. (2013) Nearshore marine habitats of the Adelaide and Mount Lofty Ranges NRM region: values, threats and actions. Report to the Adelaide and Mount Lofty Ranges Natural Resources Management Board, Dr Simon Richard Bryars, Adelaide.
Bryars, S. (2003) An Inventory of Important Coastal Fisheries Habitats in South Australia. Fish Habitat Program, Primary Industries and Resources SA, Adelaide.
Buick, A.M. and Paton, D.C. (1989) Impact of off-road vehicles on the nesting success of Hooded Plovers Charadrius rubricollis in the Coorong Region of South Australia. Emu 89, 159–172.

Burger, J., M. A. Howe, D. Caldwell Hahn & J. Chase, 1977. Effects of tide cycles on habitat selection and habitat partitioning by migrating shorebirds. The Auk 94: 743–758.
Burger, J., Jeitner, C., Clark, K. and Niles, L.J. (2004) The effect of human activities on migrant shorebirds: successful adaptive management. Environmental Conservation 31, 283–288.
Burton, N.H.K., Evans, P.R. and Robinson, M.A. (1996) Effects on shorebird numbers of disturbance, the loss of a roost site and its replacement by an artificial island at Hartlepool, Cleveland. Biological Conservation 77, 193–201.
Campbell, L.H. (1984). The impact of changes in sewage treatment on seaducks wintering in the Firth of Forth. *Biological Conservation* 28:173–180.
Campbell, S. 1994. A review of the effects of coastal sewage discharges on ecosystem processes involving marine flora in southern Australia. *Department of Environmental Management; Victoria University of Technology: 23.*
Carpelan, L. H., 1957. Hydrobiology of the Alviso salt ponds. Ecology 38: 382–385.
Carpenter, G. (2008) *Birds of Section Bank, Outer Harbour*. Unpublished report for Coast and Marine Branch, Department of Environment and Heritage, Adelaide.
Carter, V., Riybicki, N. & Jaworski, N.A. 1993. The upper Paotmac Estuary: an environmental management and ecological restoration success. Part 2. Macrophyte resurgence and wildlife implications. *ASLO and SWS 1993 Annual Meeting Abstracts. USA: ASLO-SWS.*
Castillo-Guerrero, J.A., Fernández, G., Arellano, G. and Mellink, E. (2009) Diurnal abundance, foraging behavior and habitat use by non-breeding Marbled Godwits and Willets at Guerrero Negro, Baja California Sur, México. *Waterbirds* 32, 400–407.
Caton, B., Fotheringham, D., Krahnert, E., Pearson, J., Royal, M. & Sandercock, R. 2009, Metropolitan Adelaide and Northern Coastal Action Plan (MANCAP), Prepared for the Adelaide and Mount Lofty NRM Board and Department for Environment and Heritage, Adelaide.
Christie, M. and Standon, R. (2015). Grey Plover tracking in Gulf St Vincent. A report prepared by the Victorian Wader study Group and Friends of Shorebirds SE for the Adelaide and Mount Lofty Ranges Natural Resources Management Board, Adelaide.
CHSM (Committee for Holarctic Shorebird Monitoring) (2004) Monitoring Arctic-nesting shorebirds: an international vision for the future. *Wader Study Group Bulletin* 103, 2–5.
Clarke, B. and Simpson, N. (2010) *Climate Change Vulnerability — Identification of Threatened Coastal Habitat in the AMLR based on Existing Coastal Action Plans (CAPS)*. Report on behalf of the Adelaide and Mount Lofty Ranges Natural Resources Management Board, Adelaide.
Clarke, T. Ash Island Saltmarsh and Shorebird Habitat Restoration Project, Project Report 2014
https://www.hboc.org.au/wp-content/uploads/Appendix-B-2014-Ash-Island-rehabilitation.pdf
Clemens, R.S (2016). Ecology and Conservation of Australia's Shorebirds. PhD thesis. University of Queensland. School of Biological Sciences
Clemens, R., Rogers, D. and Priest, B. (2007a) *Shorebird Habitat Mapping Project: West Gippsland*. BirdLife Australia report to the WWF–Australia and the Australian Government's Department of Natural Heritage and Environment, Canberra.
Clemens, R.S., Weston, M.A., Spencer, J., Milton, D., Rogers, D., Rogers, K., Gosbell, K., Ferris, J. and Bamford, M. (2007b) *Progress Report: Developing a Population Monitoring Program for Shorebirds in Australia*. Unpublished report by Birds Australia to the Australian Government's Department of Natural Environment and Water Resources.
Clemens, R.S., Weston, M.A., Haslem, A., Silcocks, A. and Ferris, J. (2010) Identification of significant shorebird areas: thresholds and criteria. *Diversity and Distributions* 16, 229–242.
Clemens, R.S, Hansen, B., Rogers, D., Gosbell, K, Minton, C., Straw, P., Bamford, M., Woehler, E., Milton, D., Weston, M., Venables, B., Weller, D., Purnell, C., Hassell, C., Rutherford, B., Onton, K., Herrod, A., Choi, C., Dhanjal-Adams, K., Skilleter, K., Fuller, F. (Unpublished) *Local changes in shorebird abundance in Australia driven largely by external factors*. A School of Biological Sciences, University of Queensland, St. Lucia, Qld. 4072, Australia.

Clemens, R. S., Rogers, D. I., Hansen, B. D., Gosbell, K., Minton, C. D., Straw, P., ... & Venables, B. (2016). Continental-scale decreases in shorebird populations in Australia. Emu, 116(2), 119-135.
Close, D.H. (2008) Changes in wader numbers in Gulf St Vincent, 1979–2008. *Stilt* 54, 24–27.
Close, D.H. and McCrie, N. (1986) Seasonal fluctuations of waders in the Gulf St Vincent, 1976–1985. *Emu* 86, 145–154.
Coleman, P. (2013) *Risk and opportunities: A Briefing Paper on Coastal Habitat and Shorebird Conservation in the Light of Potential Closure of the Ridley Dry Creek Salt Fields*. Prepared for the AMLR NRM Board.
Coleman, P. and Cook, F. (2003) *Saint Kilda — Restoration Options*. Report by Delta Environmental Consulting for the St Kilda Progress Association, Adelaide.
Coleman, P. and Cook, F. (2009) *Adelaide and Mt Lofty Ranges NRMB: Shorebird Management and Conservation*. Report by Delta Environmental Consulting for the Adelaide and Mt Lofty Ranges Natural Resources Management Board, Adelaide.
Collazo, J.A., O'Harra, D.A. and Kelly, C.A. (2002) Accessible habitat for shorebirds: factors influencing its availability and conservation implications. *Waterbirds* 25 (Special Publication 2), 13–24.
Colombelli-Négrel, D., and Kleindorfer, S., (2014), Penguin monitoring and conservation activities in the Gulf St Vincent July 2013 – June 2014, Report to the Adelaide and Mt Lofty Natural Resources Management Board April 2014, School of Biological Sciences, Flinders University.
Colwell, M.A. (2010) *Shorebird Ecology, Conservation and Management*. University of California Press, Berkeley and Los Angeles, California.
Coman, B.J., Robinson, J. and Beaumont, C. (1991) Home range, dispersal and density of Red Foxes (Vulpes vulpes L.) in Central Victoria. Wildlife Research 18, 215–223.
Commonwealth of Australia 2015, Wildlife Conservation Plan for Migratory Shorebirds,
Commonwealth of Australia 2015EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species.
Commonwealth of Australia 2015 The Emergency Marine Pest Plan (EMPPla
Cook, F. and Coleman, P. (2003). Environmental Management Plan, Mutton Cove, SA.
Cooper, R., 1966, Birds of a salt-field, Imperial Chemical Industries, Melbourne, Vic. The Saltfield Sanctuary.
Conklin, J.R., Y.I. Verkuil & B.R. Smith. 2014. Prioritizing Migratory Shorebirds for Conservation Action on the East Asian-Australasian Flyway WWF-Hong Kong, Hong Kong.
Crick, H.Q.P. and Sparks, T.H. (2006) Changes in the phenology of breeding and migration in relation to global climate change. Acta Zoologica Sinica 52 (Suppl.), 154–157.
Crooks, S. (2004) The effect of sea-level rise on coastal geomorphology. *Ibis* 146 (Suppl. 1), 18–20.
Day, F.A.G. (2005) Birding on the Penrice Saltfields- An account of the birdlife on the saltfields and surrounding St Kilda, South Australia. Private publish.
Dann, P. (2007). Information Review on the Use of Western Treatment Plant by Waterbirds in Relation to Proposed Changes to the Sewage Treatment Process. Unpublished report to Melbourne Water Corporation, Melbourne.
Davies, S. and Brown, V. (1995) *Effect of Effluent from Western Treatment Plant on Benthic Biota: Monitoring Studies 1983–84*. Research Report 16. Melbourne Water PLC, Melbourne.
Dhanjal-Adams K.L., Hanson, J.O., Murray, N.J., Phinn, S.R., Wingate, V.R., Mustin, K., Lee, J.R., Allan, J.R., Cappadonna, J.L., Studds, C.E., Clemens, R.S., Roelfsema, C.M. and Fuller, R.A. 2016. Distribution and protection of intertidal habitats in Australia. Emu, 116, 208-214
DECC (Department of Environment and Climate Change NSW). (2008) Protecting and Restoring Coastal Saltmarsh. Accessed online at <www.environment.nsw.gov.au/resources/threatenedspecies/08609coastalsaltmarshbro.pdf>.
DELM (Department of Environment and Land Management). (1993) *The State of the Environment Report for South Australia 1993*. Community Education and Policy Development Group, Department of Environment and Land Management, Adelaide.

Delany, S. (2003) How many of the world's wader species are declining, and where are the globally threatened species? *Wader Study Group Bulletin* 101/102, 13.

Demers, S.A., Takekawa, J.Y., Ackerman, J.T., Warnock, N., & Athearn, N.D. (2010). Space use and habitat selection of migrant and resident American Avocets in San Francisco Bay. Condor 112:511–520.

Dias, M.P. (2009) Use of salt ponds by wintering shorebirds throughout the tidal cycle. *Waterbirds* 32, 531–537.

Dittmann, S., Baggalley, S., J. Keuning and Imgraben, S. (2012) *Mudflat Condition Monitoring in Gulf St Vincent*. Final Report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board, Adelaide.

Dittmann, S., Baring, R.J., Campbell R., Jessup-Case H., Evans-Sanchez K. (2015). Assessment of presence and distribution of the European shore crab Carcinus maenas in the nearshore habitats of Gulf St. Vincent, 2015/2016. Report for the Adelaide & Mount Lofty Ranges NRM Board, Adelaide. Flinders University.

Dittmann, S., Baring, R.J., Jessup-Case H., Campbell R. (2017). Monitoring and morphometric studies of the European shore crab (Carcinus maenas) in Gulf St Vincent 2016/17. Report for the Adelaide & Mount Lofty Ranges NRM Board, Adelaide. Flinders University.

Dorsey, J.H. (1982). Intertidal community offshore from the Werribee Sewage-treatment Farm: an opportunistic infaunal assemblage. Australian Journal of Marine and Freshwater Research 33: 45–54.

Dowling, B. and Weston, M.A. (1999) Managing a breeding population of the Hooded Plover *Thinornis rubricollis* in a high-use recreational environment. *Bird Conservation International* 9, 255–270.

Durell, S.E.A.L., Stillman, R.A., Triplet, P., Aulert, C., Biot, D.O.D., Bouchet, A., Duhamel, S., Mayot, S. and Goss-Custard, J.D. (2005) Modelling the efficacy of proposed mitigation areas for shorebirds: a case study on the Seine estuary, France. *Biological Conservation* 123, 67–77.

Durell, S.E.A.L., Stillman, R.A, Caldow, R.W.G., McGorty, S., West, A.D. and Humphreys, J. (2006) Modelling the effect of environmental change on shorebirds: a case study on Poole Harbour, UK. *Biological Conservation* 131, 459–473.

Ecological Associates Pty Ltd (2003), Environmental Water Requirements of Aldinga Scrub, Blue Lagoon and the Washpool.

Edyvane, K.S. (1999) Coastal and marine wetlands in Gulf St Vincent, South Australia: understanding their loss and degradation. *Wetlands Ecology and Management* 7, 83–104.

Elner, R.W. and Seaman, D.A. (2003) Calidrid conservation: unrequited needs. *Wader Study Group Bulletin* 100, 30–34.

EPA (Environmental Protection Authority). (2005) *A Tradable Rights Instrument to Reduce Nutrient Pollution in the Port Waterways: Feasibility Study*. Environmental Protection Authority, Adelaide.

EPA (Environmental Protection Authority). (2009). *A Risk Assessment of Threats to Water Quality in Gulf St Vincent*. Environmental Protection Authority, Adelaide.

Erickson, W. P., Johnson, G. D., & Young Jr, D. P. (2005). A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report PSWGTR-191, 1029-1042.

Erwin, R.M. (1996) Dependence of waterbirds and shorebirds on shallow-water habitats in the mid-Atlantic coastal region: an ecological profile and management recommendations. *Estuaries and Coasts* 19, 213–219.

Erwin, R.M. and Beck, R.A. (2007) Restoration of waterbird habitats in Chesapeake Bay: great expectations or Sisyphus revisited? *Waterbirds* 30 (Special Publication 1), 163–176.

Erwin, R.M., Allen, D.H. and Jenkins, D. (2003) Created versus natural coastal islands: Atlantic waterbird populations, habitat choices, and management implications. *Estuaries and Coasts* 26, 949–955.

Erwin, R.M., Sanders, G.M., Prosser, D.J. and Cahoon, D.R. (2006) High tides and rising seas: potential effects on estuarine waterbirds. *Studies in Avian Biology* 32, 214–228.

Fernandes, M. B., Daly, R., van Gils, J., Kildea, T., Caires, S., & Erftemeijer, P. L. (2017). Parameterization of an optical model to refine seagrass habitat requirements in an urbanized coastline. Estuarine, Coastal and Shelf Science.

Finlayson, C.M. and Rea, N. (1999) Reasons for the loss and degradation of Australian wetlands. *Wetlands Ecology and Management* 7, 1–11.

Finn, P.G., Catterall, C.P. and Driscoll, P.V. (2008) Prey versus substrate as determinants of habitat choice in a feeding shorebird. *Estuarine, Coastal and Shelf Science* 80, 381–390.

Fitzpatrick, S. and Bouchez, B. (1998) Effects of recreational disturbance on the foraging behaviour of waders on a rocky beach. *Bird Study* 45, 157–171.

Flaherty, T. & Sampson, K. (2005). “Taking NRM Beyond the Shore: Integrating Coastal Issues into Natural Resource Management.” Marine and Coastal Community Network, Yeronga, Queensland

Flaherty, T. (2013) *Adelaide and Mt Lofty Ranges NRM Board Briefing Paper: Potential Environmental Implications Regarding Dry Creek Salt Fields*. Adelaide and Mt Lofty Ranges NRM Board, Adelaide.

Flaherty, T. 2015, Shorebirds embark on spectacular journey, information sheet Natural Resources Adelaide and Mt Lofty Shorebirds Project website Accessed online at <http://www.naturalresources.sa.gov.au/adelaidemtloftyranges/plants-and-animals/native-plants-animals-and-biodiversity/native-animals/birds/shore-birds-project>.Flinders Ports (2013) Accessed online at <http://www.flindersports.com.au>.

Fox, D.R., Batley, G.E., Blackburn, D., Bone, Y., Bryars, S., Cheshire, A., Collings, G., Ellis, D., Fairweather, P., Fallowfield, H., Harris, G., Henderson, B., Kämpf, J., Nayar, S., Pattiaratchi, C., Petrusevics, P., Townsend, M., Westphalen, G. and Wilkinson, J. (2007) *Adelaide Coastal Waters Study*. CSIRO Report prepared for South Australian Environment Protection Authority, Adelaide.

Friess, D., I. Möller and Spencer, T. (2008) Case Study: managed alignment and the re-establishment of saltmarsh habitat, Freiston Shore, Lincolnshire, United Kingdom. In: ProAct Network. 2008. *The Role of Environmental Management and Eco-Engineering in Disaster Risk Reduction and Climate Change Adoption*. Accessed online at <http://www.unisdr.org/files/4148_emecoengindrrcca1.pdf>.

French, P.W. (2006) Managed realignment — the developing story of a comparatively new approach to soft engineering. *Estuarine, Coastal and Shelf Science* 67, 409–423.

Garnett, S., J. Szabo & G. Dutson. 2011. Action Plan for Australian Birds 2010. CSIRO, Collingwood.

Galbraith, H., Jones, R. Park, R., Clough, J., Herrod-Julius, S. Harrington, B. and Page, G. (2002) Global climate change and sea level rise: potential losses of intertidal habitat for shorebirds. *Waterbirds* 25, 173–183.

Garnett S.T. Szabo J.K. and Dutson G. (2011).The Action Plan for Australian Birds 2010. Birds Australia, CSIRO Publishing, Melbourne.

Geering, A., Agnew, L., and Haarding, S. (Eds) (2007). *Shorebirds in Australia*. CSIRO Publishing, Melbourne.

Gesch, D.B., Gutierrez, B.T. and Gill, S.K. (2009) Coastal Elevations. In: J.G. Titus, K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler and S.J. Williams (Eds). *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. Pp. 25–42. Report by U.S. Climate Change Science Program and Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington D.C.

GHD (2009). Multiple outlets trial. Outcomes of trial. Report no. 31/8465/151230. Melbourne, Australia.

Gibbs, M.T. (2007). Assessing the risk of an aquaculture development on shorebirds using a Bayesian belief model. Human & Ecological Risk Assessment 13: 156–179.

Gibbs, J. P. and Ene, E. (2010) Program Monitor: Estimating the statistical power of ecological monitoring programs. Version 11.0.0. Accessed online at <http://www.esf.edu/efb/gibbs/monitor/>.
Gill, J. (2007) Approaches to measuring the effects of human disturbance on birds. *Ibis* 149, 9–14.
Glover, H. (2009) *Response Distances of Shorebirds to Disturbance: Towards Meaningful Buffers*. Unpublished Honours thesis, Deakin University, Melbourne.
Gosbell, K. and Clemens, R. (2006) Population monitoring in Australia: some insights after 25 years and future directions. *Stilt* 50, 162–175.
Goss-Custard, J.D., Triplet, P., Sueur, F. and West, A.D. (2006) Critical thresholds of disturbance by people and raptors in foraging wading birds. *Biological Conservation* 127, 88–97.
Grays Harbor Shorebird Festival. (2013) Grays Harbor Shorebird Festival. Accessed online at <http://www.shorebirdfestival.com/>.
Greening Australia (2011) *Vertebrate Pest Mapping, Gulf St Vincent, Port Gawler to Port Parham 2010/2011*. Report to Adelaide and Mt Lofty Ranges Natural Resources Management Board, Adelaide.
Gutierrez, B.T., Williams, S.J. and Thieler, E.R. (2009) Ocean Coasts. In: J.G. Titus, K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (Eds). *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. Pp. 43–56. Report by U.S. Climate Change Science Program and Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington D.C..
Halcrow Group Ltd. (2005) *Paull Holme Strays Environmental Monitoring Report 2005*. Report to U.K. Environment Agency, London.
Halcrow Group Ltd. (2007) *Paull Holme Strays Environmental Monitoring Report 2007*. Report to U.K. Environment Agency, London.
Hansen, B.D., Fuller, R.A., Watkins, D., Rogers, D.I., Clemens, R.S., Newman, M., Woehler, E.J. and Weller, D.R. (2016) Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species. Unpublished report for the Department of the Environment. BirdLife Australia, Melbourne.
Hanisch, D. (1998) *Effects of human disturbance on the reproductive performance of the Hooded Plover*. Unpublished BSc. Honours thesis, University of Tasmania, Hobart.
Harris, C. (2011) *Opportunities and Constraints for Mangrove and Saltmarsh Retreats in the Coastal Zone of the District Council of Mallala*. Final Report to the Coastal Management Branch, Adelaide.
Harty, C. (2004) *Mangroves and saltmarshes- muddy management*. Wetlands Australia National Wetland update 2004. Autralian Government Department of the Environement and Heritage.
Herrod, A. (2010) *Migratory shorebird monitoring in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site*. BirdLife Australia Report, Melbourne.
Higgins, P.J. and Davies, S.J.J.F. (Eds) (1996) *Handbook of Australian, New Zealand and Antarctic Birds. Volume 3. Snipe to Pigeons*. Oxford University Press, Melbourne.
Hoffmann, L. 1958. An Ecological Sketch of the Camargue. British Birds, vol. LI: 321-349.
Hoffmann, L. 1964. La valeur des salins comme milieux biologiques. Project Mar, I.U.C.N., N.S. 3: 410-413.
Hong Kong Wetland Park. (2013) Hong Kong Wetland Park. Accessed online at <http://wetlandpark.gov.hk/en/aboutus/overview.asp>.
Hough, J. (2008), Salt production in South Australia, (Geological Survey Branch, PIRSA) in MESA Journal, 50, September 2008, pp 32 – 34 34, ww.pir.sa.gov.au/__data/assets/pdf_file/0005/93803/mj50_salt_production.pdf
Huang, S. C., Shih, S. S., Ho, Y. S., Chen, C. P., & Hsieh, H. L. (2012). Restoration of shorebird-roosting mudflats by partial removal of estuarine mangroves in northern Taiwan. Restoration Ecology, 20(1), 76-84.

Hughes, L. (2003) Climate change and Australia: trends, projections and impacts. *Austral Ecology* 28, 423–443.
Hughes, R.G. (2004) Climate change and loss of saltmarshes: consequences for birds. *Ibis* 146 (Suppl. 1), 21–28.
Hvenegaard, G.T. (1994) Ecotourism: a status report and conceptual framework. Journal of Tourism Studies 5(2), 24–35.
Hvenegaard, G.T., Butler, J.R. and Krystofiak, D.K. (1989) Economic values of bird watching at Point Pelee National Park, Canada. Wildlife Society Bulletin 17, 526–531.
International Union of the Conservation of Nature. 2012. Guidelines for Application of IUCN Red List Criteria at Regional and National Levels; Version 4.0. IUCN, Gland, Switzerland & Cambridge, UK.
IWSG (International Wader Study Group). (2003) Are waders world-wide in decline? Reviewing the evidence. Wader Study Group Bulletin 101/102, 8–12.
Iwamura, T., Possingham, H. P., Chadès, I., Minton, C., Murray, N. J., Rogers, D. I., ... & Fuller, R. A. (2013). Migratory connectivity magnifies the consequences of habitat loss from sea-level rise for shorebird populations. Proceedings of the Royal Society of London B: Biological Sciences, 280(1761), 20130325.
Jensen, A. (2004) Samphire Coast Shorebird Trails: Thompson Beach, Northern Gulf St Vincent. Wetland Care Australia for the Thompson Beach Ratepayers Association, Adelaide.
Johnston, G. and Wiebkin, A. (2008). Birds of Gulf St Vincent. In “Natural history of Gulf St Vincent”. S. A. Shepherd, S. Bryars, I. Kirkegaard, P. Harbison and J. T. Jennings (eds). Royal Society of South Australia, Adelaide. pp. 324-338.
Jones, K. (2009). 2007-08 South Australian Recreational Fishing Survey. South Australian Fisheries Management Series No. 55, PIRSA Fisheries, Adelaide. 84 pp.
Jones, A.S., Bosch, C. and Strange, E. (2009) Vulnerable species: the effects of sea-level rise on coastal habitats. In: J.G. Titus, K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (Eds). *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. Pp. 73–83. Report by U.S. Climate Change Science Program and Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington D.C.
Jones, D.N. and Buckley, R. (2001) *Birdwatching Tourism in Australia*. Wildlife Tourism Research Report Series 10. Cooperative Research Centre for Sustainable Tourism, Brisbane.
Jones, H. P., Tershy, B. R., Zavaleta, E. S., Croll, D. A., Keitt, B. S., Finkelstein, M. E. and Howald, G. R. (2008). Severity of the effects of invasive rats on seabirds: a global review. Conservation Biology 22: 16-26.
Keating, J, and Jarman, M.R. (2003) *South Coast Shorebird Recovery Program. Breeding Season 2002–2003*. NSW National Parks and Wildlife Service, Queanbeyan, NSW.
Kelly, J.P., Evens J.G., Stallcup R.W. & Wimpfheimer, D. (1996). The effects of aquaculture on habitat use by wintering shorebirds. California Fish and Game 82(4): 160–174.
Kellogg, B. and Root Pty Ltd (2003) *Barker Inlet Wetlands and the Range Wetlands: Bird Species Assessment*.
Kellogg, B. and Root Pty Ltd (2011) *Northern Connector Technical report 4- Project Impact Report.* Prepared for the Department of Transport, Energy and Infrastructure.
Keogh, M., (2006) “Synergies Between Coastal Threats: Do Marine Pests Affect Nutrient Management?” presentation by Prof. Michael Keough, Department of Zoology, Melbourne University to the Coast to Coast 2006 - Australia's National Coastal Conference http://www.vcc.vic.gov.au/coasttocoast2006.htm
Kinhill, Metcalf and Eddy, Inc. (1995) *Remote Sensing, Numerical Modelling and Field Studies of Environmental Impacts on Marine Communities of the Bolivar Wastewater Treatment Plan Effluent Discharge. Final Report.* Engineering and Water Supply Department, Adelaide.
Kirby, J.S., Clee, C. and Seager, V. (1993) Impact and extent of recreational disturbance to wader roosts on the Dee estuary: some preliminary results. *Wader Study Group Bulletin* 68, 53–58.
Knox, G.A. (1986). *Estuarine Ecosystems: A Systems Approach VI*. CRC Press Inc., Boca Raton, Florida.

Kratochvil, M., Hannon, N.J. and Clarke, L.D. (1972) Mangrove swamp and salt marsh communities in eastern Australia. *Proceedings of the Linnaean Society of NSW* 97, 262–274.

Lane, B. and Davies, J.N., (1987) *Shorebirds in Australia*. Nelson, Melbourne.

Lane, B. (2009) *Cheetham Wetlands Operational Manual — Volume 2.* Report produced for Parks Victoria. Report No.9025 (1.2).

Lane, B.A., Schulz, M. & Wood, K.W. (1984). Birds of Port Phillip Bay. Coastal Unit Technical Report No. 1, Ministry for Planning and Environment, Melbourne.

Larkum, A.W.D., McComb, A.J. and Shepherd, S.A. (1989) *Biology of Seagrasses*. Elsevier, Amsterdam.

Lawler, W. (1996) *Guidelines for Management of Migratory Shorebird Habitat in Southern East Coast Estuaries, Australia*. Unpublished Master of Resource Science thesis, University of New England, Armidale, NSW.

Lendon, A. (1965), Introduction to Cooper, R.P., (1965) Birds of a Saltfield, ICI, 1965.

Lonzarich, D. G. & J. J. Smith, 1997. Water chemistry and community structure of saline and hypersaline salt evaporation ponds in San Francisco Bay, California. California Fish and Game 83: 89–104.

Loyn, R.H., Lane, B.A., Tonkinson D., Berry L., Hulzebosch, M. & Swindley, R.J. (2002). Shorebird Use of Managed Habitats at the Western Treatment Plant. Report for Melbourne Water by Arthur Rylah Institute and Brett Lane & Associates, Melbourne.

Ma, Z. J., Y. T. Cai, B. Li & J. K. Chen, 2010. Managing wetland habitats for waterbirds: an international perspective. Wetlands 30: 15–27.

Mackenzie, C.L. (2000) The abundances of small invertebrates in relation to Sea Lettuce, *Ulva lactuca*, mats. *Bulletin of the New Jersey Academy of Science* 45, 13–17.

Maclean, I.M.D., Rehfisch, M.M., Delany, S. and Robinson, R.A. (2007) *The Effects of Climate Change on Migratory Waterbirds Within the African–Eurasian Flyway*. AEWA Technical Series 21. Bonn, Germany.

Maguire, G.S. (2008) *A Practical Guide for Managing Beach-nesting Birds in Australia*. Birds Australia, Melbourne.

Maine Office of Tourism. (n.d.) Maine Birding Trail. Accessed online at <http://www.visitmaine.com/rich-media/brochures/bird/>.

MacKinnon, J., Verkuil, Y.I. & Murray, N. (2012) IUCN situation analysis on East and Southeast Asian intertidal habitats, with particular reference to the Yellow Sea (including the Bohai Sea). Occasional Paper of the IUCN Species Survival Commission No. 47. IUCN, Gland, Switzerland and Cambridge, UK. ii + 70 pp.

Mander, L. and Cutts, N.D. (2004) *Ornithological Monitoring, Thorngumbald: Annual Report 2. January to December 2003*. Institute of Estuarine and Coastal Studies, University of Hull, Hull.

Marks, C.A. and Short, R.V. (1996) Out-foxing the fox. *Nature Australia* Winter, 39–45.

Martin J.M. and Dawes J. (2005) Egg oil: a tool for the management of pest bird populations. In '13th Australasian Vertebrate Pest Conference Management Conference'. Wellington. (Ed. Research, L.).

Martin J.M., French K. and Major R. (2006) Australian White Ibis (Threskiornis molucca), WINNERS as an urban coloniser: A laboratory and field evaluation of vegetable oil to prevent eggs hatching. In 'Ibis Management Conference'. John Flynn Hospital, Gold Coast. (Ed. Ecosure Pty Ltd).

Martin, G. R., and J. M. Shaw. 2010. Bird collisions with power lines: failing to see the way ahead? Biological Conservation 143:2695–2702.

Masero, J.A. (2003) Assessing alternative anthropogenic habitats for conserving waterbirds: salinas as buffer areas against the impact of natural habitat loss for shorebirds. Biodiversity and Conservation 12, 1157–1173.

Masero, J. A. & A. Pe´rez-Hurtado, 2001. Importance of the supratidal habitats for maintaining overwintering shorebird populations: how redshanks use tidal mudflats and adjacent saltworks in southern Europe. The Condor 103: 21–30.

Masero, J.A., Pérez-Hurtado, A., Castro, M. and Arroyo, G.M. (2000) Complementary use of intertidal mudflats and adjacent salinas by foraging waders. *Ardea* 88, 177–191.

Mathis, M. and Matisoff, D. (2004) *Valuing Nature in Texas. A Characterization of Ecotourism in the Texas Lower Rio Grande Valley*. Discussion Paper VNT-04-01. Houston Advanced Research Centre, Houston, Texas.

McGrath, M. (2006) *Planning a Shorebird Project to Target 4WD Impacts on Sensitive Shorebird Habitat*. Factsheet by Social Change Media, prepared for WWF-Australia.

McKie, R. (2005) Puffins being wiped out as shrub chokes nesting sites. *The Observer* 18 December 2005.

Melbourne Water 2013, Eastern Treatment Plant Upgrade: Information in support of a works approval application. <www.epa.vic.gov.au/compliance-enforcement/comments/docs/ETP-Works-Approval-application-21July2009.pdf>

Milne, T., and Telfer, S. (2014), *Bird Island Biodiversity Action Plan, prepared for* AMLRNRMB by Ecological Evaluation Pty Ltd, June 2014.

Milton Delaware Chamber of Commerce. (2013) Horseshoe Crab and Shorebird Festival. Accessed online at <http://www.historicmilton.com/events/event/285-Horseshoe%20Crab%20and%20Shorebird%20Festival.html>.

Mines and Energy South Australia, (1996), Report 245, PP218 on the 'Accident to the Mobile Offshore Drilling Unit (Maersk Victory) on November 16 1996'.

Mitchell, R.J., Morecroft, M.D., Acreman, M., Crick, H.Q.P., Frost, M., Harley, M., Maclean, I.M.D., Mountford, O., Piper, J., Pontier, H., Rehfisch, M.M., Ross, L.C., Smithers, R. J., Stott, A., Walmsley, C., Watts, O. and Wilson, E. (2007) England Biodiversity Strategy — Towards Adaptation to Climate Change. Defra, London.

Möller, I. [n.d.] *European Approaches to Managed Realignment*. Accessed online at <www.geog.cam.ac.uk/reserach/projects/europeanmanagedrealignment/>.

Morris, L. and Keough, M. J. (2001). Vertical migration of infaunal invertebrates in response to dosing with secondary treated sewage effluent: a microcosm experiment. Journal of Aquatic Ecosystem Stress and Recovery 9, 43-65.

Morris, L. and Keough, M. J. (2003). Testing the effects of nutrient additions on mudflat macroinfaunal assemblages in the presence and absence of shorebird predators Marine and Freshwater research 54, 7: 859-874.

Morrison, R.I.G., Aubry, Y., Butler, R.W., Beyersbergen, G.W., Donaldson, G.M., Gratto-Trevor, C.L., Hicklin, P.W., Johnston, V.H. and Ross, R.K. (2001) Declines in North American shorebird populations. *Wader Study Group Bulletin* 94, 34–38.

Murphy-Klassen, H.M., Underwood, T.J., Sealy, S.G., and Czyrnyj, A.A. (2005) Long-term trends in spring arrival dates of migrant birds at a delta marsh, Manitoba, in relation to climate change. *Auk* 122, 1130–1148.

Murray. N.J. Clemens, R.S., Phinn, S.R., Possingham, H.P. and Fuller, R.A. (2013) Tracking the rapid loss of tidal wetlands in the Yellow Sea. *Frontiers in Ecology and the Environment* 12, 267–272.

Murray, N.J., Ma, Z. & Fuller, R.A. (2015) Tidal flats of the Yellow Sea: A review of ecosystem status and anthropogenic threats. *Austral Ecology*.

National Oceanographic and Atmospheric Administration. (2007) *Ocean and Coastal Resource Management — Managed Retreat Studies.* Accessed online at <http://coastalmanagement.noaa.gov/initiatives/shoreline_ppr_retreat.html>.

Nebel, S., Porter, J.L. and Kingsford, R.T. (2008) Long-term trends in shorebird populations in eastern Australia and impacts of freshwater extraction. *Biological Conservation* 141, 971–980.

New Jersey Division of Fish and Wildlife. (2000) Study reveals shorebird viewing delivers huge economic benefit. *New Jersey Division of Fish and Wildlife News*, 16 August 2000.

New York City Audubon. (2012) 7th Annual Shorebird Festival at Jamaica Bay Wildlife Refuge. Accessed online at <http://nycaudubon.org/7th-annual-shorebird-festival-at-jamaica-bay-wildlife-refuge>.

NIMPIS 2002, Carcinus maenas (European shore crab) species summary, National Introduced Marine Pest Information System, available at data.daff.gov.au/marinepests/index.cfm?fa=main.spDetailsDB&sp=6000006243

Oldland, J.M., Clemens, R.S., Haslem, A., Shelley, L.D. and Kearney, B.D. (2008) *Final Report: Shorebirds 2020: Migratory Shorebird Population Monitoring Project*. Unpublished report by Birds Australia to the Australian Government's Department of Environment, Water, Heritage and the Arts.

Olsen, P., Weston, M., Cunningham, R. and Silcocks, A. (2003) The State of Australia's Birds 2003. *Wingspan* 13 (Supplement), 1–21.

Page, G.W., Warriner, J.S., Warriner, J.C. and Halbeisen, R.M. (1977) *Status of the Snowy Plover on the Northern California Coast. Part I: Reproductive Timing and Success*. California Department of Fish and Game Nongame Wildlife Investigations, Sacramento, California.

Parliament of South Australia, 2011, Adelaide and Mount Lofty Ranges NRM Region Fact Finding Visit Sixty Second Report of the Natural Resources Committee Tabled in the House of Assembly and ordered to be published, Tuesday 8 November 2011 First Session, Fifty Second Parliament.

Paracuellos, M., H. Castro, J. C. Nevado, J. A. On˜a, J. J. Matamala, L. Garcı´a & G. Salas, 2002. Repercussions of the abandonment of Mediterranean saltpans on waterbird communities. Waterbirds 25: 492–498.

Park, P. (1994) Hooded Plovers and Marram Grass. *Stilt* 25, 22.

Paton, D.C., Ziembicki, M., Owen, P. and Heddle, C. (2000) Disturbance distances for water birds and the management of human recreation with special reference to the Coorong region of South Australia [Abstract]. *Stilt* 37, 46.

Peters, K, J. and Flaherty, A (2013). Current impacts and threat abatement of marine debris within Gulf St Vincent: Re-assessment 2 years after preliminary monitoring. Final report to the Commonwealth Government of Australia (Commonwealth identification No: OC13-00496). Adelaide and Mount Lofty Ranges Natural Resources Management Board. Adelaide. 54 pp.

Peters, K.A. and Otis, D.L. (2007) Shorebird roost-site selection at two temporal scales: is human disturbance a factor? *Journal of Applied Ecology* 44, 196–209.

Pfister, C., Harrington, B.A. and Lavine, D.M. (1992) The impact of human disturbance on shorebirds at a migration staging area. *Biological Conservation* 60, 115–126.

Phillip Island Nature Parks. (2012) *Annual Report 2011–12*. Phillip Island Nature Parks, Phillip Island, Victoria.

Piersma, T. and Lindström, Å. (2004) Migrating shorebirds as integrative sentinels of global environmental change. *Ibis* 146 (Suppl.1), 61–69.

PIRSA 2015, Status of South Australian Fisheries Report. South Australian Fisheries Management Series, Paper number 69. Primary Industries and Regions SA, Adelaide

Poore, G.C.B. and Kudenov, J.D. (1978) Benthos around an outfall of the Werribee Sewage Treatment Farm, Port Phillip Bay, Victoria. *Australian Journal of Marine and Freshwater Research* 29, 157–167.

Port Adelaide Enfield CouncilDevelopment Plan, Consolidated – 6 February 2018 - Metropolitan Open Space System Zone Conservation Policy Area 17

Pounder, B. (1976). Wintering flocks of Goldeneyes at sewage outfalls in the Tay Estuary. Bird Study 23:121–131.

Purnell, C., Diyan, M.A.A., Clemens, R., Berry, L., Peter, J. and Oldland, J. (2009) *Shorebird Habitat Mapping Project: Gulf St Vincent*. Birds Australia Report for the Adelaide–Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.

Purnell, C., Clemens, R. and Peter, J. (2010) *Shorebird Population Monitoring within Gulf St Vincent: July 2009 to June 2010 Annual Report*. Birds Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.

Purnell, C., Clemens, R. and Peter, J. (2011) *Shorebird Population Monitoring within Gulf St Vincent: July 2010 to June 2011 Annual Report*. Birds Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.

Purnell, C., Peter, J., Clemens, R and Herman, K. (2012) *Shorebird Population Monitoring within Gulf St Vincent: July 2010 to June 2011 Annual Report*. Birds Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.

Purnell, C., Peter, J. & Clemens, R. (2013). Shorebird Population Monitoring within Gulf St Vincent: July 2011 to June 2012 Annual Report. BirdLife Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board and the Department of the Environment, Water, Heritage and the Arts.

Purnell, C., Peter, J., Clemens, R. 2015. Shorebird Population Monitoring within Gulf St Vincent: July 2014 to June 2015 Annual Report. BirdLife Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

Raffaelli, D.G. and Hawkins, S.J. (1999) *Intertidal Ecology*. Kluwer Academic, Dordrecht, The Netherlands.

Raincoast Education Society. (2013) Tofino Shorebird Festival. Accessed online at <http://raincoasteducation.org/events/tofino-shorebird-festival>.

Rehfisch, M.M. and Austin, G.E. (2006) Climate change and coastal waterbirds: the United Kingdom experience reviewed. In: G.C. Boere, C.A. Galbraith & D.A. Stroud (Eds). *Waterbirds Around the World.* The Stationery Office, Edinburgh, pp. 398–404.

Rehfisch, M., Clark, N., Langston, R. and Greenwood, J. (1996) A guide to the provision of refuges for waders: an analysis of 30 years of ringing data from the Wash, England. *Journal of Applied Ecology* 33, 673–687.

Rehfisch, M.M., Austin, G.E., Freeman, S.N., Armitage, M.J.S. and Burton N.H.K. (2004) The possible impact of climate change on the future distributions and numbers of waders on Britain's non-estuarine coast. *Ibis* 146 (Suppl. 1), 70–81.

Riegen, A.C.; Minton, C.D.T.; Jessop, R.; Collins, P. 2005: Movements of red knot between Australia and New Zealand. Pp. 175–182 in Straw, P. (Ed.): Status and conservation of shorebirds in the East Asian-Australasian Flyway; Proceedings of the Australasian Shorebirds Conference 13–15 December 2003, Canberra, Australia. Wetlands International Global Series 18, International Wader Studies 17, Sydney, Australia. http://www.waderstudygroup.org/article/6177/

Rix, C.E. (1978) Companion to Cooper’s Birds of a Salt-field, Melbourne, ICI Australia.

Rioux, S., J.-P. L. Savard, and A. A. Gerick. 2013. Avian mortalities due to transmission line collisions: a review of current estimates and field methods with an emphasis on applications to the Canadian electric network. Avian Conservation and Ecology 8(2): 7.

Robinson, R.A., Learmonth, J.A., Hutson, A.M., Macleod, C.D., Sparks, T.H., Leech, D.I., Pierce, G.J., Rehfisch, M.M. and Crick, H.Q.P. (2005) *Climate Change and Migratory Species*. A Report for Defra Research Contract CR0302. BTO Research Report 414.

Rogers, D.J., Loyn, Cumbo, B., Papas, P., Steel, W. (2010) Abundance of Benthos in non-tidal ponds at Western Treatment Plat, Werribee, and implication for shorebird conservation. Arthur Rylah Institute for Environmental Research Technical Report unpublished.

Rogers, D., Hulzebosch, M. (2014) Use of non-tidal ponds by shorebirds at the Western Treatment Plant. Unpublished Client Report for Melbourne Water, Department of Environment and Primary Industries.

Rogers, D.I., Piersma, T. and Hassell, C.J. (2006). Roost availability may constrain shorebird distribution: exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation* 133, 225–235.

Rogers, D.I., Loyn, R., McKay, S., Bryant, D., Swindley, R. and Papas, P. (2007). *Relationships between shorebird and benthos distribution at the Western Treatment Plant*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 169.

Rogers, D., Hassell, C., Oldland, J., Clemens, R., Boyle, A. and Rogers, K. (2009) *Monitoring Yellow Sea Migrants in Australia (MYSMA): North-western Australian Shorebird Surveys and Workshops, December 2008*. Arthur Rylah Institute for Environmental Studies, Melbourne.

Rogers, D. I., Yang, H. Y., Hassell, C. J., Boyle, A. N., Rogers, K. G., Chen, B., ... & Piersma, T. (2010). Red Knots (Calidris canutus piersmai and C. c. rogersi) depend on a small threatened staging area in Bohai Bay, China. Emu, 110(4), 307-315.

Ross, D. J., Johnson, C. R., Hewitt, C. L., & Ruiz, G. M. (2004). Interaction and impacts of two introduced species on a soft-sediment marine assemblage in SE Tasmania. Marine Biology, 144(4), 747-756.

Ross, D.J., 2001, Impact of the northern Pacific seastar Asterias amurensis on soft sediment assemblages, including commercial species, in southeast Tasmania, PhD thesis University of Tasmania

Rudman, T. (2003) *Tasmanian Beach Weed Strategy for Marram Grass, Sea Spurge, Sea Wheatgrass, Pyp Grass and Beach Daisy*. Nature Conservation Report 03/2, Nature Conservation Branch, Department of Primary Industries, Water and Environment, Hobart.

Rufino, R., A. Araujo, J. P. Pina & P. S. Miranda, 1984. The use of salinas by waders in the Algarve, South Portugal. Wader Study Group Bulletin 42: 41–42.

Saintilan, N. and Williams, R.J. (1999) Mangrove transgression into salt marsh environments in eastern Australia. *Global Ecology and Biogeography* 8, 117–124.

Saintilan, N. and Williams, R.J. (2000) The decline of salt marshes in southeast Australia: results of recent survey. *Wetlands (Australia)* 18, 49–54.

Sanchez, M. I., A. J. Green & E. M. Castellanos, 2006. Spatial and temporal fluctuations in presence and use of chironomid prey by shorebirds in the Odiel saltpans, south-west Spain. Hydrobiologia 567: 329–340.

Sargent, S. (Ed) 2012, with contributions from Allan, R., Bilham, K., Clarke, B., Faulkner, A., Flaherty, T., Gleave, D., Lansdown, D., McCuaig, A., Payne, M., Prior, S., Taylor, C. and Woehler, E.J. Discussion Paper; Off-road Vehicles on Beaches - the impacts, implications and options for coastal managers in Australia, produced for 2012 Coast to Coast National Coastal Conference, Off road vehicle workshop.

Schaeffer-Novelli, .Y, Cintrón-Molero, G. & Coelho, V Jr (2006). Managing shorebird flyways: shrimp aquaculture, shorebird populations and flyway integrity. In: Boere G.C., Galbraith C.A. & Stroud D.A. (eds) Waterbirds Around the World. The Stationary Office, Edinburgh, pp. 812–816.

Schlacher, T., Richardson, D. and McLean, I. (2008) Impacts of off-road vehicles (ORVs) on macrobenthic assemblages on sandy beaches. Environmental Management 41, 878–892.

Senate Environment, Communications, Information Technology and the Arts References Committee, (2000), Gulf St Vincent Inquiry, evidence from McFarlane, Mr Alistair Gordon, Independent Chairman, Gulf St Vincent Prawn Boat Owners Association; Wait, Mr Jeffery Paul, Alternate Director, South Australian Fishing Industry Council,(2000) , Official Committee Hansard, p 44,Thursday, 3 February 2000, Adelaide, Commonwealth Of Australia.

Smith G.C. and Carlile N. (1993) Methods for population control within a silver gull colony. Wildlife Research 20: 219-226.

Larkum, A.W.D., McComb, A.J., Shepherd, S.A. (1989) *Biology of Seagrasses*. Elsevier, Amsterdam.

Singh, D. (2012) Ban on tourists, free run for poachers. *Indian Express*, 29 August 2012.

Smart, J. and Gill, J.A. (2003) Climate change and potential impacts on breeding waders in the UK. *Wader Study Group Bulletin* 100, 80–85.

Steele, W.K. (1996). An Annotated Bibliography of Inter-relationships Between Waterbirds and Changes in Effluent Flows — With Particular Reference to the Western Treatment Plant, Victoria. RAOU Report 112.

Stralberg, D., Applegate, D.L., Phillips, S.J., Herzog, M.P., Nur, N. & Warnock, N. (2009). Optimizing wetland restoration and management for avian communities using a mixed integer programming approach. Biological Conservation 142: 94–109.

Steven, R., Pickering, C., & Castley, J. G. (2011). A review of the impacts of nature based recreation on birds. Journal of environmental management, 92(10), 2287-2294.

Straw, P. and Saintilan, N. (2006) Loss of shorebird habitat as a result of mangrove incursion due to sea-level rise and urbanization. Pp. 717–720 in: G.C. Boere, C.A. Galbraith and D.A. Stroud (Eds) *Waterbirds Around the World*. The Stationery Office, Edinburgh, pp. 717–720.

Sutherland, W.J. (2004). Climate change and coastal birds: research questions and policy responses. *Ibis* 146 (Suppl. 1), 120–124.

Takekawa, J. Y., C. T. Lu & R. T. Pratt, 2001. Bird communities in salt evaporation ponds and baylands of the northern San Francisco Bay estuary. Hydrobiologia 466: 317–328.

Takekawa, J.Y., Miles, A.K., Schoellhamer, D.H., Athearn, N.D., Saiki, M.K., Duffy, W.D., Kleinschmidt, S., Shellenbarger, G.G., & Jannusch, C.A. (2006). Trophic structure and avian communities across a salinity gradient in evaporation ponds of the San Francisco Bay estuary. Hydrobiologia 567: 307–327.

Tanner, J.E., and Theil, M.J. (2016). Adelaide Seagrass Rehabilitation Project: 2014-2016. Final report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board

Tanner, J. E., Irving, A. D., Fernandes, M., Fotheringham, D., McArdle, A., & Murray-Jones, S. (2014). Seagrass rehabilitation off metropolitan Adelaide: a case study of loss, action, failure and success. Ecological management & restoration, 15(3), 168-179

Ter Braak, C.J.F., Van Strien, A.J., Meijer, R., & Verstrael, T.J. (1994) Analysis of monitoring data with many missing values: which method? In: E.J.M. Hagemeijer & T.J. Verstrael (Eds.) Bird Numbers 1992. Distribution, monitoring and ecological aspects. *Proceedings of the 12th International Conference of IBCC and EOAC, Noordwijkerhout, The Netherlands*. Statistics Netherlands, Voorburg/Heerlen & SOVON, Beek-Ubbergen, pp. 663-673.

Thébault, J., Schraga, T.S., Cloern, J.E., & Dunlavey, E.G. (2008). Primary production and carrying capacity of former salt ponds after reconnection to San Francisco Bay. Wetlands 28: 841–851.

Threatened Species Scientific Committee (2013) *Commonwealth Conservation Advice for Subtropical and Temperate Coastal Saltmarsh for* inclusion of ecological communities in the list of threatened ecological communities under section 181 of the Environment Protection and Biodiversity Conservation Act 1999.

Threatened Species Scientific Committee (TSSC), (2006), 'Predation by exotic rats on Australian offshore islands of less than 1000 km2 (100,000 ha)', Advice to the Minister for the Environment and Heritage from the on Amendments to the List of Key Threatening Processes under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Titus, J.G. and Strange, E.M. (Eds) (2008) *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1: Coastal Evaluations and Sensitivity to Sea Level Rise*. US EPA, Washington D.C..

Tombre, I.M., Madsen, J., Tommervik, H., Haugen, K.P. and Eythorsson, E. (2005) Influence of organised scaring on distribution and habitat choice of geese on pastures in northern Norway. *Agriculture, Ecosystems and Environment* 111, 311–320.

Tubbs, C.R., Tubbs, J.M. and Kirby, J.S. (1992) Dunlin *Calidris alpina alpina* in The Solent, southern England. *Biological Conservation* 60, 15–24.

Turner, R. K., Burgess, D., Hadley, D., Coombes, E. and Jackson, N. (2007) A cost-benefit appraisal of coastal managed realignment policy. *Global Environmental Change* 17, 397–407.

United Nations Environment Programme. (2002) *Ecotourism: Principles, Practices and Policies for Sustainability*. United Nations Environment Programme, Division of Technology, Industry and Economics, Paris.

United Nations Environment Programme (2006) *Report on the eighth meeting of the Conference of the Parties to the Convention on Biological Diversity*. Convention of Biological Diversity, Curitiba, Brazil.

US Fish & Wildlife Service. (2012) *South Carolina Lowcountry Refuges*. Accessed online at <www.fws.gov/screfugescomplex/challenges.html>.

van de Kam, J., Ens, B., Piersma, T. and Zwarts, L. (2004) *Shorebirds: An Illustrated Behavioural Ecology*. [Translated into English by P. de Goeij and S.J. Moore]. KNNV Publishers, Utrecht, The Netherlands.

van Impe, J. (1985) Estuarine pollution as a probable cause of increase of estuarine birds. *Marine Pollution Bulletin* 16, 271–276.

Veitch, C.R. and Clout, M.N. (Eds) (2002) Turning the tide: the eradication of invasive species. *Proceedings of the International Conference on Eradication of Island Invasives*. IUCN, Gland, Switzerland and Cambridge, UK, pp. 254–259.

Velasquez, C.R. (1992) Managing artificial saltpans as a waterbird habitat: species' responses to water level manipulations. *Colonial Waterbirds* 15, 43–55.

Velasquez, C.R. and Hockey, P.A.R. (1992) The importance of supratidal foraging habitats for waders at a south temperate estuary. *Ardea* 80, 243–253.

Victorian Wader Study Group (VWSG) 2015, Grey Plover tracking in Gulf St Vincent South Australia information sheet, VWSG website Accessed online at <http://www.vwsg.org.au/greyplovertrack.pdf>.

Walmsley J.G., (1999), The ecological importance of Mediterranean salinas. Proceedings of the Post Conference Symposium SALTWORKS: Preserving Saline Coastal Ecosystems-Global NEST, 11-30 Sept 1999, Samos.

Warnock, S.E. & Takekawa, J.Y. (1995). Wintering site fidelity and movement patterns of Western Sandpipers Calidris mauri in the San Francisco Bay estuary. Ibis 138: 160–167.

Warnock, N., G. W. Page, T. D. Ruhlen, N. Nur, J. Y. Takekawa & J. T. Hanson, 2002. Management and conservation of San Francisco Bay salt ponds: effects of pond salinity, area, tide, and season on Pacific Flyway waterbirds. Waterbirds 25: 79–92.

Watkins, D. (1993) A National Plan for Shorebird Conservation in Australia. Australasian Wader Studies Group, Melbourne.

Watkins, D., R. Jaensch, D. Rogers & K. Gosbell. 2012. Unpubl. table of preliminary updated estimates of population size of selected shorebird species in the East Asian-Australasian Flyway based on trends in The Action Plan for Australian Birds 2010 (Garnett et al. 2011).

Watts, B.D. (2013) Migrant shorebirds within the Upper Bay of Panama. Accessed online at <http://dodpif.org/groups/international/migrant shorebirds.php>.

WWF Hong Kong. (2006). *Management Plan for the Mai Po Marshes Wildlife Education Centre and Nature Reserve. 2006–2010*. WWF Hong Kong, Hong Kong.

Weber, L.M. and Haig, S.M. (1996) Shorebird use of South Carolina managed and natural coastal wetlands. *Journal of Wildlife Management* 60, 73–82.

West, A.D., Goss-Custard, J.D., Stillman, R.A., Caldow, R.W.G., Durell, S.E.A.L. and McGrorty, S. (2002) Predicting the impacts of disturbance on shorebird mortality using a behaviour-based model. *Biological Conservation* 106, 319–328.

Weston, M.A. (2000) *The Effect of Human Disturbance on the Breeding Biology of the Hooded Plover*. Unpublished PhD thesis, University of Melbourne, Melbourne.

Weston, M.A. (2003) *Managing the Hooded Plover in Victoria: A Review of Existing Information*. Parks Victoria Technical Series No. 4. Parks Victoria, Melbourne.

Weston, M.A. and Morrow, F. (2000) *Managing the Hooded Plover in Western Victoria*. Threatened Bird Network report to Parks Victoria, Melbourne.

Wilcock, P.J. (1997) *Aspects of the Ecology of* Euphorbia paralias *L. (Sea Spurge) in Australia*. Unpublished Bachelor of Applied Science Honours thesis, Centre for Environmental Management, University of Ballarat, Ballarat.

Wilkinson, J., Pearce, M., Cromar, N., and H. Fallowfield. (2003). "Audit of the quality and quantity of treated wastewater discharging from Wastewater Treatment Plants (WWTPs) to the marine environment. ACWS Technical Report No.1 prepared for the Adelaide Coastal Waters Study Steering Committee, November 2003. Department of Environmental Health, Flinders University of South Australia.

Williams, S.J., Gutierrez, B.T., Titus, J.G., Gill, S.K., Cahoon, D.R., Thieler, E.R., Anderson, K.E., FitzGerald, D., Burkett, V. and Samenow, J. (2009) In: J.G. Titus, K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (Eds). Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. Pp. 11–24. Report by U.S. Climate Change Science Program and Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington D.C.

Wilson, J. (2000) The northward movement of immature Eastern Curlews in the austral winter as demonstrated by the Population Monitoring Project. *Stilt* 36, 16–19.

Wilson, J.R. 2000. South Australia wader surveys, January and February 2000. Australasian Wader Studies Group, Melbourne, Australia.

WWF Hong Kong. (2006) *Management Plan for the Mai Po Marshes Wildlife Education Centre and Nature Reserve. 2006–2010*. WWF Hong Kong, Hong Kong.

Xie, P.F. (2012) *Socio-economic Impacts of Birdwatching along Lake Erie: A Coastal Ohio Analysis*. School of Human Movement, Sport and Leisure Studies, Bowling Green State University, Bowling Green, Ohio.

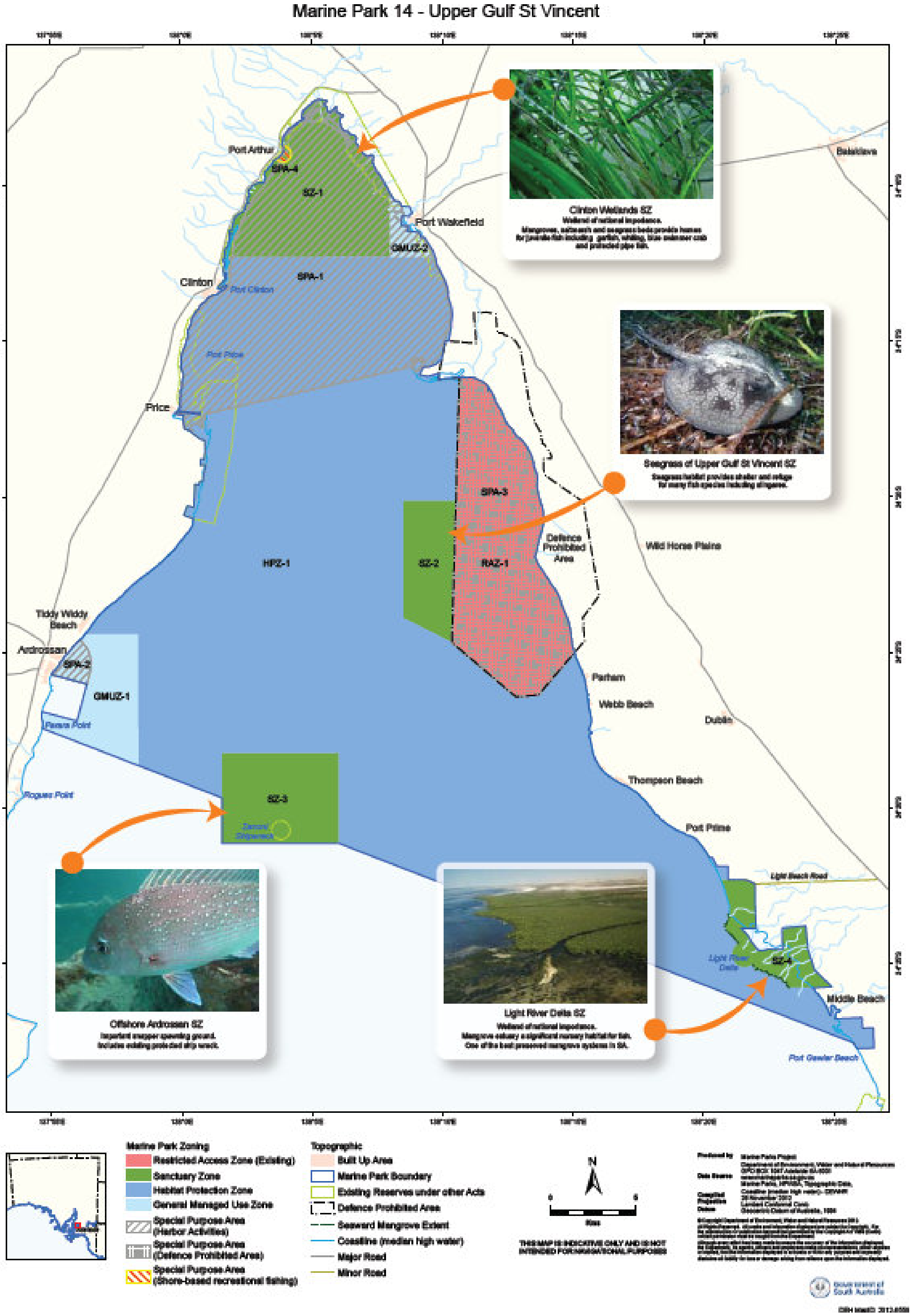
Yasué, M. (2005) The effects of human presence, flock size and prey density on shorebird foraging rates. *Journal of Ethology* 23, 199–204.

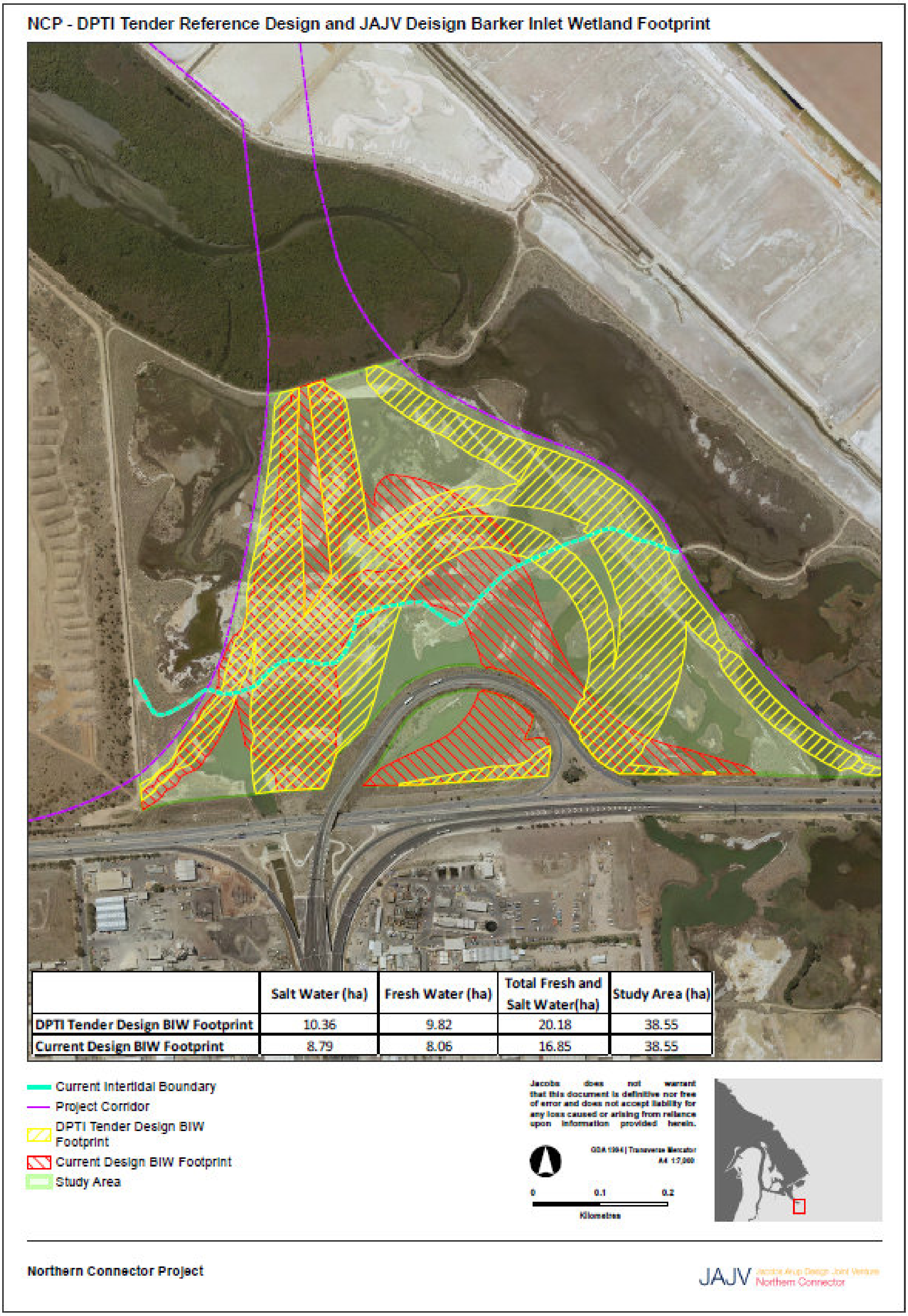
Yates, M.G., Goss-Custard, J.D. and Rispin W.E. (1996) Towards predicting the effects of loss of intertidal feeding areas of overwintering shorebirds (*Charadrii*) and shelduck (*Tadorna tadorna*): refinements and tests of a model developed for the Wash, east England. *Journal of Applied Ecology* 33, 944–954.

Zwarts L., Ens, B.J., Kersten, M. and Piersma, T. (1990) Moult, mass and flight range of waders ready to take off for long-distance migrations. Ardea 78, 339–364.

APPENDIX

Figure 79.Zoning within the Upper Gulf St Vincent Marine Park. Upper Gulf St Vincent Marine Park Management Plan Summary. DEWNR 2012





	Salt Water (ha)	Fresh Water (ha)	Total Fresh and Salt Water(ha)	Study Area (ha)
DPTI Tender Design BIW Footprint	10.36	9.82	20.18	38.55
Current Design BIW Footprint	8.79	8.06	16.85	38.55

Figure 80. Original DPTI tender design BIW (yellow) and current Lendlease design footprint on original wetland. Jacobs Arup Design Venture Northern Connector on behalf of Lendlease 2016.

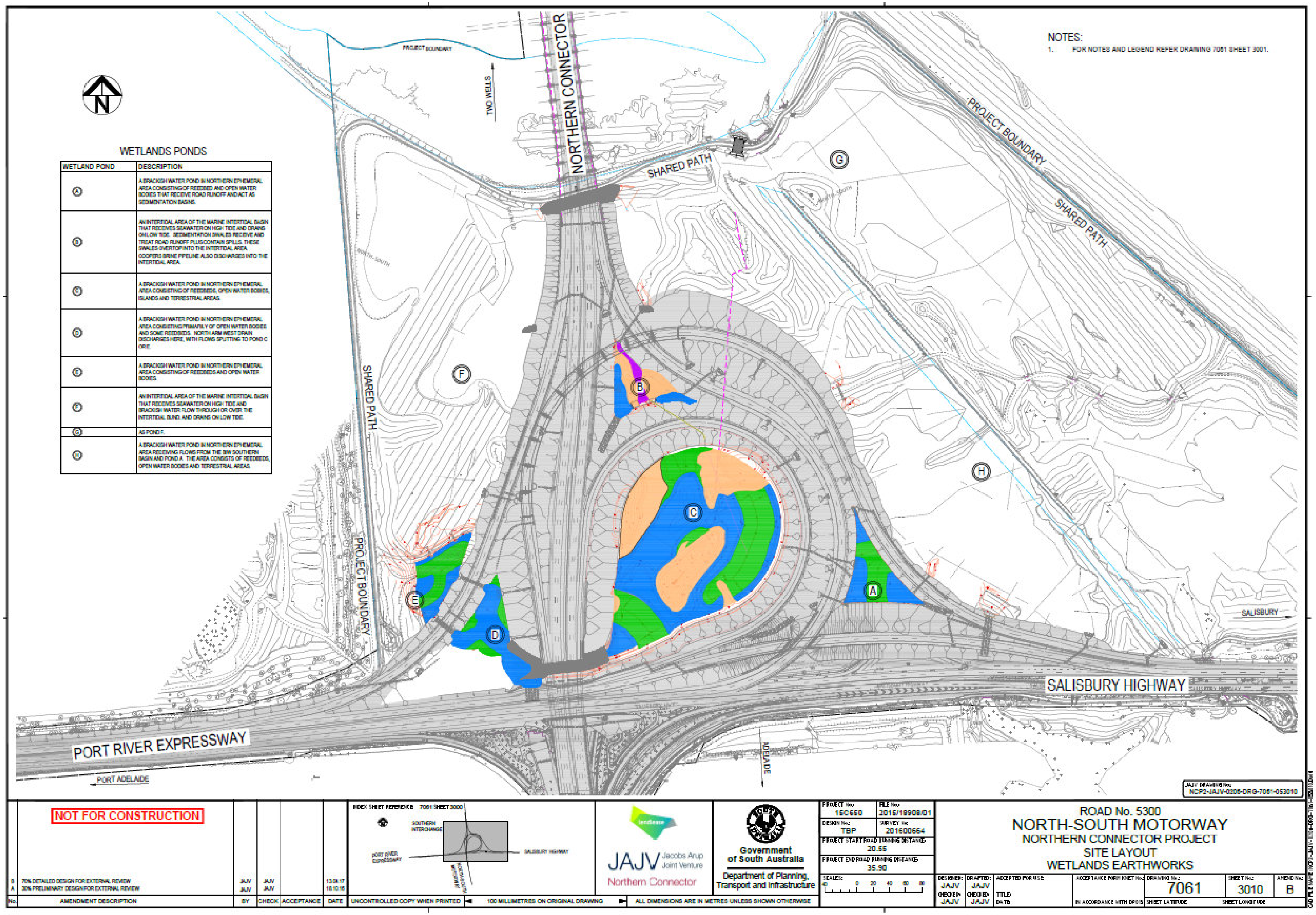


Figure 81. 70% design for Barker Inlet Wetland earthworks. Jacobs Arup Design Venture Northern Connector on behalf of Lendlease 2017.

Figure 82. Proposed Northern Connector offset wetlands. Jacobs Arup Design Venture Northern Connector on behalf of Lendlease 2017.