

Macleay River Estuary Migratory and Threatened Shorebird Species Management Strategy



InSight Ecology

for

Kempsey Shire Council

October 2017

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Photographs: Front cover, main image – lower Macleay River Estuary (placering.com), first row (from left to right) - Back Beach South West Rocks, Ford Island Jerseyville mud and sandflats, and Belmore Swamp (all three images by InSight Ecology), second row (L to R) – Australian Pied Oystercatcher (J.J. Harrison, en.wikipedia.org), Curlew Sandpiper (John Manger, scienceimage.csiro.au), Sharp-tailed Sandpiper (JJ Harrison, wikimedia.commons), inside front cover – Stuarts Point Beach looking south to South West Rocks and Trial Bay, Arakoon (InSight Ecology). All other images as credited in the text.

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Summary

Shorebirds are in global conservation crisis. Their numbers have seriously declined over the past three decades. In Australia, at least 73% fewer migratory shorebirds have been recorded returning from Russia, east Asia and Alaska via the East Asian-Australasian Flyway each spring on our beaches, estuaries and wetlands. Once a relatively common species, the Bar-tailed Godwit – a bird that has flown an avian world-record 11,680 km from Alaska to New Zealand in 9 days – has now become ‘near-threatened’ (see <http://www.abc.net.au/news/science/2016-06-17/flying-for-your-life-ann-jones/7459288>). The large-scale loss of tidal flats to coastal development along China’s Yellow Sea is a key driver of this decline. This habitat is vitally important to waders to re-fuel and rest during their arduous annual migration. The impact of a changing global climate is also implicated in this broad-scale loss of shorebird numbers.

This decline in migratory shorebird numbers appears to have been also experienced at the local level. The Macleay River estuary and its coastline support a rich and diverse avifauna but the results of two systematic surveys undertaken as part of the project and other data may support this trend. Poorly studied compared with the Hunter, Clarence, Richmond and Tweed Rivers, the Macleay River estuary is part of Hastings-Macleay Important Bird Area. It provides foraging, roosting and/or potential nesting resources for 19 listed threatened shorebird species. Three nationally endangered species are among the threatened shorebirds that occur in the area. Two of these birds – Far Eastern Curlew and Curlew Sandpiper – are listed as critically endangered while the third (Australasian Bittern) is endangered. Three other threatened aquatic species – Little Tern, White-bellied Sea-Eagle and Eastern Osprey were recorded during the surveys. Three other species are residents but are also listed as threatened within NSW – Beach Stone-curlew (Critically Endangered), Black-necked Stork (Vulnerable) and Brolga (Vulnerable). The latter species was recorded during the spring 2016 survey. A total of 26 shorebird species listed under international migratory bird protection agreements occur in Macleay River estuary.

This project was initiated by Kempsey Shire Council to obtain baseline data on migratory and resident shorebird species in the Macleay Estuary and coastline. Information on shorebird species occurrence, abundance, use of habitat, key threats and conservation management requirements were obtained through systematic field surveys in spring 2016 (26 sites) and summer 2017 (28 sites) and associated GIS mapping.

A total of 1,653 birds from 50 aquatic species were recorded during the surveys. Of these, 273 individuals were shorebirds from 16 different species. These included 10 long-distance migratory species and 6 resident or dispersive species. This result was affected by record high summer temperatures and 34% below-average rainfall received in the area during the survey period. Other records were used to augment the survey data. A number of significant shorebird foraging and roosting sites were recorded based on direct observations made during the surveys and from discussions with local bird observers.

This report is presented in three parts – shorebird ecology and conservation, the shorebird management strategy, and recommendations. Recommendations present a set of practical and prioritised actions to protect shorebirds and their habitat over time in the Macleay River estuary and along the coastline within Kempsey Local Government Area. These are based on

the results of the field surveys, discussions with local bird observers and landholders, and habitat mapping and habitat/disturbance and threat risk prioritisation assessments. As always, the potential for successful uptake of these actions depends on some key ingredients. These include adequate resourcing, local community support and engagement, especially to reduce the impact on shorebird habitat of key threats such as 4WD and trailbike access, fox predation and dog incursion into foraging, roost and nesting sites, and a commitment to further monitoring across the study area.

PART 1: SHOREBIRD ECOLOGY AND CONSERVATION

1.1 Introduction

Shorebirds are small (c. 13 cm and 30 g) to large (c. 60 cm and 1.3 kg) wading birds that belong to eleven (11) families in the taxonomic order Charadriiformes. They forage for invertebrates on ocean beaches, rocky headlands, estuarine mudflats, inland lakes and river margins around the world. They include sandpipers, plovers, stints, godwits, curlews, snipe, oystercatchers, pratincoles, stilts, avocets and stone-curlews. Gulls and terns are not generally considered to be shorebirds.

Twenty (20) shorebird species are Australian residents while another species (Australian Pratincole *Stiltia isabella*) breeds in Australia but can migrate to islands off northern Australia. Some of these species fly considerable distances between coastal and inland habitats. A further 36 species regularly migrate long distances and usually in significant numbers from their breeding grounds in the northern hemisphere to Australia. They arrive in Australia in spring and depart in autumn. The 37th listed (see Section 1.4) migratory shorebird species is the Double-banded Plover *Charadrius bicinctus* which, in contrast to its long-distance counterparts, migrates in relatively small numbers to Australia from New Zealand in winter. An additional 24 shorebird species are vagrants to Australia. Table 1 lists all shorebird species known to occur in Australia (and see Section 2).

Table 1: Resident, migratory and vagrant shorebird species recorded in Australia and listed in Conservation Statement No. 14 (Oldland et al., 2009), Appendix A of Wildlife Conservation Plan for Migratory Shorebirds (Australian Department of the Environment 2015), a recent revision of East Asian-Australasian Flyway population estimates of 37 listed migratory shorebird species (Hansen et al. 2016), and Marchant and Higgins (1993). Taxonomic order of presentation follows Christidis and Boles (2008).

Family	Scientific name	Common name	Occurrence status
Ciconiidae	<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	resident
Ardeidae	<i>Botaurus poiciloptilus</i>	Australasian Bittern	resident
Gruidae	<i>Grus rubicunda</i>	Brolga	resident
Burhinidae	<i>Burhinus grallarius</i>	Bush Stone-curlew	resident
	<i>Esacus magnirostris</i>	Beach Stone-curlew	resident
Haematopodidae	<i>Haematopus finschi</i>	South Island Pied Oystercatcher	vagrant
	<i>Haematopus longirostris</i>	Australian Pied Oystercatcher	resident
	<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	resident
Recurvirostridae	<i>Himantopus himantopus</i>	Black-winged Stilt	resident
	<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet	resident
	<i>Cladorhynchus leucocephalus</i>	Banded Stilt	resident
Charadriidae	<i>Pluvialis fulva</i>	Pacific Golden Plover	regular migrant
	<i>Pluvialis dominicus</i>	American Golden Plover	vagrant
	<i>Pluvialis squatarola</i>	Grey Plover	regular migrant

Family	Scientific name	Common name	Occurrence status
	<i>Charadrius hiaticula</i>	Ringed Plover	vagrant
	<i>Charadrius dubius</i>	Little Ringed Plover	vagrant
	<i>Charadrius alexandrinus</i>	Kentish Plover	vagrant
	<i>Charadrius ruficapillus</i>	Red-capped Plover	resident
	<i>Charadrius bicinctus</i>	Double-banded Plover	regular migrant
	<i>Charadrius mongolus</i>	Lesser Sand Plover	regular migrant
	<i>Charadrius leschenaultii</i>	Greater Sand Plover	regular migrant
	<i>Charadrius asiaticus</i>	Caspian Plover	vagrant
	<i>Charadrius veredus</i>	Oriental Plover	regular migrant
	<i>Charadrius australis</i>	Inland Dotterel	resident
	<i>Euseyonis melanops</i>	Black-fronted Dotterel	resident
	<i>Thinornis rubricollis</i>	Hooded Plover	resident
	<i>Erythrogonys cinctus</i>	Red-kneed Dotterel	resident
	<i>Vanellus tricolor</i>	Banded Lapwing	resident
	<i>Vanellus miles</i>	Masked Lapwing	resident
	<i>Vanellus cinereus</i>	Grey-headed Lapwing	vagrant
Pedionomidae	<i>Pedionomus torquatus</i>	Plains-wanderer	resident
Jacanidae	<i>Irediparra gallinacea</i>	Comb-crested Jacana	resident
	<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana	vagrant
Rostratulidae	<i>Rostratula australis</i>	Australian Painted Snipe	resident
Scolopacidae	<i>Gallinago hardwickii</i>	Latham's Snipe	regular migrant
	<i>Gallinago stenura</i>	Pin-tailed Snipe	regular migrant
	<i>Gallinago megala</i>	Swinhoe's Snipe	regular migrant
	<i>Limosa limosa</i>	Black-tailed Godwit	regular migrant
	<i>Limosa haemastica</i>	Hudsonian Godwit	vagrant
	<i>Limosa lapponica</i>	Bar-tailed Godwit	regular migrant
	<i>Numenius minutus</i>	Little Curlew	regular migrant
	<i>Numenius phaeopus</i>	Whimbrel	regular migrant
	<i>Numenius madagascariensis</i>	Far Eastern Curlew (once called Eastern Curlew)	regular migrant
	<i>Numenius arquata</i>	Eurasian Curlew	vagrant
	<i>Bartramia longicauda</i>	Upland Sandpiper	vagrant
	<i>Xenus cinereus</i>	Terek Sandpiper	regular migrant
	<i>Actitis hypoleucos</i>	Common Sandpiper	regular migrant
	<i>Tringa ochropus</i>	Green Sandpiper	vagrant
	<i>Tringa brevipes</i>	Grey-tailed Tattler	regular migrant
	<i>Tringa incana</i>	Wandering Tattler	regular migrant
	<i>Tringa erythropus</i>	Spotted Redshank	vagrant
	<i>Tringa guttifer</i>	Nordmann's Greenshank	vagrant
	<i>Tringa nebularia</i>	Common Greenshank	regular migrant
	<i>Tringa flavipes</i>	Lesser Yellowlegs	vagrant
	<i>Tringa stagnatilis</i>	Marsh Sandpiper	regular migrant
	<i>Tringa totanus</i>	Common Redshank	regular migrant
	<i>Tringa glareola</i>	Wood Sandpiper	regular migrant
	<i>Arenaria interpres</i>	Ruddy Turnstone	regular migrant
	<i>Limnodromus semipalmatus</i>	Asian Dowitcher	regular migrant

Family	Scientific name	Common name	Occurrence status
	<i>Limnodromus griseus</i>	Short-billed Dowitcher	vagrant
	<i>Calidris tenuirostris</i>	Great Knot	regular migrant
	<i>Calidris canutus</i>	Red Knot	regular migrant
	<i>Calidris alba</i>	Sanderling	regular migrant
	<i>Calidris minuta</i>	Little Stint	vagrant
	<i>Calidris ruficollis</i>	Red-necked Stint	regular migrant
	<i>Calidris subminuta</i>	Long-toed Stint	regular migrant
	<i>Calidris fuscicollis</i>	White-rumped Sandpiper	vagrant
	<i>Calidris bairdii</i>	Baird's Sandpiper	vagrant
	<i>Calidris melanotos</i>	Pectoral Sandpiper	regular migrant
	<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	regular migrant
	<i>Calidris alpina</i>	Dunlin	vagrant
	<i>Calidris ferruginea</i>	Curlew Sandpiper	regular migrant
	<i>Calidris himantopus</i>	Stilt Sandpiper	vagrant
	<i>Tryngites subruficollis</i>	Buff-breasted Sandpiper	vagrant
	<i>Limicola falcinellus</i>	Broad-billed Sandpiper	regular migrant
	<i>Philomachus pugnax</i>	Ruff	regular migrant
	<i>Steganopus tricolor</i>	Wilson's Phalarope	vagrant
	<i>Phalaropus lobatus</i>	Red-necked Phalarope	regular migrant
	<i>Phalaropus fulicarius</i>	Grey Phalarope	vagrant
Glareolidae	<i>Glareola maldivarum</i>	Oriental Pratincole	regular migrant

1.2 Life-history traits

Shorebirds possess remarkable life-history traits that make them unique among the animal kingdom. Many shorebirds migrate long distances twice a year, between their breeding grounds in the Arctic and Alaska and wintering sites in the southern hemisphere. Some birds fly about 24,000 km or 12,000 km each way on these migrations, departing from the northern hemisphere in July and arriving at their non-breeding grounds in Australasia in October before returning north in March. The longest known migrational journey in the animal world is by a Bar-tailed Godwit (a large wader - 38-46 cm in body size) that flew 11,680 km from breeding grounds in Alaska to New Zealand in 9 days (see <http://www.abc.net.au/news/science/2016-06-17/flying-for-your-life-ann-jones/7459288>).

Many migratory shorebirds use the same stopover, breeding and wintering sites along their migration route or flyway for every journey (Barter 2002; Murray and Fuller 2015). Staging areas or sites where shorebirds gather often in large numbers to feed to build vital fat reserves before departing on their long migrational journeys are also critically important, e.g. Roebuck Bay at Broome in northern Western Australia (<http://www.roebuckbay.org.au/our-bay/migratory-shorebirds/>). Staging and stopover sites are also used by shorebirds during their migrational journeys along flyways - specific wetland and coastal sites are routinely used by shorebirds to re-fuel during stopovers in preparation for the remaining stages of their migration (Kirby 2011 and see Section 1.3). This high degree of philopatry or site fidelity places these birds at significant risk of mortality if anthropogenic change occurs at these sites such as the draining of a wetland or loss of mudflats to coastal development.

Shorebird vulnerability to human or environmental change is accentuated by their relatively small population sizes. Low reproductive potential and high egg and nestling mortality rates are significant causal factors, although adult shorebirds have relatively high survivorship (Marchant and Higgins 1993; Higgins and Davies 1996). Small population sizes render many shorebird species highly vulnerable to changes, specifically in the size, quality, availability and connectivity of habitat along their migration routes and at their summer breeding grounds (Kirby et al. 2008).

1.3 Shorebird conservation status and the East Asian-Australasian Flyway

There is global recognition that shorebird populations have seriously declined over the past three decades (Clemens et al. 2010; Australian Department of the Environment 2015; BirdLife International 2016; Piersma et al. 2016). In Australia, numbers of migratory waders returning to the east coast via the East Asian-Australasian Flyway (EAAF – Figure 1) have plummeted by 73% between 1983 and 2006 (Nebel et al. 2008) and this trend continues unabated today (BirdLife Australia 2015a and see Figure 2). The International Union for Conservation of Nature (IUCN)'s Red List Index has identified shorebirds and seabirds to be in urgent need of conservation action in Australia (Szabo et al. 2012; BirdLife Australia 2015a; IUCN Red List 2017).



Figure 1: The globally significant East Asian-Australasian Flyway spans 22 countries (45% of the world's human population) and is traversed each year by 50 million (207 species) migratory waterbirds, shorebirds and seabirds (BirdLife Australia 2015a). These include 33 globally threatened species and 13 near-threatened species (BirdLife Australia 2015a). The thick light blue line below shows the location of the EAAF. Eight (8) other flyways occur across the world (see Global Flyway Network, 2012).

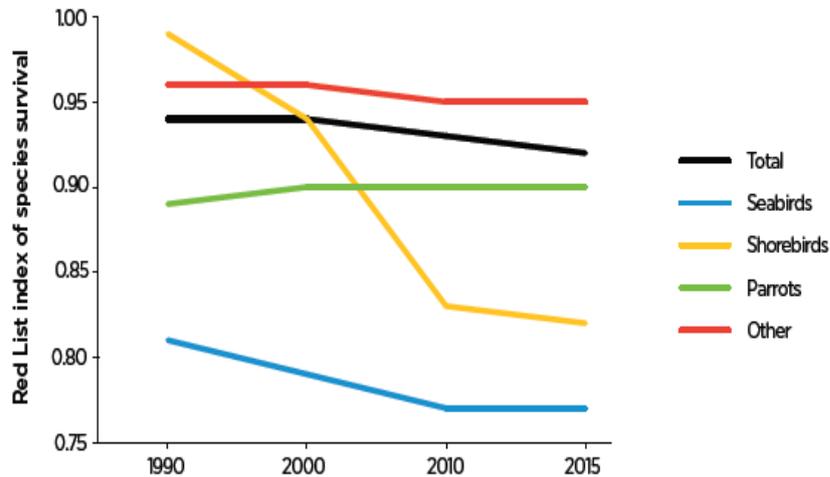


Figure 2: A sharp and sustained decline in the numbers of particularly shorebird species, many of which include long-distance migrants that utilise the EAAF, recorded in Australia from 1990-2015 is of national and international conservation concern and still continues today (BirdLife Australia 2015a and IUCN Red List 2017)

The sustained large-scale loss of tidal flats through land reclamation for coastal development along China’s Yellow Sea and the Korean Peninsula has been a key driver of this decline (Murray et al. 2015, Piersma et al. 2016; Studds et al. 2017). Intertidal mud and sandflats provide key habitat for long-distance migrating shorebirds to stopover and refuel before continuing their arduous journeys to and from the Arctic (Murray and Fuller 2015). They are also important staging sites where they feed to re-build critical fat reserves and body mass for the next stage of their migration (see, for example, key research conducted on great knots at Yellow Sea sites by Ma et al. 2013).

At the southern end of the EAAF, Australian coastal and freshwater wetlands and estuaries provide important food, roost and shelter sites and habitat connectivity for 77 migratory and resident shorebird species (DECCW 2010). About half (35) of these species are migratory shorebirds that regularly visit Australia during their non-breeding season, from the Austral spring to autumn (Australian Department of the Environment 2015). A total of 42 migratory and resident shorebird species occur along the NSW North Coast (DECCW 2010). Resident shorebird species also breed in the region.

Two species illustrate how important the EAAF is to migratory shorebirds on an intercontinental scale. The critically endangered Far Eastern Curlew can travel about 20,000 km each year in return trips between south-eastern Australia and north-eastern China (Figure 3). The Asian migratory population of Little Tern commutes about 16,000 to 17,000 km annually on their return trips between south-eastern Australia and Japan and South Korea (Figure 4). These are truly outstanding migratory journeys of the natural world.

Far Eastern Curlew (*Numenius madagascariensis*)
 Band Recoveries and Engraved Leg Flag Sightings for movements >1000km.

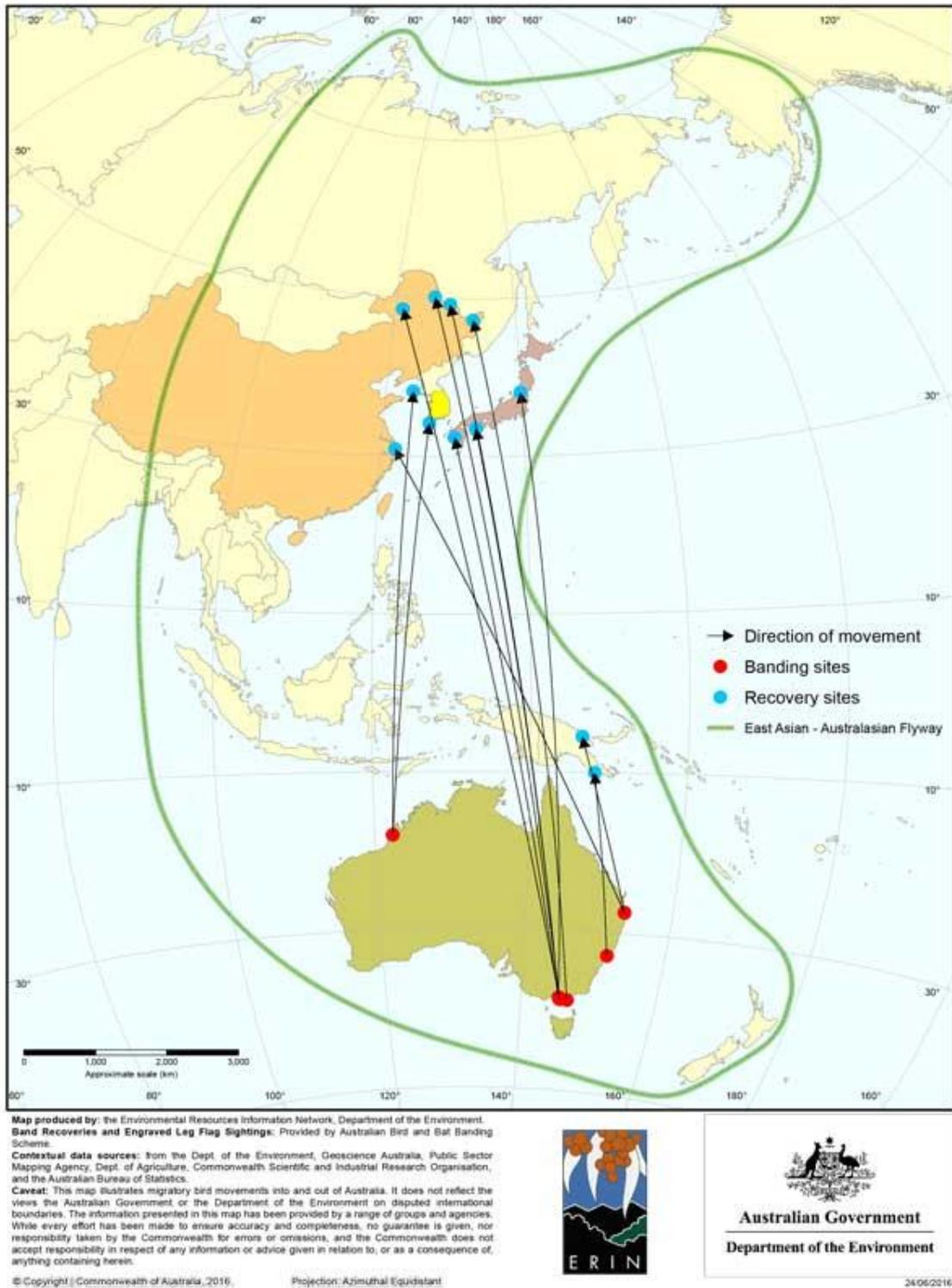


Figure 3: An example of distances travelled by Far Eastern Curlew on migration to and from this species' breeding grounds in China, Japan, South Korea and North Korea via the EAAF. This is based on band recoveries and leg flag sightings on birds of this species submitted through the Australian Bird and Bat Banding Scheme (ABBBS) (Australian Department of Environment and Energy 2016).

Little Tern (*Sternula albifrons*)
 Band Recoveries and Engraved Leg Flag Sightings for movements >1000km.

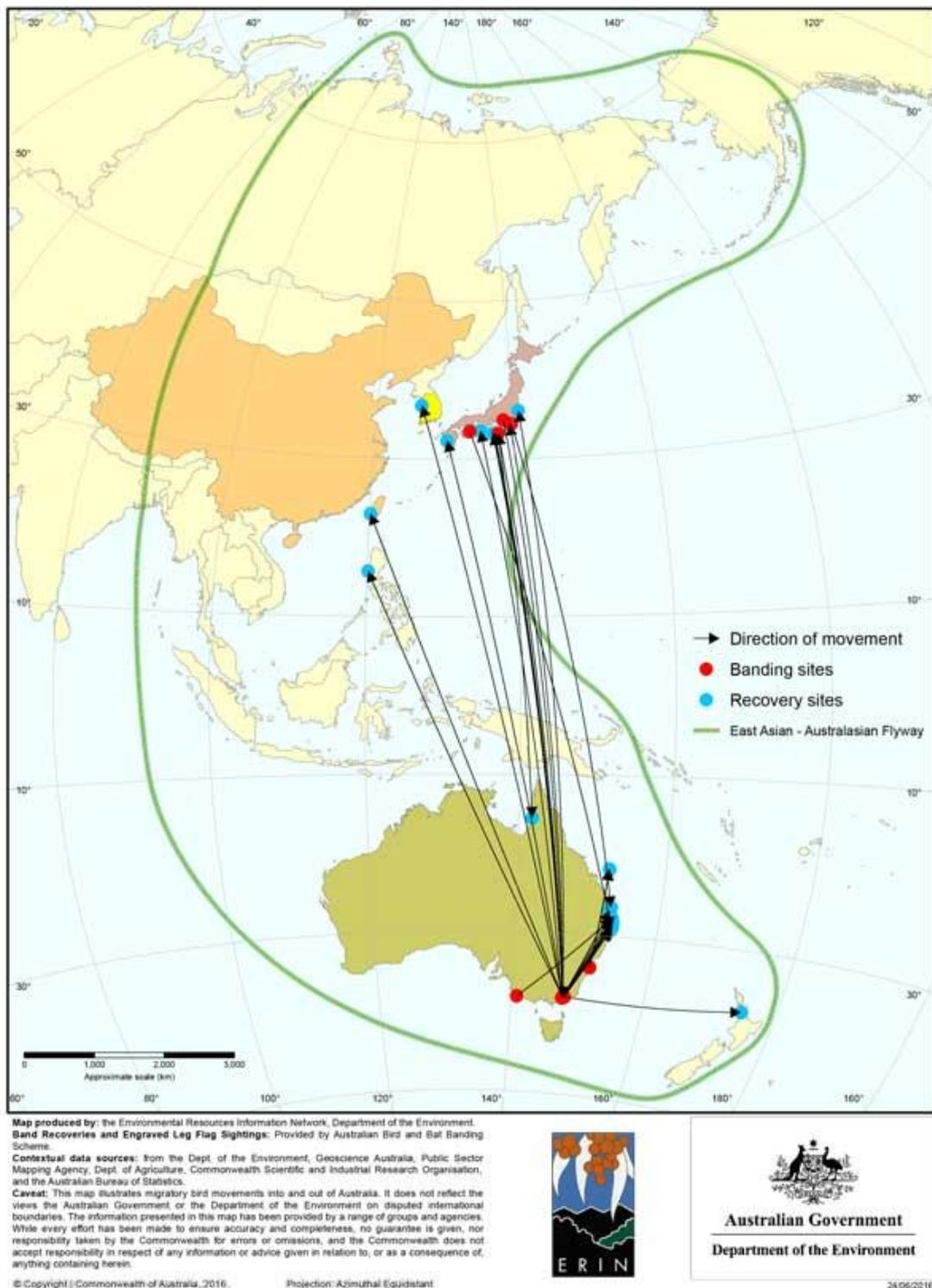


Figure 4: Little Tern populations in eastern Australia comprise a mix of local breeding residents and Asian-breeding birds, the latter being summer migrants to the eastern and northern Australia that also use the EAAF. Band recovery and leg flag data supplied by the ABBBS show the distances travelled by Asian-breeding members of this species (Australian Department of Environment and Energy 2016). Although not technically a shorebird, the Little Tern is endangered in NSW and occurs in the study area.

1.4 Legal framework

A range of environmental protection legislation, international conventions, bilateral agreements and community-based conservation initiatives exist to protect migratory and resident shorebirds and their habitat across Australia and along the East Asian-Australasian Flyway (EAAF). Key features of these mechanisms are outlined below.

The Australian Government's Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) protects migratory animal species under Section 209 of the Act as well as resident indigenous species. These migratory species are listed under the Convention on Conservation of Migratory Species of Wild Animals (the Bonn Convention) and bilateral migratory bird agreements between the Australian Government and the governments of China (CAMBA), Japan (JAMBA) and the Republic of Korea (ROKAMBA).

The NSW Biodiversity Conservation Act 2016 protects migratory and resident animal and plant species and their habitat. Listings are provided under Schedule 1 (Threatened species) and Parts 1 (Critically Endangered), 2 (Endangered), and 3 (Vulnerable).

Table 2 lists migratory and resident shorebird species protected under these mechanisms including recent revisions to these lists (Australian Department of Environment and Energy 2016, 2017). The current conservation status of these species under the EPBC Act and NSW Biodiversity Conservation Act (BC Act) is also provided.

Table 2: Migratory and resident shorebird and other conservation-significant aquatic bird species listed under the EPBC Act and NSW Biodiversity Conservation Act and/or international conservation conventions and agreements - the Bonn Convention (BONN) and agreements between Australia and China (CAMBA), Japan (JAMBA) and the Republic of Korea (ROKAMBA). Regular migrant and not vagrant species are shown. Codes for EPBC Act and BC Act columns: CE = Critically Endangered E = Endangered V = Vulnerable, M = migratory. Bonn Convention (BOC) codes: A1 = species listed explicitly in BOC Appendix 1, A2S = species listed explicitly in BOC Appendix A2S, A2H = species is a member of a family listed in BOC Appendix 2. L = listed under relevant international migratory species conservation agreement, NL = not listed under EPBC or BC Acts or international migratory species conservation agreements. Lettering after common names indicate IUCN Red List (2017) status: RLCE = listed as a globally Critically Endangered species, RLE = listed as a globally Endangered species and RLN = listed as a globally Near-Threatened species. Common names in bold indicate that the species has been recorded in Macleay River estuary and adjacent sites or is considered likely to occur in the area (Alan Morris and Ken Shingleton, pers. comm.).

Scientific name	Common name	EPBC Act	BC Act	International convention/agreement			
				BONN	CAMBA	JAMBA	ROKAMBA
<i>Esacus magnirostris</i>	Beach Stone-curlew RLN	NL	CE	NL	NL	NL	NL
<i>Burhinus grallarius</i>	Bush Stone-curlew	NL	E	NL	NL	NL	NL
<i>Pedionomus torquatus</i>	Plains-wanderer ^{RLE}	CE	E	NL	NL	NL	NL
<i>Calidris ferruginea</i>	Curlew Sandpiper RLN	CE	E	A2H	L	L	L

Scientific name	Common name	EPBC Act	BC Act	International convention/agreement			
				BONN	CAMBA	JAMBA	ROKAMBA
<i>Calidris tenuirostris</i>	Great Knot ^{RLE}	CE	V	A2H	L	L	L
<i>Numenius madagascariensis</i>	Far Eastern Curlew ^{RLCE}	CE	NL	A1	L	L	L
<i>Botaurus poiciloptilus</i>	Australasian Bittern ^{RLE}	E	E	NL	NL	NL	NL
<i>Ixobrychus flavicollis</i>	Black Bittern	NL	V	NL	NL	NL	NL
<i>Calidris canutus</i>	Red Knot ^{RLN}	E	NL	A2H	L	L	L
<i>Charadrius mongolus</i>	Lesser Sand Plover	E	V	A2H	L	L	L
<i>Charadrius bicinctus</i>	Double-banded Plover	NL	NL	A2H	NL	NL	NL
<i>Charadrius leschenaultii</i>	Greater Sand Plover	E	E	A2H	L	L	L
<i>Calidris alba</i>	Sanderling	NL	V	A2H	L	L	L
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	NL	V	A2H	L	L	L
<i>Xenus cinereus</i>	Terek Sandpiper	NL	V	A2H	L	L	L
<i>Actitis hypoleucos</i>	Common Sandpiper	NL	NL	A2H	L	L	L
<i>Calidris melanotos</i>	Pectoral Sandpiper	NL	NL	A2H	NL	L	L
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	NL	NL	A2H	L	L	L
<i>Calidris ruficollis</i>	Red-necked Stint ^{RLN}	NL	NL	A2H	L	L	L
<i>Calidris subminuta</i>	Long-toed Stint	NL	NL	A2H	L	L	L
<i>Rostratula australis</i>	Australian Painted Snipe ^{RLE}	E	E	NL	NL	NL	NL
<i>Arenaria interpres</i>	Ruddy Turnstone	NL	NL	A2H	L	L	L
<i>Irediparra gallinacea</i>	Comb-crested Jacana	NL	V	NL	NL	NL	NL
<i>Gallinago hardwickii</i>	Latham's Snipe	NL	NL	A2H	NL	L	L
<i>Limosa lapponica</i> subsp. <i>baueri</i>	Bar-tailed Godwit ^{RLN}	V	NL	A2H	L	L	L
<i>Limosa limosa</i>	Black-tailed Godwit ^{RLN}	NL	V	A2H	L	L	L
<i>Numenius phaeopus</i>	Whimbrel	NL	NL	A2H	L	L	L
<i>Numenius minutus</i>	Little Curlew	NL	NL	A2H	L	L	L
<i>Thinornis rubicollis</i>	Hooded Plover	V	CE	NL	NL	NL	NL
<i>Charadrius veredus</i>	Oriental Plover	NL	NL	A2H	L	L	L
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher	NL	E	NL	NL	NL	NL
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	NL	V	NL	NL	NL	NL
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork ^{RLN}	NL	E	NL	NL	NL	NL

Scientific name	Common name	EPBC Act	BC Act	International convention/agreement			
				BONN	CAMBA	JAMBA	ROKAMBA
<i>Grus rubicunda</i>	Brolga	NL	V	NL	NL	NL	NL
<i>Sternula albifrons</i>	Little Tern	NL	E	A2S	L	L	L
<i>Gygis alba</i>	White Tern	NL	V	NL	NL	NL	NL
<i>Chlidonias leucopterus</i>	White-winged Black Tern	NL	NL	NL	L	L	NL
<i>Onychoprion fuscata</i>	Sooty Tern	NL	V	NL	NL	NL	NL
<i>Gelochelidon nilotica</i>	Gull-billed Tern	NL	NL	NL	L	NL	NL
<i>Hydroprogne caspia</i>	Caspian Tern	NL	NL	NL	NL	L	NL
<i>Thalasseus bergii</i>	Crested Tern	NL	NL	NL	NL	L	NL
<i>Sterna hirundo</i>	Common Tern	NL	NL	NL	L	L	L
<i>Sterna dougallii</i>	Roseate Tern	NL	NL	NL	L	L	NL
<i>Sterna sumatrana</i>	Black-naped Tern	NL	NL	NL	L	L	NL
<i>Procelsterna cerulea</i>	Grey Ternlet	NL	V				
<i>Onychoprion anaethetus</i>	Bridled Tern	NL	NL	NL	L	L	NL
<i>Pandion cristatus</i>	Eastern Osprey	M	V	A2S	NL	NL	NL
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	NL	V	NL	L	NL	NL
<i>Limnodromus semipalmatus</i>	Asian Dowitcher	NL	NL	A2H	L	L	L
<i>Philomachus pugnax</i>	Ruff	NL	NL	A2H	L	L	L
<i>Pluvialis fulva</i>	Pacific Golden Plover	NL	NL	A2H	L	L	L
<i>Pluvialis squatarola</i>	Grey Plover	NL	NL	A2H	L	L	L
<i>Tringa incanus</i>	Wandering Tattler	NL	NL	A2H	NL	L	NL
<i>Tringa brevipes</i>	Grey-tailed Tattler RLN	NL	NL	A2H	L	L	L
<i>Tringa glareola</i>	Wood Sandpiper	NL	NL	A2H	NL	L	NL
<i>Tringa nebularia</i>	Common Greenshank	NL	NL	A2H	L	L	L
<i>Tringa stagnatilis</i>	Marsh Sandpiper	NL	NL	A2H	L	L	L
<i>Tringa totanus</i>	Common Redshank	NL	NL	A2H	L	L	L
<i>Phalaropus lobatus</i>	Red-necked Phalarope	NL	NL	A2H	L	L	L

The protection provided to migratory birds by the Bonn Convention, CAMBA, JAMBA and ROKAMBA is limited to a small group of countries and does not apply to all migratory species. Multilateral cooperation on migratory bird conservation throughout the EAAF has developed through the Ramsar Convention on Wetlands and the EAAF Partnership, itself a Ramsar initiative.

The Ramsar Convention seeks to conserve important wetland habitats instead of species *per se*. There are 65 Wetlands of International Importance listed under the Ramsar Convention on the Australian Wetlands Database (<http://environment.gov.au/cgi-bin/wetlands/simplesearch.pl>). No Ramsar-listed wetlands occur in the Macleay River estuary and its adjacent coastal zone.

The EAAF Partnership is a voluntary collaboration of countries, non-government organisations, government agencies and the business sector to help protect migratory waterbirds and their habitat across the flyway. Key participating countries include China, Japan, Russia, Mongolia, Indonesia, South Korea, North Korea, Thailand, Cambodia, Malaysia, Philippines, Vietnam, Australia, New Zealand and USA (Alaska). A network of internationally important sites for migratory waterbirds has been established. A number of working groups and task forces exist within the partnership to focus on the conservation of migratory shorebirds and their habitat (see <http://www.eaaflyway.net/>).

Australian efforts to protect and conserve migratory shorebirds and their habitat occur through the Shorebirds 2020 Program and Australasian Wader Studies Group, both affiliated with the non-government bird conservation organisation BirdLife Australia. A network of State and local voluntary bird observer groups assist in protecting, conserving and studying the ecology of shorebirds and other bird species across the continent.

1.5 Important habitat for migratory shorebirds in Australia

Important habitat for migratory shorebirds in Australia is habitat that has been identified under the EPBC Act as having national environmental significance (Australian Department of the Environment 2013). The identification of internationally important shorebird habitat is based on Ramsar Convention criteria. These stipulate that to be considered internationally important, wetland habitat must regularly support one (1) per cent of the individuals in a population of one species or subspecies of waterbird or a total abundance of at least 20,000 waterbirds (Ramsar Convention on Wetlands 2016). Similarly, migratory shorebird habitat qualifies as nationally important if the habitat regularly supports 0.1 per cent of the flyway population of a single species of migratory bird or 2,000 migratory shorebirds or 15 migratory shorebird species (Ramsar Convention on Wetlands 2016).

Identification of important habitat for Latham's Snipe *Gallinago hardwickii* is based on different criteria from that used for other migratory shorebirds. This is because this species does not congregate in large flocks and uses habitat different to that utilised by other migratory shorebird species. These include the wet shorelines of freshwater and brackish lagoons, creeks with tussocky/reedy margins including in cattle paddocks, saltmarsh and even shrubland/open woodland (Higgins and Davies, 1996). Thus, important habitat for Latham's Snipe includes areas previously identified as internationally important for this species or areas that support at least 18 individuals of the species (Hansen et al. 2016).

The Macleay River estuary and coastline provide important foraging, roosting and potentially nesting habitat for 43 shorebird species - 13 resident and 30 regular migratory species (see Tables 1 and 2; BirdLife International 2016). Foraging and roosting habitat for shorebirds and other aquatic bird species occurs in the lower Macleay River and its major tributaries including Macleay Arm, Clybucca Creek and Belmore River, Pelican Island, Rainbow Reach, Belmore Swamp, Swan Pool at Kinchela, Ryans Cut, Limeburners Creek National Park (NP) and beaches and rocky headlands in Hat Head and Goolawah NPs (BirdLife International 2016; Ken Shingleton pers. comm. and see Section 2.4). A further 5 shorebird species are vagrants to the area (Ken Shingleton pers. comm.).

A total of 19 shorebird species listed under EPBC Act and/or NSW Biodiversity Conservation Act have been recorded in Macleay River estuary and coastline (see Section 2.4). Three additional listed threatened species - Little Tern, Eastern Osprey and White-bellied Sea-Eagle - also occur in the area (see Table 2). A total of 26 shorebird species listed under international migratory bird protection agreements have also been recorded in Macleay River estuary and along its coastline (Table 2).

The estuary and its coastline occur within Hastings-Macleay Important Bird Area (IBA), an internationally significant area for aquatic and terrestrial avifauna (BirdLife International 2016). The Hastings-Macleay IBA also supports at least 1% or 850 individuals of the known EAAF population of Sharp-tailed Sandpiper *Calidris acuminata* (Hansen et al. 2016), in addition to a small breeding population of the resident Australasian Bittern *Botaurus poiciloptilus* (BirdLife International 2016; Ken Shingleton pers. comm.). These are criteria or “trigger species” for recognition of the Hastings-Macleay as an internationally important area for shorebirds (Clemens et al. 2010; BirdLife International 2016) and other aquatic avifauna.

1.6 Key threats

Resident and migratory shorebirds face many threats to their survival in the habitats they utilise for foraging, roosting, breeding and migration around the world. Sutherland et al. (2012) identified 45 threats to shorebird populations globally and divided these into three categories – natural, current anthropogenic and future issues. Natural issues include earthquakes, tsunamis, large-scale flooding and cyclones. Current human-generated threats are climate change, disturbance of foraging, roosting and breeding grounds and habitat loss and modification particularly of wetland and coastline habitats. Some disturbance effects are perhaps less obvious such as the impact of land-based artificial lighting on nesting seabirds and some shorebirds (Rodríguez et al. 2017). Future issues include the impact of microplastics, hydroelectricity schemes and their security, and changes in sedimentation rates. However, ocean and waterway pollution by coarse and fine-scale (microplastics) particles is already impacting on many ecosystems in Australia and globally so this is a current anthropogenic threat. The probability and magnitude of these threats ranges from likely with minor effects to unlikely but with catastrophic effects causing the extinction of shorebird species.

Recent research has revealed that most current threats to Australian and EAAF shorebird populations are associated with changes in the availability and quality of non-breeding, stopover and breeding habitats (MacKinnon et al. 2012). The loss of key stopover sites along the EAAF will have significant adverse effects on a range of migratory shorebird species.

In the Macleay River estuary and along its associated coastline key threats currently or potentially affecting shorebird populations are climate change, development causing the loss, modification or fragmentation of habitat, disturbance of foraging and roosting habitat by humans, dogs, watercraft, fishing, aquaculture, 4WDs and trailbikes, modification of wetland habitat by grazing cattle and drainage schemes, predation by and competition from invasive species, pollution, and a lack of community awareness, support and education. Each of these threats is discussed in Sections 2.4 and 2.5 of this document.

PART 2: MACLEAY RIVER ESTUARY SHOREBIRD MANAGEMENT STRATEGY

2.1 Introduction

The Macleay River Estuary Migratory and Threatened Shorebird Species Management Strategy (the “project”) was commissioned by Kempsey Shire Council in accordance with Strategy 21 of the Macleay River Estuary Coastal Zone Management Plan (Geolink 2012). Funding assistance was provided to the project by NSW Office of Environment and Heritage. The coastal zone management plan recommended a suite of actions needed to protect shorebirds and their habitat. These included surveying and monitoring shorebird populations, identifying high conservation value shorebird habitat, identifying key threats and prioritising management action, mapping shorebird habitat, and implementing management plans (Geolink 2012 and see Section 2.4).

The project obtained data on shorebird abundance, species richness, habitat use and key threats and identified conservation management actions needed in Macleay River Estuary and the adjacent coastline within Kempsey Local Government Area (the “study area”). This information was obtained through field surveys conducted for the project and augmented by records from experienced local bird observers. This work will help address an existing gap in the knowledge of shorebird populations and their use of habitat in Macleay River estuary and coastline (DECCW 2010a).

2.2 Objectives

The project focuses on obtaining baseline data on shorebird occurrence, abundance, species richness and habitat use in the study area. Information on key threats to shorebirds and management actions needed to protect these species and their habitat was also sought.

Specifically, the project aims to:

1. Review the literature on shorebird ecology and conservation in Australia and the East Asian-Australasian Flyway, including previous studies and records of shorebirds in the study area;
2. Present data obtained on shorebird occurrence, relative abundance, species richness and habitat use at sites surveyed in spring 2016 and summer 2017;
3. Identify and map shorebird habitat including foraging and roosting sites surveyed in the study area and record breeding activity, where detected;
4. Identify and describe key threats to shorebirds and their habitat at sites surveyed in the study area;
5. Recommend practical actions to protect shorebirds and their habitat, targeting the mitigation of key threats, community education, support and participation, implementation of priority management actions and monitoring of shorebird populations over time.

2.3 Methods

2.3.1 Literature and data review

A review of the existing literature on shorebird ecology and conservation was undertaken to determine both the current state of knowledge and advances in the management of threats in Australia and overseas. This included published scientific research, shorebird management programs, plans, studies, reports and conservation statements, ornithological science reference texts, shorebird group newsletters, local ecological management plans and studies, survey data, and records held by local bird observers. Current biodiversity conservation legislation, international migratory bird agreements and conservation programs were also consulted. An example of the latter is an Australian Pied Oystercatcher Saving Our Species project <http://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=27>.

Local ecological management plans and studies consulted included Macleay River Data Compilation Study - Flora and Fauna Habitat Study (ID Landscape Management 2005) and Data Compilation Report (Telfer 2005), Macleay River Estuary Processes Study (WMA Water 2009), Macleay River Estuary and Floodplain Ecology Study (Aquatic Science and Management and Geolink 2010), Macleay River Estuary Management Study (Geolink 2010), and Macleay River Estuary Coastal Zone Management Plan (Geolink 2012). A report on the shorebirds of northern NSW (DECCW 2010a) and a biodiversity management plan for NSW northern rivers (DECCW 2010b) were also reviewed.

Recent (2000-2016) local records of shorebirds and other aquatic bird species in the study area were examined. These were part of a larger set of records contributed to the NSW Bird Atlas since 1991 by a former South West Rocks-based bird observer Ken Shingleton and other observers. Threatened and protected bird species data held in the NSW Wildlife Atlas (BioNet) were inspected under licence to InSight Ecology from NSW Office of Environment and Heritage (OEH).

2.3.2 Location and site selection

Twenty-eight (28) sites (totalling 350.9 ha) were surveyed for shorebirds in four (4) separate target zones in the study area. These were the northern zone - Grassy Head/Stuarts Point (6 sites), northern central zone - South West Rocks and lower Macleay River and tributaries (16 sites), southern central zone - Crescent Head (4 sites) and southern zone - Point Plomer (2 sites). Twenty-six (26) of these sites were surveyed during early spring (6-16 September, 2016) when most long-distance migratory shorebirds were absent. These sites were surveyed again in summer (January 31- February 10, 2017) when long-distance migratory shorebirds were likely to be present and prior to their March departure to breeding grounds in China, Japan, Korea, Russia and western Alaska. Two (2) additional sites were surveyed in summer only – mudflats, mangroves and open water along Upper Macleay Arm (Site 2) and mud/sandflats at Pelican Island, Rainbow Reach (Site 18). Therefore, two separate sets of surveys were undertaken to determine the abundance, species composition and habitat utilisation of resident shorebird communities in spring relative to summer when both migratory and resident species were present.

There was a physical limit to the number of sites that could be effectively surveyed within the timeframe and budget of the project. Thus, the central zone which encompasses Hat Head was not included in the survey program, although the northern end of South Smoky Beach (Site 13) which extends south to Hat Head was surveyed. Nonetheless, the central zone should be surveyed in any future shorebird monitoring work provided that sufficient funds are available. It is important to note that the total number of sites surveyed (28) exceeded the total of 21 sites specified in the original project proposal.

The location of each of the surveyed sites was obtained using a Garmin GPSmap62s. Waypoints were recorded to identify the survey route taken and mark locations of significant shorebird and other aquatic bird species and threats. GPS data obtained was uploaded to an Excel spreadsheet. Table 3 lists this information for each site surveyed in the study. Figures 5-9 show the location of each of the surveyed zones in the study area.

Table 3: Location of sites surveyed for shorebirds and other aquatic bird species by InSight Ecology in the study area, September 6-16, 2016 and January 31-February 10, 2017. *coordinates given as decimal degrees in latitude (S = south) and longitude (E = east); based on Map Datum WGS 84 and Zone 56J of the Universal Transverse Mercator (UTM) coordinate system.

Site number	Site name	Waypoint	GPS coordinates*		Comments
			Latitude (S)	Longitude (E)	
1	Grassy Head Beach	GH01	30.79339	152.99911	southern end of beach
		GH02	30.77961	152.99669	northern end of beach
		OSPREY	30.78568	152.99635	Eastern Osprey (perched)
2	Upper Macleay Arm, off Millington Avenue, Grassy Head	UM01	30.79605	152.99471	kayak launch point
		UM02	30.80026	152.99391	Black Swan
		UM03	30.80430	152.99512	southern end of transect
3	Stuarts Point (North) Beach	SPTN01	30.79763	153.00015	No. 2 Access
		SPTN02	30.80770	151.00021	southern end of transect
4	Stuarts Point (South) Beach	SPTS01	30.82192	153.00159	beach entry
		SPTS02	30.83841	153.00439	Whistling Kite & Brahminy Kite in <i>Allocasuarina</i>
		PIEDOC	30.83395	153.00346	Australian Pied Oystercatcher
		TEREKSP	30.84009	153.00516	Terek Sandpiper (31/1/17)
5	Macleay Arm Site 1 (south of caravan park)	MARM01	30.82687	152.99359	west bank south of caravan park

Site number	Site name	Waypoint	GPS coordinates*		Comments
			Latitude (S)	Longitude (E)	
6	Macleay Arm Site 2 (Fishermans Reach)	MARM021	30.85855	152.99931	west bank at end Fishermans Trail near private jetties
		MARM022	30.85882	153.00613	mudflats nr junction Macleay Arm & Spencers Ck; 18 Far Eastern Curlew
7	Back Beach, South West Rocks	BACKBCH01	30.88198	153.03647	S end nr SWR Ck
		BACKBCH02	30.87288	153.02846	N end nr breakwall
		3TERNSPP	30.87369	153.02985	Little Tern, Bar-tailed Godwit (8/2/17)
8	South West Rocks Creek at Back Creek footbridge	SWRCK01	30.88613	153.03677	sandflat
		SWRCK02	30.88544	153.03757	Sooty Oystercatcher
		SWRCK03	30.88679	153.03539	W end upstream
9	Front Beach, South West Rocks	FBCH01	30.88673	153.05209	central section
		FBCH02	30.88362	153.04315	N end nr creek
10	Saltwater Creek, South West Rocks	SCK01	30.88527	153.04358	at footbridge
		SCK02	30.88694	153.04709	
		SCK03	30.89013	153.05440	at old broken bridge
11	Saltwater Lagoon, Arakoon (Hat Head NP)	SL01	30.89334	153.06621	kayak launch in Saltwater Creek
		SL02	30.89342	153.06404	main lagoon N end, Latham's Snipe
		SL03	30.89771	153.06093	cormorant nests
		SL04	30.89916	153.06229	cormorant "island"
		SL05	30.89493	153.06490	egrets
		AZUREKF	30.89210	153.06767	Azure Kingfisher
12	North Smoky Beach, Hat Head NP	NSB01	30.91502	153.08708	Sooty Oystercatcher
		NSB02	30.91744	153.08565	opp. track entrance
13	South Smoky Beach, Hat Head NP	SSB01	30.93048	153.07970	entrance opp. toilet, 4WD beach use
		SSB02	30.93552	153.07509	foredune, 4WD beach use
		SSB03	30.93783	153.07323	4WD beach use
14	"Saltaire", Pelican Island, Jerseyville	SALT01	30.91393	153.02235	main gate
		SALT02	30.91291	153.02078	water's edge
		SALT03	30.91242	153.01750	nr corduroy crossing
		SALT04	30.91121	153.01489	nr mangrove creek
		SALT05	30.90573	153.01263	river's edge
		SALT06	30.90444	153.01334	bank of Macleay R.

Site number	Site name	Waypoint	GPS coordinates*		Comments
			Latitude (S)	Longitude (E)	
15	Boyter's Lane wetland, Jerseyville	BLW01	30.91644	153.03793	nr Boyter's Lane, Black-fronted Dotterel (in carpark)
		BLW02	30.91413	153.03778	trail crossing
		BLW03	30.91644	153.03952	SW end nr road
16	Boyter's Lane wet paddocks, Jerseyville	BWP01	30.91522	153.03065	north end
		BWP02	30.91579	153.03406	south end
		STP	30.91560	153.03226	Sharp-tailed Sandpiper (3/2/17)
17	Macleay Arm at confluence of Clybucca Creek & Andersons Inlet	CLY01	30.89145	152.99950	Clybucca Ck
		CLY02	30.88784	152.99849	Whimbrel
		CLY03	30.88554	152.99602	Macleay Arm bank
18	sand/mudflat, Pelican Island at Rainbow Reach	RR01	30.91449	153.00907	sand/mudflat W side Pelican Island
19	Macleay River sand/mudflat opp. Suez Road & Plummers Lane, Jerseyville	SPIT01	30.92969	153.02832	oppos. Suez Road
		SPIT02	30.93265	153.02696	SW end of spit – Far Eastern Curlew
20	Macleay River sand/mudflats at Ford Island, Jerseyville	FISL01	30.936647	153.02997	sand/mudflats – Far Eastern Curlew, Bar-tailed Godwit
21	Macleay River sand/mudflats at Long Reach Island	LRI01	30.948588	153.007081	sand/mudspit - Whimbrel
22	Back Creek, Kinchela	BCK01	30.97320	152.99219	south end
		BCK02	30.6659	152.99454	Latham's Snipe, Black-winged Stilt, Royal Spoonbill, Purple Swamphen
23	Belmore Swamp, off Seale Road	BS01	31.11203	152.95004	Seale Road east
		BS02	31.11201	152.94609	Seale Road west, Australasian Bittern, Forest Kingfisher, Black Swan

Site number	Site name	Waypoint	GPS coordinates*		Comments
			Latitude (S)	Longitude (E)	
24	Ryan's Cut, Hat Head NP	RCT01	31.12759	152.99943	Common Greenshank
		RCT02	31.12752	152.99721	Marsh Sandpiper, White-bellied Sea-Eagle, Rainbow Bee-Eater
25	Killick Beach at Richardsons Crossing, Hat Head NP	RC01	31.15950	152.98283	4WD beach use
		RC02	31.16399	152.98026	4WD beach use, Australian Pied Oystercatcher
		RC03	31.16817	152.97867	4WD beach use
26	Goolawah Beach, Goolawah NP, Crescent Head south	GBCH01	31.19601	152.97618	N end, White-bellied Sea-Eagle, Eastern Osprey, Brahminy Kite
		GBCH02	31.20351	152.97104	S end, 4WD beach use
27	Racecourse Beach, Goolawah NP	RCBCH01	31.24935	152.96118	south end
		RCBCH02	31.24671	152.96034	4WD beach use, White-bellied Sea- Eagle
		RCBCH03	31.24117	152.96001	4WD beach use
28	Barrie's Bay Beach, Point Plomer, Limeburners Creek NP	PP01	31.31280	152.97089	southern end
		PP02	31.30452	152.96442	Rainbow Bee-eater
		PP03	31.29382	152.96464	northern end

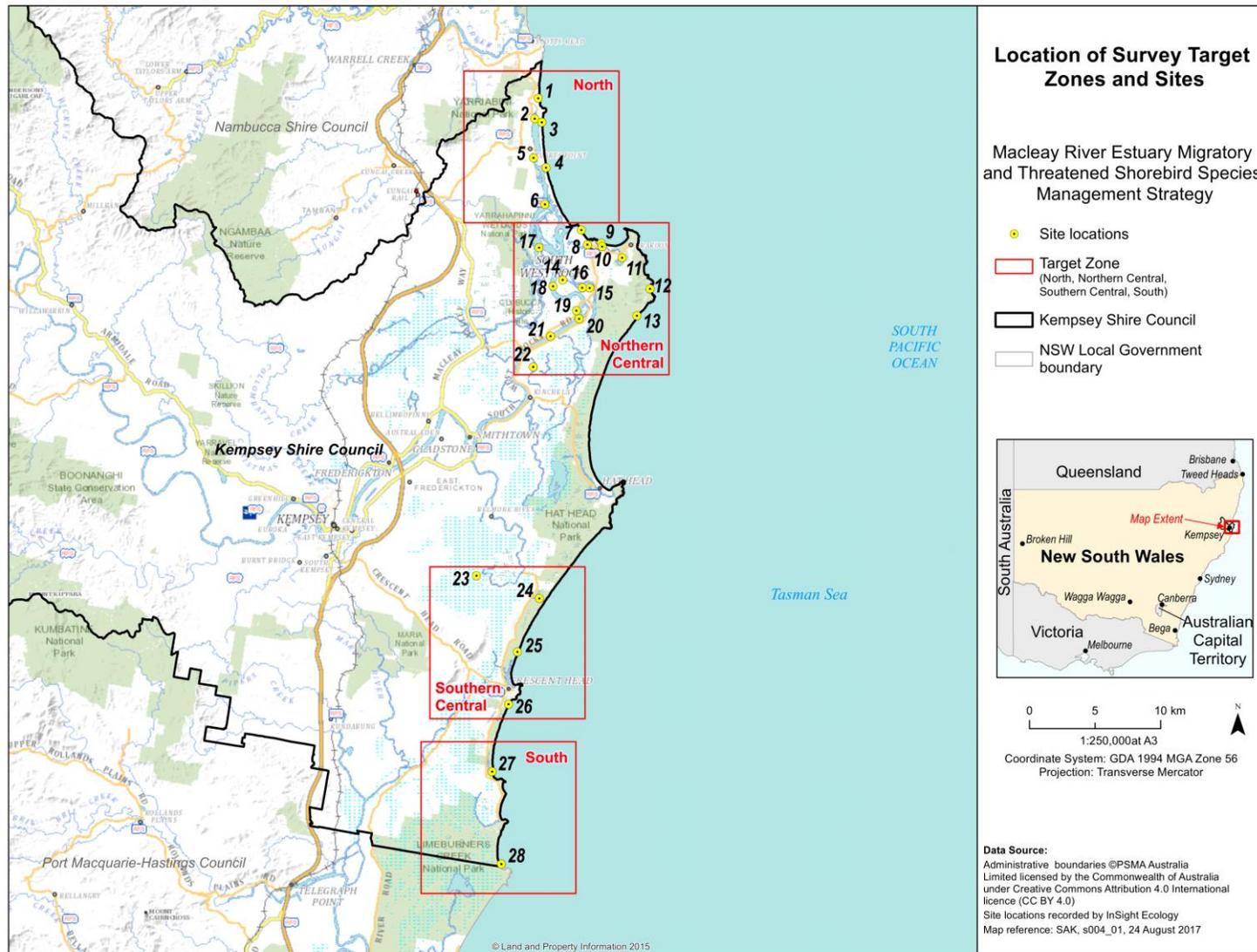


Figure 5: Location of survey target zones and sites surveyed for shorebirds and other aquatic bird species by InSight Ecology in spring and summer 2016-2017 in the study area

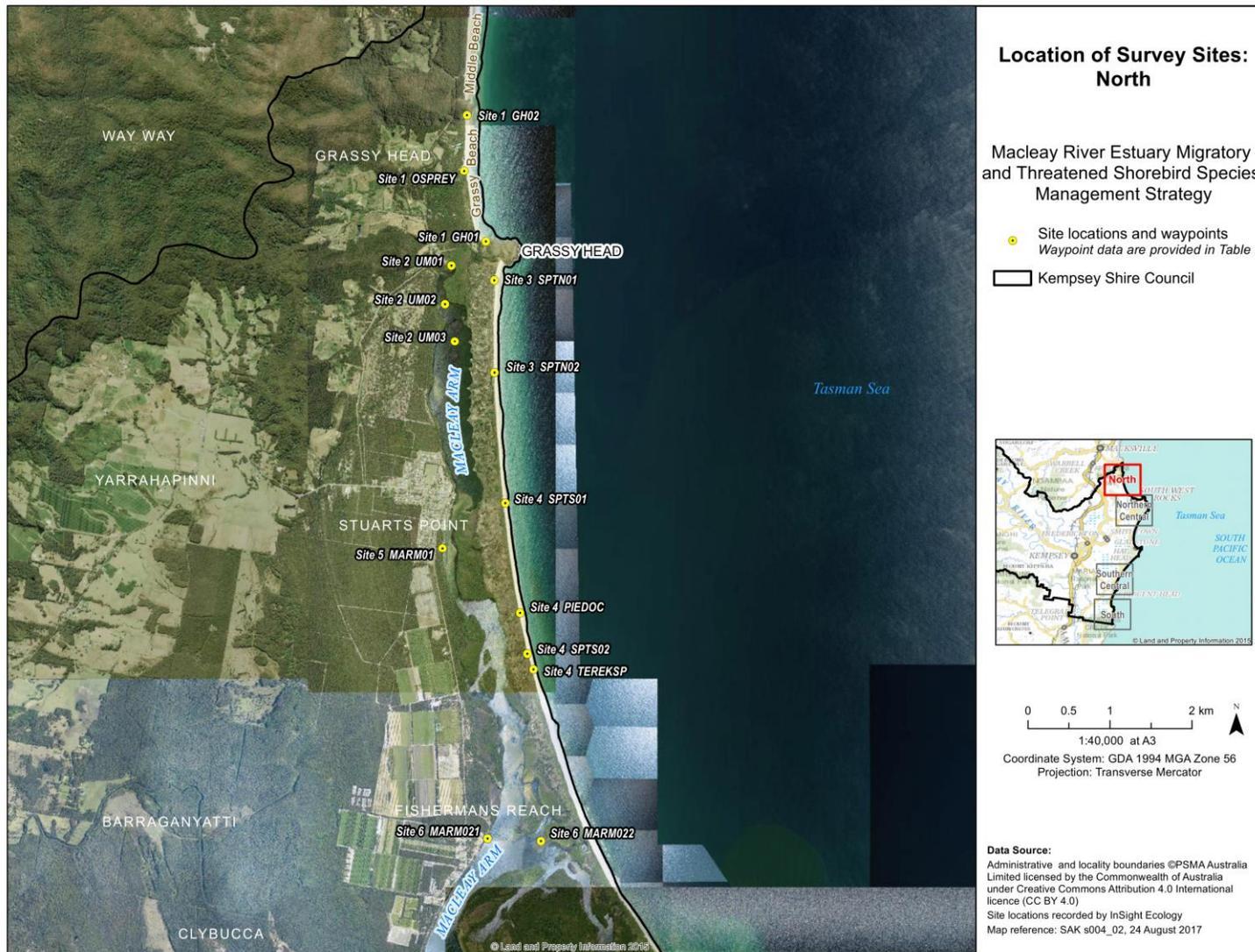


Figure 6: Location of sites surveyed for shorebirds and other aquatic bird species by InSight Ecology in spring and summer 2016-2017 in the North Zone

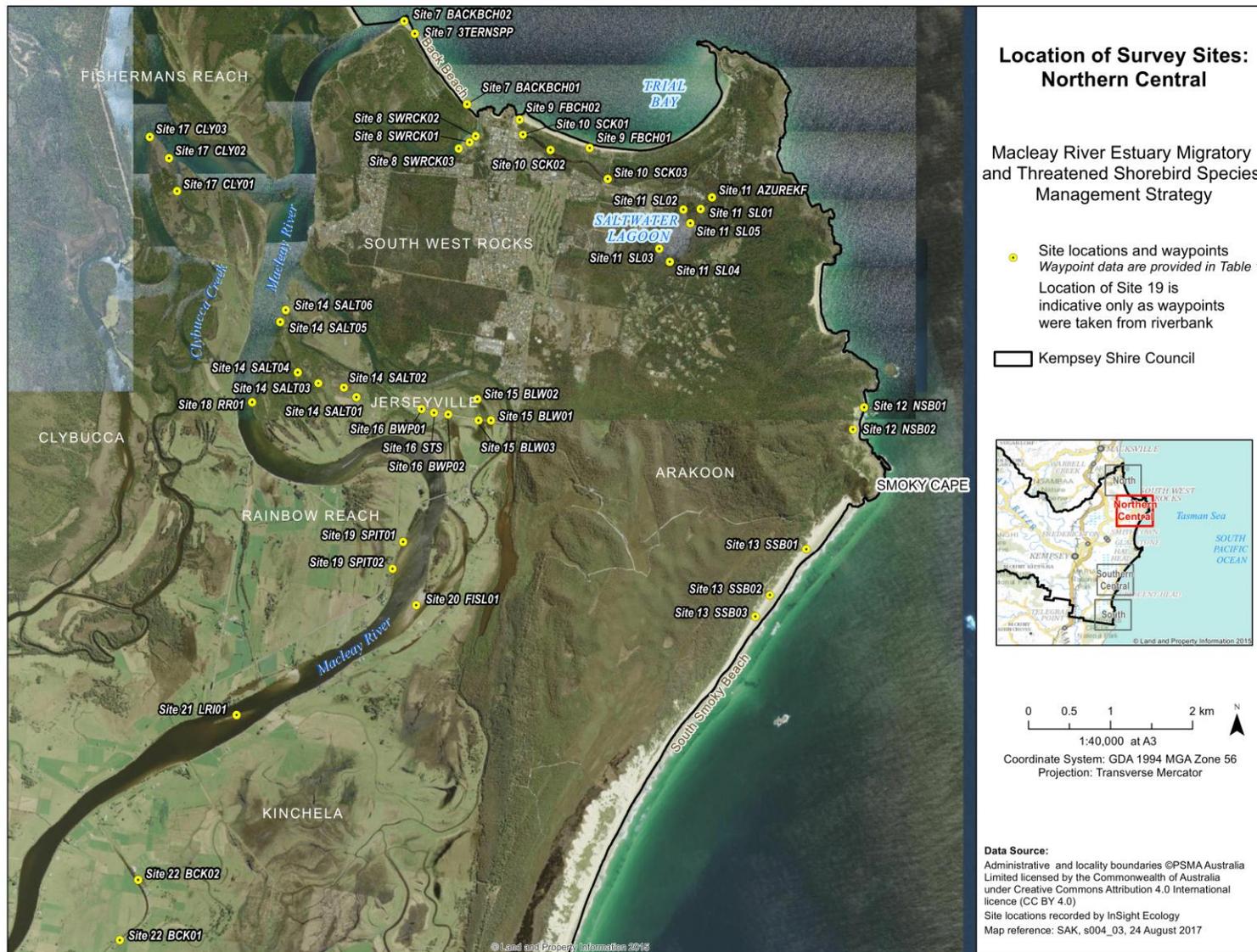


Figure 7: Location of sites surveyed for shorebirds and other aquatic bird species by InSight Ecology in spring-summer 2016-17 in the Northern Central Zone

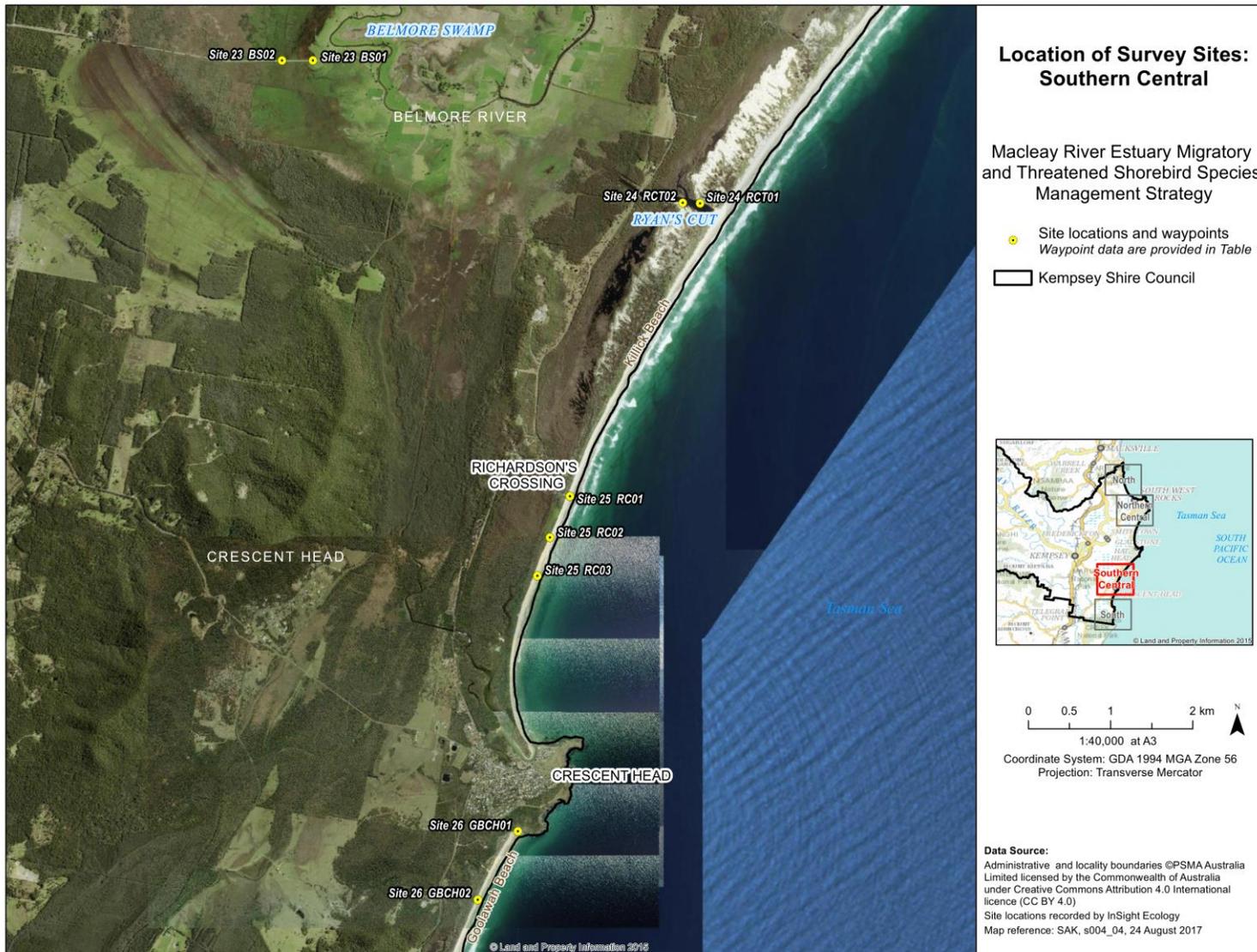


Figure 8: Location of sites surveyed for shorebirds and other aquatic bird species by InSight Ecology in spring and summer 2016-2017 in the Southern Central Zone

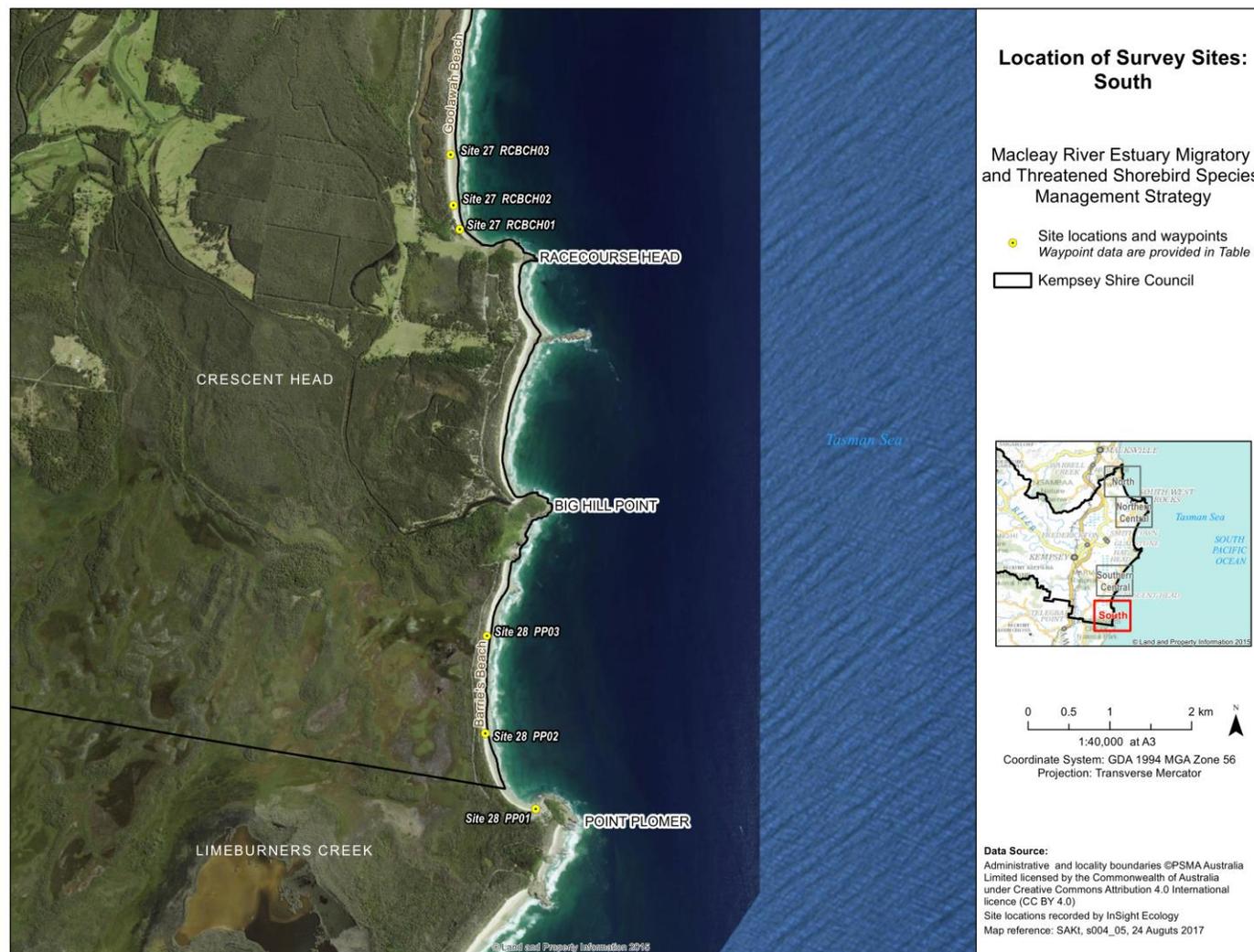


Figure 9: Location of sites surveyed for shorebirds and other aquatic bird species by InSight Ecology in spring and summer 2016-2017 in the South Zone

2.3.3 Target species and habitat types

The project specifically targeted resident and migratory shorebirds since these taxa were the focus of the study. Other aquatic bird species detected during surveying were recorded opportunistically during the surveys, particularly those of conservation significance. Obligate or strictly terrestrial birds were not recorded.

A range of different vegetation communities used by shorebirds and other aquatic bird species in the study area were sampled during the field survey program. These included a number of threatened ecological communities listed under NSW Biodiversity Conservation Act 2016 – swamp oak floodplain forest, coastal saltmarsh, river-flat eucalypt forest on coastal floodplains, swamp sclerophyll forest on coastal floodplains and freshwater wetlands on coastal floodplains.

Habitat types used by shorebirds for foraging, roosting or, potentially, breeding included sandy beaches, intertidal mud/sandflats, rocky substrates (rock platforms, seacliffs, headlands, artificial rockwalls), mangrove/swamp oak forest/saltmarsh complex, saltwater lagoons, freshwater and brackish wetlands, creeks and open water in rivers and major estuaries. These were sampled at each survey site and occurred along the coastline from Grassy Head to Point Plomer, in Macleay River estuary and its main tributaries, in freshwater/brackish swamps such as Belmore Swamp and wet paddocks grazed by livestock.

2.3.4 Field surveying

Reconnaissance of the study area occurred between April and July 2016. This enabled familiarisation with the area, tidal conditions, habitat types and bird communities present, selection of survey sites, and review of threats. A field trip to Pelican Island, Rainbow Reach and Belmore River was undertaken in April 2016 with Ken Shingleton, a long-time local bird observer.

Diurnal shorebird surveys were conducted at a total of 26 sites in the study area in both spring and summer 2016-2017. Two additional sites were surveyed in the summer survey but not in the spring work. Therefore, a total of 28 sites were surveyed in the study. The surveys focused on obtaining baseline data on shorebird occurrence, abundance (number of individual birds), species richness (number of different shorebird species), habitat use and threats.

Methods used in the surveys conformed with shorebird and wetland bird survey methods and recording standards recommended in DEWHA (2010) and currently used in the Shorebirds 2020 Program (BirdLife Australia 2016). These were:

Conspicuous species (oystercatchers, stilts, some sandpipers): Observation using high-powered binoculars and/or telescope from vantage points overlooking suitable foraging or roosting habitat at appropriate stages of the tidal cycle. For foraging activity, sites were surveyed during the receding (ebb) tide and at low tide when sandflats, sandspits and mudflats were exposed. Roosting sites were surveyed at high tide. Transect surveys along beaches, shorelines and rivers. Surveys also occurred during incoming tides.

Inconspicuous species (dotterels, some sandpipers, snipe): High-powered binoculars and a spotting scope were used from vantage points overlooking suitable foraging and roosting habitat at high, ebb, low and incoming tidal phases. Diurnal area searches were conducted in preferred shorebird habitat at selected shorebird foraging and roosting sites.

Transects of between 1-1.6 km in length and 40-50 m in sampling width were walked on beaches, accessible intertidal mud/sandflats and sandbars/spits, wetlands and river banks. Sites that included open water and lagoons with mud, mangrove and reedland/rushland margins were surveyed by kayak using outbound and return routes separated by at least 100 metres where possible. Terrestrial sites that included mangrove forest intermixed with swamp oak floodplain forest and saltmarsh complex were surveyed using area searches. Rock platforms were surveyed at both low and high tide by observation using high-powered binoculars at key vantage points. Two of the three Shorebirds 2020 count areas were surveyed in the study – Clybucca Creek Mouth and Boyters Lane (Figure 10).

All shorebirds observed or heard at a site were recorded, including individuals moving between different habitats. For transect-based surveys, all shorebirds detected within the 40-50 m wide x 1-1.6 km long sampling zone were recorded. Data recorded included date, time and location, survey site, species, number of individuals present, use of habitat (foraging, roosting, preening, taking refuge or nesting), interactions between species, relevant threats and weather and tidal conditions at time of survey. These data conformed with those used in the Shorebirds 2020 Program and shorebird count form (Appendix 1). Care was taken not to record the same bird twice especially where birds moved between different habitats.

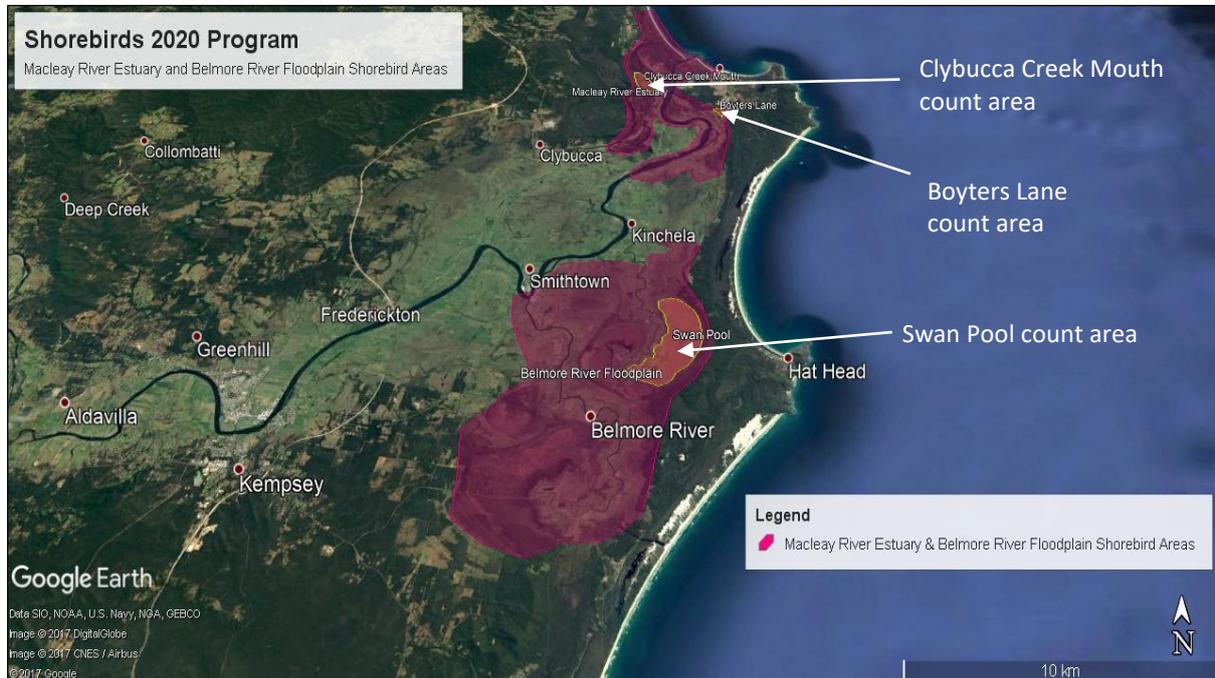


Figure 10: Location of two Shorebird Areas registered with Shorebirds 2020 Program that occur in the study area. These are Macleay River Estuary and Belmore River Floodplain. Two shorebird count areas - Clybucca Creek Mouth and Boyters Lane occur within Macleay River Estuary while one - Swan Pool occurs in Belmore River Floodplain. Image: BirdLife Australia 2016; Google Earth, 2017.

Surveys were conducted by InSight Ecology using Zeiss 10x40BTP® binoculars fixed to a Pro-Harness® chest-strap. A Vortex Viper HD 20-60x80® spotting scope mounted on a monopod was used to confirm shorebird species identity and observe their behaviour.

A total of 52 field survey sessions were completed at 28 survey sites over 17 survey days in the study area. The duration of survey sessions was between 20-150 minutes, depending on the site, tidal conditions and survey method deployed. Total survey effort expended in the project was 73.6 hours with about the same number of hours invested in each of the two surveys. Tide times and phases were based on the times and heights of high and low waters at South West Rocks provided by Bureau of Meteorology (2016).

A photographic record of each survey site, shorebirds present, threats and management issues was established. This included 2,098 photographs (20.1 GB) taken by InSight Ecology during the project using a Nikon D3200® (Nikkor® 55-300 mm lens) SLR digital camera. In addition, some local bird observers provided photographs of shorebirds. All images and data were stored on a standard 500GB ATA HDD backed up to a 500GB external HDD.

2.3.5 Data analysis and scoring

Shorebird survey data obtained in the study were analysed to identify species of conservation significance and their conservation management requirements. Sites of high foraging and roosting habitat value and high threat levels were also identified. This informed the development of a suite of recommended actions to protect, conserve and manage shorebirds and their habitat in the study area (see Part 3 of this report).

Foraging habitat values were determined using scored habitat criteria derived from a study of northern NSW shorebirds (DECCW 2010) and recent shorebird mapping work in Richmond River estuary at Ballina (Lisson et al. 2017). The criteria used in these investigations were adapted for use in the study area. This approach allocated scores to the abundance of shorebirds recorded per site, shorebird density as a correlate of prey concentration and thus habitat quality (see, for example, Piersma 2012), and migratory and threatened shorebird species to indicate habitat utilised by high conservation value taxa. This approach was repeated to identify sites of high shorebird roosting habitat value in the study area.

Threat data obtained during site surveys were analysed to determine sites with high levels of threats to shorebirds. These related primarily to types of human disturbance of shorebird habitat and distinguished between incidents detected during the surveys and threats which were permanent features at each site. For instance, people walking on a beach was a disturbance incident or event (see Lisson et al. 2017) while a dog exercise area such as an off-leash section of Front Beach at South West Rocks was a permanent feature that had potential to increase shorebird disturbance events over time. Each disturbance event was allocated a score and calculated for each site, as detailed in Table 4.

Scoring of the level of threat to shorebirds was based on direct observations of shorebird responses to disturbance events that occurred during the surveys as well as the results of previous studies (DECC 2008; Williams et al. 2009, van Polanen Petel and Bunce 2012; Schneider 2013; Lisson et al. 2017). Threat levels at each site were then specified as very

high (> 35), high (25-35), medium (10-25) or low (0-10), based on the scoring tally of disturbance at each site.

Table 4: The scoring system used for shorebird disturbance events observed during the surveys. Scores for disturbance events that occurred during the surveys are shown in the first column and were additive, ie. 3 4WD disturbance events detected = 3 points scored. Threats associated with permanent features present at each site are provided in the third column and were scored once only per site. Adapted from Lisson et al. (2017)

Disturbance event present during surveys	Score	Permanent feature present at the surveyed site	Score
people < 25 m away	1	dog off-leash area	1
people 25-100 m away	0.5	dog on-leash area	0.5
people 100-200 m away	0.25	picnic/BBQ area	1
dogs – off leash	1	caravan/camping area	1
dogs – on leash	0.5	boat ramp	1
4WD vehicles	1	canoe/kayak launch site	0.5
jet skis	1	boating channel	0.5
power boats	1	4WD area	1
sailing boats	0.5	fishing area	1
fishing	0.5	bait collection area	1
bait collecting	0.5	walking track/path/bridge	0.5
shorebird flights caused	1	swimming/surfing area	1
windsurfing	0.5	livestock trampling	1

A matrix of foraging and roosting habitat value scores and disturbance level scores for each site was developed for the study area, based on the approach used in the Richmond River estuary study (Lisson et al. 2017). This approach identified sites with high, medium and low assessed foraging and roosting habitat values and disturbance levels. This allowed the identification of sites most affected by disturbance and thus requiring priority management action.

2.3.6 GIS mapping

Handheld GPS survey data were collected at each site during field surveys and collated in ArcGIS 10.4. Additional survey information was digitised as required based on site investigations. Maps were produced from these data showing the location of surveyed sites, shorebird habitat types, threats, and significant shorebird species recorded during the surveys. Other spatial data layers were provided by Kempsey Shire Council. Additional aerial imagery was obtained from Google Earth.

2.3.7 Threat identification and prioritisation

Threats to resident and migratory shorebird populations were identified through information gathered during the reconnaissance, field survey and stakeholder consultation phases of the project. A risk matrix was used to determine the risk posed to shorebirds by key threats in the study area and provide the basis for recommending priority management actions (presented in Part 3 of this document). This considered the likelihood of an incident

occurring and its consequence. This was based on a risk prioritisation method used in the national migratory shorebirds conservation plan (Australian Department of the Environment 2015 and see Table 5 below). This approach uses a qualitative assessment to determine levels of risk and the associated priority for mitigation action based on published literature and expert opinion. It applies the precautionary principle (Cooney 2004) to allocate threat categories according to bird groups most at risk of adverse impact and where the consequences of activities are unknown (BirdLife Australia 2015b).

Table 5: The risk prioritisation matrix developed to assess the likelihood and consequences of incidents occurring that have potential to deleteriously affect shorebird populations. This includes the associated priority for mitigation action. Based on a method presented in the national conservation plan for migratory shorebirds (Australian Department of the Environment 2015) - Level of risk: very high = immediate mitigation action is required, high = mitigation action and an adaptive management plan is required, the precautionary principle should be applied; moderate = obtain additional information and develop mitigation if required; low = monitor the threat occurrence and reassess threat level if likelihood or consequences change. Categories for likelihood of an incident occurring: almost certain/certain – expected to occur every year/frequently; likely – expected to occur at least once every 5 years or more frequently; possible – might occur at some time; unlikely – these events are known to have occurred globally but only a few times; rare or unknown – may occur only in exceptional circumstances or it is currently unknown how frequently the incident will occur. Categories for consequences of the incident occurring: not significant – no long-term impact on individuals or populations; minor – individuals are adversely affected but the population is not affected; moderate – population recovery stalls or is reduced; major – population decreases; catastrophic – population extinction.

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
almost certain/certain	low	moderate	very high	very high	very high
likely	low	moderate	high	very high	very high
possible	low	moderate	high	very high	very high
unlikely	low	low	moderate	high	very high
rare or unknown	low	low	moderate	high	very high

2.3.8 Stakeholder consultation and communication

Meetings were held with Kempsey Shire Council, Office of Environment and Heritage (OEH) and North Coast Local Land Services (NCLLS) during the project. These provided survey updates, supplied information on the study area and management issues, and allowed for feedback on community consultation and reporting.

Discussions were also held with local volunteer shorebird observers and data custodians during the project. These were Ken Shingleton (formerly of South West Rocks), Ian Bradshaw (South West Rocks), Lawrie and Julie McEnally (Jerseyville – Macleay Valley Bird Observers), Peter West (Hastings Bird Observers) and Dick Cooper (NSW Bird Atlasers). Ian Bradshaw

provided access to a copy of his Boyters Lane Wetlands book. Ken Shingleton provided valuable information to assist in the selection of survey sites and accompanied InSight Ecology on a study area reconnaissance trip.

A community information evening/workshop was held by InSight Ecology in association with Kempsey Shire Council and OEH to increase local community awareness of the project, present preliminary survey results, and provide a forum for discussion. This was attended by 25 local residents and representatives from Kempsey Shire Council, OEH and NCLLS at South West Rocks Surf Lifesaving Club on 16 March 2017.

2.4 Results

2.4.1 Shorebird species recorded during the study

A total of 1,653 birds from 50 aquatic species were recorded during the surveys conducted for the study. Of these, 273 individuals were shorebirds from 16 different species (Table 6). These included 10 long-distance migratory species and 6 resident or dispersive species. Two migratory species listed as nationally Critically Endangered – Far Eastern Curlew and Curlew Sandpiper – were recorded during the study. Two other resident species – Eastern Osprey and White-bellied Sea-Eagle – are listed as Vulnerable under NSW Biodiversity Conservation Act 2016. The osprey was recorded at 4 sites along the coastal zone while the sea-eagle was detected at 3 sites (Table 6). Other conservation-significant shorebird species detected during the surveys were Australian Pied Oystercatcher (Endangered in NSW), Sooty Oystercatcher (Vulnerable in NSW), Terek Sandpiper (Vulnerable in NSW), Bar-tailed Godwit (near-threatened – IUCN Red List), and 4 species listed under international migratory bird agreements - Latham’s Snipe, Marsh Sandpiper, Sharp-tailed Sandpiper and Common Greenshank (see Table 2, Section 1.4).

No records of nesting activity were obtained for the resident species. However, Sooty Oystercatcher, Black-winged Stilt and Black-fronted Dotterel were observed with immature birds at some sites during the summer survey.

Table 6: All shorebird and other conservation-significant aquatic bird species recorded by InSight Ecology in the spring 2016 and summer 2017 surveys undertaken for this project. Common names of shorebirds and their taxonomic order of presentation below accord with Christidis and Boles 2008. Location data are in accordance with sites and waypoints provided in Table 3. Threatened shorebird species and other conservation-significant aquatic bird species are indicated by an asterisk (*) after their common name. (R) = resident, (M) = migratory. Masked Lapwing, although a (resident) member of the Charadriidae family, was not included in this table because of its common occurrence and tolerance of a range of different habitats including urban parks and gardens. Illustrations in the bottom right panel of the table are by Jeff Davies.

Common name	Number of birds recorded	Location (site number and survey zone)	Date	Habitat type	Use of habitat	Tidal phase
Australian Pied Oystercatcher* (R)	1	4 (North)	7/9/16	beach	ate prey	high tide

Common name	Number of birds recorded	Location (site number and survey zone)	Date	Habitat type	Use of habitat	Tidal phase
Australian Pied Oystercatcher* (R)	2	1 (North)	7/9/16	beach	flew over S end beach	low tide
Australian Pied Oystercatcher* (R)	1	27 (South)	15/9/16	beach	foraged	ebb tide
Australian Pied Oystercatcher* (R)	1	26 (Southern Central)	15/9/16	beach	foraged, roosted	ebb tide
Australian Pied Oystercatcher* (R)	1	25 (Southern Central)	16/9/16	beach	foraged, flew S to Crescent Head	low tide
Australian Pied Oystercatcher* (R)	1	6 (North)	1/2/17	mud/sandflat	foraged	low tide
Sooty Oystercatcher* (R)	2	3 (North)	6/9/16	rock platform	foraged	ebb tide
Sooty Oystercatcher* (R)	2	12 (Northern Central)	12/9/16	rocky islet	foraged, roosted	incoming tide
Sooty Oystercatcher* (R)	1	8 (Northern Central)	14/9/16	sandflat	foraged, rested	low tide
Sooty Oystercatcher* (R)	3	12 (Northern Central)	7/2/17	rocky islet	high tide roost site	incoming tide
Little Tern * (R/M)	18	7 (Northern Central)	8/2/17	beach	rested	low tide
Eastern Osprey * (R)	8	1 (North – 3 birds), 3 (North – 1 bird), 7 (Northern Central – 3 birds), 9 (Northern Central – 1 bird)	6/9/16, 7/9/16, 7/2/17, 8/2/17	beach, dunes	foraged, perched	low tide, ebb tide
White-bellied Sea-Eagle * (R)	6	2 (North – immature), 12 (Northern Central), 14 (Northern Central), 24 (Southern Central), 26 (Southern Central - juvenile), 27 (South)	15/9/16, 16/9/16, 2/2/17, 3/2/17, 7/2/17, 10/2/17	rocky headland, beach, ocean	foraged, perched	high, low & ebb tides
Australasian Bittern* (R)	2	23 (Southern Central), 11 (Northern Central)	16/9/16, 8/2/17	paperbark swamp, rushland	called	n/a
Black-winged Stilt (R)	2	16 (Northern Central)	15/9/16	wet paddock (tidal)	foraged	high tide

Common name	Number of birds recorded	Location (site number and survey zone)	Date	Habitat type	Use of habitat	Tidal phase
Black-winged Stilt (R)	2	21 (Northern Central)	16/9/16	sand/mudflat	roosted	low tide
Black-winged Stilt (R)	30	16 (Northern Central)	3/2/17	wet paddocks	foraged	low tide
Black-winged Stilt (R)	15	15 (Northern Central)	3/2/17	Teal Lagoon	foraged	lack of tidal influence
Black-winged Stilt (R)	18	14 (Northern Central)	3/2/17	muddy shores of small lagoons	foraged, called	high tide (limited tidal influence)
Black-winged Stilt (R)	1	11 (Northern Central)	8/2/17	muddy shores of lagoon	foraged	lack of tidal influence (ICOLL – closed)
Black-winged Stilt (R)	13	22 (Northern Central)	9/2/17	muddy shores	foraged, incl immature birds	lack of tidal influence
Black-fronted Dotterel (R)	2	15 (Northern Central)	15/9/16	wetland	foraged	lack of tidal influence
Black-fronted Dotterel (R)	2	16 (Northern Central)	3/2/17	wet paddocks	foraged (adult & immature bird)	low tide
Latham's Snipe* (M)	2	11 (Northern Central)	8/2/17	muddy shores of lagoon with rank vegetation	foraged, roosted	lack of tidal influence (ICOLL)
Latham's Snipe* (M)	2	22 (Northern Central)	9/2/17	muddy shores	foraged, roosted	lack of tidal influence
Bar-tailed Godwit* (M)	1	17 (Northern Central)	9/9/16	mudflat	foraged	incoming tide
Bar-tailed Godwit* (M)	20	20 (Northern Central)	16/9/16	mud/sandflat	foraged across flat	low tide
Bar-tailed Godwit* (M)	1	7 (Northern Central)	8/2/17	beach	roosted, wet sand	low tide
Whimbrel (M)	5	17 (Northern Central)	9/9/16	mudflat	foraged	incoming tide
Whimbrel (M)	1	21 (Northern Central)	16/9/16	sand/mudflat	roosted, foraged	low tide
Whimbrel (M)	1	17 (Northern Central)	9/2/17	mudflat	foraged	incoming tide
Far Eastern Curlew* (M)	18	6 (North)	8/9/16	mud/sandflat	foraged	low tide
Far Eastern Curlew* (M)	3	17 (Northern Central)	9/9/16	mudflat	foraged	incoming tide
Far Eastern Curlew* (M)	1	19 (Northern Central)	14/9/16	mud/sandflat	foraged, ate crab	low tide
Far Eastern Curlew* (M)	2	6 (North)	1/2/17	mud/sandflat	foraged	low tide

Common name	Number of birds recorded	Location (site number and survey zone)	Date	Habitat type	Use of habitat	Tidal phase
Far Eastern Curlew* (M)	1	19 (Northern Central)	9/2/17	mud/sandflat	foraged	incoming tide
Far Eastern Curlew* (M)	8	18 (Northern Central)	9/2/17	mud/sandflat	foraged	incoming tide
Far Eastern Curlew* (M)	1	20 (Northern Central)	10/2/17	mud/sandflat	foraged	ebb tide
Terek Sandpiper* (M)	5	4 (North)	31/1/17	beach (water's edge)	foraged, flew	incoming tide
Common Greenshank* (M)	2	24 (Southern Central)	10/2/17	small sandy shoreline	roosted, some foraging	low tide
Marsh Sandpiper* (M)	2	24 (Southern Central)	16/9/16	sandy shore along river	roosted	incoming tide
Sharp-tailed Sandpiper* (M)	16	16 (Northern Central)	3/2/17	wet paddocks	foraged	low tide
Curlew Sandpiper* (M)	53	17 (Northern Central)	9/9/16	mudflat and supratidal sandbank	foraged, roosted	incoming tide
Total shorebirds recorded in the project	273					
Total shorebird species recorded in the project	16					

Some shorebird species were recorded at different sites during both survey periods. These included Australian Pied Oystercatcher, Sooty Oystercatcher, Black-winged Stilt, Black-fronted Dotterel and individuals of Bar-tailed Godwit, Far Eastern Curlew and Whimbrel. Plates 1-13 show key shorebird species recorded in the study area during the surveys.

Plate 1: Far Eastern Curlew
(Photograph: Burnett Mary Regional NRM Group)



Plate 2: Curlew Sandpiper
(Photograph: John Manger, scienceimage.csiro.au)



Plate 3: Black-fronted Dotterel
(Photo: Jason Girvan, commons.wikimedia.org)



Plate 4: Bar-tailed Godwit
(Photograph: Andy Doldissen)



Plate 5: Australian Pied Oystercatcher
(Photograph: J. J. Harrison, en.wikipedia.org)



Plate 6: Sooty Oystercatcher, nominate
race *fuliginosus* (southern Australia)
(Photograph: Viktoria Buckley, taken at Arakoon)



Plate 7: Sharp-tailed Sandpiper
(Photograph: J. J. Harrison, en.wikipedia.org)



Plate 8: Marsh Sandpiper
(Photo: Jason Girvan, commons.wikimedia.org)



Plate 9: Latham's Snipe
(Photograph: Jason Girvan, commons.wikimedia.org)



Plate 10: Black-winged Stilt
(Photograph: Andy Doldissen)



Plate 11: Terek Sandpiper, showing the distinctive slightly upturned bill and colour leg flags applied to track the bird's long-distance migratory movement and map its route and use of important staging sites along the way. A metal band containing a unique identifying number that, upon re-capture, allows the bird to be identified to the date and site of its original banding is applied to its left leg. This information is vital in helping to understand the species' longevity and use of foraging, staging and breeding habitat. Photograph: birdlife.org.au



Plates 12 and 13: Little Tern (left – Plate 12) populations in eastern Australia consist of local birds mixed with birds that migrate to Asia in the austral winter returning to Australian shores in spring. The northern end of Back Beach at South West Rocks (Site 7) was a roost site for 18 birds of this species and other terns and Silver Gull (right – Plate 13). Plate 12: southcoastshorebirds.com.au, Plate 13: InSight Ecology



2.4.2 Other significant aquatic bird species recorded during the study

A number of other aquatic bird species of conservation significance were recorded during the surveys in the study area. These included some listed threatened species – Australasian Bittern, Eastern Osprey, White-bellied Sea-Eagle and Brolga, as well as a group of species of local conservation significance.

Australasian Bittern *Botaurus poiciloptilus*

Two breeding males of the globally endangered Australasian Bittern were detected calling at Belmore Swamp during the September 2016 survey (Plates 14-15) and near Saltwater Lagoon in the February 2017 survey. This is a species dependent on standing bodies of freshwater, typically swamps and wetlands fringed by tall reedbeds and rushes that provide dense cover. They also occur in ricefields and agricultural drains. Individuals have been recorded crossing Seale Road at Belmore Swamp and calling on private property just north of Limeburners Creek NP (Ken Shingleton, pers. comm.).

Eastern Osprey *Pandion cristatus*

Eight (8) individuals of this species were recorded in the study area during the spring and summer surveys – at Grassy Head Beach, South West Rocks (Front Beach and Back Beach), Arakoon (Trial Bay – see Plates 16-17) and Crescent Head (Goolawah Beach and Racecourse Beach). They included adult, juvenile and immature birds indicating that this species had recently successfully bred in or near the study area. Eastern Osprey is Vulnerable in NSW and requires tall dead trees to nest in, located within proximity of their coastal and riverine fishing grounds. An artificial nest pole has been installed along the lower Macleay River at Rainbow Reach. Ospreys have previously nested atop a tall communication tower along Phillip Drive at South West Rocks Country Club (Ken Shingleton pers. comm. and pers. obs.).

Plates 14-15: Australasian Bittern are cryptic, part-nocturnal birds that forage in and over the water, wading stealthily with neck extended and when disturbed can freeze and point their bill skyward (Pizzey and Knight 2007). Plate 14: P. Merritt, <http://www.bitternsinrice.com.au/about-birp/> Inset (Plate 15): BirdLife Australia, birdlife.org.au



Plates 16-17: Eastern Osprey – adult perched at Lagers Point, Arakoon (Plate 16 - Viktoria Buckley) and adult perched on dead sheoaks behind Grassy Head Beach (7/9/16 – Plate 17: InSight Ecology)





White-bellied Sea-Eagle *Haliaeetus leucogaster*

Six (6) sea-eagles were recorded in the study area in both surveys – at Upper Macleay Arm, Pelican Island, North Smoky Beach headland, Ryan’s Cut, Goolawah Beach and Racecourse Beach south of Crescent Head (Plate 18). They included adult, immature and juvenile birds, again indicating that breeding had occurred in the study area.

Plate 18: An adult White-bellied Sea-Eagle flying over Back Beach near Macleay River breakwall (Site 7), 14/9/16. Photograph: InSight Ecology



Brolga *Grus rubicunda*

One Brolga (Vulnerable in NSW) was recorded foraging in a wet paddock beside South West Rocks at Jerseyville during the September 2016 survey (Plates 19-20). Two Brolga were reported at an oyster shed on South West Rocks Creek and in wet paddocks along Boyters Lane by an experienced bird observer just prior to and during the February 2017 survey. Five (5) Brolga have been recorded in the study area (Ken Shingleton, pers. comm.).

Plates 19-20: One Brolga was recorded foraging in a wet paddock beside South West Rocks Road about 500 m south of the southern tip of Ford Island. The photographs taken at the site (on 14/9/16), show the bird about to fly out of the paddock (Plate 19) and soon after narrowly avoiding collision with overhead powerlines (Plate 20). Photographs: InSight Ecology.



Flocks and individual birds of other conservation-significant aquatic species were recorded during the surveys. A flock of 156 Black Swan comprising adults with fledglings foraged at Belmore Swamp in the spring survey (Plates 21-22) while 21 were counted at Saltwater Lagoon. Fewer birds were detected in the summer survey - 50 at Upper Macleay Arm and a lone bird at Saltwater Lagoon. At the time of the summer survey, Saltwater Lagoon, an intermittently closed and opened lake and lagoon system, was closed from tidal influence at its entrance to Trial Bay. Thus, lower water quality and less available food in the lagoon would have created poor or unsuitable foraging and breeding conditions for swans and other waterbirds at that time. Flocks of c. 200 Black Swan have been recorded on Saltwater Lagoon in August 2016 and c. 350-1000 at Belmore Swamp (Ken Shingleton pers. comm.).

Plates 21-22: Part of a Black Swan breeding colony recorded at Belmore Swamp in September 2016. The swamp still contained significant water bodies (Plate 21) supporting foraging and breeding waterbird populations. Disputes between rival males (or cobs) were observed with young cygnets seeking shelter with the mother (or pen), as shown in Plate 22. Photos: InSight Ecology



Other significant aquatic bird species recorded in the study area included:

- Striated Heron – individuals were recorded foraging in South West Rocks Creek near Back Beach footbridge (Plate 23), at North Smoky Beach rock platforms and on rocks in Macleay River at Rainbow Reach;
- Cattle Egret – flocks of c. 500 adult and immature birds were detected flying to night roosts in coral trees along the left bank of upper Belmore River on 15/9/16;
- Eastern Great Egret – individuals were recorded foraging along South West Rocks Creek near Back Beach footbridge, Back Creek at Kinchela, Macleay Arm and parts of lower Macleay River;
- Royal Spoonbill - small flocks of 12-18 birds foraged along upper Belmore River, Back Creek (Kinchela) and a mangrove-lined tributary at a vehicular bridge across Boyter's Lane, Pelican Island;
- Azure Kingfisher – a likely breeding pair was recorded during the 13/9/16 kayak survey session (and in the summer survey) along Saltwater Creek between German Creek bridge and Big4 Sunshine Caravan Park at Arakoon (Plates 24-25);
- Forest Kingfisher – an individual bird occurred at Belmore Swamp in summer 2017;
- Pied Cormorant – a small colony was recorded nesting in paperbarks fringing Saltwater Lagoon in the spring survey.

Plate 23: Striated Heron (intermediate morph – buff chest and underbelly obscured) foraging from rocks along the northern bank of South West Rocks Creek near Back Beach footbridge, 14/9/16. Photo: InSight Ecology



Plates 24-25: Azure Kingfisher foraged and most likely bred along Saltwater Creek between the kayak launch site at Big4 Sunshine Caravan Park, Arakoon and German Creek bridge. Photos: main photo (Plate 24, taken in Saltwater Creek) – InSight Ecology, inset (Plate 25) – birdphotos.com.au



2.4.3 Shorebird and waterbird species previously recorded in the study area

A range of shorebird and significant waterbird species have been previously recorded in the study area (Table 7). Some of these species were not recorded during the spring and summer surveys conducted for the present study. These are observation-based records contributed mostly by experienced volunteer bird observers including Ken Shingleton and members of two local birding groups – Macleay Valley and Hastings Bird Observers.

Table 7: Shorebird and significant waterbird species recorded by bird observers in the study area, including data contributed to the Atlas of NSW Wildlife (BioNet) and NSW Bird Atlas for the period 1 January 1991 to 13 September 2017 inclusive. Data sources: NSW Office of Environment and Heritage (licensed access to BioNet), NSW Bird Atlas, Ken Shingleton (KS), Alan Morris (AM), Viktoria Buckley (VB) and Lawrie McEnally (LM). Status accords with NSW Biodiversity Conservation Act 2016 and EPBC Act 1999 – P = Protected, V = Vulnerable, E = Endangered, CE = Critically Endangered, 2 = endangered), C, J, K = migratory bird protection agreements with China (C), Japan (J) and Republic of South Korea (K).

Scientific Name	Common Name	NSW status	Federal status	Number of records	Notes
<i>Anseranas semipalmata</i>	Magpie Goose	V, P		1	

Scientific Name	Common Name	NSW status	Federal status	Number of records	Notes
<i>Anas rhynchotis</i>	Australasian Shoveller	P		14	c. 1000 recorded during wet years at Belmore Swamp (KS)
<i>Biziura lobata</i>	Musk Duck	P		7	
<i>Cygnus atratus</i>	Black Swan	P		54	individual records of 100-250 birds at Belmore Swamp (KS)
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck	P		3	bred in Belmore Swamp (KS)
<i>Oxyura australis</i>	Blue-billed Duck	V, P		2	
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe	P		2	
<i>Anhinga novaehollandiae</i>	Australasian Darter	P		12	
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E1, P		86	includes nesting
<i>Ardea ibis</i>	Cattle Egret	P	C, J	49	500+ roosting records in upper Belmore River
<i>Ardea modesta</i>	Eastern Great Egret	P		33	South West Rocks Creek, Swan Pool
<i>Botaurus poiciloptilus</i>	Australasian Bittern	E1, P	E	6	Belmore Swamp, Limeburners Creek NP (KS)
<i>Butorides striatus</i>	Striated Heron	P		9	
<i>Egretta garzetta</i>	Little Egret	P		10	
<i>Egretta sacra</i>	Eastern Reef Egret	P	C	8	North Smoky Beach, South Smoky Beach, Point Plomer
<i>Ixobrychus flavicollis</i>	Black Bittern	V, P		8	Limeburners Creek NP
<i>Nycticorax caledonicus</i>	Nankeen Night Heron	P		18	30 birds at roost in upper Belmore River (KS)
<i>Platalea flavipes</i>	Yellow-billed Spoonbill	P		2	
<i>Platalea regia</i>	Royal Spoonbill	P		23	300 roosted in camphor laurels upper Belmore River (KS); also at Back Creek, Pelican Island,

Scientific Name	Common Name	NSW status	Federal status	Number of records	Notes
					Rainbow Reach, Swan Pool
<i>Plegadis falcinellus</i>	Glossy Ibis	P	C	5	Belmore Swamp
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	V, P	C	65	
<i>Lophoictinia isura</i>	Square-tailed Kite	V, P		35	Stuarts Point Beach & others
<i>Pandion cristatus</i>	Eastern Osprey	V, P		96	
<i>Grus rubicunda</i>	Brolga	V, P		6	
<i>Burhinus grallarius</i>	Bush Stone-curlew	E1, P		1	single bird – also one rehabilitated bird released in 2012 by NPWS along Maria River Road, south of study area
<i>Esacus magnirostris</i>	Beach Stone-curlew	E1, P		2	single birds recorded along Clybucca Creek (LM) and Front Beach at Trial Bay (VB, in May 2013)
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V, P		17	
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher	E1, P		26	
<i>Himantopus himantopus</i>	Black-winged Stilt	P		34	bred at Belmore Swamp; large numbers in wet times
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet	P		8	bred at Belmore Swamp
<i>Charadrius bicinctus</i>	Double-banded Plover	P		3	
<i>Pluvialis fulva</i>	Pacific Golden Plover	P	C, J, K	5	
<i>Pluvialis squatarola</i>	Grey Plover	P		1	
<i>Charadrius mongolus</i>	Lesser Sand Plover	V, P	E, C, J, K	1	
<i>Charadrius leschenaultii</i>	Greater Sand Plover	E, P	E, C, J, K	2	
<i>Vanellus tricolor</i>	Banded Lapwing	P		2	
<i>Irediparra gallinace</i>	Comb-crested Jacana	V, P		21	Belmore Swamp

Scientific Name	Common Name	NSW status	Federal status	Number of records	Notes
<i>Rostratula australis</i>	Australian Painted Snipe	E1, P	E	1	
<i>Calidris tenuirostris</i>	Great Knot	V, P	CE, C, J, K	2	
<i>Calidris canutus</i>	Red Knot	P	E, C, J, K	3	
<i>Actitis hypoleucos</i>	Common Sandpiper	P	C, J, K	4	
<i>Arenaria interpres</i>	Ruddy Turnstone	P	C, J, K	4	
<i>Calidris melanotos</i>	Pectoral Sandpiper	P	C, J, K	3	
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	P	C, J, K	22	1,250 at Pelican Island (9-12/12/06, 780 on lower Macleay wetlands, 300 at Rainbow Reach (1-14/4/07) (AM)
<i>Xenus cinereus</i>	Terek Sandpiper	V, P	C, J, K	7	
<i>Calidris alba</i>	Sanderling	V, P	C, J, K	1	
<i>Calidris ferruginea</i>	Curlew Sandpiper	E1, P	CE, C, J, K	3	lower Macleay River, Clybucca Creek
<i>Calidris ruficollis</i>	Red-necked Stint	P	C, J, K	5	
<i>Calidris subminuta</i>	Long-toed Stint	P	C, J, K	1	
<i>Gallinago hardwickii</i>	Latham's Snipe	P	C, J, K	11	Saltwater Lagoon, Saltwater Creek, Limeburners Creek NP, Rainbow Reach
<i>Limosa lapponica</i>	Bar-tailed Godwit	P	C, J, K	13	
<i>Limosa limosa</i>	Black-tailed Godwit	V, P	C, J, K	1	
<i>Numenius madagascariensis</i>	Far Eastern Curlew	P	CE, C, J, K	11	Macleay River, Macleay Arm, Clybucca Creek
<i>Numenius phaeopus</i>	Whimbrel	P	C, J, K	5	Clybucca Creek
<i>Numenius minutus</i>	Little Curlew	P	C, J, K	2	
<i>Thinornis rubicollis</i>	Hooded Plover	CE, P	V	1	old record from Clybucca Creek;

Scientific Name	Common Name	NSW status	Federal status	Number of records	Notes
					likely extinct in study area
<i>Charadrius veredus</i>	Oriental Plover	P	C, J, K	1	
<i>Tringa brevipes</i>	Grey-tailed Tattler	P	C, J, K	3	
<i>Tringa glareola</i>	Wood Sandpiper	P	C, J, K	1	
<i>Tringa incana</i>	Wandering Tattler	P	J	1	
<i>Tringa nebularia</i>	Common Greenshank	P	C, J, K	4	Ryan's Cut
<i>Tringa stagnatilis</i>	Marsh Sandpiper	P	C, J, K	7	Ryan's Cut
<i>Tringa totanus</i>	Common Redshank	P	C, K	2	
<i>Gelochelidon nilotica</i>	Gull-billed Tern	P	C	1	
<i>Hydroprogne caspia</i>	Caspian Tern	P	C, J	2	
<i>Sterna hirundo</i>	Common Tern	P	C, J	5	
<i>Sterna albifrons</i>	Little Tern	E1, P	C, J, K	7	
<i>Thalasseus bergii</i>	Crested Tern	P		35	
<i>Onychoprion fuscata</i>	Sooty Tern	V, P		2	
<i>Chlidonias leucopterus</i>	White-winged Black Tern	P		4	
<i>Gygis alba</i>	White Tern	P		1	
<i>Sterna dougallii</i>	Roseate Tern	P		3	
<i>Sterna sumatrana</i>	Black-naped Tern	P		11	
<i>Procelsterna cerulea</i>	Grey Ternlet	V, P		2	
<i>Phalaropus lobatus</i>	Red-necked Phalarope	P		1	
<i>Limnodromus semipalmatus</i>	Asian Dowitcher	P		1	
<i>Philomachus pugnax</i>	Ruff	P		2	

Two species of high conservation significance included in Table 7 deserve special mention. The critically endangered (in NSW) Beach Stone-curlew (Plate 26) has been recorded foraging on sandy beaches along Clybucca Creek in 2013-2015 (Lawrie McEnally and Ken Shingleton, pers. comm.). An adult bird was also recorded on Front Beach at Trial Bay in May

2013 (Viktorija Buckley, pers. comm.) – possibly the same bird as sighted along Clybucca Creek in that year.

The endangered (in NSW) Black-necked Stork (Plate 27) has been recently (2013-2016) observed foraging in wetlands along Boyters Lane at Pelican Island (David and Caroline Adams, Ken Shingleton, pers. comm.) and at Rainbow Reach (Noel Nilsen, pers. comm.). During the summer 2017 survey at Boyters Lane, a visiting Victorian bird observer reported seeing two storks foraging in a paddock at Smithtown in 2015. A pair of storks were recorded nesting on a property near Kinchela in 1998 and at Belmore Swamp in 2006 (Ken Shingleton, pers. comm.).

Plate 26: An adult Beach Stone-curlew was recorded foraging along the Trial Bay section of Front Beach on 9 May 2013 at 0751 hours (Viktorija Buckley, pers. comm.). 4WD vehicles and leashed and unleashed dogs are not permitted on this section of the beach. Photograph: Viktorija Buckley (taken on the above beach)



Plate 27: The Black-necked Stork forages in wetlands, irrigated paddocks, farm dams, mangroves and tidal mudflats for frogs, fish, crustaceans, small birds and other prey. The Macleay River estuary is toward the southern end of this species' Australian range which is centred around northern Australia. Photograph: GDW.45 at www.commonswikimedia.org (male shown)



2.4.4 Shorebird habitats and their use

A range of habitats were utilised by shorebirds and waterbirds for foraging, roosting, sheltering and, in some instances, breeding in the study area. These included sandy beaches, intertidal mudflats and sandflats, rocky substrates – rock platforms, seacliffs, coastal headlands and artificial rockwalls including breakwalls and groynes, lagoons, creeks, freshwater and brackish wetlands, mangroves, saltmarsh and swamp oak forest, and open water in rivers and estuaries. Some of these habitats occurred in threatened ecological communities – swamp oak floodplain forest, coastal saltmarsh, freshwater wetlands, river-flat eucalypt forest on coastal floodplains and swamp sclerophyll forest on coastal floodplains.

Figures 11-27 show habitat types utilised by shorebirds at surveyed sites in the study area. The results of an assessment of shorebird foraging and roosting habitat value are presented after these maps.

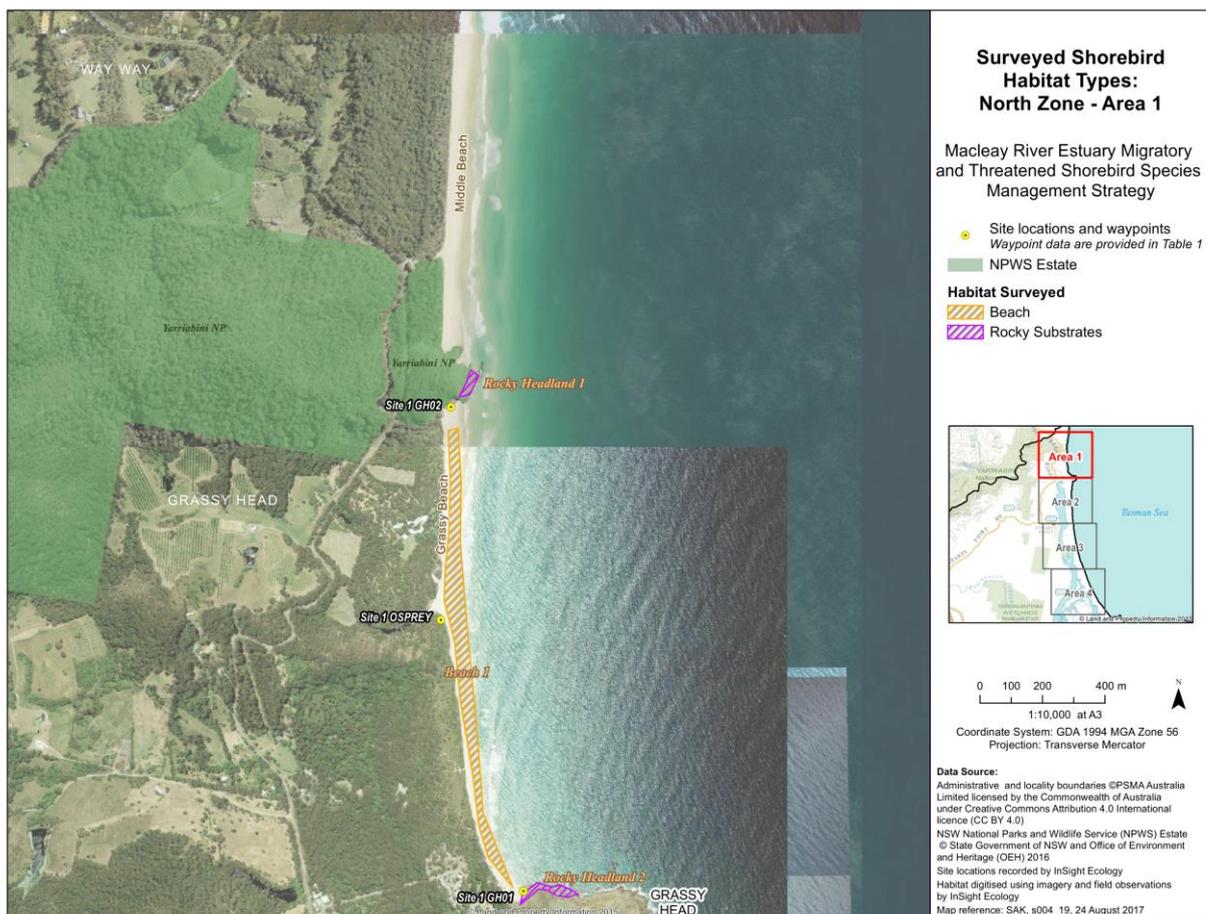


Figure 11: Shorebird habitat types surveyed in North Zone – Area 1. The location of a significant aquatic bird species (Eastern Osprey) recorded during the surveys is also shown.

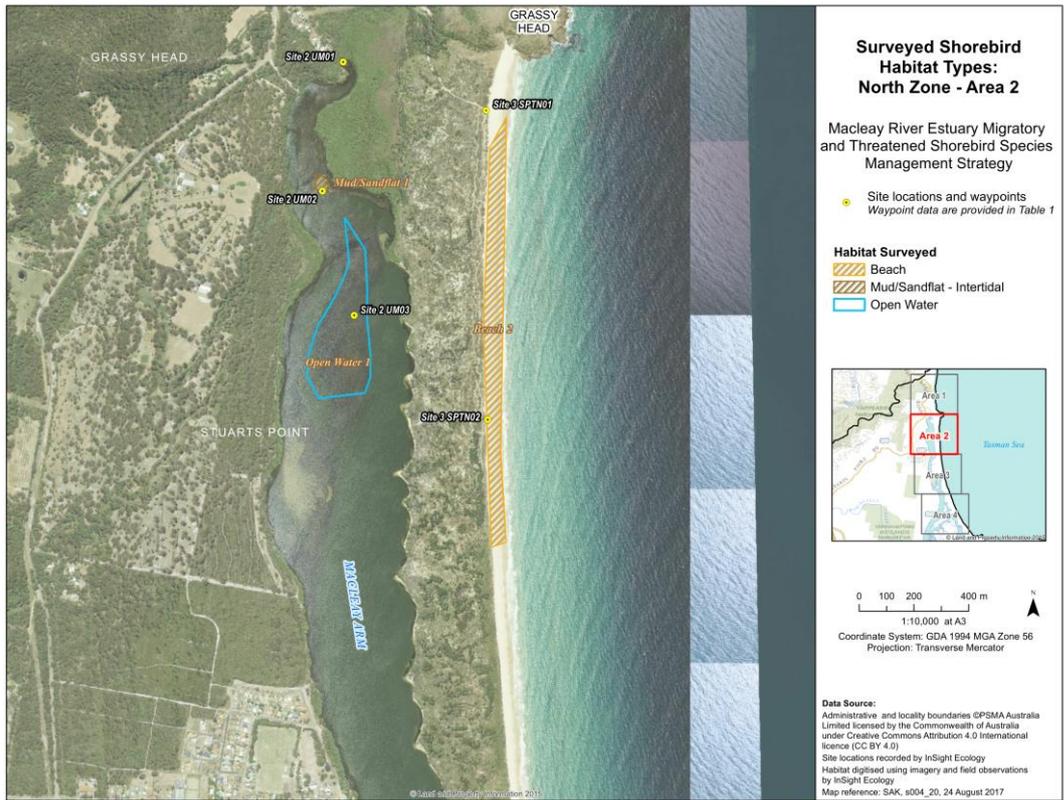


Figure 12: Shorebird habitat types surveyed in North Zone – Area 2

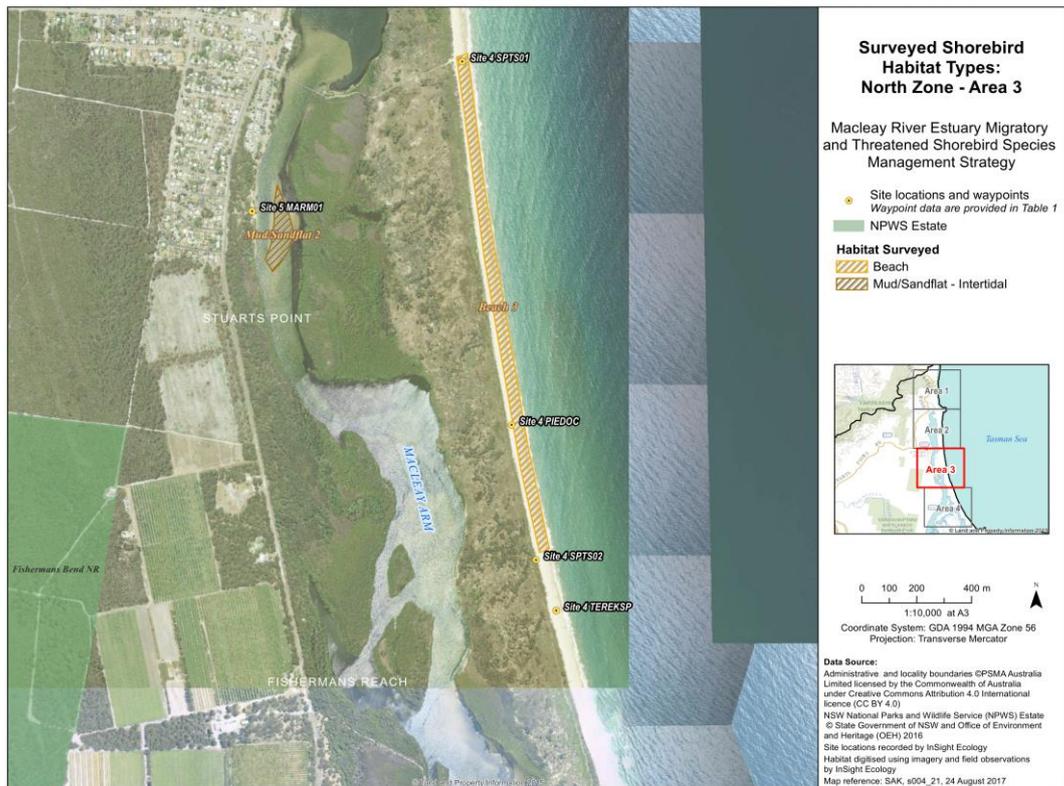


Figure 13: Shorebird habitat types surveyed in North Zone – Area 3. Locations of Australian Pied Oystercatcher and Terek Sandpiper sightings are also shown.

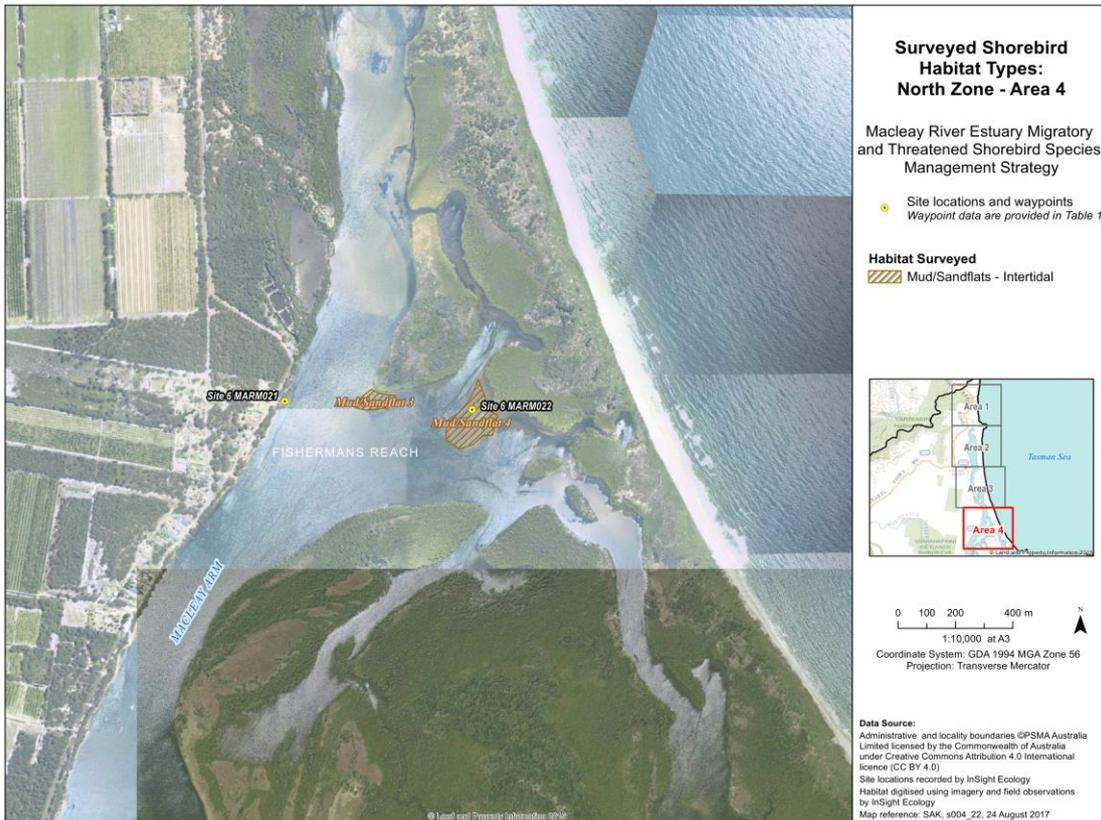


Figure 14: Shorebird habitat types surveyed in North Zone – Area 4.

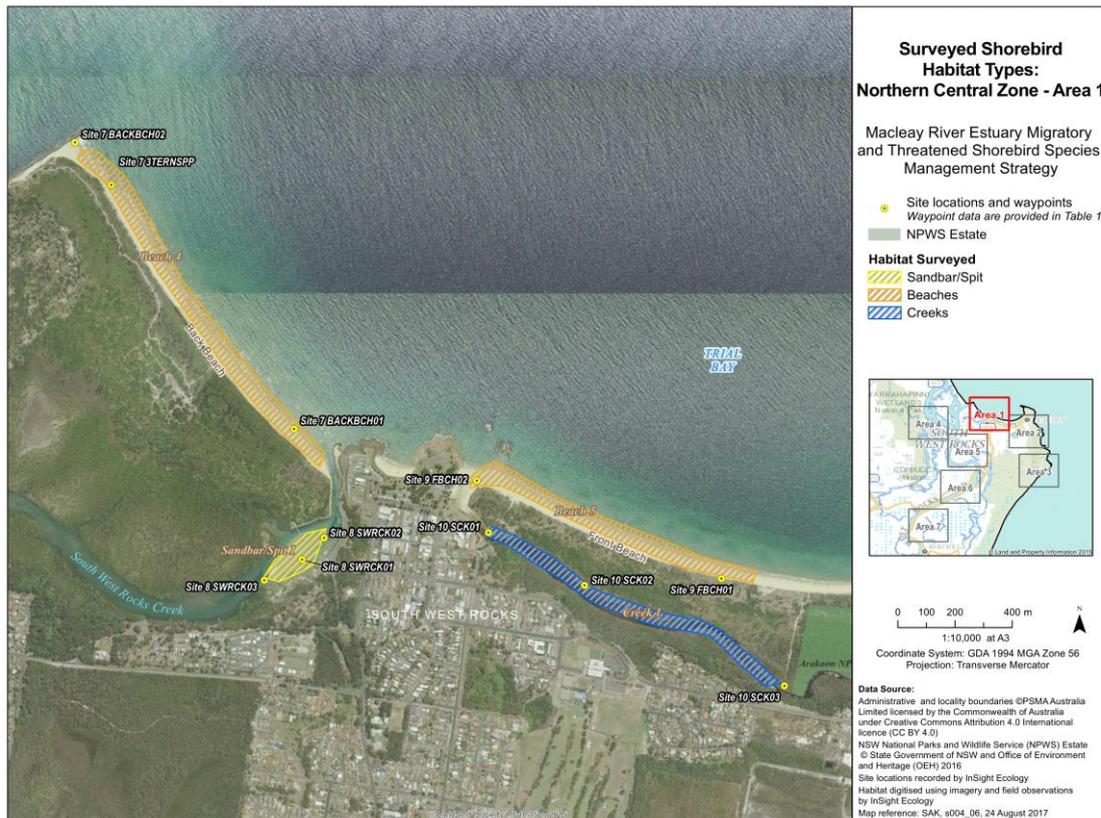


Figure 15: Shorebird habitat types surveyed in Northern Central Zone – Area 1

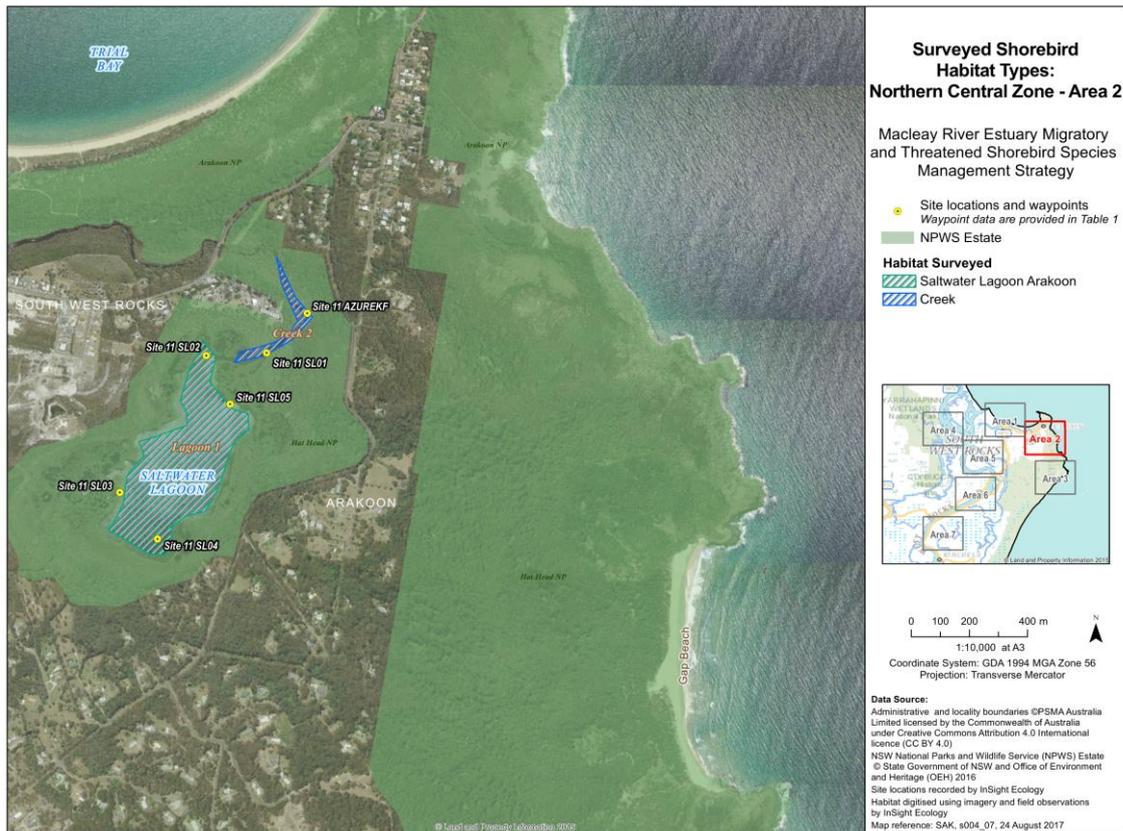


Figure 16: Shorebird habitat types surveyed in Northern Central Zone – Area 2

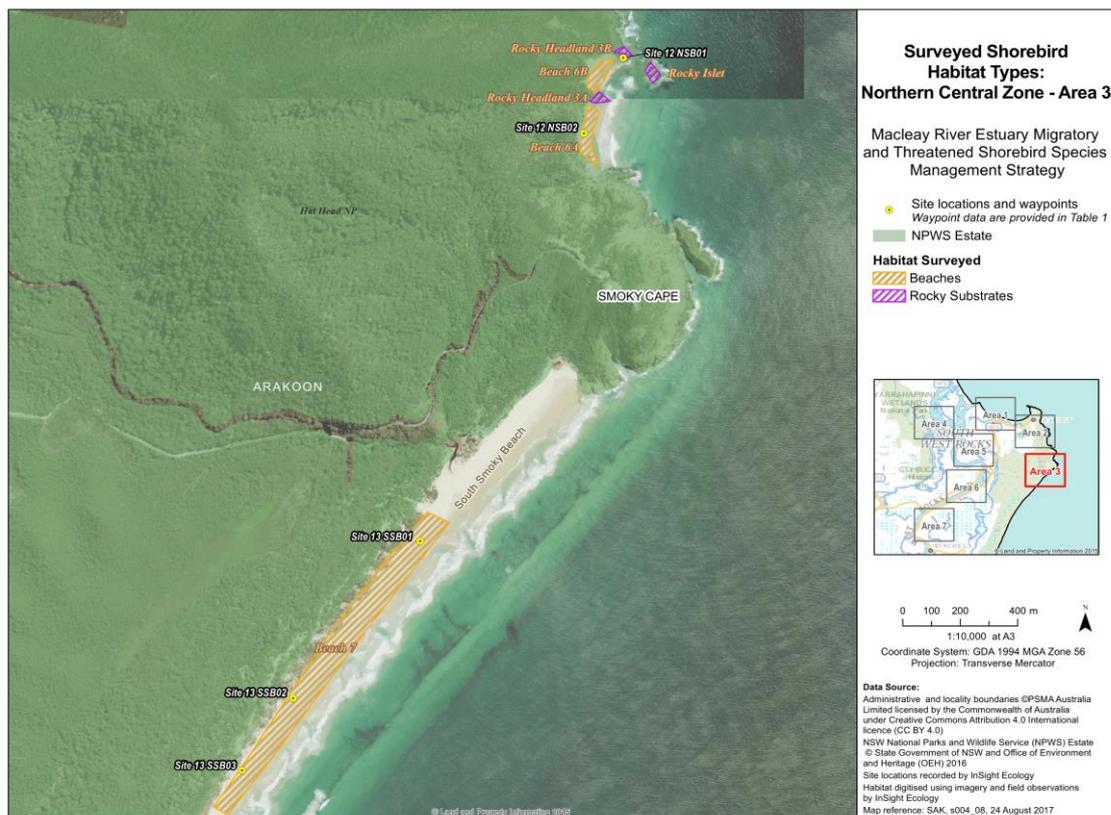


Figure 17: Shorebird habitat types surveyed in Northern Central Zone – Area 3

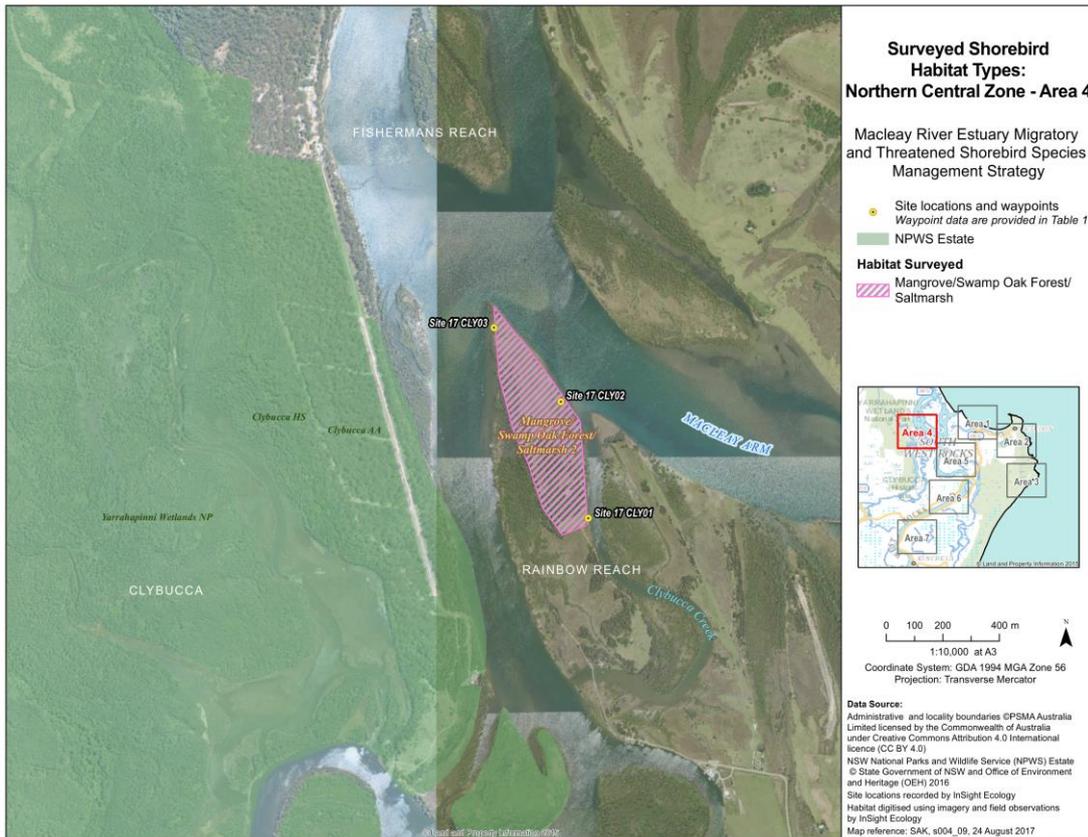


Figure 18: Shorebird habitat types surveyed in Northern Central Zone – Area 4

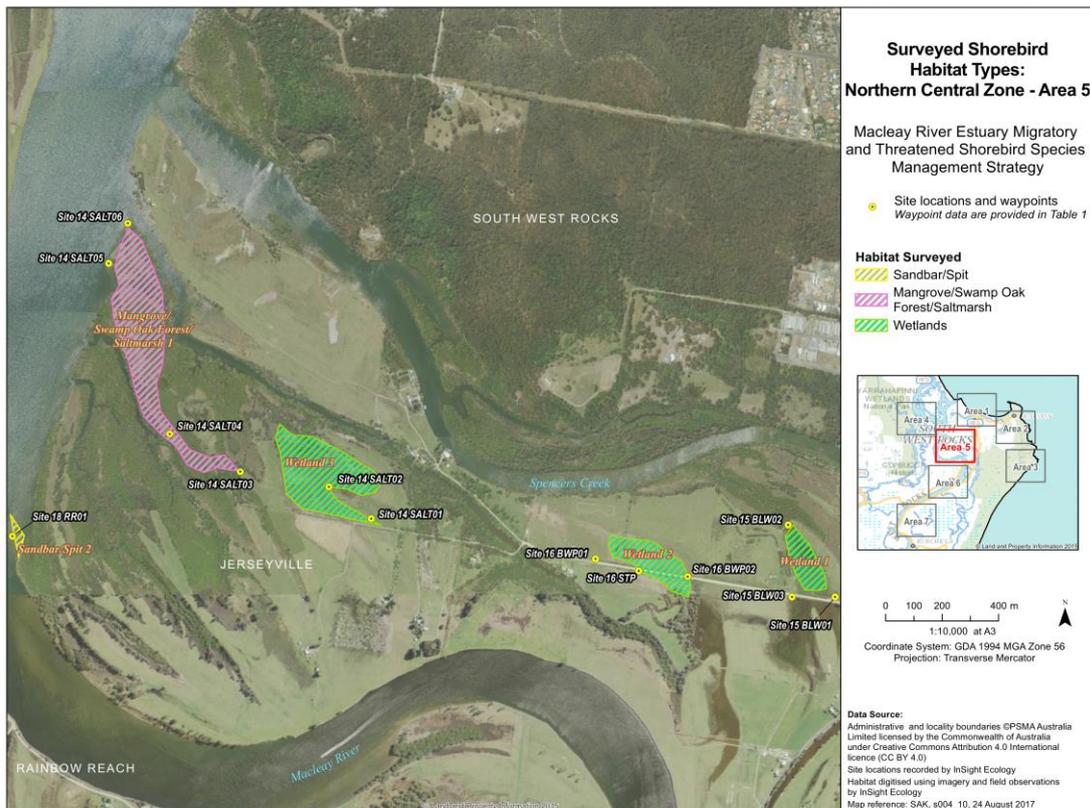


Figure 19: Shorebird habitat types surveyed in Northern Central Zone – Area 5

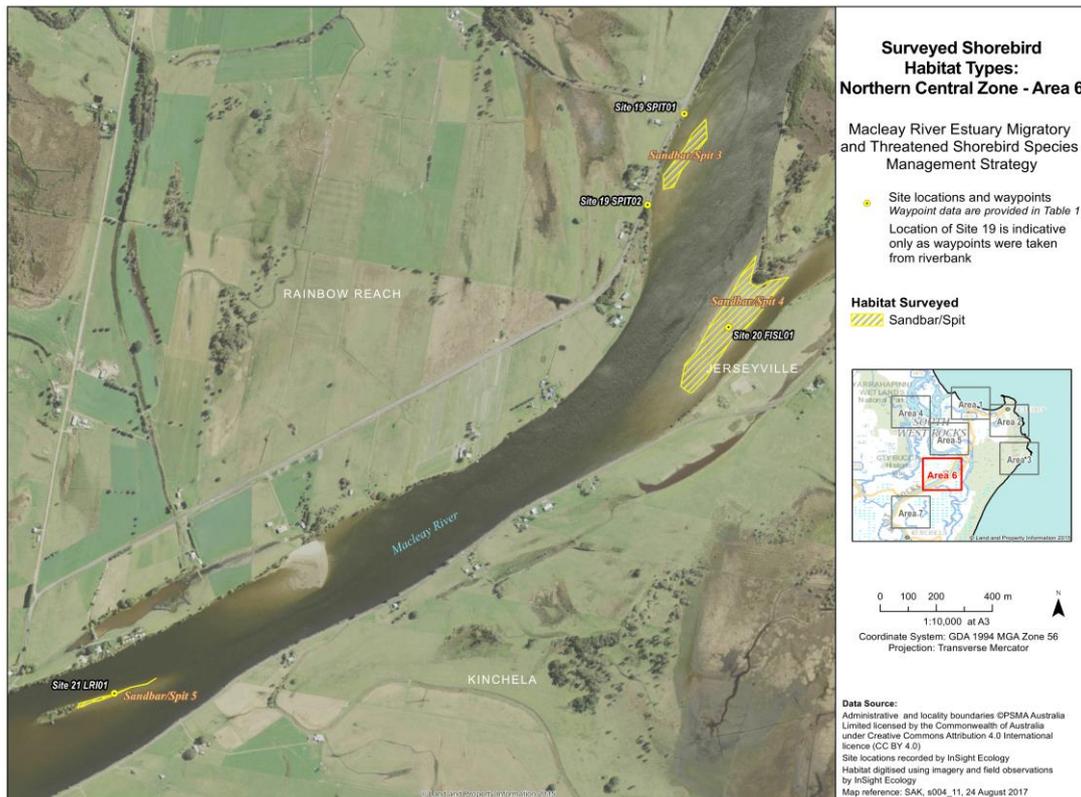


Figure 20: Shorebird habitat types surveyed in Northern Central Zone – Area 6

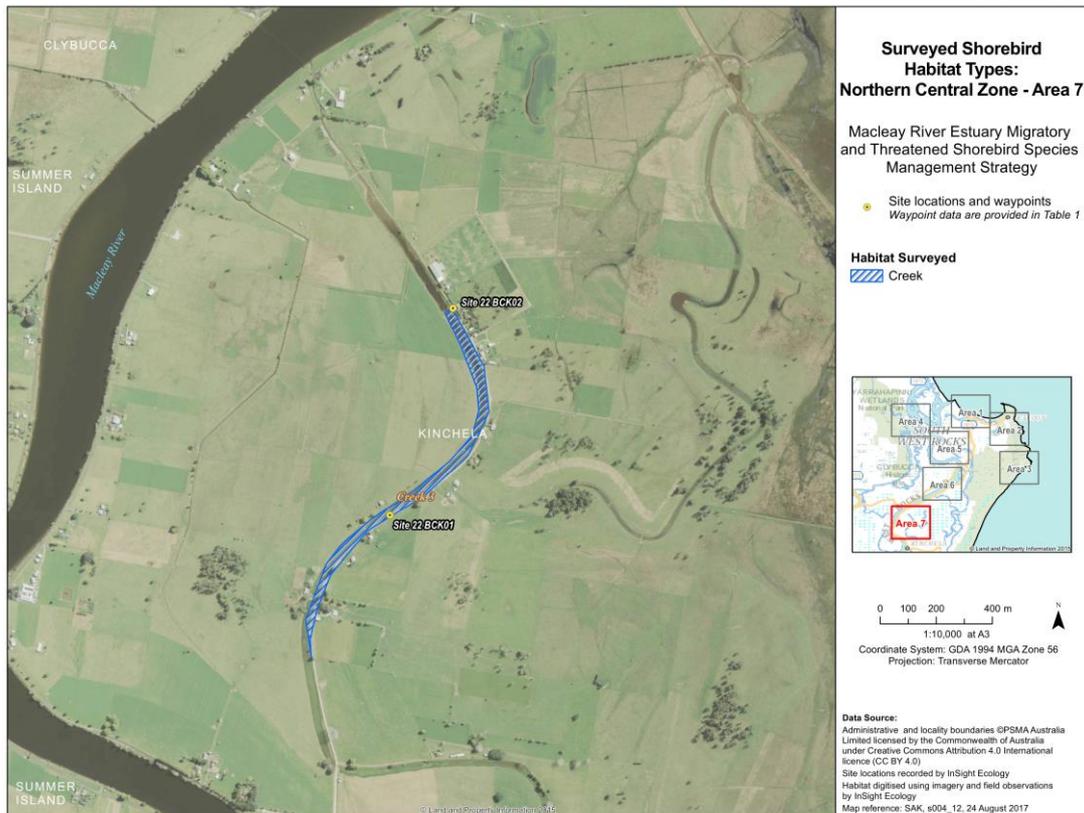


Figure 21: Shorebird habitat types surveyed in Northern Central Zone – Area 7

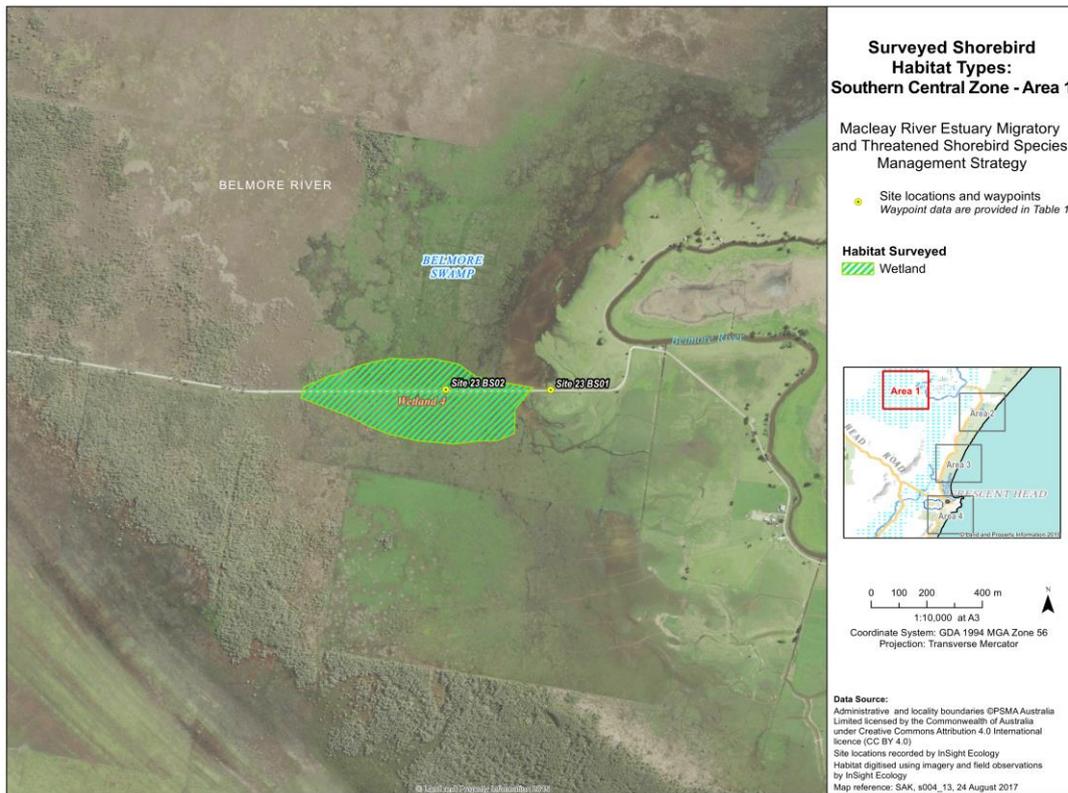


Figure 22: Shorebird habitat types surveyed in Southern Central Zone – Area 1

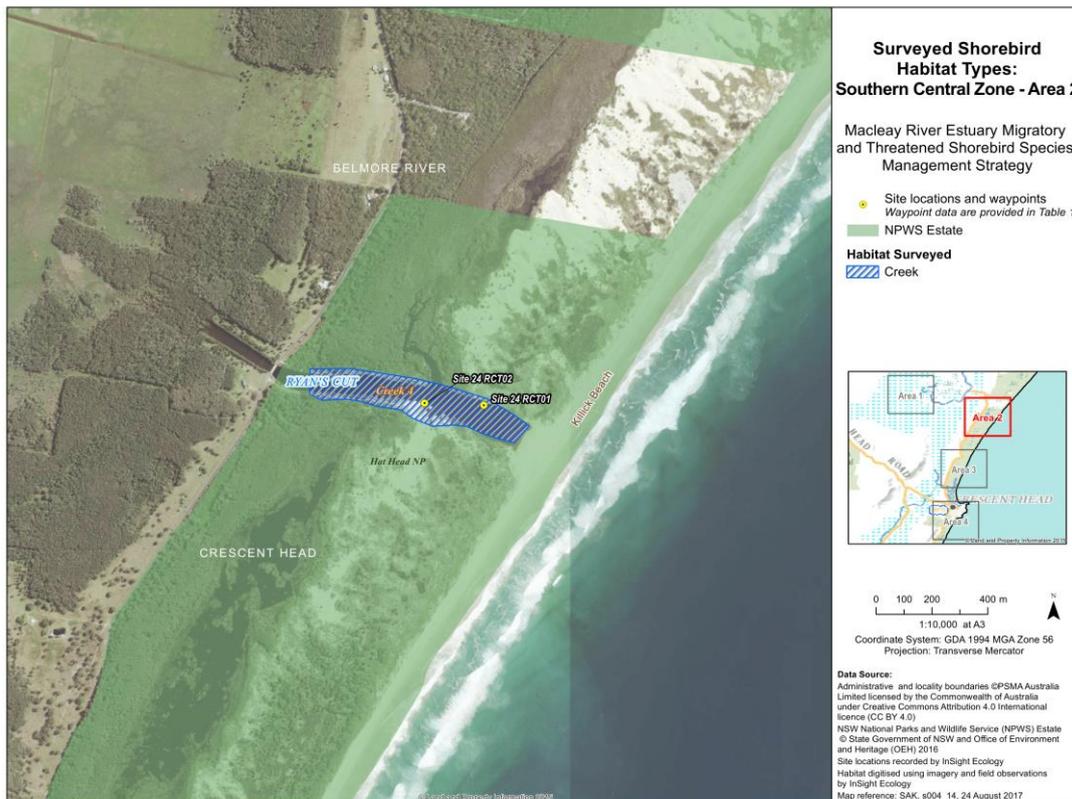


Figure 23: Shorebird habitat types surveyed in Southern Central Zone – Area 2

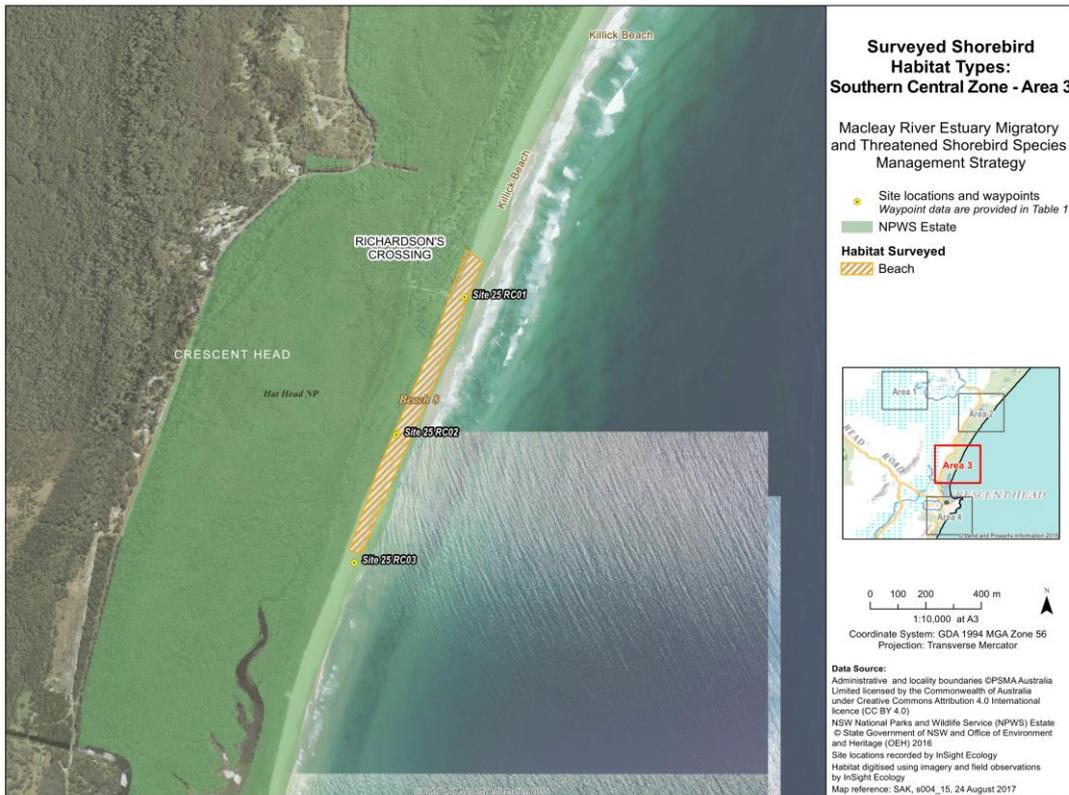


Figure 24: Shorebird habitat types surveyed in Southern Central Zone – Area 3

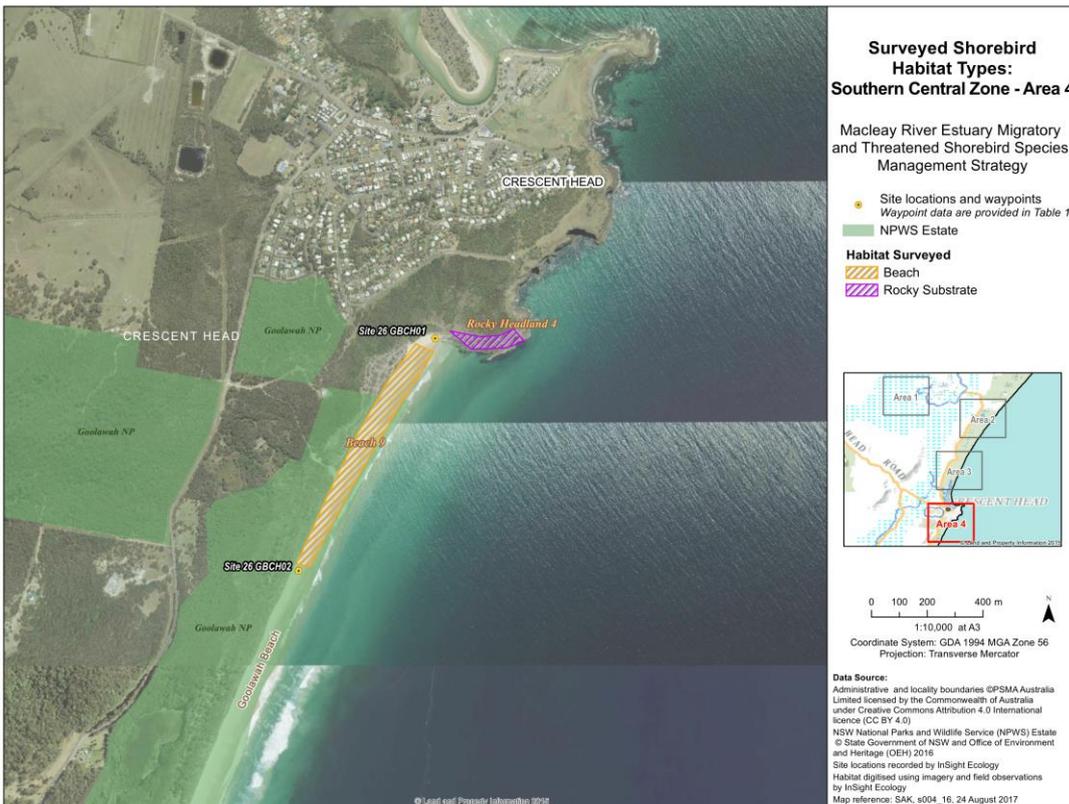


Figure 25: Shorebird habitat types surveyed in Southern Central Zone – Area 4

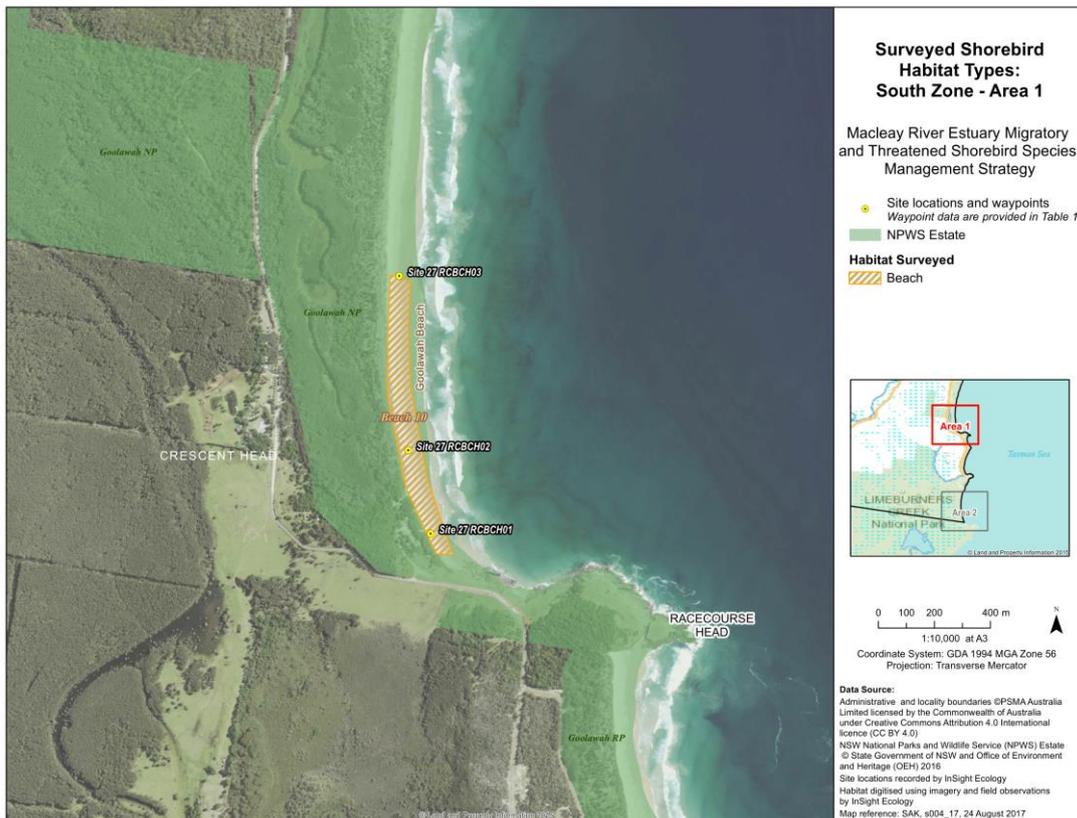


Figure 26: Shorebird habitat types surveyed in South Zone – Area 1

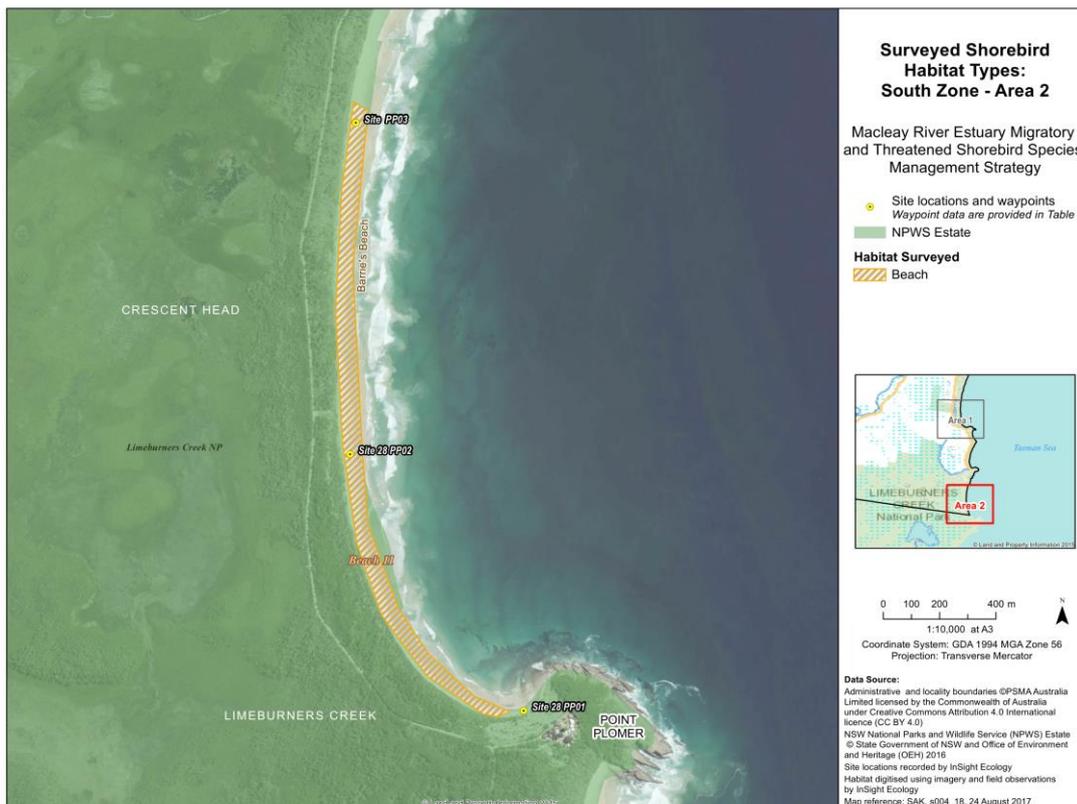


Figure 27: Shorebird habitat types surveyed in South Zone – Area 2

Foraging habitat value

The quality of shorebird foraging habitat varied between high, medium and low at sites surveyed in the study area (Figures 28-31). This delineation was based on the scoring system presented in Table 8 and foraging and roosting site survey results contained in Table 9. High value sites returned scores of 10-21, medium value sites scored between 5 and 9, while low value sites had scores of 0-4.

A total of 6 sites provided high foraging habitat value for shorebirds in the study area. These occurred in the Northern Central Zone at Back Beach, South West Rocks Creek (Site 7), Saltwater Lagoon (Site 11), Boyter's Lane wet paddocks (Site 16), Macleay Arm at the confluence of Clybucca Creek and Anderson's Inlet (Site 17) and Back Creek at Kinchela (Site 22), and in the Southern Central Zone at Belmore Swamp (Site 23).

Eleven (11) sites were of medium foraging habitat value for shorebirds in the study area. These included:

- North Zone: Grassy Head Beach (Site 1), Upper Macleay Arm (Site 2), Stuarts Point Beach (north and south – Sites 3 and 4 respectively), , Macleay Arm Site 2 - Fishermans Reach (Site 6);
- Northern Central Zone: North Smoky Beach (Site 12), Boyter's Lane wetland (Site 15), a sand/mudflat on the western side of Pelican Island (Site 18), sand/mudflat on Macleay River opposite the junction of Suez Road and Plummers Lane (Site 19), Macleay River sand/mudflats at Ford Island, Jerseyville (Site 20);
- Southern Central Zone: Ryan's Cut (Site 24).

Eleven (11) sites were assessed to have low value as shorebird foraging habitat. These were Macleay Arm Site 1 (Site 5), South West Rocks Creek at Back Creek footbridge (Site 8), Front Beach at South West Rocks (Site 9), Saltwater Creek (Site 10), South Smoky Beach (Site 13), "Saltaire", Pelican Island (Site 14), Long Reach Island sand/mudflat (Site 21), Killick Beach at Richardson's Crossing (Site 25), Goolawah Beach at Crescent Head south (Site 26), Racecourse Beach in Goolawah NP (Site 27), Barrie's Bay Beach at Point Plomer (Site 28).

Table 8: Scoring of foraging and roosting habitat value in the study area, adapted from Lisson et al. (2017) and criteria derived from DECCW (2010). Abundance was based on every 30 birds (considered realistic for the survey results which were obtained during a period of significant drought and lowered shorebird presence). Density was based on every 5 birds per hectare (considered realistic given lowered shorebird presence during the surveys). Satellite imagery was used to obtain the area of each surveyed site.

Foraging and roosting habitat value scoring criteria for each site	Score
Every 30 birds	1
Density scored for every 5 birds per hectare	1
Each migratory shorebird species	1
Each threatened shorebird species recorded	1
Each shorebird species recorded	1
Presence of shorebird high tide roost site	1

Roosting habitat value

A total of 11 shorebird roosting sites were recorded during the surveys. Of these, 3 were sites of high roosting habitat value - 2 in the Northern Central Zone (Sites 7 and 11) and 1 in Southern Central Zone (Site 23). Six (6) sites had medium roosting habitat value for shorebirds. These included Sites 1, 2, 3 and 6 in North Zone, Site 12 in Northern Central Zone and Site 24 in Southern Central Zone (Figures 28-31). The remaining sites were of low roosting habitat value, occurring at Sites 27 and 28. High value sites returned scores of 10-21, medium value sites scored between 5 and 9, while low value sites had scores of 0-4.

Table 9: Results of foraging and roosting site surveys and analysis of shorebird habitat use in the study area. Number of birds per site is the mean number recorded at each site. Area refers to the area (in hectares) sampled at each site during the surveys and was calculated from GIS digitisation of satellite imagery. Number of birds per site is the mean number of shorebirds and other aquatic birds recorded in both surveys. Density is the total number of birds surveyed per hectare (rounded to the nearest 0.1 of a decimal place). TSP = listed threatened species. MS = migratory species. CSS = other conservation-significant species. Foraging and roosting habitat scoring was based on Table 8 criteria.

Site no.	Site name	Area (ha)	Species richness	No. birds per site	Density	No. TSP	No. MS	No. other CSS	Foraging habitat score	Roosting habitat score
1	Grassy Head Beach	8.7	7	7.5	0.9	3	1	0	5	5
2	Upper Macleay Arm estuary	25.08	10	10	3.6	1	1	3	5	5
3	Stuarts Point Beach (North)	7.95	7	20	5	3	1	1	5	5
4	Stuarts Point Beach (South)	9.75	6	16.5	3.4	2	0	0	5	4
5	Macleay Arm Site 1	4	6	8.5	4.2	0	0	1	1	0
6	Macleay Arm Site 2 (Fishermans Reach)	9.69	12	42	8.7	2	0	3	7	8
7	Back Beach, South West Rocks	9.45	11	52	11	4	1	1	15	15
8	South West Rocks Creek at Back Creek footbridge	3.02	14	18.5	12.2	1	0	0	4	2
9	Front Beach, South West Rocks	8.48	5	14	3.3	1	1	0	3	0
10	Saltwater Creek, South West Rocks	8.05	7	6.5	1.6	0	0	1	1	1
11	Saltwater Lagoon and creek inflow	50.41	16	57	2.3	2	1	2	10	12

Site no.	Site name	Area (ha)	Species richness	No. birds per site	Density	No. TSP	No. MS	No. other CSS	Foraging habitat score	Roosting habitat score
12	North Smoky Beach	3.24	7	12	7.4	2	0	2	5	5
13	South Smoky Beach	9.3	5	22	4.7	0	0	0	3	1
14	"Saltaire", Pelican Island	82.38	5	13.5	0.3	1	0	2	3	1
15	Boyter's Lane wetland	2.39	11	22	18.4	0	0	4	7	0
16	Boyter's Lane wet paddocks	7.26	15	99.5	27.4	1	1	9	21	0
17	Macleay Arm at junction of Clybucca Ck & Andersons Inlet	24.96	14	65.5	5.2	6	5	2	20	21
18	sand/mudflat, Pelican Island	0.4	7	42	105	1	1	0	6	0
19	sand/mudflat opp Suez Rd & Plummers Lane	1.14	7	10	5	2	1	0	5	0
20	sand/mudflats at Ford Island	4.5	6	19	8.4	2	2	0	5	0
21	sand/mudflat at Long Reach Island	0.16	5	16	100	0	0	0	3	1
22	Back Creek, Kinchela	3.7	16	93	50.3	2	1	7	26	0
23	Belmore Swamp	29.25	13	206	14.1	1	0	4	20	21
24	Ryan's Cut	10.42	6	16.5	3.2	3	2	0	6	7
25	Killick Beach at Richardsons Crossing	7.5	3	9.5	2.5	1	0	0	1	0
26	Goolawah Beach, Crescent Head south	7.14	4	3	0.8	2	0	0	2	3
27	Racecourse Beach, Goolawah NP	5.4	4	16.5	6.1	2	0	0	3	4
28	Barrie's Bay Beach, Point Plomer	10.5	4	24	4.6	1	0	0	2	0

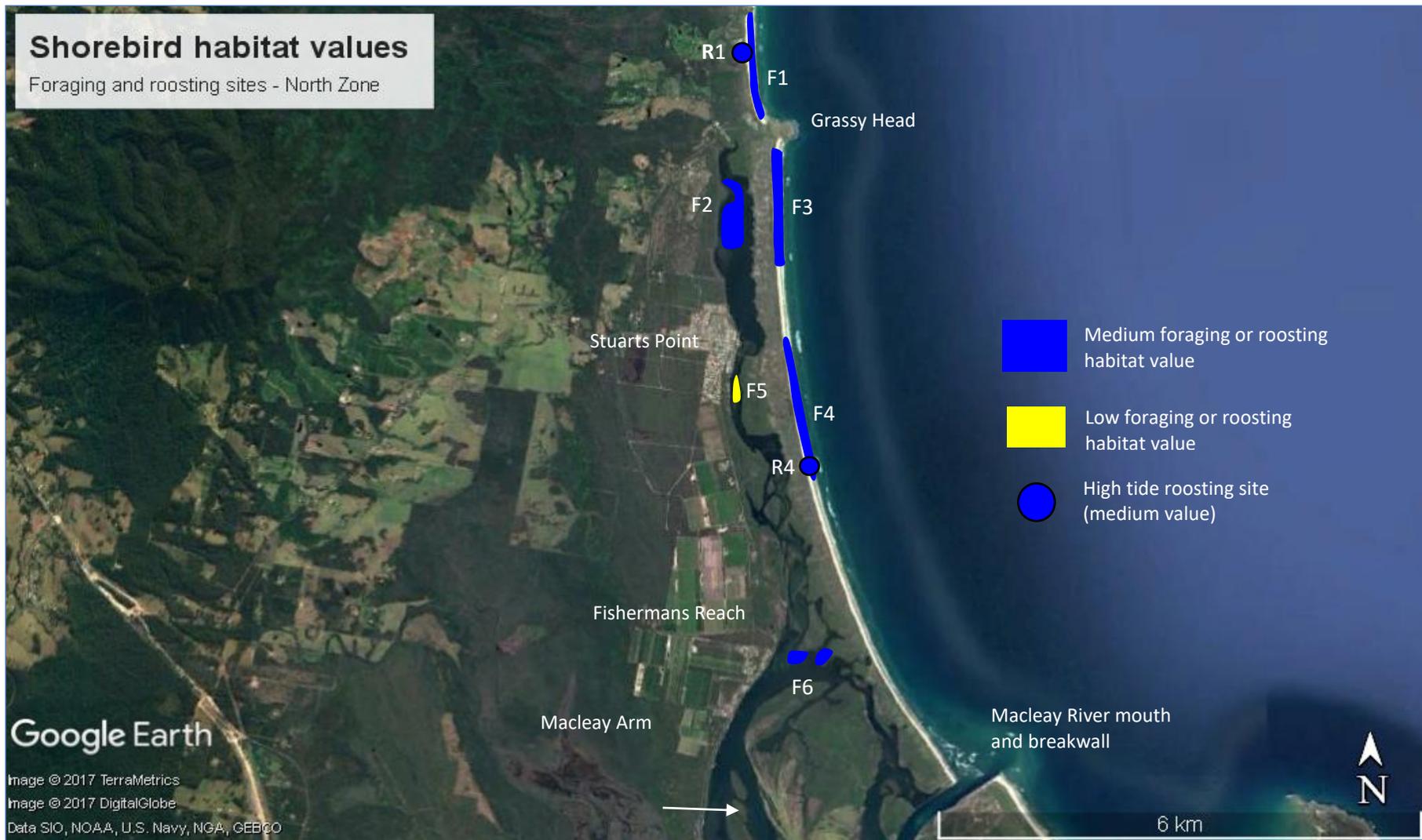


Figure 28: Foraging and roosting habitat value of sites surveyed for shorebirds in the study area’s North Zone. F = foraging, R = roosting. Numbers after “F” and “R” indicate surveyed site numbers (listed in Table 3). Allocation of habitat value is based on scored habitat criteria (Table 8) and foraging and roosting site survey results (Table 9). Image: Google Earth

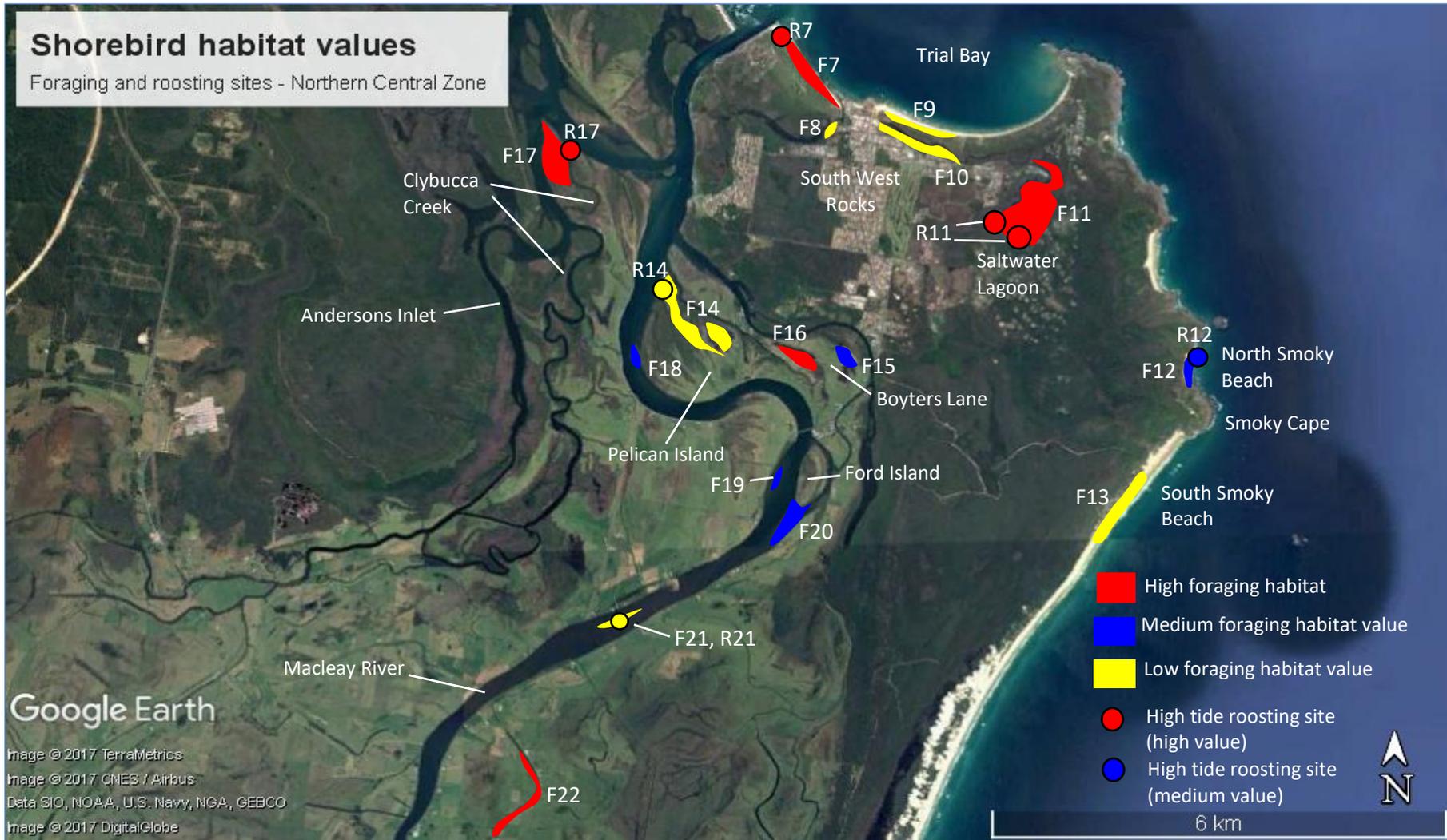


Figure 29: Foraging and roosting habitat value of sites surveyed for shorebirds in the study area's Northern Central Zone. F = foraging, R = roosting. Numbers after "F" and "R" indicate surveyed site numbers (listed in Table 3). Allocation of habitat value is based on scored habitat criteria (Table 8) and foraging and roosting site survey results (Table 9). Image: Google Earth

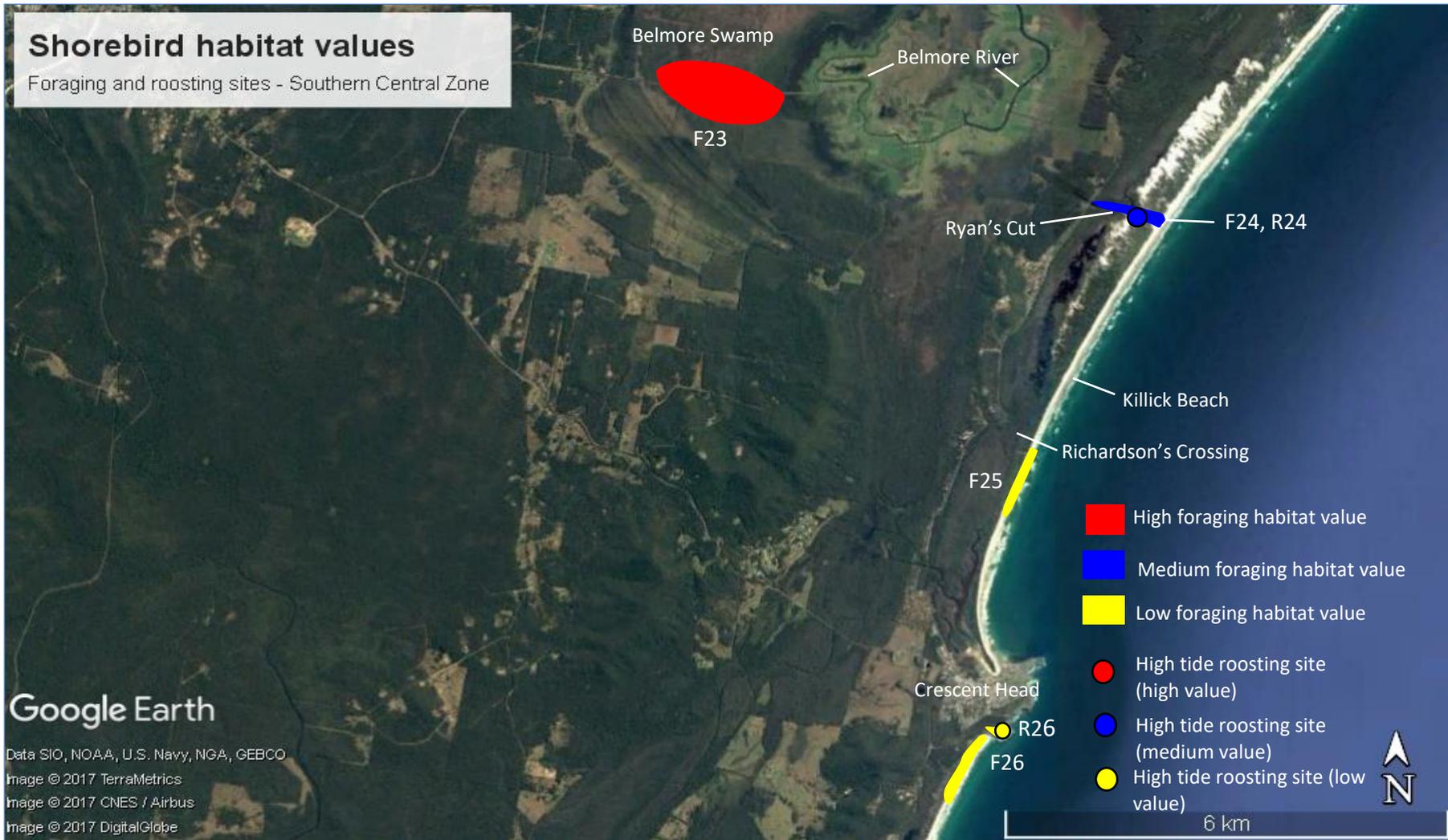


Figure 30: : Foraging and roosting habitat value of surveyed sites for shorebirds in the study area's Southern Central Zone. F = foraging, R = roosting. Numbers after "F" and "R" indicate surveyed site numbers (listed in Table 3). Allocation of habitat value is based on scored habitat criteria (Table 8) and foraging and roosting site survey results (Table 9). Image: Google Earth

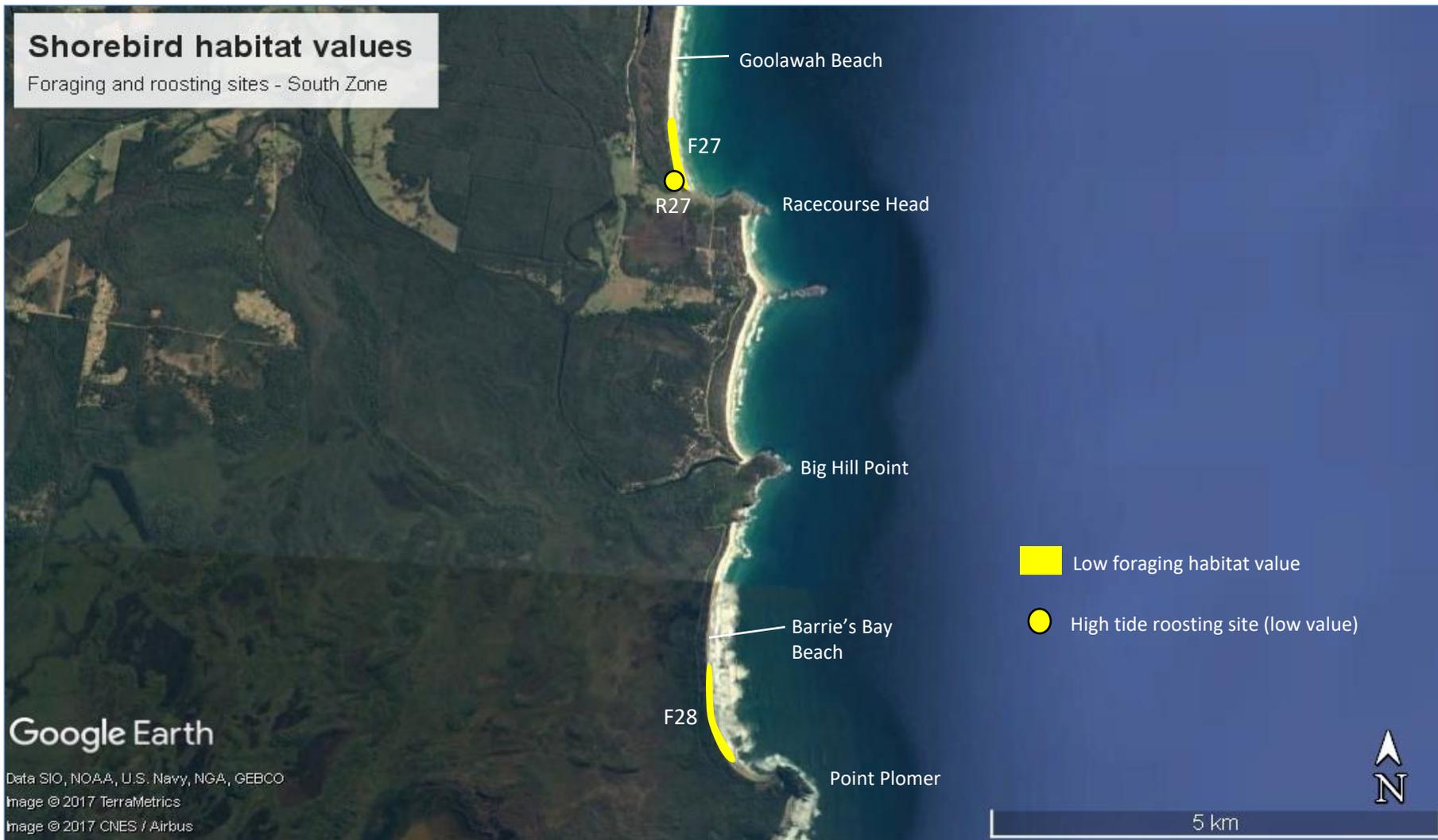


Figure 31: : Foraging and roosting habitat value of surveyed sites for shorebirds in the study area's South Zone. F = foraging, R = roosting. Numbers after "F" and "R" indicate surveyed site numbers (listed in Table 3). Allocation of habitat value is based on scored habitat criteria (Table 8) and foraging and roosting site survey results (Table 9). Image: Google Earth

2.4.5 Habitat disturbance levels and matrix scores

The highest levels of disturbance of shorebird foraging habitat as scored using Table 4 occurred at Front Beach (Site 7 and included roosting habitat disturbance), Back Creek footbridge sandflat (Site 8) and Killick Beach at Richardson’s Crossing (Site 25). High levels of disturbance of foraging and roosting habitat were at Grassy Head Beach, Stuarts Point Beach (north and south), South Smoky Beach (Site 13) and Goolawah Beach (Site 26). Medium levels were recorded for 9 sites while 11 sites returned low levels of disturbance. Table 10 presents these data for each surveyed site in the study area. The most frequently recorded disturbance events during the surveys were people within 25 metres and 25-100 metres of shorebirds, off-leash dogs, 4WD vehicles on or near beach sites and recreational fishing.

The highest scoring sites of the foraging habitat/disturbance matrix (Table 10) were Macleay Arm at junction of Clybucca Creek and Andersons Inlet (Site 17), Boyter’s Lane wet paddocks (Site 16), Back Beach (Site 7), Back Creek footbridge sandflat (Site 8) and Front Beach (Site 9). Five sites returned high foraging habitat/disturbance matrix scores, 10 had medium range scores while 8 produced low scores (see Table 10). Roosting habitat/disturbance matrix scores were very high at Sites 7 and 17, high at Sites 1, 3 and 26, medium at 10 sites, and low at 13 sites, as listed in Table 10. Thus, Sites 7, 8, 9, 16 and 17 were assessed to be of high priority for management intervention based on their elevated disturbance levels and habitat values.

Table 10: Foraging and roosting habitat disturbance and habitat/disturbance matrix scores for each surveyed site in the study area, based on a scoring system adapted from Lisson et al. (2017). Habitat disturbance scores are derived from habitat scores presented in Table 9 and disturbance scores calculated using Table 4. Disturbance scores were the same for both foraging and roosting habitats and so are shown in the one column. Habitat/disturbance matrix scores were obtained by multiplying foraging or roosting habitat scores by disturbance scores. For example, Site 1’s matrix score of 82.5 was derived from a foraging habitat score of 5 multiplied by a disturbance score of 16.5. Matrix score ratings are provided as very high, high, medium and low.

Site no.	Site name	Habitat disturbance score	Foraging habitat/disturbance matrix score	Rating (foraging habitat)	Roosting habitat/disturbance matrix score	Rating (roosting habitat)
1	Grassy Head Beach	16.5	82.5	high	82.5	high
2	Upper Macleay Arm estuary	10	50	medium	50	medium
3	Stuarts Point Beach (North)	19.5	97.5	high	97.5	high
4	Stuarts Point Beach (South)	16.5	82.5	high	66	medium
5	Macleay Arm Site 1	9.5	9.5	low	0	low
6	Macleay Arm Site 2	8	56	medium	64	medium

Site no.	Site name	Habitat disturbance score	Foraging habitat/ disturbance matrix score	Rating (foraging habitat)	Roosting habitat/ disturbance matrix score	Rating (roosting habitat)
	(Fishermans Reach)					
7	Back Beach, South West Rocks	10	150	very high	150	very high
8	South West Rocks Creek at Back Ck footbridge	31	124	very high	62	medium
9	Front Beach, South West Rocks	41.5	124.5	very high	0	low
10	Saltwater Creek, South West Rocks	4	4	low	4	low
11	Saltwater Lagoon and creek inflow	4.5	45	medium	54	medium
12	North Smoky Beach	8.5	42.5	medium	42.5	medium
13	South Smoky Beach	27	81	high	27	medium
14	"Saltaire", Pelican Island	6.5	19.5	low	6.5	low
15	Boyter's Lane wetland	2.5	17.5	low	0	low
16	Boyter's Lane wet paddocks	7.5	157.5	very high	0	low
17	Macleay Arm at junction of Clybucca Ck & Andersons Inlet	9.5	190	very high	199.5	very high
18	sand/mudflat, Pelican Island	9.5	57	medium	0	low
19	sand/mudflat opp Suez Rd & Plummers Lane	10.5	52.5	medium	0	low
20	sand/mudflats at Ford Island	11	55	medium	0	low
21	sand/mudflat at Long Reach Island	10	30	low	10	low
22	Back Creek, Kinchela	3.5	91	high	0	low
23	Belmore Swamp	2	40	medium	42	medium
24	Ryan's Cut	8	48	medium	56	medium
25	Killick Beach at	32.5	32.5	low	0	low

Site no.	Site name	Habitat disturbance score	Foraging habitat/ disturbance matrix score	Rating (foraging habitat)	Roosting habitat/ disturbance matrix score	Rating (roosting habitat)
	Richardsons Crossing					
26	Goolawah Beach, Crescent Head south	25	50	medium	75	high
27	Racecourse Beach, Goolawah NP	6	18	low	24	medium
28	Barrie's Bay Beach, Point Plomer	10.5	21	low	0	low

2.4.6 Breeding activity

Records of breeding activity by resident shorebirds and other aquatic bird species during the study were limited. This reflected, in part, the prevalence of east coastal drought conditions during the period of the study (Bureau of Meteorology 2017). Detailed investigation of the breeding ecology of shorebird populations are needed in the study area (see part 3).

Individual males of Australasian Bittern were detected calling breeding territories in reedbeds and rushes to the southwest of Saltwater Lagoon (one bird) and at Belmore Swamp (one bird). Small flocks of Black-winged Stilt comprising adult and immature birds were recorded in February at "Saltaire", in Boyter's Lane wet paddocks and at Back Creek Kinchela. Adult Sooty Oystercatchers were observed with immature birds at North Smoky Beach in February. A pair of Black-fronted Dotterel were recorded defending breeding territory at Boyter's Lane artificial wetland in September while an adult bird was observed with a juvenile bird in February, having likely bred at this site. Immature and juvenile birds of White-bellied Sea-Eagle occurred at Goolawah Beach, Racecourse Beach and Upper Macleay Arm estuary suggesting nesting success had occurred near these surveyed sites or at least in the area. An immature Eastern Osprey was photographed during the survey at Grassy Head in September and flew along Front Beach in February. Black Swan bred at Belmore Swamp in September and probably Saltwater Lagoon. A breeding colony of Pied Cormorant also occurred at Saltwater Lagoon.

2.4.7 Key threats

A set of key threats to shorebird populations in the study area were identified through fieldwork and discussions with landholders, managers and bird observers. These are the ongoing loss and fragmentation of foraging, roosting and nesting habitat, pollution including microplastics, human disturbance including 4WD and dog incursions, invasive species, harvesting of shorebird prey, climate change and altered hydrological regimes. Threats in the

East Asian-Australasian Flyway are also pertinent and have been discussed in Part 1 of this document.

The types of specific threats present at each relevant surveyed site are provided in Table 11, together with the results of the risk prioritisation matrix assessment undertaken in the study area (structure presented in Table 5).

Table 11: Key threats present at sites surveyed for shorebirds and other aquatic bird species in the study area. The level of threat, likelihood of occurrence and consequences ratings are provided for key threats at each site based on the risk prioritisation matrix assessment of surveyed sites in the study area. Rating categories conform with the national wildlife conservation plan for migratory shorebirds (Australian Department of the Environment 2015).

Site no.	Site name	Key threats	Level of threat	Likelihood of occurrence	Consequences		
					Minor	Moderate	Major
1	Grassy Head Beach	unleashed dogs, walking, fishing	low	certain	moderate		
2	Upper Macleay Arm estuary	boating, fishing	low	certain	moderate		
3	Stuarts Point Beach (North)	4WD use, fishing, unleashed dogs, harvesting shorebird prey	moderate	certain		very high	
4	Stuarts Point Beach (South)	4WD use, fishing, unleashed dogs, harvesting shorebird prey	moderate	certain		very high	
5	Macleay Arm Site 1	boating, fishing	low	certain	moderate		
6	Macleay Arm Site 2 (Fishermans Reach)	boating, fishing, harvesting shorebird prey	low	certain/ likely	moderate		
7	Back Beach, SW Rocks	walking, unleashed dogs, fishing, swimming, harvesting shorebird prey, dune erosion, pollution	high	certain		very high	
8	SW Rocks Creek at Back	walking, unleashed	high	certain		very high	

Site no.	Site name	Key threats	Level of threat	Likelihood of occurrence	Consequences		
					Minor	Moderate	Major
	Creek footbridge	dogs, fishing, swimming, harvesting shorebird prey, invasive/predatory species, pollution					
9	Front Beach, SW Rocks	walking, unleashed dogs, fishing, swimming, harvesting shorebird prey, invasive/predatory species, pollution	high	certain			very high
10	Saltwater Creek	invasive species, pollution, unleashed dogs	moderate	certain/likely	moderate		
11	Saltwater Lagoon	fishing, canoeing/disturbance of nesting site	low	likely	low/moderate		
12	North Smoky Beach	fishing, swimming	low	likely	low		
13	South Smoky Beach	4WD use, fishing, unleashed dogs, pollution, dune erosion	moderate	certain		very high	
14	"Saltaire", Pelican Island	walking, dog access	low	likely	low		
15	Boyter's Lane wetland	walking, lack of tidal flush/absence of mudbanks for foraging	moderate	certain		very high	
16	Boyter's Lane wet paddocks	livestock trampling, invasive/predatory species	moderate	certain		very high	
17	Macleay Arm at junction of Clybucca Creek and Andersons	boating wave erosion, livestock access, fishing,	low	certain/likely	moderate		

Site no.	Site name	Key threats	Level of threat	Likelihood of occurrence	Consequences		
					Minor	Moderate	Major
	Inlet	invasive/ predatory species					
18	sand/mudflat, Pelican Island	wave erosion, windsurfers, boating, fishing	low	likely	low/ moderate		
19	sand/mudflat opp Suez Rd & Plummers Lane	boating, fishing, windsurfers	low	likely	low		
20	sand/mudflats at Ford Island	windsurfers, boating, fishing, harvesting shorebird prey	moderate	certain		very high	
21	sand/mudflat at Long Reach Island	boating, fishing	low	likely	low		
22	Back Creek, Kinchela	livestock access, invasive species	high	certain		very high	
23	Belmore Swamp	livestock access, invasive/ predatory species, roadkills of birds crossing Seale Road	high	certain, likely		very high	
24	Ryan's Cut	fishing, camping, harvesting shorebird prey	moderate	certain, likely		high	
25	Killick Beach at Richardsons Crossing	4WD use, unleashed dogs, fishing, harvesting shorebird prey	moderate	certain		very high	
26	Goolawah Beach, Crescent Head south	4WD use, unleashed dogs, fishing, harvesting shorebird prey	moderate	certain	very high		
27	Racecourse Beach,	fishing, swimming,	low	certain, likely	low		

Site no.	Site name	Key threats	Level of threat	Likelihood of occurrence	Consequences		
					Minor	Moderate	Major
	Goolawah NP	4WD use					
28	Barrie's Bay Beach, Point Plomer	swimming, walking, fishing	low	certain, likely	moderate		

2.5 Discussion

2.5.1 Factors affecting the results of the shorebird surveys

The relative abundance and species richness of shorebird communities surveyed in the project were substantially reduced by extreme weather conditions that occurred along the NSW coast in the 2016-2017 spring and summer. Record high summer temperatures, particularly in northern NSW and in February (at the time of the summer survey), coupled with 34% below-average spring-summer rainfall (Bureau of Meteorology 2017) seems likely to have significantly reduced food availability and thus foraging habitat quality for shorebirds.

Combined with other factors such as habitat loss and degradation in the EAAF for migratory shorebird species and habitat damage and disturbance by humans at several surveyed sites, it was perhaps not surprising to have achieved these results. There was also anecdotal evidence from landholders at Grassy Head, Arakoon, Pelican Island, Rainbow Reach and Upper Belmore River of noticeably lower numbers of shorebirds present in the 2016-2017 summer relative to preceding summers.

Increased replication of survey effort may have assisted in obtaining more data on shorebird occurrence, abundance, species richness and habitat use in the study area. More repeated monitoring of sites can help to build a fuller picture of the structure and composition of bird communities present within and between seasons. However, the surveying program needed to work within the budget available for the project. Additional surveying would add to the baseline now established through this project and is recommended (see Part 3 of this document).

2.5.2 Important shorebird communities and sites in the study area

Fourteen (14) shorebird and other aquatic bird species of conservation significance foraged, roosted and, in some cases, bred at several key sites in the study area. In terms of shorebird foraging and roosting habitat value the most significant of these were Back Beach, Boyter's Lane wet paddocks, Macleay Arm at the junction of Clybucca Creek and Andersons Inlet, Back Creek at Kinchela and Belmore Swamp.

Management actions need to focus on protecting and enhancing the quality of shorebird habitat available at these sites (see Part 3). These sites also returned high foraging habitat/disturbance matrix scores indicating that foraging habitat value, disturbance levels and therefore management priority were high.

2.5.3 Mitigating key threats

Mitigation of threats to shorebird communities is a cornerstone of effective conservation management programs worldwide (see, for example, Australian Department of the Environment 2015). The key threats to shorebirds detected in the study area centred on human damage and disturbance of foraging and roosting sites – use of 4WD and other recreational vehicles on beaches and in the dunes, unleashed dogs, invasive plant and animal species, pollution of creeks and beaches, and erosion of high tide roost sites along beaches and dunes.

A number of strategies and management actions are recommended to better manage and mitigate these threats to shorebirds and their habitat in the study area (Part 3). These target the protection of shorebirds and their habitat, reduction of key threats, improving community awareness, support and participation, and long-term monitoring of shorebirds and their habitat.

PART 3: RECOMMENDATIONS

3.1. Overview

A set of management strategies and actions are recommended to protect shorebird populations and their habitat in the study area. These are based on the results of the surveys, habitat mapping and threat identification carried out in the project and current approaches and standards used in recent shorebird studies and conservation plans, particularly the Wildlife Conservation Plan for Migratory Shorebirds (Australian Department of the Environment 2015) and the Shorebirds of Northern NSW study (DECCW 2010a).

The determination of priority management status assigned to recommended actions in Table 12 below was based on the scoring system used to rate foraging and roosting habitat value and disturbance levels, derived from the field surveying and as presented in Section 2.4.4 and the resultant habitat/disturbance matrix scoring in Section 2.4.5. Discussions with members of local communities, experienced bird observers and landholders during the surveys on their properties also helped influence the assignment of some priority levels such as the community education strategy. Results of the threat risk prioritisation matrix scores presented in Section 2.4.7 were also used in this process. This approach is consistent with other shorebird studies (see, for example, Lisson et al. 2017) and identification and prioritisation of shorebird threats contained in the national shorebird conservation plan (Australian Department of the Environment 2015).

3.2 Recommended management strategies and actions

A set of management strategies and prioritised management actions are presented in Table 12. These aim to protect shorebirds and their habitat, mitigate key threats, increase community education and support, promote understanding of shorebird ecology and their conservation management requirements, and promote the undertaking of long-term monitoring of shorebird populations in the study area.

Table 12: Recommended management strategies and actions for shorebirds and their habitat in the study area.

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
1: Improve community awareness, knowledge and support of shorebirds and their habitats using educational & capacity building initiatives.	All	All	All	Feedback from shorebird talk (16/3/17), engagement with landholders & survey results have indicated interest in shorebird ecology among some local community members. Potential exists for educating other local communities.	Poor or no community awareness of shorebirds & their ecology prevents uptake of actions to protect and improve shorebirds & their habitat.	High	Local communities need to understand shorebird ecology including their foraging, roosting, migration and breeding habitat requirements. This will help inform, develop empathy and inspire individual and collective action to participate in monitoring and protecting and restoring key shorebird habitat in the study area.	1.1: Develop a community education and information program targeting recreational and shoreline users to reduce the incidences of recreational disturbance on foraging, roosting and, potentially, nesting (resident species only) shorebirds. Utilise resources available through BirdLife Australia (Aust. Wader Study Group) and other groups. 1.2: As part of this program, develop and distribute a guide to Macleay shorebirds and their conservation requirements to individual residents, community groups and beach/estuary user groups through South West Community Centre and Library, surf clubs at SW Rocks & Crescent Head, and local shops including Hat Head. 1.3: Design and install interpretative signs at key entry-point locations – Grassy Head Beach, Stuarts Point Beach No. 1 and 2 access points, Stuarts Point footbridge to beach on caravan park side, Back Creek footbridge at SW Rocks (both sides of bridge), Back Beach at southern & northern (breakwall) ends, Saltwater Creek footbridge (both ends), accesses to South Smoky, Hat Head, Goolawah & Killick beaches, high tide mark on southern end of Ford Island, road reserve at Belmore Swamp (east & west sides), dunes at Ryan’s Cut and along Crescent Head

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
								Road where 4WD trails start near bridge, and along Back Creek Road, Kinchela near the first house at south end. 1.4: Integrate shorebird conservation requirements into current and future natural resource management initiatives by council & other land managers.
2: Design and implement a shorebird monitoring program to determine changes in patterns of abundance, species richness, community structure & habitat use over time at existing sites in the study area. Consider adding new sites, especially in the Central Zone (Hat Head). This will also improve understanding	All	All	All	Baseline sites have now been established by current project. Opportunity exists to build on this work by systematically monitoring a set of sites across all zones of the study area.	Limited amount of existing site data; gaps in coverage especially around Hat Head. Older records contributed by bird observers require spatial referencing & curation. These data need to be more readily accessible by stakeholders	High	Management decision making requires accurate and current information to support implementation and allocation of funds to onground works. Some gaps still exist in knowledge of interannual and intraseasonal shorebird abundance and habitat use, especially for breeding, in study area. More quantitative data is needed on shorebird use of roosting and breeding habitats at high conservation value sites.	2.1: Identify all key stakeholders in shorebird conservation and monitoring in the study area and adjoining areas such as the Hastings River catchment. 2.2: Form a small working group comprising relevant and skilled interagency staff and informed local community members to help guide the implementation of shorebird conservation management strategies and actions. 2.3: Repeat baseline shorebird surveys in two years and include the Central Zone around Hat Head. These should include shorebird vulnerability and qualitative risk assessment components. Obtain a detailed report on the results of this work. 2.4: If possible and dependent on funds available, increase replication of surveys at each site (or at a smaller number of key sites), ie. instead of 2 surveys undertake 6 surveys at each selected site over the peak summer period only (not spring & summer) when both migrant & resident shorebird species are present. This will add rigour to data obtained and make data more amenable to statistical analysis. 2.5: Compare and contrast the 2016-17

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
of shorebird ecology and habitat use along Kempsey LGA coastline.								<p>survey results with those obtained in 2018-19, focusing on patterns of shorebird abundance, species richness, community structure, habitat use, threat analysis and reviewing/updating management actions.</p> <p>2.6: Evaluate existing shorebird habitat management strategies in the light of this new information and revise where necessary to ensure shorebirds and their habitat are adequately protected and enhanced.</p> <p>2.7: Support and facilitate collaboration on shorebird research and monitoring programs with universities, Aust. Wader Studies Group & relevant government agencies, e.g. NSW OEH, LLS, DPI.</p>
3: Reduce threats from 4WD, trailbike & other recreational vehicles disturbing shorebirds and damaging their shoreline habitats	North	2	3 & 4	Foraging habitat for threatened Aust. Pied Oystercatcher, Little Tern, Terek Sandpiper, Bar-tailed Godwit & potentially Beach Stone-curlew	Flushing of foraging birds by 4WDs along beach; damage to invertebrate prey that occur just under surface sand layers driven over by 4WDs; reversing vehicles into dunes damaging potential nest	High	Direct effects of injury or mortality to beach foraging and dune-nesting shorebirds such as Aust. Pied Oystercatcher. Disturbance significantly affects foraging, roosting and nesting patterns, particularly of Little Tern and Aust. Pied Oystercatcher.	<p>3.1: Review Council's 4WD beach access permit system to consider options for vehicle exclusion from sections of beaches containing identified foraging and/or nesting sites, exclusion during Aust. Pied Oystercatcher and Little Tern breeding season, or permanent exclusion. A visitor to Grassy Head Caravan Park for the past 60 years described heavy daily 4WD use of Stuarts Point Beach to Macleay River's northern breakwall in Dec-Jan holidays by tourists commuting to fish off the breakwall.</p> <p>3.2: Enforce existing 4WD exclusion zones where 4WDs were observed driving in during the surveys – Sites 25 (Killick Beach at Richardsons Crossing – south of beach</p>
	Northern Central	1	7 & 9					
	Northern Central	3	13					
	Southern Central	2	24					
	Southern Central	3	25					
Southern Central	4	26						

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
	South	1	27		sites of Aust. Pied Oystercatcher; discarded fishing lines, hooks and other rubbish to injure/ entangle foraging birds			access), 26 (Goolawah Beach north – north of beach access) and 27 (Racecourse Beach). 3.3: Provide shorebird conservation management information to accompany beach access material when licences are obtained and/or renewed. 3.4: Install high-strength shorebird information signs at key beach access points identified in Strategy 1, Management Action 1.3 above. 3.5: Erect new protection barrier fencing to deter 4WD access. This is urgently needed at Site 27 (Racecourse Beach) where an existing barrier been removed & vehicles have driven along the beach and also at Site 24 (Ryan’s Cut) and Site 7 (Back Beach – at track from northern end along breakwall).
4: Reduce threats from domestic and feral animals	All	All	All	Several sites supported foraging threatened/ conservation-significant shorebirds, e.g. Sites 4, 7, 8, 12, 16, 17, 22, 23, 24, 25, 26, 27.	Disturbance and predation of shorebirds and other aquatic birds by dog, fox and cat can adversely impact on population size, especially of species with small local populations,	High/ medium, depends on site	Direct predation on eggs, nestlings, fledglings and adult birds reduces population size, particularly of less abundant, patchily-distributed or habitat-specialist species. Disturbance of habitat can reduce nesting success and result in lower reproduction rates.	4.1: Design and implement a fox control program that includes buffer zones around sites of high shorebird habitat value. These exist at Sites 7, 11, 16, 17, 22, 23 – Sites 16, 17, 22 & 23 occur on privately owned land so coordination with the property owners would be needed. 4.2: Educate local residents about the impact of cats and dogs on shorebirds and other wildlife and the need to leash dogs when walking them on beaches or along estuaries where shorebirds are present. This requires a level of community knowledge to be able to identify

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
					e.g. nationally endangered Australasian Bittern, Far Eastern Curlew & vulnerable Brolga			shorebirds from, for example, gulls, and approach distances to shorebird species. Both require community education initiatives. 4.3: Install shorebird and dog/cat/fox impact information signage at key beach access points listed in Management Action 1.3 above. 4.4: Enforce dogs on leash requirement at beaches and shorelines where dogs on leash signs are displayed.
5: Improve local community knowledge & understanding of climate change impacts on shorebirds including migration ecology and coastal zone processes	All	All	All	Lack of knowledge & understanding of climate change and coastal processes' impacts on shorebirds in Aust. & the EAAF hinders planning to protect shorebird foraging and nest sites from future storm events and plan strategic habitat restoration strategies and programs.	Adverse impacts on intertidal foraging sites, food quality & availability. Inundation of important foraging and nesting sites. Erosion of nest sites in dunes and along upper beach areas by increased frequency of damaging storm events and king tides.	Medium	Current knowledge and understanding of the scope and nature of the impacts of climate change and coastal zone processes on shorebirds is scant and fragmented. Knowledge often exists for the larger and better studied estuaries or is incomplete.	5.1: Review progress made by other organisations globally and within Australia on the existing and modelled future impact of climate change on shorebirds and their habitat. Ornithologists specialising in this field exist in Bureau of Meteorology (Melbourne), University of NSW's Climate Change Research Centre and other universities in Australia and the UK, USA and France. They should be consulted for their research inputs and knowledge. 5.2: Ensure shorebird vulnerability and threat/risk assessments incorporate climate change considerations. 5.3: Support and access the results of research projects targeting the modelled and actual responses of key indicator taxa such as shorebirds to changes in anthropogenic climatic stressors; use this knowledge to help inform shorebird management actions, such as habitat protection & restoration works.

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
6: Reduce threats from boating, windsurfing and fishing activities	North	2	2	Foraging habitat for critically endangered Far Eastern Curlew (Sites 6, 18, 19, 20); high tide roosting habitat for critically endangered Curlew Sandpiper (Site 17)	Disturbance of foraging and roosting habitat by boating, windsurfing and fishing	Medium	Foraging patterns could be adversely affected by boating and windsurfing. This was observed during surveys at Sites 6 and 20. Further monitoring in key disturbance areas (mostly in Macleay River at Sites 19 & 20) is needed	6.1: Install shorebird information signs at boat ramps at Stuarts Point near caravan park, Fishermans Reach on Macleay Arm, Jerseyville and other points along the lower Macleay River. 6.2: Prepare and supply shorebird information leaflet to fishing tackle and bait stores for distribution to recreational fishermen 6.3: Engage and encourage NSW Roads and Maritime Service to assist in distribution of shorebird information 6.4: Disseminate shorebird information and tips to avoid sand/mudflats at low tide where shorebirds are present to windsurfing clubs, hire shops and individual windsurfers, where possible.
	North	3	5					
	North	4	6					
	Northern	4	18					
	Central	5	14					
	Northern	6	17, 19, 20					
	Central	6	17, 19, 20					
Southern	3	25						
Central	4	26						
Southern	4	26						
Central	4	26						
South	1	27						
7. Encourage reduction in the amount of microplastics and other pollutants contaminating shorebird foraging sites through community and industry education initiatives	All	All	All	Foraging habitat (mudflats, sandflats, beaches etc.) utilised several species of threatened shorebirds and other conservation-significant aquatic birds	Accumulated microplastics and other pollutants can significantly degrade shorebird foraging substrates and damage/kill birds that have ingested the microparticles	Medium	Birds can ingest microplastics leading to their eventual and prolonged death. Microplastics can also accumulate in fish preyed upon by threatened birds such as Eastern Osprey and White-bellied Sea-Eagle	7.1: Raise awareness of the insidious and all-pervasive nature of microplastics among local communities by including information in shorebird leaflets distributed among local communities. 7.2 Support the global initiative to educate consumers about the perils of microplastics in the marine environment and to help change consumer buying behaviour through not purchasing products containing these harmful substances. 7.3: Support efforts such as CleanUp Australia day to remove these materials from beaches and waterways in the study area.

Strategy	Zone	Area	Site no.	Significance of site/relevance	Threats	Priority	Basis for action	Management action
8: Increase landholder knowledge and support of wetlands, their value to shorebirds and reduction of trampling by livestock	All	All	All	Belmore Swamp is an important wetland area for the globally endangered Australasian Bittern and other conservation-significant waterbirds; other wetlands such as along Boyter's Lane have high foraging value for migratory shorebirds	Cattle access to wetlands trampling foraging habitat; draining of wetlands for agriculture via diversion drain networks along the lower Macleay River & Belmore River floodplains	Low	Livestock can disturb shorebird foraging and breeding patterns, as well as potentially causing deaths of nestlings and adults on nests by direct trampling.	8.1: Conduct landholder workshops to educate people about the importance of wetlands for shorebirds and how to manage them to reduce threats such as cattle trampling of shorebird foraging and potentially breeding habitat. 8.2: Continue to identify and map key wetland sites occurring on private property in the study area. 8.3: Engage landholders in wetland conservation activities, working with LLS and DPI to promote the values of ecologically well managed wetlands for threatened shorebirds and other aquatic bird species.
9. Encourage restoration of eroding sand dunes to improve shorebird habitat availability in the study area	North	3	4	Eroding dune systems at beaches provide sheltering and foraging habitat for shorebirds; ongoing dune erosion can smother sand/mudflat foraging areas	Dune erosion can reduce the amount, quality and availability of sand/mudflat foraging substrates and food supplies for shorebirds	Low	Eroding dunes can encroach on suitable foraging habitat for shorebirds, potentially reducing overall food supplies at an affected site	9.1: Encourage the stabilisation and restoration of eroding sand dunes by Dunecare groups working with OEH particularly at South Smoky Beach (Site 13), Ryan's Cut (Site 24) and Barrie's Beach (Site 28). 9.2: Include information on sand dune erosion impacts on foraging and nesting sites for shorebirds in community information distributed to local communities at South West Rocks, Grassy Head, Stuarts Point, Hat Head, Crescent Head and Point Plomer.
Northern Central	1	9						
Northern Central	3	13						
Southern Central	2	24						
	South	2	28					

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Appendix

The Shorebirds 2020 count form used across Australia to survey shorebirds. Image: BirdLife Australia (Shorebirds 2020 Program) and Australasian Wader Studies Group.

SHOREBIRD COUNT FORM





CARING FOR OUR COUNTRY

OFFICE USE

VISIT ID:

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OBSERVER DETAILS For detailed instructions on how to fill out this form refer to "Count Form Instructions"

FULL NAME: PHONE NUMBER:

If more than one observer, only name the count leader or main contact

EMAIL: TOTAL NO. OBSERVERS: YEARS OF COUNTING EXPERIENCE OF MOST EXP. COUNTER:

TIME & DATE

SURVEY DATE: DAY MONTH YEAR TIME STARTED: (24 hour clock) HOUR MINS TIME FINISHED: (24 hour clock) HOUR MINS

SURVEY DETAILS

IF COUNT WAS CONDUCTED IN A SHOREBIRDS 2020 COUNT AREA (count area names and maps available at www.shorebirds.org.au) YES or NO

SHOREBIRD AREA: COUNT AREA: COMPLETE COVERAGE OF MAPPED COUNT AREA?

OR IF COUNT WAS NOT CONDUCTED IN A SHOREBIRDS 2020 COUNT AREA:

SITE NAME: LAT/ LONG:

STATE: SURVEY TYPE (land, boat, air): L.B.A. TIDE HEIGHT: Height in metres or rising, high, falling or low: AREA UNDER WATER (wetlands only): %: WIND DIRECTION:

WIND SPEED: 0 - 5 kph (flat to ripples / wind not felt on face) 6 - 11 kph (small wavelets, crests not breaking / wind felt on face) 12 - 19 kph (large wavelets, crests begin to break / leaves in motion) 20 - 28 kph (small waves / dust, small foam & spray / small trees sway) 29 - 38 kph (moderate waves, some foam & spray / small trees sway) 39 - 49 kph (large waves with foam, crests and spray / large branches in motion) >50 kph (sea heaps up, foam begins to streak / strong resistance while walking)

HUMAN ACTIVITY Write down the number of times the following were observed during the count within the count area:

PEOPLE MOVING <input style="width: 30px;" type="text"/>	BOATS - AT ANCHOR <input style="width: 30px;" type="text"/>	JET SKI <input style="width: 30px;" type="text"/>
PEOPLE FISHING <input style="width: 30px;" type="text"/>	BOATS - MOVING <input style="width: 30px;" type="text"/>	ATV/MOTORCYCLE <input style="width: 30px;" type="text"/>
DOGS - OFF LEAD <input style="width: 30px;" type="text"/>	BOATS - WATERSKIING <input style="width: 30px;" type="text"/>	CARS/TRUCKS <input style="width: 30px;" type="text"/>
DOGS - ON LEAD <input style="width: 30px;" type="text"/>	BOATS - VERY LOUD/FAST <input style="width: 30px;" type="text"/>	OTHER (specify) <input style="width: 100%;" type="text"/>

NUMBER OF FLIGHTS CAUSED BY DISTURBANCE:

THREATS Add timing, scale and severity scores to obtain a total threat score for each threat type

	TIMING		SEVERITY		SCALE		TOTAL THREAT SCORES
	3 = Occurring now		3 = Will persist for >10 years		3 = >90% population decline		0-5 = Low threat
	2 = Likely to occur within 1-3 years		2 = Will persist for 3-10 years		2 = 50-90% population decline		6-7 = Medium threat
	1 = Likely to occur in >3 years		1 = Will persist for 0-3 years		1 = 10-49% population decline		8-9 = High threat
	0 = Not occurring, not likely in future		0 = Will not persist		0 = 0-9 % population decline		
HABITAT LOSS	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	=	<input style="width: 30px;" type="text"/>
HUMAN DISTURBANCE	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	=	<input style="width: 30px;" type="text"/>
INVASIVE SPECIES	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	=	<input style="width: 30px;" type="text"/>
POLLUTION	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	=	<input style="width: 30px;" type="text"/>
WATER LEVEL	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	+	<input style="width: 30px;" type="text"/>	=	<input style="width: 30px;" type="text"/>

HABITAT CHANGE

HAS HABITAT CHANGED SINCE LAST COUNT?: YES or NO AREA AFFECTED BY HABITAT CHANGE: (area used by shorebirds only) %

TYPE OF HABITAT CHANGE: (mark all that apply)

URBAN DEVELOPMENT (within 200m) RECLAMATION HARVESTING/FISHING

FISH FARMING/AQUACULTURE CHANGE IN WATER LEVELS EROSION POLLUTION

ENCROACHMENT FROM NATIVE VEGETATION INVASIVE SPECIES/INTRODUCED PESTS ALGAL BLOOMS

Count forms, count area maps, instructions at www.shorebirds.org.au. Return form to Shorebirds 2020, Birds Australia, 60 Leicester Street, Carlton, Victoria, 3053. Ph (03) 9347 0757. Email: shorebirds@birdsaustralia.com.au.
Online data entry form at <http://data.shorebirds.org.au/>

Macleay River Estuary Migratory and Threatened Shorebird Species Management Strategy
InSight Ecology – October 2017

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SHOREBIRDS		B= ^(B) breeding; please enter comments below Enter 'P' for present in box where a species was present but not counted	
STONE-CURLEWS			
<input type="checkbox"/> Bush Stone-curlew		Little Curlew	
<input type="checkbox"/> Beach Stone-curlew		Whimbrel	
OYSTERCATCHERS, STILTS			
<input type="checkbox"/> Aust. Pied Oystercatcher		Eastern Curlew	
<input type="checkbox"/> Sooty Oystercatcher		Terek Sandpiper	
<input type="checkbox"/> Black-winged Stilt		Common Sandpiper	
<input type="checkbox"/> Red-necked Avocet		Grey-tailed Tattler	
<input type="checkbox"/> Banded Stilt		Wandering Tattler	
PELVICAN, HERONS, ALLIES			
<input type="checkbox"/> Pacific Golden Plover		Common Greenshank	
<input type="checkbox"/> Grey Plover		Marsh Sandpiper	
<input type="checkbox"/> Little Ringed Plover		Common Redshank	
<input type="checkbox"/> Red-capped Plover		Ruddy Turnstone	
<input type="checkbox"/> Double-banded Plover		Wood Sandpiper	
<input type="checkbox"/> Lesser Sand Plover		Asian Dowitcher	
<input type="checkbox"/> Greater Sand Plover		Great Knot	
<input type="checkbox"/> Oriental Plover		Red Knot	
<input type="checkbox"/> Black-fronted Dotterel		Sanderling	
<input type="checkbox"/> Hooded Plover		Long-toed Stint	
<input type="checkbox"/> Red-kneed Dotterel		Pectoral Sandpiper	
<input type="checkbox"/> Banded Lapwing		Sharp-tailed Sandpiper	
<input type="checkbox"/> Masked Lapwing		Curlew Sandpiper	
JACANA, PAINTED SNIFE, SNIFE			
<input type="checkbox"/> Comb-crested Jacana		Broad-billed Sandpiper	
<input type="checkbox"/> Australian Painted Snipe		Ruff	
<input type="checkbox"/> Latham's Snipe		Red-necked Phalarope	
<input type="checkbox"/> Other <i>Gallinago</i> sp.		PRATINCOLES	
GODWITS, CURLEWS, SANDPIPERS, ALLIES			
<input type="checkbox"/> Black-tailed Godwit		Unident. <i>small wader</i>	
<input type="checkbox"/> Bar-tailed Godwit		Unident. <i>med. wader</i>	
		Unident. <i>large wader</i>	
GEESE, DUCKS, SWANS, GREBES			
<input type="checkbox"/> Magpie Goose		<input type="checkbox"/> Cattle Egret	
<input type="checkbox"/> Plumed Whistling-duck		<input type="checkbox"/> White-faced Heron	
<input type="checkbox"/> Musk Duck		<input type="checkbox"/> Little Egret	
<input type="checkbox"/> Cape Barran Goose		<input type="checkbox"/> Nankeen Night Heron	
<input type="checkbox"/> Black Swan		<input type="checkbox"/> Glossy Ibis	
<input type="checkbox"/> Australian Shelduck		<input type="checkbox"/> Australian White Ibis	
<input type="checkbox"/> Australian Wood Duck		<input type="checkbox"/> Straw-necked Ibis	
<input type="checkbox"/> Pink-eared Duck		<input type="checkbox"/> Royal Spoonbill	
<input type="checkbox"/> Australasian Shoveler		<input type="checkbox"/> Yellow-billed Spoonbill	
<input type="checkbox"/> Grey Teal		<input type="checkbox"/> Purple Swamphen	
<input type="checkbox"/> Chestnut Teal		<input type="checkbox"/> Dusky Moorhen	
<input type="checkbox"/> Northern Mallard		<input type="checkbox"/> Eurasian Coot	
<input type="checkbox"/> Pacific Black Duck		GULLS, TERNS	
<input type="checkbox"/> Hardhead		<input type="checkbox"/> Little Tern	
<input type="checkbox"/> Blue-billed Duck		<input type="checkbox"/> Fairy Tern	
<input type="checkbox"/> Australasian Grebe		<input type="checkbox"/> Caspian Tern	
<input type="checkbox"/> Hoary-headed Grebe		<input type="checkbox"/> Whiskered Tern	
<input type="checkbox"/> Great Crested Grebe		<input type="checkbox"/> White-fronted Tern	
GANNETS, CORMORANTS			
<input type="checkbox"/> Australasian Gannet		<input type="checkbox"/> Common Tern	
<input type="checkbox"/> Australasian Darter		<input type="checkbox"/> Crested Tern	
<input type="checkbox"/> Little Pied Cormorant		<input type="checkbox"/> Pacific Gull	
<input type="checkbox"/> Great Cormorant		<input type="checkbox"/> Kelp Gull	
<input type="checkbox"/> Little Black Cormorant		<input type="checkbox"/> Silver Gull	
<input type="checkbox"/> Pied Cormorant		EXTRA BIRDS NOT LISTED ABOVE	
<input type="checkbox"/> Black-faced Cormorant		<input type="checkbox"/>	
PELVICAN, HERONS, ALLIES			
<input type="checkbox"/> Australian Pelican		<input type="checkbox"/>	
<input type="checkbox"/> White-necked Heron		<input type="checkbox"/>	
<input type="checkbox"/> Eastern Great Egret		<input type="checkbox"/>	
<input type="checkbox"/> Intermediate Egret		<input type="checkbox"/>	
TOTAL BIRDS			
Total shorebirds		<input type="text"/>	<input type="text"/>
Total other birds		<input type="text"/>	<input type="text"/>
COMMENTS			
Enter comments, extra species counts, presence of dead birds, details of habitat change, disturbances and threats here. Attach additional pages if necessary.			
WERE ALL VISIBLE SHOREBIRDS COUNTED?		YES or NO	
<input type="checkbox"/>		<input type="checkbox"/>	
WERE ALL WATER-BIRDS COUNTED?		YES or NO	
<input type="checkbox"/>		<input type="checkbox"/>	