

Macleay River Estuary Migratory and Threatened Shorebird Species Strategy – Follow-up shorebird survey 2018/19



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Cover Photo: Sharp-tailed sandpiper at Boyters lane wetland - east

Disclaimer:

This report has been prepared in accordance with the scope of services described in the contract or agreement between Sandpiper Ecological Surveys (ABN 82 084 096 828) and Kempsey Shire Council. The report relies upon data, surveys and measurement obtained at the times and locations specified herein. The report has been prepared solely for Kempsey Shire Council and Sandpiper Ecological Surveys accepts no responsibility for its use by other parties. Sandpiper Ecological Surveys accepts no responsibility or liability for changes in context, meaning, conclusions or omissions caused by cutting, pasting or editing the report.

Table of contents

1. Introduction	1
1.1 Background	2
1.1.1 Shorebird surveys in the study area	2
1.1.2 Shorebirds in the Kempsey LGA	3
1.1.3 Migratory shorebird management strategy	5
Figure 1: Location of sites surveyed by InSight Ecology in September 2016 and February 2017 in the Kempsey LGA. (Source: InSight Ecology 2017).	7
1.1.4 Threats to shorebirds	8
2. Study Area	9
3. Methods	11
3.1 Survey timing and design	11
3.2 Selecting shorebird sample sites	12
3.3 Survey methods	21
3.3.1 High tide surveys – Macleay estuary and adjacent coastline	21
3.3.2 Low tide surveys – Macleay estuary and adjacent coastline	21
3.3.3 Coastline and floodplain wetlands (phase one surveys)	22
3.4 Data summary and analysis	22
3.4.1 Data assumptions	23
3.4.2 Estuarine birds	23
3.5 Community information session	23
3.6 Site prioritisation	24
3.6.1 Site value prioritisation	24
3.5.2 Site threat prioritisation	25
3.7 Mapping	25
4. Results	26
4.1 Survey effort and habitat types	26
4.2 Abundance and species richness of shorebirds	27
4.2.1 Phase one surveys	27
4.2.2 Phase two surveys	29
4.2.3 Maximum counts	30
4.3 Site assessment	32
4.3.1 Abundance and species richness of shorebirds at sample sites	32
4.3.2 Site prioritisation	43
4.4 Community information session	48
4.5 Threat prioritisation	48
4.5.1 Threats identified during the field survey	48
4.5.2 Threat prioritisation at each sample site	49
4.6 Estuarine birds	54
5. Discussion	55
5.1 Shorebird habitat in the study area	55

5.1.1	Roosting habitat	55
5.1.2	Foraging habitat.....	55
5.1.3	Freshwater floodplain wetlands	56
5.2	Significance of the Macleay Coast to shorebirds	56
5.2.1	International and national populations	58
5.2.2	Sites of high conservation value	58
5.3	Additional shorebird habitat	59
5.4	Survey limitations	59
5.5	Comparison between 2018/19 and 2016/17.....	59
5.5.1	Shorebird species richness and abundance.....	59
5.5.2	Site prioritisation	61
5.6	Key outcomes	61
5.7	Knowledge Gaps	62
5.7.1	Abundance and species richness	62
5.7.2	Use of habitat in the Macleay Arm.....	62
5.7.3	Importance of freshwater floodplain wetlands.....	62
5.7.4	Movement between estuarine and freshwater floodplain wetlands.....	62
5.7.5	Identification of additional estuarine roost and foraging areas.....	62
5.7.6	Impact of 4WD vehicles and feral predators on beach nesting shorebirds.....	63
6.	Recommendations	63
7.	References	66
	Appendix A – Shorebird count data.....	69
	Appendix B – Site Values Prioritisation	87
	Appendix C - Threats and Threat Prioritisation	89

List of tables

Table 1: Species of shorebird (sub-order Charadrii) recorded in Kempsey LGA. CE = critically endangered; E = endangered; V = vulnerable; R = resident; M = migrant; V = vagrant.....	3
Table 2: Selected counts from a summary of shorebird counts collated by Ken Shingleton.....	5
Table 3: Species of shorebird and number of individuals recorded in the Kempsey LGA study area by InSight Ecology (2017).	6
Table 4: Survey timing and tide heights. All times are eastern daylight savings time.	11
Table 5: Sites sampled during the 2018/19 Kempsey shire threatened shorebird surveys.	13
Table 6: Recorded and sources of disturbance identified within the study area during the field surveys and community information session and the weighting given to each disturbance category.	25
Table 7: Sites surveyed during each of five samples between December 2018 and February 2019. P1 = phase 1; P2 = phase 2.	26

Table 8: Abundance of each shorebird species recorded during phase one surveys across the entire study area during each sample period. V = vulnerable; E = endangered; CE = critically endangered.....	28
Table 9: Abundance of each shorebird species recorded during phase two surveys in the northern central zone during each sample period. V = vulnerable; E = endangered; CE = critically endangered.....	29
Table 10: Maximum counts of each shorebird species recorded during each sample period. Orange shading denotes a low tide count.....	30
Table 11: Maximum and average counts of shorebirds, species richness of shorebirds, number of migratory species, and number of threatened shorebird species recorded at each sample site..	34
Table 12: Very high, high, and, medium priority sites identified from the site prioritisation.	44
Table 13: Counts for selected shorebird species that exceed the 1% (international significance) and 0.1% (national significance) thresholds.	58
Table 14: Comparison of species richness and abundance in 2016/17 and 2018/19.....	60
Table 15: Recommendations	63

List of figures

Figure 1: Location of sites surveyed by InSight Ecology in September 2016 and February 2017 in the Kempsey LGA. (Source: InSight Ecology 2017).....	7
Figure 2: The study area, showing key locations and the Kempsey Shire boundary.	10
Figure 3: Location of sample sites between Middle Head and the Macleay River.	15
Figure 4: Location of sample sites in the Macleay River estuary and adjoining coastline.	16
Figure 5: Location of sample sites between Smoky Cape and Hat Head, including Korogoro Creek. ...	17
Figure 6: Location of sample sites between Hat Head and Crescent Head.	18
Figure 7: Location of sample sites between Crescent Head and racecourse Head.	19
Figure 8: Location of sample sites between Racecourse Head and Point Plomer.	20
Figure 9: Maximum count of migratory and resident shorebirds recorded in the study area between December 2018 and February 2019.	31
Figure 10: Maximum counts of eastern curlew and whimbrel during each of five surveys between December 2018 and February 2019.	31
Figure 11: Maximum counts of bar-tailed godwit and sharp-tailed sandpiper during each of five surveys between December 2018 and February 2019.	32

Figure 12: Maximum counts of Pacific golden plover and grey-tailed tattler during each of five surveys between December 2018 and February 2019.	32
Figure 13: Threatened species records in the Macleay Arm and around Stuarts Point.	36
Figure 14: Threatened species records in the lower Macleay Arm and Macleay River.	37
Figure 15: Threatened species records in the Macleay River and Hat Head Beach.	38
Figure 16: Threatened species records at Hat Head and on Killick Beach.	39
Figure 17: Threatened species records on Killick Beach.	40
Figure 18: Threatened species records at Crescent Head and Goolawah Beach.	41
Figure 19: Threatened species records between Delicate Nobby and Point Plomer.	42
Figure 20: Site values prioritization of Macleay Arm and South West Rocks area.	44
Figure 21: Site values prioritisation of Macleay River and Hat Head.	45
Figure 22: Site values prioritisation of Killick Beach and Crescent Head.	46
Figure 23: Site values prioritization of Crescent Head to Point Plomer.	47
Figure 24: Management priorities in the lower Macleay Estuary.	50
Figure 25: Management priorities in the upper Macleay Estuary and Hat Head area.	51
Figure 26: Management priorities between Hat head and Crescent Head.	52
Figure 27: Management priorities between Crescent Head and Point Plomer.	53
Figure 28: Location of floodplain wetlands in Kempsey Shire as mapped by ASM <i>et al.</i> (2019).	57

1. Introduction

Kempsey Shire Council recently completed the Macleay River Estuary Migratory and Threatened Shorebird Species Management Strategy (the Shorebird strategy; InSight Ecology 2017). The Shorebird strategy aimed to obtain baseline data on shorebird occurrence, abundance, species richness and habitat use in Kempsey Shire, and information on key threats and management actions needed to protect shorebirds and their habitats. The need for targeted work on shorebirds in the Macleay River Estuary was identified in the Macleay River Estuary Coastal Zone Management Plan (Strategy 21, Geolink 2012), the Kempsey Coastal Zone Management Plan (Action 15, WBM BMT 2015), and by Sandpiper Ecological Surveys (2009) during an audit of shorebird data in the Northern River Catchment Management Authority region.

Strategy N^o. 2 of the Shorebird strategy (InSight Ecology 2017) recommended the “Design and implementation of a shorebird monitoring program to determine changes in patterns of abundance, species richness, community structure and habitat use over time at existing sites in the study area. Consider adding new sites, especially in the Central Zone (Hat Head), to the monitoring program.” Strategy N^o. 2 included seven actions:

- 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), i.e. 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 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.
- 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.
- 2.7: Support and facilitate collaboration on shorebird research and monitoring programs with universities, Aust. Wader Studies Group and relevant government agencies, e.g. NSW OEH, LLS, DPI.

Sandpiper Ecological Surveys was contracted by Kempsey Shire Council to undertake follow-up shorebird surveys, focusing primarily on addressing Actions 2.3-2.6 inclusive. The aim of this study, as specified in the project brief, is to review the findings and recommendations of the 2017 Strategy and gather additional spatial and temporal information to assist in

identifying high and important conservation value habitats for migratory, threatened and resident shorebird species in the Kempsey LGA coastal zone.

The primary objective of the survey was to physically survey and collect information and interpret new and existing data on the shorebird community within the Kempsey LGA coastal zone that will:

- value-add to the findings of the 2017 Strategy survey;
- aid in the protection of important migratory, threatened and resident shorebirds within the Kempsey Shire LGA coastal zone;
- minimise and where possible eliminate anthropogenic and predation threats to migratory shorebirds within the Kempsey Shire LGA coastal zone;
- improve public awareness and knowledge of shorebird ecology within the Kempsey LGA coastal zone;
- identify knowledge gaps in shorebird ecology within the Kempsey Shire LGA coastal zone;
- promote shorebird recovery programs if required; and
- be the basis of a detailed report on the findings and observations of the survey task elements.

Shorebirds belonging to the sub-order Charadrii are the focus of this assessment and the following report concentrates primarily on that group as opposed to the Order Charadriiformes, which also includes gulls and terns. Other species of estuarine bird are mentioned within the report but there is limited detailed analysis or discussion of those species.

1.1 Background

1.1.1 Shorebird surveys in the study area

Knowledge on the species richness, abundance and habitat use of shorebirds in the Macleay estuary is poorly understood (Sandpiper Ecological 2009). Like most species, information on shorebird abundance and distribution in NSW is strongly influenced by survey effort (Sandpiper Ecological 2009). Unlike other north coast estuaries, the Macleay River received minimal survey effort during the 1980's and 1990's, which has contributed to the dearth of information on the local shorebird community (Sandpiper Ecological 2009).

In the late 1990's/early 2000's Ken Shingleton (OAM), a local ornithologist, began sampling shorebirds around Boyters Lane and that area's value to shorebirds became evident. Local ornithologists continue to sample accessible wetlands, particularly those around Boyters Lane, and ocean beaches, providing further information on the occurrence of shorebirds. Ian Bradshaw, a local ornithologist, kindly provided some of Ken Shingleton's records from a 2016 count summary.

There are three shorebirds 2020 count areas in Kempsey LGA – Clybucca Creek Mouth, Boyters Lane, and Swan Pool. Other shorebird surveys in Kempsey LGA include Lawler (1994) and the NSW Wader Studies Group biennial beach nesting bird surveys. The eastern Australian waterbird survey does not cover Kempsey LGA (Porter *et al.* 2018).

1.1.2 Shorebirds in the Kempsey LGA

According to the Atlas of NSW Wildlife ('Bionet') and records of local ornithologists, 45 species of shorebird, from the sub-order Charadrii, have been recorded in the Kempsey LGA (Table 1). This includes 32 palearctic (northern hemisphere) migrants, one trans-Tasman migrant (double-banded plover), one vagrant (buff-breasted sandpiper) and 11 resident species. Nine species listed on the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and 14 species listed on the NSW *Biodiversity Conservation (BC) Act 2016* have been recorded in the LGA. Several migratory species that are uncommon on the east coast of Australia have also been recorded in the Kempsey LGA, including common redshank, long-toed stint, buff-breasted sandpiper, ruff, and red-necked phalarope (Table 1).

Table 1: Species of shorebird (sub-order Charadrii) recorded in Kempsey LGA. CE = critically endangered; E = endangered; V = vulnerable; R = resident; M = migrant; V = vagrant.

Common name	Species name	EPBC status	BC status	Migratory/ Resident
<i>Esacus magnirostris</i>	Beach Stone-curlew		CE	R
<i>Burhinus grallarius</i>	Bush Stone-curlew		E	R
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher		E	R
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher		V	R
<i>Himantopus himantopus</i>	Black-winged Stilt			R
<i>Recurvirostra novaehollandiae</i>	Red-necked avocet			R
<i>Pluvialis fulva</i>	Pacific Golden Plover			M
<i>Pluvialis squatarola</i>	Grey Plover			M
<i>Charadrius ruficapillus</i>	Red-capped Plover			R
<i>Charadrius bicinctus</i>	Double-banded Plover			M
<i>Charadrius mongolus</i>	Lesser Sand Plover	E	V	M
<i>Charadrius leschenaultii</i>	Greater Sand Plover	E	E	M
<i>Charadrius veredus</i>	Oriental Plover			M
<i>Euseyonis melanops</i>	Black-fronted Dotterel			M
<i>Thinornis rubricollis</i>	Hooded Plover	V	CE	R
<i>Erythrogonys cinctus</i>	Red-kneed Dotterel			R
<i>Vanellus miles</i>	Masked Lapwing			R
<i>Rostratula australis</i>	Australian Painted Snipe	E	E	R
<i>Gallinago hardwickii</i>	Latham's Snipe			M
<i>Limosa lapponica subsp. Baueri</i>	Bar-tailed Godwit	V		M
<i>Limosa limosa</i>	Black-tailed Godwit		V	M
<i>Numenius minutus</i>	Little Curlew			M
<i>Numenius phaeopus</i>	Whimbrel			M
<i>Numenius madagascariensis</i>	Eastern Curlew	CE		M
<i>Xenus cinereus</i>	Terek Sandpiper		V	M
<i>Actitis hypoleucos</i>	Common Sandpiper			M
<i>Tringa brevipes</i>	Grey-tailed Tattler			M
<i>Tringa incanus</i>	Wandering Tattler			M
<i>Tringa nebularia</i>	Common Greenshank			M
<i>Tringa stagnatilis</i>	Marsh Sandpiper			M

Common name	Species name	EPBC status	BC status	Migratory/ Resident
<i>Tringa totanus</i>	Common Redshank			M
<i>Tringa glareola</i>	Wood Sandpiper			M
<i>Arenaria interpres</i>	Ruddy Turnstone			M
<i>Calidris tenuirostris</i>	Great Knot	CE	V	M
<i>Calidris canutus</i>	Red Knot	E		M
<i>Calidris alba</i>	Sanderling		V	M
<i>Calidris ruficollis</i>	Red-necked Stint			M
<i>Calidris subminuta</i>	Long-toed Stint			M
<i>Calidris melanotos</i>	Pectoral Sandpiper			M
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper			M
<i>Calidris ferruginea</i>	Curlew Sandpiper	CE	E	M
<i>Tryngites subruficollis</i>	Buff-breasted Sandpiper			V
<i>Limicola falcinellus</i>	Broad-billed Sandpiper		V	M
<i>Philomachus pugnax</i>	Ruff			M
<i>Phalaropus lobatus</i>	Red-necked Phalarope			M

Data on the abundance of shorebirds in the Macleay estuary are limited. Smith (1991), in an analysis of shorebird count data for NSW, listed no migratory species and only three resident species – (Australian) pied oystercatcher (*Haematopus longirostris*), sooty oystercatcher (*Ha. fuliginosus*) and red-capped plover (*Charadrius ruficapillus*) – as occurring in the Macleay estuary. Avifauna Research and Services (2006) did not list the Macleay Estuary as containing any habitat for threatened migratory shorebirds. Lawler (1994) provides one of the only published systematic high and low tide surveys of the Macleay Estuary, with surveys conducted in March 1993 and February 1994. Lawler (1994) recorded a maximum count of 492 individuals. Notable species counts from that survey include:

- eastern curlew (*Numenius madagascariensis*) – 72 individuals;
- whimbrel (*N. phaeopus*) – 196 individuals;
- greenshank (*Tringa nebularia*) – 56 individuals; and
- bar-tailed godwit (*Limosa lapponica*) – 125 individuals.

Lawler (1994) recorded single counts of 184 whimbrel and 68 bar-tailed godwits at a high tide roost in the Macleay Arm, just south of Stuarts Point. The whimbrel count exceeds the 1% Australian population for that time period (see Watkins 1993). The Macleay estuary has not been listed as containing significant numbers of shorebirds in any state, national, or flyway population analysis (e.g. Lane 1987; Smith 1991; Watkins 1993; Bamford *et al.* 2008; Hansen *et al.* 2016).

Data obtained from a 2016 summary of count data by the late Ken Shingleton suggest that the abundance of several migratory species has declined since the 1990's and early 2000's (Table 2). Significant counts include 40-50 eastern curlew in the 1990's, 65 bar-tailed godwits in 2013, and over 1200 sharp-tailed sandpipers in 2006.

Table 2: Selected counts from a summary of shorebird counts collated by Ken Shingleton.

Species	2016 count	Previous counts
Eastern curlew		40-50 at three roosts in 1990's
Whimbrel	25	
Bar-tailed godwit	16	65 recorded in 2013
Marsh sandpiper	6	Maximum count of 35 recorded between 2003 and 2006.
Common greenshank	6	19 in 2002; 17 in 2005 and 2006.
Sharp-tailed sandpiper	105	500 prior to 2006; 1250 in 2006; 800 in 2007; average maximum since 2007 140; 3 individuals in 2010/11 summer.

Between 1996 and 2002 the NSW Wader Studies Group organised volunteer biennial surveys of beach nesting birds along the NSW coastline, including 14 beaches within the Kempsey LGA. Up to six individuals each of the Australian pied oystercatcher and sooty oystercatcher were recorded during those surveys.

1.1.3 Migratory shorebird management strategy

InSight Ecology (2017) sampled 28 sites distributed across the Kempsey Local Government Area (LGA; Figure 1). Surveys were undertaken between 6 and 16 September 2016 (26 sites), and 31 January and 10 February 2017 (28 sites). Site N^o 2 and 18 were sampled in summer only. In addition to field survey, InSight Ecology (2017) reviewed available literature, and collated records of shorebirds from the study area.

Survey methods conformed to DEWHA (2010) and involved land-based surveys of foraging and roosting sites, including rock platforms, at appropriate stages of the tidal cycle (i.e. high, ebb, low and flood tide stages) from vantage points and transects 1-1.6km long and 40-50m wide on beaches, intertidal mud/sandflats, sandbars/spits, wetlands and river banks. Open water habitats were sampled by kayak and terrestrial habitats were sampled using the area search method. A total of 52 field survey sessions were completed at the 28 sites, over 17 days.

In addition, InSight (2017) prioritised sample sites and assessed threats to sample sites. The method used for the site prioritisation was based largely on Sandpiper Ecological (2009) who presented a threat prioritisation originally undertaken during a study in the Clarence Estuary (Sandpiper Ecological 2004). The method involves using several ecological criteria to score sample sites and multiplying this value by the cumulative score for threats present at each site. Resultant scores for each site were then assigned to one of four categories – very high, high, medium, or low, as per Sandpiper Ecological (2004; 2009).

InSight Ecology (2017) recorded 13 species of shorebird and counted 237¹ individuals in the study area (Table 3). The shorebird community was comprised of nine migratory and four resident species, and included two species listed as critically endangered (eastern curlew & curlew sandpiper), and one as vulnerable (bar-tailed godwit) on the EPBC Act, and four

¹ The figure of 237 individuals was obtained by adding species counts from Table 6 of InSight (2017) and excluding duplicate counts.

threatened species (Australian pied oystercatcher, sooty oystercatcher, terek sandpiper & curlew sandpiper) listed on the BC Act. No nesting records were obtained, although immature sooty oystercatcher (*Haematopus fuliginosus*), black-winged stilt (*Himantopus himantopus*), and black-fronted dotterel (*Euseyornis melanops*) were recorded.

Table 3: Species of shorebird and number of individuals recorded in the Kempsey LGA study area by InSight Ecology (2017).

Common name	Cumulative number of individuals	N ^o . of sites present
Australian Pied Oystercatcher	7	6
Sooty Oystercatcher	6	3
Black-winged Stilt	79	6
Black-fronted Dotterel	4	2
Latham's Snipe	4	2
Bar-tailed Godwit	22	3
Whimbrel	6	2
Eastern Curlew	31	5
Terek Sandpiper	5	1
Common Greenshank	2	1
Marsh Sandpiper	2	1
Sharp-tailed Sandpiper	16	1
Curlew Sandpiper	53	1

InSight (2017) identified Back Beach, South West Rocks Creek, Front Beach, Boyters Lane wet paddocks, and the Macleay Arm at junction of Clybucca Creek and Anderson Inlet as the highest priority sites for management.

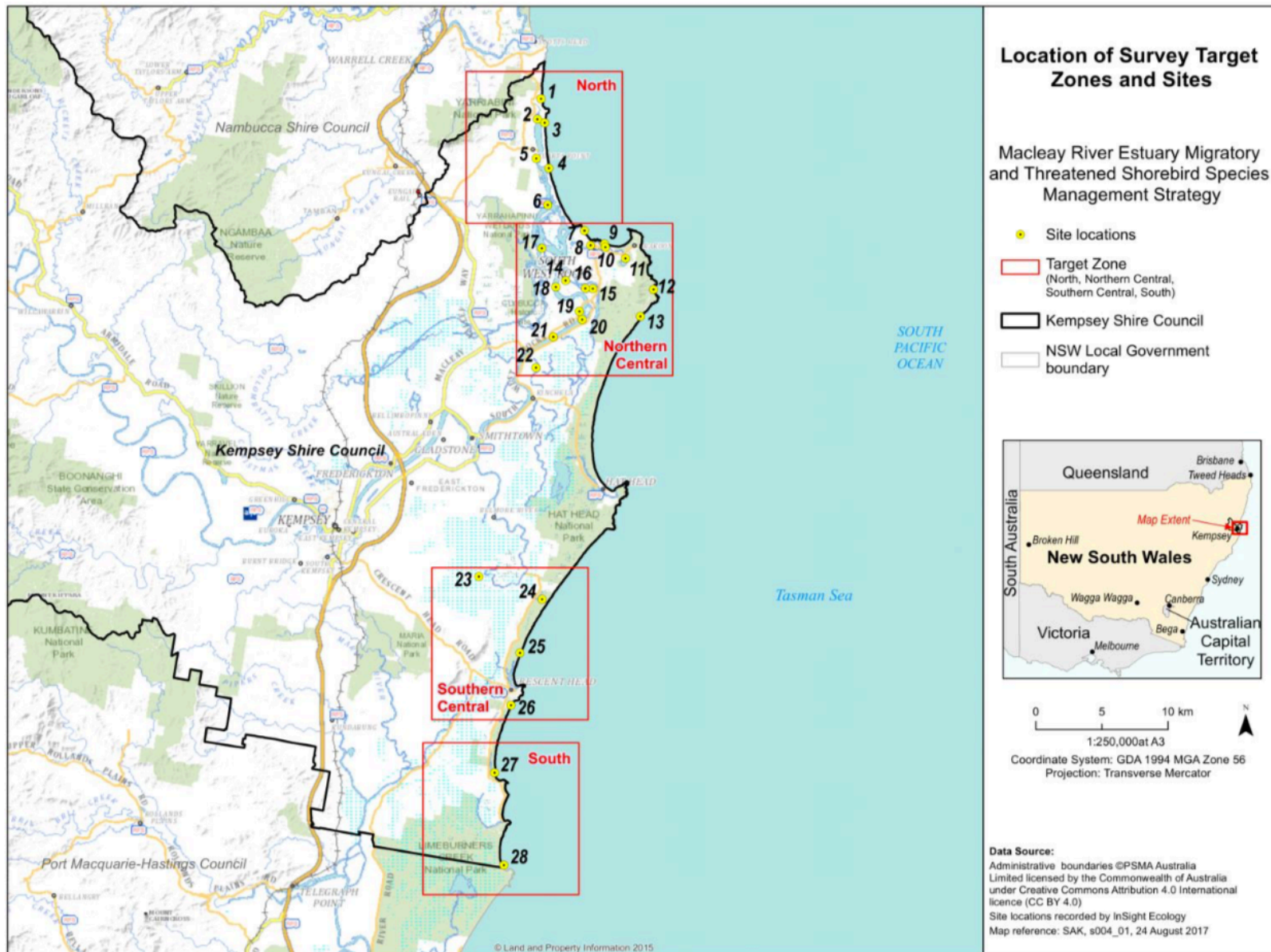


Figure 1: Location of sites surveyed by InSight Ecology in September 2016 and February 2017 in the Kempsey LGA. (Source: InSight Ecology 2017).

1.1.4 Threats to shorebirds

Shorebirds experience a wide array of threats both locally and within the East Asian - Australasian Flyway. Major threats within the flyway include reclamation of intertidal habitat, degradation of habitat due to aquaculture, gross pollution, and invasion of *Spartina* (Melville 2007; Melville *et al.* 2016). These threats have been linked to substantial declines in populations of several species (Moore *et al.* 2016). Loss and degradation of key staging sites along the migration route of several species has been identified as a primary reason for population declines (DoE 2015). Hunting of shorebirds has historically been of concern in a flyway context, however evidence suggests that hunting has declined since the late 1990's (DoE 2015). Anthropogenic climate change is likely to affect shorebirds throughout the flyway due to higher sea-level, variable rainfall, and more frequent and intense climate events.

In Australia, shorebirds continue to experience a range of threats including anthropogenic disturbance, habitat modification, habitat loss, and harvesting of shorebird prey (DoE 2015). Evidence on the effect of prey harvesting is equivocal. Commercial harvesting of prey appears to have a negative effect on prey and shorebird abundance (Shepherd & Boates 1999; Melville *et al.* 2016), however, the effect of recreational harvesting is less obvious. Some studies have concluded negative effects (Masero *et al.* 2005) and others no evidence of an effect (Zharikov & Skilleter 2004). Although the rate of habitat loss in Australia has declined in recent decades it remains an issue of concern, and historically has contributed to declines in shorebird abundance.

Threats common to the north coast of NSW include: human disturbance, habitat modification, introduced predators, and anthropogenic climate change (Sandpiper Ecological 2004; 2009). Human disturbance is particularly significant due to the high rates of coastal recreation. Dogs, boats, bait collectors, fishers, and 4WD vehicles often disturb roosting, foraging and nesting shorebirds on the north coast. The cumulative effect of this disturbance is lower food intake and reduced energy reserves in migratory species (Burger & Gochfeld 1991; Lillyman *et al.* 2016) and reduced incubation in resident species (Weston & Elgar 2007). Introduced predators can have a serious impact on breeding success by resident shorebirds (Mahon 2009).

Habitat modification, particularly erosion of banks from boat wash, and invasion of saltmarsh (roosts) and mudflats (foraging areas) by mangroves are common threats in many north coast estuaries. The issue of mangrove colonisation of saltmarsh and intertidal areas is attributed to sea-level rise, and sedimentation and poor catchment management (Straw & Saintilan 2003). Erosion of saltmarsh from boat wash creates steep banks that are unsuitable for roosting and has been noted as an issue in the Clarence and Richmond estuaries (Sandpiper Environmental 2004).

2. Study Area

Kempsey shire is situated on the mid-north coast of NSW (Figure 2). The Shire has approximately 80 kilometres of coast extending from just north of Middle Head in the north to Point Plomer in the south. The Macleay River is a major feature of Kempsey Shire, and meets the ocean north of Trial Bay and the town of South West Rocks. The river includes a number of major tributaries, including Belmore River, Clybucca, Kinchela, and Christmas Creeks, and the Macleay Arm (Figure 2). The Macleay Arm represents the former river channel and extends from Grassy Head to South West Rocks.

The Macleay River estuary is a complex system consisting of numerous mangrove lined tidal channels, mangrove islands, saltmarsh, and seagrass. The estuary contains approximately 5km² of mangrove, 3.7km² of saltmarsh and 1.1km² of seagrass (West *et al.* 1985). The majority of seagrass occurs in the Macleay Arm and the majority of saltmarsh occurs as fields of marine rush and salt couch in the Clybucca Creek / Andersons Inlet area (Geolink 2012). Intertidal sand and mudflats occur within the Macleay Arm, main channel, Spencers Creek, and Clybucca Creek. The lower floodplain is characterised by numerous freshwater wetlands with small claypans and tidal lagoons situated on the spring tide limit of some channels, such as around Boyters Lane.

The study area also contains five small coastal creeks, South West Rocks Creek on the north side of South West Rocks, Saltwater Creek on the south side of South West Rocks, Korogoro Creek at Hat Head, Ryan's Cut, north of Crescent Head, and Killick Creek at Crescent Head (Figure 2). Saltwater Creek and Ryan's Cut are Intermittently Closed and Open Coastal Lake and Lagoon (ICOLL) and the former creek drains Saltwater Lagoon. The entrance to South West Rocks Creek is kept open by a dredge to maintain tidal flushing and water quality.

The Kempsey Shire coastline is predominantly undeveloped and consists of extensive sandy beaches interspersed with rocky shores and headlands. The majority of rocky shores are steep facing and the coastline lacks rock platforms that occur elsewhere on the NSW coast. The major coastal residential areas of the shire include Stuarts Point, South West Rocks, Hat Head and Crescent Head. Virtually the entire coastline south of Trial Bay is situated in Arakoon, Hat Head, and Goolawah National Parks (Figure 2).



Figure 2: The study area, showing key locations and the Kempsey Shire boundary.

3. Methods

3.1 Survey timing and design

Shorebird surveys occurred between 5 December 2018 and 21 February 2019, over the summer period when migratory shorebird populations tend to be most stable (Haslem *et al.* 2008). Surveys were conducted during five three-day sample periods, and included three spring tides and two neap tides. Sample periods were timed to coincide with both spring and neap tide cycles to a) maximise the opportunity to identify important roost and foraging sites, and b) increase the accuracy of counts (Table 4). Shorebird use of habitat varies between spring and neap tides, particularly in systems where birds move between floodplain and estuarine wetlands. Variation is due to changes in habitat and prey availability. During spring tides shorebirds coalesce at the highest roosts, whilst during neap high tides birds may remain dispersed along tidal channels and at sandflats. Surveying shorebirds during the astronomically highest spring tides can be challenging but these tides can also force birds to leave secluded roosts, or flood claypans and saltmarsh thereby enabling better counts

Table 4: Survey timing and tide heights. All times are eastern daylight savings time.

Survey N ^o	Date	Time High Tide (24hrs)	Height High Tide (M)	Time Low Tide (24hrs)	Height Low Tide (M)
1	4/12/18	0657	1.65	1319	0.45
	5/12/18	0742	1.72	1411	0.39
	6/12/18	0824	1.77	1457	0.36
	7/12/18	0903	1.79	1539	0.34
2	21/1/19	0905	2.02	1545	0.14
	22/1/19	0956	2.07	1635	0.10
	23/1/19	1047	2.05	1724	0.12
3	29/1/19	1628	1.25	1037	0.63
	30/1/19	1740	1.21	1152	0.61
	1/2/19	1935	1.24	1346	0.51
4	12/2/19	1402	1.34	0802	0.66
	13/2/19	1505	1.27	0909	0.67
	14/2/19	1621	1.23	1028	0.64
5	19/2/19	0849	2.01	1527	0.13
	20/2/19	0941	2.04	1614	0.10
	21/2/19	1030	2.01	1659	0.13

It was initially intended to sample each site at high and low tide during each survey (i.e. 10 surveys/site over the sample period). However, with the inclusion of several additional sites (refer Section 3.2) and extension of some sample sites, specifically ocean beaches, it was impossible to sample all sites at high and low tide during each three-day sample period. Consequently it was decided to survey the Macleay estuary and immediately adjacent coastline sites at high and low tide, ocean beaches at low tide, and all remaining sites at either high or low tide.

Sampling the Macleay estuary and immediately adjacent coastline sites at high and low tide was considered a high priority as shorebirds often move between estuaries and the adjacent coastline between tide phases. Large-scale movement from the Macleay Estuary to ocean beach habitats in the south of the study area was unlikely due to the energetic cost of such movement. Movement of shorebirds between claypans and floodplain wetlands is likely in response to tides and rainfall. All claypans near the Macleay Estuary were sampled at the same time as estuarine and adjacent ocean beach sites. Sampling some sites was dependent on access. For example, Stuarts Point Beach was unsuitable for driving during neap low tides or when there was a high risk of becoming bogged. At those times the beach was sampled from the northern and southern ends.

3.2 Selecting shorebird sample sites

InSight Ecology (2017) identified 28 sample sites within the study area. A total of 54 waypoints were provided for these 28 sites, refer Table 3 of InSight (2017). The 28 sites were used as a baseline to determine survey effort for this study. Some of the waypoints signified observation points and others were point locality records of birds observed. The mobility of shorebirds and their regular movement between habitats in response to the tide means that careful consideration is required when selecting sample sites. The designation of multiple sample sites situated in proximity to each other can be meaningless, particularly if the sites have the same habitat and provide the same ecological function (i.e. foraging). Some of the sites identified by InSight (2017) were not suitable for shorebirds, whilst others provided the same function and their proximity meant they warranted combining. Care was exercised when combining sites as unnecessarily grouping sites can have a negative effect on the ability to identify important areas.

The original 54 sample sites were rationalised during the December 2018 survey. The use of a boat to access estuarine sites, and a 4WD to sample ocean beaches meant that several nearby sites were combined, for example the four sites on Goolawah Beach (GBCH01, GBCH02, RCBCH01, RCBCH01), the three sites on Stuarts Point Beach (SPTN01, SPTN02, SPTS01), and two sites at Belmore Swamp BS01/BS02. Two sites on Killick Beach (RCT01 & RC01), two sites on Back Beach (BACKBCH01 & BACKBCH02), two sites at Front Beach (FBCH01 & FBCH02), and sites SALT04/SALT06, SPIT01/SPIT02, in the Macleay estuary were combined due to their proximity. Following an initial inspection, sites SALT05 (mangroves) and BCK01 (floodplain lagoon) were not sampled due to the absence of shorebird habitat. As per the Brief, an additional four sites were sampled at Hat Head, Korogoro Creek #1-4 (Figures 3-8). Additional sites were added as they were encountered, with most included in the first two surveys.

A total of 63 sites were sampled during the summer 2018/19 shorebird survey (Table 5). This included 34 sites identified in the baseline survey, and 29 additional sites. The remaining sites sampled during the baseline survey were either discarded or combined, as described above.

Table 5: Sites sampled during the 2018/19 Kempsey shire threatened shorebird surveys.

Site No.	Site Name	InSight (2017) Code	Habitat	Easting	Northing
1.0	Grassy Head Beach - nth end	GH02	Ocean beach	499683	6594820
1.1	Grassy Head Beach - sth end	GH01	Ocean beach	499910	6593290
2.0	Millington Avenue	UM01	Open water - estuarine	499489	6593013
2.1	Millington Avenue	UM02	Open water - estuarine	499410	6592552
2.2	Millington Avenue	UM03	Open water - estuarine	499523	6592090
3, 3.1, & 4	Stuarts Point Beach	SPTN01, SPTN02, SPTS01	Ocean beach	500584	6587913
5.0	Macleay Arm Site 1 (south of caravan park)	MARM01	Sandflat	499387	6589585
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	MARM021	Sandflat	500264	6585886
7 & 7.1	Back Beach - nth end	BACKBCH02	Ocean beach	503114	6583906
8.0	Back Ck footbridge - SWR	SWRCK01	Sandflat	503509	6583012
9 & 9.1	Front Beach - nth	FBCH02	Ocean beach	504950	6583003
10.0	Saltwater Creek #1	SCK01	Sandflat - ICOLL	504158	6583124
10.1	Saltwater Creek #2	SCK02	Open water - estuarine	504487	6582933
10.2	Saltwater Creek #3	SCK03	Open water - estuarine	505192	6582576
11.0	Saltwater Lagoon	SL02	Open water - estuarine	506118	6582208
12.0	North Smoky Beach	NSB02	Ocean beach	508177	6579542
13.0	South Smoky Beach/Hat Head beach	SSB03	Ocean beach	504258	6571882
14 & 14.1	Saltaire	SALTO1	Tidal lagoon	501915	6580004
14.4 & 14.5	Saltaire - shoreline	SALTO4	Saltmarsh/Mudflat	501284	6580985
15 & 15.1	Boyter's Lane wetland east	BLW01	Claypan	503693	6579631
15.2	Boyter's Lane wetland rehab.	BLW02	Mangrove inlet	503608	6579915
16.0	Boyter's Lane wet paddocks,	BWPO2	Tidal lagoon	503251	6579732
16.1	Boyter's Lane wet paddocks,	BWPO1	Claypan	502928	6579792
17.0	Andersons Inlet	CLY01	Saltmarsh	499626	6583083
17.1	Clybucca Creek	CLY03	Oyster racks, saltmarsh	499950	6582427
18.0	Macleay River opposite Suez Road	RR01	Rocks	500867	6579872
19.0, & 19.1	Pelican Island	SPIT01, SPIT02	Sandflat	503030	6578167
20.0	Pelican Island sandspit	FISL01	Sandflat	502862	6577415
21.0	Long Reach Island - sandspit	LRI01	Sandflat	500680	6576098
23 & 23.1	Belmore Swamp, off Seale Road	BS01, BS02	Freshwater wetland	495117	6558471
24 & 25	Killick Beach/Ryans Cut/Richardsons Crossing	RCT01, RC01	Ocean Beach & ICOLL	500210	6556028
26, 26.1, 27, 27.1	Goolawah Beach to Racecourse Head	GBCH01, GBCH02, RCBCH01, RCBCH01	Ocean Beach	496629	6546075
28.0	Barries Beach - nth end	PP03	Ocean Beach	496622	6537859
28.1	Barries Beach - sth end (Pt Plomer)	PP01	Ocean Beach & Rocky Shore	497237	6535808
29	Macleay Arm - nth of Stuarts Point		Open water - estuarine	499347	6591423
30	Stuarts Point footbridge		Sandflat	499495	6590101
31	Macleay Arm oysters #2		Oyster racks	501000	6585621
32	Macleay Arm oysters #3		Oyster racks	501300	6584500
33	Seagrass Inlet		Mud flat	499849	6583641
34	Whimbrel roost		Mangroves	500389	6583057

Site No.	Site Name	InSight (2017) Code	Habitat	Easting	Northing
35	Macleay arm sandflat		Sandflat	500542	6582750
36	Macleay Arm saltmarsh #1		Saltmarsh	500716	6582420
37	Macleay Arm saltmarsh #2		Saltmarsh	500308	6582611
38	SW Rocks Ck upstream		Sandflat	502209	6583232
39	Macleay Arm rocks - Tattler roost		Rocks	500959	6582388
40	Boat Ramp bay & saltmarsh		Rocks & beach	501028	6582255
41	Boat Ramp sandflat		Sandflat	501178	6582092
42	Spencers Creek		Saltmarsh	501529	6581333
43	Suez road small claypan		Claypan	501017	6579049
44	Suez road wetland		Freshwater wetland	500495	6580241
45	Macleay River bank	-	Rocks	501276	6579251
46	Macleay river upstream sandspit		Sandflat	502862	6577415
47	SWR Headland		Rocky shore	503763	6583433
48	Laggers Point		Rocky shore	506437	6584208
49	Trial Bay Headland		Rocky shore	506865	6584074
50	Korogoro ck1		Sandflat	505402	6564415
51	Korogoro ck2		Sandflat	505443	6564015
52	Korogoro ck3		Sandflat	504544	6564313
53	Korogoro ck4		Sandflat	504045	6564786
54	Pebbly Beach/Little Nobby		Rocky shore	498448	6549676
55	Big Hill Point to Delicate Nobby		Ocean Beach & Rocky Shore	497240	6541420
56	Seale Road wetland		Freshwater wetland	495854	6558320
57	Point Pioneer to Pt Plomer - outside LGA		Ocean Beach & Rocky Shore	497551	6535191

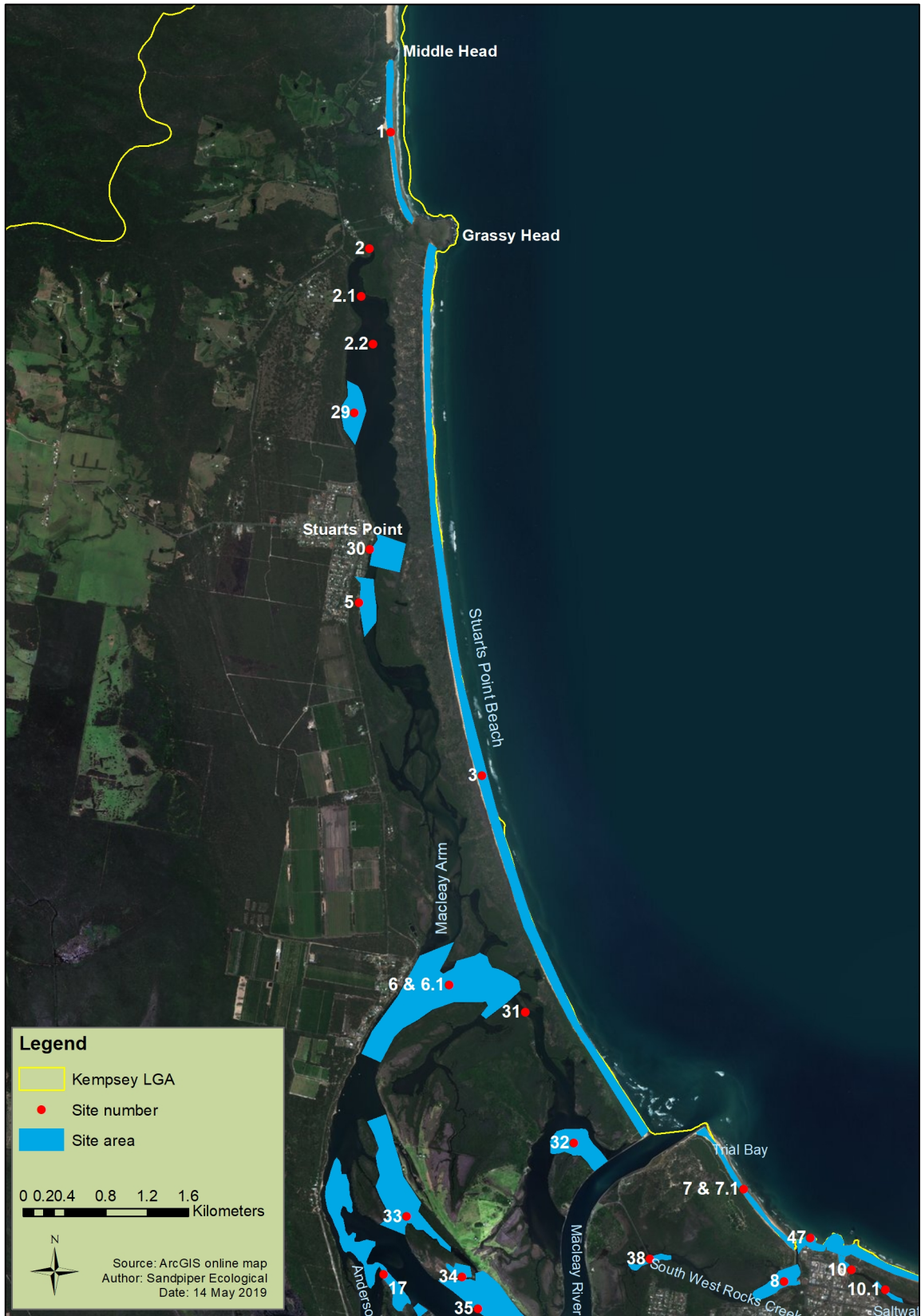


Figure 3: Location of sample sites between Middle Head and the Macleay River.



Figure 4: Location of sample sites in the Macleay River estuary and adjoining coastline.



Figure 5: Location of sample sites between Smoky Cape and Hat Head, including Korogoro Creek.



Figure 6: Location of sample sites between Hat Head and Crescent Head.

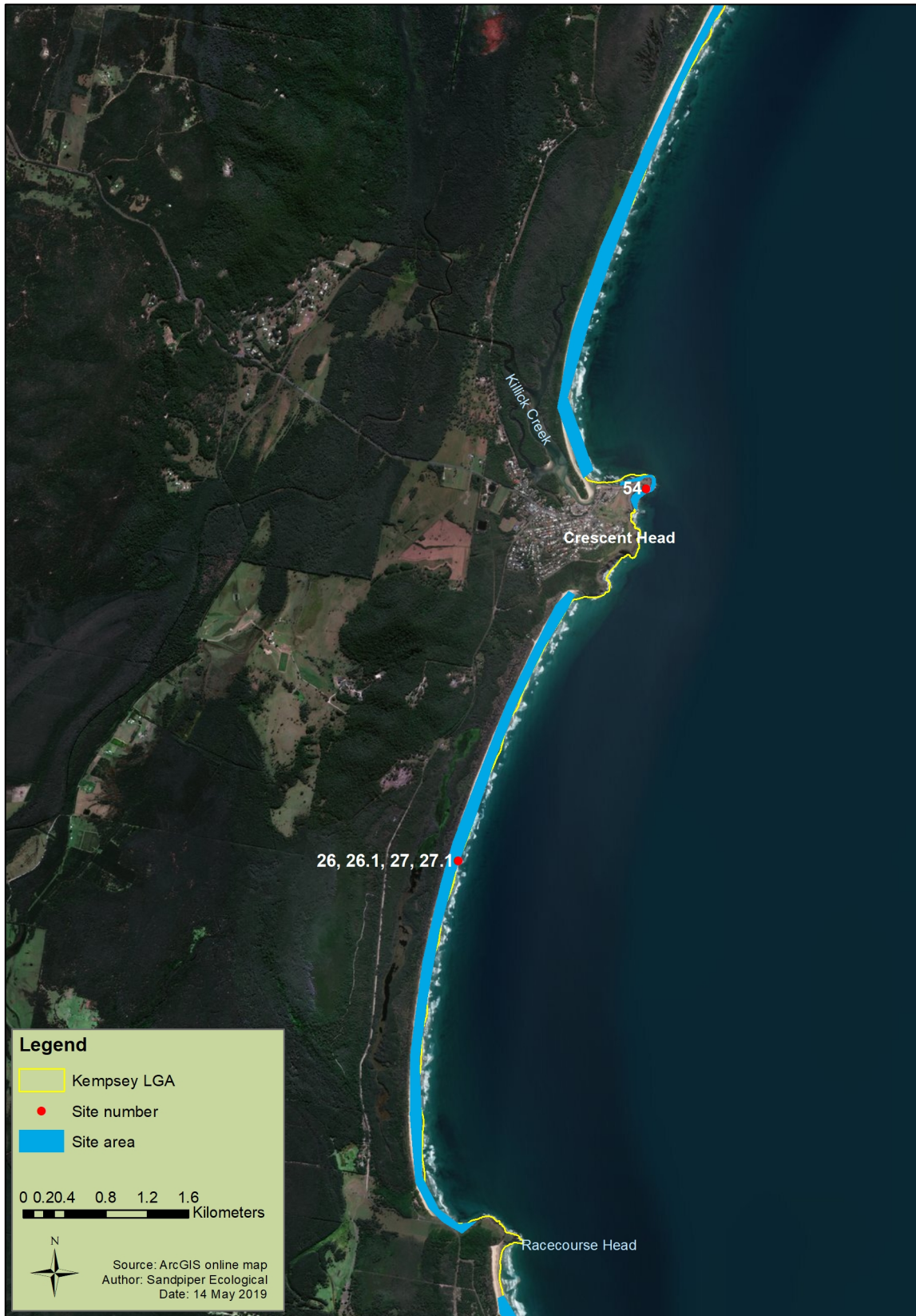


Figure 7: Location of sample sites between Crescent Head and racecourse Head.



Figure 8: Location of sample sites between Racecourse Head and Point Plomer.

3.3 Survey methods

Two observers, experienced in the identification of shorebirds, conducted each survey. All species of shorebird and estuarine bird encountered during the surveys were identified and counted.

Passerines, in Mangrove habitat, were not recorded unless they were listed as threatened. All data were recorded on a standard survey proforma. Surveys typically commenced at Middle Head in the north of the study area and progressed south. Due to the large number of sites, resulting from the combination of baseline sites and additional sites, it was impossible to sample all sites at high and low tide. Sites within and immediately adjoining the Macleay Estuary were sampled at high and low tide whilst, predominantly coastal, sites elsewhere were sampled at either high or low tide. Ocean beaches were sampled at low tide. The time spent at each site varied depending on the number of birds present and access. The key determinant of effort was that surveys were conducted within the four hour period surrounding high and low tide.

3.3.1 High tide surveys – Macleay estuary and adjacent coastline (phase one surveys)

Sites within the Macleay estuary and adjacent coastline were sampled by two observers, one in a boat and one on land. Surveys commenced 2hrs prior to high water (HW; RMS 2018) and were completed 1-2hrs after HW. Boat-based surveys commenced in the lower reaches of the Macleay Arm (Site #6) and were completed at site #21 (Long reach Island) in the Macleay River. Land-based surveys commenced at Boyters Lane and concluded at Smoky Cape. There were some subtle differences in sample sites between spring and neap tides. For example, site 34 (Whimbrel roost) was sampled during spring tides only, and Macleay Arm sandflat was sampled during neap high tides (and all low tides) only. These differences were due to variation in availability and use of habitats during different tide heights.

Care was taken to select the most appropriate observation point to avoid flushing birds. In the estuary this included observing birds from the boat and land. Care was taken when approaching each roost to ensure birds were not flushed. If birds were flushed an approximate count and direction of flight was recorded to assist in determining if they were counted at another site. Generally, birds at a site were counted several times until consistency in counts was achieved. Observations were conducted from both land and boat using a 20-60*80mm spotting scope and pair of 10*42mm binoculars. Data collected at each site included: number of individuals and species, wind speed and direction, tide stage, human activity, and location (easting & northing).

3.3.2 Low tide surveys – Macleay estuary and adjacent coastline (phase two surveys)

Sites in the Macleay estuary and adjacent coastline sampled at high tide were resampled at low tide by the same two observers. The survey team was divided into land-based, and boat based observers. Low tide surveys followed the same pattern as high tide surveys. Surveys were conducted within 1.5hrs of low water (LW). The tidal lag within the Macleay Arm affected low tide surveys in that area. Observations were conducted from both land and boat using a 20-60*80mm spotting scope and pair of 10*42mm binoculars. Data collected at each site included: number of individuals and species, wind speed and direction, tidal stage, human activity, and location (easting & northing).

3.3.3 Coastline and floodplain wetlands (phase one surveys)

The timing of coastline and floodplain surveys south of Smoky Cape (i.e. south central and southern zones) was dictated by the need to sample ocean beaches at low tide. South Smoky/Hat Head, Killicks and Goolawah Beaches represented the focal sample areas around which these surveys were planned. Surveys were conducted by one or two observers and commenced at South Smoky Beach two hours prior to low tide. Ocean beaches were sampled by 4WD vehicle travelling at a maximum speed of 40km/hr. Data collected on each shorebird detected included species, number of individuals, age (resident shorebirds), and location. Other (non-shorebird) species were tallied across the entire sample site.

Sites situated between the abovementioned beaches were sampled as they were encountered, whilst moving north to south. Four sites were sampled in Korogoro Creek (Hat Head). These sites were initially selected (and sampled) at high tide and then subsequently sampled during five low tide periods. Birds were identified and counted using a pair of 10x42mm binoculars and a 20-60x80mm spotting scope, and locations determined using a Garmin Montana GPS. The southern-most site #57 was typically sampled at mid tide. Once that site was completed Belmore Swamp (site 23) and Seale Road wetland (site 56) were sampled.

3.4 Data summary and analysis

Data were uploaded into Site x Species spreadsheets in Excel for each sample and were checked for accuracy. Prior to developing any population estimates data were vetted to remove potential double-counts. Population estimates were derived for each shorebird species during each survey by summing the number of individuals of each species recorded during a sample period. Separate population estimates were derived for high (phase one) and low (phase two) tide surveys in the Macleay Estuary and adjoining coastline. Summary statistics generated include: abundance of each shorebird species during each sample across the entire study area, excluding phase two counts in the northern central zone; abundance of each shorebird species during phase two surveys in the northern central zone; maximum counts of each shorebird species recorded during each sample period and all surveys combined; and maximum counts, average counts, species richness of all shorebirds and threatened shorebirds at each sample site. Maximum counts during each sample for the entire population and selected migratory species were graphed.

When deriving maximum counts, or population estimates, for each species care was taken to minimise the likelihood of duplication. The accepted procedure for determining population estimates for shorebirds is to rely on high tide counts only. As some sites were sampled at low tide only it was impossible to apply this procedure. Furthermore, the careful use of low-tide data to derive population estimates is considered a viable option. For example, counts at individual small sites with limited movement, or counts (with limited movement) at widely spaced sites are considered reliable. Pacific golden plover is a good example of a species whose abundance was best derived from low-tide counts.

3.4.1 Data assumptions

1. No movement of birds between the Macleay Estuary and adjacent coastline, and other zones over the sample period. The highest risk of double-counting occurs with species that utilise both floodplain and estuarine wetlands such as sharp-tailed sandpiper, Pacific golden plover, black-winged stilt, and masked lapwing. The likelihood of duplication is regarded as low for the following reasons:
 - a. The number of sharp-tailed sandpipers recorded at sites around the Macleay Estuary was consistently high over the sample period suggesting that birds were not moving regularly between that area and southern floodplain wetlands.
 - b. The distance between sample sites reduces the likelihood of rapid movement by reasonably sedentary species like masked lapwing.
 - c. The low diversity and small number of birds outside the estuary means that movement by some individuals was unlikely to have a substantial impact on population estimates.
2. Limited movement of birds between sites during high and low tide surveys. There is always a risk that birds will move between sites during a sample period. Care is taken to ensure that such movement is not due to disturbance from observers, however, birds of prey, and other humans may cause disturbance. The speed of survey and sequence in which sites are sampled aims to minimise the risk of duplication. The likelihood of movement between sites during a survey is regarded as low due to the low frequency that birds were disturbed or recorded in flight.

3.4.2 Estuarine birds

Estuarine birds (cormorants, pelicans, gulls, terns, egrets, heron, ibis, waterfowl, and birds of prey) were identified and counted when observed. These species were not targeted during the survey but often occupy similar habitats to shorebirds and the surveys provide a reasonably accurate indication of species richness and abundance at the sites sampled. Estuarine birds are more broadly distributed than shorebirds and counts are likely to underestimate overall abundance in the study area.

3.5 Community information session

A community information session was held at the South West Rocks Surf Life Saving Club on Friday 17 May 2019. The aim of the information session was to present the community, local government, and state agency representatives with an overview of survey methods, results, site values (refer section 3.6.1), and threats. The second half of the presentation involved a workshop where attendees were asked to identify key threats to shorebirds in the study area, and high-risk sites. Data collected on threats and high risk sites was used in the site threat prioritisation (refer section 3.6.2).

The community information session was advertised via an article in the Macleay Argus, a television interview by Kempsey Council staff, and by posting notification on the Mid North Coast Birders Network Facebook page.

3.6 Site prioritisation

3.6.1 Site value prioritisation

The site prioritisation undertaken by Sandpiper Environmental (2004) and Sandpiper Ecological (2009) has been adopted. The prioritisation method has been amended by giving increased weight to threatened species listed on the *EPBC Act*, and sites that support >50% of a species maximum count. The prioritisation method used by InSight (2017) was not adopted as it was considered deficient. Analysis was restricted to data collected during this survey. Whilst this approach may underestimate the value of floodplain wetlands that were dry during the survey (e.g. Belmore Swamp) it fits within the scope of the project and avoids possible bias associated with survey effort. Some survey data were collected on accessible freshwater wetlands (e.g. Seale Road and Suez Road) and that habitat type was not ignored in the prioritisation.

Criteria used in the site prioritisation included:

1. 1 point for every 100 individuals recorded at a site under the category of Maximum count.
2. 2 points for every 100 individuals recorded at a site under the category of Average N°. birds.
3. 1 point for each species recorded at a site.
4. 2 points for each migratory species recorded at a site.
5. 2 points for each threatened species listed on the *BC Act*.
6. 5 points for each critically endangered and three points for each vulnerable migratory species listed on the *EPBC Act*.
7. 10 points if a site is used as a spring tide roost.
8. 5 points for each resident shorebird species that exceeded 50% of that species estimated population.
9. 10 points for each migratory shorebird species that exceeded 50% of that species estimated population.

The weighting given to sites available during spring high tides recognises the critical importance of these sites for shorebirds, and the weighting given to migratory shorebirds and threatened migratory shorebirds reflects the focus of this project. Scores for each criterion were added together and the cumulative total was used to assess the relative importance of each roost. Sites with a cumulative score of 50 or higher were ranked as very high value, sites scoring 30 to 50 as high value, between 10 and 29 as medium value and less than 10 as low value.

3.5.2 Site threat prioritisation

Threats were divided into two categories:

1. recorded disturbance events; and
2. sources of disturbance.

Each category contained multiple potential threats that were condensed into seven criteria and each criterion was given a score of 1 or 0.5 based on its documented impact on shorebirds (Table 6).

Documented impact on shorebirds was based on the authors experience and scientific literature.

Table 6: Recorded and sources of disturbance identified within the study area during the field surveys and community information session and the weighting given to each disturbance category.

Recorded disturbance	Score	Sources of disturbance	Score
People on foot (walkers, fishers, bait collectors)	2	People on foot (picnic, camping, fishing area, bait collection, walking track, swimming/surfing)	2
Dogs off leash	3	Dog off leash area	3
Dogs on leash	1	Dog on leash area	1
4WD vehicles	2	Boat ramp	1
Jet skis	2	Boat channel/mooring	1
Boats	1	4WD area	2
Horse riding	1	Cattle	1
Mangrove encroachment	1	Professional fishing area	1
Erosion	1		
Altered hydrology	2		
Cattle	1		

All sample sites were assessed against each criterion and the scores tallied to provide a cumulative threat score. The higher the score the greater the threat. Sources of disturbance were considered relevant if they occurred within 250m of a sample site. A combination of Council mapping, Google Earth, and knowledge of the study area was used to assign disturbance sources to each site.

Threat scores were multiplied by value scores with the resulting score used to indicate the significance of threats at each site. Sites with high value and high threat scores tend to have the highest combined scores and therefore represent priority sites for management. Sites were divided into four categories (very high, high, medium, and low) depending on the final threat x value score.

3.7 Mapping

The location of sample sites and important habitats within the study area was mapped using ArcGIS 10. Shapefiles were created showing the extent of each (high and low tide) sample site and high, medium, and low conservation priority sites. The distribution of threatened species within the study area was also mapped.

4. Results

4.1 Survey effort and habitat types

Sixty-three 62 sites were surveyed during the 2018/19 sample period. The number of sites surveyed during a single sample period (i.e. phase 1 or phase 2) ranged from 49 in sample one to 57 in sample five (Table 7). The combined total (phase 1 & 2) of sites surveyed during a sample ranged from 51 in sample 1 to 60 in sample 5. Not all sites were sampled during a single phase as some sites were used for foraging or roosting only. Thirteen habitat types were sampled during the survey (Table 5).

Table 7: Sites surveyed during each of five samples between December 2018 and February 2019. P1 = phase 1; P2 = phase 2.

Site No.	Site Name	5-7 Dec		21-23 Jan		29 Jan-1 Feb		11-14 Feb		19-21 Feb	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
1 & 1.1	Grassy Head Beach - nth end	✓	✓	✓		✓		✓		✓	
2.0, 2.1	Millington Avenue	✓	✓	✓		✓		✓		✓	
2.1	Millington Avenue	✓	✓	✓		✓		✓		✓	
2.2	Millington Avenue	✓	✓	✓		✓		✓		✓	
3, 3.1, 4	Stuarts Point Beach	✓	✓	✓		✓		✓		✓	
5.0	Macleay Arm Site 1 (south of caravan park)	✓	✓	✓		✓		✓		✓	
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7 & 7.1	Back Beach - nth end	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8.0	South West Rocks footbridge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9 & 9.1	Front Beach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10.0	Saltwater Creek #1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10.1	Saltwater Creek #2			✓	✓			✓		✓	
10.2	Saltwater Creek #3	✓	✓	✓	✓			✓	□	✓	
11.0	Saltwater Lagoon							□		✓	✓
12.0	North Smoky Beach	✓	✓	✓		✓		✓	✓	✓	
13.0	South Smoky Beach/Hat Head beach	✓	✓	✓	✓	✓		✓	✓	✓	
14 & 14.1	Saltaire	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14.4 & 14.5	Saltaire - shoreline	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15 & 15.1	Boyers Lane wetland - east	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15.2	Boyer's Lane wetland - rehab	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16.0	Boyer's Lane wet paddocks, Jerseyville	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16.1	Boyer's Lane wet paddocks, Jerseyville	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
17.0	Andersons Inlet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
17.1	Clybucca Creek	✓	✓	✓		✓		✓	□	✓	
18.0	Macleay River opposite Suez Road	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19 & 19.1	Pelican Island	✓		✓	✓	✓	✓	✓	□	✓	✓
20.0	Pelican Island sandspit	✓	✓	✓	✓	✓	✓	✓	□	✓	✓
21.0	Long Reach Island - sandspit	✓	✓	✓	✓	✓	✓	✓	□	✓	✓
23 & 23.1	Belmore Swamp, off Seale Road	✓		✓		✓		✓		✓	

Site No.	Site Name	5-7 Dec		21-23 Jan		29 Jan-1 Feb		11-14 Feb		19-21 Feb	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
24 & 25	Killick Beach	✓		✓		✓		✓		✓	
26, 26.1, 27, 27.1	Goolawah Beach	✓		✓		✓		✓		✓	
28.0	Barries Beach - nth end	✓		✓		✓		✓		✓	
28.1	Barries Beach - sth end (Pt Plomer)	✓		✓		✓		✓		✓	
29	Macleay Arm - nth Stuarts Point	✓		✓				✓			
30	Stuarts Point footbridge	✓	✓					✓			
31	Macleay arm oysters #2					✓		✓		✓	
32	Macleay Arm oysters #3	✓		✓		✓	✓	✓	✓	✓	✓
33	Seagrass Inlet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
34	Whimbrel roost			✓				□		✓	
35	Macleay Arm Sandflat		✓		✓		✓	□	✓		✓
36	Macleay Arm saltmarsh #1	✓	✓	✓		✓		✓	□	✓	
37	Macleay Arm saltmarsh #2	✓		✓		✓		✓		✓	
38	South West Rocks Ck		✓					□			
39	Macleay Arm Rocks - Tattler roost			✓				✓	□	✓	
40	Boat Ramp bay & saltmarsh	✓	✓	✓		✓		✓		✓	
41	Boat Ramp Sandflat		✓	□	✓		✓		✓		✓
42	Spencers Ck			✓	✓	✓	✓	✓	✓	✓	✓
43	Suez road small claypan						✓			✓	
44	Suez road wetland			✓	✓	✓	✓	✓	✓	✓	✓
45	Macleay River bank					✓			✓	✓	✓
46	Macleay river upstream sandspit					✓	✓	✓	✓	✓	✓
47	SWR Headland	✓		✓		✓		✓		✓	
48	Laggers Point			✓	✓	✓		✓		✓	
49	Trial Bay Headland	✓	✓	✓		✓		✓		✓	
50	Korogoro ck1	✓	✓	✓	□	✓		✓		✓	
51	Korogoro ck2	✓	✓	✓		✓		✓		✓	
52	Korogoro ck3	✓	✓	✓		✓		✓		✓	
53	Korogoro ck4	✓	✓	✓		✓		✓		✓	
54	Pebbly beach/Little nobby	✓		✓		✓		✓		✓	
55	Big Hill Point- Delicate Nobby	✓		✓		✓		✓		✓	
56	Seale Rd wetland	✓		✓		✓		✓		✓	
57	Point Pioneer to Point Plomer - outside LGA	✓		✓		✓		✓		✓	
Total number of sites		37		25		52	24	55	23	57	25

4.2 Abundance and species richness of shorebirds

4.2.1 Phase one surveys

Phase one surveys of all sites during each sample period recorded 18 species of shorebird, including eight resident and 10 migratory species (Table 8). Five threatened species were recorded during

phase one surveys, including two resident (pied and sooty oystercatcher) and three migratory species (bar-tailed godwit, eastern curlew and broad-billed sandpiper). Oystercatchers were recorded during each sample period, bar-tailed godwit and eastern curlew were recorded during the first four sample periods, and broad-billed sandpiper was recorded during the first sample only (Table 8). Most species were recorded in four or more samples, exceptions were red-necked avocet (sample 1), red-capped plover (samples 1 & 3), common greenshank (samples 2 & 4), red-necked stint (sample 1) and broad-billed sandpiper (sample 1; Table 8).

Shorebird abundance ranged from 897 to 1468 individuals across the five phase one samples (Table 8). The abundance of migratory species ranged from 439 in sample five to 1134 in sample two, and resident shorebirds from 320 in sample one to 458 in sample five. Sharp-tailed sandpiper was the most abundant species comprising between 39 and 64% of the total shorebird community across the five samples. The maximum number of both eastern curlew and bar-tailed godwit recorded was 25 (Table 8). Abundance of pied oystercatcher ranged from nine to 12, and abundance of sooty oystercatcher from eight to 10 individuals. One broad-billed sandpiper was recorded. Counts of grey-tailed tattler in surveys two and four were adjusted to remove duplication.

Table 8: Abundance of each shorebird species recorded during phase one surveys across the entire study area during each sample period. V = vulnerable; E = endangered; CE = critically endangered.

Common name	Survey No.				
	1	2	3	4	5
Australian pied oystercatcher ^E	12	12	9	10	10
Sooty oystercatcher ^V	10	8	8	8	9
Black-winged stilt	261	251	305	299	330
Red-necked avocet	1	0	0	0	0
Red-capped plover	7	0	7	0	0
Black-fronted dotterel	0	4	1	0	1
Red-kneed dotterel	7	5	1	2	1
Masked lapwing	22	54	119	18	107
Total resident species	7	6	7	5	6
Total resident individuals	320	334	450	337	458
Pacific golden plover	24	42	29	2	37
Latham's snipe	2	6	3	2	1
Bar-tailed godwit ^V	25	16	13	11	0
Whimbrel	41	58	42	37	20
Eastern curlew ^{CE}	10	14	25	25	0
Grey-tailed tattler	2	41	25	30	27
Common greenshank	0	6	0	3	0
Red-necked stint	4	0	0	0	0
Sharp-tailed sandpiper	517	951	620	772	354
Broad-billed sandpiper ^V	1	0	0	0	0
Total migratory species	9	8	7	8	5
Total migratory individuals	626	1134	757	882	439
Total species	16	14	14	13	11
Total individuals	946	1468	1207	1219	897

4.2.2 Phase two surveys

Phase two surveys recorded 17 species of shorebird, including six resident and 11 migratory species (Table 9). Species richness ranged from 10 to 13 across the five samples. One double-banded plover, a trans-Tasman migrant, was recorded during sample five. Five threatened species were recorded during phase two surveys. These were the same as phase one, with the addition of curlew sandpiper, and omission of broad-billed sandpiper (Tables 8 & 9). Abundance of all shorebirds during phase two surveys ranged from 827 to 1115 individuals (Table 9). The abundance of migratory shorebirds ranged from 606 in sample one to 791 in sample three. Species richness of migratory shorebirds decreased from sample one (9 species) to sample five (5 species). The abundance of resident shorebirds ranged from 221 in sample one to 324 in sample three.

Sharp-tailed sandpiper was the most abundant species comprising between 39 and 73% of the shorebird community in phase two surveys. The abundance of oystercatchers was low in phase two, ranging from 1 to 4 individuals for pied and one individual for sooty. Black-winged stilt was the most abundant resident species in phase two surveys, with a maximum population of 302 individuals recorded in sample three (Table 9).

Table 9: Abundance of each shorebird species recorded during phase two surveys in the northern central zone during each sample period. V = vulnerable; E = endangered; CE = critically endangered.

Common name	Survey No.				
	1	2	3	4	5
Australian pied oystercatcher ^E	4	4	0	3	1
Sooty oystercatcher ^V	1	0	0	1	0
Black-winged stilt	183	202	302	245	254
Double-banded plover	0	0	0	0	1
Black-fronted dotterel	0	2	2	4	0
Red-kneed dotterel	7	7	2	5	6
Masked lapwing	26	19	18	7	31
Total resident species	4	5	4	6	5
Total resident individuals	221	234	324	265	293
Pacific golden plover	133	34	67	7	211
Latham's snipe	1	0	3	1	0
Bar-tailed godwit ^V	19	17	25	0	0
Whimbrel	32	44	20	2	30
Eastern curlew ^{CE}	5	20	21	0	6
Grey-tailed tattler	9	28	29	1	25
Common greenshank	0	6	2	2	0
Red-necked stint	6	0	0	1	0
Sharp-tailed sandpiper	401	523	624	754	367
Curlew sandpiper ^{CE}	0	1	0	0	0
Total migratory species	9	8	8	7	5
Total migratory individuals	606	673	791	768	639

Total species	13	13	12	13	10
Total abundance	827	907	1115	1033	932

4.2.3 Maximum counts

The maximum cumulative count of shorebirds in the study area during the sample period was 1822 individuals (Table 10). A total of 20 shorebird species were recorded, including eight resident and 12 migratory species (Table 10). Six threatened species were recorded, three listed on the NSW *BC Act* (Australian pied oystercatcher, sooty oystercatcher, & broad-billed sandpiper), and three listed on the Commonwealth *EPBC Act* (bar-tailed godwit, eastern curlew, & curlew sandpiper). Both the eastern curlew and curlew sandpiper are listed as critically endangered and bar-tailed godwit (sub-species *baueri*) as vulnerable.

Table 10: Maximum counts of each shorebird species recorded during each sample period.

Common name	Maximum count	Survey No.				
		1	2	3	4	5
Australian pied oystercatcher ^E	12	12	12	9	10	10
Sooty oystercatcher ^V	10	10	8	8	8	9
Black-winged stilt	330	261	251	305	299	330
Red-necked avocet	1	1	0	0	0	0
Red-capped plover	7	7	0	7	0	0
Black-fronted dotterel	4	0	4	2	4	1
Red-kneed dotterel	7	7	7	2	5	6
Masked lapwing	119	26	54	119	18	107
Total resident species	8	7	6	7	6	6
Total resident individuals	490	324	336	452	344	463
Pacific golden plover	211	133	42	67	7	211
Double-banded plover	1	0	0	0	0	1
Latham's snipe	6	2	6	3	2	1
Bar-tailed godwit ^V	25	25	17	25	11	0
Whimbrel	58	41	58	42	37	20
Eastern curlew ^{CE}	25	10	20	25	25	6
Grey-tailed tattler	41	9	41	25	30	27
Common greenshank	6	0	6	2	3	0
Red-necked stint	6	6	0	0	1	0
Sharp-tailed sandpiper	951	517	951	624	772	367
Curlew sandpiper ^{CE}	1	0	1	0	0	0
Broad-billed sandpiper ^V	1	1	0	0	0	0
Total migratory species	12	9	9	8	9	7
Total migratory individuals	1332	744	1142	813	888	633
Total species	20	16	15	15	15	13
Total individuals	1822	1068	1478	1265	1232	1096

The maximum count for migratory shorebirds was 1332 individuals and for resident shorebirds 490 individuals (Table 10). Maximum counts of all shorebirds across the five samples ranged from 1068 in sample one to 1478 in sample two. Maximum counts per sample for migratory shorebirds ranged from 1142 in sample two to 633 in sample five. There is some evidence of declining abundance and species richness of migratory shorebirds from mid January (sample two) to late February (sample five; Figure 9).

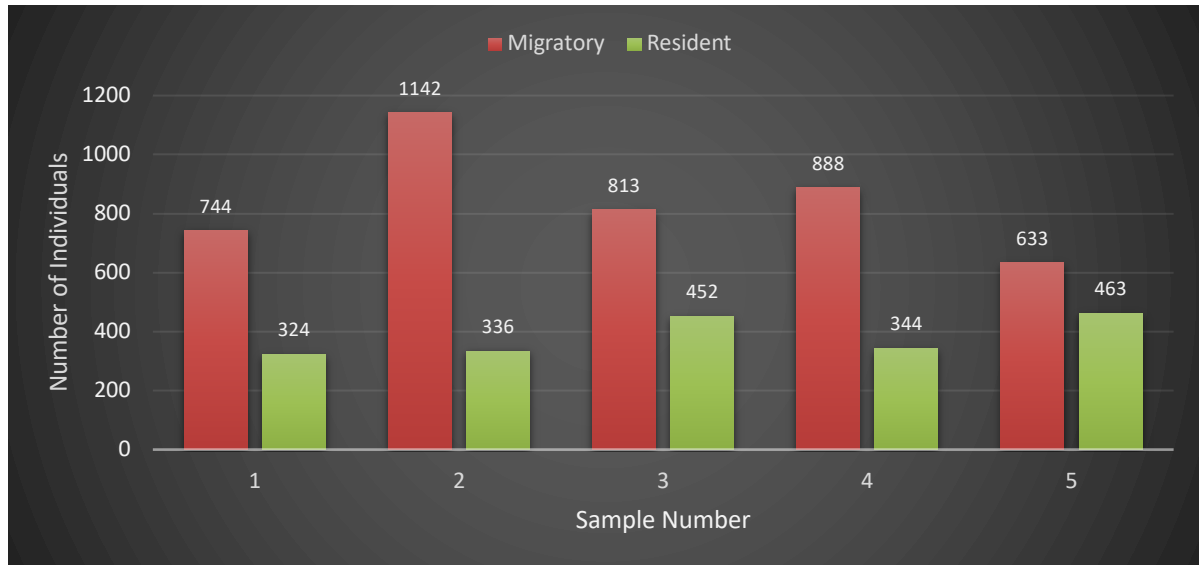


Figure 9: Maximum count of migratory and resident shorebirds recorded in the study area between December 2018 and February 2019.

The abundance of eastern curlew, whimbrel, bar-tailed godwit, and sharp-tailed sandpiper declined in late February (Figures 10-12). The opposite trend occurred for Pacific golden plover with the highest abundance recorded in sample five (Figure 12). Abundance of grey-tailed tattler remained stable from samples three to five. The abundance of whimbrel, grey-tailed tattler and sharp-tailed sandpiper increased in sample two.

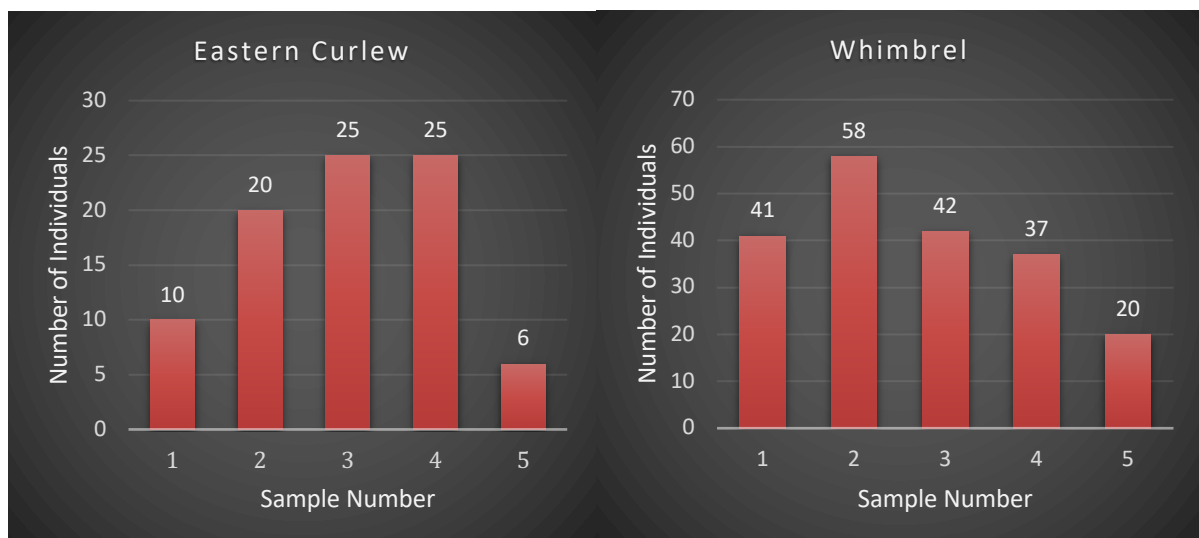


Figure 10: Maximum counts of eastern curlew and whimbrel during each of five surveys between December 2018 and February 2019.

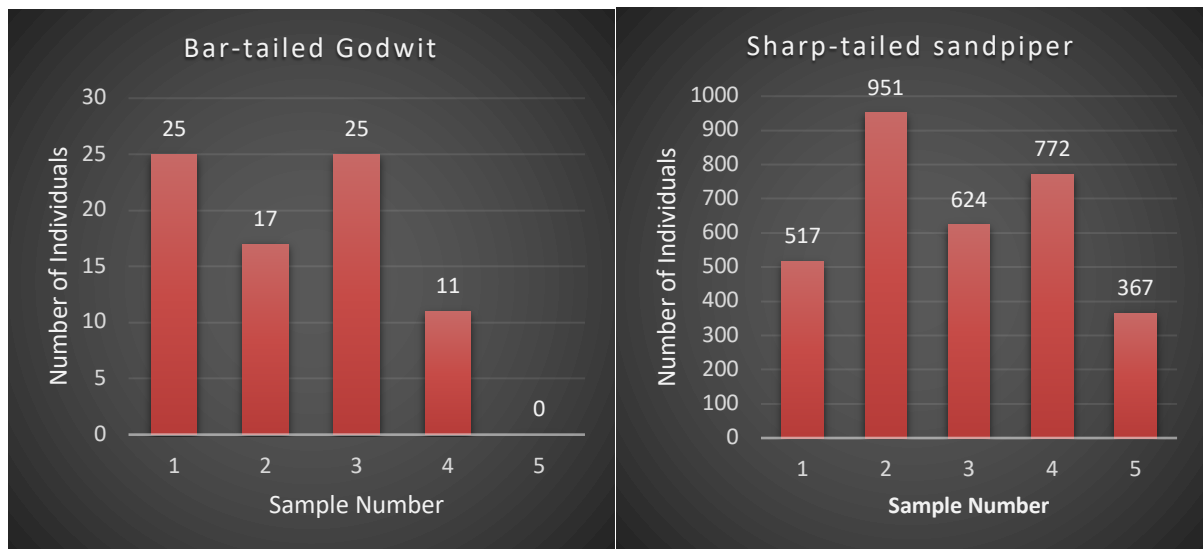


Figure 11: Maximum counts of bar-tailed godwit and sharp-tailed sandpiper during each of five surveys between December 2018 and February 2019.

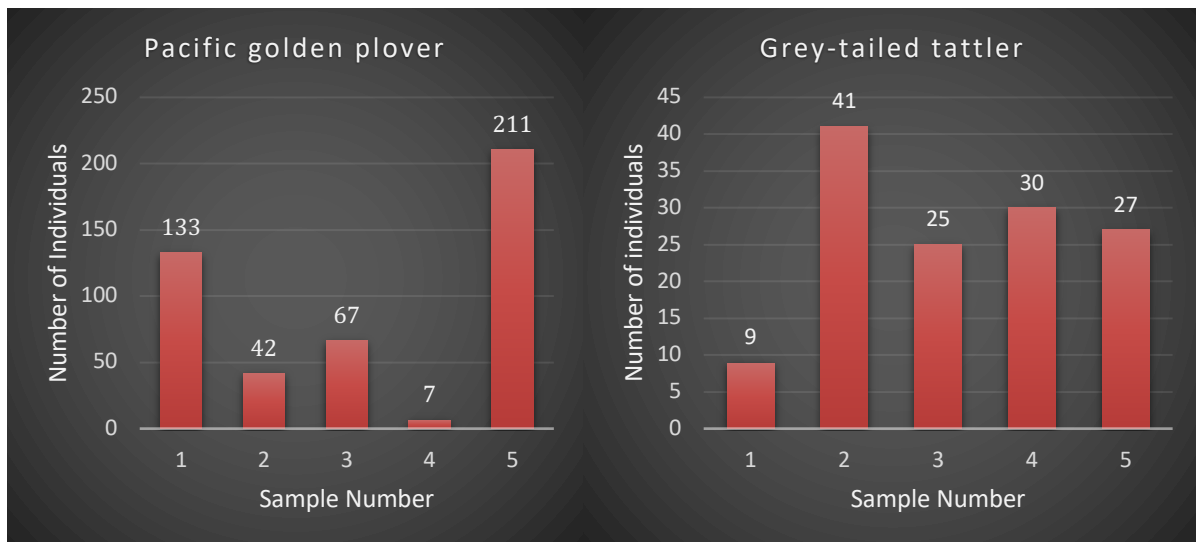


Figure 12: Maximum counts of Pacific golden plover and grey-tailed tattler during each of five surveys between December 2018 and February 2019.

The most abundant species across the entire sample period were sharp-tailed sandpiper (951 individuals), black-winged stilt (330 ind), Pacific golden plover (211 ind), and masked lapwing (119 ind). Maximum counts for bar-tailed godwit and eastern curlew were both 25 individuals, whilst single individuals of curlew sandpiper and broad-billed sandpiper were recorded. Maximum counts of pied and sooty oystercatcher were 12 and 10 individuals respectively.

4.3 Site assessment

4.3.1 Abundance and species richness of shorebirds at sample sites

Of the 59 sites considered in the site assessment, nine did not support shorebirds during the sample period. These were Lagers Point (site 48), Pelican Island (sites 19 & 19.1), North Smoky Beach (site 12), Saltwater Creek #3 (site 10.2), Front Beach (sites 9 & 9.1), Goolawah Beach (sites 26 & 27),

Millington Avenue (sites 2 & 2.1), Long Reach Island (site 21), and Macleay Arm north Stuarts Point (site 29; Table 11). Masked lapwing was the only shorebird species recorded at a further 10 sites, including three of the four Korogoro Creek sites.

The highest species richness of shorebirds was nine recorded at Boyters Lane wet paddocks north (site 16.1) and Macleay Arm sandflat (site 35), followed by eight at Saltaire (site 14 & 14.1), and seven at Boyters Lane flooded paddocks south (site 16; Table 11). The highest species richness of migratory species was six at Macleay Arm sandflat, followed by Saltaire (5 species), Boyters Lane wet paddocks north, and Macleay Arm saltmarsh #1 with five species each.

The highest maximum count of shorebirds was 511 individuals recorded at Saltaire (sites 14 & 14.1), followed by Boyters Lane wet paddocks north (366 individuals), Seale Road wetland (343 individuals), Boyters Lane wet paddocks south (249 individuals), and Boyters Lane wetland east (207 individuals; Table 11). The highest counts at estuarine sites were 159 at Pelican Island sandspit, 128 at Macleay Arm sandflat, and 96 at the Macleay River upstream sandspit (Table 11). The latter site was dominated by resident species, namely masked lapwing and black-winged stilt.

4.3.2 Distribution and abundance of threatened shorebirds

Twenty-five sites supported threatened shorebirds, although 14 of these supported either Australian pied oystercatcher or sooty oystercatcher only (Figures 13 to 19). Over the sample period both species of oystercatcher were recorded at eight sites each. Sooty Oystercatcher was strictly coastal with individuals recorded on rocky shores only. Australian pied oystercatcher was recorded at four ocean beaches (Middle Beach, Stuarts Point Beach, South Smoky/Hat Head Beach, Killick Beach), two estuarine sandflats at low tide (Macleay Arm-site 35, & Boat ramp-site 41), and two saltmarshes (sites 17 & 17.1) at high tide. The highest number of Australian pied oystercatcher recorded at a site was seven at Killick Beach (site 24/25). The highest number of sooty oystercatcher recorded at a single site was three at Big Hill Point to Delicate Nobby (site 55).

Curlew sandpiper was recorded at site 14/14.1 (Saltire lagoon) only, and broad-billed sandpiper at site 16.1 (Boyters Lane flooded paddocks) only (Figures 13 to 19). Bar-tailed godwit was recorded at six estuarine sites, including three roosts (sites 34, 36 & 37), and three feeding areas (sites 5, 6/6.1, & 35). All sites used by bar-tailed godwit were in the Macleay Arm (Figure 13). The highest number of bar-tailed godwit recorded at a single site at mid tide was 25 at Macleay Arm sandflat (Site 35). The highest number recorded at a single high tide roost was 15 at Macleay Arm saltmarsh #2.

Eastern curlew was recorded at seven sites, four foraging sites (sites 6/6.1, 20, 35, 41) and three roosts (sites 36, 37, 42). Six of these sites were in the lower estuary, with four in the Macleay Arm and two near Spencers Creek. The other site, Pelican Island sandspit (#20) was situated in the upper estuary (Figure 15). The highest count of eastern curlew recorded at a single roost was 25 at Spencers Creek (site 42), and during a neap high tide at Macleay Arm sandflat (site 35). The highest count of eastern curlew recorded at low tide was 19 at Macleay Arm sandflat.

Table 11: Maximum and average (\pm sd) counts of shorebirds, species richness of shorebirds, number of migratory species, and number of threatened shorebird species recorded at each sample site.

Site No.	Site Name	Max count	Average count (SD + n)	Total species	Migr species	EPBC Act (thr)	BC Act
1 & 1.1	Grassy Head Beach - nth end	1	0.17 (sd=0.41, n=6)	1	0	0	1
2 & 2.1	Millington Avenue	0	n=6	NA	NA	NA	NA
3, 3.1, 4	Stuarts Point Beach	1	0.33 (sd=0.52, n=6)	1	0	0	1
5.0	Macleay Arm Site 1 (south of caravan park)	7	1.17 (sd=2.86, n=6)	2	1	1	0
6 & 6.1	Macleay Arm - Fishermans Reach	9	1 (sd=3, n=9)	3	3	2	0
7.0 & 7.1	Back Beach	1	0.25 (sd=0.46, n=8)	1	0	0	1
8.0	Back Creek footbridge	3	0.875 (sd=1.25, n=8)	1	0	0	0
9 & 9.1	Front Beach	0	n=7	NA	NA	NA	NA
10.0	Saltwater Creek #1	2	0.67 (sd=1.03, n=6)	1	0	0	0
10.1	Saltwater Creek #2	3	1.5 (2.12, n=2)	1	0	0	0
10.2	Saltwater Creek #3	0	n=5	NA	NA	NA	NA
11.0	Saltwater Lagoon	4	2 (sd=2.83, n=2)	1	0	0	0
12	North Smoky Beach	0	n=6	NA	NA	NA	NA
13 & 13.1	South Smoky Beach/Hat Head beach	4	3.14 (sd=0.38, n=7)	1	0	0	1
14 & 14.1	Saltaire	511	285.5 (sd=124, n=10)	8	5	1	1
14.4 & 14.5	Saltaire shoreline	9	2 (sd=3.04, n=9)	4	3	0	0
15 & 15.1	Boyter's Lane wetland - east	207	81.6 (sd=73.56, n=10)	3	1	0	0
15.2	Boyter's Lane wetland - rehab	90	31.7 (sd=35.67, n=10)	3	1	0	0
16.0	Boyter's Lane wet paddocks, south	249	137.4 (sd=79.8, n=10)	7	4	0	1
16.1	Boyter's Lane wet paddocks, north	366	239.7 (sd=81.42, n=10)	9	5	0	0
17.0	Andersons Inlet	4	1.29 (sd=1.6, n=7)	5	3	2	1
17.1	Clybucca Creek	29	16.6 (sd=13.2, n=5)	4	3	0	1
18.0	Macleay River opposite Suez Road	16	2 (sd=4.99, n=10)	3	1	0	0
19 & 19.1	Pelican Island	0	n=6	NA	NA	NA	NA
20	Pelican Island sandspit	159	37.1 (sd=57.5, n=9)	4	3	1	0
21	Long Reach Island	0	n=6	NA	NA	NA	NA
24 & 25	Killicks Beach/Ryans Cut/Richardsons Crossing	14	9.6 (sd=3.65, n=5)	4	1	0	1
26 & 27	Goolawah Beach	0	n=6	NA	NA	NA	NA
28.0	Barries Beach nth end	3	1 (sd=1.41, n=5)	1	0	0	1
28.1	Barries Beach sth end	4	2.6 (sd=0.89, n=5)	2	0	0	1
29	Macleay Arm north Stuarts Point	0	n=6	NA	NA	NA	NA
30	Stuarts Point footbridge	5	3.33 (sd=2.89, n=3)	1	0	0	0
31	Macleay Arm oysters #2	3	1 (sd=1.73, n=3)	1	1	0	0
32	Macleay Arm Oysters #3	2	0.29 (sd=0.76, n=7)	1	0	0	0
33	Seagrass Inlet	3	0.44 (sd=1.01, n=9)	1	1	0	0
34	Whimbrel roost	32	43 (sd=31, n=3)	2	2	1	0
35	Macleay Arm Sandflat	128	90 (sd=27.2, n=5)	9	6	2	1
36	Macleay arm Saltmarsh #1	24	8.83 (sd=10.70, n=6)	6	5	2	0
37	Macleay Arm saltmarsh #2	78	35.4 (sd=35.3, n=5)	5	4	2	0
38	SW Rocks Creek upstream	4	n=1	1	1	0	0

Site No.	Site Name	Max count	Average count (SD + n)	Total species	Migr species	EPBC Act (thr)	BC Act
39	Macleay Arm rocks - Tattler roost	43	10.75 (sd=21.5, n=4)	2	1	0	0
40	Boat Ramp bay & saltmarsh	3	0.8 (sd=1.3, n=5)	1	1	0	0
41	Boat Ramp sandflat	6	4.75 (sd=1.5, n=4)	4	3	1	1
42	Spencers Creek	70	33 (sd=24.72, n=8)	6	4	1	0
43	Suez Road small claypan	22	15.5 (sd=9.19, n=2)	2	1	0	0
44	Suez Road wetland	135	53 (sd=59.90, n=6)	6	3	0	0
45	Macleay river bank	18	12 (sd=7.79, n=4)	1	0	0	0
46	Macleay River upstream sandspit	96	28.4 (sd=38.4, n=5)	4	2	0	0
47	SWR Headland	2	2 (sd=0, n=2)	2	0	0	1
48	Laggers Point	0	NA	NA	NA	NA	NA
49	Trial Bay Headland	3	0.83 (sd=1.17, n=6)	2	0	0	1
50	Korogoro Ck #1	2	0.3 (sd=0.82, n=6)	1	0	0	0
51	Korogoro Ck #2	2	1 (sd=1, n=5)	1	0	0	0
52	Korogoro Ck #3	3	1.6 (sd=1.52, n=5)	2	1	0	0
53	Korogoro Ck #4	2	1 (sd=1, n=5)	1	0	0	0
54	Pebbly beach little nobby	2	1.6 (sd=0.89, n=5)	1	0	0	1
55	Big Hill Point to Delicate Nobby	3	2.2 (sd=1.09, n=5)	2	0	0	1
56	Seale Road wetland	343	114.8 (sd=133.5, n=5)	4	2	0	0
57	Point Pioneer to Pt Plummer outside LGA	3	0.8 (sd=1.30, n=5)	1	0	0	1

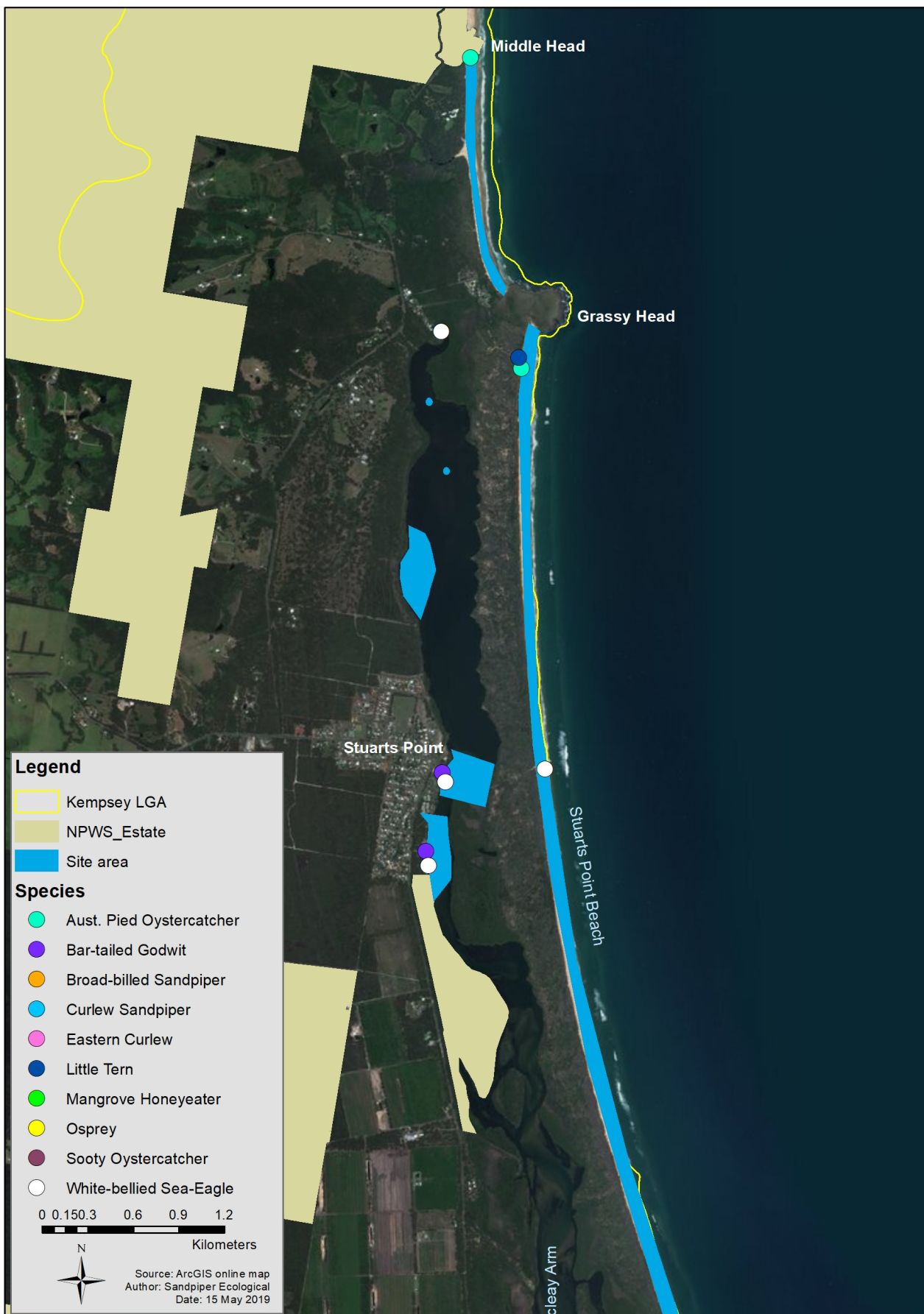


Figure 13: Threatened species records in the Macleay Arm and around Stuarts Point.

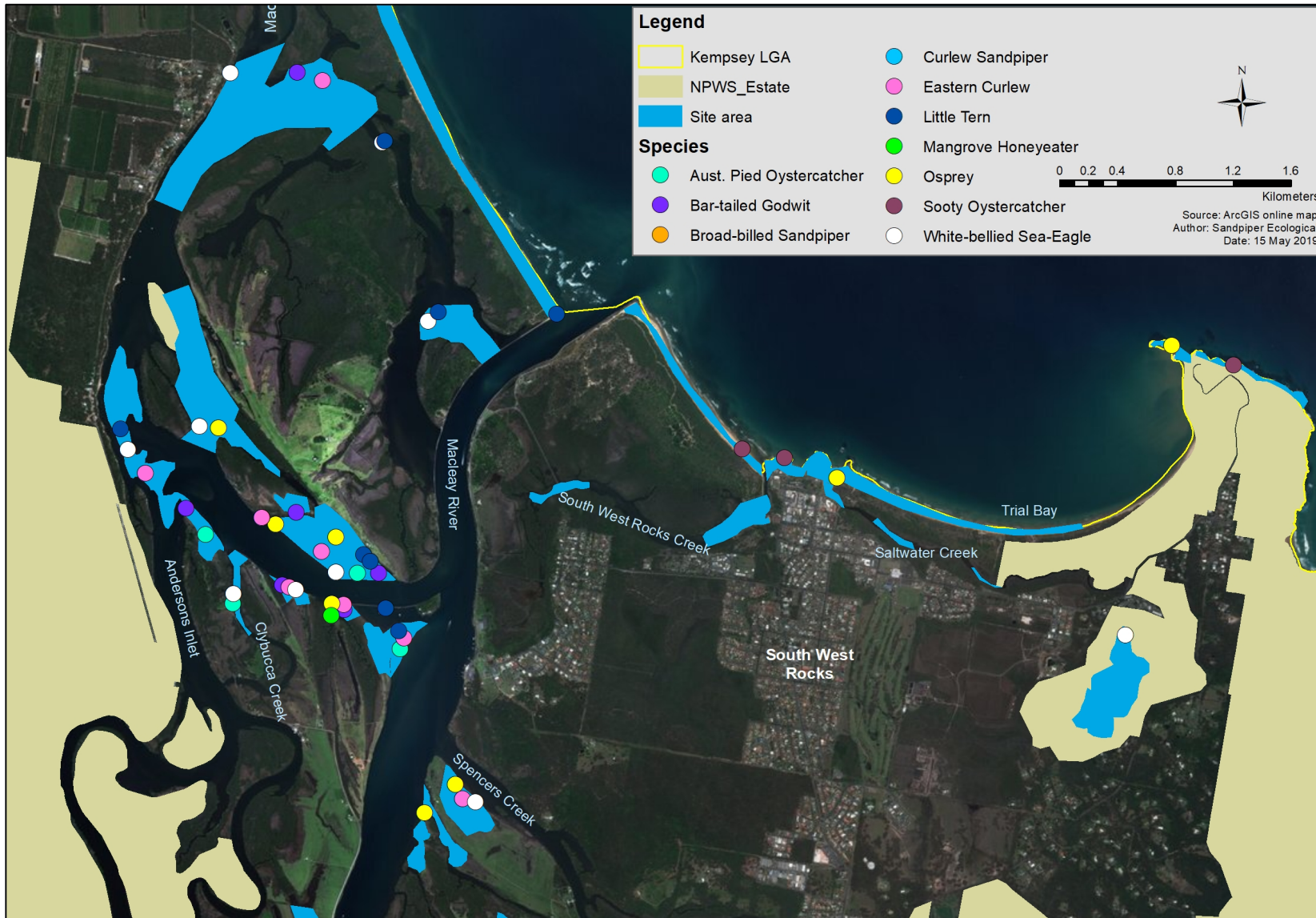


Figure 14: Threatened species records in the lower Macleay Arm and Macleay River.

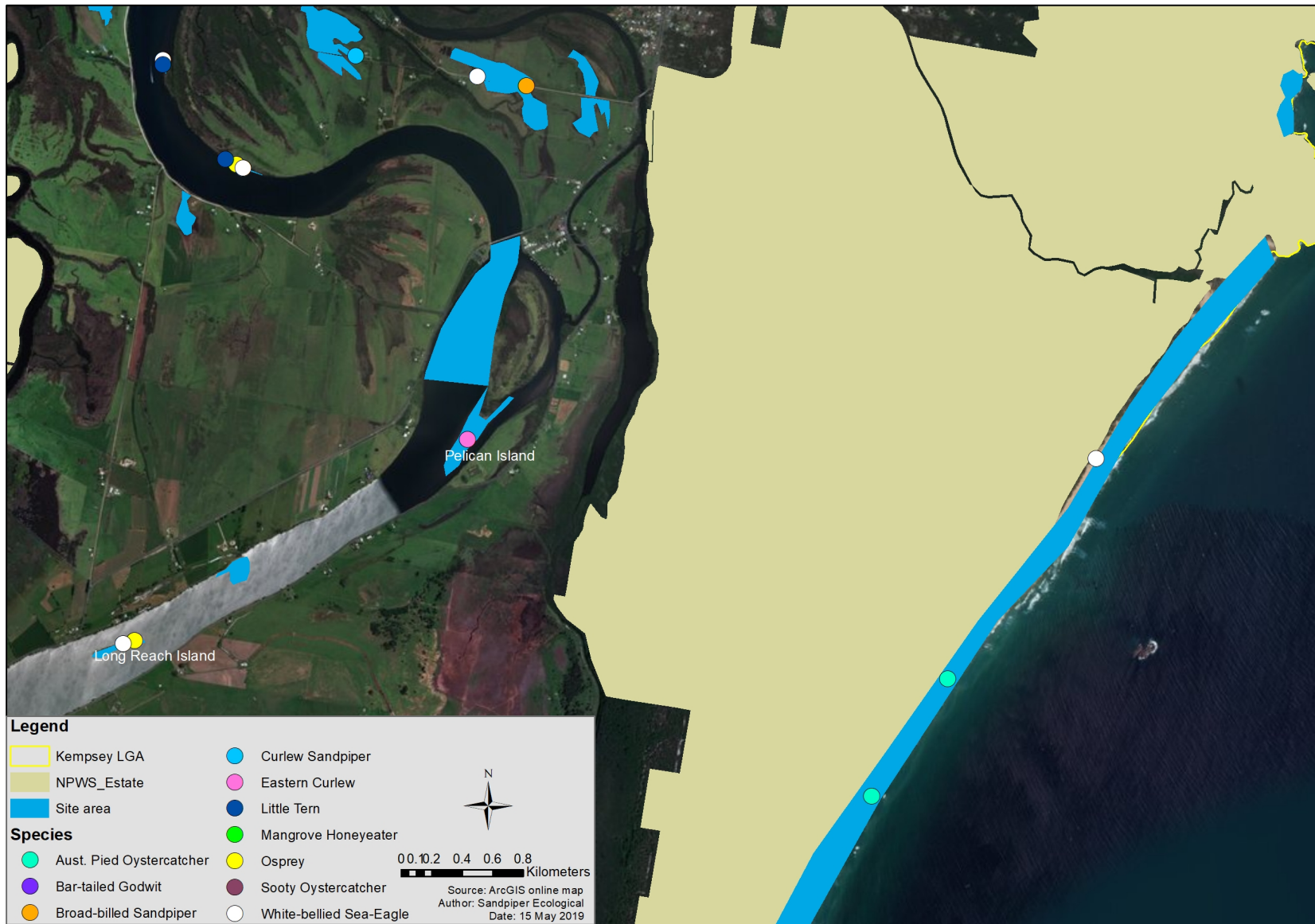


Figure 15: Threatened species records in the Macleay River and Hat Head Beach.

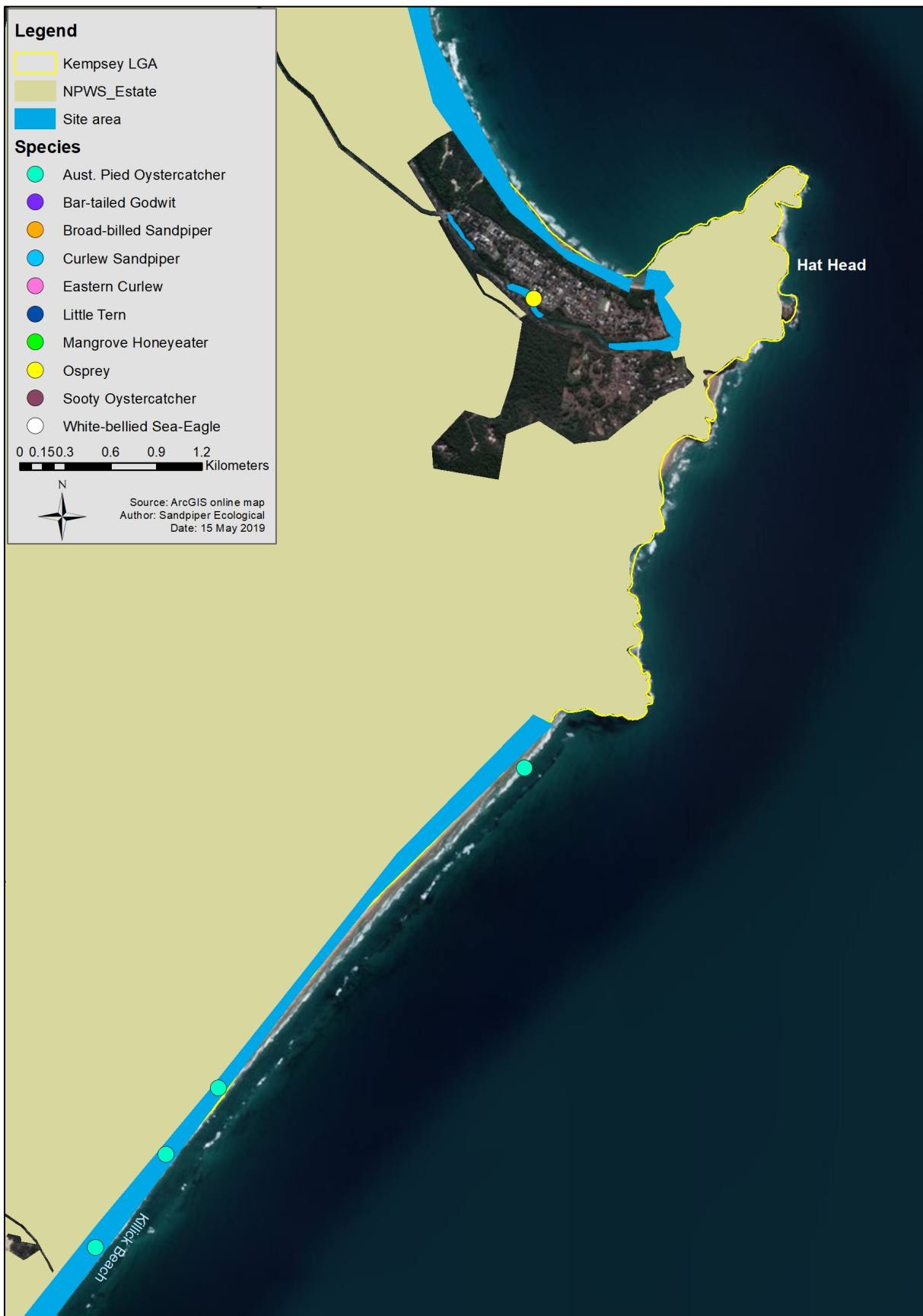


Figure 16: Threatened species records at Hat Head and on Killick Beach.

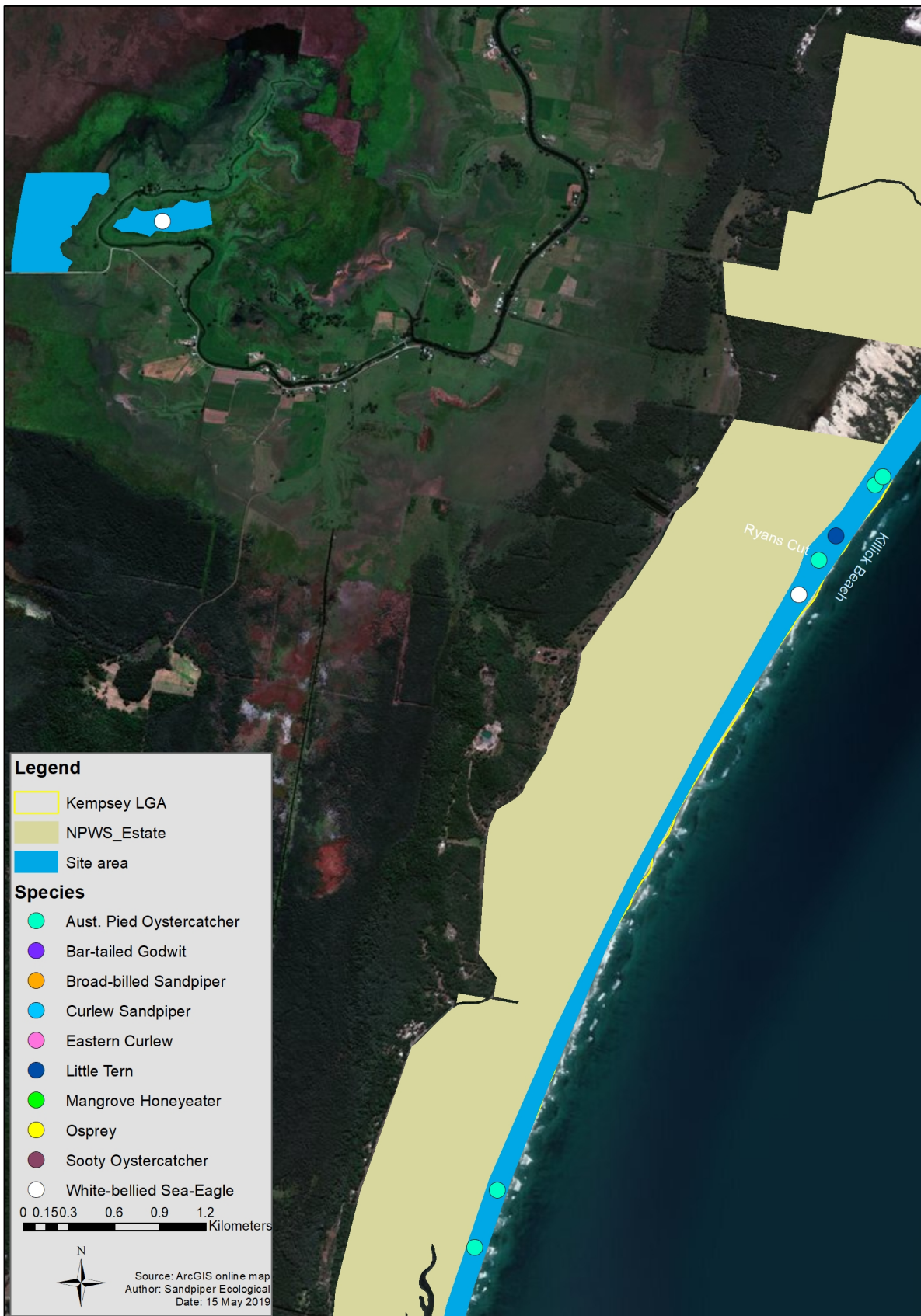


Figure 17: Threatened species records on Killick Beach.

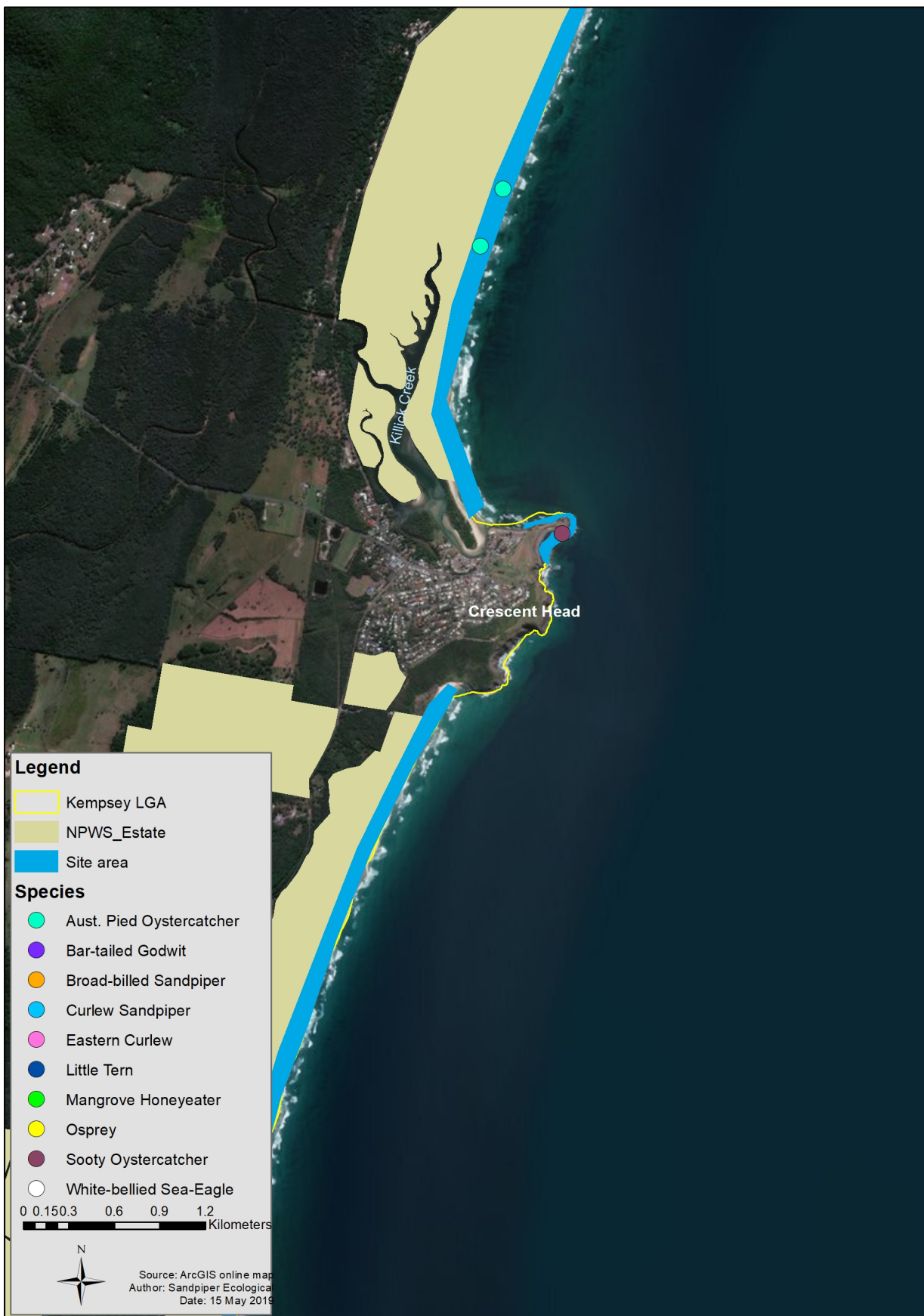


Figure 18: Threatened species records at Crescent Head and Goolawah Beach.

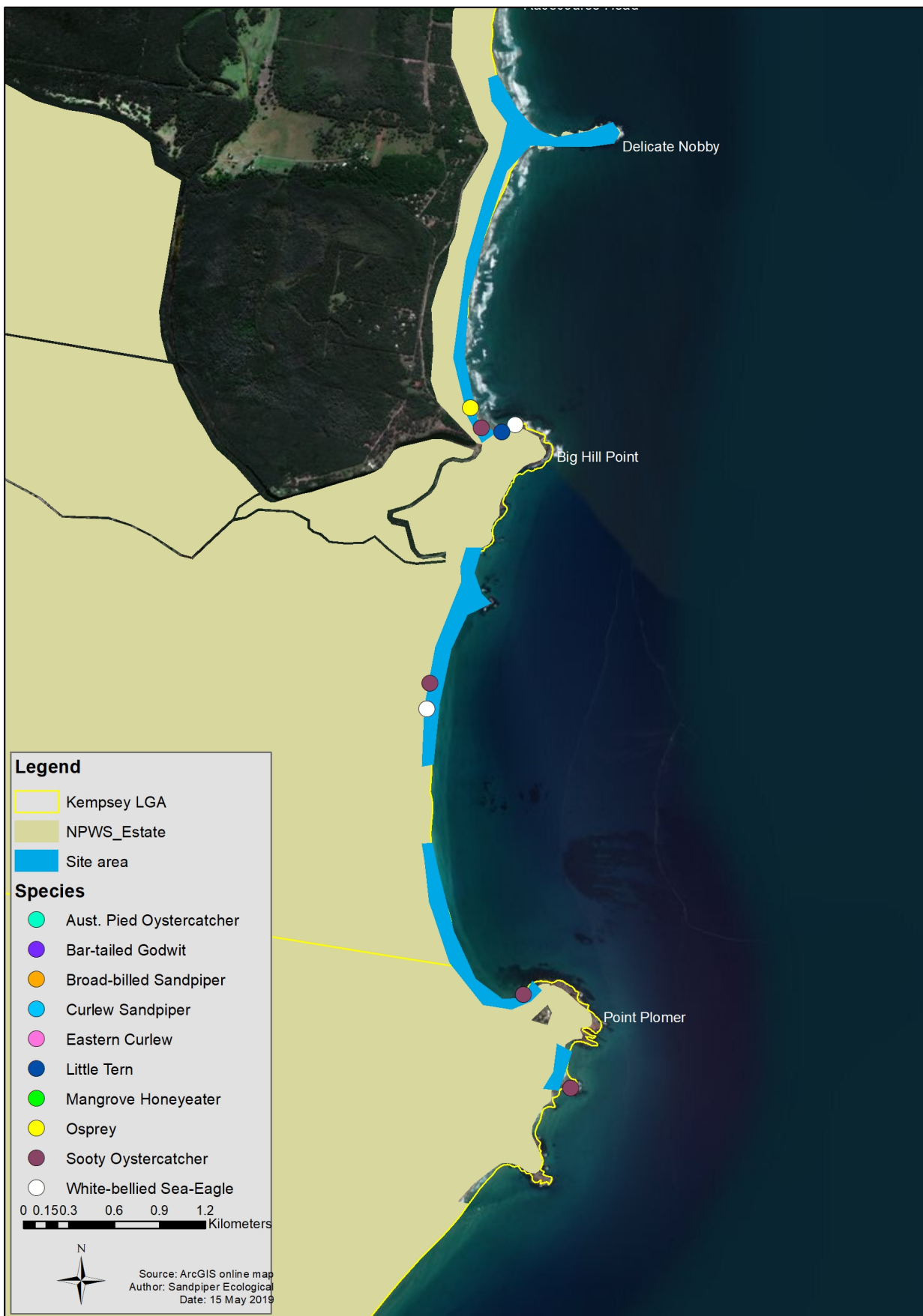


Figure 19: Threatened species records between Delicate Nobby and Point Plomer.

4.3.2 Site prioritisation

The site prioritisation identified three very high, four high, 11 medium, and 37 low priority sites (Figures 20 to 23). Medium to very high priority sites are presented in Table 12 and the ranking for all sites is presented in Appendix B. Very high priority sites, in rank order, were Macleay Arm sandflat, Saltaire, and Macleay Arm saltmarsh #2. Macleay Arm sandflat scored substantially higher than all other sites as it is the primary foraging site for eastern curlew, bar-tailed godwit, whimbrel and grey-tailed tattler in the Macleay estuary. Macleay Arm sandflat is situated in the lower reaches of the estuary, and is one of the first foraging areas exposed. The site is also used as a neap tide roost.

High priority sites, in rank order, were Spencers Creek, Boyters Lane wet paddocks north, Macleay Arm saltmarsh #1, and Clybucca Creek (Table 12). Spencers Creek ranked highest of these sites as it is a spring tide roost that at times supported 100% of the eastern curlew population. Other migratory species recorded at Spencers Creek were Pacific golden plover and sharp-tailed sandpiper. Boyters Lane wet paddocks (north) supported large numbers of sharp-tailed sandpiper and black-winged stilt, and >50% of the local populations of red-kneed dotterel and black-fronted plover. Macleay Arm saltmarsh #1 consistently provided roosting habitat for grey-tailed tattler and Pacific golden plover, and was used by small numbers of eastern curlew and bar-tailed godwit. Further sampling may prove that the site supports >50% of the local population of some species. Clybucca Creek (site 17.1) consistently supported a substantial number of grey-tailed tattler, and a pair of Australian pied oystercatchers.

Notable medium priority sites were Pelican island sandspit, which provided important foraging habitat for Pacific golden plovers during some low tides, and Killicks Beach which supported >50% of the Australian pied oystercatcher, and red-capped plover populations in the study area. Killicks Beach was the only coastline site to rank above low.

Table 12: Very high, high, and, medium priority sites identified from the site prioritisation.

Site No.	Site Name	Priority Score	CE & V Species (EPBC)	Spr roost	>50% local popn	Total	Ranking
6 & 6.1	Macleay Arm - Fishermans Reach	9	8			17	Medium
14 & 14.1	Saltaire	29	5		20	54	Very high
14.4 & 14.5	Saltaire shoreline	10				10	Medium
16.0	Boyer's Lane wet paddocks, south	21				21	Medium
16.1	Boyer's Lane wet paddocks, north	26			10	36	High
17	Andersons Inlet	13	8			21	Medium
17.1	Clybucca Creek	10		10	10	30	High
20	Pelican Island sandspit	11	5		10	26	Medium
24 & 25	Killicks Beach	8			10	18	Medium
31	Macleay Arm oysters #2	3		10		13	Medium
34	Whimbrel roost	8		10	10	28	Medium
35	Macleay Arm Sandflat	24	8		40	72	Very high
36	Macleay arm Saltmarsh #1	16	8	10		34	High
37	Macleay Arm saltmarsh #2	13	8	10	20	51	Very high
39	Macleay Arm rocks - Tattler roost	4		10	10	24	Medium
41	Boat Ramp Sandflat	12	5			17	Medium
42	Spencers Creek	14	5	10	10	39	High
44	Suez Road large claypan	13			10	23	Medium
56	Seale Road wetland	13				13	Medium

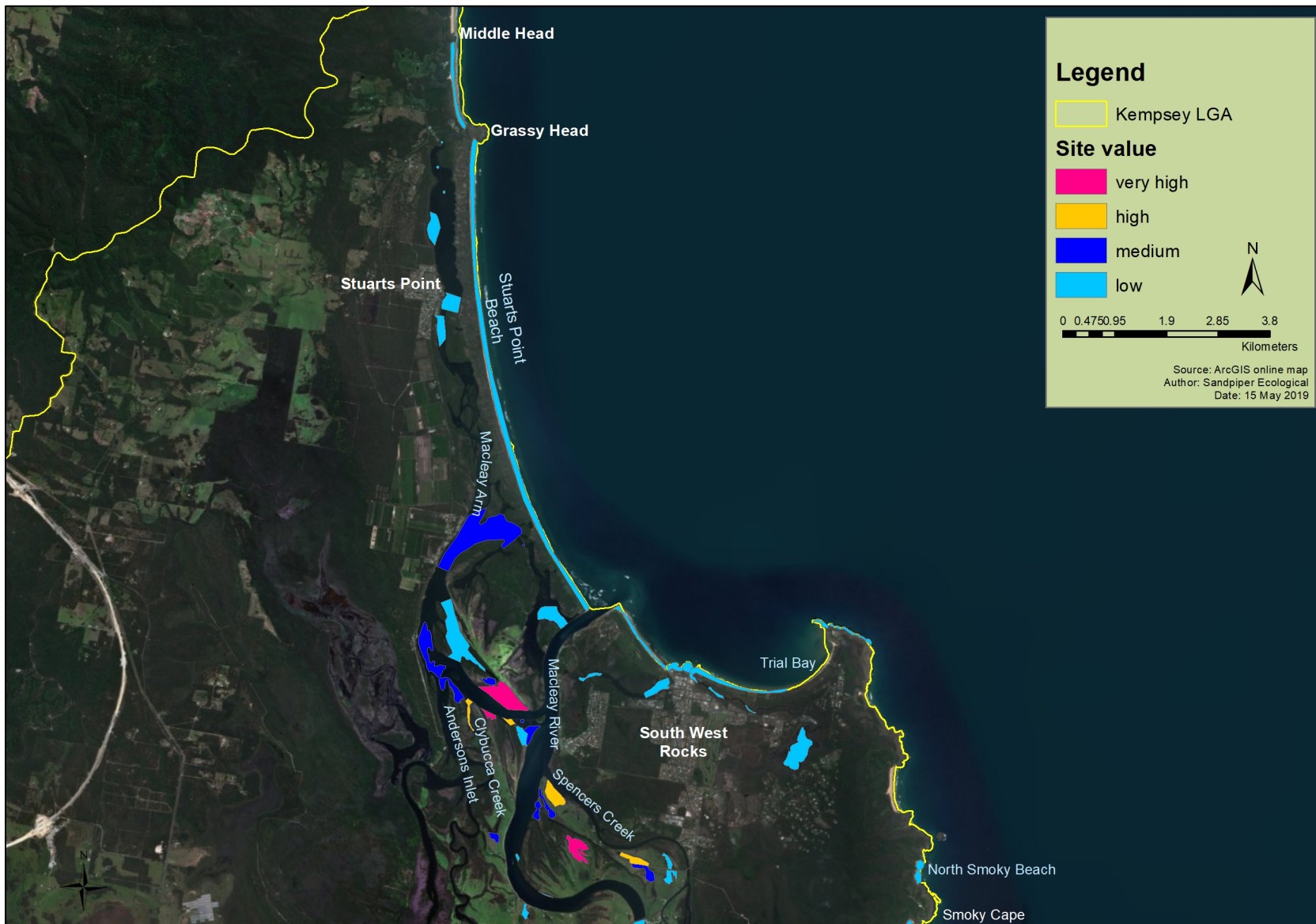


Figure 20: Site values prioritization of Macleay Arm and South West Rocks area.



Figure 21: Site values prioritisation of Macleay River and Hat Head.

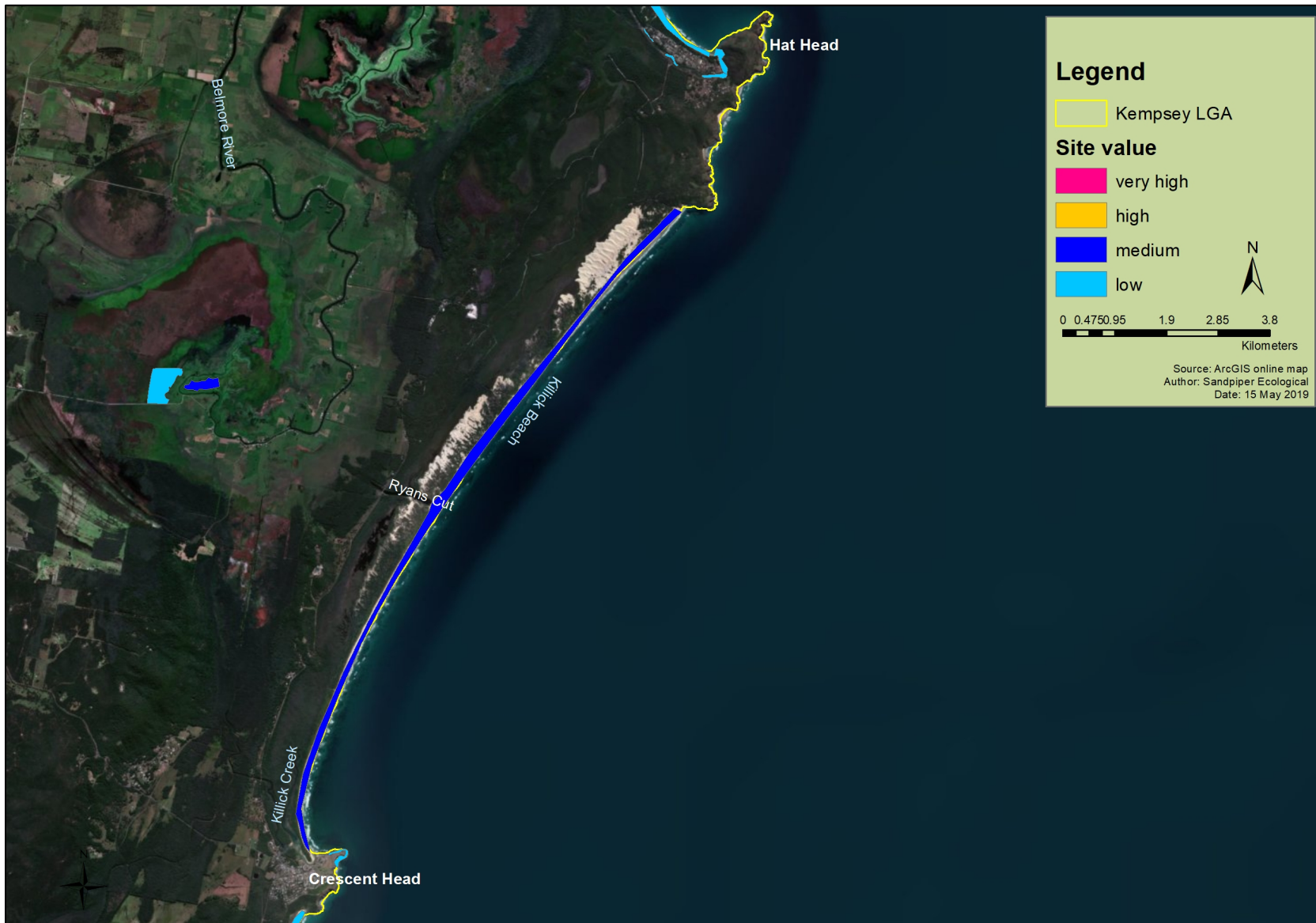


Figure 22: Site values prioritisation of Killick Beach and Crescent Head.

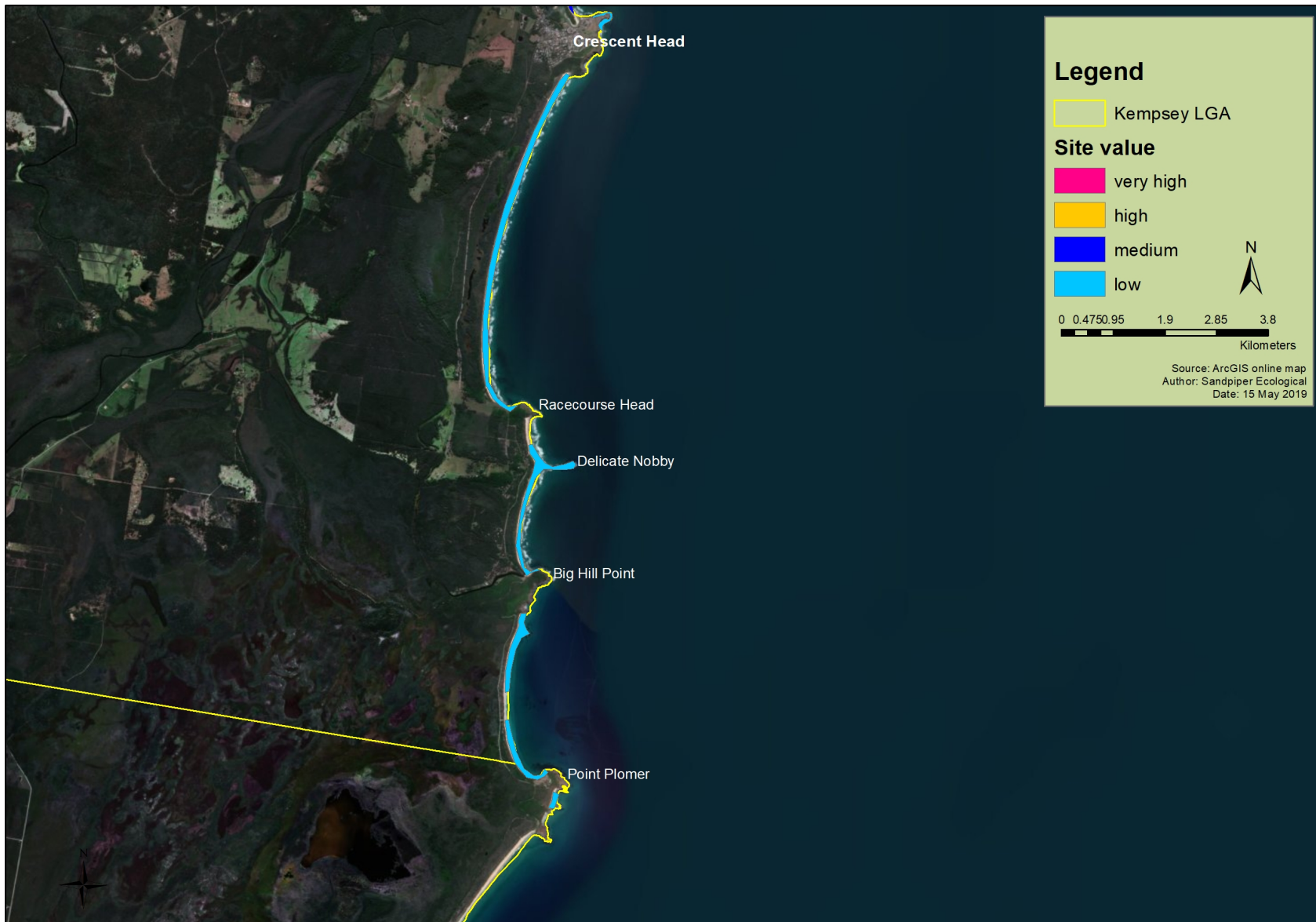


Figure 23: Site values prioritization of Crescent Head to Point Plomer.

4.4 Community information session

Twenty local residents, and members of local ornithological groups, such as the Hastings Valley Bird Watchers, attended the community information session. The discussion on shorebird threats identified several additional potential threats to those recorded during the field survey. Additional potential threats highlighted by the community included; horse riding, litter, jet skis, and cats. The community also provided further details on the distribution and intensity of threats in the study area. This information has been included in the following threat prioritisation. Local ornithologists also emphasised the importance of freshwater floodplain wetlands to shorebirds.

4.5 Threat prioritisation

4.5.1 Threats identified during the field survey

In general, there was limited direct observation of disturbance to shorebirds during the field survey, although several potential threats to shorebirds and their habitat were identified (Table C1, Appendix C). Types of potential threats included: people moving (within shorebird habitat), dogs on and off leash, 4WD vehicles, boats, fishers, road vehicles, and habitat modification. Habitat modification included bank erosion, colonisation of habitat by mangroves, altered hydrology of tidal lagoons, and agriculture/cattle.

People were recorded moving on foot at 28 sites with high frequency of occurrence (>60% of samples) recorded at 12 sites (Table C1; Appendix C). Grassy Head Beach, Stuarts Point Beach, Back beach, South West Rocks Creek, Front Beach, South Smoky/Hat Head Beach, Killick Beach, Korogoro Creek, and Big Hill Point to Delicate Nobby had the highest levels of human activity. Apart from Killick Beach these sites also had low numbers of shorebirds. Off-leash dogs were recorded at 12 sites and on leash dogs at four sites. Seventy-five percent of sites with dogs off leash coincided with sites where there was a high frequency of people walking. Dogs off leash were recorded at several sites adjoining national parks, including South Smoky/Hat Head Beach, Killicks Beach, Goolawah Beach and Delicate Nobby.

Fishers and boats were recorded infrequently (i.e. 20-40% of surveys) at 10 and 15 sites respectively. The highest occurrence of boats was around the Macleay Arm sandflat. Four-wheel drive vehicles were recorded at five sites and road vehicles at three sites. The three sites with road vehicles were all on Boyters Lane. The highest levels of 4WD vehicle activity was recorded on South Smoky/Hat Head and Killicks Beaches and correlated with a high frequency of people moving on foot.

Colonisation of habitat by mangroves was most severe at Macleay Arm saltmarsh #1 where mangroves (predominantly *Avicennia marina*) have colonised most of the saltmarsh. Colonisation at that site is in an advanced state. Evidence of minor mangrove colonisation was recorded at the south and north ends of Pelican Island. No feral predators were observed during the survey, although foxes are reportedly a problem at Boyters Lane (D. Adams pers. comm.).

During the sample period a tidal channel into a small tidal lagoon on the south side of Boyters Lane (site 14.1) was blocked and a drain dug to improve drainage. The aim of this work was seemingly to promote pasture growth. Part of site 16.1, also on Boyters Lane, was lightly tilled/aerated presumably to facilitate grass growth.

Cattle were regularly recorded in claypans and floodplain wetlands at sites 15, 16, 23, 44, and 56. The presence of cattle in wetlands has both positive and negative effects on shorebirds. Negative impacts include disturbance of the substrate and inputs of nutrients. Positive impacts include suppression of vegetation growth and providing a source of nutrients for invertebrates, which represent shorebird prey.

4.5.2 Threat prioritisation at each sample site

Analysis of threats recorded during the field survey at each sample site shows the highest level of threat at ocean beaches. Big Hill Point to Delicate Nobby, Killick Beach, Goolawah Beach, South Smoky Beach, and Stuarts Point Beach all recorded threat scores of seven or eight (Table C2, Appendix C). These sites were followed by other beaches and high use recreation areas, including Grassy Beach, Macleay Arm site 1, Back Beach, Back Creek footbridge, Front Beach, and Korogoro Creek (Table C2). Boyters Lane wetland east (site 15 & 15.1) recorded a higher than expected threat level due to the regular presence of pedestrians and dogs off leash. This result does not reflect actual disturbance at that site as disturbance was restricted to the road adjoining the site.

Sources of disturbance were also highest at ocean beaches and sites near major recreation areas (Table C2). The highest scoring sites were: Macleay Arm site 1, Killicks Beach, Goolawah Beach, and Korogoro Creek. Sites with the highest cumulative (recorded and source) disturbance scores, in rank order, were Goolawah Beach, South Smoky Beach, Macleay Arm site 1, Killick Beach, Big Hill Point to Delicate Nobby, and Korogoro Creek. Grassy Head Beach, Back beach, Back Creek footbridge, Front Beach, and Stuarts Point Beach also scored highly (Table C2).

The site value by threat analysis identified three sites with a very high (scores >200) rating, Macleay Arm sandflat (360), Killick Beach (234), and Saltaire (216), and five sites with a high rating (scores 100 – 199), Macleay Arm saltmarsh #2 (153), Clybucca Creek (150), Anderson Inlet (126), Spencers Creek (117), and Macleay Arm saltmarsh #1 (102) (Figures 24 to 27). The value by threat analysis provided similar results to the site value analysis with exception of Killick Beach, which increased from a medium to very high ranking based on a high threat level.

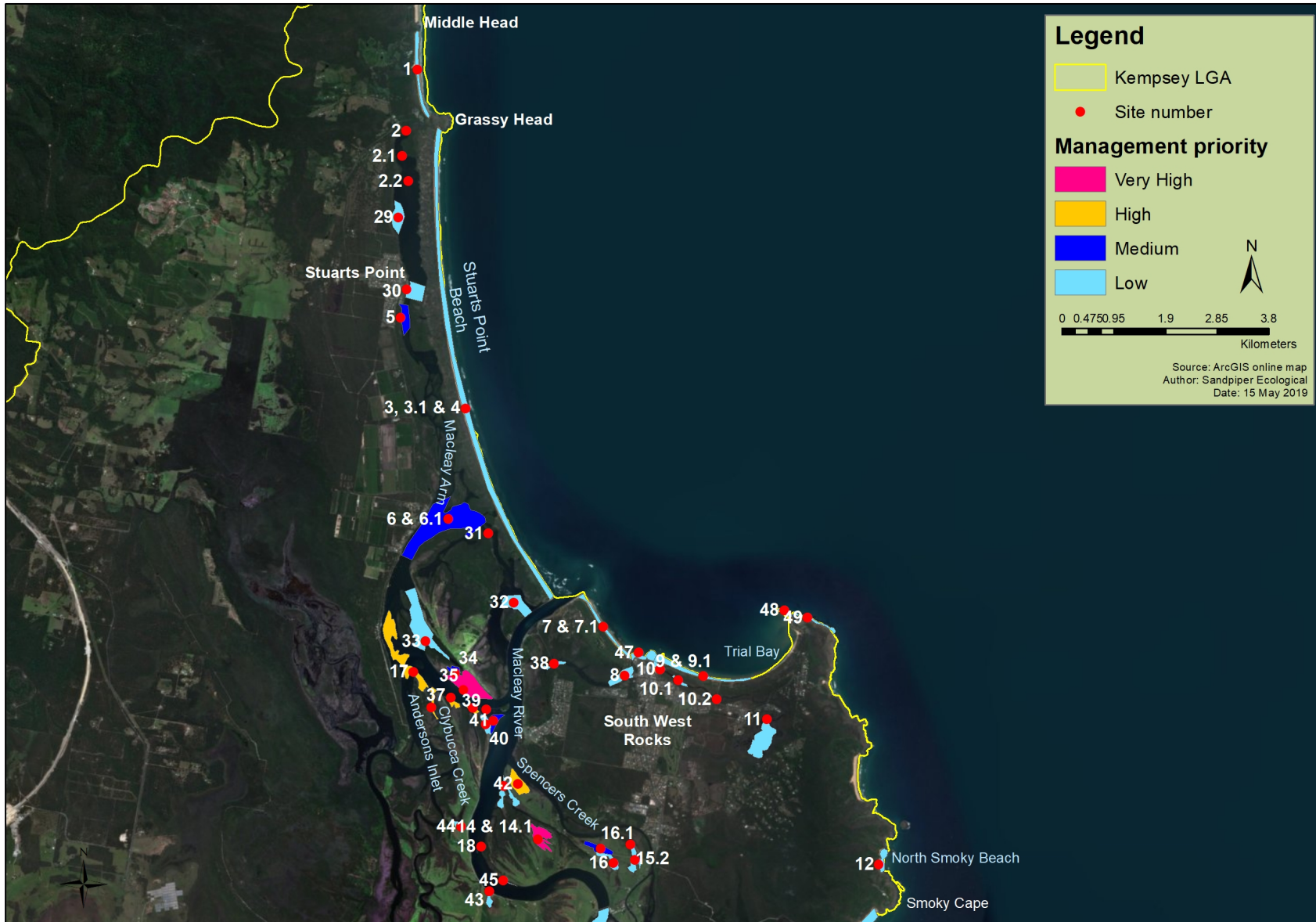


Figure 24: Management priorities in the lower Macleay Estuary.



Figure 25: Management priorities in the upper Macleay Estuary and Hat Head area.

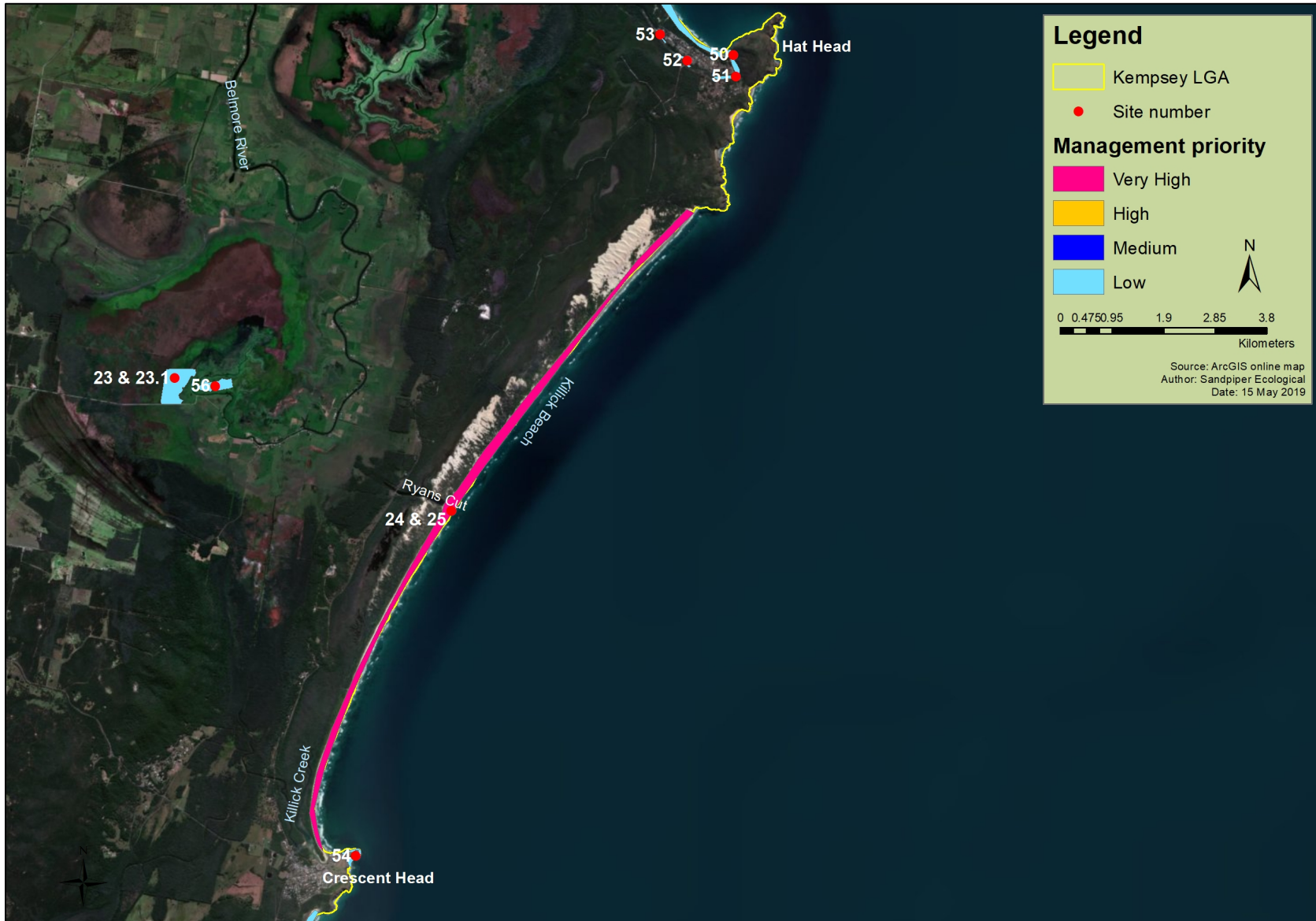


Figure 26: Management priorities between Hat head and Crescent Head.



Figure 27: Management priorities between Crescent Head and Point Plomer.

4.6 Estuarine birds

Forty-four species of estuarine bird were recorded during the survey, with counts ranging from 3173 to 5038 individuals per sample. The peak count of 5038 individuals occurred during sample two and coincided with a spring tide cycle. Teal (chestnut and grey) were the most abundant estuarine species with up to 1355 individuals recorded during sample 2. Other large counts included 813 greater crested tern (sample 2), 441 silver gull (sample 5), 257 common tern (sample 5), and 189 little tern (sample 3)

Five threatened species of estuarine bird were recorded during the survey. The most widespread species was white-bellied sea-eagle which was recorded at 23 sites, followed by osprey (11 sites), little tern (11 sites), black-necked stork (1 site) and mangrove honeyeater (1 site). The Macleay estuary is outside the recognised range of mangrove honeyeater, with the nearest record, according to the Atlas of NSW Wildlife, occurring at Urunga. Apparently, Glen Holmes a renowned ornithologist, recorded mangrove honeyeater in the Macleay estuary in the 1980's (D. Charley pers comm). The individual recorded during this study was heard calling from mangroves near site 36 in the Macleay Arm.

5. Discussion

5.1 Shorebird habitat in the study area

5.1.1 Roosting habitat

Several shorebird roosts were identified in the lower estuary, including the lower reaches of the Macleay Arm. Shorebirds were recorded using a variety of habitats including saltmarsh, sandspits and banks, rock groins, oyster racks, mangroves, and ocean beaches. Some sites, such as those on Boyters Lane (sites 14, 15, & 16) function as both roost and foraging habitat. No evidence of bird movement between the Boyters Lane sites and estuary was recorded during this survey, however, such movement is likely given their proximity.

There were notable differences in roosts between spring and neap tides. During neap high tides shorebirds remained at the Macleay Arm sandflat, with birds dispersing to nearby saltmarsh roosts as the sandflat becomes inundated at higher tides. During high spring tides whimbrel and bar-tailed godwit moved to mangroves to roost and eastern curlew congregated at a saltmarsh in Spencers Creek. No shorebirds were recorded moving from the estuary to roost on nearby ocean beaches, although residents suggested that double-banded plovers roost on Back Beach in winter. Suitability of Stuarts Point Beach immediately north of the river mouth appears constrained by beach width. Pied and sooty oystercatchers roosted and foraged in the same areas with exception of a pair of pied oystercatchers that move between Stuarts point Beach and the Macleay Arm.

In general roosts within the lower estuary, particularly the Macleay Arm, likely experience high levels of disturbance and are constrained by size. The absence of an exposed sandbar/spit or suitable ocean beach may explain the low numbers of migratory shorebirds using the estuary.

5.1.2 Foraging habitat

Wetlands along Boyters Lane provide important foraging habitat for sharp-tailed sandpipers and black-winged stilts. Estuarine sandflats, particularly those in the Macleay Arm provide foraging habitat for eastern curlew, whimbrel, bar-tailed godwit, Pacific golden plover, and grey-tailed tattler. Whilst not confirmed during this study it is likely that shorebirds move upstream within the Macleay Arm as the tide recedes and intertidal flats become exposed. This pattern of behaviour is typical of other north coast estuaries. All the tidal flats in the lower Macleay Arm likely provide an important function for shorebirds and further low tide surveys are warranted to confirm use of these habitats.

Foraging habitat in the Macleay River is limited, with exception of the Pelican Island, and Macleay River upstream sandspits. The former site represents the major Pacific golden plover foraging habitat in the estuary, and the latter is used by Pacific golden plover, black-winged stilt, and masked lapwing. Double-banded plovers are also predicted to utilise the Pelican Island site. The presence and abundance of golden plovers at Pelican Island appears correlated with soldier crab (*Mictyris* spp) activity. Soldier crabs represent an important prey

item for golden plovers and a similar relationship between bird abundance and crab activity has been recorded elsewhere on the north coast (Rohweder & Baverstock 1996). Evidence gathered during this survey suggests that soldier crabs were most active during spring tides and it was during those tides when plover abundance peaked.

5.1.3 Freshwater floodplain wetlands

Three freshwater floodplain wetlands were sampled, Suez Road wetland, Seale Road Wetland, and Belmore Swamp. The latter site was dry throughout the survey and supported no shorebirds and the two former sites were wet for part of the survey period only. The community emphasised the importance of floodplain wetlands to shorebirds during the community information session.

ASM *et al.* (2010) mapped wetlands on the Macleay Floodplain (Figure 28). According to ASM *et al.* (2010) the floodplain contains almost 900ha of swamp and spike rush-water couch communities that may represent suitable habitat for shorebirds. Approximately 10% of the total area of floodplain wetland would have been sampled during this study and there is a high likelihood that shorebirds utilise unsampled freshwater floodplain wetlands. Pacific golden plovers were observed flying from Pelican Island to the southeast, towards an unsampled floodplain wetland.

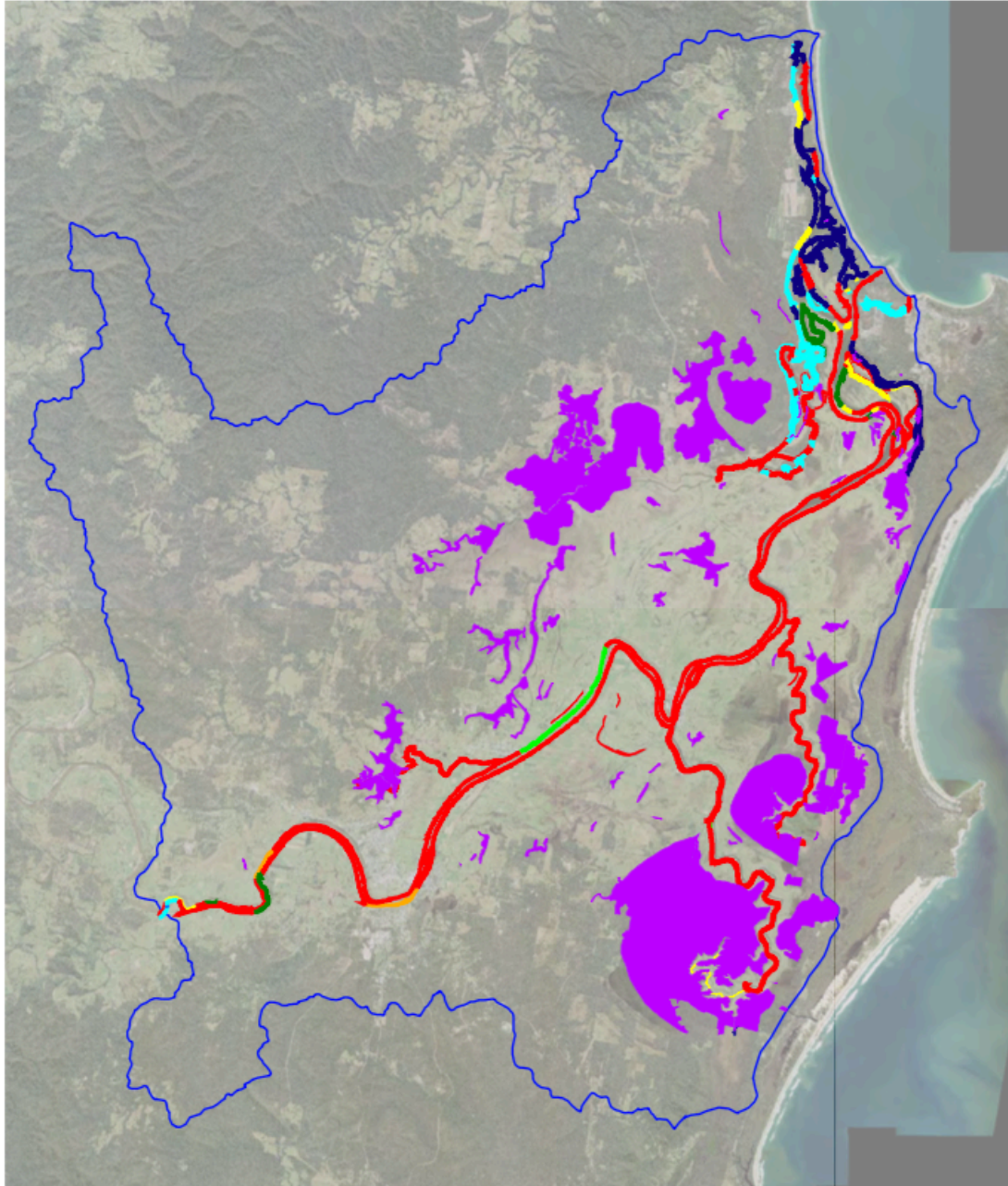
5.2 Significance of the Macleay Coast to shorebirds

In a regional context, the Macleay Coast supports a high abundance and diversity of shorebirds. The maximum summer count of 1822 individuals means the Macleay Coast ranks second in shorebird abundance to the Clarence Estuary for all sites between Port Macquarie and Tweed Heads (Sandpiper Ecological 2009). Although this study sampled a much larger area than just the Macleay estuary the comparison to other estuaries is reasonable as most individuals and all species occurred in or immediately adjacent to the estuary. Species richness in the Macleay is also comparable to, or greater than, other north coast estuaries.














The shorebird population estimate for the Macleay Coast would increase with better survey coverage of floodplain wetlands. Only a small proportion (<10%) of floodplain wetlands were sampled during this study and it is highly likely that unsampled floodplain wetlands would support both migratory and resident shorebirds. Targeted survey of these wetlands would be a worthwhile addition to future surveys to enable the shorebird value of the Macleay Coast to be fully realised. Accurate sampling of floodplain wetlands may indicate that the Macleay Coast is one of the most important shorebird habitats in coastal NSW. With permission of landowner's drones may be a cost effective means of determining the number of shorebirds using floodplain wetlands.

Information shown is for illustrative purposes only

Map Created by Aquatic Science and Management, June 2010
 Data Sources: ID Management (2005), NRCMA (2006)



LEGEND

- | | | | |
|---|-----------------|---|---|
|  | Not assessed |  | Freshwater Swamp or Marsh |
|  | Intact |  | Freshwater Lagoon |
|  | Low |  | Large Permanent Freshwater Lake (>8ha) |
|  | Low - Moderate |  | Permanent Freshwater Pond or Swamp (<8ha) |
|  | Low - High |  | Ecostudyarea.shp |
|  | Moderate | | |
|  | Moderate - High | | |
|  | High | | |

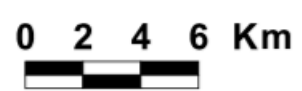


Figure 28: Location of floodplain wetlands in Kempsey Shire as mapped by ASM *et al.* (2019).

5.2.1 International and national populations

The Wildlife Conservation Plan for Migratory Shorebirds (DotE 2015) and Ramsar Convention consider sites to be of international importance if they support 1% of the flyway population and nationally important if they support 0.1% of the flyway population of an individual species (with exception of Latham's snipe for which the threshold is 0.05%). Based on the latest flyway population estimates (see Hansen *et al.* 2016) the Macleay Coast is Internationally important for sharp-tailed sandpiper, and nationally important for Pacific golden plover (Table 13). The Macleay Coast may also be nationally important for double-banded plover and Latham's snipe. Better coverage of floodplain wetlands is likely to substantially increase the Latham's snipe population estimate, and sampling in winter is required to confirm the population of double-banded plover.

Table 13: Counts for selected shorebird species that exceed the 1% (international significance) and 0.1% (national significance) thresholds (orange highlight).

Species	Macleay Coast Maximum Count	Flyway Population	1% of Flyway	0.1% of Flyway
Pacific golden plover	211	120,000	1,200	120
Sharp-tailed sandpiper	917	85,000	850	85
Latham's snipe	6	30,000	300	30 (15 @ 0.5%)
Double-banded plover	1	19,000	190	19

5.2.2 Sites of high conservation value

Wetlands along Boyters Lane (sites 14, 14.1, 15, 15.1, 15.2, 16, 16.1) collectively support nationally significant numbers of sharp-tailed sandpiper. The maximum count of 768 sharp-tailed sandpiper at the Boyters Lane sites on 13 February 2019 almost exceeds the 1% flyway threshold of 850. Whilst the number of sharp-tailed sandpipers present in 2018/19 was most likely elevated by drought conditions in inland NSW and Queensland the Macleay Coast may consistently support in excess of 1% of the flyway population of this species. Historical counts of 1200 sharp-tailed sandpiper suggest this is likely. Sites along Boyters Lane may also at times exceed the 1% threshold making them of high conservation value.

Pelican Island sandspit supported most of the Pacific golden plover population during spring low tides. The number of plovers at Pelican Island sandspit exceeded 0.1% of the flyway population on two occasions, making the site of high conservation value despite its ranking in the site prioritisation.

The site prioritisation highlighted the value of sites along Boyters Lane and the lower estuary, particularly the Macleay Arm. Conservation of saltmarsh and intertidal habitats in the lower Macleay Arm and at Spencers Creek combined with claypans and tidal lagoons along Boyters Lane would protect the majority of important shorebird habitat.

5.3 Additional shorebird habitat

As noted above there is a high likelihood that shorebirds utilise additional freshwater floodplain wetlands. Inclusion of these wetlands in future surveys would substantiate the high conservation value of the Macleay Coast for shorebirds. Whilst all effort was made to sample all estuarine roosts it is likely that some remain undetected. For example, eastern curlew were not recorded during the spring high tide survey in sample five but were recorded at low tide suggesting there is an unknown roost. Eastern curlew were recorded flying from the northwest towards Spencers Creek at peak high tide during survey two suggesting the possibility of a roost in the Anderson Inlet/Clybucca Creek area.

5.4 Survey limitations

The field survey represents one of the few systematic surveys of shorebird habitat on the Macleay Coast. There is a high degree of certainty with the data collected, however, survey results were constrained by a small number of issues including:

1. *Condition of floodplain wetlands* – Below average rainfall in 2018 and early 2019 and a hotter than average summer meant there was limited water in floodplain wetlands, such as Belmore Swamp and Seale Road. During wet years these wetlands may support more shorebirds than recorded in this study and their value to the shorebird community would be higher than the site value prioritisation has indicated. Notwithstanding, no shorebirds were recorded at Belmore Swamp during the 2016/17 surveys (InSight 2017). Including historical data in the site value prioritisation was raised during the community information session. Whilst this approach has some merit historical data would likely bias the analysis to sites with a high visitation rate such as Boyters Lane and Belmore Swamp at the expense of estuarine sites that are surveyed less frequently.
2. *Sample sites* – A number of the sample sites identified by InSight (2017) do not support shorebirds and do not warrant sampling during a systematic population survey. Inclusion of these sites detracted from sampling effort at other, more important, sites.
3. *Macleay Arm tidal lag* - Low tide surveys did not consistently capture the tidal lag in the Macleay Arm. As the tide recedes it is likely that shorebirds progressively move from the lower Macleay Arm upstream stopping at intertidal habitats as they are exposed. The failure to adequately capture this tidal lag during all low tide surveys means value scores for intertidal habitat in the Macleay Arm upstream of Macleay Arm sandflat are underestimates.

5.5 Comparison between 2018/19 and 2016/17

5.5.1 Shorebird species richness and abundance

Shorebird abundance and species richness was substantially higher in 2018/19 than 2016/17 (Table 14). This result is attributed to the inclusion of several additional estuarine sites in 2018/19, and the low abundance of shorebirds at the Boyters Lane wetlands (Sites 14 to 16)

in 2016/17. It is unknown if the Boyters Lane sites were dry or flooded in 2016/17. Either condition is likely to result in lower numbers of shorebirds as less foraging habitat would be available. The fact that some Boyters Lane sites were labeled as “flooded paddocks” suggests that water levels were high during the 2016/17 surveys.

Species richness of shorebirds in 2016/17 was 13 compared to 20 in 2018/19 (Table 14). Terek sandpiper and marsh sandpiper were recorded in 2016/17 but not in 2018/19. Red-necked avocet, red-capped plover, red-kneed dotterel, Pacific golden plover, double-banded plover, grey-tailed tattler, red-necked stint and broad-billed sandpiper were recorded in 2018/19 only. Masked lapwing was recorded in 2016/17 but individuals were not counted (InSight 2017). The population estimate of shorebirds in 2018/19 was 1822 compared to 273 in 2016/17. Once again this result is due to wetland condition and site selection. Several sites used by shorebirds in 2018/19 were not sampled in 2016/17, which makes any comparison of species richness or abundance invalid.

Table 14: Comparison of species richness and abundance in 2016/17 and 2018/19. NR = not recorded.

Common name	Maximum Counts	
	2016/17	2018/19
Australian Pied Oystercatcher	7	12
Sooty Oystercatcher	6	10
Black-winged Stilt	79	330
Red-necked avocet		1
Red-capped plover		7
Black-fronted Dotterel	4	4
Red-kneed Dotterel		7
Masked Lapwing	NR	119
Pacific Golden Plover		211
Double-banded Plover		1
Latham's Snipe	4	6
Bar-tailed Godwit	22	25
Whimbrel	6	58
Eastern Curlew	31	25
Grey-tailed Tattler		41
Terek Sandpiper	5	
Common Greenshank	2	6
Marsh Sandpiper	2	
Red-necked Stint		6
Sharp-tailed Sandpiper	16	951
Curlew Sandpiper	53	1
Broad-billed Sandpiper		1
Total species	13	20
Total individuals	273	1822

5.5.2 Site prioritisation

There are substantial differences in site prioritisation between 2016/17 and 2018/19. These differences are largely attributed to the inclusion of non-shorebird related values in the 2016/17 analysis (InSight 2017). High priority sites for management action identified by InSight (2017) included: Back Beach (site 7), Front Beach (site 9), Andersons Inlet (site 17), Back Creek footbridge (site 8), and Boyters lane wet paddocks (site 16). Of these sites only Andersons Inlet and Boyters Lane wet paddocks regularly supported shorebirds during the 2018/19 surveys, and both were identified as high value sites in the 2018/19 analysis. Other high priority sites identified in 2018/19 were Macleay Arm sandflat, Killicks Beach, Saltaire (sites 14 & 14.1), Macleay Arm Saltmarsh #2, Clybucca Creek, and Spencers Creek. These sites consistently supported shorebirds during the 2018/19 sample period.

5.6 Key outcomes

Key outcomes of the 2018/19 Macleay Coast shorebird surveys include:

1. Confirmation that the Macleay Coast supports comparable diversity and abundance of shorebirds to other large estuaries on the NSW North Coast, such as the Clarence and Richmond.
2. Confirms the presence of internationally and nationally significant populations of sharp-tailed sandpiper and Pacific golden plover.
3. Confirms the importance of freshwater floodplain and estuarine wetlands and the linkages between these habitats for migratory and resident shorebirds.
4. Supports the temporal trend of declining abundance of eastern curlew and bar-tailed godwit in the EAAF.
5. Confirms the presence of large populations of sharp-tailed sandpiper and Pacific golden plover that are equivalent to or greater than other North Coast estuaries.
6. Confirms the national and potential international importance of wetlands along Boyters Lane as foraging and roosting habitat for migratory and resident shorebirds.
7. Confirms the presence of several state and federally listed threatened species within the Kempsey LGA.
8. Confirms the value of roost and foraging habitats in Spencers Creek and the Macleay Arm for threatened migratory shorebirds.
9. Highlights the value of Killicks Beach for Australian pied oystercatcher.
10. Highlights the need to protect a matrix of wetlands including both estuarine and freshwater to ensure the long-term viability of the Macleay Coast shorebird community.

5.7 Knowledge Gaps

5.7.1 Abundance and species richness

The 2018/19 surveys have added substantially to our knowledge of shorebirds on the Macleay Coast, identified previously unknown sites, and confirmed the value of known sites, such as the Boyters Lane wetlands. Confirmation of important shorebird habitat is based on repeat systematic surveys over several years. Such surveys are lacking on the Macleay Coast with exception of the Boyters Lane wetlands.

5.7.2 Use of habitat in the Macleay Arm

In most north coast estuaries shorebirds move upstream with the receding tide to capitalise on recently exposed habitat. This pattern of habitat use is likely to occur in the Macleay Arm, particularly between the Macleay Arm sandflat (site 35), and Macleay Arm site 2 (sites 6/6.1). Use of habitat upstream of site 6/6.1 is unclear, although large counts of whimbrel and bar-tailed godwit near Stuarts Point suggests that birds once used most of the Macleay Arm (Lawler 1994). Further systematic low-tide surveys of the Macleay Arm are warranted to confirm habitat use and important sites. It is highly likely that the local population of eastern curlew and bar-tailed godwit rely upon multiple intertidal habitats.

5.7.3 Importance of freshwater floodplain wetlands

Further systematic sampling of floodplain wetlands is warranted to confirm the importance of these sites for shorebirds. Floodplain wetlands at Seale Road (site 56), and Suez Road (site 44) supported moderate numbers of sharp-tailed sandpiper, Pacific golden plover, and black-winged stilt during the field survey, however, Belmore Swamp, a renowned waterbird site, was dry throughout the 2018/19 surveys. Belmore Swamp did not support shorebirds during the 2016/17 surveys and it is possible that the site may only support shorebirds when water level reaches a certain height. Further sampling is required to confirm use of Belmore Swamp and other large floodplain wetlands by shorebirds. These data would assist in confirming the international significance of the Macleay Coast to migratory shorebirds.

5.7.4 Movement between estuarine and freshwater floodplain wetlands

Evidence gathered during the 2018/19 survey suggests that sharp-tailed sandpiper and Pacific golden plover move between estuarine and floodplain wetlands. Movement is most likely related to prey availability and in the case of golden plovers occurs in response to soldier crab (*Mictyris* spp.) activity at Pelican Island (site 20). Movement by sharp-tailed sandpipers is more likely in response to rainfall and floodplain wetland condition. The failure to record equivalent numbers of golden plovers between high and low high tide indicates the presence of an unknown high tide floodplain roost/foraging site.

5.7.5 Identification of additional estuarine roost and foraging areas

During spring high tide surveys shorebirds were recorded flying from areas that were not known to support the subject species during high or low tides. For example:

1. Bar-tailed godwits were recorded flying up the Macleay River channel to an unknown site on 23/1/19.
2. Eastern curlews were recorded flying into Spencers Creek from the Andersons Inlet/Clybucca Creek area at high tide on 22/1/19.
3. Sharp-tailed sandpipers were recorded flying towards Spencers Creek from Andersons Inlet at high tide on 23/1/19.

Further surveys would assist with the identification of additional habitats.

5.7.6 Impact of 4WD vehicles and feral predators on beach nesting shorebirds

Four-wheel drive vehicles on ocean beaches have been shown to have a detrimental impact on beach nesting birds (Buick & Paton 1989), shorebird prey (Moss & McPhee 2007), and dune structure (Thompson & Schlacher 2008). Killick Beach supports three pairs of Australian pied oystercatcher and is frequently used by 4WD vehicles. Whilst no direct evidence of impact was recorded during this study further observation is warranted to confirm if vehicles affect breeding success.

6. Recommendations

Eleven recommendations have been made to improve protection of shorebird habitat and address existing data gaps (Table 15).

Table 15: Recommendations

Action & aim	Description	Organisations
<p>1. Macleay Estuary shorebird conservation area Aim: Develop a coordinated approach with state government agencies to protect important shorebird habitat on public land. The conservation area would represent the focal point for community education and shorebird conservation on the Macleay Coast.</p>	<p>The shorebird conservation area should include the lower section of Spencers Creek, and the Macleay Arm from the confluence with the Macleay River upstream to Seagrass Inlet. The conservation area should encompass sample sites 17, 17.1, 33, 34, 35, 36, 37, 42 (Figure 4).</p> <p>The shorebird conservation area would include all intertidal habitat, saltmarsh, and mangroves within the abovementioned area. Key actions should include signage warning boat operators of bank erosion, and information boards at key sites (see Action 2).</p>	<p>Kempsey Shire Council; Department of Industry (Crown Lands); Office of Environment & Heritage; Roads and Maritime Services; NSW Fisheries.</p>
<p>2. Information boards Aim: Increase public awareness on the importance of the Macleay estuary for shorebirds and particularly the Macleay Estuary Shorebird Conservation Area</p>	<p>Install information signs at key location around the Macleay estuary. Major boat ramps at New Entrance Road and Plummers Lane are high priority sites.</p> <p>There are numerous examples of shorebird information signs available on the web. Key components include: basic information on shorebird migration, local threatened species, important habitats, things people should do to avoid impacting shorebirds, and a map of the Macleay Estuary Shorebird</p>	<p>Kempsey Shire Council; Roads and Maritime Services</p>

Action & aim	Description	Organisations
	Conservation Area.	
3. Education Aim: Educate professional fishers to consider roosting and foraging shorebirds whilst conducting their daily work	Produce an information brochure, or signage, to educate professional fishers about shorebirds, important habitats, and simple actions that can be implemented to avoid impacting birds.	Kempsey Shire Council NSW Fisheries Office of Environment and Heritage
4. Wetland conservation on private land Aim: Educate landowners with floodplain and/or estuarine wetlands on their property about the importance of these habitats for shorebirds and waterbirds, and the need to maintain a matrix of wetlands over the floodplain.	Educate landowners with wetlands on their properties on the importance of maintaining these habitats for shorebirds and waterbirds. The need to maintain a matrix of wetlands across floodplain and estuarine sites should be emphasised. Actions could include an information brochure, site visits, and a community information session that targets property owners.	Kempsey Shire Council Local Land Services Office of Environment and Heritage
5. Boyters Lane wetland management plan Aim: Prepare a management plan for significant Boyters Lane wetlands to ensure their long-term viability for shorebirds.	Boyters Lane supports Nationally and potentially Internationally significant numbers of migratory shorebirds. Owners/managers of these sites should be approached to develop an agreement to protect and manage the sites.	Kempsey Shire Council Boyters lane land owners Local Land Services
6. Evaluate shorebird threats at Killick Beach Aim: Gather information on the impact of threatening processes on shorebirds at Killick Beach. Information should be used to determine if management action is required.	The site value by threat prioritisation identified Killick Beach as a very high priority site. The sites primary shorebird value is that it supports three pairs of Australian pied oystercatcher, a species that is known to be affected by 4WD vehicles and feral predators. It is unclear to what extent oystercatchers on Killick Beach are affected by these threats. Before undertaking site management further data on breeding territories, foraging habitat and the actual threat level should be obtained. The most effective means of achieving this may be to liaise with the Office of Environment and Heritage to undertake regular surveys along the beach.	Kempsey Shire Council Office of Environment and Heritage
7. Targeted feral animal control Aim: Assist land owners along Boyters Lane to undertake a cooperative feral animal control program.	Foxes and cats have been identified as a threat to shorebirds around Boyters Lane. Council should liaise with Local Land Services to assist landholders develop a coordinated program and, as a land manager, to participate in such a program.	Kempsey Shire Council Local Land Services Land owners
8. Floodplain wetland bird survey Aim: Undertake a systematic survey of suitable floodplain wetlands to assess their value as shorebird habitat.	The community information session highlighted the potential value of floodplain wetlands for shorebirds. Targeted sampling of suitable wetlands would assist in confirming the significance of the Macleay Coast to migratory shorebirds. Foot-based or drone surveys could be used to gather data on species occurrence and abundance.	Kempsey Shire Council Local Land Services Land owners
9. Wetland stewardship sites Aim: Encourage landowners to create stewardship sites over important wetlands.	Using provisions under the <i>Biodiversity Conservation Act 2016</i> encourage landowners with significant wetlands to create Biodiversity Stewardship sites under the Biodiversity Offsets Scheme. These sites can be used to offset impacts on wetlands and provide funds for landowners to manage	Kempsey Shire Council Office of Environment and Heritage Land owners

Action & aim	Description	Organisations
	sites. Removal of cattle may not be necessary due to the role they can play in maintaining existing wetland condition. Stewardship agreements could be promoted through Councils website.	
10. Review existing zoning of key shorebird sites Aim: Ensure important shorebird habitat is appropriately zoned	Existing zoning of Site 42 (Spencers Creek) and Sites 14, 14.1, 15, 15.1, 16 & 16.1 (Boyers Lane) should be changed from RU1/2 to E2.	Kempsey Shire Council
11. Macleay Coast shorebird population surveys Aim: Undertake another round of surveys to confirm shorebird abundance, species richness and important habitats.	Additional shorebird population surveys should be conducted in 2020/21 to gather further data on shorebird abundance, species richness and important habitats. The surveys should include six samples, one during southern migration (October), four during summer (December & January), and one during northern migration (March). The number of sample sites should be rationalised prior to commencing surveys. Each survey should occur over two days, with additional time allocated to travel.	Kempsey Shire Council.

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Appendix A – Shorebird count data

Table A1: Shorebirds recorded during sample No. 1 at high tide.

Site No.	Site Name & No.	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	BfD	RkD	ML	LS	BtG	W	EC	GtT	RnS	StS	BbS	
K21	Long Reach Island - sandspit	7/12/18	0930	0945	Land																		
36	Macleay arm Saltmarsh #1	7/12/18	0845	0855	Boat					21							1		2				
37	Macleay Arm saltmarsh #2	7/12/18	0900	0910	Boat											15	37	9					
K16.1	Boyers Lane wet paddocks	6/12/18	0740	0825	Land			38	1	3					2					3	223		
K14 & K14.1	Saltaire	6/12/18	0830	1010	Land			49					6	1							121		
K15 & K15.1	Boyers Lane wetland - east	6/12/18	0710	0718	Land			3						4							6		
K16	Boyers Lane wet paddocks	6/12/18	0722	0730	Land			85					1	2						1	146	1	
K15.2	Boyers Lane wetland - rehab	6/12/18	1030	1100	Land			12															
K5	Macleay Arm site 1	5/12/18	0615	0622	Land									2		5							
30	Stuarts Point footbridge	5/12/18	0905	0930	Land											5							
K4	Stuarts Point beach	5/12/18	0645	0650	Land																		
K2	Millington Avenue	5/12/18	0705	0720	Land																		
K3	Stuarts Point Beach	5/12/18	0725	0730	Land	1																	
K1	Stuarts Point Beach	5/12/18	0730	0800	Land																		
29	Macleay Arm nth Stuarts Pt	5/12/18	0630	0645	Land																		
19 & 19.1	Pelican Island	5/12/18	0855	0901	Boat																		
K18	Macleay River opposite Suez Rd	5/12/18	0843	0850	Boat																		
K14.4 & 14.5	Saltaire shoreline	5/12/18	0835	0845	Boat												3						
32	Macleay Arm oysters	5/12/18	0803	0810	Boat																		

Site No.	Site Name & No.	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	BfD	RkD	ML	LS	BtG	W	EC	GtT	RnS	StS	BbS	
	#3																						
K6.1	Macleay Arm site 2	5/12/18	0740	0742	Boat																		
K6	Macleay Arm site 2	5/12/18	0730	0737	Boat																		
K17	Andersons Inlet	5/12/18	0705	0709	Boat	1																	
33	Seagrass Inlet	5/12/18	0710	0720	Boat																		
17.1	Clybucca Creek	5/12/18	0650	0700	Boat																		
40	Boat Ramp bay & saltmarsh	5/12/18	0645	0650	Boat																		
K20	Pelican Island - sandspit	5/12/18	0900	0910	Boat													1					
K3.1	North Wall	5/12/18	0750	0800	Land																		
K7 & K7.1	Back beach	6/12/18	0715	0720	Land																		
K8	Back Ck footbridge	6/12/18	0740	0745	Land																		
K9, K9.1 & K10	Front Beach & Saltwater Ck #1	6/12/18	0750	0755	Land									2									
K10.2	Saltwater Creek #3	6/12/18	0805	0510	Land																		
49	Trial Bay headland	6/12/18	0830	0845	Land		1																
K12	North Smoky Beach & Green Island K12	6/12/18	0905	0910	Land																		
50	Korogoro Ck 1	6/12/18	0945	0955	Land																		
51	Korogoro Ck 2	6/12/18	1000	1005	Land									2									
54	Pebbly beach/Little Nobby	6/12/18	1115	1120	Land																		
57	Point Pioneer -> Pt Plummer	6/12/18	1450	1500	Land		3																
K28.1	Point Plummer	6/12/18	1510	1520	Land		3																
28	K 28 Point Plummer- Big Head Hill	6/12/18	1525	1540	Land																		
55	Big Hill Point- Delicate Nobby	6/12/18	1150	1200	Land		3																
K26 & 27	Goolawah Beach	6/12/18	1140	1145	Land																		
13	South Smokey Beach (from lighthouse)	6/12/18	0900	0905	Land	3																	

Site No.	Site Name & No.	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	BfD	RkD	ML	LS	BtG	W	EC	GtT	RnS	StS	BbS	
24 & 25	Killick beach	6/12/18	1127	1130	Land	7					7												
56	Seale Rd wetland	5/12/18	1239	1245	Land			73						11								25	
15.2	15.2 Boyters Lane wetland	5/12/18	1145	1200	Land			5															
K2	Site 2 UM02 & Site 2 UM03	5/12/18	0845	0900	Land																		
K1	Site 1 GH02 & Site 1 osprey	5/12/18	0800	0825	Land																		
K25	Killick Beach																						
K27 & K27.1	Goolawah Beach	6/12/18	1605	1615	Land																		
K13	Hat Head Beach	6/12/18	0935	0940	Land	1																	
K21	Long Reach Island	6/12/18	0920	0922	Land																		
55	Big Hill Point- Delicate Nobby	6/12/18	1550	1600	Land		1																
55	Delicate Nobby	6/12/18	1210	1220	Land		3																
K15 & 15.1	Boyters Lane wetland - east	5/12/18	1020	1035	Land			4						2								2	

Table A2: Shorebirds recorded during sample No. 1 at low tide.

Species	Site Name	Date	Start Time	End Time	Survey Type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS	BbS
K14 & K14.1	Saltire	6/12/18	1640	1650	Land			59						7	2								85		
K5	Macleay Arm Site 1	5/12/18	1230	1241	Land																				
K1	Grassy Head Beach - nth end	5/12/18	1255	1315	Land	1																			
K1.1	Grassy Head Beach - sth end	5/12/18	1320	1345	Land																				
K4	Stuarts Point Beach	5/12/18	1350	1430	Land																				
K2	Millington Avenue	5/12/18	1440	1500	Land																				
K3	Stuarts Point Beach	5/12/18	1350	1400	Land																				
K16	Boyters lane wet paddocks	5/12/18	1610	1620	Land			41							2								3		
K15 & 15.1	Boyters lane wetland - rehab	5/12/18	1600	1610	Land										1								6		
K15.2	Boyters lane wetland - east	5/12/18	1655	1715	Land			25																	

Species	Site Name	Date	Start Time	End Time	Survey Type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS	BbS
K16.1	Boyers Lane wet paddocks	5/12/18	1611	1621	Land			58		3						1						6	298		
41	Boat ramp sandflat	4/12/18	1315	1325	Land													6							
36	Macleay Arm saltmarsh #1	4/12/18	1300	1310	Land												1	1	2						
35	Macleay Arm sandflat	4/12/18	1330	1340	Land					28					2		13	16		9			7		
K12	North Smoky beach	4/12/18	1410	1415	Land													1							
K12.1	SW rocks creek upstream	4/12/18	1417	1425	Land													4							
K17 & 17.1	Anderson Inlet & Clybucca Creek	4/12/18	1425	1430	Land												2	1	1						
33	Seagrass Inlet	4/12/18	1435	1440	Land													3							
K6 & K6.1	Macleay Arm site 2	4/12/18	1445	1455	Land												3	4	2						
3.1	Stuarts Point Beach	4/12/18	1515	1525	Land																				
K14.5 & K14.4	Saltaire shoreline	4/12/18	1610	1615	Land									2											
K18	Macleay River opposite suez road	4/12/18	1620	1630	Land																				
K7 & K7.1	Back Beach	5/12/18	1300	1305	Land																				
K8	Back Creek - footbridge	5/12/18	1310	1315	Land																				
K9, K10 & K9.1	Front Beach & Saltwater Creek	5/12/18	1325	1330	Land									2											
10.2	Saltwater Creek #3	5/12/18	1340	1345	Land																				
49	Trial Bay headland	5/12/18	1355	1415	Land		1																		
K12	North Smoky Beach & Green Island K12	5/12/18	1355	1415	Land																				
50	Korogoro Ck #1	5/12/18	1530	1540	Land										2										
51	Korogoro Ck #2	5/12/18	1550	1555	Land										2										
52	Korogoro Ck #3	5/12/18	1600	1605	Land										2										
30	Stuarts Point Footbridge	6/12/18	1530	1540	Land										5										
K21	Long Reach Island - sandspit	5/12/18	1620	1630	Land																				
K20	Pelican Island sandspit	5/12/18	1635	1645	Land					102					4								2		
K13&13.1	Hat head Beach	6/12/18	1400	1453	Land	3																			
13	South Smokey Beach (from lighthouse)	5/12/18	1435	1440	Land																				

Table A3: Shorebirds recorded during sample No. 2.

Site No.	Site name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	StS	CS
1.0	Grassy Head Beach - nth end	21/1/19	1653	1705	Land																		
1.1	Grassy Head Beach - sth end	21/1/19	1630	1640	Land																		
2.0	Upper Macleay Arm, off Millington Avenue	21/1/19	1645	1650	Land																		
3, 3.1, 4	Stuarts Point Beach	21/1/19	1400	1455	Land	1																	
	North wall - Stuarts point beach	22/1/19	955	1010	Land																		
5.0	Macleay Arm Site 1 (south of caravan park)	21/1/19	1730	1735	Land																		
6.0	Macleay Arm Site 2 (Fishermans Reach)	22/1/19	930	935	Boat																		
6.1	Macleay Arm Site 2 (Fishermans Reach)	22/1/19	938	945	Boat																		
7 & 7.1	Back Beach	22/1/19	1120	1125	Land																		
8.0	Back Ck footbridge SWR	22/1/19	1510	1520	Land										2								
9.0	Front Beach - nth end	22/1/19	1150	1200	Land																		
9.1	Front Beach - sth end	22/1/19	1205	1220	Land																		
10.0	Saltwater Creek #1	22/1/19	1145	1150	Land																		
	Trial Bay Headland	22/1/19	1425	1440	Land		2								1								
12.0	North Smoky Beach	23/1/19	850	900	Land																		
13 & 13.1	South Smoky Beach/ Hat Head Beach	23/1/19	1640	1705	Land	3																	
14.0	Saltaire	22/1/19	940	nr	Land			2								1						40	
14.1	Saltaire	22/1/19	950	nr	Land			88							2	5						123	
14.4 & 14.5	Saltaire - shoreline	22/1/19	1130	1135	Boat																		
15 & 15.1	Boyter's Lane wetland, Jerseyville	22/1/19	800	810	Land			2							2							158	
15.2	Boyter's Lane wetland, Jerseyville	22/1/19	1015	nr	Boat			4															
16.0	Boyter's Lane wet paddocks, Jerseyville	22/1/19	815	nr	Land			70														130	

16.1	Boyter's Lane wet paddocks, Jerseyville	22/1/19	830	nr	Land			50				3	5	5					82
17.0	Macleay Arm/Clybucca Creek/saltmarsh	22/1/19	902	912	Land											1			
17.1	Oyster rack channel	22/1/19	900	902	Boat	2										2		25	
	Spencers Ck	22/1/19	1100	1115	Boat			2						2			14		52
18.0	Macleay River opposite Suez rd	22/1/19	1145	1150	Boat									2					
19.0	Macleay River sand/mudflat opp. Suez Road & Plummers Lane, Jerseyville	22/1/19	1220	1225	Boat														
19.1	Macleay River sand/mudflat opp. Suez Road & Plummers Lane, Jerseyville	22/1/19	1220	1225	Boat														
20.0	Pelican Island sandspit	22/1/19	1200	1220	Boat														
21.0	Long Reach island - sandspit	22/1/19	1235	1240	Boat														
22.0	Back Creek, Kinchela																		
23 & 23.1	Belmore Swamp, off Seale Road	23/1/19	1710	1720	Land														
56	Seale Road wetland	23/1/19	1050	nr	Land			40						28					275
24 & 25	Killick Beach/Ryans Cut/Richardsons crossing	23/1/19	1540	1620	Land	6													
54	Pebbly Beach & Little Nobby	23/1/19	1150	1225	Land		2												
26&2 6.1	Goolawah Beach nth end	23/1/19	1230	1245	Land														
27&2 7.1	Goolawah Beach sth end	23/1/19	1300	1305	Land														
55	Delicate Nobby	23/1/19	1310	1315	Land														
55	Big Hill Point to Delicate Nobby	23/1/19	1325	1330	Land		1							2					
28.0	Barries beach - nth end	23/1/19	1335	1345	Land														
28.1	Barries beach - sth end	23/1/19	1348	1355	Land		2												
57	Point Pioneer to Pt Plomer - outside LGA	23/1/19	1400	1410	Land		1												
39	Macleay Arm rocks - Tattler roost	22/1/19	1255	1305	Boat									2				41	
40	Boat ramp	22/1/19	820	830	Land											3			
36	Macleay arm saltmarsh #1	22/1/19	902	905	Boat														
37	Macleay arm saltmarsh #2	22/1/19	850	900	Boat									2	8	28			

34	Whimbrel roost	22/1/19	950	1000	Boat												8	24						
33	Seagrass Inlet	22/1/19	900	905	Land																			
32	Macleay Arm Oysters #3	22/1/19	1020	1030	Boat																			
48	Laggers Pt	22/1/19	1425	1435	Land																			
50	Korogoro Ck #1	23/1/19	925	950	Land																			
51	Korogoro ck #2	23/1/19	952	957	Land																			
52	KCk#3	23/1/19	1000	1005	Land																			
53	KCk #4	23/1/19	1015	1030	Land																			
44	Suez Road wetland	22/1/19	1045	1045	Land			35														6	91	
29	Macleay Arm - nth Stuarts Point	21/1/19	1715	1730	Land																			
6.0	Macleay Arm Site 2 (Fishermans Reach)	22/1/19	1515	1519	Boat																			
6.1	Macleay Arm Site 2 (Fishermans Reach)	22/1/19	1505	1510	Boat																			
7 & 7.1	Back Beach	22/1/19	1500	1503	Land																			
8.0	Back ck footbridge	22/1/19	1510	1520	Land																			
9.0	Front beach - nth	22/1/19	1450	nr	Land																			
9.1 & 10.2	Front beach - sth & Saltwater Ck#3			nr																				
10.0	Saltwater Ck #1	22/1/19	1450	nr	Land																			
10.1	Saltwater Ck #2	22/1/19	1450	1500	Land																			
10 & 10.1	Saltwater Creek #2&3	22/1/19	1450	1500	Land																			
13	South Smoky Beach/ Hat Head Beach	23/1/19	1640	1705	Land																			
14.0	Saltaire	22/1/19	1635	1642	Land																		25	1
14.1	Saltaire	22/1/19	1643	nr	Land																			5
14.4 & 14.5	Saltaire - shoreline	22/1/19	1720	1725	Boat																			
15 & 15.1	Boyter's Lane wetland, Jerseyville	22/1/19	1600	1610	Land																			133
15.2	Boyter's Lane wetland, Jerseyville	22/1/19	1710	1720	Land																			
16.0	Boyter's Lane wet paddocks,		1612	nr	Land																			71

Site No.	Site name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	MS	RnS	StS	CS	BbS
8.0	Back creek footbridge	30/1/19	1200	1205	Land																					
9 & 9.1	Front Beach	30/1/19	1218	1220	Land																					
10.0	Saltwater Creek #1	30/1/19	1220	1222	Land																					
13 & 13.1	South Smoky Beach/Hat Head beach	31/1/19	1100	1124	Land	3																				
14.0	Saltaire	30/1/19	1615	1723	Land			132							2	3								125		
14.4 & 14.5	Saltaire shoreline	29/1/19	1640	1645	Boat																					
15 & 15.1	Boyter's Lane wetland, Jerseyville	30/1/19	1421	1430	Land			1							2									204		
15.2	Boyter's Lane wetland, Jerseyville	30/1/19	1547	1555	Land			90																		
16.0	Boyter's Lane wet paddocks, Jerseyville	30/1/19	1434	1444	Land																			85		
16.1	Boyter's Lane wet paddocks, Jerseyville	30/1/19	1443	1514	Land			16					1	1	3									184		
17.0	Macleay Arm/Clybuca Creek/Saltmarsh	29/1/19	1520	NR	Boat																					
17.1	Macleay Arm - confluence of Clybuca Creek & Andersons Inlet	29/1/19	1455	1505	Boat															22						
18.0	Macleay River opposite Suez Road	29/1/19	1645	NR	Boat																					
45	Macleay river bank	29/1/19	1644	1647	Boat										17											
19 & 19.1	Macleay River sand/mudflat opp. Suez Road & Plummers Lane, Jerseyville	29/1/19	1655	NR	Boat																					
20.0	Pelican Island sandspit	29/1/19	1700	1707	Land										4											
21.0	Long Reach Island - sandspit	29/1/19	1720	NR	Boat																					
46	Macleay River upstream sandspit	29/1/19	1710	1718	Boat			47							49											
22.0	Back Creek, Kinchela																									
23 & 23.1	Belmore Swamp, off Seale Road	31/1/19	1645	1655	Land																					
24 & 25	Killick Beach/Ryans Cut/Richardsons Crossing	31/1/19	1200	1245	Land	6					7															
54	Pebbly beach & little nobby	31/1/19	1245	1250	Land		2																			
26, 26.1, 27, 27.1	Goolawah/Racecourse Beach	31/1/19	1255	1305	Land																					
55	Delicate Nobby	31/1/19	1355	1410	Land		1																			
55	Big Hill Point- Delicate Nobby	31/1/19	1418	1420	Land																					
28.0	Barries Beach nth end	31/1/19	1320	nr	Land		3																			
28.1	Barries Beach sth end	31/1/19	1505	1510	Land		2								2											

Site No.	Site name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	MS	RnS	StS	CS	BbS	
57	Point Pioneer to Pt Plomer - outside LGA	31/1/19	1518	1525	Land																						
40	Boat ramp	29/1/19	1415	1422	Land																						
36	Macleay Arm Saltmarsh #1	29/1/19	1453	1455	Boat													2									
37	Macleay Arm saltmarsh #2	29/1/19	1457	1500	Boat																						
32	Macleay Arm oysters #3	29/1/19	1605	1610	Boat																						
33	Seagrass Inlet	29/1/19	1523	1530	Boat													1									
49	Trial Bay Headland	30/1/19	1250	1255	Land																						
50	Korogoro ck1	31/1/19	1129	1133	Land																						
51	Korogoro ck2	31/1/19	1135	1140	Land																						
52	Korogoro ck3	31/1/19	1142	1145	Land										3												
53	Korogoro ck4	31/1/19	1446	1450	Land										2												
39	Macleay Arm Rocks- tattler roost	29/1/19	1422	1425	Boat																						
43	Spencers Ck	29/1/19	1430	1440	Boat					18								1						2			
48	Laggers Pt	30/1/19	1240	1245	Land																						
35	Macleay arm sandflat #1	29/1/19	1430	1440	Land																						
35	Macleay arm sandflat #2	29/1/19	1440	1515	Land			11		2					2		13	38	25								
31	Macleay Arm oysters #2	29/1/19	1615	1620	Boat															3							
56	Seale Rd wetland	31/1/19	1630	1442	Land			8		9					31									3			
44	Suez Road wetland	30/1/19	1525	1540	Land																			17			
47	SWR Headland	30/1/19	1215	1218	Land										2												
Phase two																											
6.0 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	30/1/19	900	907	Boat																						
14.1	Saltaire	1/2/19	905	943	Land			174							2	2					2				201		
15 & 15.1	Boyter's Lane wetland, Jerseyville	1/2/19	650	705	Land			4																	16		
15.2	Boyter's Lane wetland, Jerseyville	1/2/19	710	720	Land			79																	4		
16.0	Boyter's Lane wet paddocks, Jerseyville	1/2/19	723	735	Land			11							4										234		
16.1	Boyter's Lane wet paddocks, Jerseyville	1/2/19	737	755	Land			34					2	2		1									123		

Site No.	Site name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	MS	RnS	StS	CS	BbS
18.0	Macleay River opposite Suez Road	30/1/19	1017	NR	Boat																					
19 & 19.1	Macleay River sand/mudflat opp. Suez Road & Plummers Lane, Jerseyville	30/1/19	1030	1032	Boat																					
20.0	Pelican Island sandspit	30/1/19	1033	1042	Boat					41																
21.0	Long Reach Island sandspit	30/1/19	1056	1102	Boat																					
46	Macleay River upstream sandspit	30/1/19	1052	1055	Boat					2					7									5		
41	Boat ramp sandflat	30/1/19	955	nr	Boat													1	1							
1	Seagrass Inlet	30/1/19	910	925	Boat																					
	Spencers Ck	30/1/19	1005	1013	Boat					14								2	1					13		
	Macleay arm sandflat #2	30/1/19	937	950	Land					10							25	17	19	29						
	Macleay arm oysters #3	30/1/19	927	935	Boat																					
	Suez Road small claypan	1/2/19	807	812	Land																			22		
	Suez Road large claypan	1/2/19	815	830	Land										5									6		

Table A5: Shorebirds recorded during sample No. 4.

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RmA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS	
1.0	Grassy Head Beach - nth	11/2/19	1345	1400	Land																				
1.1	Grassy Head Beach - sth	11/2/19	1405	1410	Land																				
2 & 2.1	Upper Macleay Arm, off Millington Avenue	11/2/19	1425	1433	Land																				
3.1	North wall	13/2/19	1420	1425	Land																				
3 & 4	Stuarts Point Beach	11/2/19	1413	1520	Land																				
5.0	Macleay Arm Site 1 (south of caravan park)	11/2/19	1530	1540	Land																				
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	13/2/19	1437	1447	Boat																				
7.0 & 7.1	Back Beach	13/2/19	1005	1015	Land		1																		
8.0	Back Creek footbridge	13/2/19	1550	1600	Land																				

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RmA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS
9& 10	Front Beach # Saltwater Ck #1	13/2/19	1020	1025	Land																			
9.1	Front Beach - sth	13/2/19	1150	1200	Land																			
10.2	Saltwater Creek # 3	13/2/19	1145	1150	Land																			
12	North Smoky beach	13/2/19	1250	1255	Land																			
13 & 13.1	South Smoky Beach/Hat Head beach	14/2/19	830	900	Land	3																		
14.0	Saltaire	13/2/19	1425	1430	Land																			
14.1	Saltaire	13/2/19	1430	1500	Land			182							2	1					2		324	
14.4& 14.5	Saltaire - shoreline	13/2/19	1630	1645	Boat																			
15 & 15.1	Boyter's Lane wetland, Jerseyville	13/2/19	1345	1350	Land			2															60	
15.2	Boyter's Lane wetland, Jerseyville	13/2/19	1510	1525	Land			66																
16.0	Boyter's Lane wet paddocks, Jerseyville	13/2/19	1350	1355	Land																		70	
16.1	Boyter's Lane wet paddocks, Jerseyville	13/2/19	1355	1407	Land			36					2										314	
17.0	Macleay Arm/Cylbucca Creek/saltmarsh	13/2/19	1503	1507	Boat																			
17.1	Macleay Arm - confluence of Clybucca Creek & Andersons Inlet	13/2/19	1510	1520	Boat	1																	4	
18.0	Macleay River opposite Suez Road	13/2/19	1700	1705	Boat																			
19, 19.1	Macleay River sand/mudflat opp. Suez Road & Plummers Lane, Jerseyville	13/2/19	1622	1630	Boat																			
20.0	Pelican island sandspit									2					8									
21.0	Long Reach Island - sandspit	13/2/19	1610	1615	Boat																			
46	Macleay River upstream sandspit	13/2/19	1615	1620	Boat			13							5									
23 & 23.1	Belmore Swamp, off Seale Road	14/2/19	1520	1530	Land																			
24 & 25	Killick Beach/Ryans Cut/Richardsons Crossing	14/2/19	1030	1100	Land	6															1			
54	Pebbly Beach & Little nobby	14/2/19	1140	1200	Land		2																	
26 &	Goolawah Beach - nth	14/2/19	1453	1500	Land																			

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RmA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS
26.1																								
27 & 27.1	Goolawah Beach - sth	14/2/19	1210	1225	Land																			
55	Delicate nobby	14/2/19	1240	1300	Land																			
55	Big Hill Point to Delicate Nobby	14/2/19	1305	1315	Land		3																	
28.0	Barries Beach nth end	14/2/19	1320	1330	Land																			
28.1	Barries Beach south end	14/2/19	1345	1400	Land		2																	
57	Point Pioneer to Pt Plomer - outside LGA	14/2/19	1405	1415	Land																			
32	Macleay Arm - oysters #3	13/2/19	1225	1235	Boat																			
30	Stuarts Point footbridge	11/2/19	1520	1525	Land																			
33	Seagrass Inlet	13/2/19	1448	1500	Boat																			
49	Trial Bay Headland	13/2/19	1220	1230	Land																			
50	Korogoro ck1	14/2/19	905	910	Land																			
51	Korogoro ck2	14/2/19	912	915	Land																			
52	Korogoro ck3	14/2/19	920	932	Land										2	1								
53	Korogoro ck4	14/2/19	935	940	Land																			
29	Macleay Arm - nth Stuarts Point	11/2/19	1443	1452	Land																			
43	Spencers Ck	12/2/19	1615	1625	Boat														25					
37	Macleay arm saltmarsh #2	13/2/19	1520	1535	Boat												11	37		30				
44	Suez Road wetland	13/2/19	935	940	Land																			
48	Laggers Pt	13/2/19	1208	1218	Land																			
31	Macleay arm oysters #2	13/2/19	1433	1436	Boat																			
56	Seale Rd swamp	14/2/19	1532	1540	Land																			
40	Boat ramp	13/2/19	1600	1610	Boat																			
36	Macleay Arm Saltmarsh #1	13/2/19	1545	1552	Boat										1					20				
39	Macleay arm rocks- tattler roost	13/2/19	1545	1552	Boat																			
7.0 &	Back Beach	13/2/19	1005	1015	Land		1																	

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RmA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS
7.1																								
8.0	Back Creek footbridge	13/2/19	950	1000	Land										3									
12	North Smoky beach	13/2/19	1250	1255	Land																			
13	South Smoky Beach	13/2/19	1255	1300	Land	3																		
14.0	Saltaire	13/2/19	817	820	Land																		6	
14.1	Saltaire	13/2/19	820	905	Land			174							2						2		247	
14.4 & 14.5	Saltaire shoreline	13/2/19	1205	1220	Boat					7								1		1				
15 & 15.1	Boyter's Lane wetland, Jerseyville	13/2/19	709	719	Land																		19	
15.2	Boyter's Lane wetland, Jerseyville	13/2/19	914	925	Land			37																
16.0	Boyter's Lane wet paddocks, Jerseyville	13/2/19	720	725	Land			4															207	
16.1	Boyter's Lane wet paddocks, Jerseyville	13/2/19	726	815	Land			30					4	5		1						1	275	
18.0	Macleay River opposite Suez Road	13/2/19	1225	1227	Boat																			
45	Macleay River bank	13/2/19	1230	1240	Boat													1						
43	Spencers Ck	13/2/19	1155	1200	Boat										2									

Table A6: Shorebirds recorded during sample No. 5.

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS
1.0	Grassy Head Beach - nth	21/2/19	1215	1225	Land																			
1.1	Grassy Head Beach - sth	21/2/19	1140	1145	Land																			
2.0	Millington Avenue	21/2/19	1204	1207	Land																			
3.1	North Wall	20/2/19	820	830	Land																			
3.0	Stuarts Point Beach - nth	21/2/19	1154	1157	Land																			
4.0	Stuarts Point Beach access	21/2/19	1154	1157	Land																			
5.0	Macleay Arm Site 1 (south of caravan park)	21/2/19	1240	1244	Land																			
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	20/2/19	852	859	Boat																			
7 & 7.1	Back Beach	20/2/19	1154	1157	Land																			
8.0	Back Creek footbridge	20/2/19	1147	1151	Land																			
9 & 9.1	Front Beach	20/2/19	1205	1210	Land																			
10.0	Saltwater Creek #1	20/2/19	1211	1215	Land																			
10.1 & 10.2	Saltwater Creek # 2 & 3	20/2/19	1217	1225	Land										3									
11.0	Saltwater Lagoon	21/2/19	810	824	Land			2							2									
12.0	North Smoky Beach	19/2/19	1250	1255	Land																			
13&1 3.1	South Smoky Beach/Hat Head Beach	19/2/19	1310	1340	Land	4																		
14 & 14.1	Saltaire	21/2/19	1000	1030	Land			219															30	
14.4 & 14.5	Saltaire shoreline	20/2/18	1018	1023	Boat																			
15 & 15.1	Boyter's Lane wetland, Jerseyville	21/2/19	905	908	Land			44															72	
15.2	Boyter's Lane wetland, Jerseyville	21/2/19	910	917	Land																			
16.0	Boyter's Lane wet paddocks, Jerseyville	21/2/19	922	930	Land			43							1								67	
16.1	Boyter's Lane wet paddocks,	21/2/19	930	947	Land			20					1	1	2								137	

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS
	Jerseyville																							
17.0	Macleay Arm/Clybucca Creek/saltmarsh	20/2/19	910	915	Boat																			
17.1	Macleay Arm - confluence of Clybucca Creek & Andersons Inlet	20/2/19	920	925	Boat															27				
18.0	Macleay River opposite Suez Road	20/2/19	1031	1032	Boat																			
	Macleay river bank	20/2/19	1033	1039	Boat										18									
19, 19.1	Pelican Island	20/2/19	1040	1100	Boat																			
20.0	Pelican Island sandspit																							
	Macleay river upstream sandspit	20/2/19	1047	1052	Boat																			
21.0	Long Reach Island	20/2/19	1047	1052	Boat																			
22.0	Back Creek, Kinchela	19/2/19	1723	1730	Land																			
23 & 23.1	Belmore Swamp, off Seale Road	19/2/19	1815	1820	Land																			
24 & 25	Killick beach/Ryans Cut/Richardsons crossing	19/2/19	1415	1445	Land	6									2									
26, 26.1, 27, 27.1	Goolawah Beach to Racecourse Head	19/2/19	1525	1545	Land																			
28.0	Barrie's Bay Beach - nth end	19/2/19	1650	1705	Land		2																	
28.1	Barries Beach - sth end	19/2/19	1715	1720	Land		2																	
36	Macleay arm saltmarsh #1	20/2/19	945	950	Boat										2									
37	Macleay arm saltmarsh #2	20/2/19	925	930	Boat																			
33	Seagrass Inlet	20/2/19	859	907	Boat																			
50	Korogoro ck1	19/2/19	1340	1344	Land																			
51	Korogoro ck2	19/2/19	1346	1352	Land										1									
52	Korogoro ck3	19/2/19	1356	1400	Land																			
53	Korogoro ck4	19/2/19	1402	1406	Land										1									
55	Delicate nobby	19/2/19	1615	1630	Land		1																	
57	Point Pioneer to Pt Plomer - outside LGA	19/2/19	1723	1730	Land																			

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS
55	Big Hill Point- Delicate Nobby	19/2/19	1640	1645	Land																			
39	Macleay Arm Rocks - Tattler roost	20/2/19	847	851	Boat																			
43	Spencers Ck	20/2/19	1003	1013	Boat					7					3								41	
48	Laggers Pt	19/2/19	1230	1235	Land																			
34	Whimbrel roost	20/2/19	935	941	Land													19						
32	Macleay arm oysters #3	20/2/19	840	845	Boat																			
40	Boat ramp	20/2/19	952	1000	Boat													1						
49	Trial Bay Headland	19/2/19	1240	1245	Land																			
56	Seale Rd wetland	19/2/19	1821	1825	Land										71									
43	Suez road small claypan	21/1/19	835	839	Land			2															7	
44	Suez road wetland	21/2/19	842	847	Land					30					2									
47	SWR Headland	20/2/19	1158	1203	Land		2																	
54	Pebbly beach little nobby	19/2/19	1455	1505	Land		2																	
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	20/2/19	1438	1451	Boat																			
11.0	Saltwater Lagoon	19/2/19	1215		Land																			
14 & 14.1	Saltaire	20/2/19	1710	1750	Land			205		1					2								97	
14.4 & 14.5	Saltaire shoreline	20/2/19	1539	1544	Boat													4						
15 & 15.1	Boyter's Lane wetland	20/2/19	1837	1845	Land			15															43	
15.2	Boyter's Lane wetland	21/2/19	910	917	Land																			
16.0	Boyter's Lane wet paddocks	20/2/19	1830	1835	Land									3									38	
16.1	Boyter's Lane wet paddocks	20/2/19	1800	1820	Land			34			1			3									182	
18.0	Macleay River opposite Suez Road	20/2/19	1545	1550	Boat													2						
	Macleay river bank	20/2/19	1551	1552	Boat										12									
19, 19.1	Pelican Island	20/2/19	1557	1610	Boat																			
20.0	Pelican Island sandspit									159														

Site No.	Site Name	Date	Start time	End time	Survey type	APO	SO	BwS	RnA	PGP	RcP	DbP	BfD	RkD	ML	LS	BtG	W	EC	GtT	CG	RnS	StS	CS	
46	Macleay river upstream sandspit	20/2/19	1613		Boat					1					13										
21.0	Long Reach Island	20/2/19	1613		Boat																				
33	Seagrass Inlet	20/2/19	1451	1457	Boat																				
43	Spencers Ck	20/2/19	1531	1537	Boat					50								2					7		
31	Macleay Arm oysters #2	20/2/19	1432	1436	Boat																				
41	Boat ramp sandflat	20/2/19	1524	1527	Boat	1												2							
35	Macleay arm sandflat	20/2/19	1507	1518	Boat										4			20	6	25					
32	Macleay arm oysters #3	20/2/19	1454	1503	Boat																				

Appendix B – Site Values Prioritisation

Table B1: Scoring of each site in relation to nine shorebird values.

Site No.	Site Name	Priority Score	CE & V Species (EPBC)	Spr roost	>50% of local popn	Total
1 & 1.1	Grassy Head Beach - nth end	3				3
2 & 2.1	Millington Avenue					0
3 , 3.1, 4	Stuarts Point Beach	3				3
5.0	Macleay Arm Site 1 (south of caravan park)	4	3			7
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	9	8			17
7.0 & 7.1	Back Beach	3				3
8.0	Back Creek footbridge	1				1
9 & 9.1	Front Beach	0				0
10.0	Saltwater Creek #1	1				1
10.1	Saltwater Creek #2	1				1
10.2	Saltwater Creek #3	0				0
11.0	Saltwater Lagoon	1				1
12	North Smoky Beach	0				0
13 & 13.1	South Smoky Beach/Hat Head beach	3				3
14 & 14.1	Saltaire	29	5		20	54
14.4 & 14.5	Saltaire shoreline	10				10
15 & 15.1	Boyter's Lane wetland - east	7				7
15.2	Boyter's Lane wetland - rehab	5				5
16.0	Boyter's Lane wet paddocks, Jerseyville	21				21
16.1	Boyter's Lane wet paddocks, Jerseyville	26			10	36
17.0	Andersons Inlet	13	8			21
17.1	Clybucca Creek	10		10	10	30
18.0	Macleay River opposite Suez Road	5				5
19 & 19.1	Pelican Island	0				0
20	Pelican Island sandspit	11	5		10	26
21	Long Reach Island	0				0
24 & 25	Killicks Beach/Ryans Cut/Richardsons Crossing	8			10	18
26 & 27	Goolawah Beach					0
28.0	Barries Beach nth end	3				3
28.1	Barries Beach sth end	4				4
29	Macleay Arm north Stuarts Point					0
30	Stuarts Point footbridge	1				1
31	Macleay Arm oysters #2	3		10		13
32	Macleay Arm Oysters #3	1				1
33	Seagrass Inlet	3				3
34	Whimbrel roost	8		10	10	28
35	Macleay Arm sandflat	24	8		40	72
36	Macleay Arm saltmarsh #1	16	8	10		34
37	Macleay Arm saltmarsh #2	13	8	10	20	51
38	Back creek upstream	3				3
39	Macleay Arm rocks - Tattler roost	4		10	10	24
40	Boat Ramp	3				3

Site No.	Site Name	Priority Score	CE & V Species (EPBC)	Spr roost	>50% of local popn	Total
41	Boat Ramp Sandflat	12	5			17
42	Spencers Creek	14	5	10	10	39
43	Suez Road small claypan	4				4
44	Suez Road large claypan	13			10	23
45	Macleay river bank	1				1
46	Macleay River upstream sandspit	8				8
47	SWR Headland	4				4
48	Laggers Point	0				0
49	Trial Bay Headland	4				4
50	Korogoro Ck #1	1				1
51	Korogoro Ck #2	1				1
52	Korogoro Ck #3	4				4
53	Korogoro Ck #4	1				1
54	Pebbly beach little nobby	3				3
55	Big Hill Point to Delicate Nobby	4				4
56	Seale Road wetland	13				13
57	Point Pioneer -> Pt Plummer outside LGA	3				3

Appendix C - Threats and Threat Prioritisation

Table C1: Proportion of surveys during which different types of disturbance were recorded at each sample site during the field survey. * = vehicle on council road. PM = people moving; DoFFL = dogs off leash; DonL = dogs on leash; Fish = fishers; Veh = vehicle moving; Mang = mangroves; Ero = erosion; A/H = altered hydrology; Cat/Ag = cattle/agriculture.

Site No.	Site Name	PM	DoFFL	DonL	Fish	Boat	Veh	4WD	Mang	Ero	A/H	Cat/Ag
1 & 1.1	Grassy Head Beach - nth end	80	60									
3 , 3.1, 4	Stuarts Point Beach	100	80					20				
5.0	Macleay Arm Site 1 (south of caravan park)	20	20		20	20						
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)					20						
7.0 & 7.1	Back Beach	100	40									
8.0	South West Rocks Creek footbridge	80	60			20						
9 & 9.1	Front Beach	100	60	40								
10.0	Saltwater Creek #1	60		20	20							
10.1	Saltwater Creek #2											
10.2	Saltwater Creek #3											
11.0	Saltwater Lagoon											
12	North Smoky Beach	20										
13 & 13.1	South Smoky Beach/Hat Head beach	100	80	20	20			100				
14 & 14.1	Saltaire	20					20				X	X
14.4 & 14.5	Saltaire shoreline					20						
15 & 15.1	Boyter's Lane wetland - east	20	20				100					X
15.2	Boyter's Lane wetland - rehab	20										
16.0	Boyter's Lane wet paddocks						100					X
16.1	Boyter's Lane wet paddock						100					X
17.0	Andersons Inlet					20				X		
17.1	Clybucca Creek				20	20						
18.0	Macleay River opposite Suez Road					20						
19 & 19.1	Pelican Island					20			X			
20	Pelican Island sandspit				20				X			
21	Long Reach Island				20	20						
24 & 25	Killicks Beach/Ryans Cut/Richardsons Crossing	100	60					80				
26 & 27	Goolawah Beach	80	60		20			40				
28.0	Barries Beach nth end	40										
28.1	Barries Beach sth end	20										
29	Macleay Arm north stuarts point	20			20	20						
30	Stuarts Point footbridge	20				20						
31	Macleay Arm oysters #2	20										
32	Macleay Arm Oysters #3											
33	Seagrass Inlet					20						
34	Whimbrel roost				20	20						

Site No.	Site Name	PM	DoffL	DonL	Fish	Boat	Veh	4WD	Mang	Ero	A/H	Cat/ Ag
35	Macleay Arm Sandflat				40	60						
36	Macleay Arm saltmarsh #1								X			
37	Macleay Arm saltmarsh #2									X		
38	South West Rocks creek	20										
39	Macleay Arm rocks - Tattler roost											
40	Boat Ramp											
41	Boat Ramp Sandflat											
42	Spencers Creek					20						
43	Suez Road small claypan											X
44	Suez Road large claypan											X
45	Macleay river bank					20						
46	Macleay River upstream sandspit											
47	SWR Headland	40										
48	Laggers Point	40										
49	Trial Bay Headland	40										
50	Korogoro Ck #1	80	40									
51	Korogoro Ck #2	60										
52	Korogoro Ck #3											
53	Korogoro Ck #4											
54	Pebbly beach little nobby	40										
55	Big Hill Point to Delicate Nobby	100	80	20	20			20				
56	Seale Road wetland											X
57	Point Pioneer -> Pt Plummer outside LGA	20										

Table C2: Threat prioritization. Recorded disturbance and sources of disturbance are derived from Table 6.

Site No.	Site Name	Recorded disturbance													Sources of disturbance								Cumulative total	
		1	2	3	4	5	6	7	8	9	10	11	Total	1	2	3	4	5	6	7	8	Total		
1 & 1.1	Grassy Head Beach - nth end	2	3										5	2	3							5	10	
2 & 2.1	Millington Avenue												0									0	0	
3, 3.1, 4	Stuarts Point Beach	2	3		2								7	2								2	9	
5.0	Macleay Arm Site 1 (south of caravan park)	2	3				1						6	2	3				1			6	12	
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)						1						1					1	1			1	3	4
7.0 & 7.1	Back Beach	2	3										5	2	3							5	10	
8.0	Back Creek footbridge	2	3				1						6	2				1	1			4	10	
9 & 9.1	Front Beach	2	3	1									6	2				1				1	4	10
10.0	Saltwater Creek #1	2		1									3	2								2	5	
10.1	Saltwater Creek #2												0									0	0	
10.2	Saltwater Creek #3												0									0	0	
11.0	Saltwater Lagoon												0									0	0	
12	North Smoky Beach	2											2	2								2	4	
13 & 13.1	South Smoky Beach/Hat Head beach	2	3	1			1						7	2						2		1	5	12
14 & 14.1	Saltaire	2									1	1	4									0	4	
14.4 & 14.5	Saltaire shoreline						1						1						1			1	2	
15 & 15.1	Boyter's Lane wetland - east	2	3									1	6									0	6	
15.2	Boyter's Lane wetland - rehab	2											2									0	2	
16.0	Boyter's Lane wet paddocks, Jerseyville											1	1								1	1	2	
16.1	Boyter's Lane wet paddocks, Jerseyville											1	1								1	1	2	
17.0	Andersons Inlet	2					1			1			4						1		1	2	6	

Site No.	Site Name	Recorded disturbance													Sources of disturbance								Cumulative total
		1	2	3	4	5	6	7	8	9	10	11	Total	1	2	3	4	5	6	7	8	Total	
17.1	Clybucca Creek	2					1						3					1			1	2	5
18.0	Macleay River opposite Suez Road						1						1					1				1	2
19 & 19.1	Pelican Island						1						1					1				1	2
20	Pelican Island sandspit	2											2					1				1	3
21	Long Reach Island						1						1									0	1
24 & 25	Killicks Beach/Ryans Cut/Richardsons Crossing	2	3		2								7	2		1			2		1	6	13
26 & 27	Goolawah Beach	2	3		2								7	2	3				2		1	8	15
28.0	Barries Beach nth end	2											2									0	2
28.1	Barries Beach sth end	2											2	2								2	4
29	Macleay Arm north Stuarts Point	2					1						3		3							3	6
30	Stuarts Point footbridge	2					1						3	2								2	5
31	Macleay Arm oysters #2	2					1						3								1	1	4
32	Macleay Arm Oysters #3	2					1						3								1	1	4
33	Seagrass Inlet						1						1								1	1	2
34	Whimbrel roost	2					1						3									0	3
35	Macleay Arm sandflat	2					1						3					1			1	2	5
36	Macleay Arm saltmarsh #1								1				1					1			1	2	3
37	Macleay Arm saltmarsh #2									1			1					1			1	2	3
38	Back creek upstream	2											2									0	2
39	Macleay Arm rocks - Tattler roost												0				1	1				2	2
40	Boat Ramp												0				1	1			1	3	3
41	Boat Ramp Sandflat												0				1	1			1	3	3
42	Spencers Creek						1						1			1	1					2	3
43	Suez Road small claypan											1	1								1	1	2
44	Suez Road large claypan											1	1								1	1	2
45	Macleay river bank						1						1					1		1		2	3
46	Macleay River upstream sandspit												0					1			1	2	2

Site No.	Site Name	Recorded disturbance													Sources of disturbance								Cumulative total		
		1	2	3	4	5	6	7	8	9	10	11	Total	1	2	3	4	5	6	7	8	Total			
47	SWR Headland	2												2	2									2	4
48	Laggers Point	2												2	2		1							3	5
49	Trial Bay Headland	2												2	2		1							3	5
50	Korogoro Ck #1	2	3											5	2	3	1							6	11
51	Korogoro Ck #2	2												2	2									2	4
52	Korogoro Ck #3													0	2									2	2
53	Korogoro Ck #4													0	2									2	2
54	Pebbly beach little nobby	2												2	2		1							3	5
55	Big Hill Point to Delicate Nobby	2	3	1	2									8	2							1	3	11	
56	Seale Road wetland											1	1								1		1	2	
57	Point Pioneer -> Pt Plomer	2												2	2									2	4

Table C3: Combined site value and threat scores

Site No.	Site Name	Value Score	Threat Score	Value x Threat Score
1 & 1.1	Grassy Head Beach - nth end	3	10	30
2 & 2.1	Millington Avenue	0	0	0
3, 3.1, 4	Stuarts Point Beach	3	9	27
5.0	Macleay Arm Site 1 (south of caravan park)	7	12	84
6 & 6.1	Macleay Arm Site 2 (Fishermans Reach)	17	4	68
7.0 & 7.1	Back Beach	3	10	30
8.0	Back Creek footbridge	1	10	10
9 & 9.1	Front Beach	0	10	10
10.0	Saltwater Creek #1	1	5	5
10.1	Saltwater Creek #2	1	0	1
10.2	Saltwater Creek #3	0	0	0
11.0	Saltwater Lagoon	1	0	1
12	North Smoky Beach	0	4	4
13 & 13.1	South Smoky Beach/Hat Head beach	3	12	36
14 & 14.1	Saltaire	54	4	216
14.4 & 14.5	Saltaire shoreline	10	2	20
15 & 15.1	Boyter's Lane wetland - east	7	6	42
15.2	Boyter's Lane wetland - rehab	5	2	10
16.0	Boyter's Lane wet paddocks, Jerseyville	21	2	42
16.1	Boyter's Lane wet paddocks, Jerseyville	36	2	72
17.0	Andersons Inlet	21	6	126
17.1	Clybucca Creek	30	5	150
18.0	Macleay River opposite Suez Road	5	2	10
19 & 19.1	Pelican Island	0	2	2
20	Pelican Island sandspit	26	3	78
24 & 25	Killicks Beach/Ryans Cut/Richardsons Crossing	18	13	234
26 & 27	Goolawah Beach	0	15	15
28.0	Barries Beach nth end	3	2	6
28.1	Barries Beach sth end	4	4	16
29	Macleay Arm north Stuarts Point	0	6	6
30	Stuarts Point footbridge	1	5	5
31	Macleay Arm oysters #2	13	4	52
32	Macleay Arm Oysters #3	1	4	4
33	Seagrass Inlet	3	2	6
34	Whimbrel roost	28	3	84
35	Macleay Arm sandflat	72	5	360
36	Macleay Arm saltmarsh #1	34	3	102
37	Macleay Arm saltmarsh #2	51	3	153
38	Back creek upstream	3	2	6
39	Macleay Arm rocks - Tattler roost	24	2	48
40	Boat Ramp	3	3	9
41	Boat Ramp Sandflat	17	3	51

Site No.	Site Name	Value Score	Threat Score	Value x Threat Score
42	Spencers Creek	39	3	117
43	Suez Road small claypan	4	2	8
44	Suez Road large claypan	23	2	46
45	Macleay river bank	1	3	3
46	Macleay River upstream sandspit	8	2	16
47	SWR Headland	4	4	16
48	Laggers Point	0	5	5
49	Trial Bay Headland	4	5	20
50	Korogoro Ck #1	1	11	11
51	Korogoro Ck #2	1	4	4
52	Korogoro Ck #3	4	2	8
53	Korogoro Ck #4	1	2	2
54	Pebbly beach little nobby	3	5	15
55	Big Hill Point to Delicate Nobby	4	11	44
56	Seale Road wetland	13	2	26
57	Point Pioneer -> Pt Plomer	3	4	12