

Macleay Coast Migratory and Threatened Shorebird Species Survey – 2021/22



Sandpiper Ecological

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Cover Photo: Macleay Arm sandflat (site 35) at low tide

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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	2
1.1.3 Important sites	5
1.1.4 Local threats to shorebirds	5
2. Study Area	5
3. Methods	8
3.1 Sample sites	8
3.2 Survey timing and design	15
3.3 Survey methods	15
3.3.1 High tide surveys – Macleay estuary and adjacent coastline	16
3.3.2 Low tide surveys – Macleay estuary and adjacent coastline	16
3.3.3 Coastline and floodplain wetlands	16
3.3.4 Additional surveys	17
3.4 Data summary and analysis	17
3.4.1 Data assumptions	17
3.4.2 Estuarine birds	18
3.5 Site prioritisation	18
3.6 Mapping	18
4. Results	18
4.1 Survey constraints	18
4.2 Abundance and species richness of shorebirds	19
4.2.1 Phase one surveys	19
4.2.2 Phase two surveys	20
4.2.3 Additional count data	21
4.2.4 Maximum count and species richness	22
4.2.5 Comparison with 2018/19 survey	23
4.3 Estuarine birds	26
4.4 Site assessment	27
4.4.1 Abundance and species richness of shorebirds at sample sites	27
4.5 Threats identified during the field survey	36
5. Discussion	37
5.1 Comparison to previous surveys	38
5.1.1 Abundance of migratory and threatened species	38
5.1.2 Important shorebird habitat	40
Roosting habitat	40
Foraging habitat	41
5.1.3 Sites of high conservation value	42
5.2 Significance of the Macleay Coast to shorebirds	43

5.3 Key findings.....	44
6. Recommendations	44
7. References	47
Appendix A – 2018/19 survey results	42

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: Sites sampled during the 2021/22 Kempsey shire threatened shorebird surveys.	8
Table 3: Survey dates and tide heights during the 2021/22 Macleay Coast migratory and threatened bird surveys. All times are eastern daylight savings time.....	15
Table 5: 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.	19
Table 6: 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.	21
Table 7: Maximum counts of each shorebird species recorded during each sample period. * count obtained on 18 November 2021.	22
Table 8: Threatened species of estuarine bird and their abundance on the Macleay coast during each of the 2021/22 surveys.....	26
Table 9: 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. AB = Australasian bittern; B = Brolga	28
Table 13: Recommendations.....	44

List of figures

Figure 1: The study area, showing key locations and the Kempsey Shire boundary.....	7
Figure 2: Location of sample sites between Middle Head and the Macleay River.....	10
Figure 3: Location of sample sites within the Macleay estuary and coastline.	11
Figure 4: Location of sample sites at Hat Head and Hat Head Beach.....	12

Figure 5: Location of sample sites between Hat Head and Crescent Head.	13
Figure 6: Location of sample sites between Crescent Head and Point Plomer.	14
Figure 7: Maximum counts of threatened resident and migratory species recorded on the Macleay Coast in 2018/19 and 2021/22.	24
Figure 8: Maximum counts of migratory species recorded on the Macleay Coast in 2018/19 and 2021/22.	24
Figure 9: Maximum counts of sharp-tailed sandpiper recorded on the Macleay Coast in 2018/19 and 2021/22.	25
Figure 10: Comparison of average abundance of resident shorebirds with the count of black-winged stilt (Bws) included and excluded.	25
Figure 11: Comparison of average abundance of resident shorebirds with the count of sharp-tailed sandpiper (Sts) included and excluded.	25
Figure 12: Threatened species records in the Macleay Arm and around Stuarts Point.	31
Figure 13: Location of threatened species recorded in the Macleay Estuary and adjacent coastline. .	32
Figure 14: Location of threatened species recorded at Hat Head and Hat Head Beach.	33
Figure 15: Location of threatened species recorded between Hat Head and Crescent Head.	34
Figure 16: Location of threatened species records between Crescent Head and Point Plomer.	35

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.

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”. Kempsey Shire Council implemented Strategy No. 2 in 2018 by contracting Sandpiper Ecological Surveys to undertake targeted surveys for threatened and migratory shorebirds within coastal areas of Kempsey Shire in summer/autumn 2018/2019 (Sandpiper Ecological 2019). Results were subsequently published in the Journal of the Australasian Wader Studies Group (Rohweder & Priest 2020).

The need for targeted work on shorebirds in the Macleay River Estuary has been known for some time (see Sandpiper Ecological 2009) and recommendations for surveys were included in the Macleay River Estuary Coastal Zone Management Plan (Strategy 21, Geolink 2012) and the Kempsey Coastal Zone Management Plan (Action 15, WBM BMT 2016). Sandpiper Ecological (2019) recommended (Rec N^o. 11) additional shorebird population surveys to gather further data on shorebird abundance, species richness and important habitats.

Sandpiper Ecological was contracted by Kempsey Shire Council to undertake additional targeted surveys for threatened and migratory shorebirds between spring (southern migration) 2021 and autumn (northern migration) 2022. The aim of these surveys was to 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 objectives of the project include:

- 1) value-add to the findings of the 2017 strategy and 2019 survey
- 2) aid in the protection of important migratory, threatened and resident shorebirds within the Kempsey Shire LGA coastal zone
- 3) minimise and where possible eliminate anthropogenic and predation threats to migratory shorebirds within the Kempsey Shire LGA coastal zone,
- 4) improve public awareness and knowledge of shorebird ecology within the Kempsey LGA coastal zone
- 5) identify knowledge gaps in shorebird ecology within the Kempsey Shire LGA coastal zone,
- 6) promote shorebird recovery programs if required, and

- 7) 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

Prior to surveys for the Macleay Coast Shorebird Strategy (InSight 2017) and the subsequent targeted surveys (Sandpiper Ecological 2019) knowledge on the species richness, abundance and habitat use of shorebirds in the Macleay estuary was 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 received minimal survey effort during the 1980's and 1990's, which 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.

Kempsey local government area (LGA) included three Shorebird 2020 count areas – 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>Euseyornis 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
<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

Common name	Species name	EPBC status	BC status	Migratory/ Resident
<i>Limicola falcinellus</i>	Broad-billed Sandpiper		V	M
<i>Philomachus pugnax</i>	Ruff			M
<i>Phalaropus lobatus</i>	Red-necked Phalarope			M

Early studies suggested that the Macleay estuary was not important for migratory shorebirds. Smith (1991), in an analysis of shorebird count data for NSW, listed no migratory species and only three resident species – (Australian) pied oystercatcher, sooty oystercatcher and red-capped plover – 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 single counts of 184 whimbrel and 68 bar-tailed godwit at a high tide roost in the Macleay Arm, just south of Stuarts Point. The whimbrel count exceeded 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). 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.

The 2018/2019 surveys confirmed that the Macleay Coast contained a variety of shorebird habitats and supported a diverse shorebird and estuarine bird community (Sandpiper Ecological 2019). Rohweder and Priest (2020) reported a maximum shorebird population estimate (i.e. cumulative tally of maximum counts for each species) over summer 2018/19 of 1822 individuals. The most abundant species were sharp-tailed sandpiper (951 individuals), black-winged stilt (330 individuals), and Pacific golden plover (211 individuals). Threatened species and their abundance included: eastern curlew (25 individuals), bar-tailed godwit (25 individuals), curlew sandpiper (1 individual), Australian pied oystercatcher (12 individuals), sooty oystercatcher (10 individuals), and broad-billed sandpiper (1 individual). In 2018/19 the Macleay coast supported an internationally significant population of sharp-tailed sandpiper and a nationally significant population of Pacific golden plover (Rohweder & Priest 2020).

The 2018/19 population estimate was substantially greater than the estimate of 237¹ individuals obtained by InSight (2017) during the 2016/17 summer period. This difference is due to a combination of lower survey effort in 2016/17 and the influence of weather conditions, particularly rainfall, on occurrence of sharp-tailed sandpiper and Pacific golden

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

plover.

1.1.3 Important sites

Sandpiper Ecological (2019) assessed all sample sites against a set of value-based criteria for migratory and threatened shorebirds. The site prioritisation identified three very high priority sites and four high priority sites for shorebirds. Very high priority sites 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.

1.1.4 Local threats to shorebirds

Sandpiper Ecological (2019) identified several threats to the local shorebird community all of which are common on the NSW North Coast (Sandpiper Ecological 2004; 2009). Key threats included: people moving (within shorebird habitat), dogs on and off leash, 4WD vehicles on ocean beaches, 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. The highest levels of threat were recorded at sites along the coast, particularly those near residential areas and camp grounds. To identify high priority sites for management Sandpiper Ecological (2019) undertook a site value by threat analysis, which identified Macleay Arm sandflat, Killick Beach, and Saltaire as being priority sites for conservation and management.

2. Study Area

Kempsey shire is situated on the mid-north coast of NSW (Figure 1). 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 1). 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 contained 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 Lake and Lagoon (ICOLLs) and the former creek drains Saltwater Lagoon. Ryans Cut is an artificial channel constructed to drain the adjacent floodplain. 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 consisted 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 1).

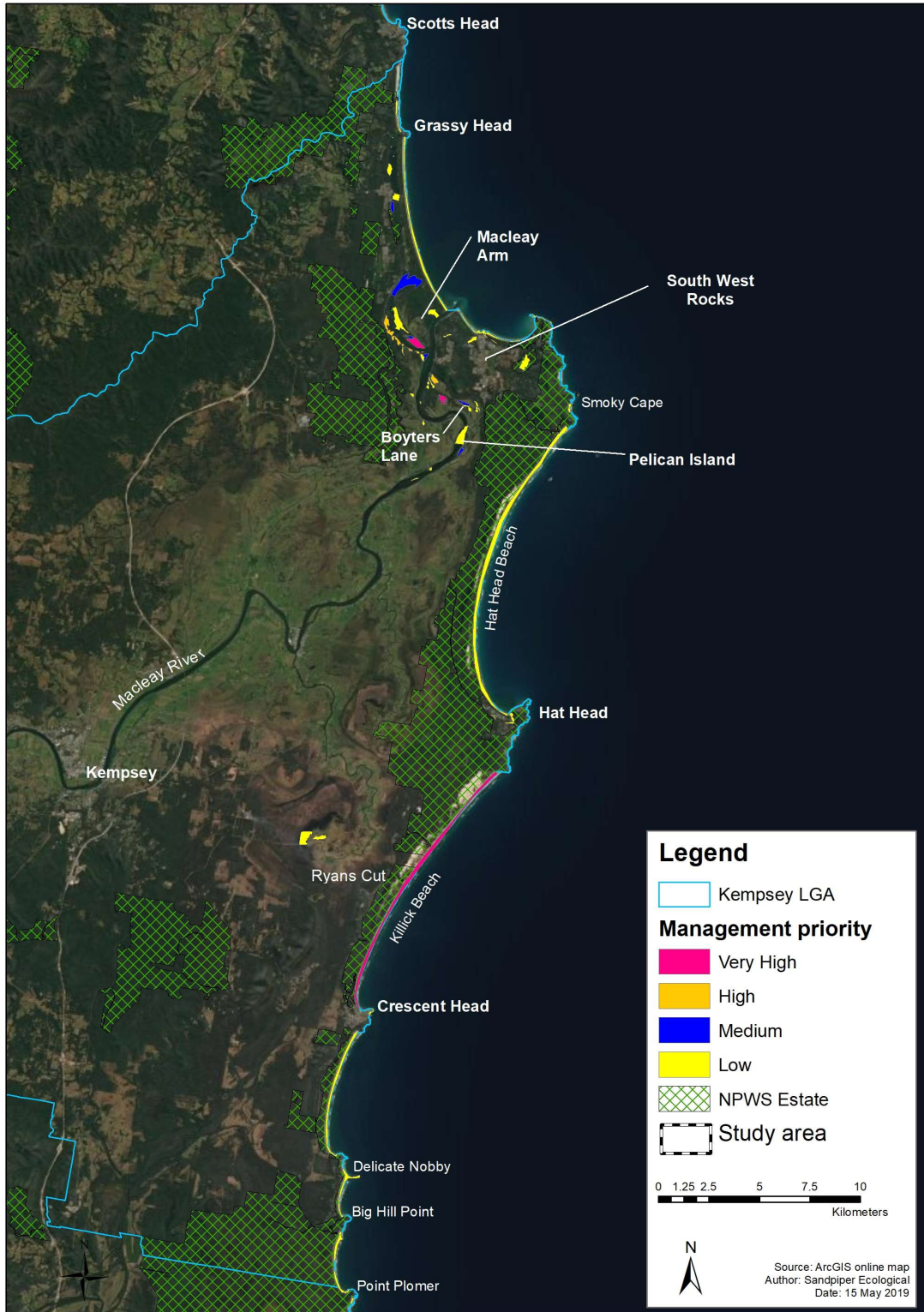


Figure 1: The study area, showing key locations, the Kempsey Shire boundary, priority management sites within the study area.

3. Methods

3.1 Sample sites

Sandpiper Ecological (2019) sampled 63 sites during the summer 2018/19 shorebird survey (Table 2). This included 34 sites identified in the baseline survey (i.e. InSight 2017), and 29 additional sites. Refer to Sandpiper Ecological (2019) for a discussion on how sites were combined or excluded between the two surveys. As specified in recommendation 11 (Sandpiper Ecological 2019), the number of sample sites was reviewed prior to commencement of the 2021/22 surveys.

The review resulted in removal of a small number of sites that either did not support shorebirds during the 2018/19 survey or were unlikely to support shorebirds and were difficult to access. Excluded sites included: S1 - Grassy Head Beach north end, S2, 2.1, 2.2 - Millington Avenue, S9.1 – Front beach central, S10.1, 10.2 – Saltwater Creek #2 and #3, S12 – North Smoky Beach, S29 – Macleay Arm north of Stuarts point, S57 – Point Pioneer.

Sites 19.1, 30, 31 and 41 were combined with sites 19, 3.1, 6 and 40 respectively, and site 8 - Back Creek footbridge - was extended upstream to the boat ramp and included two observation points, one at the boat ramp and one at the footbridge. A total of 54 sites were sampled during the 2021/22 survey (Figures 2-6).

Table 2: Sites sampled during the 2021/22 Kempsey shire threatened shorebird surveys.

Site No.	Site Name	Site Access	Habitat	Easting	Northing
1	Grassy Head Beach - sth end	Foot	Ocean beach	499910	6593290
3	Stuarts Point Beach – nth end	Foot	Ocean beach	500584	6587913
3.1	Stuarts Point Beach – central & footbridge	Foot	Ocean beach & estuarine	500161	6590116
4	North wall beach	Boat	Ocean beach	502139	6584528
5	Macleay Arm Site 1 (south of caravan park)	Foot	Sandflat	499387	6589585
6	Macleay Arm Site 2 (Fishermans Reach)	Boat	Sandflat	500264	6585886
7	Back Beach - nth end	Foot	Ocean beach	503114	6583906
7.1	Back Beach – sth end	Foot	Ocean beach	503559	6583398
8	Back Ck – footbridge & boat ramp	Foot	Sandflat	503277	6582891
9	Front Beach – nth end	Foot	Ocean beach	504950	6583003
10	Saltwater Creek #1	Foot	Sandflat - ICOLL	504158	6583124
11	Saltwater Lagoon	Foot	Open water - estuarine	506118	6582208
13	South Smoky Beach/Hat Head beach	Vehicle	Ocean beach	504258	6571882
14/14.1	Saltaire	Foot	Tidal lagoon	501915	6580004
14.4/14.5	Saltaire - shoreline	Boat	Saltmarsh/Mudflat	501284	6580985
15/15.1	Boyter's Lane wetland east	Foot	Claypan	503693	6579631
15.2	Boyter's Lane wetland rehab.	Foot	Mangrove inlet	503608	6579915
16	Boyter's Lane wet paddocks,	Foot	Tidal lagoon	503251	6579732
16.1	Boyter's Lane wet paddocks,	Foot	Claypan	502928	6579792
17	Andersons Inlet	Boat	Saltmarsh	499626	6583083

Site No.	Site Name	Site Access	Habitat	Easting	Northing
17.1	Clybucca Creek	Boat	Oyster racks, saltmarsh	499950	6582427
18	Macleay River opposite Suez Road	Boat	Rocks	500867	6579872
19	Pelican Island	Boat	Sandflat	503030	6578167
20	Pelican Island sandspit	Boat	Sandflat	502862	6577415
21	Long Reach Island - sandspit	Boat	Sandflat	500680	6576098
23	Belmore Swamp, off Seale Road	Vehicle	Freshwater wetland	495117	6558471
24/25	Killick Beach/Ryans Cut/Richardsons Crossing	Vehicle	Ocean Beach & ICOLL	500210	6556028
26/27	Goolawah Beach to Racecourse Head	Vehicle	Ocean Beach	496629	6546075
28	Barries Beach - nth end	Foot	Ocean Beach	496622	6537859
28.1	Barries Beach - sth end (Pt Plomer)	Foot	Ocean Beach & Rocky Shore	497237	6535808
32	Macleay Arm oysters #3		Oyster racks	501300	6584500
33	Seagrass Inlet		Mud flat	499849	6583641
34	Whimbrel roost		Mangroves	500389	6583057
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		Rocks, sand spit, sand flat, saltmarsh	501071	6582288
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

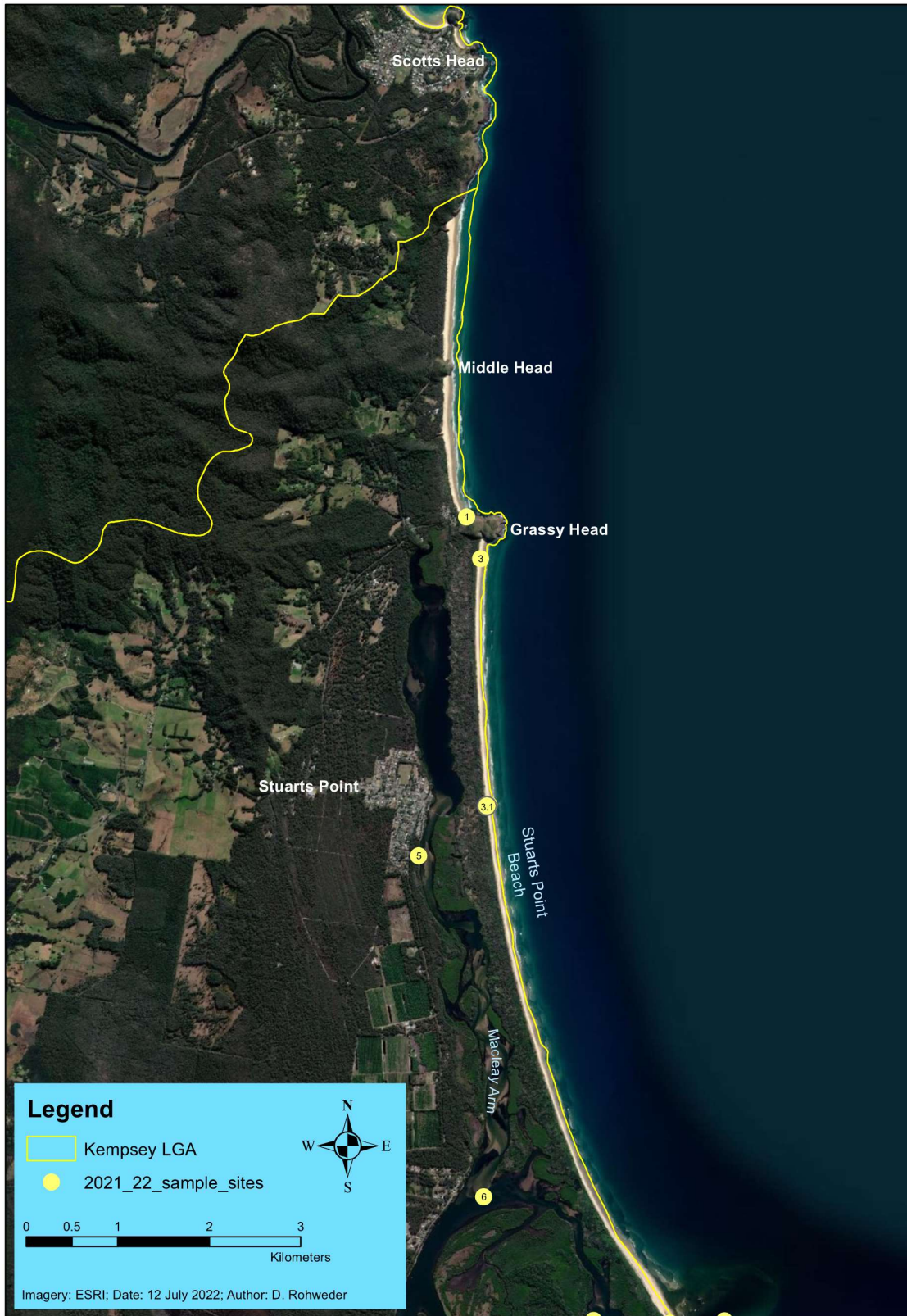


Figure 2: Location of sample sites between Middle Head and the Macleay River.



Figure 3: Location of sample sites within the Macleay estuary and coastline.



Figure 4: Location of sample sites at Hat Head and Hat Head Beach.



Figure 5: Location of sample sites between Hat Head and Crescent Head.

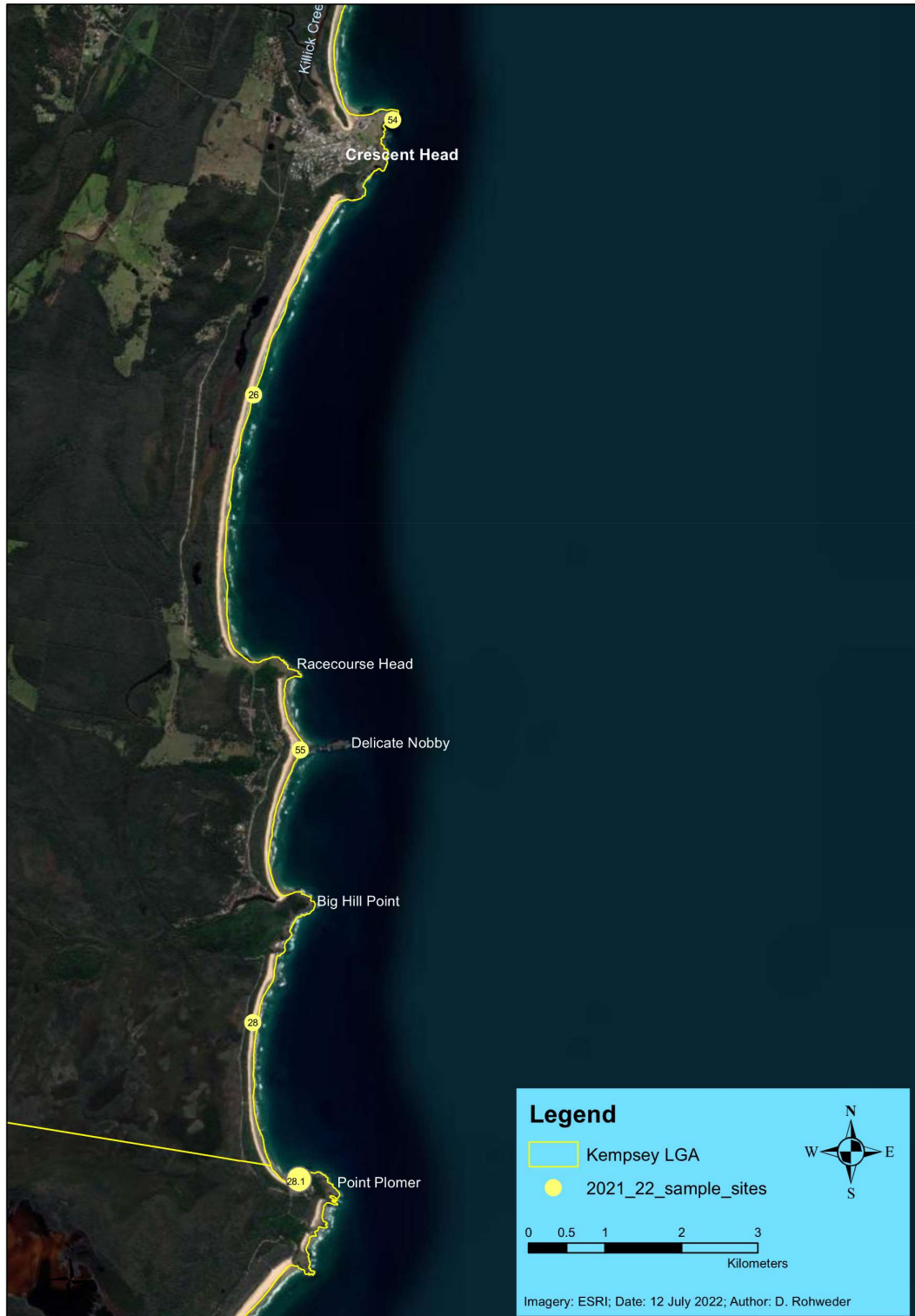


Figure 6: Location of sample sites between Crescent Head and Point Plomer.

3.2 Survey timing and design

Shorebird surveys occurred between 21 October 2021 and 14 April 2022. The sample period encompassed the south and north migrations and the summer period when migratory shorebird populations tend to be most stable (Haslem *et al.* 2008). Surveys were conducted during six 2-5 day sample periods, and included four 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 3). 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 coalesce at a smaller number of sites, thereby enabling better counts.

Table 3: Survey dates and tide heights during the 2021/22 Macleay Coast migratory and threatened bird surveys. 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	21/10/21	0929	1.65	1544	0.40
	22/10/21	1000	1.67	1621	0.41
	23/10/21	1033	1.67	1700	0.43
2	6/12/21	1027	2.06	1714	0.15
	7/12/21	1119	2.01	1811	0.20
	8/12/21	1214	1.92	1908	0.27
3	17/1/22	0849	1.75	1533	0.41
	19/1/22	1004	1.80	1644	0.37
	21/1/22	1118	1.77	1755	0.37
	24/1/22	1324	1.55	0715	0.61
	25/1/22	1418	1.44	0816	0.64
4	8/2/22	1429	1.25	0840	0.71
	10/2/22	1649	1.11	1107	0.73
5	16/3/22	0759	1.71	1434	0.41
	17/3/22	0837	1.76	1506	0.36
	18/3/22	0915	1.79	1538	0.32
6	12/4/22	1745	1.34	1134	0.57
	13/4/22	1823	1.44	1213	0.50
	14/4/22	1859	1.55	1247	0.43

3.3 Survey methods

One-three 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 Grassy Head

in the north of the study area and progressed south. Due to the large number of sites it was impossible to sample all sites at high and low tide during each sample period. 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 between Smoky Cape and Racecourse Head 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

Sites within the Macleay estuary and adjacent coastline were generally sampled by 1-3 observers, one in a boat and two on land. Boat-based surveys either commenced at site 4 (North Wall) two hours prior to high water (HW, TfNSW 2021), or at site 21 (Long Reach Island) one hour prior to HW. Surveys were completed 1-2hrs after MHW. 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 (site 35) 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.

At each site 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

Sites in the Macleay estuary and adjacent coastline sampled at high tide were resampled at low tide by the same observers. The survey team was divided into land-based, and boat based observers. Low tide surveys followed the same pattern as high tide surveys and were conducted within 1.5hrs of low water (LW). The tidal lag within the Macleay Arm meant that low tide surveys in that area typically occurred prior to LW. 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

The timing of coastline and floodplain surveys south of Smoky Cape 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 observer and commenced at Hat Head 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 six 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, Point Plomer, was typically sampled at mid-tide. Once that site was completed Belmore Swamp (site 23) and Seale Road wetland (site 56) were sampled.

3.3.4 Additional surveys

One additional site was sampled at the upstream limit of South West Rocks Creek (also known as Back Creek). The site was sampled on advice from Ian Bradshaw, a local ornithologist, who suggested that eastern curlew had been recorded roosting at the site. The site was sampled at high tide on 8 December 2021. An opportunistic survey of sites 15, 15.1, 16 and 16.1 at Boyters Lane was undertaken on 18 November 2021. The survey was undertaken following several weeks of dry weather.

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 phase one (i.e. high tide surveys in the Macleay Estuary and adjoining coastline, and all surveys elsewhere), and phase two (i.e. low tide surveys in the Macleay estuary and adjoining coastline).

When deriving maximum counts, 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 southern or northern sites 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 move during a sample period. 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 low over the sample period and no birds were recorded at

floodplain wetlands suggesting that birds were not moving regularly between that area and southern floodplain wetlands.

- b. The low diversity and small number of shorebirds outside the estuary meant that movement by some individuals into the estuary would not impact the population estimate.
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. In addition, counts were always scrutinised to assess the possibility of duplication.

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 Site prioritisation

The 2021/22 survey data were not subject to a detailed site and threat prioritisation. Differences in survey conditions between 2018/19 and 2021/22 resulted in substantial differences in species abundance and a site prioritisation on 2021/22 data would provide substantially different and misleading results for some sites. The approach adopted on this occasion was to describe changes in habitat use and identify additional important sites based on experience and survey observations. A similar approach was applied to threats.

3.6 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 point locality data for threatened species.

4. Results

4.1 Survey constraints

The 2021/22 surveys were influenced by a number of constraining factors, including:

1. *High rainfall and minor flooding* – The 2021/22 La-nina weather event resulted in consistent heavy rainfall from early December 2021 until May 2022, encompassing most of the sample period. Not only did rainfall disrupt or delay surveys on several occasions, minor flooding in the Macleay River and major flooding elsewhere on the north coast affected site access.

Indeed, rain during the survey period also had a major effect on species occurrence and abundance.

2. *High levels of human activity at ocean beach sites between October 2021 and February 2022* – Human activity at ocean beach sites, which includes the majority of sites sampled, was substantially higher in 2021/22 than 2018/19. This is attributed to previous Covid-19 lockdowns and restrictions on interstate and overseas travel. High levels of human activity affected the ability of surveyors to sample sites and disturbed birds.
3. *The third Covid-19 (Omicron) wave* – The rapid spread of Covid-19 in January and February 2022 and uncertainty regarding the severity of the Omicron variant influenced survey timing and duration of site visits.

In the authors experience the period from December 2021 to May 2022 has been the most challenging for field surveys in three decades of undertaking such work.

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 15 species of shorebird, including eight resident and seven migratory species (Table 4). Pied and sooty oystercatcher, masked lapwing and whimbrel were recorded during all phase one surveys. Black-winged stilt was recorded during five surveys, with bar-tailed godwit and grey-tailed tattler recorded during four surveys. Red-kneed dotterel, knot and curlew sandpiper were each recorded during one sample only (Table 4).

Shorebird abundance ranged from 61 to 154 individuals across the six phase one samples (Table 4). The abundance of migratory species ranged from 20 in sample six to 102 in sample one, and resident shorebirds from 28 in sample two to 85 in sample six. Bar-tailed godwit was the most abundant species with counts of 47 and 52 individuals recorded in samples one and two respectively. The maximum number of eastern curlew recorded in phase one was 20 in sample four (Table 4). Abundance of pied oystercatcher ranged from two to 19, and abundance of sooty oystercatcher from three to five individuals. A pair of beach stone-curlew was recorded during sample four and single birds were recorded during samples two and six. One curlew sandpiper was recorded during sample one.

Table 4: 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	6
Beach Stone-Curlew ^{CE}		1		2		1
Australian pied oystercatcher ^E	19	2	2	2	4	7
Sooty oystercatcher ^V	5	4	3	4	5	5
Black-winged stilt	7	1		6	49	38
Red-capped plover					1	
Black-fronted dotterel		13		6		
Red-kneed dotterel			5			
Masked lapwing	21	7	23	24	20	34

Common name	Survey No.					
	1	2	3	4	5	6
Total resident species	4	6	4	6	5	5
Total resident individuals	52	28	33	44	79	85
Double-banded Plover				1		11
Bar-tailed godwit ^V	47	52	4	1		
Whimbrel	32	2	23	17	26	9
Eastern curlew ^{CE}	2	15		20		
Grey-tailed tattler	13	12	1		9	
Knot spp	7					
Medium shorebird					6	
Sandpiper spp.	1					
Total migratory species	6	4	3	4	3	2
Total migratory individuals	102	81	28	39	41	20
Total species	10	10	7	10	8	7
Total individuals	154	109	61	83	120	105

4.2.2 Phase two surveys

Fifteen species of shorebird were recorded during phase two surveys, including six resident and nine migratory species (Table 5). Sandpiper spp. has been included as a distinct species as it is most likely sharp-tailed sandpiper. Species richness ranged from seven to 11 across the six samples. Migratory species included double-banded plover, a trans-Tasman migrant. Six and 14 double-banded plovers were recorded during samples five and six respectively (Table 5).

Abundance of all shorebirds during phase two surveys ranged from 51 to 265 individuals (Table 5). The abundance of migratory shorebirds ranged from 35 in sample six to 145 in sample four. Species richness of migratory shorebirds peaked, at seven species, during sample one and fluctuated between five and six species between samples three and six (Table 5). The abundance of resident shorebirds ranged from 14 in samples one and six to 140 in sample three.

Pacific golden plover was the most abundant species with peak counts of 92 and 55 individuals recorded in samples four and five, followed by bar-tailed godwit with peak counts of 47 and 51 individuals recorded in samples one and two (Table 5). The abundance of whimbrel and grey-tailed tattler peaked in sample three with counts of 43 and 22 individuals respectively. The abundance of sharp-tailed sandpiper was low and ranged from six to 12 individuals with the species recorded during samples one, three and four only. One greenshank was recorded in sample six only.

Resident shorebirds were recorded during all samples, although masked lapwing was the only species recorded during each sample (Table 5). The abundance of Australian pied oystercatcher peaked at four individuals during sample two. Masked lapwing was the most abundant resident species in phase two surveys, with a maximum count of 133 individuals recorded in sample three (Table 5).

Table 5: 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	6
Beach Stone-curlew ^{CE}					2	
Australian pied oystercatcher ^E		4				
Sooty oystercatcher ^V	3	2	5	6		
Black-winged stilt	9		2	11		
Black-fronted dotterel		2		6		
Masked lapwing	5	78	133	87	46	16
Total resident individuals	14	86	140	110	48	16
Total resident species	3	4	3	4	2	1
Pacific golden plover	21		17	92	55	
Double-banded plover					6	14
Bar-tailed godwit ^V	47	51	17	1	1	3
Whimbrel	22	23	43	30	29	14
Eastern curlew ^{CE}	16	7	15			1
Grey-tailed tattler	8	16	22	12	8	2
Common greenshank						1
Curlew sandpiper	8					
Sharp-tailed sandpiper	12		6	10		
Total migratory individuals	134	97	120	145	99	35
Total migratory species	7	4	6	5	5	6
Total species	11	8	9	9	7	7
Total abundance	180	183	260	265	147	51

4.2.3 Additional count data

Additional surveys at the Boyters Lane wetlands (i.e. sites 14-16), in the upper Macleay Estuary (sites 18, 20, 21) and at the upper end of South West Rocks Creek on 24 October, 18 November and 8 December recorded some important results. On 24 October, 47 Pacific golden plover were recorded at S21, 42 bar-tailed godwit at S18 and S20, and 21 black-winged stilt at S15.1 and 16. On 18 November following three weeks with no rainfall 287 sharp-tailed sandpiper were recorded at S16 and 16.1. The count of sharp-tailed sandpiper was the highest recorded for that species during the 2021/22 sample period, whilst the counts for black-winged stilt and Pacific golden plover were the third highest recorded for both species.

The upper end of South West Rocks Creek was inundated and unsuitable for roosting during the inspection on 8 December. During neap tides and low rainfall the site could provide high tide roost and foraging habitat for migratory shorebirds and warrants sampling during future surveys. One adult black bittern (*Ixobrychus flavicollis*), which is listed as vulnerable by the *Biodiversity Conservation Act 2016*, was recorded at the site.

4.2.4 Maximum count and species richness

The maximum cumulative count of shorebirds in the study area during the sample period was 782 individuals (Table 6). A total of 19 shorebird species were recorded, including eight resident and 11 migratory species (Table 6). Seven threatened shorebird species were recorded, including three resident species (beach stone-curlew, pied and sooty oystercatcher) and four migratory species (bar-tailed godwit, eastern curlew, curlew sandpiper & knot spp). Knot species, either red or great knot, was recorded during sample one at sites 20 and 21 in the upper Macleay estuary. Both species of knot are listed as threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and great knot is also listed as vulnerable by the *Biodiversity Conservation (BC) Act 2016*.

Both species of oystercatcher were recorded during all surveys, beach stone-curlew during four surveys, and bar-tailed godwit, eastern curlew and curlew sandpiper were recorded during six, five and one survey respectively (Table 6). Three critically endangered species were recorded in the study area, including eastern curlew, curlew sandpiper and beach stone-curlew, with a fourth species, great knot, remaining unconfirmed.

The maximum count for migratory shorebirds was 554 individuals and for resident shorebirds 228 individuals (Table 6). Maximum counts of all shorebirds across the six samples ranged from 120 in sample six to 543 in sample two. Maximum counts per sample for migratory shorebirds ranged from 35 in sample six to 442 in sample two.

Table 6: Maximum counts of each shorebird species recorded during each sample period. * count obtained on 18 November 2021. CE = critically endangered, E = endangered, V = vulnerable; tr = threatened

Common name	Maximum Count	Survey No.					
		1	2	3	4	5	6
Beach Stone-Curlew ^{CE}	2		1		2	2	1
Australian pied oystercatcher ^E	19	19	4	2	2	4	7
Sooty oystercatcher ^V	6	5	4	3	6	5	5
Black-winged stilt	49	9	1	2	11	49	38
Red-capped plover	1					1	
Black-fronted dotterel	13		13		6		
Red-kneed dotterel	5			5			
Masked lapwing	133	21	78	133	87	46	34
Total resident species	8	4	6	5	7	6	5
Total resident individuals	228	54	101	145	114	107	85
Pacific golden plover	92	21	47	17	92	55	
Double-banded Plover	14				1	6	14
Latham's snipe	2		2*				
Bar-tailed godwit ^V	52	47	52	17	1	1	3
Whimbrel	43	32	23	43	30	29	14
Eastern curlew ^{CE}	20	16	15	15	20		1
Grey-tailed tattler	22	13	16	22	12	9	2
Common greenshank	1						1
Sharp-tailed sandpiper	287	12	287*	6	10		

Common name	Maximum Count	Survey No.					
		1	2	3	4	5	6
Curlew Sandpiper ^{CE}	8	8					
Knot spp ^{tr}	7	7					
Medium shorebird	6					6	
Total migratory species	11	8	7	6	7	5	6
Total migratory individuals	554	156	442	120	166	106	35
Total species	19	12	13	11	14	11	11
Total individuals	782	210	543	265	280	213	120

The abundance of eastern curlew remained stable from October to January and peaked in late February. Abundance of bar-tailed godwit peaked in October and December and declined sharply in January and February. The trend observed for bar-tailed godwit is contrary to usual patterns of abundance at north coast estuaries and may have been due to flooding in December or high levels of human activity over the Christmas holiday period. Identifying a trend in abundance for Pacific golden plover is difficult as individuals seem to regularly move in and out of the sample area. Abundance of grey-tailed tattler remained fairly stable from samples one to four, with a peak of 22 individuals recorded in sample three (Table 6).

4.2.5 Comparison with 2018/19 survey

The maximum count of shorebirds in 2021/22 (774 individuals) was substantially less than recorded in 2018/19 (1822 individuals). Species richness was also slightly lower in 2021/22 at 18 compared to 20 in 2018/19. Species composition differed between the surveys with red-necked avocet, red-necked stint and broad-billed sandpiper recorded in 2018/19 only and beach stone-curlew and red/great knot recorded in 2021/22 only (Table 6; Appendix A).

Direct comparison of maximum counts for threatened species recorded in both surveys shows that higher numbers of Australian pied oystercatcher and bar-tailed godwit were recorded in 2021/22, whilst numbers of sooty oystercatcher and eastern curlew were higher in 2018/19 (Figure 7). Differences were also recorded for other migratory species, with higher numbers of Pacific golden plover, whimbrel and grey-tailed tattler recorded in 2018/19 and higher number of double-banded plover recorded in 2021/22 (Figure 8). Another resident species that declined substantially in 2021/22 was red-capped plover with seven individuals recorded in 2018/19 and only one individual recorded in 2021/22 (Appendix A & Table 6).

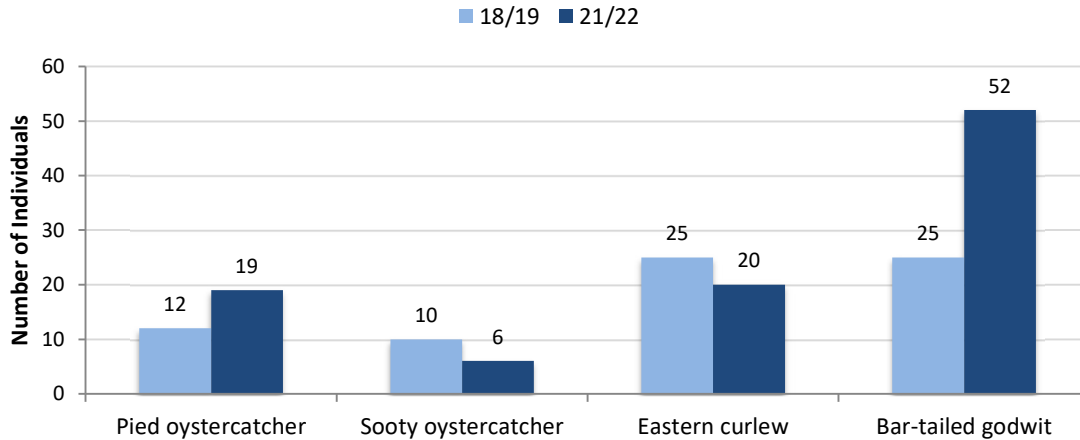


Figure 7: Maximum counts of threatened resident and migratory species recorded on the Macleay Coast in 2018/19 and 2021/22.

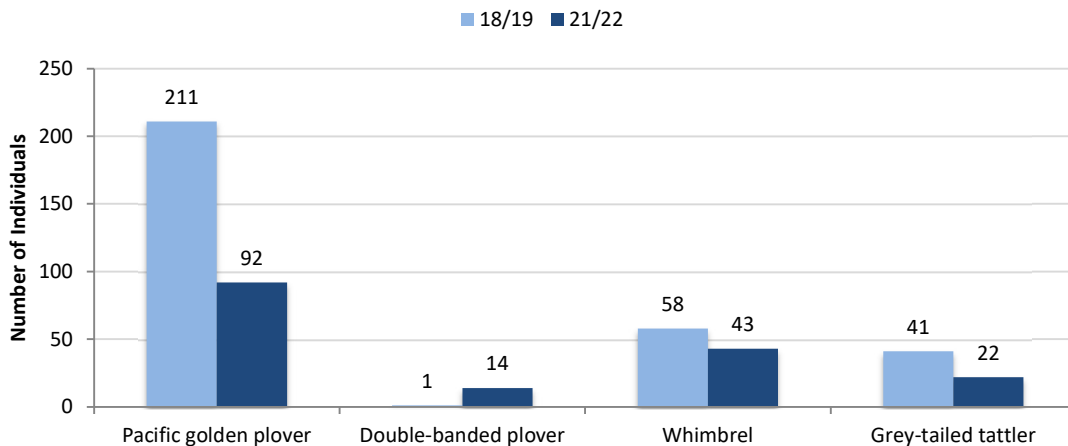


Figure 8: Maximum counts of migratory species recorded on the Macleay Coast in 2018/19 and 2021/22.

Of the migratory species, sharp-tailed sandpiper displayed the largest difference between surveys with a maximum count of 951 individuals recorded in 2018/19 compared to 287 individuals in 2021/22 (Figure 9). Similarly, the difference in abundance of resident shorebirds can be attributed to lower numbers of black-winged stilt in 2021/22. The influence of sharp-tailed sandpiper and black-winged stilt on abundance was assessed by comparing average abundance of resident and migratory species with and without those species. The April 2022 survey was removed from the 2021/22 sample to make the surveys more comparable.

The comparison clearly shows the influence that the two species have on abundance of resident and migratory shorebirds (Figures 10 & 11). Average abundance of resident shorebirds including black-winged stilts in 2018/19 was 384 individuals compared to 104 in 2021/22. In contrast, average abundance excluding black-winged stilt was 95 in 2018/19 and 90 in 2021/22 (Figure 10). Average abundance of migratory shorebirds including sharp-tailed sandpiper was 844 individuals in 2018/19 and 198 in 2021/22 (Figure 11). With sharp-tailed sandpipers removed, average abundance was 198 in 2018/19 and 135 in 2021/22.

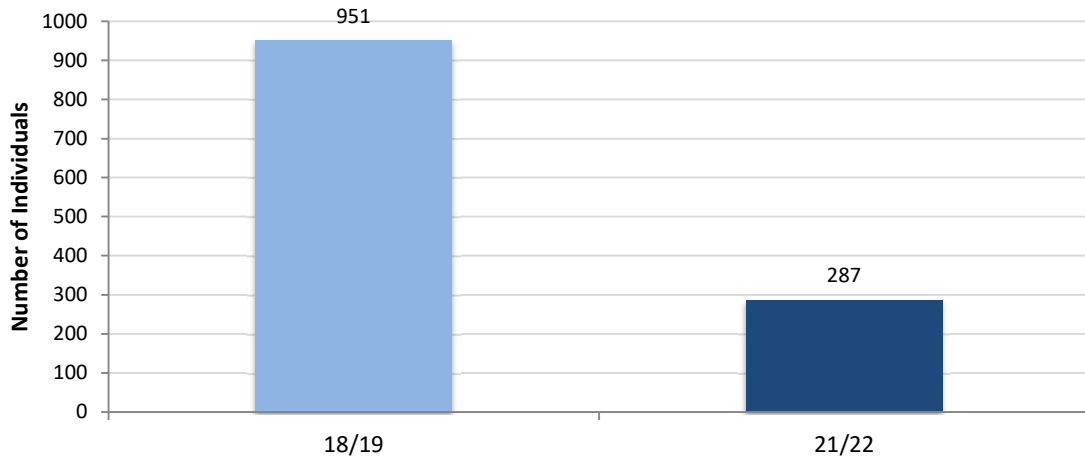


Figure 9: Maximum counts of sharp-tailed sandpiper recorded on the Macleay Coast in 2018/19 and 2021/22.

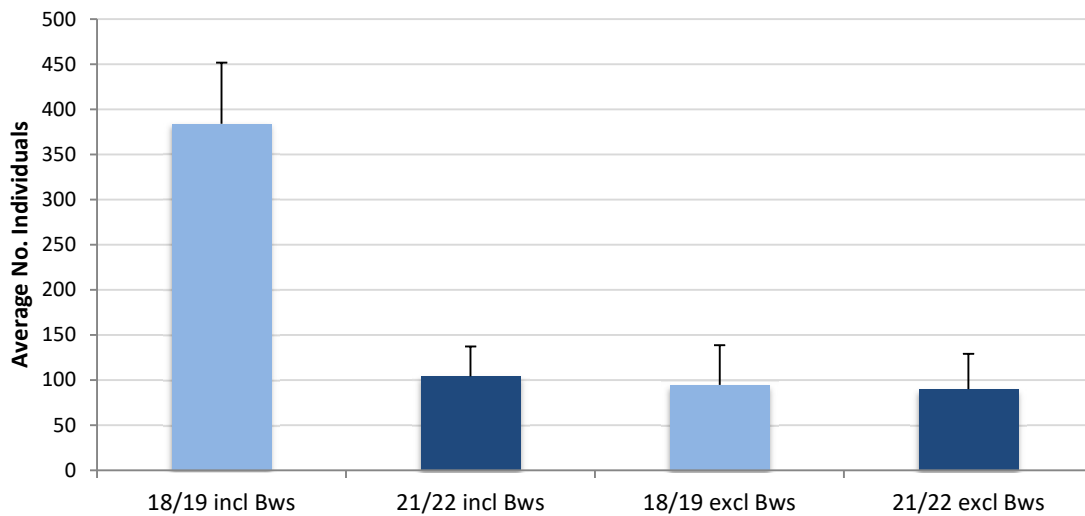


Figure 10: Comparison of average abundance of resident shorebirds with the count of black-winged stilt (Bws) included and excluded.

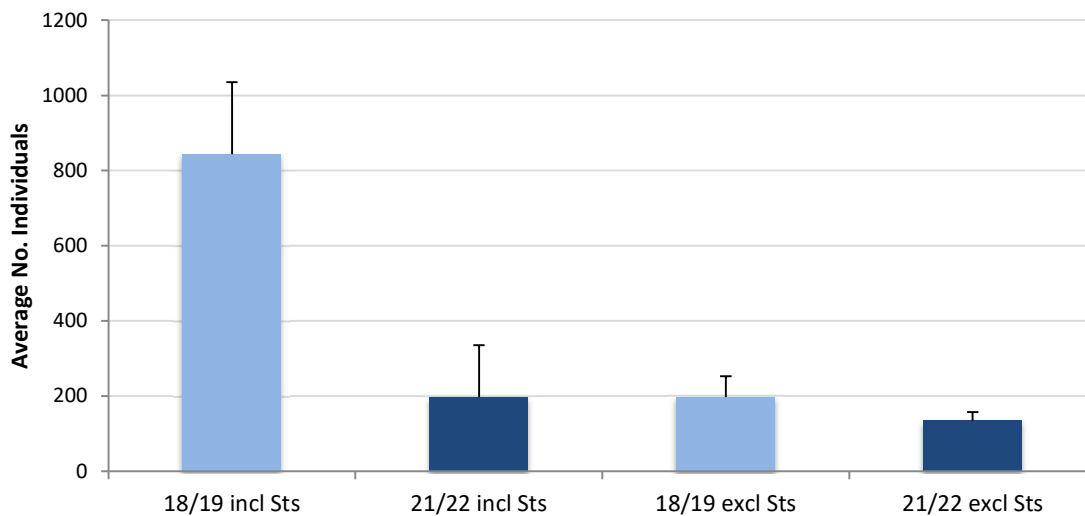


Figure 11: Comparison of average abundance of resident shorebirds with the count of sharp-tailed sandpiper (Sts) included and excluded.

4.3 Estuarine birds

Fifty-two species of estuarine bird were recorded during the survey, with counts ranging from 699 to 2013 individuals per sample. The peak count of 2013 individuals occurred during sample six. Greater crested tern (*Thalasseus bergii*) and silver gull (*Chroicocephalus novaehollandiae*) were the most abundant species of estuarine bird with maximum population estimates of 601 and 631 individuals respectively. The population of grey and chestnut teal (*Anas gracilis* & *A. castanea*) peaked at 343 individuals in sample one. Other important counts included 50 and 52 royal spoonbill (*Platalea regia*) in February and March respectively, 17 and 24 great egret (*Ardea alba*) in March and April respectively, 13 intermediate egret (*Ardea intermedia*) in April, and 14 little egret (*Egretta garzetta*) in March 2022.

Seven threatened species of estuarine bird were recorded during the survey (Table 7). Obtaining accurate population estimates for estuarine species is challenging due to their large home ranges, high likelihood of rapid movements during a survey and use of habitats outside the study area, particularly floodplain wetlands. Eastern osprey and white-bellied sea-eagle are particularly challenging and the numbers presented in Table 7 have been adjusted to account for likely duplication. Notwithstanding, the estimate of 11 white-bellied sea-eagle in sample five is regarded as accurate and possibly an underestimate. It is based on the number of individuals recorded during a single high tide survey of estuarine sites only. The survey occurred during a minor fish kill in the estuary and all sea-eagles observed were perched with no individuals recorded moving during the survey.

White-bellied sea-eagle and eastern osprey were the most widespread estuarine species with individuals recorded at 22 and 23 sites respectively (Figures 12 – 16). The number of sites with eastern osprey increased substantially from 2018/19, when the species was recorded at 11 sites only. Sub-adult sea-eagles and osprey were recorded in 2021/22. Other significant records include six black-necked stork in samples 5 and 6, and one black bittern and one Australian bittern in sample 1. Black-necked storks were recorded at eight sites, including all sites along Boyters Lane (S14, 15 & 16), and four estuarine sites (#17.1, 20, 35 & 43). The six individuals recorded at site 20 in sample five were all juveniles.

Table 7: Threatened species of estuarine bird and their abundance on the Macleay coast during each of the 2021/22 surveys.

Species	Number of individuals in each sample					
	1	2	3	4	5	6
Eastern osprey	3	4	3	2	4	3
White-bellied Sea-eagle	1	6	5	4	11	3
Little tern	0	89	81	50	65	0
Brolga	2	0	0	0	0	0
Black-necked stork	1	1	4	1	6	6
Black bittern	1	0	0	0	0	0
Australasian bittern	1	0	0	0	0	0

4.4 Site assessment

4.4.1 Abundance and species richness of shorebirds at sample sites

Of the 54 sites sampled, eight did not support shorebirds during the sample period. These were Grassy Head Beach (site 1), Back Beach (sites 7 & 7.1), Saltwater Creek #1 (site 10), Boyters Lane wetland rehab (site 15.2), Goolawah Beach to Racecourse Head (sites 26/27), Macleay Arm Oysters #3 (site 32), Korogoro Ck1 (site 50), and Korogoro Ck2 (site 51; Table 9). Masked lapwing was the only shorebird species recorded at a further nine sites, including two of the four Korogoro Creek sites. No other species of shorebird was recorded at Korogoro Creek (Table 8).

The highest species richness of shorebirds at a single site was 10 recorded at Macleay Arm sandflat (site 35), followed by nine at Pelican Island sandspit (site 20). Seven species were recorded at sites 4 (North wall beach), and 16 (Boyters Lane flooded paddocks south; Table 8). The highest species richness of migratory species was seven at Macleay Arm sandflat, and Pelican Island sandspit.

The highest maximum count of shorebirds at a site was 319 individuals recorded at Boyters Lane flooded paddocks (sites 16 & 16.1). The highest counts at estuarine sites were 87 at Pelican Island sandspit (site 20), and 82 at Macleay Arm sandflat (site 35). These sites were also identified as key sites in 2018/19. Major changes in number and species richness between 2018/19 and 2021/22 included:

- substantially fewer birds at Saltaire wetland (sites 14/14.1), Boyters Lane wetland (sites 15/15.1), and Spencers Creek (site 42), in 2021/22;
- less frequent use of Macleay Arm saltmarshes #1 and #2 in 2021/22;
- increased number of migratory species (whimbrel & godwit) in South West Rocks Creek in 2021/22;
- 10 Australian pied oystercatcher at Hat Head Beach in October 2021/22;
- two breeding pair of Australian pied oystercatcher at Killick Beach, down from three in 2018/19; and
- increased use of site 4 (North wall beach), and site 20 (Pelican Island sandspit) in 2021/22.

North wall beach (site 4) may be an important roost that was overlooked during the 2018/19 survey and the early part of 2021/22. The area sampled at site 4 typically extended for 500m north of the northern river breakwall, with observations undertaken from the breakwall using a spotting scope. In the later part of 2021/22 shorebirds were recorded roosting beyond the usual sample area and it is suspected that North wall beach may be the missing roost referred to in the 2018/19 report (Sandpiper Ecological 2019). The tidal lagoon at the upper end of South West Rocks Creek also has potential as a high tide roost/foraging habitat.

4.4.2 Distribution and abundance of threatened shorebirds

Twenty-eight sites supported threatened shorebirds, although 10 of these supported either Australian pied oystercatcher or sooty oystercatcher only (Figures 12 to 16). Over the sample period Australian pied oystercatcher were recorded at nine sites and sooty oystercatcher at 11 sites. Sooty oystercatcher was strictly coastal with individuals recorded on rocky shores and ocean beaches only.

Australian pied oystercatcher was recorded at three ocean beaches (Stuarts Point Beach, South Smoky/Hat Head Beach, & Killick Beach), and three intertidal estuarine sites at low tide (Back Creek-site 8, Seagrass inlet-site 33, & Macleay Arm-site 35), and one sandspit at high tide (Boat ramp bay-site 40/41). A pair of birds was suspected to be nesting at site 40 in October 2021. The highest number of Australian pied oystercatcher recorded at a site was 10 at Hat Head Beach (site 13) followed by seven at Killick Beach (site 24/25) and five at Macleay Arm sandflat (site 35). The highest number of sooty oystercatcher recorded at a single site was four on the rocky headland at the north end of Front Beach (site 9).

Between one and two beach stone-curlews, most likely a breeding pair, were recorded at three sites, North wall beach (site 4), Macleay Arm saltmarsh #2 (site 37), and Macleay Arm rocks (site 39). A resident reported a pair of stone-curlews roosting on Shark Island and identification was confirmed by viewing photographs (Mark Robinson pers comm). According to the resident, the pair occasionally roost in an area of mown grass beneath scattered swamp oak (*Casuarina glauca*).

Eastern curlew was recorded at eight sites, four foraging sites (sites 6, 17, 18, 40), two roosts (sites 4 & 42), and two foraging and roost sites (sites 20 & 35). Birds were recorded roosting at site 35 during neap high tides. Six of these sites were in the lower estuary, with three in the Macleay Arm, two near Spencers Creek (sites 40/41 & 42) and one ocean beach (site 4). Sites 18 and 20 are situated in the upper estuary (Figure 13). The highest count of eastern curlew recorded at a single roost was 20 at North wall beach (site 4). Fifteen individuals were recorded at Spencers Creek (site 42), and during a neap high tide at Macleay Arm sandflat (site 35). At low tide, eastern curlew dispersed over several sites including three in the lower estuary (sites 6, 17 and 35), with small numbers also foraging at sites 18 and 20 in the upper estuary.

Curlew sandpiper was recorded at site 14/14.1 (Saltaire lagoon) and Boyters lane flooded paddocks (sites 16 & 16.1), with an unconfirmed record at site 11 (Saltwater Lagoon; Figures 12 to 16). Bar-tailed godwit was recorded at 10 estuarine sites and one ocean beach (Killick Beach), including two roosts (sites 37 & 42), six feeding areas (sites 8, 17, 18, 21, 40/41 & 46) and two foraging and roost sites (sites 20 & 35; Figure 12 & 13). Habitat use by bar-tailed godwit in 2021/22 contrasted with 2018/19 when they were recorded at six sites in the Macleay Arm only. Indeed, the maximum count of godwits recorded in 2021/22 (52 individuals) was double that recorded in 2018/19. The highest counts of bar-tailed godwit recorded at individual sites included 48 individuals at site 20, 36 individuals at site 35, and 20 individuals at site 37. Peak counts occurred in October and December with abundance declining substantially in January 2022.

Table 8: Number of migratory species and resident species, and number of threatened species recorded at each sample site. APO = Australian pied oystercatcher, BSC = beach stone-curlew, SO = sooty oystercatcher, EC = eastern curlew, EO = Eastern osprey, WBSE = White-bellied sea-eagle, LT = little tern, BtG = Bar-tailed

godwit, AB = Australasian bittern, B = Brolga, BnS = Black-necked stork, CS = curlew sandpiper, Ksp = Knot species

Site No.	Site Name	Habitat	Migratory species	Resident species	Threatened species
1	Grassy Head Beach - sth end	Ocean beach	0	0	
3	Stuarts Point Beach – nth end	Ocean beach	1	1	APO
3.1	Stuarts Point Beach – central & footbridge	Ocean beach & estuarine	1	1	APO
4	North wall beach	Ocean beach	3	4	BSC, APO, SO, EC, EO, WBSE, LT
5	Macleay Arm Site 1 (south of caravan park)	Sandflat	0	1	EO, WBSE
6	Macleay Arm Site 2 (Fishermans Reach)	Sandflat	3	1	EC, WBSE, LT,
7	Back Beach - nth end	Ocean beach	0	0	EO, LT,
7.1	Back Beach – sth end	Ocean beach	0	0	EO
8	Back Creek	Sandflat	3	3	APO, SO, BtG
9	Front Beach – nth end	Ocean beach	0	2	SO
10	Saltwater Creek #1	Sandflat - ICOLL	1	0	
11	Saltwater Lagoon	Open water - estuarine	1	0	AB
13	South Smoky Beach/Hat Head beach	Ocean beach	0	3	APO, SO, EO, WBSE
14 & 14.1	Saltaire	Tidal lagoon	2	2	CS, WBSE
14.5	Saltaire - shoreline	Saltmarsh/Mudflat	1	1	EO, WBSE
15 & 15.1	Boyster's Lane wetland east	Claypan	1	2	
15.2	Boyster's Lane wetland rehab.	Mangrove inlet	0	0	
16	Boyster's Lane wet paddocks,	Tidal lagoon	4	3	CS, EO, WBSE, BnS
16.1	Boyster's Lane wet paddocks,	Claypan	2	2	CS, BnS, B
17	Andersons Inlet	Saltmarsh	3	0	EC, BtG, EO, WBSE, LT
17.1	Clybucca Creek	Oyster racks, saltmarsh	1	0	WBSE, LT, BnS
18	Macleay River opposite Suez Road	Rocks	3	2	EC, BtG, WBSE, LT
19	Pelican Island	Sandflat	1	1	EO, WBSE
20	Pelican Island sandspit	Sandflat	7	2	Ksp, BtG, EC, LT, BnS, EO, WBSE
21	Long Reach Island - sandspit	Sandflat	3	1	BtG, Ksp
23	Belmore Swamp, off Seale Road	Freshwater wetland	0	1	
24/25	Killick Beach/Ryans Cut/Richardsons Crossing	Ocean Beach & ICOLL	2	3	APO, BtG, EO, WBSE
26/ 27	Goolawah Beach to Racecourse Head	Ocean Beach	0	0	
28	Barries Beach - nth end	Ocean Beach	0	1	
28.1	Barries Beach - sth end (Pt Plomer)	Ocean Beach & Rocky Shore	0	1	SO, EO
32	Macleay Arm oysters #3	Oyster racks	0	0	EO, LT
33	Seagrass Inlet	Mud flat	1	1	APO, EO, WBSE
34	Whimbrel roost	Mangroves	1	0	
35	Macleay arm sandflat	Sandflat	7	3	APO, SO, BtG, EC, WBSE, BnS, LT
36	Macleay Arm saltmarsh #1	Saltmarsh	2	1	SO, EO

Site No.	Site Name	Habitat	Migratory species	Resident species	Threatened species
37	Macleay Arm saltmarsh #2	Saltmarsh	1	1	BtG, BSC
38	SW Rocks Ck upstream	Sandflat	1	1	
39	Macleay Arm rocks - Tattler roost	Rocks	2	1	BSC, EO, WBSE
40 (incl 41)	Boat Ramp bay	Rocks, sand spit, sand flat, saltmarsh	4	2	APO, BtG, EC, EO, WBSE, LT
42	Spencers Creek	Saltmarsh	3	1	EC, BtG, EO, WBSE,
43	Suez road small claypan	Claypan	1	4	
44	Suez road wetland	Freshwater wetland	0	1	WBSE
45	Macleay River bank	Rocks	0	1	WBSE
46	Macleay river upstream sandspit	Sandflat	2	1	BtG, WBSE, LT
47	SWR Headland	Rocky shore	0	1	SO, EO
48	Laggers Point	Rocky shore	0	1	
49	Trial Bay Headland	Rocky shore	0	2	SO
50	Korogoro ck1	Sandflat	0	0	
51	Korogoro ck2	Sandflat	0	0	
52	Korogoro ck3	Sandflat	0	1	
53	Korogoro ck4	Sandflat	0	1	
54	Pebbly Beach/Little Nobby	Rocky shore	0	1	SO, EO
55	Big Hill Point to Delicate Nobby	Ocean Beach & Rocky Shore	0	1	SO
56	Seale Road wetland	Freshwater wetland	0	1	



Figure 12: Threatened species records in the Macleay Arm and around Stuarts Point.

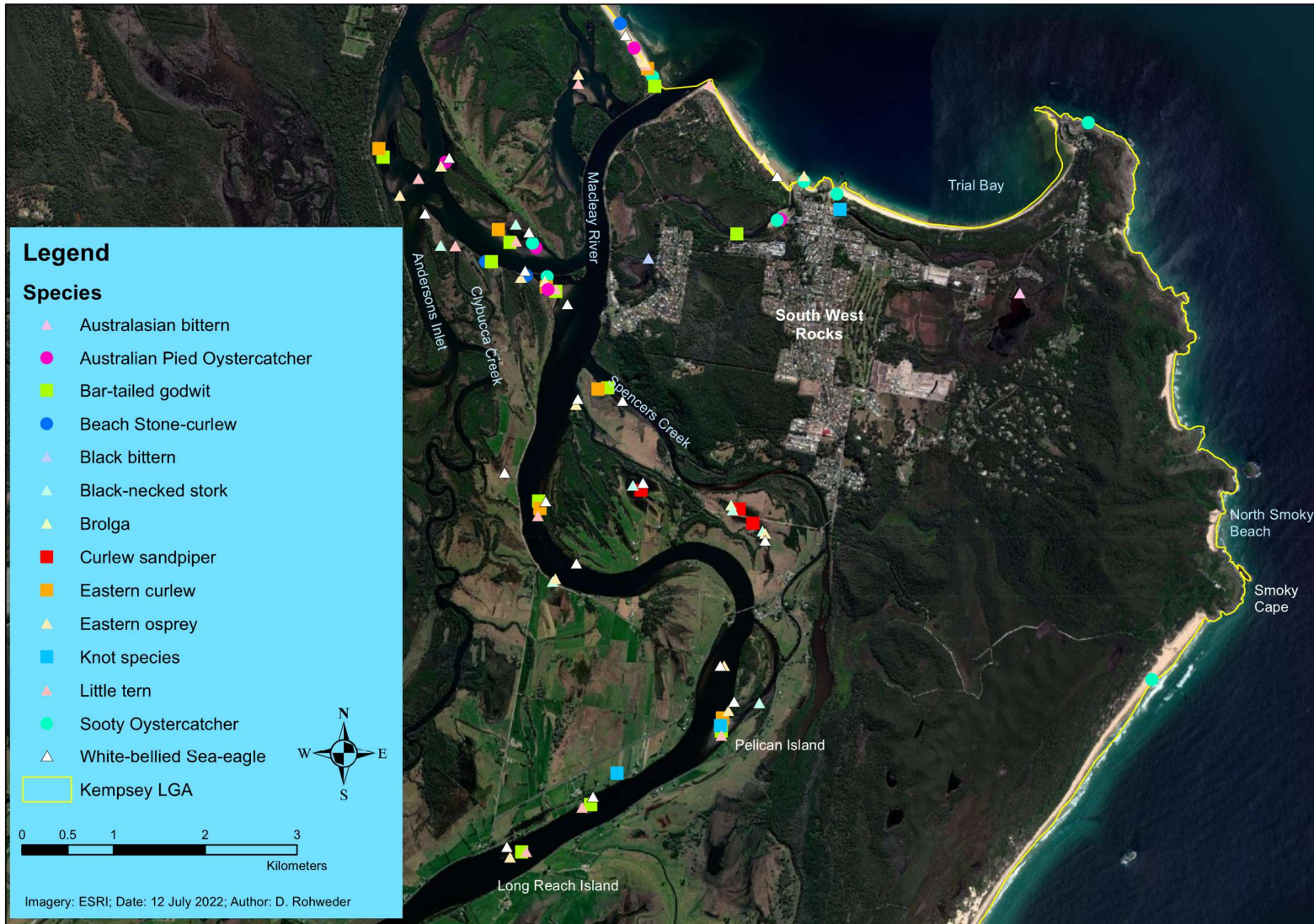


Figure 13: Location of threatened species recorded in the Macleay Estuary and adjacent coastline.



Figure 14: Location of threatened species recorded at Hat Head and Hat Head Beach.



Figure 15: Location of threatened species recorded between Hat Head and Crescent Head.

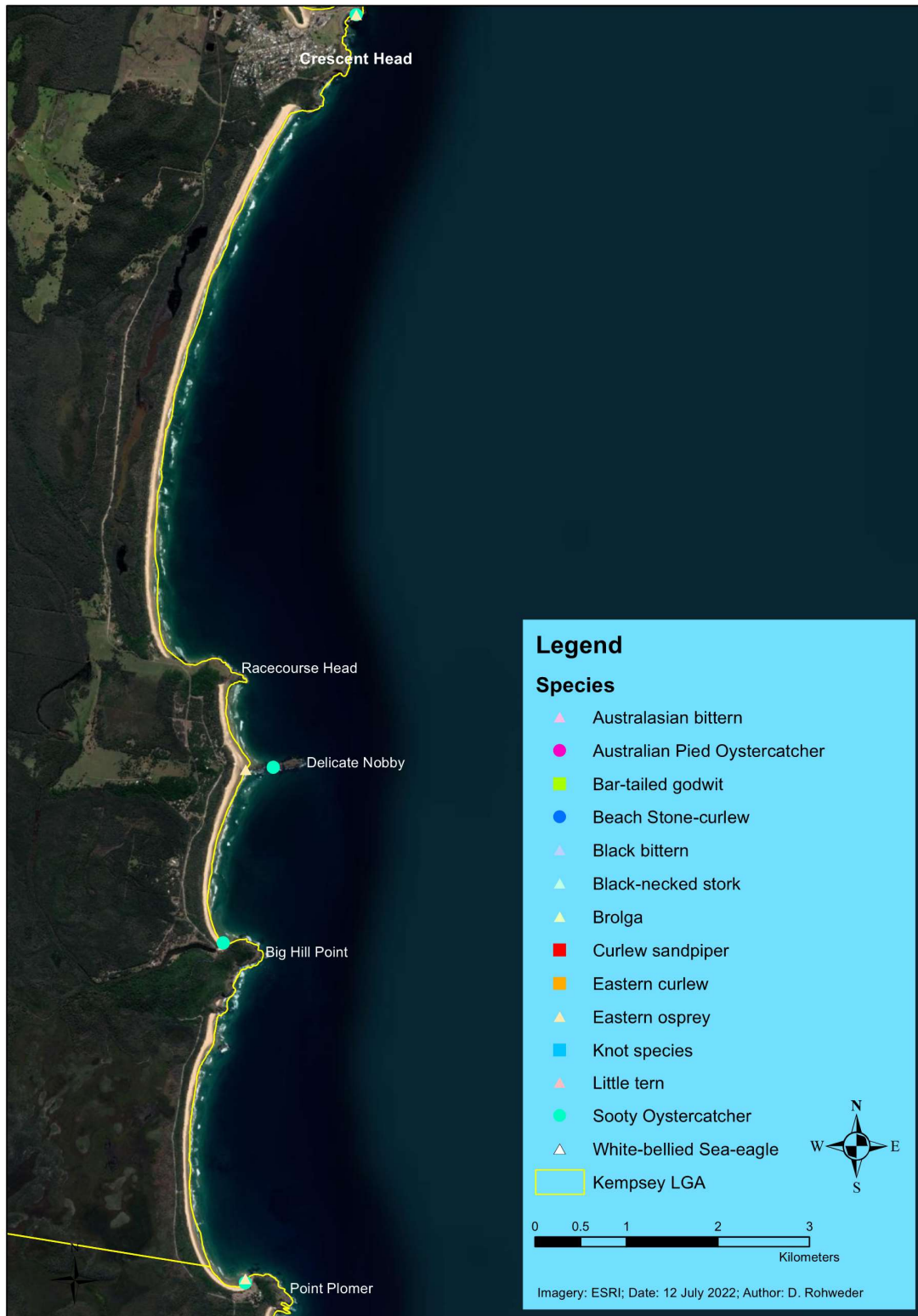


Figure 16: Location of threatened species records between Crescent Head and Point Plomer.

4.5 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. These 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, and agriculture/cattle.

People were recorded moving on foot at 30 sites with high frequency of occurrence (>60% of samples) recorded at 17 sites, an increase of 30% on 2018/19 results. The majority of coastal sites were heavily impacted by human activity. Grassy Head Beach, Stuarts Point Beach, Back Beach, South West Rocks Creek (lower reach), Front Beach, Laggars Point, South Smoky/Hat Head Beach, Killick Beach, Goolawah Beach, Korogoro Creek, Pebbly Beach/Little Nobby (Crescent Head), Big Hill Point to Delicate Nobby and Point Plomer had the highest levels of human activity. As noted in section 4.1 the level of human activity at ocean beach sites was considered a constraint on surveys.

Four-wheel drive vehicles were recorded at five sites, with an average number of vehicles/survey of eight recorded at Hat Head (site 13) and Killick (site 24) Beaches. Large congregations of vehicles (& people) were recorded at Ryans Cut where 30 people and 10 vehicles were recorded in October 2021. Dogs were recorded at 13 sites with the highest number off-leash at Hat Head and Killick Beaches. In general, dogs at ocean sites around South West Rocks were on-leash.

The combination of people, 4WD vehicles and dogs has limited impact on migratory and threatened shorebirds at most ocean beach sites, with exception of Hat Head and Killick Beaches, which both support resident Australian Pied Oystercatcher. Killick Beach supported two breeding pair of pied oystercatchers in October 2021 and a possible chick was present in December 2021. Ryans Cut has the potential to be an important bird habitat, however, this potential is constrained by human activity. Australian pied oystercatchers nest north of the cut and likely roost and forage near the site when human activity allows. The site is also known to support resident red-capped plover and often has large flocks of gulls and terns. The site contained potential nesting habitat for little tern.

Site 4 (North wall beach) is a site that receives low, yet regular, human activity mainly small numbers of 4WD vehicles and people fishing. Most vehicle activity occurs during the lower tidal stages, and fishing primarily occurs within 1km of the breakwall. Whilst some disturbance of roosting birds is likely impacts are considered to be minor.

Colonisation of habitat by mangroves was most severe at Macleay Arm saltmarsh #1 and #2 where mangroves (predominantly *Avicennia marina*) have colonised most of the saltmarsh (Plate 1). Colonisation at those sites is in an advanced state. Evidence of minor mangrove colonisation was evident at the south and north ends of Pelican Island, however, the area colonised has not expanded since 2018/19.



Plate 1: Mangrove growth at site 37 in the Macleay Arm. In 2018/19 shorebirds roosted in the central part of the photograph.

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.

5. Discussion

The 2021/22 shorebird survey provided further information on the species composition and abundance of threatened and migratory shorebirds in the Macleay Coast, and collected further data on habitat use and the distribution of important habitats. The surveys provide an insight into the role that weather patterns play in influencing species richness and abundance and how geomorphological processes can influence habitat use. The data collected have further confirmed the value of the Macleay coast to resident and migratory shorebirds and the regional and state-wide conservation significance of many sites. The following discussion focuses on comparing results of the 2021/22 surveys with the 2018/19 surveys and published literature in the context of abundance, species composition and important habitats used by threatened and migratory shorebirds. Surveys have also confirmed the importance of the Macleay Coast for estuarine birds with seven threatened estuarine species recorded, including significant numbers of white-bellied sea-eagle and black-necked stork.

5.1 Comparison to previous surveys

5.1.1 Abundance of migratory and threatened species

Differences in abundance of migratory and threatened shorebirds between surveys in 2016/17 (InSight 2017), 2018/19 (Sandpiper Ecological 2019) and 2021/22 (this study) are attributed to a number of causative factors associated with timing of surveys between years, global population trends, local rainfall, and levels of human activity at coastal sites. In some respects the 2021/22 results are similar to the 2016/17 survey, which also coincided with rainfall and low occupancy of the Boyters Lane wetlands (i.e. sites 14-16).

The low abundance of sharp-tailed sandpiper in 2021/22 was due to inundation of key wetlands. Changes in the abundance of migrating sandpipers in relation to environmental conditions have been recorded elsewhere (Canham *et al.* 2021). A stark example of how water level in the study area impacted sharp-tailed sandpiper abundance was provided by the incidental survey conducted in November 2021 after three weeks of dry weather. During that survey over 280 sharp-tailed sandpipers were recorded, yet maximum counts during the six targeted surveys did not exceed 12 individuals.

High spring/summer rainfall inundates floodplain and claypan wetlands making them unsuitable for foraging by shorebirds which tend to prefer habitats with areas of bare mud and shallow water. The Macleay Coast shorebird population is dominated numerically by species that utilise floodplain and claypan wetlands, such as sharp-tailed sandpiper and black-winged stilt (Rohweder & Priest 2020). Shorebirds will not remain at wetlands if they are inundated during winter and spring (i.e. southern migration) and are therefore unsuitable for foraging.

Rainfall not only influences the suitability of habitat on the Macleay Floodplain it also improves foraging conditions elsewhere, particularly at large inland floodplain wetlands that are used by sharp-tailed sandpiper (Clemens *et al.* 2021). This means that fewer sandpipers are likely to rely on coastal wetlands in years of high rainfall. Lower abundance of black-winged stilt, Latham's snipe and Pacific golden plover during the 2021/22 survey can also be explained by high rainfall and inundation of habitat.

Changes in abundance of several other species are easily explained. For example, the higher number of double-banded plover recorded in 2021/22 is due to the extension of surveys into April which is approaching their peak migration period (Marchant & Higgins 1993). Lower numbers of eastern curlew in 2021/22 is consistent with a global trend of declining abundance for that species (Morrisk *et al.* 2021), whilst the lower abundance of sooty oystercatcher and red-capped plover is attributed to high levels of human disturbance at coastal sites during the 2021/22 surveys.

The higher count of Australian pied oystercatcher in 2021/22 is attributed to the inclusion of a survey in October, which coincided with the breeding season for that species (Marchant & Higgins 1993). The population estimate of Australian pied oystercatcher likely included a combination of breeding and non-breeding individuals. The population estimate of 19

individuals was derived from the October count and was comprised of three birds from Stuarts Point Beach (2 adult & 1 juvenile), two birds (a breeding pair) from Boat Ramp Bay (Site 40/41), 10 adult birds from Hat Head Beach (site 13) and four adult birds (2 breeding pair) from Killick Beach (site 24). Whilst the estimate of 19 is a maximum the likely population range was 16-19, with 16 individuals recorded on 23 October. That count was comprised of a breeding pair at Boat Ramp Bay (site 40/41), 10 non-breeding birds at Hat Head Beach and 4 birds (two breeding pair) at Killick Beach. Addition of the three individuals recorded at Stuarts Point on 22 October, to provide a maximum count of 19, is reasonable given that group included two adult and one sub-adult and no sub-adults was recorded elsewhere.

Australian pied oystercatcher is a mobile species and movement of non-breeding individuals between estuary and ocean beach habitat is not unusual (Sandpiper unpublished data). Movement of birds from Stuarts Point Beach and Hat Head Beach into the estuary is likely and this was reflected by the low tide count on 22 October when seven individuals were recorded in the Macleay Arm. A population estimate of 19 individuals is approximately 5% of the estimated NSW population of 350 individuals (Sandpiper Ecological 2019b).

In 2021/22, the maximum population estimate for bar-tailed godwit (52 individuals) was double that recorded in 2018/19 (25 individuals). This may in-part be due to a successful breeding season in 2019 (Schuckard *et al.* 2020). The substantial decline in godwits between December and January may reflect a normal transition from southern migration to stable summer population, although it could also be due to high levels of human disturbance and minor flooding over that period. The continual decline in abundance recorded into February suggests that factors other than migration influenced abundance.

A pair of beach stone-curlew, a critically endangered resident shorebird, was present in the estuary for the entire sample period. Stone-curlews were absent from the estuary during targeted surveys in 2000 (Rohweder 2003) but have occurred sporadically since then. The resident pair is likely to breed in the estuary if they can establish a suitable territory that includes appropriate nest, refuge and foraging habitat. Recent surveys suggest that birds regularly move between saltmarsh in the lower Macleay Arm, Shark Island and the south end of Stuarts Point Beach (site 4). Preferred prey of beach stone-curlews are ghost crabs (*Ocypode* spp) and soldier crabs (*Mictyris* spp; Mellish & Rohweder 2012) and it is likely that birds are foraging on the Macleay Arm sandflats and Stuarts Point Beach at night.

In summary, the migratory and threatened shorebird population in the Macleay coast in 2021/22 was substantially less than recorded in 2018/19. This difference was largely due to lower abundance of sharp-tailed sandpiper and the general unsuitability of floodplain and saltmarsh wetlands, particularly those at Boyters Lane. Populations and species richness of birds that do not rely on floodplain and saltmarsh wetlands were broadly similar between the two surveys. The 2021/22 surveys have added to the understanding of how shorebirds utilise the Macleay Coast and the areas importance for migratory and resident species.

5.1.2 Important shorebird habitat

Roosting habitat

High tide roost use by shorebirds was consistent between 2018/19 and 2021/22, although the number of individuals and species recorded at some sites, and thus their importance to the population did vary. Shorebirds continued to utilise a variety of roosting habitats including saltmarsh, sandspits and banks, rock groins, mangroves, and ocean beaches, although no birds were observed using oyster racks in 2021/22.

Notable differences in roost use included lower use of saltmarsh at sites 36 and 37 in the Macleay Arm, and site 42 in Spencers Creek, and higher use of Stuarts Point Beach (site 4) and Pelican Island (site 20). Site 4, at the south end of Stuarts Point Beach may be the missing roost referred to by Sandpiper Ecological (2019). Whilst site 4 was surveyed consistently in 2018/19 and 2021/22 it seems that birds may be roosting further north than originally sampled. Ocean beach roosts adjacent to estuaries are a feature of many north coast estuaries, including the Tweed, Richmond, and Clarence (Sandpiper Ecological 2009). It is predicted that both eastern curlew and bar-tailed godwit roost at site 4 during spring high tides. The site is also used by beach stone-curlew, Australian pied oystercatcher and double-banded plover.

Sandpiper Ecological (2019) suggested that Stuarts Point Beach was unsuitable as a roost due to its narrow width. This was not the case in 2021/22 when a wide gently sloping beach was evident. Differences in beach profile between 2018/19 and 2021/22 may explain the changes in use by curlew and godwits.

Site 20 at times supported the entire bar-tailed godwit and Pacific golden plover population and small numbers of whimbrel and eastern curlew. The site may also be an important nocturnal roost. Lower use of sites 36 and 37 is attributed to continued growth and colonisation of mangroves, which are known to have a detrimental impact on roost and foraging habitat (Straw & Saintilan 2003; Woodley 2003; Huang *et al.* 2012; Choi *et al.* 2022). It is likely that the growth of mangroves in saltmarsh at sites 36 and 37 has rendered these roosts unsuitable for shorebirds (see Plate 1). Colonisation of saltmarsh by mangroves is a common issue in north coast estuaries and has been identified as a threat to the viability of numerous roosts particularly as sea-level rises (Sandpiper Ecological 2009).

The reason for lower use of site 42 and the absence of tattlers on oyster racks at site 17.1 is unconfirmed as neither site appears to have changed since the 2018/19 survey. The absence of tattlers at site 17.1 could be due to the lower abundance of that species in 2021/22, with the site only used when numbers make other roosts unsuitable. For most of the 2021/22 survey period tattlers roosted on rocks at sites 39 and 40/41. Less frequent use of Spencers Creek in 2021/22 may be associated with improved condition of site 4 (i.e. North wall beach). If this is the case it highlights the importance of having multiple spring tide roosts whose functionality changes with conditions.

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 roosts as the sandflat becomes inundated at higher tides. During high spring tides whimbrel moved to mangroves to roost (Plate 2) and eastern curlew move to the south end of Stuarts Point Beach or Spencers Creek.



Plate 2: Site 34 (whimbrel roost) at high tide. At this site whimbrel's roost on bar sand and as the tide rises move to the bare branches of mature mangroves.

Foraging habitat

The distribution, size and quality of foraging habitat on the Macleay Coast did not vary between the 2018/19 and 2021/22 surveys. 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. Upstream movement of birds as the tide recedes is likely to occur in both the Macleay Arm (sites 35, 17 & 6) and main channel (sites 18, 20 and 46). This pattern of behaviour is typical of other north coast estuaries. The 2021/22 surveys have confirmed the importance of all tidal flats in the lower Macleay Arm and sites 8, 20 and 46 in the main channel. A large (>30%) proportion of the whimbrel and godwit population was also recorded in South West Rocks Creek and sheltered intertidal flats in the creek may provide important supplementary foraging habitat when sites in the main channel are unsuitable due to strong wind, floods or human disturbance.

Ocean beaches and rocky shores

Ocean beaches and rocky shores function as both roost and foraging habitat for shorebirds. Along the Macleay coast ocean beaches and rocky shores support small numbers and a low diversity of shorebirds. Two key species that rely on these habitats are Australian pied oystercatcher, which predominantly use ocean beaches, and sooty oystercatcher, which predominantly use rocky shores. Both species are listed as threatened under the *Biodiversity Conservation Act 2016*. Sooty oystercatchers typically nest on off-shore islands and forage in pairs or small flocks on rocky and muddy shores (Hansen *et al.* 2014). There are several roost/foraging areas for sooty oystercatcher along the Macleay Coast and these did not change between the 2018/19 and 2021/22 surveys. Most sites supported 1-3 individuals and based on published population estimates (see Hansen *et al.* 2014; Wooding 2019) none are nationally or internationally important.

Pied oystercatchers use a combination of ocean beach and estuarine habitats (Taylor *et al.* 2014). Whilst they often forage on intertidal sand and mudflats the species is occasionally observed foraging on rocky shores and oyster beds. Pied oystercatchers use a variety of habitats for roosting. Four locations appear important for pied oystercatcher on the Macleay coast, Stuarts Point Beach (sites 3, 3.1 & 4), Macleay Arm (sites 17, 35, 40/41), Hat Head Beach (site 13) and Killick Beach (site 24). There was no confirmed evidence of breeding during the survey, however, sub-adult birds were recorded at Stuarts Point Beach and Killick Beach, and chicks were suspected to be present in October and December at sites 40/41 (Boast ramp bay), and site 24 (Killick Beach, incl Ryans Cut) respectively.

Ryans Cut is an artificial channel constructed to drain floodplain wetlands. The channel functions similarly to an Intermittently Closed and Open Lake and Lagoon (ICOLL) and represents a focal point for human recreation on Killick Beach. Ryans Cut regularly supports Australian pied oystercatcher, red-capped plover (a regionally significant species) and roosting flocks of gulls and terns. The suite of species recorded at the site is similar to other ICOLLS in northern New South Wales, such as Salty Lagoon, Jerusalem Creek and Belongil Creek (Sandpiper unpublished data). If managed for conservation Ryans Cut and the adjacent sections of beach could become an important breeding, foraging and roosting habitat for shorebirds.

5.1.3 Sites of high conservation value

Despite noted differences in habitat use between the 2018/19 and 2021/22 surveys there is no reason to downgrade the conservation status of important sites identified in 2018/19. This is because decreases in use identified in 2021/22 are likely to be temporary and due to the unique set of conditions experienced during those surveys. For example, wetlands along Boyters Lane (sites 14, 14.1, 15, 15.1, 15.2, 16, 16.1) are highly likely to support nationally (& possibly internationally) significant numbers of sharp-tailed sandpiper in the future, and the Spencers Creek saltmarsh is likely to be used more regularly by eastern curlew if ocean conditions alter the profile of Stuarts Point Beach rendering it less suitable for roosting.

Pelican Island sandspit (site 20) remains an important shorebird habitat in the upper estuary. In both survey periods the site has supported most of the study areas Pacific golden plover population during spring low tides. Whilst fewer plovers were present in 2021/22, site 20 provided foraging and roosting habitat for most of the bar-tailed godwit population and small numbers of eastern curlew at different times. In addition, the channel between the island and east bank was used for foraging by six juvenile black-necked stork making it a significant non-floodplain habitat for that species.

The 2021/22 surveys further confirm the importance of the Macleay Arm, from Fishermans Reach to the Macleay River and including Boat ramp bay (site 40/41), as a particularly important shorebird habitat that contained a number of roost and foraging areas. The area also contained an Australian pied oystercatcher nest, an eastern osprey nest and is regularly used by white-bellied sea-eagle. In addition, the area supported several high quality examples of estuarine saltmarsh, seagrass beds and mature mangrove forest. Conservation of saltmarsh and intertidal habitats in the lower Macleay Arm and at Spencers Creek combined with claypans and tidal lagoons along Boyters Lane, the south end of Stuarts Point Beach (i.e. site 4), and the Pelican Island area would protect the majority of important shorebird habitat in the Macleay Estuary.

Ocean beaches and rocky shores along the Macleay Coast do not support significant numbers of pied and sooty oystercatchers, however, some sites are suspected of supporting breeding pairs. Most notably, Killick Beach at, and for several kilometres north of, Ryans Cut, and possibly Stuarts Point Beach. Hat Head Beach was used by a non-breeding flock of 10 pied oystercatcher in October 2021. The distribution of pied oystercatchers is strongly influenced by abundance of their preferred prey, the pipi (*Plebidonax deltoides*; see Owner & Rohweder 2003) and management of pipi's is critical to managing the oystercatcher population. A flock of 10 non-breeding birds is locally significant and further survey may reveal evidence of breeding at that site.

Ryans Cut and the section of Killick Beach 2km north and south has potential to be a regionally important shorebird habitat. The site is similar in some respects to other north coast ICOLLS which support small numbers of resident and migratory shorebirds, breeding pairs of Australian pied oystercatcher, and occasionally little tern. Use of these sites by shorebirds is typically constrained by high levels of human activity as occurs at Ryans Cut.

5.2 Significance of the Macleay Coast to shorebirds

Despite supporting substantially fewer individuals in 2021/22 the Macleay Coast remains a regional and state significant site for threatened and migratory shorebirds. Importantly, the recent surveys have provided further information on how the area is used by migratory species, such as sharp-tailed sandpiper. Species richness in 2021/22 was equivalent to the previous survey and comparable to other large NSW estuaries. The combined total of 14 threatened species including seven threatened shorebird species, further highlights the areas value. As noted by Sandpiper Ecological (2019), the shorebird population estimate for the Macleay Coast would likely increase with better survey coverage of floodplain wetlands. Although, to obtain the best results such surveys should occur during El-nino years.

5.3 Key findings

Key outcomes of the 2021/22 Macleay Coast shorebird surveys include:

1. Confirmation that shorebirds require a matrix of roost and foraging habitats distributed throughout an estuary. Multiple sites are essential to support birds during variable environmental conditions and to account for temporary changes in structure due to coastal processes.
2. Confirmation that the Macleay Coast supports a diverse shorebird community and provides habitat for several threatened and migratory shorebird species.
3. Confirms that the areas shorebird population is influenced by broad rainfall patterns, highlighting the importance of including temporal variation in any shorebird survey.
4. Supports the temporal trend of declining abundance of eastern curlew in the East-Asian Australasian Flyway.
5. Confirms the presence of several state and federally listed threatened estuarine species within the Kempsey LGA.
6. Confirms the value of roost and foraging habitats in the Macleay Arm for threatened migratory shorebirds.
7. Confirmed the presence of a pair of critically endangered beach stone-curlew and identified sites used by that species.
8. Identified changes in roost quality due to mangrove growth and highlights that changes in use of roosts can occur between years due to natural processes, emphasising the need to consider temporal trends when assessing conservation priorities and the need to provide a variety of roosting sites.
9. Highlights the value of Killicks Beach and Ryans Cut 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.

6. Recommendations

Recommendations proposed by Sandpiper Ecological (2019) are included in Table 13 with a revised recommendation for further targeted survey, and inclusion of further details based on findings of the 2021/22 survey.

Table 9: Recommendations

Action & aim	Description	Organisations
<p>1. Macleay Estuary shorebird conservation area</p> <p>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, the Macleay Arm from the confluence with the Macleay River upstream to Fishermans Reach, and include the southern 2km of Stuarts Point Beach. The conservation area should encompass sample sites 4, 6, 17, 17.1, 32, 33, 34, 35, 36, 37, 39, 40/41 & 42.</p> <p>The shorebird conservation area would include all intertidal and supra-tidal habitat, saltmarsh, and mangroves within the abovementioned area.</p> <p>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); Department of Planning, Infrastructure and Environment (DPIE); Transport for NSW; NSW Fisheries.</p>
<p>2. Information boards</p> <p>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 Conservation Area.</p>	<p>Kempsey Shire Council; Roads and Maritime Services</p>
<p>3. Education</p> <p>Aim: Educate professional fishers to consider roosting and foraging shorebirds whilst conducting their daily work</p>	<p>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.</p>	<p>Kempsey Shire Council NSW Fisheries Office of Environment and Heritage</p>
<p>4. Wetland conservation on private land</p> <p>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.</p>	<p>Educate landowners with wetlands on their properties on the importance of maintaining these habitats for shorebirds and waterbirds.</p> <p>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.</p>	<p>Kempsey Shire Council Local Land Services Office of Environment and Heritage</p>
<p>5. Boyters Lane wetland management plan</p> <p>Aim: Prepare a management plan for significant Boyters Lane wetlands to ensure their long-term viability for shorebirds.</p>	<p>Boyters Lane supports Nationally and potentially Internationally significant numbers of migratory shorebirds.</p> <p>Owners/managers of these sites should be approached to develop an agreement to protect and manage the sites.</p>	<p>Kempsey Shire Council Boyters lane land owners Local Land Services</p>
<p>6. Evaluate shorebird threats at Killick Beach</p> <p>Aim: Gather information on the impact of threatening processes on shorebirds at Killick Beach. Information should be used to determine</p>	<p>Killick Beach is a high priority site for protection. The sites primary shorebird value is that it supports breeding 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</p>	<p>Kempsey Shire Council Office of Environment and Heritage</p>

<p>if management action is required.</p>	<p>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 Environment, Energy and Sustainability Division of the DPIE to undertake regular surveys along the beach.</p>	
<p>8. Floodplain wetland bird survey Aim: Undertake a systematic survey of suitable floodplain wetlands to assess their value as shorebird habitat.</p>	<p>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.</p>	<p>Kempsey Shire Council Local Land Services Land owners</p>
<p>9. Wetland stewardship sites Aim: Encourage landowners to create stewardship sites over important wetlands.</p>	<p>Using provisions under the <i>Biodiversity Conservation Act</i> 2016 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 sites. Removal of cattle may not be necessary due to the role they can play in maintaining existing wetland condition. The Saltaire wetland (site 14) represents an ideal opportunity to create a stewardship site that protects shorebird habitat.</p>	<p>Kempsey Shire Council Department of Planning, Infrastructure and Environment Land owners</p>
<p>10. Review existing zoning of key shorebird sites Aim: Ensure important shorebird habitat is appropriately zoned</p>	<p>Existing zoning of Site 42 (Spencers Creek) and Sites 14, 14.1, 15, 15.1, 16 & 16.1 (Boyters Lane) should be changed from RU1/2 to E2.</p>	<p>Kempsey Shire Council</p>
<p>11. Targeted shorebird survey (reduced scale) Aim: Obtain further information on the importance of the Macleay estuary for threatened and migratory shorebirds.</p>	<p>One additional round of shorebird population surveys should be conducted to gather further data on shorebird abundance, species richness and important habitats. The surveys should include six samples, one each in Oct, Nov, Dec, Jan, Feb & Mar. Surveys should focus on the Macleay estuary only with inclusion of key ocean beaches (i.e. Stuarts Point Beach, Hat head Beach and Killick Beach).</p>	<p>Kempsey Shire Council</p>

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Appendix A – 2018/19 survey results

Table A1: 2018/19 – phase 1 survey results

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 - 59	334 - 83	450 - 145	337 - 38	458 - 128
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

Table A2: 2018/19 – phase 2 survey results

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

Table A3: 2018/19 – maximum counts

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 - 63	336 - 85	452 - 147	344 - 45	463 - 133
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

Table A4: Average shorebird abundance and number of threatened species at each sample site in 2018/19.

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	Boyer's Lane wetland - east	207	81.6 (sd=73.56, n=10)	3	1	0	0
15.2	Boyer's Lane wetland - rehab	90	31.7 (sd=35.67, n=10)	3	1	0	0
16.0	Boyer's Lane wet paddocks, south	249	137.4 (sd=79.8, n=10)	7	4	0	1
16.1	Boyer'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

Site No.	Site Name	Max count	Average count (SD + n)	Total species	Migr species	EPBC Act (thr)	BC Act
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
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