SHOREBIRD CONSERVATION ACTION PLAN 2021/22 SURVEYS AND ASSESSMENT

SUNSHINE COAST

Prepared for
Sunshine Coast Council

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Project Author/s: Dr Penn Lloyd and Dr Peter Driscoll

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Date: 25/07/2022

Principal Ecologist and Director

EXECUTIVE SUMMARY

BACKGROUND

Sunshine Coast Council (SCC) has developed a Shorebird Conservation Action Plan to raise awareness and educate the public around shorebirds, to manage and protect shorebird habitat and to provide management solutions for shorebird conservation, with a particular focus on important habitat for migratory and resident shorebirds that gather in large numbers on the sandbanks and mudflats of the lower Maroochy River and the Caloundra Banks on the northern Pumicestone Passage.

Three key objectives of the Shorebird Conservation Action Plan are to:

- Identify current migratory and resident shorebird habitats within the SCC local government area (LGA);
- Identify species and abundance of migratory and resident shorebirds in those habitats; and
- Determine the main threats to migratory and resident shorebirds in the SCC LGA and incorporate site management needs and recommendations.

During 2020/21 BAAM completed four summer surveys and one winter survey at both low tide (surveying shorebird use of feeding habitat) and high tide (surveying shorebird use of roost sites) in the lower Maroochy River and at Caloundra in the northern Pumicestone Passage. This study also reviewed and analyzed shorebird survey data for the SCC LGA collected by the Queensland Wader Study Group (QWSG), a special interest group of the Queensland Ornithological Society Incorporated that monitor shorebird populations in Queensland and conduct regular shorebird surveys of different parts of the Queensland coast that have large shorebird populations. Based on the findings of this initial season of surveys and subsequent recommendations by BAAM, SCC requested a further four surveys of shorebird use of roost sites at high tide during the summer period in the lower Maroochy River and at Caloundra since the QWSG does not currently monitor shorebird use of roost sites in these areas, focusing instead on monitoring shorebird use of feeding habitat areas at low tide.

STUDY APPROACH

This study aims to further implement the key objectives of the Shorebird Conservation Action Plan through a combination of:

- conducting four shorebird surveys of the lower Maroochy River and the Caloundra Banks at high tide during the 2021/22 summer season to identify any new roost sites, monitor existing known roost sites and determine current shorebird use of roost sites, identify which shorebird species are present, and determine the type and extent of disturbance; and
- conducting an updated analysis of trends in shorebird use of high tide roost sites and low tide feeding habitat areas based on the additional season of data since the analysis of 2020/21 reported by BAAM (2021), combining the survey data with the latest QWSG data as well as a single low tide survey of the lower Maroochy River conducted by Dr Simone Bosshard (Coastal Conservation and Permits Officer, Sunshine Coast Council).

KEY RESULTS

Lower Maroochy River

A single low tide survey of the main tidal flat shorebird foraging habitat areas along the lower Maroochy River was conducted during the outward migration period on 31/03/222 by Dr Simone Bosshard. Most migratory shorebirds (92 individuals of three different species) were recorded within the tidal flat area of MR06 on the eastern side of Goat Island, consistent with the results

of previous surveys in 2020/21. The only sources of potential disturbance recorded during the survey were people and watercraft at all four of the tidal flat survey areas. Shorebirds feeding at low tide on the tidal flats in the lower Maroochy River have been regularly monitored by the QWSG since 1992. The average count of both migratory and resident shorebirds feeding in this area at low tide during the summer months has declined significantly between 1992 and 2021.

Five main roost sites used by shorebirds and other waterbirds occur in the lower Maroochy River: Goat Island (MRGI); Nojoor Road (MRNR); north shore (MRNS); sand bar (MRSB); and Maroochy River tree roost (MRTR). The raised sandbank on the eastern side of Goat Island was the main roost site used by migratory shorebirds during 2021/22, with a small flock of Grey-tailed Tattlers occasionally roosting in mangrove trees on the north-western edge of Goat Island. No birds were recorded at the Nojoor Road (MRNR), north shore (MRNS) or sand bar (MRSB) roost sites. A flock of 19 Eurasian Whimbrel were observed roosting in mangrove trees at the Maroochy River tree roost (MRTR) on the mainland shore to the north-east of Goat Island on one of the four surveys. Based on QWSG data since 1997 a total of 20 migratory shorebird species and seven resident shorebird species have been recorded roosting at high tide at roost sites on the lower Maroochy River, with the north shore, Goat Island and the sand bar being most frequently used. The QWSG discontinued monitoring of roost sites on the lower Maroochy River after 2012 due to increasing levels of disturbance affecting the counts. Based on QWSG data, the north shore has experienced the highest frequency of disturbance across all categories, including the presence of dogs. QWSG counters report that the north shore has largely been abandoned as a roost site due to the high frequency of disturbance from recreational activities. The dynamic changes to the sandbanks may also have altered roost suitability. This effective loss of a roost site reduces the resilience of shorebirds to disturbance since there are fewer alternative roost sites available should disturbance cause them to leave a particular roost site.

Caloundra

Four main areas of tidal flat feeding habitat occur in the northern Pumicestone Passage at Caloundra that have been subject to monitoring by the QWSG since 1993. The tidal flat areas of SBN1, SBN2 and PEWA are important feeding areas for migratory shorebirds, particularly for the critically endangered Far Eastern Curlew, vulnerable Bar-tailed Godwit, Eurasian Whimbrel and Pacific Golden Plover. Based on analysis of long-term QWSG data, a total of 19 migratory shorebird species and seven resident shorebird species have been recorded feeding at low tide on tidal flats at Caloundra since 1993. There is evidence that there has been a long-term reduction in the total numbers of migratory shorebirds using the SBN1, SBN2 and BECK tidal flat areas between 1993 and 2021. Several species also appear to have declined in abundance since 1993 across one or more of the four tidal flat areas, including Greater Sand Plover, Lesser Sand Plover, Curlew Sandpiper, Grey-tailed Tattler, Red-necked Stint and Bar-tailed Godwit.

Six known shorebird roost sites occur at Caloundra. Five of these roost sites (CBAR, SBN1, SBN2, BCTR, NTBI) were surveyed during the 2021/22 season, including NTBI that was identified as a new roost on the coastal shoreline of the northern tip of Bribie Island during 2021/22. The sandy beach shoreline at CBAR and NTBI were the two most frequently used roost sites during the four surveys in 2021/22, supporting up to 48 Far Eastern Curlew, up to 86 Bar-tailed Godwit and up to 49 Eurasian Whimbrel. The mangrove trees at BCTR were used occasionally by Eurasian Whimbrel. Two sandbanks in the centre of the Pumicestone Passage channel (SBN1 and SBN2) are used by roosting shorebirds and other waterbirds (mostly terns) when they remain exposed on neap high tides; these sandbanks are not available as roost sites on higher tides once they become covered by water. As the two passage sandbars become covered by the rising tide, shorebirds move either to an area of saltmarsh on the shoreline of Bribie Island that also forms part of the SBN1 roost site, or they fly east to the sandy beach shoreline at CBAR or NTBI.

The three roost sites CBAR, SBN1 and SBN2 have been monitored intermittently by the QWSG since 1993 while a minor roost site at Wickham Point (WICK) has been monitored continuously

since 1999. A total of 17 migratory shorebird species and seven resident shorebird species have been recorded roosting at these high tide roost sites at Caloundra. The most commonly recorded migratory shorebird species included the vulnerable Bar-tailed Godwit, the critically endangered Far Eastern Curlew, Eurasian Whimbrel and Pacific Golden Plover, the four species that were also most frequently present feeding on the tidal flats at low tide.

RECOMMENDATIONS

This report identifies the most important areas for shorebirds along the Lower Maroochy River and at Caloundra and existing levels of disturbance to shorebirds in these areas. This disturbance pressure is predicted to continue to increase as the region becomes more developed. Consequently, there is a need for proactive management of disturbance to shorebirds at the important roosting and feeding habitats along the Lower Maroochy River and at Caloundra.

Recommended approaches for reducing disturbance to feeding and roosting shorebirds include a combination of:

- Site-specific information signage to raise awareness of the presence of shorebirds in the area and the importance of the key habitat areas for shorebirds, particularly migratory shorebirds;
- Other approaches to raising public awareness of how the migration and feeding ecology of shorebirds are impacted by disturbances to try to change public awareness of, and attitudes towards disturbing shorebirds, particularly among dog-owners that exercise their dogs along foreshore areas;
- Planning to ensure suitable dog-walking facilities such as dog-off leash areas are situated in locations convenient and attractive to the public but separated from important shorebird foreshore habitats;
- Planning to limit access to important feeding or roosting areas by people and/or dogs; and
- Effective enforcement of access restrictions and dog on-leash areas, given that compliance to access restrictions or on-leash laws is strongly dependent on the extent of enforcement.

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SUNSHINE COAST

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Table of Terms and Abbreviations

BAAM	Biodiversity Assessment and Management Pty Ltd
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
QWSG	Queensland Wader Study Group
LGA	Local government area
NC Act	Queensland *Nature Conservation Act 1992*
SCC	Sunshine Coast Council

1.0 INTRODUCTION

1.1 BACKGROUND

Sunshine Coast Council (SCC) has developed a Shorebird Conservation Action Plan to raise awareness and educate the public around shorebirds, to manage and protect shorebird habitat and to provide management solutions for shorebird conservation, with a particular focus on important habitat for migratory and resident shorebirds that gather in large numbers on the sandbanks and mudflats of the lower Maroochy River and the Caloundra Banks on the northern Pumicestone Passage.

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1.2 OBJECTIVES OF THIS STUDY

This study aims to further implement the key objectives of the Shorebird Conservation Action Plan identified in **Section 1.1** above through a combination of:

- conducting four shorebird surveys of the lower Maroochy River and the Caloundra Banks at high tide during the 2021/22 summer season to identify any new roost sites, monitor existing known roost sites and determine current shorebird use of roost sites, identify which shorebird species are present, and determine the type and extent of disturbance; and
- conducting an updated analysis of trends in shorebird use of high tide roost sites and low tide feeding habitat areas based on the additional season of data since the analysis of 2020/21 reported by BAAM (2021), combining the survey data with the latest QWSG data as well as a single low tide survey of the lower Maroochy River conducted by Dr Simone Bosshard (Coastal Conservation and Permits Officer, Sunshine Coast Council).

2.0 STUDY APPROACH

The QWSG has historical data for roost sites monitored at both Caloundra (Caloundra Bar to 2010, Whickham Point) and the lower Maroochy River (to 2012) and four feeding habitat areas at Caloundra, and still currently undertakes monthly monitoring of many of these sites. The study approach therefore combined an analysis of all existing QWSG high tide and low tide data for the

study area with field surveys of shorebirds using roost sites at high tide and tidal flat feeding habitats at low tide, as outlined in more detail below.

2.1 HIGH TIDE SURVEYS

Four high tide surveys were conducted over the summer months December 2021 to February 2022 at each of the lower Maroochy River and in the northern Pumicestone Passage at Caloundra. All surveys were conducted using a small, motorised boat, which facilitated access to roosting habitats throughout the relatively large survey areas, including on the northern tip of Bribie Island. The surveys aimed to start on the rising tide to develop a better understanding of the movements of shorebirds to mid-tide and high-tide roosts from tidal flat feeding areas during the transition between high tide and low tide. However, the counting of shorebirds at the roost sites was conducted within the 3-hour period 1.5 hours either side of high tide, when all previously known roost sites at each locality were visited. The surveys determined the total number of individuals of each species present, to enable assessment of site and habitat importance, and collected spatial data of the area used by shorebirds for roosting to facilitate mapping of roost site extents.

Sources of actual or potential disturbance observed within or close to each survey site (close enough to cause disturbance) were recorded as a count of people, dogs on leash, dogs off leash, boats stationary, boats moving and jetskis moving during a single observation sweep of the survey site to provide a snapshot in time as per the approach of Stigner *et al*. (2016). Disturbance is an event that causes birds to cease foraging or resting activities to become alert, start walking away from the source of disturbance or take flight in response to the disturbance.

The surveys were undertaken by Dr Peter Driscoll (a shorebird specialist) with the assistance of Dr Simone Bosshard (Coastal Conservation and Permits Officer, SCC). The surveys were not undertaken during periods of high rainfall or strong winds.

2.2 QWSG DATA REVIEW

Low tide survey data for the period June 2021 to March 2022 were obtained from the QWSG free of charge on the basis of a data sharing agreement, to supplement the complete QWSG dataset for the lower Maroochy River and Caloundra that was reviewed by BAAM (2021). This updated QWSG dataset included the data from the 2020/21 surveys reported in BAAM (2021).

2.3 STATISTICAL ANALYSIS

Tests for temporal trends in shorebird count numbers at any site were conducted using a non-parametric Mann-Kendall trend test in R (R Core Team 2021) to statistically assess if there is a monotonic upward or downward trend in shorebird numbers over time. A monotonic upward (or downward) trend means that the variable consistently increases (or decreases) through time, but the trend may or may not be linear. Average counts are reported ± 1 standard deviation, where the standard deviation is a measure of the variability in the counts.

3.0 RESULTS AND DISCUSSION

3.1 BACKGROUND ON SHOREBIRD ECOLOGY

Most shorebirds live on or near the coast, on beaches, reefs and tidal mudflats, though some also frequent, or are largely confined to, freshwater habitats (Colwell 2010). Most coastal species feed on flat, tidal shores with extensive muddy or sandy intertidal areas (hereafter referred to as tidal flats). Most species are gregarious, wary and fly strongly and swiftly (Geering *et al*. 2007; Colwell 2010). A large proportion of Australia's shorebird species are migratory, spending their non-breeding season (the Austral summer) in Australia and migrating up to 13,000 km north along the East Asian–Australasian Flyway to breeding grounds in eastern Siberia and western Alaska (most

species, Bamford *et al*. 2008) or south to New Zealand (Double-banded Plover (*Charadrius bicinctus*), Pierce 1999).

On their non-breeding grounds in Australia, coastal migratory shorebirds have a daily activity pattern driven largely by the tidal cycle, roosting in flocks at sites above the high-water mark at high tide and moving to tidal flat feeding areas as the tide recedes (Colwell 2010). They are capable of feeding during both the day and night. Shorebirds feed on a wide variety of benthic invertebrates, including crustaceans, molluscs and polychaete worms that are taken either on the surface of tidal flats or extracted from soft, muddy or sandy sediments by probing with bills, which are elongated in many species. Different shorebird species specialise on different prey, prey sizes and feeding styles depending on their evolved bill morphology and body size (Lifjeld 1984; Baker 1989; Barbosa and Moreno1999; Durell 2000). Species with long, slender bills like the Far Eastern Curlew that depend on deep probing of sediments for locating prey tend to prefer feeding in softer sediments with less resistance to bill probing (Finn *et al*. 2008).

Coastal shorebirds also depend on roosting areas near their feeding areas that allow them to rest (during times when their feeding habitat is inundated at high tide) without losing too much energy to disturbance (Colwell 2010). Migratory shorebirds select roost sites on the basis of: distance from feeding areas (preferring sites close to feeding areas since that reduces their energy expenditure flying between roosting and feeding sites); distance from tall cover (preferring sites with little cover to ensure a clear view of approaching predators); climate (preferring sites at the water's edge to stay cool); height of the tide (whether the site will be inundated); and background colour of the roost site (providing camouflage against predators) (Rogers *et al*. 2006a). There is also some evidence that feeding site selection is influenced by distance from available roost sites (Rogers *et al*. 2006a), since energy expended flying between feeding and roosting sites reduces the birds' ability to store fat for migration (Rogers 2003). As a result of these requirements, both feeding and roosting habitats are essential to migratory shorebirds.

Migratory shorebirds are particularly sensitive to disturbance at roost sites since they are often concentrated into small areas at roost sites that may be quite distant from the nearest suitable alternative. Ongoing urban development and population growth in south-east Queensland is resulting in steadily increasing disturbance pressure on shorebirds at both roost sites and tidal flat feeding habitats sites (Fuller *et al.* 2019).

3.2 SURVEY TIMING AND CONDITIONS

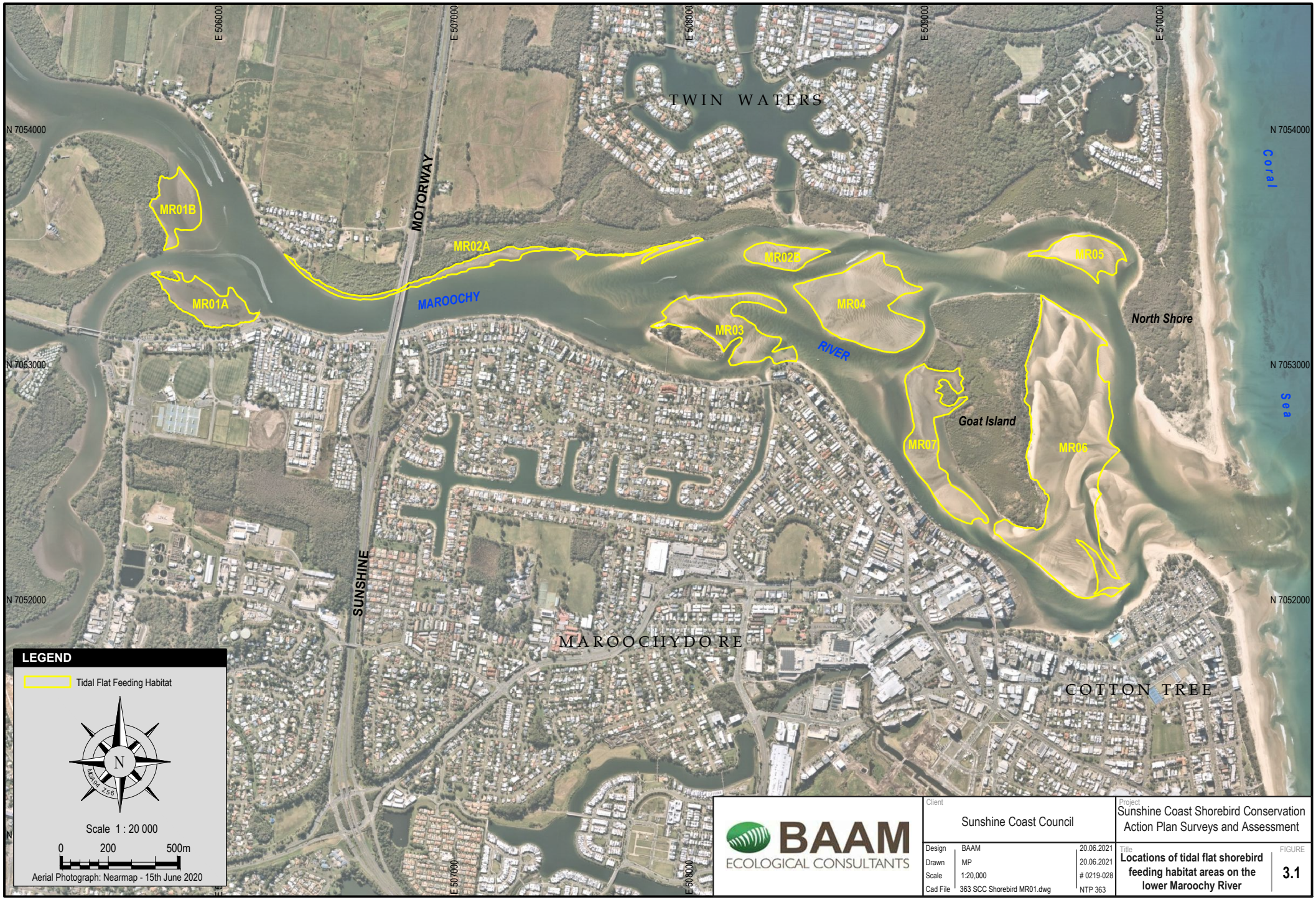
The survey dates and survey conditions during the surveys of the lower Maroochy River and Caloundra are summarised in **Appendix 1**. All surveys were conducted during conditions that were suitable for conducting a shorebird survey.

3.3 LOWER MAROOCHY RIVER

3.3.1 Low tide surveys

A single low tide survey of the main tidal flat shorebird foraging habitat areas of MR04 to MR07 along the lower Maroochy River was conducted during the outward migration period on 31/03/222 by Dr Simone Bosshard (**Table 3.1**). The locations of the low tide foraging habitat areas are shown in **Figure 3.1**. Most migratory shorebirds (92 individuals of three different species) were recorded within the tidal flat area of MR06 on the eastern side of Goat Island, consistent with the results of previous surveys (BAAM 2021). The only sources of potential disturbance recorded during the survey were people and watercraft at all four of the tidal flat survey areas.

Shorebirds feeding at low tide on the tidal flats that cover the areas of MR02B and MR04 to MR07 (see **Figure 3.1**) have been regularly monitored by the QWSG since 1992. During this time, 16 species of migratory shorebird and six species of resident shorebird have been recorded feeding on the tidal flats at low tide. The relative abundance of the different shorebird species at low tide from QWSG surveys conducted throughout the year is illustrated in **Figure 3.2**.



Migratory shorebird species were substantially more abundant than resident shorebird species (**Figure 3.2**). The most abundant migratory shorebird species were Pacific Golden Plover, Eurasian Whimbrel, Bar-tailed Godwit, Grey-tailed Tattler, Far Eastern Curlew and Double-banded Plover. The most abundant resident shorebird species were Pied Oystercatcher and Red-capped Plover (**Figure 3.2**).

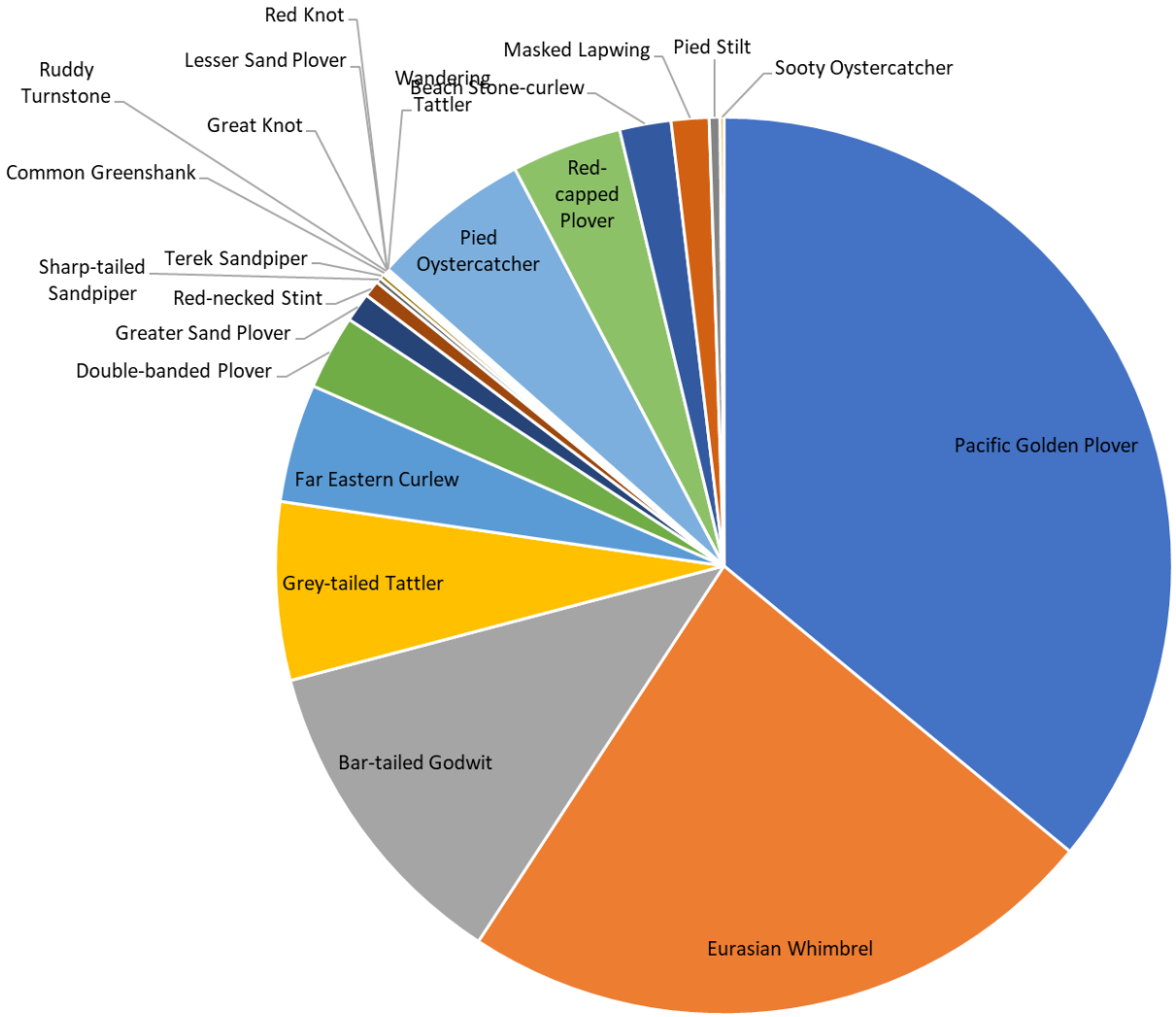


Figure 3.2. Relative abundance of migratory shorebird species (Pacific Golden Plover to Wandering Tattler) and resident shorebird species (Pied Oystercatcher to Sooty Oystercatcher) feeding on the tidal flats of the lower Maroochy River at low tide, expressed as the proportion of the sum of all shorebirds across all low tide surveys throughout each year over the period 1992-2022 from QWSG data.

The average count of both migratory and resident shorebirds feeding in this area at low tide during the summer months has declined significantly between 1992 and 2021 (**Figure 3.3**).

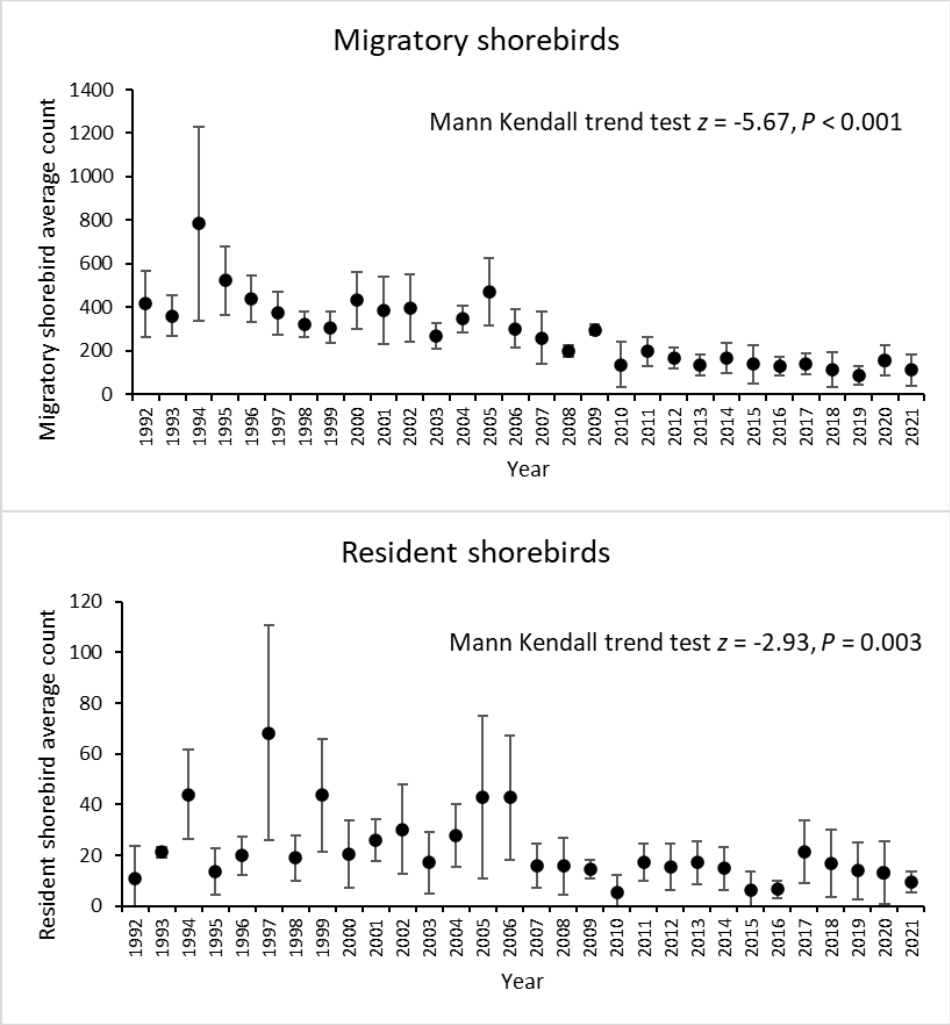


Figure 3.3. Average (± 1 standard deviation) total migratory shorebird (top) and resident shorebird (bottom) count at low tide (within 1.5 hours either side of low tide) during the summer-season each year since 1992 on tidal flats of the lower Maroochy River based on QWSG data.

Several species of migratory shorebird, including Far Eastern Curlew, Great Knot, Red Knot, Greater Sand Plover, Lesser Sand Plover, Curlew Sandpiper and Bar-tailed Godwit have experienced substantial declines in their overall populations visiting Australia, largely due to pressures operating in other portions of the flyway outside Australia (Wilson *et al.* 2011, Clemens *et al.* 2016, Studds *et al.* 2017). These background declines may explain the significant decline in migratory shorebird use of tidal flats in the lower Maroochy River. However, resident shorebirds are not known to have declined in coastal areas of south-east Queensland (Wilson *et al.* 2011). Consequently, increased human recreational use and associated disturbance of the lower Maroochy River over this time period may have contributed to the observed shorebird declines.

3.3.2 High tide surveys

Four main roost sites used by shorebirds and other waterbirds occur in the lower Maroochy River (see **Figure 3.4** for their current locations): Goat Island (MRGI); Nojoor Road (MRNR); north shore (MRNS); and sand bar (MRSB). The results of four high tide surveys conducted through the summer months of 2021/22 are presented in **Table 3.2**. The raised sandbank on the eastern side of Goat Island was the main roost site used by migratory shorebirds, with a small flock of Grey-tailed Tattlers occasionally roosting in mangrove trees on the north-western edge of Goat Island. No birds were recorded at the Nojoor Road (MRNR), north shore (MRNS) or sand bar (MRSB) roost sites.

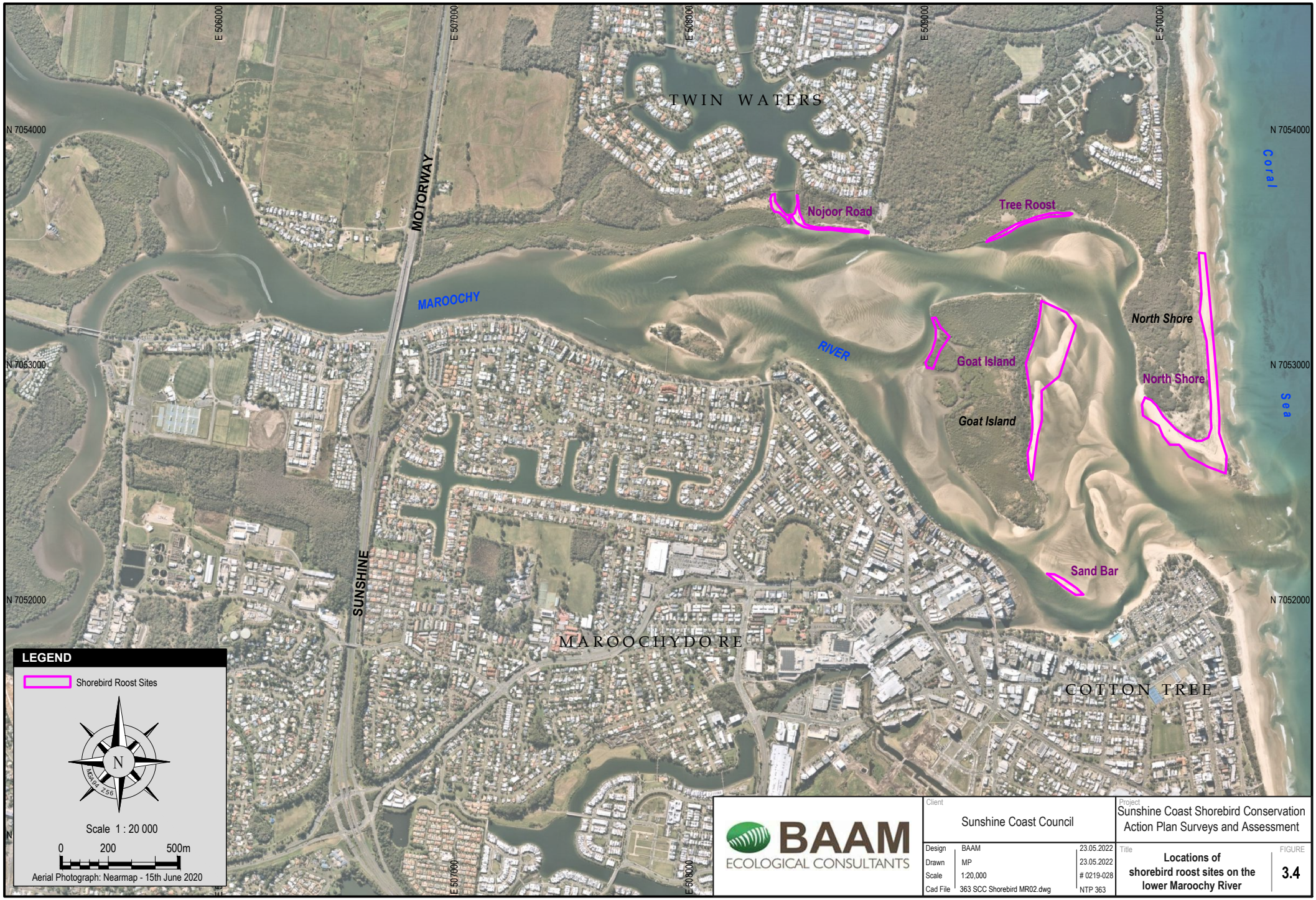


Table 3.1. Summary of shorebird species, their status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) and Queensland *Nature Conservation Act 1992* (NCA) recorded at each of four tidal flat areas (MR04 to MR07) on a single low tide survey of the lower Maroochy River on 31/03/2022.

Common name	Species	EPBC*	NCA*	MR04	MR05	MR06	MR07	Total
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	0	0	0	4	4
Eurasian Whimbrel	*Numenius phaeopus*	M	S	2	2	26	0	30
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	M, V	V	6	0	0	0	6
Pacific Golden Plover	*Pluvialis fulva*	M	S	0	2	52	0	54
Grey-tailed Tattler	*Tringa brevipes*	M	S	0	9	14	0	23
Pied Oystercatcher	*Haematopus longirostris*		LC	1	0	2	1	4
Red-capped Plover	*Charadrius ruficapillus*		LC	0	5	2	1	8
Beach Stone Curlew	*Beach Stone-curlew*		V	0	0	4	0	4
Total migratory shorebirds				**8**	**13**	**92**	**4**	**117**
Total resident shorebirds				**1**	**5**	**8**	**2**	**16**

* Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) or Queensland *Nature Conservation Act 1992* (NCA): CE = critically endangered; E = endangered; LC = least concern; M = migratory; S = special least concern (migratory); V = vulnerable.

Table 3.2. Summary of shorebird species, their status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) and Queensland *Nature Conservation Act 1992* (NCA) recorded at roost sites in the lower Maroochy River during the summer months of 2021/22; birds were recorded at the Goat Island (MRGI) roost on all surveys and the tree roost (MRTR) on one survey, but no birds were recorded at the Nojoor Road (MRNR), north shore (MRNS) or sand bar (MRSB) roost sites.

		Status		07/12/2021		19/01/2022	27/01/2022	07/02/2022
Common name	Species	EPBC*	NCA*	MRGI	MRTR	MRGI	MRGI	MRGI
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	5		4	3	3
Eurasian Whimbrel	*Numenius phaeopus*	M	S	17	19	34	43	39
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	M, V	V	25		71	12	11
Grey-tailed Tattler	*Tringa brevipes*	M	S	11				10
Pied Oystercatcher	*Haematopus longirostris*		LC	3		5	5	5
Sooty Oystercatcher	*Haematopus fuliginosus*		LC			2		
Masked Lapwing	*Vanellus miles*		LC	2				
Red-capped Plover	*Charadrius ruficapillus*		LC				4	
Total migratory shorebirds				**58**	**19**	**109**	**58**	**63**
Total resident shorebirds				**5**	**0**	**7**	**9**	**5**
Total other waterbirds				**18**	**0**	**124**	**75**	**46**

* Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) or Queensland *Nature Conservation Act 1992* (NCA): CE = critically endangered; E = endangered; LC = least concern; M = migratory; S = special least concern (migratory); V = vulnerable.

A flock of 19 Eurasian Whimbrel were observed roosting in mangrove trees on the mainland shore to the north-east of Goat Island on one of the four surveys; this roost site is now known as the Maroochy River tree roost (MRTR) by the QWSG.

The four main Maroochy River roost sites were regularly monitored by the QWSG from 1997 to 2012, with few surveys on high tides since then. The analysis that follows is based on a combination of the one high tide survey undertaken during 2020/21 and all QWSG data. The locations of the roost sites at the mouth of the Maroochy River have changed over time due to the dynamic nature of the sand bars at the river mouth. A total of 20 migratory shorebird species and seven resident shorebird species have been recorded roosting at high tide at roost sites on the lower Maroochy River, with the north shore, Goat Island and the sand bar being most frequently used (**Table 3.3**).

Table 3.3. Summary of the percentage of high tide surveys (within 1.5 hours either side of high tide) in all months of the year that shorebirds have been recorded roosting at each of the four main roost sites on the lower Maroochy River: Goat Island (MRGI); Nojoor Road (MRNR); north shore (MRNS); and sand bar (MRSB).

Roost site				MRGI	MRNR	MRNS	MRSB
Total number of high tide surveys (1997 to 2022, all months)				147	163	163	165
Common name	Species	EPBC*	NCA*				
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	19%	10%	16%	20%
Eurasian Whimbrel	*Numenius phaeopus*	M	S	27%	9%	36%	16%
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	M, V	V	24%	8%	33%	25%
Black-tailed Godwit	*Limosa limosa*	M	S	1%		1%	1%
Pacific Golden Plover	*Pluvialis fulva*	M	S	10%	1%	45%	7%
Greater Sand Plover	*Charadrius leschenaultii*	M, V	V			11%	1%
Lesser Sand Plover	*Charadrius mongolus*	M, E	E		1%	14%	
Double-banded Plover	*Charadrius bicinctus*	M	S	1%		22%	4%
Ruddy Turnstone	*Arenaria interpres*	M	S		1%	7%	1%
Sharp-tailed Sandpiper	*Calidris acuminata*	M	S	1%		1%	
Sanderling	*Calidris alba*	M	S			1%	
Red Knot	*Calidris canutus*	M, E	E				1%
Broad-billed Sandpiper	*Calidris falcinellus*	M	S			1%	
Curlew Sandpiper	*Calidris ferruginea*	M, CE	E			6%	
Red-necked Stint	*Calidris ruficollis*	M	S	1%	2%	34%	1%
Great Knot	*Calidris tenuirostris*	M, CE	E	1%		6%	2%
Grey-tailed Tattler	*Tringa brevipes*	M	S	9%	3%	6%	1%
Wandering Tattler	*Tringa incana*	M	S			3%	
Common Greenshank	*Tringa nebularia*	M	S	1%	1%		
Terek Sandpiper	*Xenus cinereus*	M	S	1%		4%	
Beach Stone-curlew	*Esacus magnirostris*		V	3%	1%	2%	
Sooty Oystercatcher	*Haematopus fuliginosus*		LC	1%		5%	3%
Pied Oystercatcher	*Haematopus longirostris*		LC	46%	16%	21%	30%
Pied Stilt	*Himantopus leucocephalus*		LC	3%	6%		1%
Masked Lapwing	*Vanellus miles*		LC	2%	13%	4%	1%
Red-capped Plover	*Charadrius ruficapillus*		LC	2%	3%	81%	17%
Black-fronted Dotterel	*Elseyornis melanops*		LC		1%		1%

* Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) or Queensland *Nature Conservation Act 1992* (NCA): CE = critically endangered; E = endangered; LC = least concern; M = migratory; S = special least concern (migratory); V = vulnerable.

Figure 3.5 shows the maximum count of migratory shorebirds at each of the four roost sites at different periods of the annual migratory shorebird season in each year that monitoring of high tide roost sites has been undertaken since 1997. The QWSG defines the different periods of the annual migratory shorebird season in Australia as: (1) inbound migration (September to mid-November), the period when shorebirds arrive in Australia after breeding in the northern hemisphere; (2) summer non-breeding (mid-November to mid-March); (3) outbound migration (mid-March to May), the period when shorebirds leave to migrate to their breeding grounds; and (4) winter breeding (June to August) periods. Birds present in Australia during the winter period are typically juvenile birds that do

not migrate back to the northern hemisphere breeding grounds for several years until they are ready to start breeding.

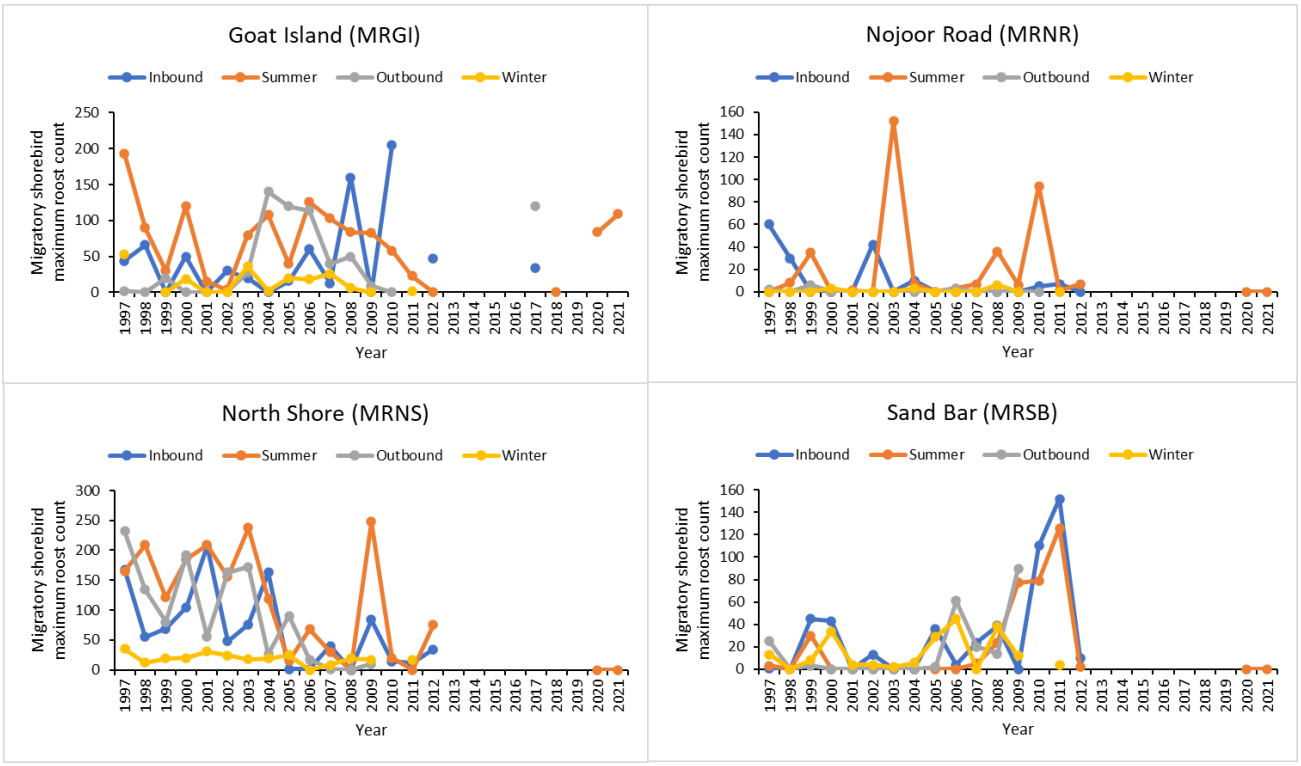


Figure 3.5. Annual maximum count of migratory shorebirds at high tide (within 1.5 hrs either side of high tide) at each of four roost sites in the lower Maroochy River since 1997 based on QWSG data and this study.

The QWSG data show that that the north shore (MRNS) was the most important migratory shorebird roost site in the lower Maroochy River area up until at least 2009. The QWSG discontinued monitoring of roost sites on the lower Maroochy River after 2012 due to increasing levels of disturbance affecting the counts. Based on QWSG data, the north shore has experienced the highest frequency of disturbance across all categories, including the presence of dogs (see **Section 3.3.3** below).

QWSG counters report that the north shore has largely been abandoned as a roost site due to the high frequency of disturbance from recreational activities. The dynamic changes to the sandbanks may also have altered roost suitability. This effective loss of a roost site reduces the resilience of shorebirds to disturbance since there are fewer alternative roost sites available should disturbance cause them to leave a particular roost site. The Goat Island (MRGI) roost is currently the most important roost site in the lower Maroochy River, supporting between 58 and 109 migratory shorebirds over the past two years (**Figure 3.5**).

3.3.3 Disturbance

Shorebird roost sites and tidal flat feeding habitat areas in the lower Maroochy River are subject to multiple sources of disturbance to roosting or feeding shorebirds, including people using the area for recreation, dogs being walked on and off-leash and various watercraft. QWSG survey data on disturbance are not captured in a format that allows examination of temporal trends in disturbance with sufficient rigour. However, the data do allow comparison of the relative frequency of different sources of potential or actual disturbance between sites. These data show that the north shore has experienced the highest disturbance pressure, particularly from people and dogs walking along the shoreline at all tides (**Table 3.4**).

Table 3.4. Percentage of surveys in which people, dogs, boats or jetskis were recorded as potential or actual sources of disturbance to roosting or feeding birds at sites in the lower Maroochy River.

Site	Surveys	People	Dogs	Boats	Jetskis
Goat Island (MRGI)	299	45%	18%	33%	14%
Nojoor Rd (MRNR)	304	55%	27%	27%	22%
North shore (MRNS)	303	72%	64%	36%	29%
Sandbank (MRSB)	312	45%	30%	29%	14%

3.4 CALOUNDRA

3.4.1 Low tide surveys

Four main areas of tidal flat feeding habitat occur at Caloundra and have been subject to monitoring by the QWSG since 1993; these are all within Pumicestone Passage and have been given the site codes SBN1, SBN2, PEWA and BECK by the QWSG (see **Figure 3.6** for locations). Based on analysis of long-term QWSG data, a total of 19 migratory shorebird species and seven resident shorebird species have been recorded feeding at low tide on tidal flats in the northern Pumicestone Passage at Caloundra since 1993 (**Table 3.5**).

Table 3.5. Summary of the percentage of low tide surveys (within 1.5 hours either side of low tide) in all months of the year that shorebirds have been recorded feeding at each of the four main tidal flat feeding habitat areas at Caloundra since 1993 based on QWSG data.

Tidal flat feeding habitat area				SBN1	SBN2	PEWA	BECK
Total low tide surveys (all months)				329	372	303	268
Common name	Species	EPBC*	NCA*				
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	77%	80%	23%	71%
Eurasian Whimbrel	*Numenius phaeopus*	M	S	76%	78%	41%	70%
Little Curlew	*Numenius minutus*	M	S				<1%
Bar-tailed Godwit	*Limosa lapponica baueri*	M, V	V	60%	85%	51%	76%
Pacific Golden Plover	*Pluvialis fulva*	M	S	45%	72%	25%	38%
Greater Sand Plover	*Charadrius leschenaultii*	M, V	V	29%	56%	2%	
Lesser Sand Plover	*Charadrius mongolus*	M, E	E	15%	27%		<1%
Double-banded Plover	*Charadrius bicinctus*	M	S	5%	19%		
Ruddy Turnstone	*Arenaria interpres*	M	S	<1%	1%	1%	<1%
Sharp-tailed Sandpiper	*Calidris acuminata*	M	S	<1%	1%	3%	4%
Red Knot	*Calidris canutus*	M, E	E	<1%	1%		
Curlew Sandpiper	*Calidris ferruginea*	M, CE	E	28%	55%	9%	10%
Red-necked Stint	*Calidris ruficollis*	M	S	12%	27%	2%	<1%
Great Knot	*Calidris tenuirostris*	M, CE	E	2%	5%		<1%
Grey-tailed Tattler	*Tringa brevipes*	M	S	6%	26%	7%	37%
Common Greenshank	*Tringa nebularia*	M	S	5%	16%	10%	26%
Marsh Sandpiper	*Tringa stagnatilis*	M	S		<1%	<1%	
Common Sandpiper	*Actitis hypoleucos*	M	S	<1%	<1%	1%	
Terek Sandpiper	*Xenus cinereus*	M	S	4%	14%	2%	8%
Beach Stone-curlew	*Esacus magnirostris*		V	4%	<1%		<1%
Sooty Oystercatcher	*Haematopus fuliginosus*		LC	<1%			<1%
Pied Oystercatcher	*Haematopus longirostris*		LC	32%	38%	18%	13%
Pied Stilt	*Himantopus leucocephalus*		LC	3%	15%	26%	79%
Masked Lapwing	*Vanellus miles*		LC	33%	9%	49%	28%
Red-capped Plover	*Charadrius ruficapillus*		LC	49%	65%	7%	9%
Black-fronted Dotterel	*Elseyornis melanops*		LC			1%	

* Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) or Queensland *Nature Conservation Act 1992* (NCA): CE = critically endangered; E = endangered; LC = least concern; M = migratory; S = special least concern (migratory); V = vulnerable.

BAAM ECOLOGICAL CONSULTANTS

Client: Sunshine Coast Council

Project: Sunshine Coast Shorebird Conservation Action Plan Surveys and Assessment

Design	BAAM	23.05.2022
Drawn	MP	23.05.2022
Scale	1:25,000	# 0219-028
Cad File	363 SCC Shorebird C02.dwg	NTP 363

Title: **Locations of tidal flat shorebird feeding habitat areas at Caloundra**

FIGURE **3.6**

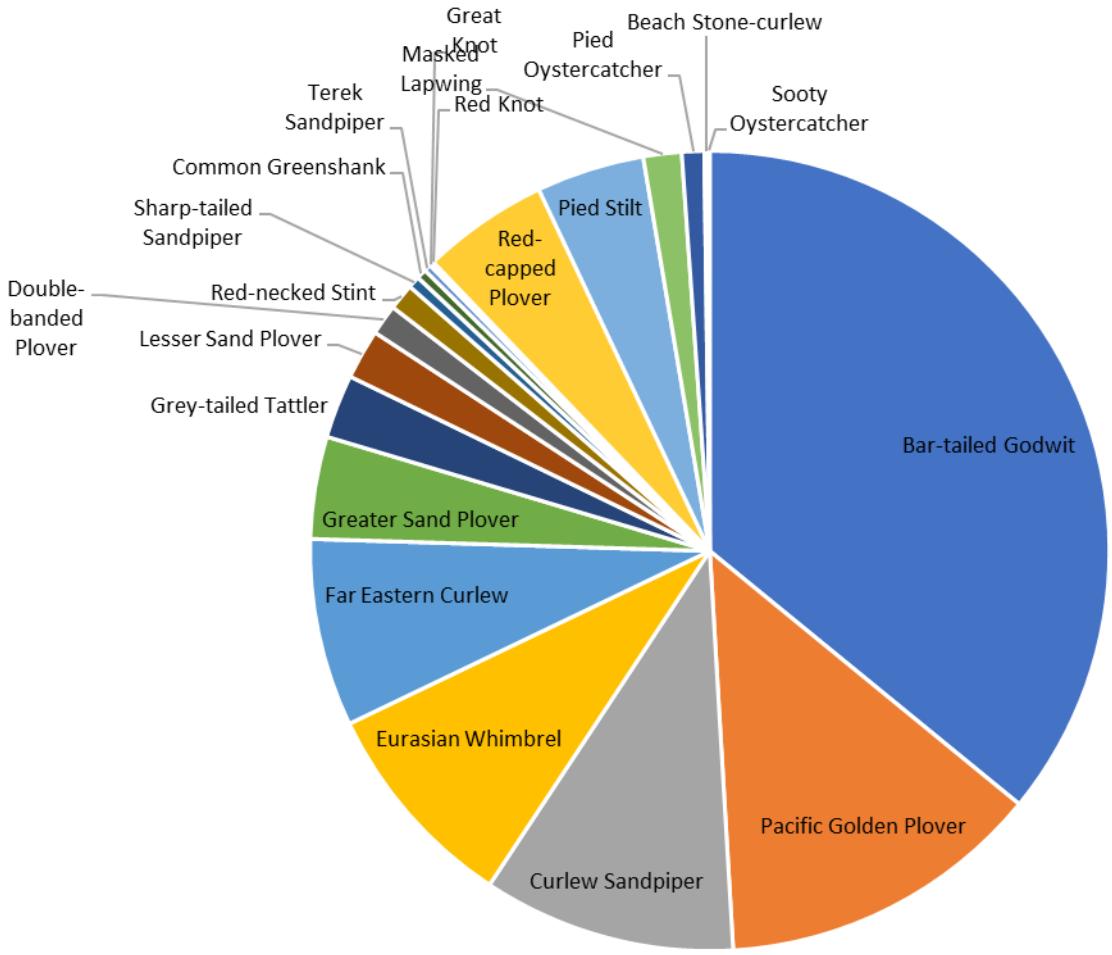


Figure 3.7. Relative abundance of migratory shorebird species (Bar-tailed Godwit to Red Knot) and resident shorebird species (Red-capped Plover to Sooty Oystercatcher) feeding on the tidal flats at Caloundra at low tide, expressed as the proportion of the sum of all shorebirds across all low tide surveys throughout each year over the period 1993-2022 from QWSG data, excluding species recorded rarely.

The relative abundance of the different shorebird species at low tide from QWSG surveys conducted throughout the year is illustrated in **Figure 3.7**. Migratory shorebird species were substantially more abundant than resident shorebird species (**Figure 3.7**). The most abundant migratory shorebird species were Bar-tailed Godwit, Pacific Golden Plover, Curlew Sandpiper, Eurasian Whimbrel, Far Eastern Curlew and Greater Sand Plover. The most abundant resident shorebird species were Red-capped Plover and Pied Stilt (**Figure 3.7**).

Figure 3.8 below shows the average (± 1 standard deviation) total migratory shorebird count at low tide (within 1.5 hours either side of low tide) during the summer-season each year since 1993 for each tidal flat feeding area at Caloundra. There is evidence that there has been a long-term reduction in the total numbers of migratory shorebirds using the SBN1, SBN2 and BECK tidal flat areas between 1993 and 2021 (**Table 3.6**).

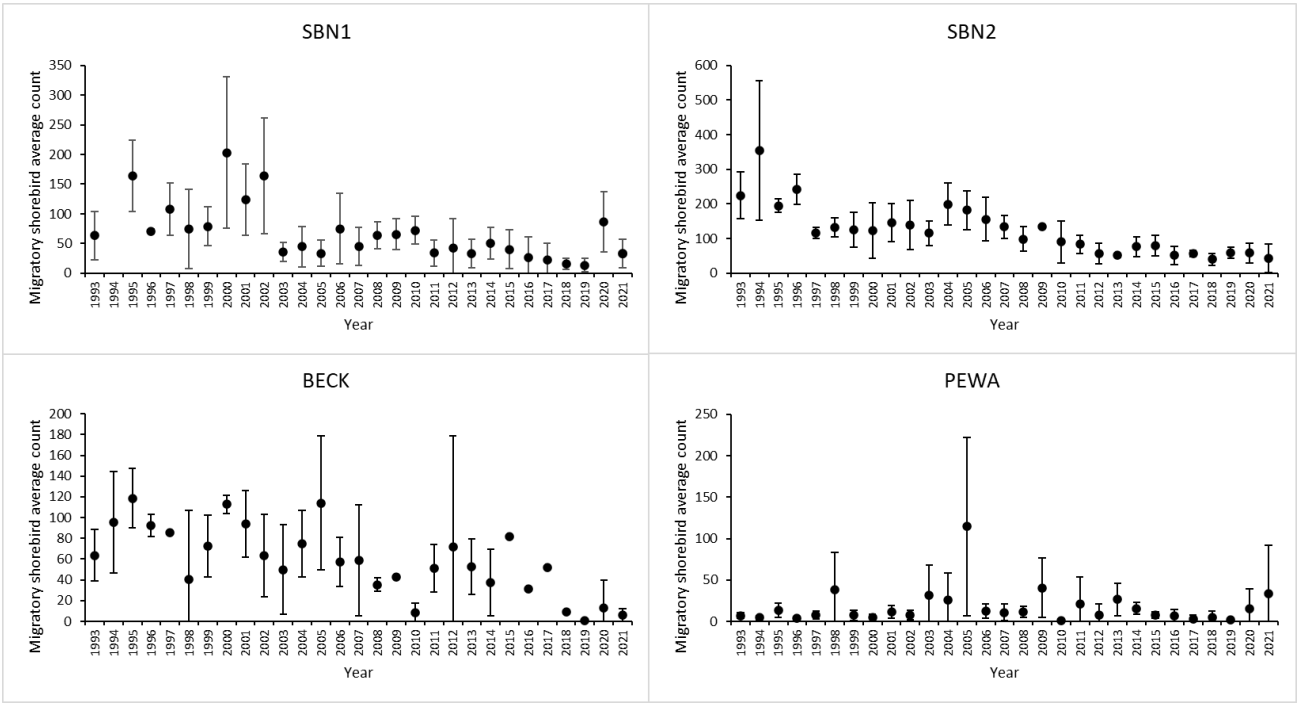


Figure 3.8. Average (± 1 standard deviation) total migratory shorebird count at low tide (within 1.5 hours either side of low tide) during the summer-season each year since 1993 for each tidal flat feeding area at Caloundra based on QWSG data and this study.

Interpretation of temporal change in migratory shorebird use of the SBN1 area is complicated by two factors. First, the position and extent of SBN1 has changed substantially since 1993 due to the dynamic nature of sand movement at the passage entrance. Second, most QWSG surveys of SBN1 have been conducted from the mainland shoreline, up to 900 m from the furthest reaches of SBN1, which results in birds, particularly individuals of smaller species being difficult to detect and identify in some portions of the SBN1 survey area, particularly on spring low tides. The detectability of birds has likely been variable over time and some surveys may have missed birds present across SBN1.

Examination of species-specific count data suggests several species have declined in abundance since 1993 across one or more of the four tidal flat areas; declining species include Greater Sand Plover, Lesser Sand Plover, Curlew Sandpiper, Grey-tailed Tattler, Red-necked Stint and Bar-tailed Godwit (**Figure 3.9**, **Table 3.6**). The decline in the numbers of Curlew Sandpiper is particularly notable since this was once a dominant species feeding on tidal flats at Caloundra (**Figures 3.7** and **3.9**) but has largely been absent from the area since 2012 (**Figure 3.9**).

For some species such as Greater Sand Plover, Lesser Sand Plover, Curlew Sandpiper and Bar-tailed Godwit, the decline may be linked to substantial declines in the overall population visiting Australia (Wilson *et al.* 2011, Clemens *et al.* 2016, Studds *et al.* 2017). In this respect, the Far Eastern Curlew is an apparent outlier; while the overall population of this critically endangered species visiting Australia has undergone a severe population decline of 66.8% over 20 years (5.8% per year) and 81.4 % over 30 years (TSSC 2015, Studds *et al.* 2017), the only tidal flat feeding area at Caloundra that has experienced a decline in Eastern Curlew numbers feeding at low tide was the BECK tidal flat area that has generally supported fewer Far Eastern Curlew than the SBN1 and SBN2 areas (**Figure 3.9**, **Table 3.6**). The decline in the use of the Bell's Creek tidal flats has been consistent across nearly all migratory shorebird species that have used this area, whereas the abundance of some species using the SNB1 and SBN2 tidal flats has not declined (**Figure 3.9**, **Table 3.6**), including species such as Far Eastern Curlew and Eurasian Whimbrel that are typically the most sensitive to disturbance. Consequently, it is difficult to determine the relative importance of different factors that might have influenced the observed declines in the use of the various tidal flat areas by different species.

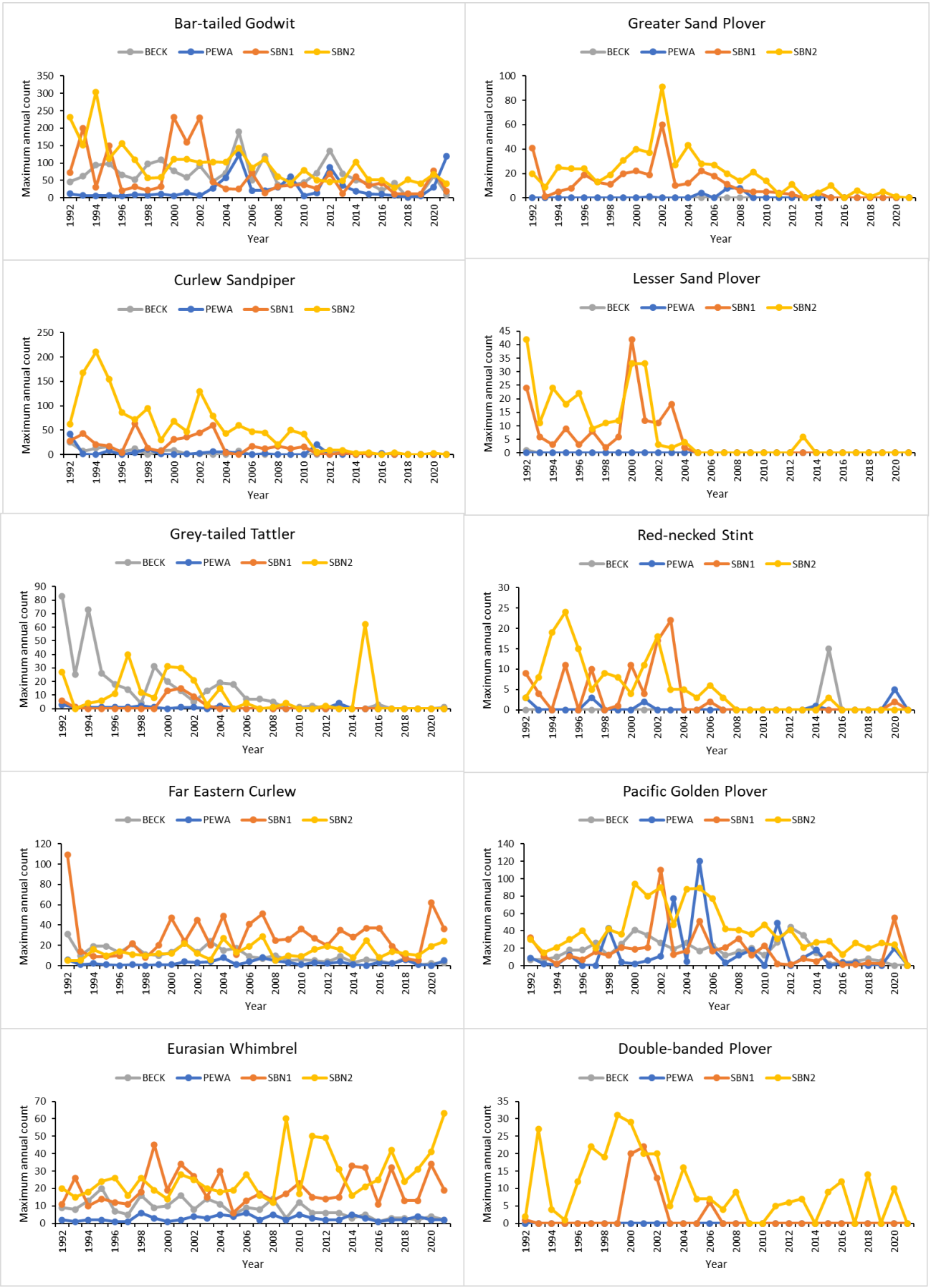


Figure 3.9. Annual maximum count of the migratory shorebird species most commonly recorded feeding at four tidal flat feeding areas at low tide at Caloundra since 1992 based on QWSG data.

Table 3.6. Summary of Mann-Kendall trend test results testing whether there are trends in the abundance of migratory shorebirds and migratory shorebird species feeding on Caloundra tidal flats at low tide between 1992 and 2020.

Species / Site	Mann-Kendall trend test (z)[1]			
	SBN1	SBN2	PEWA	BECK
Total migratory shorebirds (average summer-season count)	-3.73 ***	-5.05 ***	-0.67	-3.73 ***
Bar-tailed Godwit (maximum annual count)	-1.61	-4.34 ***	0.96	-2.38 *
Curlew Sandpiper (maximum annual count)	-4.24 ***	-5.67 ***	-2.66 **	-3.96 ***
Greater Sand Plover (maximum annual count)	-4.18 ***	-3.40 ***		
Lesser Sand Plover (maximum annual count)	-4.21 ***	-4.62 ***		
Grey-tailed Tattler (maximum annual count)	-2.34 *	-3.20 **		-5.43 ***
Red-necked Stint (maximum annual count)	-2.48 *	-4.63 ***		
Far Eastern Curlew (maximum annual count)	0.83	1.13	0.15	-4.78 ***
Eurasian Whimbrel (maximum annual count)	0.92	1.95	0.86	-3.71 ***
Pacific Golden Plover (maximum annual count)	-1.24	-1.60	-0.17	-1.30
Double-banded Plover (maximum annual count)	-1.63	-1.71		

[1] Significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The factors responsible for the observed migratory shorebird declines at Caloundra may include:

- The background decline in the populations of some species, as outlined above;
- Loss of some shorebird habitat to development (e.g. at Pelican Waters) and/or change in the areas of tidal flat feeding habitat resulting from sediment movement in Pumicestone Passage; and
- Increasing human disturbance of shorebirds at roost sites and feeding habitat areas as the region's population has increased.

3.4.2 High tide surveys

Five known shorebird roost sites occur at Caloundra (see **Figure 3.10**):

- Caloundra bar (CBAR), including a sand bank at the Pumicestone Passage entrance and the beach south of the entrance;
- Sandbank 1 (SBN1), including a sandbank in the passage (remains exposed on neap high tides only), a sandbank on the north-western shoreline of Bribie Island and an adjoining area of saltmarsh on the shoreline of Bribie Island;
- Sandbank 2 (SBN2), a sandbank in the passage that remains exposed on neap high tides only;
- A mangrove tree roost (BCTR) on the opposite side of Pumicestone Passage from Bell's Creek; and
- Wickham Point (WICK), a rock platform on the mainland coastline north of the Pumicestone Passage entrance.

Four of these roost sites (CBAR, SBN1, SBN2, BCTR) were surveyed during the 2021/22 season, together with a sixth roost (NTBI: northern tip of Bribie Island) site that was identified as a new roost site during 2021/22. The new NTBI roost site is located along the beach between the old and new entrances to Pumicestone Passage. The new entrance formed when heavy seas associated with Cyclone Seth broke though the northern coastline of Bribie Island in January 2022 (**Figure 3.10**). The results of the four summer-season surveys are summarised in **Table 3.7**; while birds were observed roosting at SBN1, they moved to other roost sites as the tide rose and were therefore recorded at those roost sites instead.

BAAM ECOLOGICAL CONSULTANTS

Client	Sunshine Coast Council
Project	Sunshine Coast Shorebird Conservation Action Plan Surveys and Assessment
Design	BAAM — 23.05.2022
Drawn	MP — 23.05.2022
Scale	1:25,000 — # 0219-028
Cad File	363 SCC Shorebird C02.dwg — NTP 363
Title	Locations of shorebird roost sites at Caloundra
FIGURE	3.10

Table 3.7. Results of the four summer-season surveys of shorebird roost sites at Caloundra during 2021/22.

Common name	Species	EPBC*	NCA*	14 Dec 2021	21 Dec 2021	26 Jan 2022	8 Feb 2022
Caloundra Bar (CBAR)							
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	30	26	0	48
Eurasian Whimbrel	*Numenius phaeopus*	M	S	49	0	0	0
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	M, V	V	77	0	0	0
Pied Oystercatcher	*Haematopus longirostris*		LC	4	5	0	3
Masked Lapwing	*Vanellus miles*		LC	3	3	0	1
Total migratory shorebirds				156	26	0	48
Total resident shorebirds				7	8	0	4
Total other waterbirds				64	49	0	55
Northern tip of Bribie Island (NTBI)							
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	0	6	31	0
Eurasian Whimbrel	*Numenius phaeopus*	M	S	0	39	35	11
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	M, V	V	0	86	45	0
Pied Oystercatcher	*Haematopus longirostris*		LC	3	0	3	0
Total migratory shorebirds				0	131	111	11
Total resident shorebirds				3	0	3	0
Total other waterbirds				55	50	44	0
Sandbank 2 (SBN2)							
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	M, V	V	0	0	0	62
Total migratory shorebirds				0	0	0	62
Total resident shorebirds				0	0	0	0
Total other waterbirds				0	0	0	30
Bells Creek Tree Roost (BCTR)							
Eurasian Whimbrel	*Numenius phaeopus*	M	S	0	21	0	5
Total migratory shorebirds				0	21	0	5
Total resident shorebirds				0	0	0	0
Total other waterbirds				32	0	15	45

* Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) or Queensland *Nature Conservation Act 1992* (NCA): CE = critically endangered; E = endangered; LC = least concern; M = migratory; S = special least concern (migratory); V = vulnerable.

The sandy beach shoreline at CBAR and NTBI were the two most frequently used roost sites during the four surveys in 2021/22, supporting up to 48 Far Eastern Curlew, up to 86 Bar-tailed Godwit and up to 49 Eurasian Whimbrel (**Table 3.7**). The mangrove trees at BCTR were used occasionally by Eurasian Whimbrel. Two sandbanks in the centre of the Pumicestone Passage channel (SBN1 and SBN2) are used by roosting shorebirds and other waterbirds (mostly terns) on the rising tide and when they remain exposed on neap high tides; these sandbanks are not available as roost sites on higher tides once they become covered by water. As the two passage sandbars become covered by the rising tide, shorebirds move either to an area of saltmarsh on the shoreline of Bribie Island that also forms part of the SBN1 roost site, or they fly east to the sandy beach shoreline at CBAR or NTBI.

The three roost sites CBAR, SBN1 and SBN2 have been monitored intermittently by the QWSG since 1993 while the WICK roost site has been monitored continuously since 1999. A total of 17 migratory shorebird species and seven resident shorebird species have been recorded roosting at these high tide roost sites at Caloundra (**Table 3.8**). The commonly recorded migratory shorebird species included the vulnerable Bar-tailed Godwit, the critically endangered Far Eastern Curlew, Eurasian Whimbrel and Pacific Golden Plover, the four species that were also most frequently present feeding on the tidal flats at low tide (**Table 3.5**).

Table 3.8. Summary of the percentage of high tide surveys (within 1.5 hours either side of high tide) in all months of the year that shorebirds have been recorded roosting at each of four roost sites at Caloundra since 1993.

Roost site				CBAR	SBN1	SBN2	WICK	BCTR	NTBI
Total high tide surveys (all months)				53	53	32	239	7	4
Common name	Species	EPBC*	NCA*						
Far Eastern Curlew	*Numenius madagascariensis*	M, CE	E	58%	68%	38%			50%
Eurasian Whimbrel	*Numenius phaeopus*	M	S	57%	62%	34%		57%	75%
Bar-tailed Godwit	*Limosa lapponica baueri*	M, V	V	47%	72%	50%	<1%		50%
Pacific Golden Plover	*Pluvialis fulva*	M	S	43%	32%	25%	<1%		
Greater Sand Plover	*Charadrius leschenaultii*	M, V	V	43%	26%	6%			
Lesser Sand Plover	*Charadrius mongolus*	M, E	E	38%	19%	6%			
Double-banded Plover	*Charadrius bicinctus*	M	S	15%	23%	9%			
Ruddy Turnstone	*Arenaria interpres*	M	S	2%			2%		
Sharp-tailed Sandpiper	*Calidris acuminata*	M	S	4%					
Red Knot	*Calidris canutus*	M, E	E	4%	2%				
Curlew Sandpiper	*Calidris ferruginea*	M, CE	E	42%	36%	19%			
Red-necked Stint	*Calidris ruficollis*	M	S	47%	30%	13%			
Great Knot	*Calidris tenuirostris*	M, CE	E	15%	19%	9%			
Grey-tailed Tattler	*Tringa brevipes*	M	S	2%	15%	13%			
Wandering Tattler	*Tringa incana*	M	S	2%			44%		
Common Greenshank	*Tringa nebularia*	M	S	2%	9%	13%			
Terek Sandpiper	*Xenus cinereus*	M	S	6%	6%	6%			
Australian Painted Snipe	*Rostratula australis*	E	E				<1%		
Beach Stone-curlew	*Esacus magnirostris*		V	4%	2%				
Sooty Oystercatcher	*Haematopus fuliginosus*		LC	4%	6%		81%		
Pied Oystercatcher	*Haematopus longirostris*		LC	42%	32%	6%	5%		
Pied Stilt	*Himantopus leucocephalus*		LC			3%	<1%		
Masked Lapwing	*Vanellus miles*		LC	11%	25%		3%		
Red-capped Plover	*Charadrius ruficapillus*		LC	64%	55%	16%			

* Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) or Queensland *Nature Conservation Act 1992* (NCA): CE = critically endangered; E = endangered; LC = least concern; M = migratory; S = special least concern (migratory); V = vulnerable.

Analysis of these data shows that the CBAR, SBN1 and SBN2 roost sites were used by up to around 550 migratory shorebirds in the period 2000 to 2002 and up to around 280 migratory shorebirds in 2008-2010 (**Figure 3.11**), but the 2020/21 surveys recorded up to 169 migratory shorebirds (BAAM 2021) and the 2021/22 surveys recorded up to 157 migratory shorebirds using these roosts and the associated NTBI roost (**Table 3.7**). This suggests there may have been a decline in the number of migratory shorebirds using these roost sites over this time period.

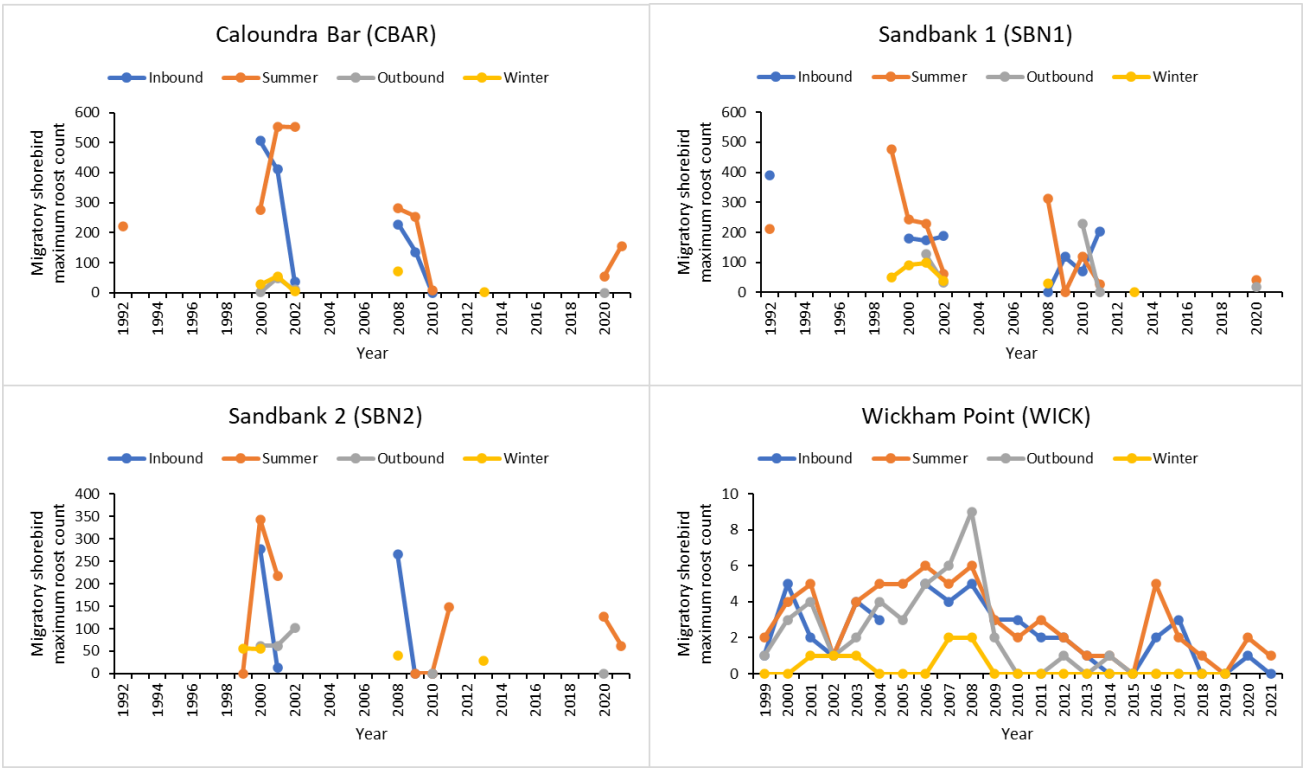


Figure 3.11. Annual maximum count of migratory shorebirds at high tide (within 1.5 hrs either side of high tide) at each of four roost sites at Caloundra since 1992 based on QWSG data and this study.

The Wickham Point (WICK) roost site is used regularly by small numbers of one migratory shorebird species, Wandering Tattler (average of 3 birds in summer) and one resident shorebird species, Sooty Oystercatcher (average of 4 birds in summer), both species being associated with rocky shorelines.

3.4.3 Disturbance

Shorebird roost sites and tidal flat feeding habitat areas at Caloundra are subject to multiple sources of disturbance to roosting or feeding shorebirds, including people using the area for recreation, dogs being walked on and off-leash and various watercraft. These data show that the Wickham Point experiences the highest disturbance pressure, particularly from people and dogs visiting the rocky shoreline (**Table 3.9**); however, this site is used by small numbers of shorebirds that are likely to be able to move along the extensive rocky shoreline at this site in response to disturbance. The other roost sites at CBAR, SBN1, SBN2, NTBI and BCTR appear to experience moderate to low levels of disturbance.

Table 3.9. Percentage of surveys in which people, dogs, boats or jetskis were recorded as potential or actual sources of disturbance to roosting or feeding birds at sites at Caloundra.

Site	Surveys	People	Dogs	Jetskis	Boats
Caloundra bar (CBAR)	164	3%	1%	1%	2%
Sandbank 1 (SBN1)	526	27%	4%	17%	34%
Sandbank 2 (SBN2)	502	25%	7%	10%	24%
Pelican Waters (PEWA)	348	43%	26%	15%	28%
Bell's Creek (BECK)	356	58%	29%	17%	41%
Tree roost (BCTR)	7	0%	0%	0%	0%
Wickham Point (WICK)	262	67%	35%	16%	9%
Northern tip of Bribie Island (NTBI)	4	0%	0%	0%	0%

4.0 RECOMMENDATIONS

4.1 LOWER MAROOCHY RIVER

While it was historically one of the most important roost sites for shorebirds on the lower Maroochy River, the north shore (MRNS) has largely been abandoned as a roost site by shorebirds due to the high levels of disturbance by people using the sandy shoreline for recreation and walking dogs off-leash. Consequently, the sandy shoreline and sand bars on the eastern side of Goat Island (MRGI and MRSB) are currently the most important shorebird roost sites, which enjoy a moderate level of protection from disturbance by being accessible at high tide only by watercraft. Nonetheless, boaters with pets on board do regularly come ashore at Goat Island and walk their dogs, often off-leash. The tidal flats on the eastern and western edges of Goat Island (MR06, MR04 and MR07) are also the most important feeding areas on the lower Maroochy River. While the MR04 and MR07 tidal flats are seldom visited by people, people regularly access the MR06 tidal flats via watercraft or wading/swimming across the southern channel at low tide, causing regular disturbance to feeding shorebirds, including by dogs being walked off-leash. These disturbance pressures are expected to continue to increase as the population of the region continues to grow. Research has shown that off-leash dogs in particular cause severe disturbance to shorebirds, reducing their use of important habitats (Dhanjal-Adams *et al.* 2016) and are a key threat to migratory shorebirds in Moreton Bay (Fuller *et al.* 2019).

Recommended approaches for reducing disturbance to feeding and roosting shorebirds include a combination of:

- Site-specific information signage to raise awareness of the presence of shorebirds in the area and the importance of the key habitat areas for shorebirds, particularly migratory shorebirds (Antos *et al.* 2006, Williams *et al.* 2009);
- Other approaches to raising public awareness of how the migration and feeding ecology of shorebirds are impacted by disturbances to try to change public awareness of, and attitudes towards disturbing shorebirds, particularly among dog-owners that exercise their dogs along foreshore areas (Antos *et al.* 2006, Williams *et al.* 2009);
- Planning to ensure suitable dog-walking facilities such as dog-off leash areas are situated in locations convenient and attractive to the public but separated from important shorebird foreshore habitats (Stigner *et al.* 2016);
- Planning to limit access to important feeding or roosting areas by people and/or dogs (Weston *et al.* 2012, Stigner *et al.* 2016); and
- Effective enforcement of access restrictions and dog on-leash areas, given that compliance to access restrictions or on-leash laws is strongly dependent on the extent of enforcement (Dhanjal-Adams *et al.* 2016, Stigner *et al.* 2016).

Research based on structured decision-making has shown that cost-effective sites for enforcement are the cheapest sites with the greatest number of target species in combination with the greatest number of illegal wildlife activities (Dhanjal-Adams *et al.* 2016). Other research suggests that trying to ensure all dogs are kept on-leash in foreshore areas may be impractical where walking dogs off-leash has already become a pervasive activity; in such situations, designating foreshore dog off-leash areas in places where shorebird foraging abundance is relatively low and recreational demand is relatively high could result in reduced overall disturbance to migratory shorebirds if there is also more effective enforcement of access restrictions or on-leash laws in important shorebird areas (Stigner *et al.* 2016, Fuller *et al.* 2019).

4.2 CALOUNDRA

The important roost sites at Caloundra, including CBAR, SBN1, SBN2, NTBI and BCTR appear to experience moderate to low levels of disturbance. The BCTR tree roost is located in a position where the risk of disturbance is very low. Disturbance to birds roosting on the in-channel sandbanks

of SBN1 and SBN2 on neap high tides is mostly from passing jet-skis and watercraft putting ashore. The CBAR and NTBI roost sites on the coastal shoreline of the northern tip of Bribie Island are the least disturbed roost sites that have now been isolated from the rest of Bribie Island by the new entrance to Pumicestone Passage. However, if the old entrance to Pumicestone Passage becomes silted up in the near future, as is predicted to occur, then disturbance to the CBAR and NTBI roost sites is expected to increase substantially once people, including people walking dogs are able to access the coastal shoreline of the northern tip of Bribie Island across a silted-up Caloundra bar.

The tidal flat feeding areas experience moderate to low levels of disturbance, with the risk of disturbance greatest along the mainland shoreline of the PEWA and BECR tidal flats, where recreational activities, including walking dogs on and off-leash across the sandy tidal flats occur more frequently. This recreational disturbance pressure is predicted to continue to increase as the region becomes more developed. Consequently, there is a need for proactive management of disturbance to shorebirds at the important roosting and feeding habitats at Caloundra that are identified above. Recommended approaches for reducing disturbance to feeding and roosting shorebirds are as recommended under **Section 4.1** above.

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APPENDIX 1

Shorebird survey conditions

Table A1.1. Shorebird survey conditions.

Date	Site	LT time	LT ht (m)	HT time	HT ht (m)	Low tide (LT)			High tide (HT)		
						Wind	Cloud	Rain	Wind	Cloud	Rain
14/12/2021	Caloundra			6:03	1.44				1	0	0
21/12/2021	Caloundra			10:22	1.77				1	6	0
26/01/2022	Caloundra			15:05	1.31				2	8	0
8/02/2022	Caloundra			14:07	1.18				2-3	0	0
7/12/2021	Maroochy River			11:26	2.06				1	8	0
19/01/2022	Maroochy River			10:10	1.91				1	1	0
27/01/2022	Maroochy River			16:19	1.35				3	8	0
7/02/2022	Maroochy River			13:15	1.48				2	6	0
31/03/2022	Maroochy River	13:54	0.3			1	0	0			

Table A1.2. Disturbance and shorebird movement observations.

Date	Site	Observations
14/12/2021	Caloundra	At 2.5 hours before high tide: over 200 terns (many Common Tern) wheeled over Pumicestone Passage and crossed to beach front; 8 Far Eastern Curlew and 3 Bar-tailed Godwit on SBN1 and on SBN2 collection of Eurasian Whimbrel and Bar-tailed Godwit; these birds later moved to the north-western portion of SBN1. No people around hence no disturbance potential.
21/12/2021	Caloundra	At 3 hours before high tide: movement of 9 Far Eastern Curlew flying in from the south and hundreds of common tern and groups of shorebirds at base of SBN2 and 10 Far Eastern Curlew along under the mangroves in the main cove at end of Bribie Is (part of SBN1). On the rising tide with the godwits and whimbrel were 10 Little Tern 950 Common Tern 10 Little Tern 70 Silver Gull. Once SBN2 become flooded by rising time, godwits and whimbrel flew in separate flocks (godwits several minutes after whimbrel) directly towards and across the Bribie peninsula to the open beach of NTBI where both flocks found there later together. Two paddle boarders moving through past 31 Far Eastern Curlew in front of mangrove in the cove - birds stayed. Also, 4 canoeists came on the SBN2 bank and probable disturbed the birds but they were ready to go due to rising tide. The Eastern Curlew in the SBN1 cove moved either further back (we couldn't find them later when we went right into the cove (only 1 there) or they went across to the outside beach at NTBI and we missed them there. The CBAR count of Far Eastern Curlew are those birds on the facing bank (corner bank). At BECK: 6 people and 14 boats with potential to disturb shorebirds.
26/01/2022	Caloundra	New opening into the Passage formed very recently and a swell is pushing through the opening producing what seems to be a higher-than-expected tide height within the passage. SBN1 and SBN2 fully covered 2 hours before high tide where several boats and many people were recreating around the new opening. More human activity than normal even for a weekend despite inclement weather. CBAR itself (facing bank and the southern edge) occupied by people dogs and boats pulled ashore as per disturbance numbers: at CBAR 16 people, 3 dogs, 3 boats causing actual disturbance; potential disturbance from 10 boats and 2 jetskis. Shorebirds roosting further south at NTBI; one person started walking towards NTBI from CBAR but turned around well before the roosting flocks. At BECK: 15 people, 2 dogs and 6 boats with potential to disturb shorebirds.

Date	Site	Observations
8/02/2022	Caloundra	Surveyed from boat anchored near SBN2 away from birds for nearly 2 hours watching for movement prior to high tide. All that remained above water of SBN2 was a thin strip of sand about 10 m long and water was lapping across the top. The Bar-tailed Godwit had been with 19 Eurasian Whimbrel on SBN2 up until 11:40 when the whimbrel left and 11 went to NTBI; 2 others were seen leaving towards the south and 6 to the north. Passed by SBN2 again at 13:15 and Bar-tailed Godwit still present. However, the gulls, Little Tern and most of the Crested Tern did leave the roost before peak of the tide. At CBAR: two people and boat well to the east beyond the birds did not cause disturbance. At SBN2: 3 stationary boats did not cause disturbance.
7/12/2021	Maroochy River	Tattlers (included in count) roosting on dead tree in from green marker north west side of Goat Island; tattler here or very close on mangroves at the mouth of the inlet on way back 3 hours later. Shorebirds roosting on eastern sandbank of Goat Island, stayed and moved in to the back of the band as the north and outer sections were flooded. Saw out the tide here except for 19 whimbrel that flew to the tree roost (MRTR). 240 common tern and 5 little tern moved away and not visible at high tide and not included in count. At MRGI: 3 people and 2 dogs with potential to cause disturbance.
19/01/2022	Maroochy River	No birds roosting in mangroves on mouth of small inlet NW Goat Island (tattlers here last year) - at entrance to the canal where there were also 2 people - 2 jetskis back towards bridge. At the roost site on the eastern bank of Goat Island: 2 paddle boarders, 2 kayaks, boat anchored, 3 people, 2 dogs. Also 2 people, 5 people in cove opposite and 3 dogs, 3 people on north shore opposite the sand bank roost.
27/01/2022	Maroochy River	Shorebirds roosting strung out along line of main bank on eastern side of Goat Island: 2 jetskis, 2 kayaks, 2 boats, 4 people farther along from birds; also, people off beach far end out with kayaks - 17 people along the beach near cove where there were 2 more jetskis - many people at cotton tree. At MRNS: 25 people.
7/02/2022	Maroochy River	10 Grey-tailed Tattler on the inside of Goat Island in the trees; remaining shorebirds roosting on eastern sandbank of MRGI. No actual or potential disturbance observed.
31/03/2022	Maroochy River	Potential disturbance at low tide: MR04: 4 people; MR05: 3 people; MR06: 6 people; MR07: 5 people.