Gladstone Ports Corporation

Report for Migratory Shorebird Monitoring

Port Curtis and the Curtis Coast

Annual Summer Survey - 2017

Report prepared for Gladstone Ports Corporation

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Cover photo: Eastern Curlew on the tidal flat at Friend Point (Adam Leavesley, Wildlife Unlimited)

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List of Acronyms

CAMBA	China-Australia Migratory Bird Agreement
DEH	Department of Environment and Heritage
DEWHA	Department of Water, Heritage and the Arts
DoE	Department of Environment
DoEE	Department of Environment and Energy
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EAAF	East Asian-Australasian Flyway
EIS	Environmental Impact Statement
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ERMP	Ecosystem Research and Monitoring Program
ERMPAP	Ecosystem Research and Monitoring Program Advisory Panel
GBRMPA	Great Barrier Reef Marine Park Authority
GPC	Gladstone Ports Corporation
GPS	Geographic Positioning System
JAMBA	Japan-Australia Migratory Bird Agreement
LNG	Liquefied Natural Gas
ROKAMBA	Republic of Korea Migratory Bird Agreement
WBDDP	Western Basin Dredging and Disposal Project
WBRA	Western Basin Reclamation Area
WICET	Wiggins Island Coal Export Terminal

EXECUTIVE SUMMARY

- The 2017 annual shorebird monitoring summer survey was carried out on the full moon spring tide from 11-15 February. A total of 154 roosts were surveyed over five days in the order of Port Curtis, Fitzroy Estuary, North Curtis Island, Mundoolin Rocks and Colosseum Inlet, Rodds Peninsula, Mainland Shoreline and the Western Basin Reclamation Area (WBRA).

- Permission was obtained to survey within Cheetham Salt Works at Bajool. The salt works are non-tidal. A single survey was conducted at mid-tide (falling) on 15 February.

- Weather conditions for the survey were very good for the first two days but winds intensified over the last three.

- Predicted tide heights were near the top of the range for Gladstone for 2017 and marginally higher than was predicted for the 2016 survey. The actual tide heights were lower than 2016 so that roosts which were inundated last year were available to birds this year. The difference between predicted and actual tide heights was probably due to the contrast in antecedent rainfall; 2016 was a wet year while 2017 was dry. This illustrates some of the variability around migratory shorebird estimates that contributes to the difficulty in determining population trajectories.

- Survey coverage was similar to the 2016 and previous summer surveys.

- A total of 14,003 migratory shorebirds consisting of 21 species was recorded during the high tide roost surveys. This was 21 percent more than the equivalent figure from February 2016 and 14 percent more than the summer average calculated from nine surveys conducted in January and February over the life of the project; 2011-2017.

- The increase in the total abundance of migratory shorebirds compared to the previous year was mostly due to a 229 percent increase in the number of Terek Sandpipers recorded. We are unable to explain the magnitude of the difference in the numbers of Terek Sandpipers between this survey and others in terms of differential detectability and so assume that the difference reflects the difference in the number of birds in the landscape.

- Other species that returned an increase in abundance compared to 2016 were Sand Plover species, Red-necked Stint and Whimbrel. These increases were partially offset by a decrease in the abundance of Great Knots.

- The 10 most abundant species accounted for 97 percent of the records and this is comparable to previous surveys. However, the composition of the 10 most abundant species changed slightly.

- The assemblage of migratory shorebirds at the Cheetham Salt Works and the Clinton Ash Ponds appears to be distinctly different from that present across the rest of the Curtis Coast.

- A total of three Curlew Sandpipers and one Whimbrel were recorded on the WBRA during the high tide survey. The Curlew Sandpipers were observed feeding. No migratory shorebirds were recorded on the bund wall.

- The distribution of migratory shorebirds was skewed to the north with the three highest abundance roosts all located there.

- The total abundance of migratory shorebirds on the Curtis Coast does not appear to be declining; however considerable variation in space and time has been documented for many species.

- Some migratory shorebird roosts in Upper Gladstone Harbour appear to continue to experience a localised reduction in migratory shorebird numbers compared with surveys conducted in 2011. This situation has been documented in previous reports. Whether the apparent localised reductions are due to work associated with the WBDDP, or any of the other activities in Port Curtis cannot be determined by monitoring work.

Important migratory shorebird roosts 2011-2017

- A summary of the use of roosts during the seven February surveys conducted for this project showed there were 23 roosts with a mean abundance >100.

- Of the nine roosts with mean migratory shorebird abundance >400, seven were located in the north of the study area.

- Concentrations of roosting migratory shorebirds were recorded adjacent to the largest areas of tidal flat at Shell Point, Curlew Spit, Yellow Patch, Curtis Island Southend and Mundoolin Rocks.

1 INTRODUCTION

1.1 The Project

Development and expansion of port facilities in the Western Basin of the Port of Gladstone is required for the continued growth and operation of the Gladstone Ports Corporation (2016). The facilities to be developed or expanded are a key component of the import/export chain for coal and will support emerging industries in the Gladstone region such as liquefied natural gas (Figure 1-1, Figure 1-2, Figure 1-3). Dredging of the Western Basin of Port Curtis was required to provide safe, efficient access to the new port facilities. The aim was to increase the depth and width of existing channels and swing basins and the construction of new channels, swing basins and berth pockets. Stage 1A of the Western Basin Dredging and Disposal Project (WBDDP) required the removal of 22.5M m^3 of which 17.6M m^3 was deposited in a 265ha land reclamation at Fisherman's Landing.

Figure 1-1 An LNG plant on Curtis Island, February 2017
All six LNG trains are in operation on Curtis Island and media reports say the construction work force has been reduced to 15 staff (Adam Leavesley, Wildlife Unlimited).

1.2 Environmental Approvals

The Queensland Coordinator-General declared the WBDDP to be a 'significant project' for which an Environmental Impact Statement (EIS) was required under the *State Development and Public Works Organisation Act 1971* (Gladstone Ports Corporation, 2016). The EIS was approved with conditions by the Queensland Coordinator-General on 23 July 2010. The project was also determined to be a 'controlled action' by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC; now the Department of Environment and Energy: DoEE) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 18 June 2009 (EPBC 2009/4904). EPBC Act approval was granted on 22 October 2010, subject to conditions.

1.3 Ecosystem Research and Monitoring Program

Conditions 25 to 37 of the EPBC Act approval (Gladstone Ports Corporation, 2016) require GPC to develop and implement the ‘Port Curtis and Port Alma Ecosystem Research and Monitoring Program’ (ERMP). The aim of the ERMP is to acquire detailed ecological understanding of the marine environment of Port Curtis and Port Alma. This information can be used to monitor, manage and/or improve the regional marine environment and to offset potential impacts from the project on listed threatened and migratory species and values of the Great Barrier Reef World Heritage Area and National Heritage Place.

The results of the ERMP are to be used to inform adaptive management response to observed impacts or potential impacts identified.

Condition 33 of the EPBC Act approval requires a study to be conducted to determine the effect of port development activities on migratory shorebirds. During years one and two a comprehensive set of five surveys were to be conducted each year. This report details the results of the fifth of six annual summer surveys to be conducted in fulfilment of condition 33 (i) which states: “single annual summer surveys (October to March) covering the high tide roost sites from years three to eight, with a repeat of the comprehensive surveys during years nine and ten.” The objectives of the program are:

- population censuses of species present;
- mapping of feeding and roosting sites;
- investigation of habitat utilisation relative to the lunar/tide cycles and season; and
- identification of critical characteristics of important habitat.

Port development activities that should be addressed include, but are not limited to:

- dredge vessel movement;
- pile driving;
- construction dredging;
- bund wall construction during dredging;
- construction of the bund wall; and
- filling of the reclamation area.

Aspects of construction that should be addressed are:

- noise and associated pressure impacts;
- light spill;
- water quality reduction;
- decreased access to intertidal foreshore habitat;
- increased sedimentation; and
- displacement.

The design of the shorebird monitoring program was developed by GHD and described in the reports covering surveys 1-4, which took place in January, February, March and August 2011 (GHD, 2011a; 2011b; 2011c; 2011d). The method was reviewed and endorsed by the Ecosystem Research and Monitoring Program Advisory Panel (ERMPAP) which was established to oversee the work. This report details the results of the fifth annual summer survey – February 2017 – following the established methods.

Figure 1-2 The Wiggins Island Coal Export Terminal (WICET), February 2017

The Eastern Glamour is a 115,000 dwt Capesize bulk carrier. Capesize ships are so named because they are too big to traverse the Panama Canal (Adam Leavesley, Wildlife Unlimited).

Figure 1-3 An LNG vessel departing Gladstone, February 2017

The CESI Gladstone, a 99,000 dwt Danish-registered vessel with tugs and pilot boat in attendance, bound for Beihai in China (Inka Veltheim, Wildlife Unlimited).

2 MIGRATORY SHOREBIRDS IN AUSTRALIA

2.1 EPBC Act listing

The Commonwealth Government has listed 37 species of migratory shorebirds under the EPBC Act (DEWHA, 2009a; DEWHA, 2009b; DoE, 2015) (Appendix 1). These species regularly visit Australia, traversing the East-Asian Australasian Flyway (EAAF) from northern hemisphere breeding grounds in northern Asia and North America to the over-wintering grounds which encompass the region between India, Australia, New Zealand and the Western Pacific (Bamford et al., 2008). Conservation of migratory species is often difficult because their ecology is often poorly understood and they require resources that are distributed throughout a number of jurisdictions. Migratory shorebirds are of particular concern because populations are declining worldwide (Howe et al., 1989; Morrison et al., 2001; International Wader Study Group, 2003; Gosbell & Clemens, 2006; Nebel et al., 2008; Clemens et al., 2010; Minton et al., 2012; Ma et al., 2014; Murray et al., 2015; Piersma et al., 2016; Wetlands International, 2015; Appendix 2), including Australia (Clemens et al., 2016).

Listing under the EPBC Act signifies that migratory shorebirds are a 'matter of national environmental significance' and any action that may have a 'significant impact' on a 'matter of national environmental significance' requires the approval of the Commonwealth Environment Minister to proceed.

"A 'significant impact' is an impact that is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is affected; and upon the intensity, duration, magnitude and geographic extent of the impacts. You should consider all these factors when determining whether an action is likely to have a significant impact on matters of national environmental significance (DEWHA, 2009a)."

Australia has signed a number of international agreements relating to migratory shorebird conservation, including the Convention on Wetlands of International Importance (Ramsar), the Convention on Conservation of Migratory Species of Wild Animals (Bonn Convention), the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA) and the Republic of Korea Migratory Bird Agreement (ROKAMBA). The EPBC Act is the key mechanism for meeting Australia's responsibilities under these agreements (DEWHA, 2009b; DoE, 2015).

Under the EPBC Act, the Australian Government may prepare wildlife conservation plans for listed species. The first conservation management plan for migratory shorebirds was published in February 2006 (DEH, 2006) and following review, the second plan was published in August 2015 (DoE, 2015). The review of the first plan found that it had "failed to meet its objectives because, it had apparently not reduced the rate of decrease of any of the listed species, nor did it have any measurable influence on the known core impacts in East Asia." The review recommended that: 1) the Little Ringed Plover be added to the EPBC Act list of migratory shorebirds bringing the total number to 37; and 2) the plan be updated to include new, focused conservation priorities.

The new plan lists 11 threats to migratory shorebird populations including three for which 'immediate mitigation action is required'. The most serious threat was coastal development outside Australia including the Yellow Sea. The threat was expected to occur annually or more frequently and had the potential to cause population extinctions. The second most serious threat was climate variability and change. The threat was expected to occur five-yearly and had the potential to cause population decreases. The third most serious threat was coastal development in Australia. The threat was expected to occur annually or more frequently and had the potential to stall or reduce population recovery (DoE, 2015).

Seven EPBC Act listed migratory shorebird species are include on the threatened species list. Curlew Sandpiper, Eastern Curlew, Great Knot and the Siberian sub-species of the Bar-tailed Godwit (*menzbieri*) are listed as critically endangered. Red Knot and Greater Sand Plover are listed as endangered; Lesser Sand Plover and the Alaskan sub-species of the Bar-tailed Godwit (*baueri*) are listed as vulnerable. The scientific committee determined that individual recovery plans were not required because the needs of all species were adequately addressed by the migratory shorebird conservation plan (DoE, 2015).

2.2 EPBC Act Listed Shorebird Species

The 37 species of migratory shorebirds listed under the EPBC Act exhibit a variety of life history attributes (Marchant & Higgins, 1993; Higgins & Davies, 1996; Colwell, 2010; Hollands & Minton, 2012). These attributes influence the likelihood of their presence in Gladstone Harbour and the Curtis Coast (Appendix 3). They also influence the likelihood of detection during survey (Bamford et al., 2008) so it is important to match the survey method to the attributes of the target species. Key life history attributes include: range in Australia; habitat; roost selection and behaviour; and migration timing.

Of the 37 species, six (Swinhoe's Snipe, Pin-tailed Snipe, Asian Dowitcher, Common Redshank, Red-necked Phalarope and Little Ringed Plover) are extremely rare in central Queensland (Marchant & Higgins, 1993; Higgins & Davies, 1996; Hollands & Minton, 2012). Another nine (Latham's Snipe, Little Curlew, Wood Sandpiper, Ruff, Pectoral Sandpiper, Sharp-tailed Sandpiper, Long-toed Stint, Oriental Plover and Oriental Pratincole) rarely utilise marine environments (Marchant & Higgins, 1993; Higgins & Davies, 1996; Hollands & Minton, 2012) so are unlikely to be present in large numbers in marine ecosystems on the Curtis Coast. The remaining 22 species frequent marine environments, are present on the central Queensland coast (Marchant & Higgins, 1993; Higgins & Davies, 1996) and have been recorded in previous surveys (GHD, 2011a; 2011b; 2011c; 2011d; Sandpiper Ecological Surveys, 2012a; 2012b; 2012c; Wildlife Unlimited, 2012; 2013a; 2013b; 2014; 2015; 2016).

Of these 22 species, most will roost in aggregations at high tide (Marchant & Higgins, 1993; Higgins & Davies, 1996; Bamford et al., 2008). Such roosts can be classified into three broad groups: 1) raised high points such as sand banks, mud banks, sand/shell/gravel bars, sand spits, beaches and islets; 2) mangroves and other vegetation; and 3) rocks, ledges, reefs and shipwrecks. Most of the shorebird species on the Curtis Coast use banks, bars, spits and beaches, while some species commonly use trees (e.g. Whimbrel, Terek Sandpiper, Grey-tailed Tattler and Common Sandpiper) and others commonly use rocks (e.g. Ruddy Turnstone, Wandering Tattler and Common Sandpiper). It is therefore important to survey all three types of roosts in order to get an accurate estimate of abundance for all species. A further complication is that some species, notably the Red-necked Stint, are known to move to coastal wetlands during the high tide and continue feeding (Higgins & Davies, 1996; Minton et al., 2012). Notwithstanding this possibility, roost counts in marine ecosystems at high tide appear to the best method for obtaining an accurate count of shorebirds on the Curtis Coast (Bamford et al., 2008; Birdlife Australia, undated; DEWHA, 2009b; GHD, 2011c). Work in locating such roosts for this project was completed by GHD and is described in previous reports (GHD, 2011a; 2011b; 2011c; 2011d).

A migratory shorebird site in the EAAF is considered of international significance if it supports >1 percent of the population estimate for the flyway (Bamford et al., 2008; DEWHA, 2009a). A site is considered of national significance if it supports >0.1 percent of the flyway estimate. The Australian Government accepts the EAAF population estimates of Bamford et al. (2008; DEWHA, 2009a; 2009b). Recent EAAF population estimates have been produced by Wetlands International (2015) and these have been added to accounts of species abundance estimates for comparison. A list is included at Appendix 2.

Figure 2-1 Migratory shorebirds feeding on a tidal flat at Mundoolin, February 2017
Pictured are Bar-tailed Godwits, Grey-tailed Tattler and Curlew Sandpiper (Adam Leavesley, Wildlife Unlimited).

Figure 2-2 Broad-billed Sandpiper at Curlew Spit, February 2017
The 2017 total was the highest recorded for the whole project (Adam Leavesley, Wildlife Unlimited).

Figure 2-3 The roost at Deception Point, February 2016
Pictured are Bar-tailed Godwits, Lesser Sand Plovers and Red-necked Stints (Inka Veltheim, Wildlife Unlimited).

Figure 2-4 Terek Sandpipers in a mangrove tree, February 2017
(Inka Veltheim, Wildlife Unlimited)

Figure 2-5 A Red-capped Plover at the Marina Ponds, February 2017
The bird was breeding on the roadside (Adam Leavesley, Wildlife Unlimited).

Figure 2-6 Black-winged Stilts at Clinton Ash Ponds, February 2017
The species is non-migratory (Adam Leavesley, Wildlife Unlimited).

3 METHODS

3.1 Shorebird Survey Guidelines

DoEE (formerly DoE, DSEWPAC, DEWHA and DEH) has published guidelines detailing the recommended survey coverage, timing, effort and minimum data requirements for conducting migratory shorebird surveys (DEWHA, 2009b). Survey coverage and effort for this project was determined by DoEE in the approval conditions and ERMP for the project (Gladstone Ports Corporation, 2016). DoEE has helped fund the *Shorebird 2020* program via the Natural Heritage Trust and there is considerable agreement between the DoEE survey guidelines and the *Shorebird 2020* procedures (DEWHA, 2009b). Use of the *Shorebird 2020* procedure is desirable for this study because most shorebird observers in Australia are familiar with it. Consequently, training requirements for observers will be minimised and the pool of skilled and experienced observers will be maximised. Over the life of the study this will increase the comparability of the data and minimise difficulty finding suitably experienced survey staff.

Timing for the survey was determined using Australian Government guidelines (DEWHA, 2009b), recommendations from previous surveys (GHD, 2011a; 2011b; 2011c; 2011d) and advice from the ERMPAP. Criteria and recommendations for the timing of shorebird surveys are:

- at a suitable time in relation to the seasonal movements of the species known to be present at the study site;
- for surveys of roosting sites, no more than two hours either side of high tide;
- for foraging surveys, no more than two hours either side of low tide;
- high rainfall and strong wind to be avoided; and
- periods when disturbance is occurring to be avoided.

3.1.1 Survey timing

The aim of the summer survey is to count the populations of migratory shorebirds that are present on the Curtis Coast during the Austral summer. To determine the range of suitable times for a summer survey in Gladstone, the timing of migration for 23 species that have been recorded during the study was obtained from Marchant and Higgins (1993) and Higgins and Davies (1996).

All species of migrating shorebirds that breed in the northern hemisphere and are regularly present on the central Queensland coast are present by the beginning of December (Appendix 3). One of these species, the Curlew Sandpiper is believed to begin its northward migration in mid-January but no other species are believed to leave before mid-February. This leaves a window of opportunity for counting from December to mid-February. Other considerations for the timing, in order of importance are tide heights, weather, predictable disturbance and the *Shorebird 2020* national census date. Spring tides are essential to concentrate birds at roosts and tide heights of >3.6m but <4.4m are desirable. At lower tides, some of the large, important roosts present difficulties when counting – i.e. some roosts are difficult to reach by boat (e.g. site C2c, Yellow Patch entrance sandbar; site 2, Curtis Island Southend west), flocks may be dispersed over large areas (e.g. site PA16, Deception Point; sites 39 and 39B, Curlew Spit; and site C13, Yellow Patch entrance sandbar) and in some cases birds hide in foliage and walk away from surveyors (e.g. sites 39 and 39B, Curlew Spit). At the highest tides and especially after rain when the rivers are high some big important roosts are inundated and cannot be occupied. Examples are site C13 Yellow Patch entrance sandbar; site PA2, Mackenzie Island north and site PA1, Rundle Beach. Stable weather is desirable because surveys cannot be conducted in strong wind or rain. This is particularly important in summer because of the possibility of prolonged bad weather associated with tropical cyclones. Major causes of predictable anthropogenic disturbance such as public holidays and fishing competitions should also be avoided if possible. In winter, longer daylight hours are desirable because a five-day program causes time constraints during the low tide surveys on the fifth day. The *Shorebird 2020* national census dates are 15 January and 15 June (or the earliest survey at each location after that date).

Where a single summer survey is required, this will best serve the aims of the ERMP (Gladstone Ports Corporation, 2016) if it is carried out when migratory shorebird numbers are at a maximum. This is likely to occur in December and January, but may have to be extended into early February due to the prevalence of prolonged bad weather in the cyclone season. Late-December and early-January should be avoided because of the likelihood of high levels of recreational boat traffic associated with the Christmas holiday period.

3.2 Study Area

The study area is centred on Port Curtis, the site of the WBDDP and extends north to Cattle Point in the Fitzroy Estuary and south to Rodds Peninsula as defined in the ERMP (Gladstone Ports Corporation, 2016). Henceforth we refer to the study area as the 'Curtis Coast'. The Curtis Coast is divided into seven locations following the method of GHD (2011c):

- North Curtis Island;
- Fitzroy Estuary;
- Port Curtis;
- Colosseum Inlet and Mundoolin Rocks;
- Rodds Peninsula;
- Cheetham Salt Works; and
- Mainland foreshore.

For the purposes of analysis, the locations have been classified into three putative ecological units following the method of GHD (2011c). The ecological units are: Port Curtis incorporating the mainland foreshore (Figure 3-4); Fitzroy Estuary-North Curtis Island (Figure 3-5); and Mundoolin-Colosseum-Rodds (Figure 3-6). Data from the Cheetham Salt Works at Bajool has been excluded from analyses using the putative ecological units because of discontinuity of access to the site. The salt works is located in the Fitzroy Estuary.

3.3 Site Selection

Survey sites were selected to be comparable with the previous summer surveys (Sandpiper Ecological Surveys, 2012a; Wildlife Unlimited, 2013a; 2014; 2015; 2016). The field work was designed to locate and count as many migratory shorebirds as possible by surveying the largest known and most easily accessible shorebird roosting sites during the two hours either side of a spring high tide (GHD, 2011c). Spring tides tend to have a greater tidal range than average due to high tides being higher and low tides being lower. The standard survey path was followed and counting was conducted from the standard survey points. A known shorebird site within the Cheetham Salt Works mine at Bajool was surveyed at mid-tide on a falling tide.

Low tide surveys were conducted on the ebb tide within two hours of the low tide. The most important intertidal foraging areas adjacent to the high tide roosts were surveyed from the standard observation points as described by GHD (2011d) or from alternative locations with safe access.

3.4 Survey Schedule

The field work was conducted for five consecutive days coinciding with a full moon spring tide, from 11-15 February (Table 3-1).

Table 3-1 Survey schedule for February 2017

Date	Scheduled locations
11 February	Port Curtis
12 February	Fitzroy Estuary
13 February	North Curtis Island
14 February	Colosseum Inlet and Mundoolin Rocks
15 February	Rodds Peninsula, Mainland Shore, Cheetham Salt Works

Each location was surveyed in a single day by two pairs of observers working simultaneously (GHD, 2011c). This was done to minimise the possibility that birds would move during the survey, confounding the count. The teams consisted of two experienced shorebird observers equipped with binoculars, a spotting scope with a 20x-60x magnifying lens, a map and a GPS containing the coordinates of all the survey sites. Surveys commenced two hours before high tide and were usually completed within four hours; any counts that took place after this period were included in the dataset provided there was no evidence of birds moving between roosts or to the foraging grounds. All sites with a history of supporting large numbers of birds were surveyed within the prescribed four-hour period. The Mainland Shoreline survey including the Western Basin Reclamation Area (WBRA) was completed at high tide. Further survey of the mud flats around the WBRA area was completed during low tide.

3.5 Count Procedure

Shorebirds were counted following the *Shorebirds 2020* procedure (Birdlife Australia, undated) recorded on a modified version of the *Shorebirds 2020* datasheet (Table 3-2). The procedure largely follows Australian Government guidelines (DEWHA, 2009b) and is commonly used around Australia.

Table 3-2 Data collected on each survey

Number of observers and their names	Survey type (land, boat or air)
Date	Tide height (rising, high or falling)
Start time and finish time	Wind direction and wind speed
Shorebird area (Curtis Coast)	Human activity
Count area	Threats
Site number and name	Species abundance
Location using GPS (datum WGS84)	Notes

In fulfilment of the conditions of the EPBC Act approval, the shorebird species for which data were collected were the 37 migratory species listed in the Migratory Shorebird Conservation Plan (DoE, 2015). The addition of the Little Ringed Plover to the migratory shorebird list is unlikely to affect the project because it is not known to visit the Curtis Coast. In addition, abundances were also collected for 10 species of non-migratory shorebirds (Appendix 4) that are part of the *Shorebirds 2020* program (Birdlife Australia, undated).

3.5.1 Roost surveys

Roost surveys were conducted two hours either side of the high tide (Table 3-3). The roosts were accessed by boat and the count was preferentially conducted by wading ashore to a suitable location. Where it was not possible to reach the shore, counting was undertaken from the boat. Both observers confirmed species identification and counted each species independently where possible. If birds were flushed care was taken to avoid double counting within the roost or at succeeding roosts. Surveys on the Mainland Shoreline including the WBRA were accessed by vehicle. A photographic record of roosts is being collected to assist with recognition of changes over time.

Table 3-3 Bureau of Meteorology predicted tide heights and times at Gladstone

Date	High tide		Low tide	
	Time	Height	Time	Height
11 February	09:33	4.59m	15:53	0.59m
12 February	10:11	4.51m	16:30	0.65m
13 February	10:48	4.35m	17:04	0.78m
14 February	11:22	4.12m	17:36	0.96m
15 February	11:55	3.86m	18:03	1.16m

3.5.2 Foraging surveys

Foraging surveys were planned to be conducted at low tide at each location on the same day as the roost surveys. Surveys commenced no earlier than two hours before the low tide and finished within 60 minutes after the low tide. The surveys were conducted in one of two ways depending on the shape of the intertidal area. Large intertidal flats were surveyed by wading ashore to reach the survey point. Long, linear flats were surveyed from a slow-moving boat.

3.5.3 Western Basin Reclamation Area high tide surveys

Potential shorebird roosting sites on the WBRA were thoroughly investigated at high tide during the mainland shoreline survey on day five. The survey was conducted in two ways: 1) survey of all sites at the WBRA; and 2) vehicle traverse of the major roads and investigation of all likely roost sites.

3.5.4 Cheetham Salt Works surveys

Cheetham Salt Works at Bajool is in the Fitzroy Estuary and within the study area of the ERMP (Gladstone Ports Corporation, 2016). The salt works were surveyed over the first 18 months of the project (GHD, 2011a; 2011b; 2011c; 2011d; Sandpiper Ecological Surveys, 2012a; 2012b). During this period, surveys were conducted at five sites within the salt works and at six sites from the Port Alma Road adjacent to the salt works. At the five internal sites, relatively high counts of a suite of migratory and non-migratory shorebirds that were rare elsewhere on the Curtis Coast were regularly obtained from particular concentration ponds where the salinity and water height generated suitable foraging conditions (Houston et al., 2012). Records from the six sites along the road were unpredictable and usually of species that were commonly recorded during the rest of the Curtis Coast survey. Permission to survey the internal salt works sites could not be obtained for the August 2012 survey or subsequent surveys (Wildlife Unlimited, 2012; 2013a; 2013b; 2014; Sandpiper Ecological Surveys, 2012c) until permission was renewed in February 2015 (Wildlife Unlimited, 2015; 2016).

The salt works were surveyed on 15 February 2017 during the mainland shoreline schedule. Although the production area of the salt works is not tidal, it is preferable that surveys are conducted at high tide to minimise the possibility of double counting of birds that may move between the salt works and nearby sites in the Fitzroy Estuary. The 2017 survey was conducted at mid-tide. The reason for this was that it was not possible to complete the rest of the mainland shoreline schedule and the mandatory Cheetham Salt Works induction within the four-hour high tide window. NB Time allocated to the salt works in the earlier surveys was re-allocated to survey of the WBRA after it was completed.

3.6 Taxonomy and nomenclature

Shorebirds were identified according to Simpson and Day (2010), Pizzey and Knight (2012), DEWHA (2007), Birds Australia (2010), Message and Taylor (2005) and Hayman *et al*. (1986). Nomenclature followed Christidis and Boles (2008).

3.7 Mapping

Mapping was completed using ArcGIS 10. The base layers were obtained from the Geoscience Australia 1:250,000 series, via MapConnect. GPC supplied data for the WBRA and the built-up areas of Gladstone. The maps were generated using the mainland and islands layers to represent the area above high tide; to this was added the WBRA data supplied by GPC. Minor edits were made to the WBRA area data so that they fit seamlessly with the Geoscience Australia data. The area below high tide was represented by tidal foreshore, sea and waterways layers. The flats layer was included to represent the claypans; the pondage layer represented the Cheetham Salt Works. The built-up area shows the location of Gladstone and Tannum Sands to aid with orientation. A roost site layer was created from GPS coordinates obtained during the project.

3.8 Analysis

Migratory shorebird densities were calculated using the high tide roost data from the February 2017 survey and the area of intertidal flat as determined by GHD (2011a). This is a blunt tool which does not take into account the tidal range or the foraging preferences of each species. It does however, serve two useful functions: 1) provides a standardised comparison between ecological units; and 2) helps to contextualise changes in shorebird community composition in Port Curtis through time. For example, the intertidal foraging area in Port Curtis will be reduced by the planned development and this would be expected to cause a decline in the abundance of migratory shorebirds. However, if the density of migratory shorebirds remains the same then this suggests that the quality of the foraging areas has remained unchanged (i.e. no habitat alteration; DEWHA, 2009b) and increased traffic in the port has not affected the birds – they may have become habituated to disturbance as discussed by GHD (2011a; 2011c). In this way the project can be treated as a natural experiment and used to inform migratory shorebird management in Australia and around the world.

The summer average total abundance of migratory shorebirds was calculated using January and February surveys conducted for this project from 2011-2017. The surveys were conducted in January 2011-2012, and February 2011-2017.

This report presents some single species comparisons between ecological units between years. This approach has been taken because: 1) it a requirement of the ERMP; and 2) the overall number of migratory shorebirds – though an important tool for monitoring – may conceal the substitution of species within the study area. For example, a decline in the type and quantity of prey or a change in the physical properties of the substrate (Colwell, 2010) may lead to the abandonment of a foraging area by one species but the change may facilitate greater use by another species with the result being no overall change in the number of shorebirds at the study site.

Figure 3-1 A mixed flock at the Deception Point roost, February 2017
Pictured are Bar-tailed Godwits, Greater and Lesser Sand Plovers, Curlew Sandpipers, Red-necked Stints and Red-capped Plovers (Inka Veltheim, Wildlife Unlimited)

Figure 3-2 A Sanderling (left) and a Red-capped Plover at Keppel Creek, February 2016
(Inka Veltheim, Wildlife Unlimited)

Figure 3-3 Common Greenshank at Cheetham Salt Works, February 2017
(Inka Veltheim, Wildlife Unlimited)

Figure 3-4 Survey sites in the Port Curtis ecological unit.

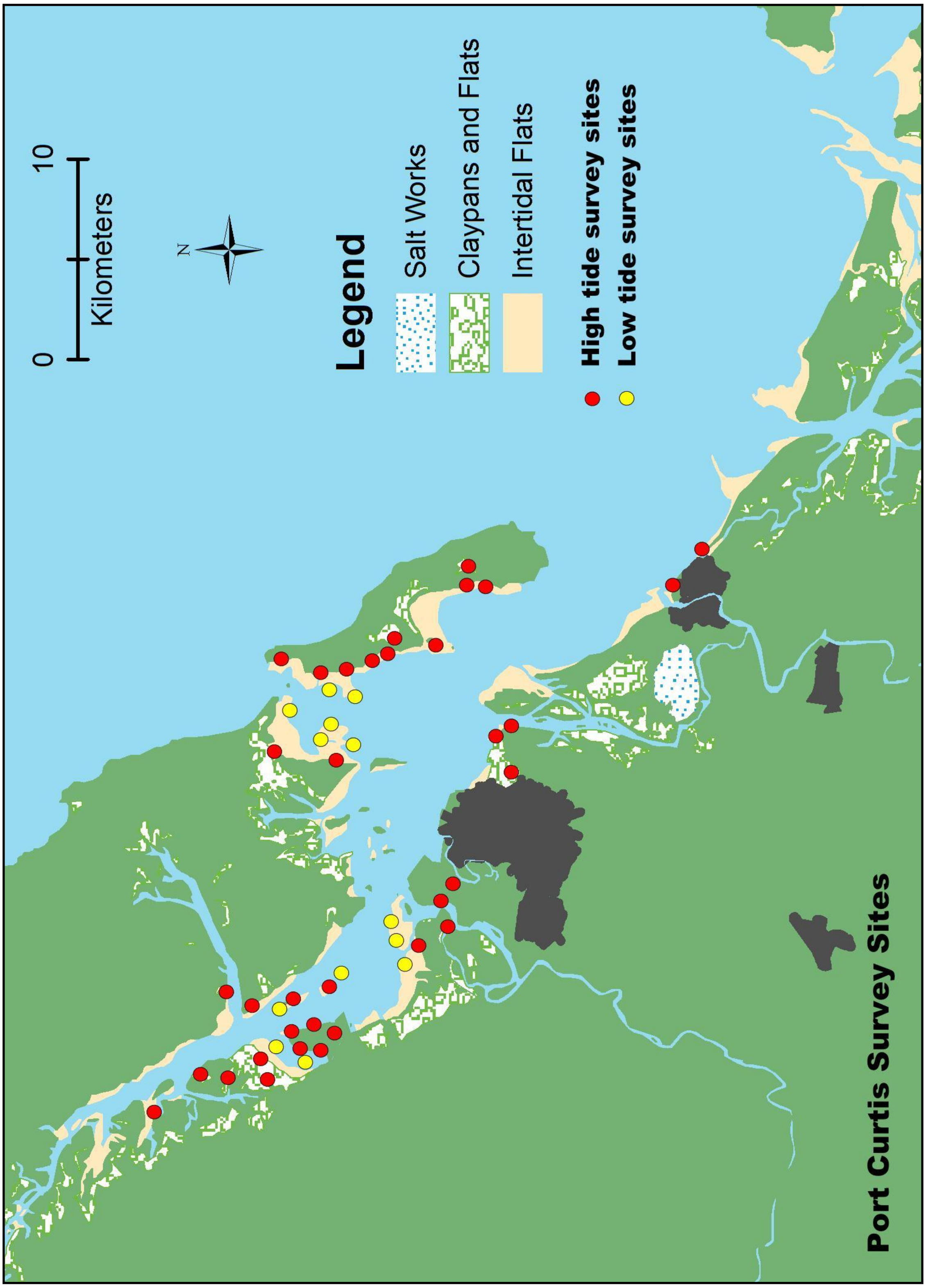


Figure 3-5 Survey sites in the Fitzroy Estuary - North Curtis Island ecological unit.

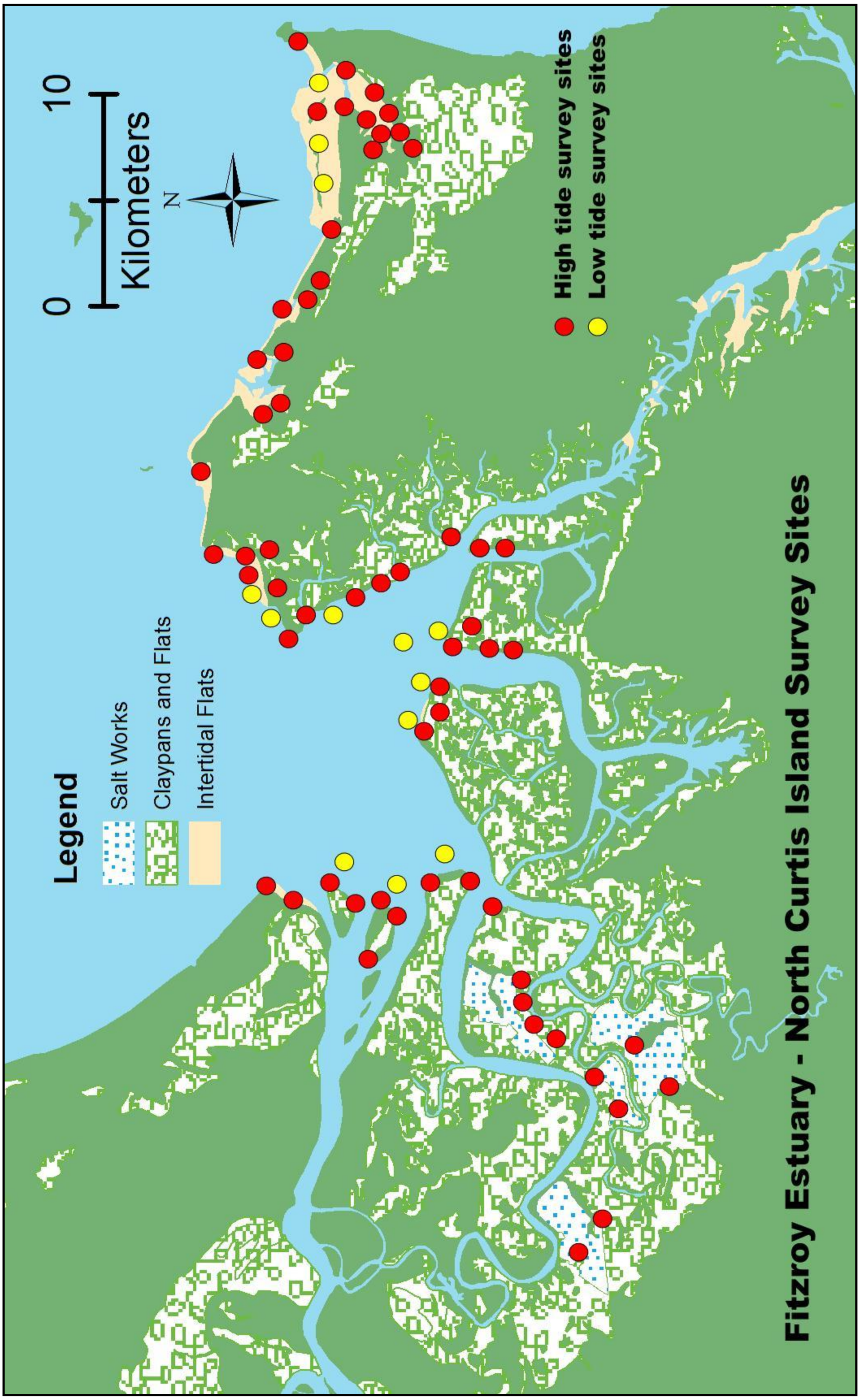
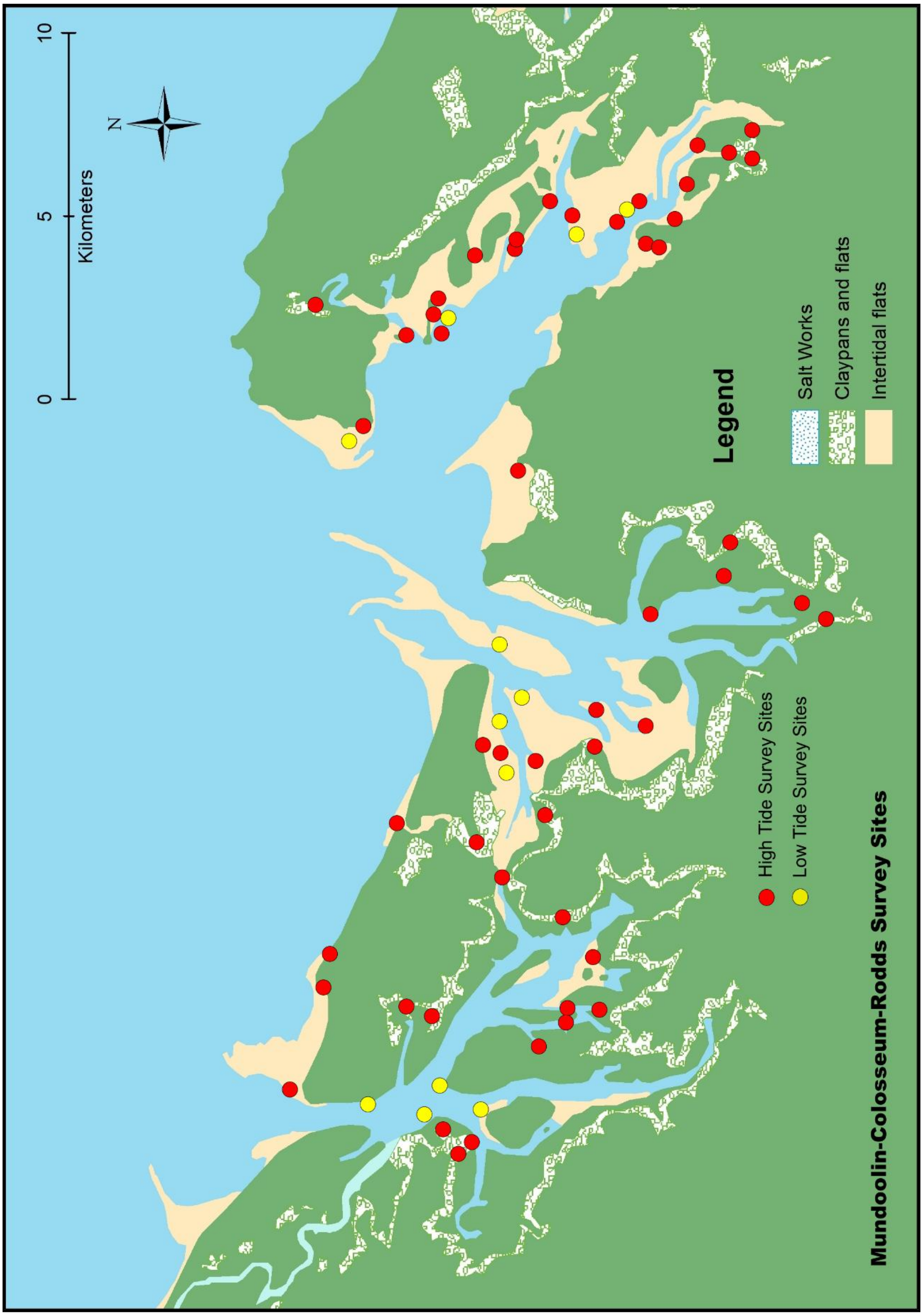


Figure 3-6 Survey sites in the Mundoolin-Colosseum-Rodds ecological unit.



4 RESULTS

4.1 Survey coverage

The coverage of this survey was comparable with that of previous years; a total of 154 high tide surveys were completed (Table 4-1) which was three less than February 2016. The total survey time at high tide was 1246 minutes. The survey at Cheetham Salt Works was conducted on 15 February at mid-tide (N.B. the salt works is not tidal) and ran for 57 minutes. All major roosts were surveyed strictly within the four-hour timeframe, so late surveys involved only small numbers of birds and exclusion of the records would not significantly alter conclusions. All records were time-stamped so future analysis could include or exclude those records.

A total of 32 sites were surveyed at low tide for a duration of 564 minutes. This was one site more than was surveyed in February 2016.

The weather during the survey was good, especially for the first two days. Fifty-eight percent of sites were counted in winds <20km/h. Conversely only one site was counted during winds >29km/h. The wind was only slightly stronger during low tide surveys. Three scheduled low tide surveys on North Curtis Island east of Keppel Point were unable to completed due to sea conditions.

Australian Government guidelines recommend that migratory shorebird surveys avoid periods of strong wind (DEWHA, 2009b). As wind strength increases, the precision of the survey decreases for several reasons: 1) increased wave action causes the boat to move making observation more difficult; 2) increased wind causes spotting scopes to shake making observation more difficult and reducing the magnification at which the instrument can be used; 3) birds tend to become flightier which makes them harder to count and reduces confidence in the assumption that they are not moving between roosts at high tide; 4) birds tend to occupy different roosting locations to escape from the wind; 5) safety considerations restrict access to some sites during high and low tide surveys; and 6) safety considerations increase the size and survey standard of the boats that can be used, and this may further restrict access to sites.

Table 4-1 Summary of survey effort: number of sites and duration for each location

Location	High tide		Low tide	
	Sites	**Duration (mins)**	**Sites**	**Duration (mins)**
Port Curtis	47	411	12	158
Fitzroy Estuary	23	220	6	148
North Curtis Island	38	270	3	98
Mundoolin-Colosseum	26	231	9	84
Rodds Peninsula	20	114	2	76
Cheetham Salt Works*	1	57	0	0
Total	**155**	**1303**	**32**	**564**

*The Cheetham Salt Works was conducted at mid-tide.

4.2 Abundance Estimates

4.2.1 Curtis Coast

The total number of EPBC Act-listed migratory shorebirds at high tide roost counts in February 2017 was 14,003 (Table 4-14, Figure 4-1) consisting of 21 species (Figure 4-2). This figure is 21.3 percent more than was recorded in February 2016 (11,547 birds). Two species were recorded this year but not last year. These were Double-banded Plover (five birds) and Black-tailed Godwit (one bird). Common Sandpiper (one bird) was recorded last year but not this year. Nine of the ten most abundant species last year – Red-necked Stint, Bar-tailed Godwit, Great Knot, Whimbrel, Greater Sand Plover, Grey-tailed Tattler, Eastern Curlew, Terek Sandpiper and Lesser Sand Plover were among the 10 most abundant species this year. The difference was that the counts of Broad-billed Sandpiper (122 birds; 10th most abundant) and Curlew Sandpiper (104 birds; 11th most abundant) exceeded the count of Grey Plover (92 birds; 12th most abundant). The foraging density of migratory shorebirds across the Curtis Coast was 1.39 birds/ha compared to 1.15 birds/ha last year. At Fitzroy Estuary-North Curtis Island the foraging density was 1.94 birds/ha compared to 1.14 birds/ha last year, at Mundoolin-Colosseum-Rodds it was 0.89 birds/ha compared to 1.15 birds/ha last year and at Port Curtis was 1.09 birds/ha compared to 1.15 birds/ha last year. It should be noted that foraging density was calculated using the area of foraging habitat on the Curtis Coast prior to the commencement of the WBDDP. The area of foraging habitat may have changed and this would affect the density estimate.

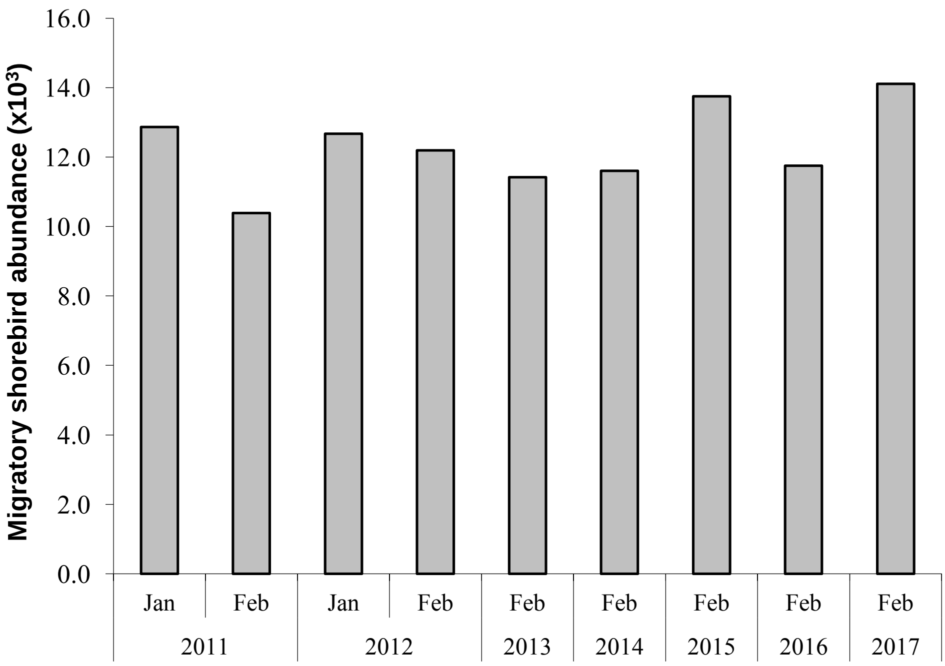


Figure 4-1 Total abundance of migratory shorebirds in summer on the Curtis Coast
Cheetham Salt Works counts have been excluded due to variability of access over the period of the study.

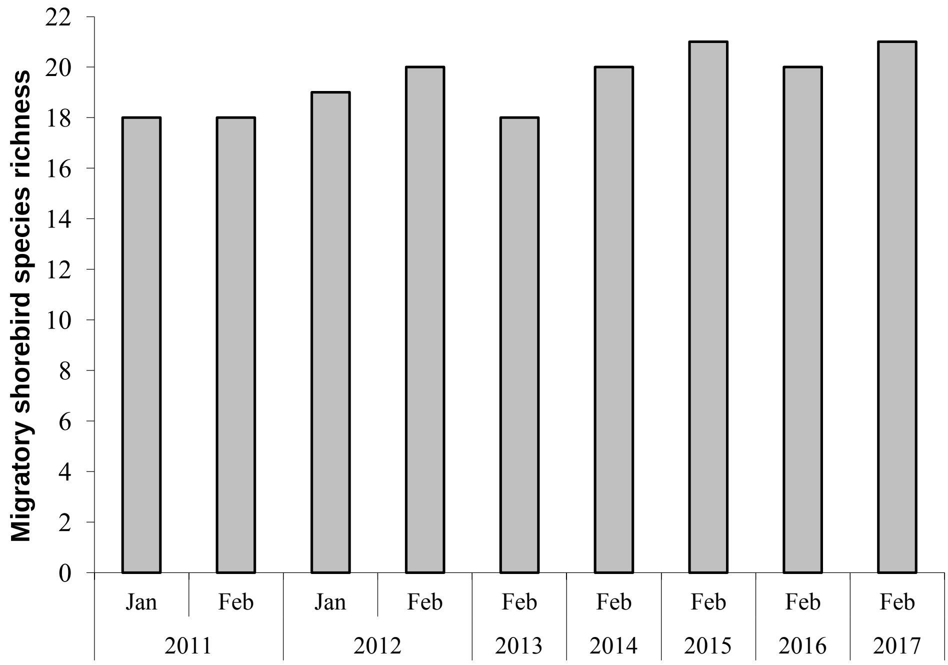


Figure 4-2 Species richness of migratory shorebirds in summer on the Curtis Coast
Cheetham Salt Works counts have been excluded due to variability of access over the period of the study.

Figure 4-3 Sharp-tailed Sandpipers at Clinton Ash Ponds, February 2017
(Adam Leavesley, Wildlife Unlimited)

The distribution of large roosts across the Curtis Coast was skewed to the north (Table 4-2, Figure 4-15). There were four roosts with >1000 birds. These were Shell Point (2362 birds), Yellow Patch sandbar (2029 birds) and Yellow Patch entrance mangrove (1355 birds) in the Fitzroy Estuary-North Curtis Island ecological unit and Curtis Island Southend claypan (1197 birds) in the Port Curtis ecological unit. There were two roosts in 500-999 birds class with one in Fitzroy Estuary-North Curtis Island and one in Mundoolin-Colosseum-Rodds. There were a further 16 roosts with 100-499 birds and they were evenly distributed between the ecological units.

Table 4-2 Place names of the roosts with the greatest abundance of migratory shorebirds

Location	Abundance	Roost
Fitzroy-North Curtis Island	>1000	1. Shell Point 2. Yellow Patch sandbar 3. Yellow Patch entrance mangrove
	500-999	1. Deception Point claypan west
	100-499	1. Keppel Creek entrance 2. Deception Point 3. Mud Bay 4. Mud Island east point 5. Yellow Patch mangrove
Port Curtis	>1000	1. Curtis Island Southend claypan
	500-999	1. Nil
	100-499	1. Facing Island 4 2. Facing Island claypan 3. Friend Point claypan 4. Calliope River 5. Curtis Island south dump claypan
Mundoolin-Colosseum-Rodds	>1000	1. Nil
	500-999	1. Mundoolin Rocks east claypan
	100-499	1. Mundoolin central mangrove island 2. Williams Bay 3. Spit End 4. Mundoolin Rocks mangrove 5. Bird Island 6. Turkey Beach mangrove island

A total of 18 migratory shorebirds, consisting of five species (Sharp-tailed Sandpiper, Eastern Curlew, Curlew Sandpiper, Whimbrel and Common Greenshank) were recorded during high tide counts on the mainland shoreline including the WBRA.

The Cheetham Salt Works was surveyed at mid-tide, however because the site is non-tidal, the birds present were possibly also present at high tide. A total of 24 migratory shorebirds consisting of four species (Curlew Sandpiper, Marsh Sandpiper, Common Greenshank and Sharp-tailed Sandpiper) were recorded.

The mean abundance of migratory shorebirds on the Curtis Coast in summer calculated from the eight surveys in January and February 2011-2017 was 12,285 birds with a range of 10,387 to 14,003 (GHD, 2011b; Sandpiper Ecological Surveys 2012a; Wildlife Unlimited 2013a; 2014; 2015; 2016). The lower bound of the range is 85 percent of the mean and the upper bound is 115 percent of the mean. In comparison, the 30 year record of counts at Corner Inlet in Victoria shows variation of 79 percent to 137 percent around the mean (Minton et al., 2012). It would therefore appear that the variation on the Curtis Coast is not exceptional for an Australian location.

Figure 4-4 Terek Sandpiper in the Fitzroy Estuary, February 2017
The Terek Sandpiper count was the highest for the whole project (Inka Veltheim, Wildlife Unlimited).

4.2.2 Bar-tailed Godwit

EAAF population estimate (Bamford *et al.*, 2008): 325,000
1% population threshold for internationally important sites: 3,250
EAAF population estimate (Wetlands International, 2015) 279,000

The Bar-tailed Godwit was the most abundant species in the 2017 summer survey with 2783 birds recorded at roosts during high tide (Table 4-3; Figure 4-5; Figure 4-16). This figure was 3 percent fewer than recorded during the survey in February 2016 (2872 birds). The figure was <1 percent of the official Australian Government EAAF population estimate (Bamford et al., 2008) but exceeded the more recent Wetlands International (2015) population estimate. Bar-tailed Godwits were recorded at 21 roosts, four of which ≥0.1 percent of the official EAAF population estimate. These were Yellow Patch sandbar (675) at Fitzroy Estuary-North Curtis Island ecological unit, Curtis Island Southend west claypan (560 birds) at Port Curtis, Mundoolin Rocks claypan east (501 birds) and Williams Bay (280 birds) in the Mundoolin-Colosseum-Rodds ecological unit. Mean flock size at roosts was 132 birds. The foraging density of Bar-tailed Godwits was similar in all three ecological units across the Curtis Coast. Bar-tailed Godwits are believed to be declining across the EAAF (Wetlands International, 2015) and in Australia. The decline is especially strong north of 27.8°S which includes the study site (Clemens et al., 2016).

Table 4-3 Comparison of the number of birds, number of roosts occupied and foraging density of Bar-tailed Godwits between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	6	633	0.26
Fitzroy Estuary-North Curtis Island	10	1193	0.28
Mundoolin-Colosseum-Rodds	5	957	0.29
Total	**21**	**2783**	**0.28**

1 Foraging density (birds/ha)

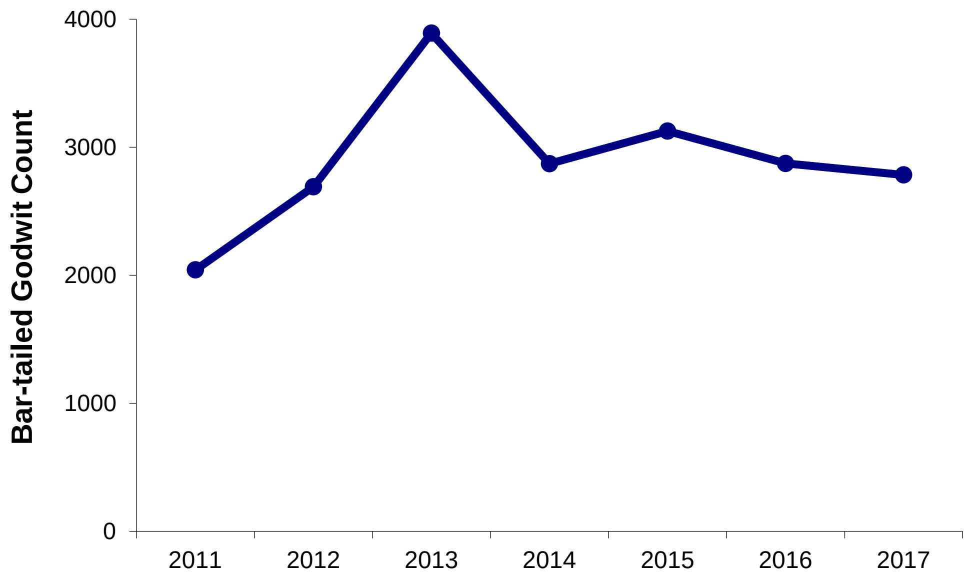


Figure 4-5 Counts of Bar-tailed Godwits on the Curtis Coast, February 2011-2017

4.2.3 Whimbrel

EAAF population estimate (Bamford *et al.*, 2008): 100,000
1% population threshold for internationally important sites: 1,000
EAAF population estimate (Wetlands International, 2015) 55,000

A total of 1334 Whimbrels was recorded on the Curtis Coast in February 2017 (Table 4-4; Figure 4-17). This was 21 percent more birds than recorded in February 2016 (1099 birds). The 1 percent population threshold for sites of international significance under the Ramsar Agreement has been exceeded during every February survey with the exception of 2014 (Figure 4-6). Whimbrels were present at 67 roosts with the largest at Curtis Island Southend claypan (245 birds) in the Port Curtis ecological unit, Keppel Creek entrance (216 birds) and Yellow Patch sandbar (147 birds) both in the Fitzroy Estuary-North Curtis Island ecological unit. The 0.1 percent threshold for sites of national significance was exceeded at these three roosts. Foraging density was greatest in the Port Curtis ecological unit and least in the Mundoolin-Colosseum-Rodds ecological unit. The Whimbrel population in the EAAF is believed to be declining (Wetlands International, 2015), but there is no evidence of this at a continental scale in Australia and the data suggest an increase in the population north of 27.8°S (Clemens et al., 2016).

Table 4-4 Comparison of the number of birds, number of roosts occupied and foraging density of Whimbrels between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	19	466	0.19
Fitzroy Estuary-North Curtis Island	24	622	0.14
Mundoolin-Colosseum-Rodds	24	246	0.07
Total	**67**	**1334**	**0.13**

1 Foraging density (birds/ha)

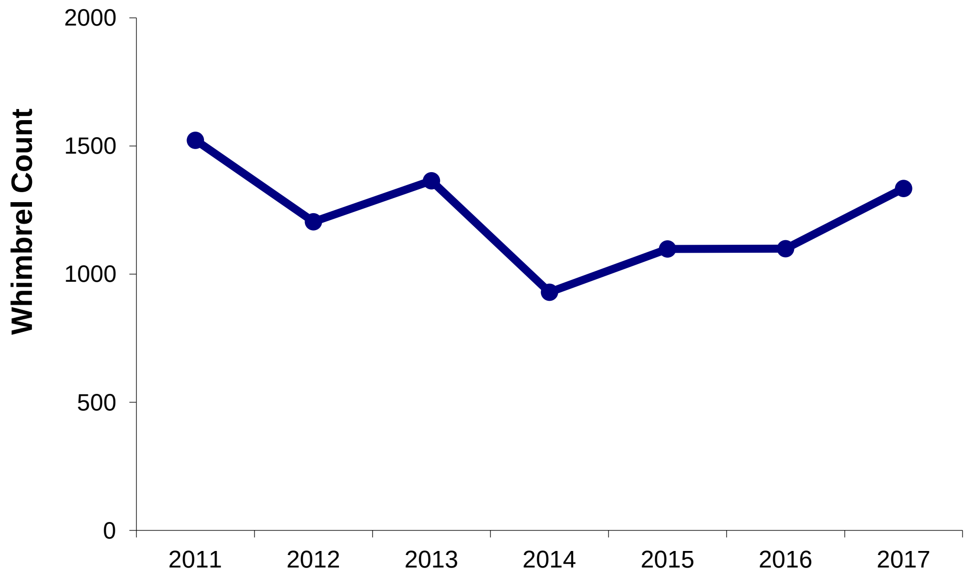


Figure 4-6 Counts of Whimbrels on the Curtis Coast, February 2011-2017

4.2.4 Eastern Curlew

EAAF population estimate (Bamford *et al.*, 2008): 38,000
1% population threshold for internationally important sites: 380
EAAF population estimate (Wetlands International, 2015) 32,000

A total of 785 Eastern Curlews was recorded on the Curtis Coast in February 2017 (Table 4-5; Figure 4-18). This was one less than was recorded in February 2016 (786 birds). The number of Eastern Curlews on the Curtis Coast has exceeded 1 percent population threshold of the official Australian Government population estimate (Bamford et al., 2008) on each of the past six summers (Figure 4-7). Eastern Curlews were present at 28 roosts with the largest at Curtis Island Southend claypan (210 birds) and Friend Point claypan (78 birds) in Port Curtis; Mundoolin Rocks east claypan (189 birds) and Spit End (129 birds) in the Mundoolin-Colosseum-Rodds ecological unit. The numbers recorded at these sites were >0.1 percent of the EAAF population estimate and therefore the sites may be of national significance. The foraging density was greatest at the Port Curtis and Mundoolin-Colosseum-Rodds ecological units and least at Fitzroy Estuary-North Curtis Island. The Eastern Curlew is considered to be in decline across the EAAF (Wetlands International, 2015) and also on the Australian continent particular south of 27.8°S and east of 129°E (Clemens et al., 2016). The species is listed as critically endangered under the EPBC Act.

Table 4-5 Comparison of the number of birds, number of roosts occupied and foraging density of Eastern Curlews between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	5	298	0.12
Fitzroy Estuary-North Curtis Island	9	81	0.02
Mundoolin-Colosseum-Rodds	14	406	0.12
Total	**28**	**785**	**0.08**

1 Foraging density (birds/ha)

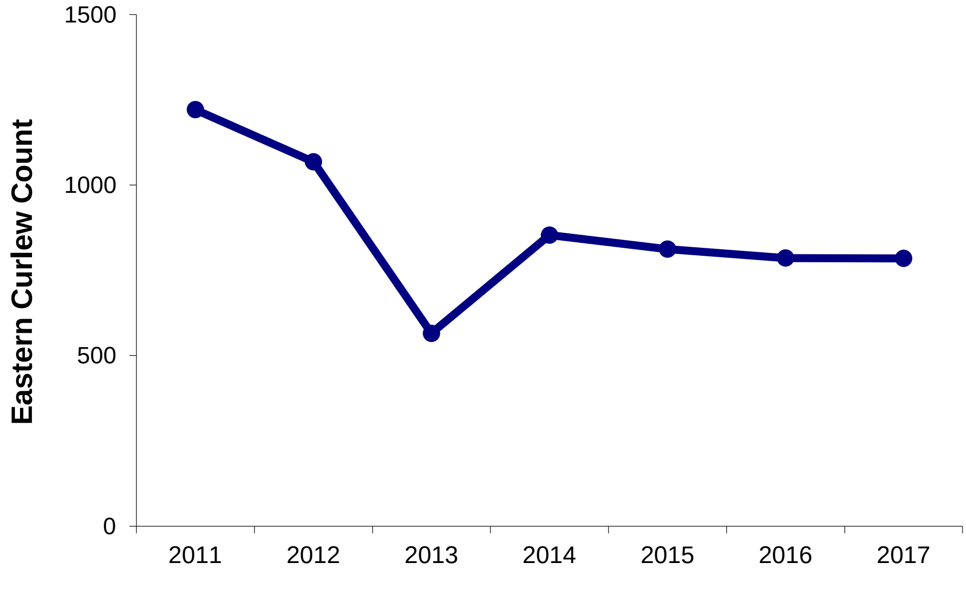


Figure 4-7 Counts of Eastern Curlews on the Curtis Coast, February 2011-2017

4.2.5 Terek Sandpiper

EAAF population estimate (Bamford *et al.*, 2008): 60,000
1% population threshold for internationally important sites: 600
EAAF population estimate (Wetlands International, 2015) 50,000

A total of 1982 Terek Sandpipers was recorded at high tide roosts on the Curtis Coast in February 2016 (Table 4-6, Figure 4-19). This was 229 percent more than was recorded the previous February (603 birds) and the highest count during the project. The number of Terek Sandpipers on the Curtis Coast has exceeded 1 percent of the official Australian Government population estimate (Bamford et al., 2008) during every summer except 2011 (Figure 4-8). Terek Sandpipers were present at 23 roosts the largest of which were Yellow Patch sandbar mangrove (780 birds), Mud Island mangrove (120 birds) and Yellow Patch mangrove (70 birds) in the Fitzroy Estuary-North Curtis Island ecological unit; Mundoolin central mangrove island (205 birds), Mundoolin Rocks mangrove (141 birds) and Turkey Beach mangrove island (70 birds) in the Mundoolin-Colosseum-Rodds ecological unit; and Facing Island mangrove (230 birds) at Port Curtis. These seven roosts exceeded 0.1 percent of the official Australian Government EAAF population estimate and may therefore be sites of national significance. The foraging density was considerably greater in the Fitzroy Estuary-North Curtis Island ecological unit than it was in the other two ecological units. It is unclear whether the number of Terek Sandpipers in the EAAF population is changing (Wetlands International, 2015). However Australian data suggest it is declining, particularly south of 27.8°S and east of 129°E (Clemens et al., 2016).

Table 4-6 Comparison of the number of birds, number of roosts occupied and foraging density of Terek Sandpipers between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	5	322	0.13
Fitzroy Estuary-North Curtis Island	11	1109	0.26
Mundoolin-Colosseum-Rodds	7	551	0.17
Total	**23**	**1982**	**0.20**

1 Foraging density (birds/ha)

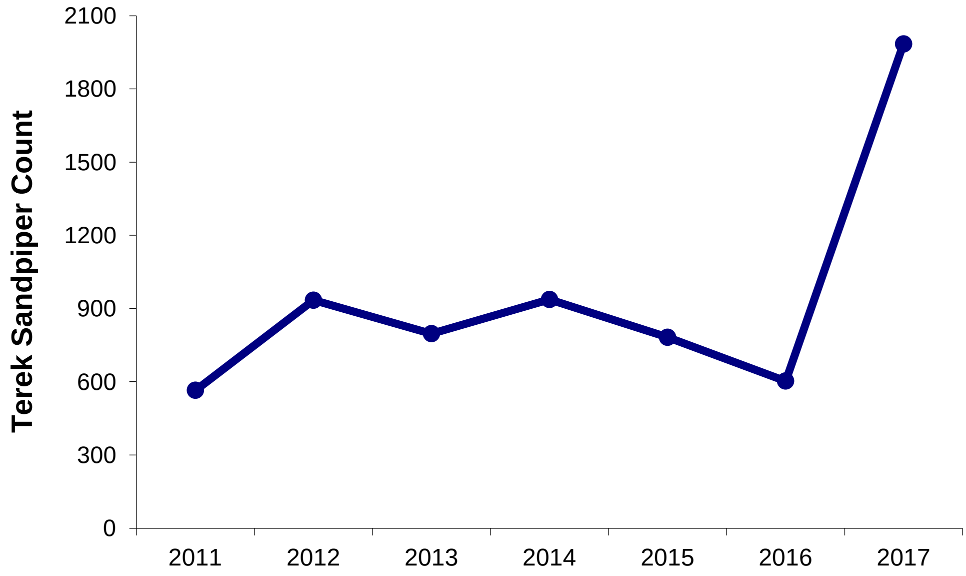


Figure 4-8 Counts of Terek Sandpipers on the Curtis Coast, February 2011-2017

4.2.6 Grey-tailed Tattler

EAAF population estimate (Bamford *et al.*, 2008): 50,000
1% population threshold for internationally important sites: 500
EAAF population estimate (Wetlands International, 2015) 44,000

A total of 1218 Grey-tailed Tattlers was recorded at high tide roosts on the Curtis Coast in February 2016 (Table 4-7, Figure 4-20). This was the same number of birds that was recorded at roosts the previous February and the equal highest count during the project. The number of Grey-tailed Tattlers on the Curtis Coast has exceeded 1 percent of the official Australian Government EAAF population estimate (Bamford et al., 2008) during every summer of the project (Figure 4-9). Grey-tailed Tattlers were present at 33 roosts across the study area. The largest roosts were Yellow Patch sandbar mangrove (520 birds) in the Fitzroy Estuary-North Curtis Island ecological unit; Mundoolin central mangrove island (205 birds) and Mundoolin Rocks mangrove (117 birds) in the Mundoolin-Colosseum-Rodds ecological unit; and Facing Island 4 (120 birds) in Port Curtis. The count at these roosts was >0.1 percent of the official Australian Government EAAF population estimate and they may therefore be sites of national significance. The foraging density was greatest at the Fitzroy Estuary-North Curtis Island ecological unit and least at the Port Curtis ecological unit. The Grey-tailed Tattler is believed to be declining in the EAAF (Wetlands International, 2015). However data from Australia suggest it may be increasing, particularly north of 27.8°S and east of 129°E (Clemens et al., 2016).

Table 4-7 Comparison of the number of birds, number of roosts occupied and foraging density of Grey-tailed Tattlers between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	9	183	0.08
Fitzroy Estuary-North Curtis Island	14	628	0.14
Mundoolin-Colosseum-Rodds	10	407	0.12
Total	**33**	**1218**	**0.12**

1 Foraging density (birds/ha)

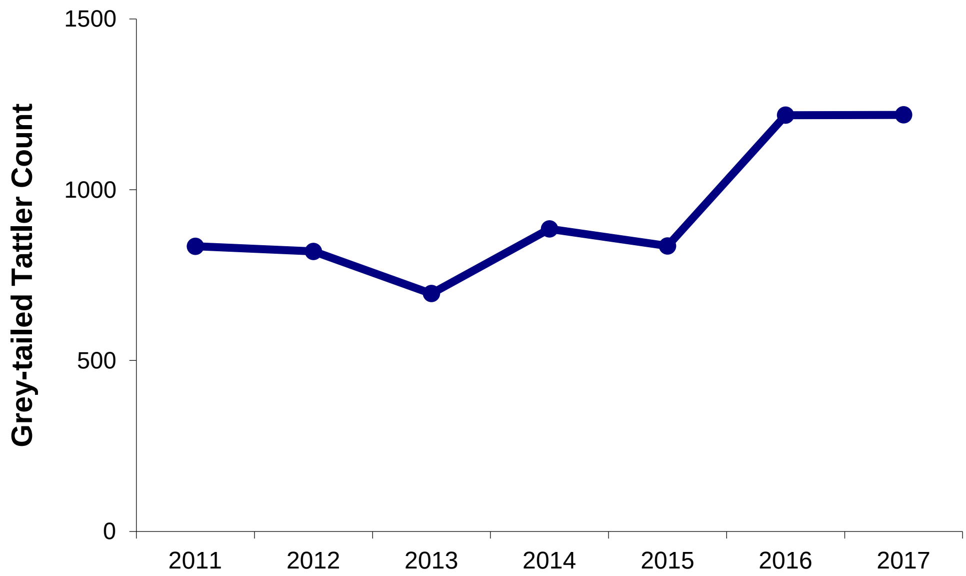


Figure 4-9 Counts of Grey-tailed Tattlers on the Curtis Coast, February 2011-2016

4.2.7 Great Knot

EAAF population estimate (Bamford *et al.*, 2008): 375,000
1% population threshold for internationally important sites: 3,750
EAAF population estimate (Wetlands International, 2015) 290,000

A total of 571 Great Knots was recorded at high tide roosts on the Curtis Coast in February 2017 (Table 4-8, Figure 4-21). This was 48 percent fewer than was recorded at roosts in February 2016 (1,107 birds). The number of Great Knots on the Curtis Coast has not exceeded 1 percent of the official Australian Government EAAF population estimate (Bamford et al., 2008) during the project (Figure 4-10). Great Knots were present at nine roosts, the largest of which were Shell Point (226 birds), and Yellow Patch sandbar (162 birds) in the Fitzroy Estuary-North Curtis Island ecological unit and Curtis Island Southend claypan (140 birds) in Port Curtis. Great Knots are believed to be in decline in the EAAF (Wetlands International, 2015) and in Victoria (Minton et al., 2012). However Australian continent-wide data suggest it may be increasing, particularly north of 27.8°S and east of 129°E (Clemens et al., 2016).

Table 4-8 Comparison of the number of birds, number of roosts occupied and foraging density of Great Knots between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	1	140	0.06
Fitzroy Estuary-North Curtis Island	5	400	0.09
Mundoolin-Colosseum-Rodds	3	31	0.01
Total	**9**	**571**	**0.06**

1 Foraging density (birds/ha)

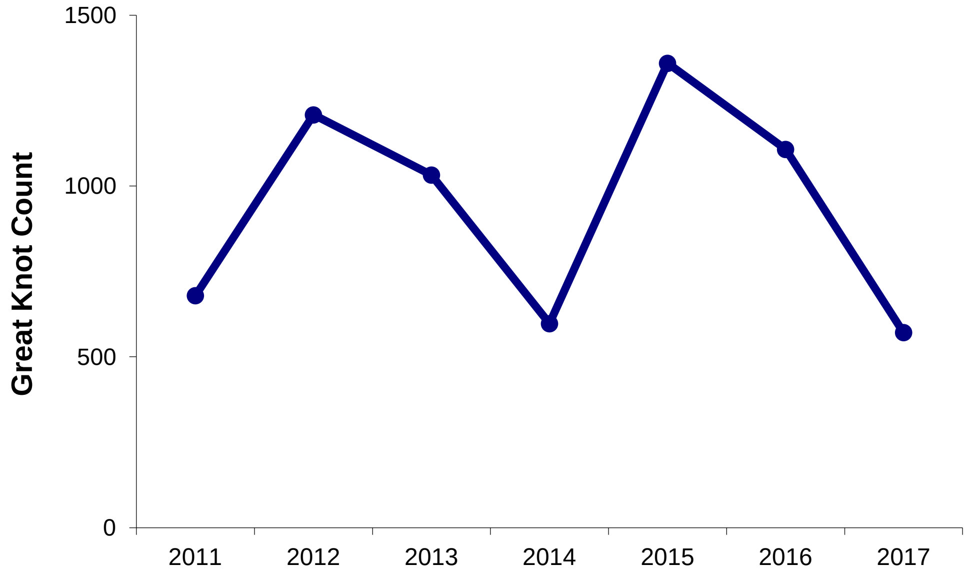


Figure 4-10 Counts of Great Knots on the Curtis Coast, February 2011-2017

4.2.8 Red-necked Stint

EAAF population estimate (Bamford *et al.*, 2008): 325,000
1% population threshold for internationally important sites: 3,250
EAAF population estimate (Wetlands International, 2015) 315,000

A total of 2780 Red-necked Stints was recorded at high tide roosts on the Curtis Coast in February 2017 (Table 4-9, Figure 4-22). This was 24 percent more than was recorded at roosts the previous February (2241 birds). The number of Red-necked Stints on the Curtis Coast has exceeded 1 percent of the official Australian Government EAAF population estimate (Bamford et al., 2008) during February surveys on one occasion – 2015 (Figure 4-11). Red-necked Stints were present at 18 roosts, the biggest of which were Shell Point (1620 birds) and Deception Point claypan (497 birds) both in the Fitzroy Estuary-North Curtis Island ecological unit. The count at these sites was >0.1 percent of the EAAF population estimate indicating that they may be sites of national significance. The foraging density was considerably higher at Fitzroy Estuary-North Curtis Island than the other two ecological units. Red-necked Stints present a particular problem when estimating numbers based on counts at high tide roosts. The species is flexible in its use of feeding habitat and is known to move to coastal wetlands during the high tide (Higgins & Davies, 1996; Hollands & Minton, 2012; Minton et al., 2012). It has been postulated that stint distribution at the Curtis Coast may relate to the amount of moisture in the claypans and this in turn relates to tide height and recent rainfall (GHD, 2011d; Sandpiper Ecological Surveys, 2012a). It is unclear whether the population of Red-necked Stints in the EAAF is changing (Wetlands International, 2015). However Australian data suggest it is declining, particularly east of 129°E (Clemens et al., 2016).

Table 4-9 Comparison of the number of birds, number of roosts occupied and foraging density of Red-necked Stints between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	3	179	0.07
Fitzroy Estuary-North Curtis Island	8	2463	0.57
Mundoolin-Colosseum-Rodds	7	138	0.04
Total	**18**	**2780**	**0.28**

1 Foraging density (birds/ha)

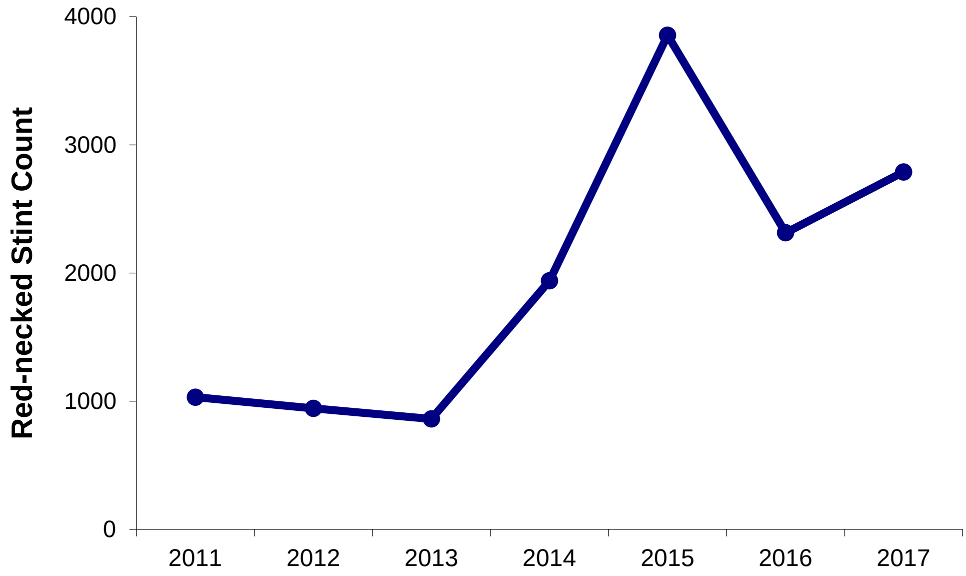


Figure 4-11 Counts of Red-necked Stints on the Curtis Coast, February 2011-2017

Figure 4-12 Curlew Sandpiper and Marsh Sandpiper at Cheetham Salt Works, February 2017 (Adam Leavesley, Wildlife Unlimited)

4.2.9 Grey Plover

EAAF population estimate (Bamford *et al.*, 2008): 125,000
1% population threshold for internationally important sites: 1,250
EAAF population estimate (Wetlands International, 2015) 104,000

A total of 92 Grey Plovers was recorded at high tide roosts on the Curtis Coast in February 2017 (Table 4-10, Figure 4-23). This was 29 percent fewer birds than was recorded at roosts the previous February (130 birds). The number of Grey Plover on the Curtis Coast has not exceeded 1 percent of the official Australian Government EAAF population estimate during the project (Figure 4-13). Grey Plovers were present at six roosts with the largest one at Yellow Patch sandbar (25 birds) in the Fitzroy Estuary-North Curtis Island ecological unit. Foraging density was similar in the Fitzroy Estuary-North Curtis Island and Mundoolin-Colosseum-Rodds ecological units and greater than that in the Port Curtis ecological unit. Grey Plovers are believed to be declining in the EAAF (Wetlands International, 2015) and in Australia, particularly south of 27.8°S and west of 129°E (Clemens et al., 2016).

Table 4-10 Comparison of the number of birds, number of roosts occupied and foraging density of Grey Plovers between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	1	5	0.00
Fitzroy Estuary-North Curtis Island	3	54	0.01
Mundoolin-Colosseum-Rodds	2	33	0.01
Total	**6**	**92**	**0.01**

1 Foraging density (birds/ha)

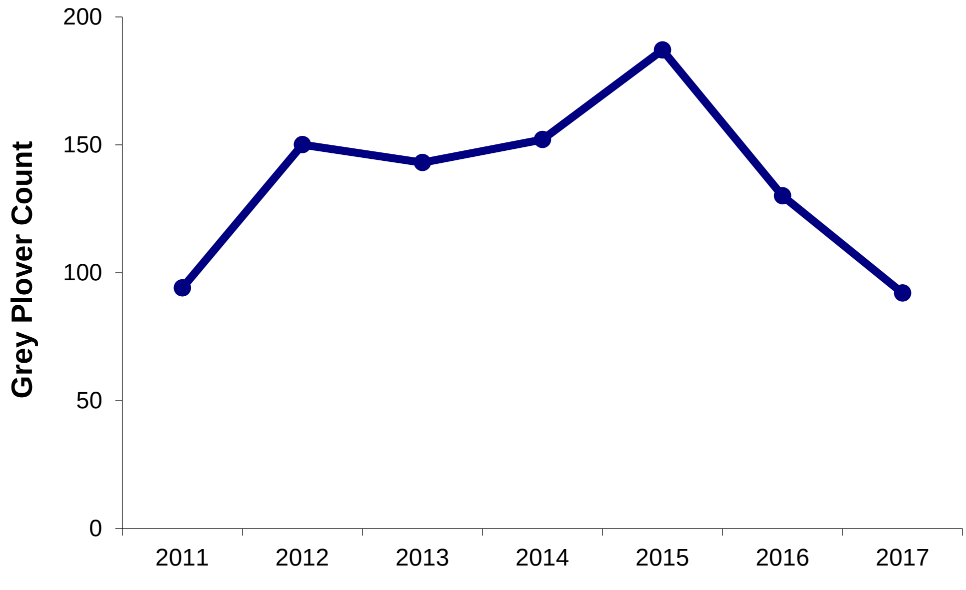


Figure 4-13 Counts of Grey Plovers on the Curtis Coast, February 2011-2017

4.2.10 Sand Plover Species

A total of 1982 Sand Plovers was recorded at high tide roosts on the Curtis Coast in February 2017. This was 69 percent more than the February 2016 survey (1171 birds). The 2017 total comprised 998 Lesser Sand Plovers and 984 Greater Sand Plovers. No birds were classified to Sand Plover spp. The proportion of birds that cannot be distinguished is affected by weather conditions. Summaries of the two species are presented below.

The official Australian Government EAAF population estimate (Bamford et al., 2008) for Lesser Sand Plover is 140,000 and for Greater Sand Plover is 110,000 giving a combined total of 250,000. The February 2012 total of Sand Plover spp. was marginally <1 percent of the combined populations suggesting that the numbers of one of the species may have exceeded the threshold on that occasion.

4.2.10.1 Lesser Sand Plover

EAAF population estimate (Bamford *et al.*, 2008): 140,000
1% population threshold for internationally important sites: 1,400
EAAF population estimate (Wetlands International, 2015) 68,500

A total of 998 Lesser Sand Plovers was recorded at high tide roosts on the Curtis Coast in February 2016 (Table 4-11, Figure 4.25). The number of Lesser Sand Plovers on the Curtis Coast did not exceed 1 percent of the official Australian Government EAAF population estimate (Bamford et al., 2008), however it did exceed 1 percent of the Wetlands International (2015) estimate. Lesser Sand Plovers were recorded at 12 roosts, the largest of which were Yellow Patch sandbar (343 birds) and Shell Point (200 birds) in the Fitzroy Estuary-North Curtis Island ecological unit. The count at these sites was >0.1 percent of the EAAF population estimate indicating that they may be sites of national significance. The highest foraging densities occurred in the Fitzroy Estuary-North Curtis Island and Port Curtis ecological units. The population of Lesser Sand Plovers in the EAAF is believed to be declining (Wetlands International, 2015) and in Australia, particularly north of 27.8°S and east of 129°E (Clemens et al., 2016).

Table 4-11 Comparison of the number of birds, number of roosts occupied and foraging density of Lesser Sand Plovers between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	4	125	0.05
Fitzroy Estuary-North Curtis Island	6	796	0.18
Mundoolin-Colosseum-Rodds	2	77	0.02
Total	**12**	**998**	**0.10**

1 Foraging density (birds/ha)

4.2.10.2 Greater Sand Plover

EAAF population estimate (Bamford *et al.*, 2008): 110,000
1% population threshold for internationally important sites: 1,100
EAAF population estimate (Wetlands International, 2015) 79,000

A total of 984 Greater Sand Plovers was recorded at high tide roosts on the Curtis Coast in February 2017 (Table 4-12, Figure 4.26). The number of Greater Sand Plovers on the Curtis Coast did not exceed 1 percent of the official Australian Government population estimate (Bamford et al., 2008) however it did exceed 1 percent of the Wetlands International (2015) estimate. Greater Sand Plovers were recorded at 12 roosts, the largest of which were Yellow Patch sandbar (343 birds), Shell Point (140 birds) and Curlew Spit claypan (134 birds) in the Fitzroy Estuary-North Curtis Island ecological unit; Facing Island claypan (233 birds) in the Port Curtis ecological unit. The count at these sites was >0.1 percent of the EAAF population estimate indicating that they may be of national significance. The greatest foraging density occurred in the Fitzroy Estuary-North Curtis Island ecological unit. The population of Greater Sand Plovers in the EAAF is believed to be declining (Wetlands International, 2015) but there is no evidence of this at a continental scale in Australia though the data do suggest a decrease in the population south of 27.8°S and west of 129°E (Clemens et al., 2016).

Table 4-12 Comparison of the number of birds, number of roosts occupied and foraging density of Greater Sand Plovers between three ecological units in February 2017

Location	Roosts	Total	Density[1]
Port Curtis	5	258	0.11
Fitzroy Estuary-North Curtis Island	5	723	0.17
Mundoolin-Colosseum-Rodds	2	3	0.00
Total	**12**	**984**	**0.10**

1 Foraging density (birds/ha)

4.3 Other Migratory Shorebird Species

The composition of the 10 most abundant species in 2017 changed from 2016 due to a relatively low count of Grey Plovers (92 birds) and high counts of Broad-billed Sandpiper (122 birds) and Curlew Sandpiper (104 birds). The Broad-billed Sandpiper count was the highest for the project and the species abundance ranking was 10; Curlew Sandpiper was ranked 11 and Grey Plover was 12.

The 10 most abundant species accounted for 97 percent of the migratory shorebirds recorded at high tide roosts in February 2017. Of the remaining 11 species, the counts for five were >40. These were Curlew Sandpiper, Grey Plover, Pacific Golden Plover (84 birds), Common Greenshank (72 birds) and Ruddy Turnstone (48 birds).

The distribution of the rarer species was relatively restricted. The Broad-billed Sandpipers were recorded from three roosts in the Fitzroy Estuary-North Curtis Island ecological unit with most at a single roost, Curlew Spit. Curlew Sandpipers were recorded at eight roosts with most birds also recorded from Curlew Spit. Pacific Golden Plovers were recorded at six roosts, Common Greenshanks at 11 roosts and Ruddy Turnstones at four roosts.

The abundances obtained for many of the rarely recorded species using the *Shorebird 2020* method may be under-estimates. Species which may be dispersed through coastal freshwater ecosystems, such as Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Marsh Sandpiper, Common Greenshank, Common Sandpiper and Latham's Snipe are likely to be undercounted using the *Shorebird 2020* method (Wildlife Unlimited, 2012; Sandpiper Ecological Surveys, 2012c). Additional targeted surveys could help to complete the picture however the vast area of coastal saltmarsh and mangroves is difficult to access and renders any aspiration of a regular exhaustive survey impractical.

4.4 Low Tide Surveys

A total of 32 low tide surveys were completed in February 2017, 2 more than in the 2016 survey. The duration of the low tide surveys was 564 minutes (Table 4-1). A total of 3079 birds comprising 16 species was counted at low tide (Table 4-15). No additional migratory shorebird species were recorded. The count of Black-tailed Godwits exceeded the count from the high tide roosts by one individual. The low tide counts are not strictly comparable with previous surveys because shorebirds move quickly around the intertidal zone in response to the movement of the tide. It is therefore difficult to replicate surveys even when they occur at the same location.

4.5 Non-migratory Species

A total of 1223 non-migratory birds of eight species were recorded during the high tide roost counts (Table 4-13). This compares with 757 birds of eight species recorded in February 2016. A Red-necked Avocet was detected during the high tide counts this year but not last year, while a Bush Stone-curlew was detected last year but not this year.

The key assumption making roost counting the preferred method for estimating migratory shorebird numbers – that the majority of birds congregate in communal roosts at high tide – does not hold for all non-migratory species. Consequently, the counts obtained using the method were unlikely to give an accurate estimate of the populations of these species on the Curtis Coast. Nonetheless, collection of the data make the survey comparable with the *Shorebird 2020* counts; help describe the distributions of the species; may be a valid index of the populations and have intrinsic value as records of presence and abundance. No further analysis was conducted because non-migratory species are beyond the scope of the ERMP (Gladstone Ports Corporation, 2016).

Table 4-13 Summary of the high tide roost counts by location for non-migratory species.

	PC	FE	NC	M-C	RP	SW	Total
Beach Stone-curlew	4	2	2	2	1	0	**11**
Bush Stone-curlew	0	0	0	0	0	0	**0**
Pied Oystercatcher	16	91	29	132	117	0	**385**
Sooty Oystercatcher	13	0	3	0	2	0	**18**
Black-winged Stilt	40	0	0	0	0	80	**120**
Red-necked Avocet	1	0	0	0	0	0	**1**
Red-capped Plover	181	136	81	145	121	0	**664**
Black-fronted Dotterel	8	0	0	0	0	0	**8**
Red-kneed Dotterel	0	0	0	0	0	0	**0**
Masked Lapwing	6	2	7	1	0	0	**16**
Total abundance	269	231	122	280	241	80	**1223**
Total species	**8**	**4**	**5**	**4**	**4**	**1**	**8**

PC = Port Curtis including the Mainland Shoreline and WBRA, FE = Fitzroy Estuary, NC = North Curtis Island, MC = Mundoolin-Colosseum, RP = Rodds Peninsula, SW = Cheetham Salt Works.

4.6 Cheetham Salt Works

One survey was completed at Cheetham Salt Works at mid-tide on 15 February for a duration of 57 minutes. A total of 24 migratory shorebirds were recorded of four species: Curlew Sandpiper (10 birds); Marsh Sandpiper (8 birds); Common Greenshank (5 birds) and Sharp-tailed Sandpiper (1 bird). The count of Marsh Sandpiper exceeded that from main high tide roost survey. The combination of species present at the salt works is only observed at one other site on the Curtis Coast, the Clinton Ash Ponds at Port Curtis. An account of regular surveys at the Cheetham Salt Works (Houston et al., 2012) assists in better understanding the contribution that the salt works makes to migratory shorebird diversity on the Curtis Coast and the population dynamics of some of the species which are rare elsewhere.

The survey was conducted at a location inside the salt works at which migratory waders have been regularly recorded. The salt works is not tidal and the survey takes the form of a search along the salt pond embankments from near the entrance gate to the survey point.

4.7 Western Basin Reclamation Area

A thorough survey of the WBRA at high tide was conducted on 15 February 2017. The aim was to investigate whether the facility was being used by migratory shorebirds as a roost.

Ten surveys were completed with a total duration of 38 minutes. The duration represents the time spent surveying at each site. A total of four migratory shorebirds was recorded of two species: Curlew Sandpiper (3 birds; Figure 4-14) and Whimbrel (1 bird). The Curlew Sandpipers were recorded foraging along the shoreline of the western pond. A non-migratory species the Red-capped Plover (3 birds) was also recorded.

Figure 4-14 Curlew Sandpipers feeding in the WBRA in February 2017
The birds were recorded from the western pond (Adam Leavesley, Wildlife Unlimited).

Table 4-14 Summary of the roost counts for migratory shorebirds at each survey location. Includes data collected from Cheetham Salt Works at mid-tide.

	PC	FE	NC	M-C	RP	SW*	Total
Pacific Golden Plover	3	50	0	31	0	0	**84**
Grey Plover	5	29	25	14	19	0	**92**
Double-banded Plover	0	0	0	5	0	0	**5**
Lesser Sand Plover	125	261	535	0	77	0	**998**
Greater Sand Plover	258	308	415	0	3	0	**984**
Latham's Snipe	0	0	0	0	0	0	**0**
Black-tailed Godwit	0	1	0	0	0	0	**1**
Bar-tailed Godwit	633	359	834	819	138	0	**2783**
Little Curlew	0	0	0	0	0	0	**0**
Whimbrel	466	11	611	202	44	0	**1334**
Eastern Curlew	298	30	51	227	179	0	**785**
Terek Sandpiper	322	198	911	352	199	0	**1982**
Common Sandpiper	0	0	0	0	0	0	**0**
Grey-tailed Tattler	183	25	603	341	66	0	**1218**
Wandering Tattler	0	0	0	0	0	0	**0**
Common Greenshank	12	0	54	6	0	5	**77**
Marsh Sandpiper	0	2	0	0	0	8	**10**
Ruddy Turnstone	3	0	0	40	5	0	**48**
Great Knot	140	238	162	29	2	0	**571**
Red Knot	0	7	1	0	0	0	**8**
Sanderling	0	0	7	0	0	0	**7**
Red-necked Stint	179	2201	262	46	92	0	**2780**
Sharp-tailed Sandpiper	10	2	3	0	0	1	**16**
Curlew Sandpiper	8	90	6	0	0	10	**114**
Broad-billed Sandpiper	0	106	16	0	0	0	**122**
Unidentified medium wader	0	8	0	0	0	0	**8**
Total abundance	**2645**	**3926**	**4496**	**2112**	**824**	**24**	**14027**
Total species	**15**	**17**	**16**	**12**	**11**	**4**	**21**

PC = Port Curtis including the Mainland Shoreline and WBRA, FE = Fitzroy Estuary, NC = North Curtis Island, MC = Mundoolin-Colosseum, RP = Rodds Peninsula.

*The Cheetham Salt Works was surveyed at mid-tide.

Figure 4-15 Important roosts on the Curtis Coast, February 2017

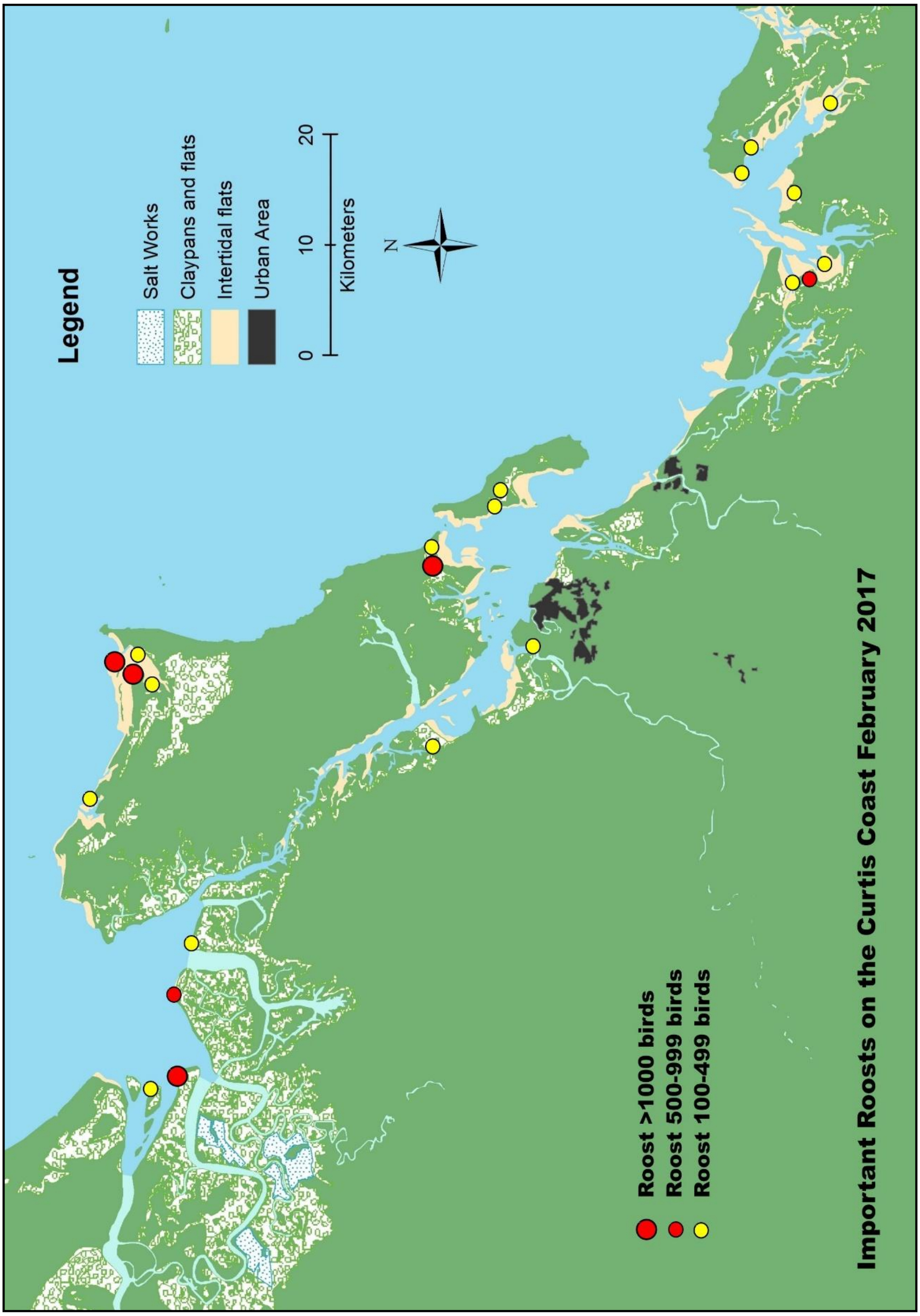


Figure 4-16 Bar-tailed Godwit roosts on the Curtis Coast, February 2017

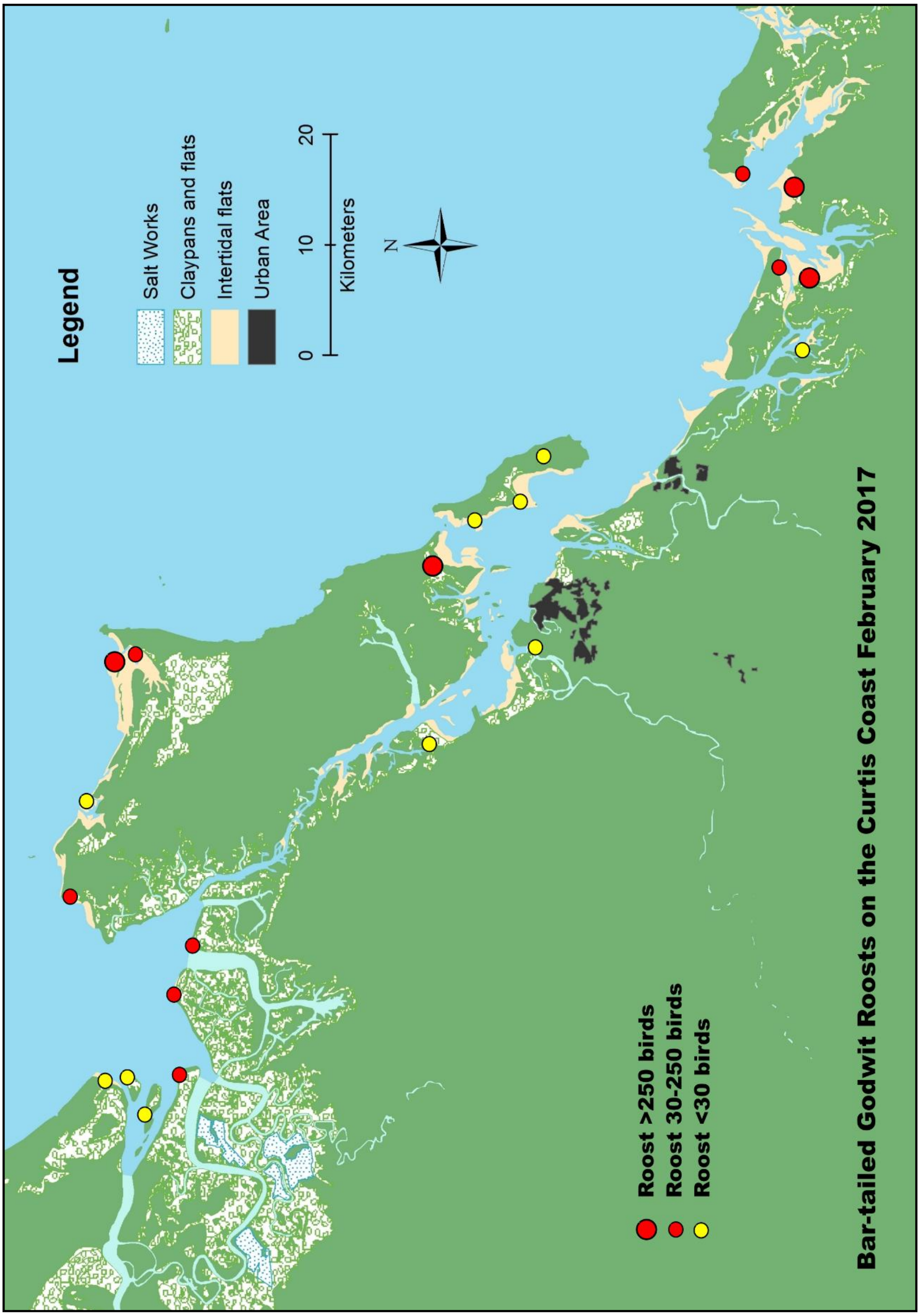


Figure 4-17 Whimbrel roosts on the Curtis Coast, February 2017

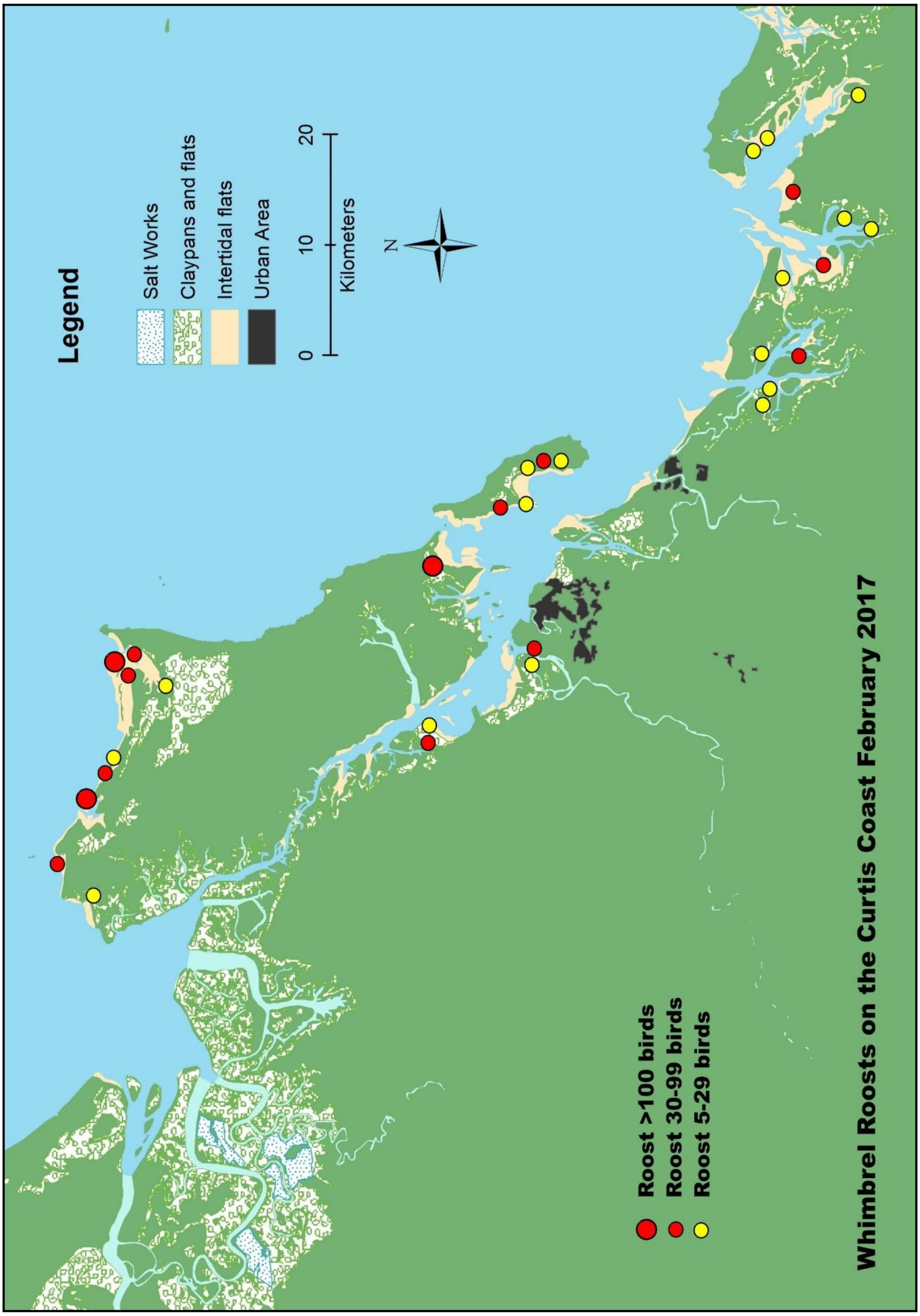


Figure 4-18 Eastern Curlew roosts on the Curtis Coast, February 2017

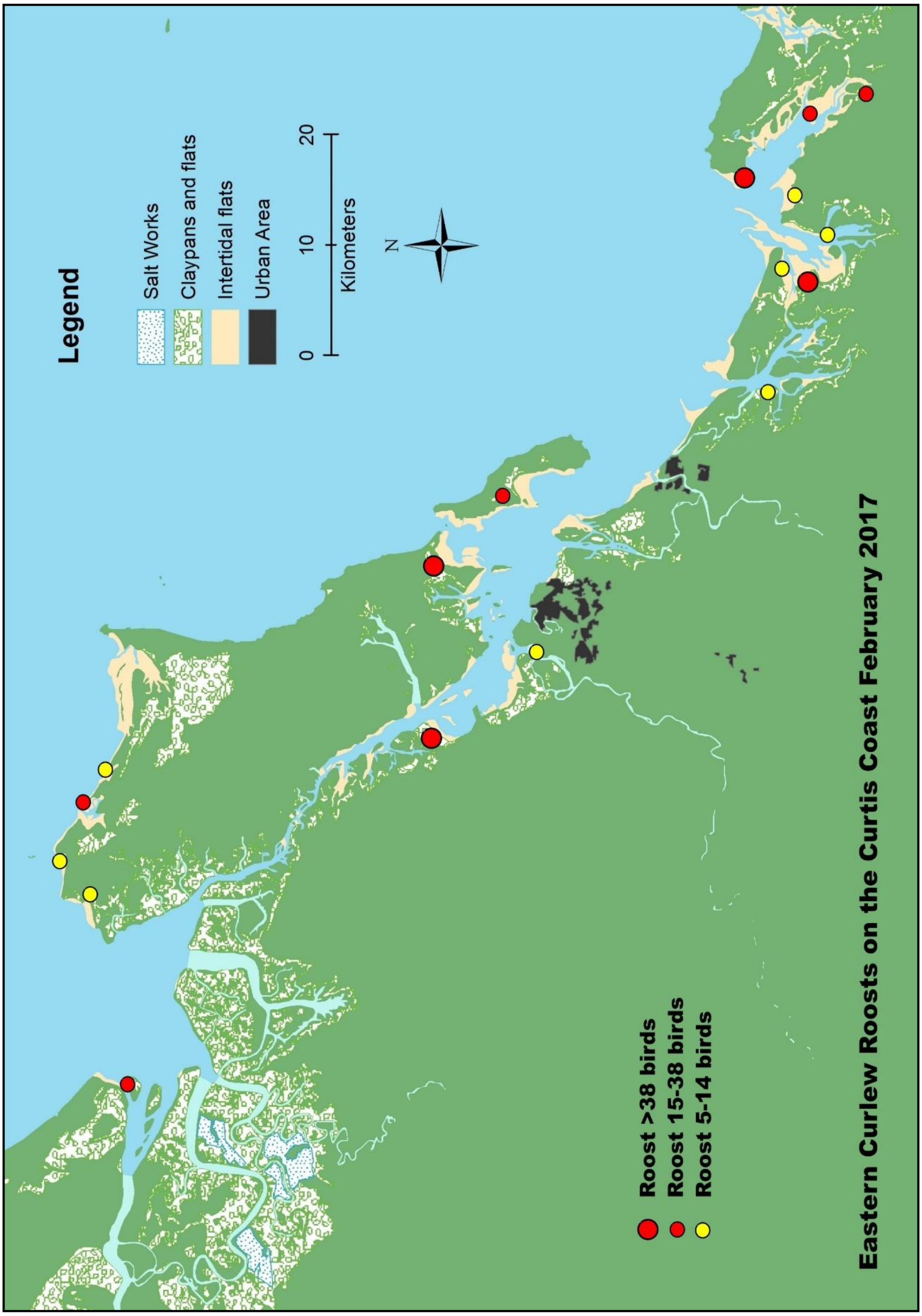


Figure 4-19 Terek Sandpiper roosts on the Curtis Coast, February 2017

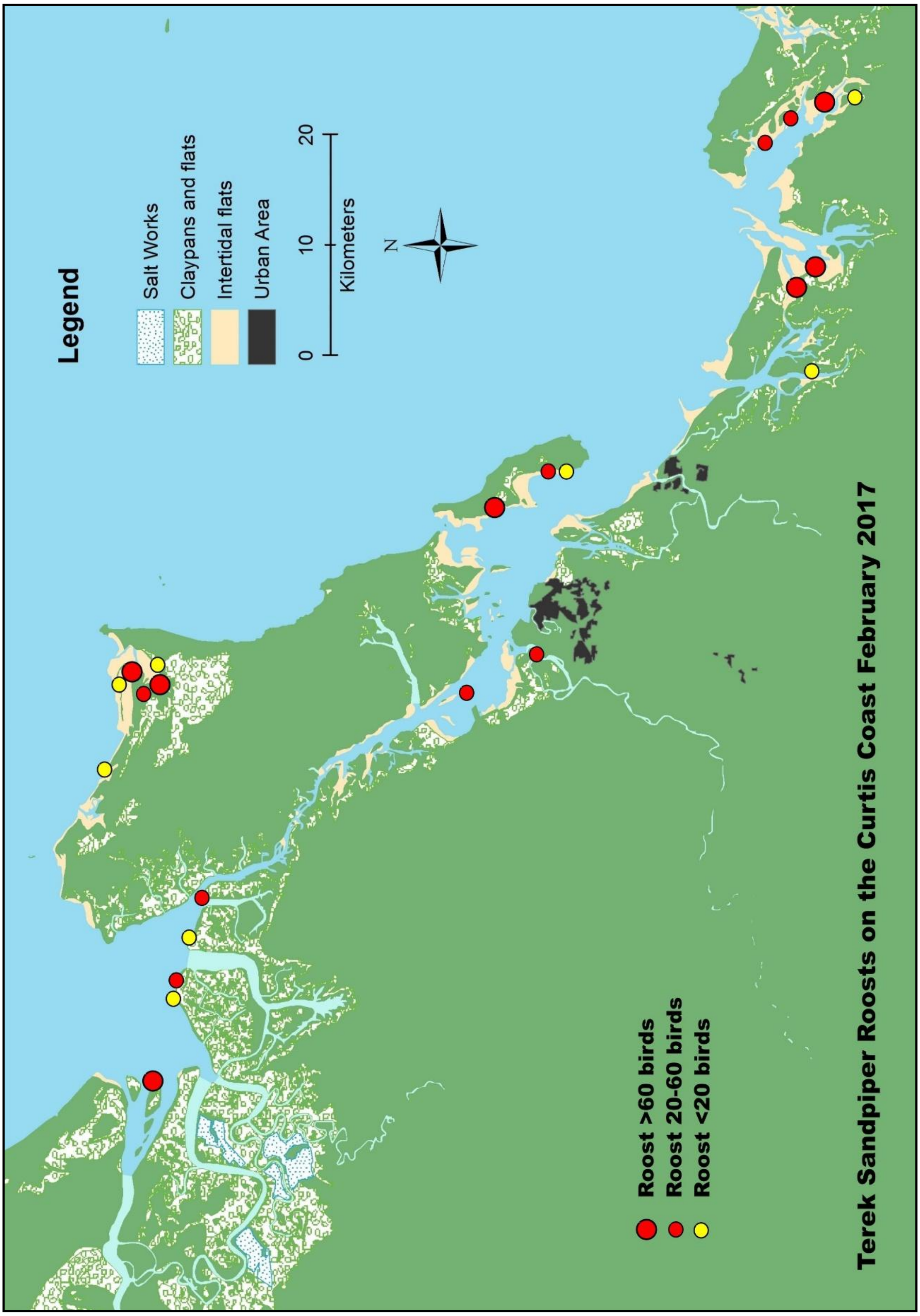


Figure 4-20 Grey-tailed Tattler roosts on the Curtis Coast, February 2017

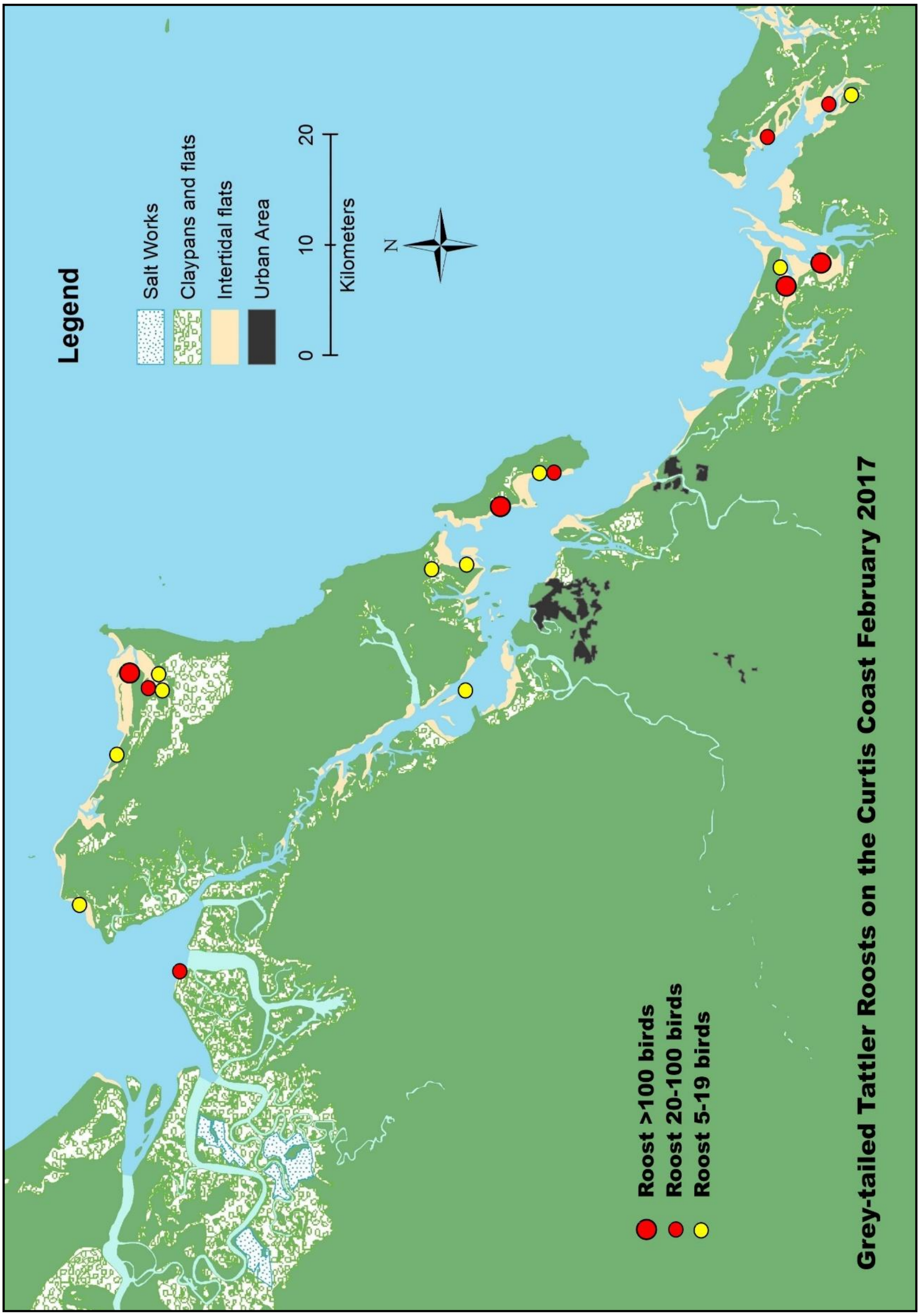


Figure 4-21 Great Knot roosts on the Curtis Coast, February 2017

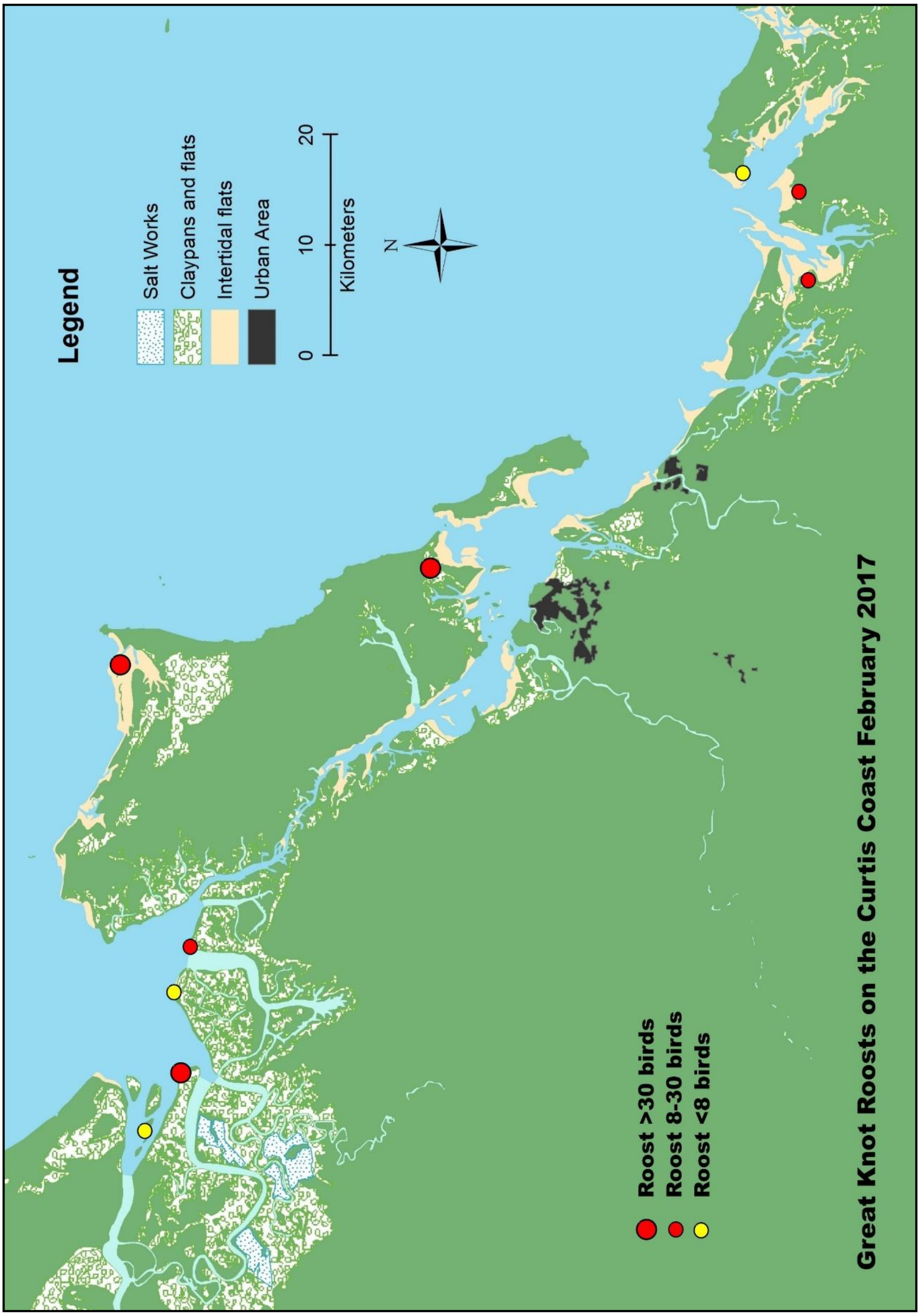


Figure 4-22 Red-necked Stint roosts on the Curtis Coast, February 2017

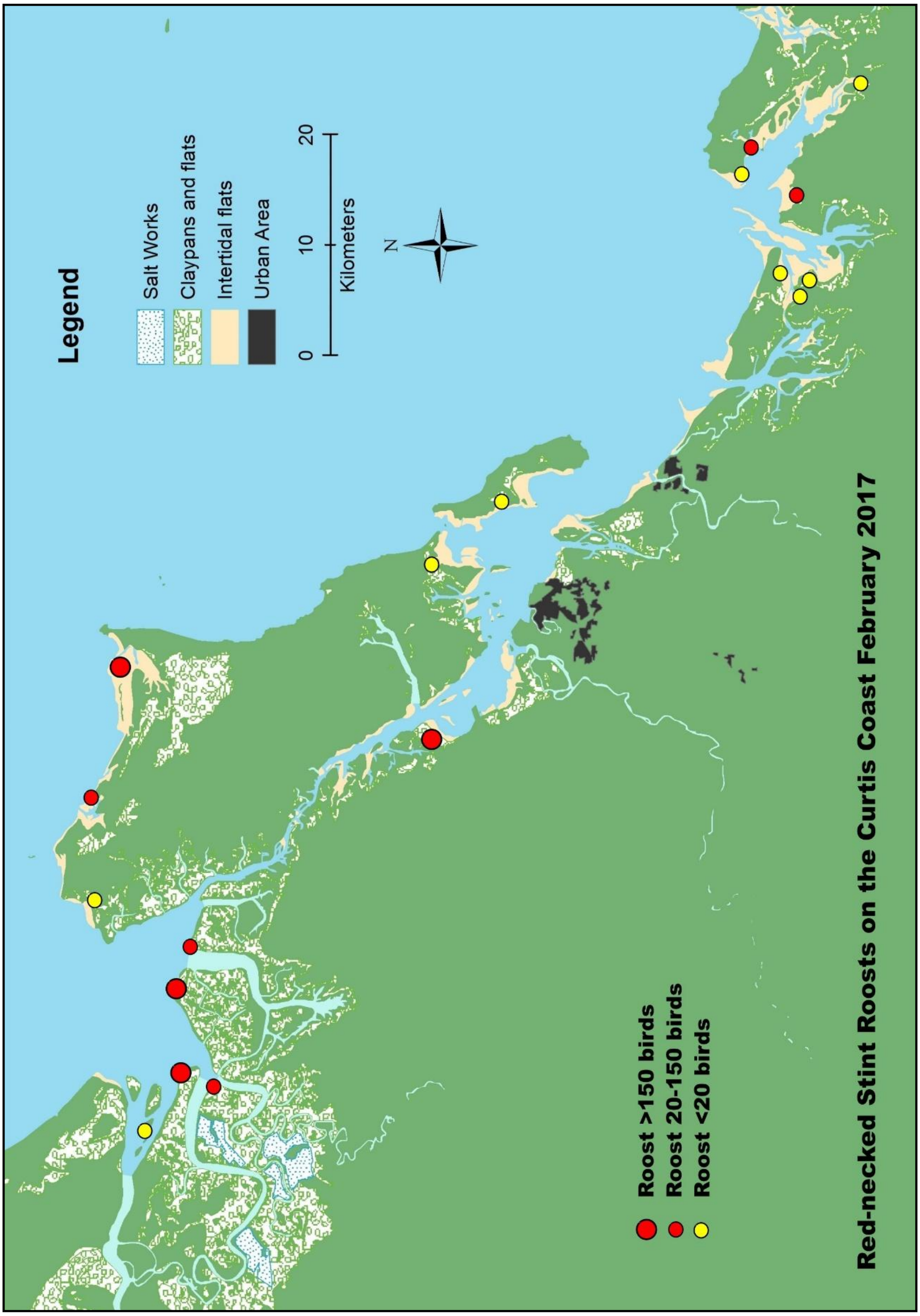


Figure 4-23 Grey Plover roosts on the Curtis Coast, February 2017

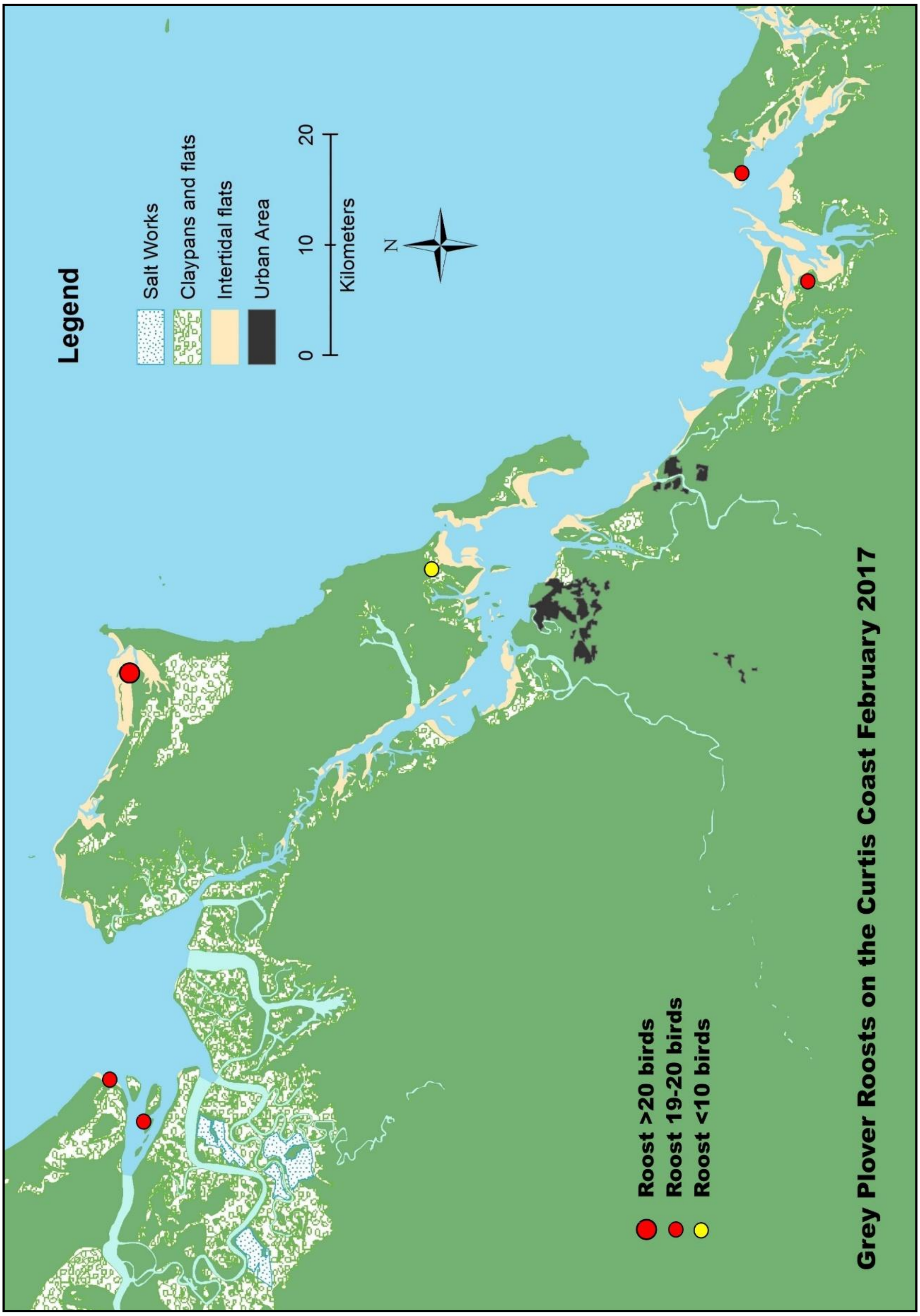


Figure 4-24 Lesser Sand Plover roosts on the Curtis Coast, February 2017

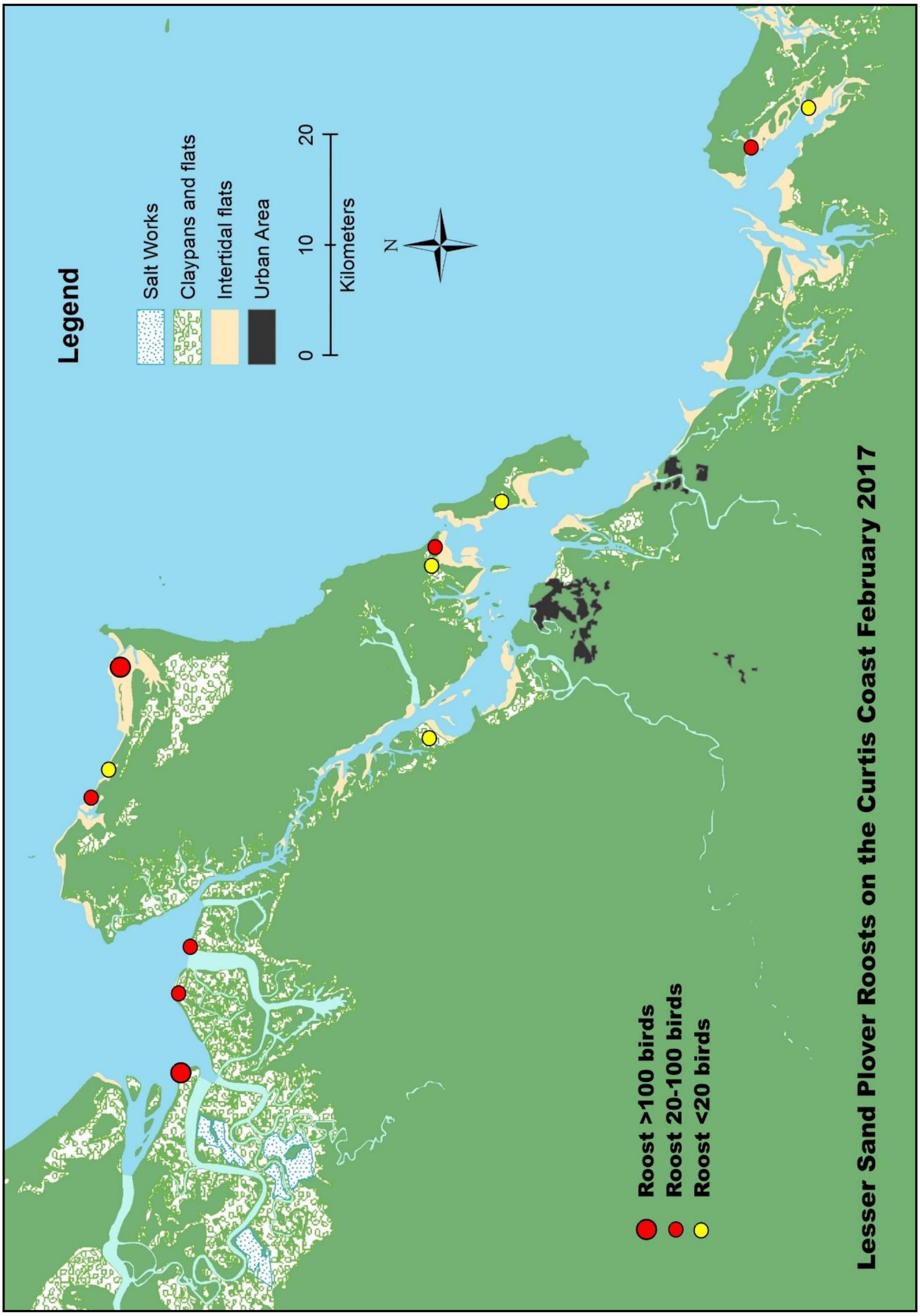


Figure 4-25 Greater Sand Plover roosts on the Curtis Coast, February 2017

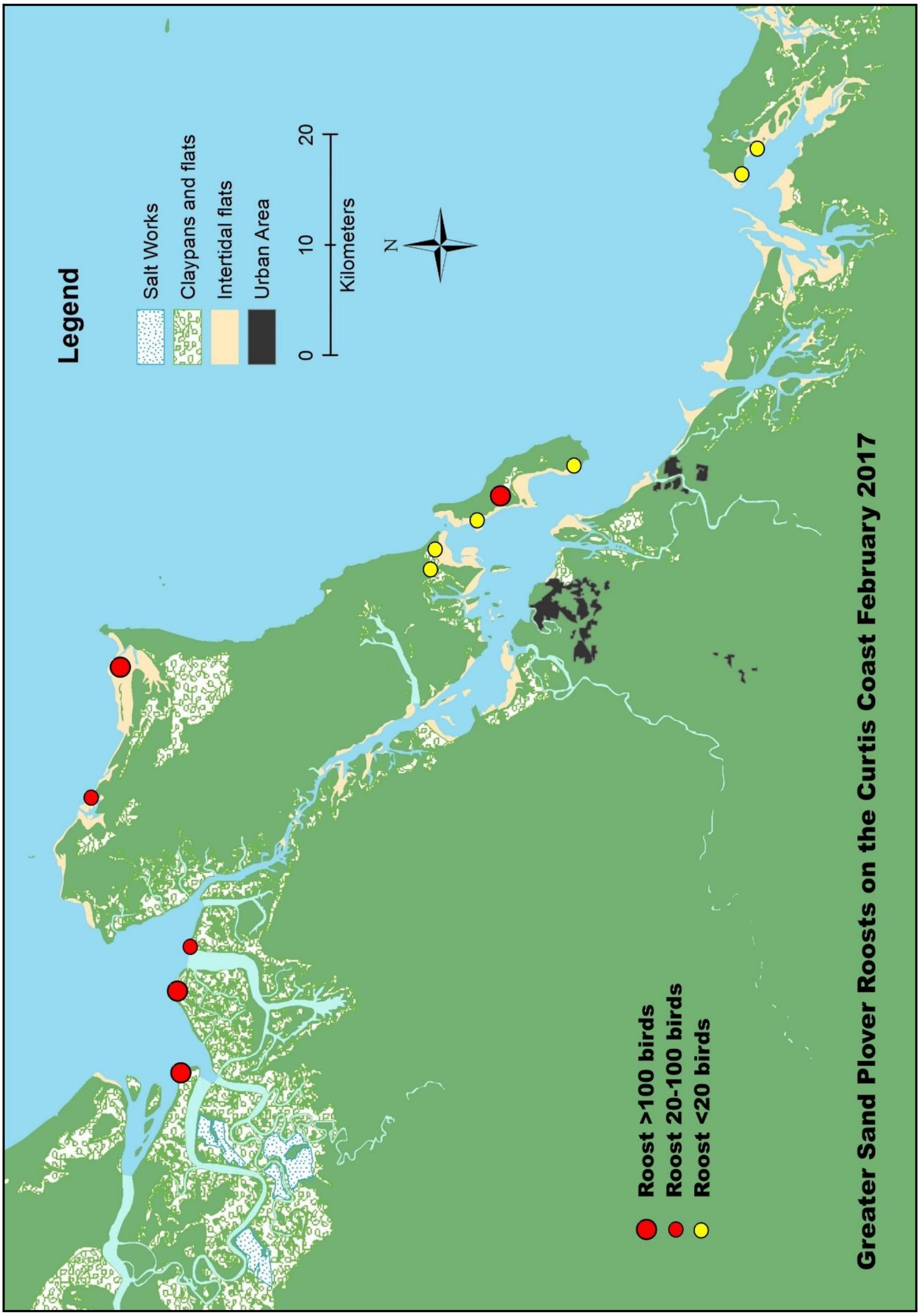


Table 4-15 Summary of low tide foraging counts for migratory shorebirds at each survey location.

	PC	FE	NC	M-C	RP	Total
Pacific Golden Plover	0	0	0	11	0	**11**
Grey Plover	0	5	1	0	0	**6**
Lesser Sand Plover	5	42	20	5	0	**72**
Greater Sand Plover	14	25	18	20	0	**77**
Black-tailed Godwit	2	0	0	0	0	**2**
Bar-tailed Godwit	171	194	94	168	168	**795**
Whimbrel	64	23	40	59	41	**227**
Eastern Curlew	43	4	2	34	103	**186**
Terek Sandpiper	39	58	0	10	31	**138**
Grey-tailed Tattler	15	8	1	1	0	**25**
Common Greenshank	1	1	0	3	0	**5**
Ruddy Turnstone	0	0	1	0	0	**1**
Great Knot	59	12	2	32	0	**105**
Red Knot	0	1	0	0	0	**1**
Red-necked Stint	236	459	0	16	4	**715**
Curlew Sandpiper	0	8	0	0	0	**8**
Sand Plover spp.	1	16	0	0	0	**17**
Unidentified medium wader	0	18	0	9	0	**27**
Unidentified small wader	5	644	0	1	11	**661**
Total abundance	**655**	**1518**	**179**	**369**	**358**	**3079**
Total species	**11**	**13**	**9**	**11**	**5**	**16**

PC = Port Curtis including the mainland foreshore, FE = Fitzroy Estuary, M-C = Mundoolin Colosseum, RP = Rodds Peninsula

5 IMPORTANT SUMMER ROOSTS 2011-2017

5.1 Introduction

A key objective of the ERMP is mapping of migratory shorebird roosting sites (Section 1.3). Results from single surveys are presented in each survey report. This analysis combines the results of the seven February surveys. The main aim of the work was to map the location of the largest roosts on the Curtis Coast. Additional aims were: 1) summarise the number of records obtained from each region; 2) investigate appropriate methods for presenting the final dataset after 10 years.

5.2 Methods

The high tide roost count data from February surveys for 2011-2017 was extracted from the project database. Analysis was focussed on the February summer surveys to minimise sources of variation associated with migration. The two January surveys were removed because some of the biggest roosts were not routinely surveyed. Surveys of the Cheetham Salt Works were retained.

Data were extracted from the project database excluding all records that were not identified to species such as Sand Plover spp., Terek/Tattler and Knot spp. This approach was taken so that species richness could be calculated and all metrics were comparable within and between roosts. Sites surveyed three times or less were excluded. Some large or complex roosts such as the claypan at Curlew Spit and the series of sandbars at Station Point were represented in the data by multiple survey points. The points were aids for fieldwork which represent specific locations which were preferentially used by different species, used by birds at different tide heights or in different weather conditions. Where this occurred the points were aggregated to give an indication of the use of the whole location (Table 5-1, Figure 5-1, Figure 5-2, Figure 5-3). Mean abundance was calculated based on the number of times a roost was surveyed. Mean species richness was calculated based on the number of surveys in which a migratory shorebird was present. Roosts were classified according to their mean abundance: >800 birds; 400-800 birds and 100-399 birds. No further analysis was conducted on roosts with a mean abundance of <100 birds.

5.3 Results

A total of 82,802 migratory shorebirds which were identified to species, were recorded in the seven February surveys from 2011-2017. This total was 4.9 percent fewer than was recorded if records not identified to species were included. Most birds were recorded from the northern end of the Curtis Coast, with 29 percent of records from North Curtis Island, 27 percent from the Fitzroy Estuary and 2 percent from Cheetham Salt Works; 18 percent were from Port Curtis, 17 percent were from Mundoolin-Colosseum and 7 percent from Rodds Peninsula.

The distribution of large roosts across the Curtis Coast was consistent with the overall number of birds recorded. Of the five roosts with a mean abundance >800 birds, three were in the north: Yellow Patch sandbar (mean = 1221 birds; range = 0-3090) at North Curtis Island, Shell Point north east (mean = 913 birds; range = 2-2362) and Curlew Spit (mean = 751 birds; range = 103-1830) both in the Fitzroy Estuary (Table 5-2, Figure 5-4). The other two large roosts were Curtis Island Southend claypan (mean = 1049 birds; range = 781-1347) in Port Curtis and Mundoolin Rocks claypan (mean = 833 birds; range = 492-1494) in the Mundoolin Inlet. A total of 45 percent of the records were from these five locations. Four roosts were in the mean abundance of 400-800 class. All four were in the north: Deception Point (mean = 499 birds; range = 145-956), Mud Bay (mean = 495 birds; range = 179-1059), Keppel Creek sandbar (mean = 455 birds; range = 158-575) and Yellow Patch entrance mangrove (mean = 413 birds; range = 104-1355). A total of 62 percent of the records were from these nine locations with a mean abundance ≥400 birds. A further 14 locations supported a mean abundance of 100-399 birds and these were distributed across the Curtis Coast. A total of 90 percent of the records were from the 23 locations with a mean abundance ≥100 birds.

5.4 Discussion

The five largest migratory shorebird roosts during a February spring tide on the Curtis Coast appear to be coincident with some of the largest areas of tidal flat as mapped by GHD (2011c). The pattern suggests that birds have a preferred set of roosting locations within close proximity to each other and the nearest large tidal flat. We speculate that factors such as the size of the roost, tide height, weather conditions and disturbance appear to have influenced where they were roosting at the moment of survey. For the purpose of producing meaningful ecological information we aggregated the data from survey locations which were in close proximity within the same geographical feature. This approach may have been conservative (Choi et al. 2016). The mapping shows clusters of large roosts within close proximity to each other and the nearest large tidal flat at Yellow Patch, Curtis Island Southend and Mundoolin Rocks. We postulate that there is little energetic difference in moving to these locations so that some species may perceive the whole complex of possible roosting sites around the tidal flat as the 'home roost'. A similar set of circumstances may exist at a larger scale at the other two large roosts in the Fitzroy Estuary, though the greater distances between these roosts make this less likely (Rogers et al. 2006a). Evidence relevant to the question has been collected at the study site by University of Queensland researchers (Choi et al. 2016) and is likely to better define what constitutes a 'roost' for the species studied on the Curtis Coast.

The results are contingent on the method described above. Although all the data have been analysed using the same method, the characteristics of each roost will have affected the results. Roosts which host large numbers of Sand Plover species are likely to have been subject to greater exclusion of data because they were not identified to species level (e.g. Sand Plover spp.), than those which host few birds of these two species. For example, the mean abundance at Yellow Patch sandbar where Sand Plovers are regularly abundant was reduced by 81 birds while that at Curtis Island Southend claypan where they are rarely recorded was reduced by one bird. Manual assessment and manipulation of records could reduce the amount of data excluded and minimise the effect. It should be noted that the effect of data exclusion was less important in determining the importance of roosts than the decisions made in aggregating sites.

More work similar to this is required to fulfil the conditions of approval for the WBDDP. The ERMP calls for "investigation of habitat utilisation relative to the lunar/tide cycles and season." We envisage that a summary of roost utilisation, similar to what we have prepared here, will need to be completed using all the monitoring data. The final monitoring dataset is planned to include 10 February surveys and four each from January, March during the northward migration, August during the Austral winter and October during the southern migration. This will support investigation of the effects of season. Extension of the work to investigate the effects of the tide cycle will be hampered by the monitoring method which is focussed on the spring tides.

We note some impressive progress has been achieved by University of Queensland researchers (Choi et al. 2016) in the preparation of other datasets from the Curtis Coast including the mapping of tidal flats at a range of tide heights, mapping of prey density and radio tracking of birds. These datasets provide crucial information for extending the validity of inference from the data reported here.

Table 5-1 Survey points in close proximity which were aggregated to single sites

Roost name	Sites aggregated; main site listed first	Ecological unit
Yellow Patch sandbar	C13	Fitzroy Estuary-North Curtis Island
Curtis Island Southend claypan	GH10, GH10A, 2	Port Curtis
Shell Point north east	PA7	Fitzroy Estuary-North Curtis Island
Mundoolin Rocks claypan	67, 67B	Mundoolin-Colosseum-Rodds
Curlew Spit	39C, 39, 39B, 39D	Fitzroy Estuary-North Curtis Island
Deception Point	40	Fitzroy Estuary-North Curtis Island
Mud Bay	C2	Fitzroy Estuary-North Curtis Island
Keppel Creek sandbar	C18, C18B	Fitzroy Estuary-North Curtis Island
Yellow Patch entrance mangrove	C13B	Fitzroy Estuary-North Curtis Island
Spit End	75	Mundoolin-Colosseum-Rodds
Williams Bay	71	Mundoolin-Colosseum-Rodds
Mundoolin central mangrove island	CM3	Mundoolin-Colosseum-Rodds
Station Point	C21A, C21, C21B, C21C	Fitzroy Estuary-North Curtis Island
Cattle Point	PA18	Fitzroy Estuary-North Curtis Island
Rundle Beach	PA1	Fitzroy Estuary-North Curtis Island
Facing Island claypan	GH8	Port Curtis
Mundoolin Rocks west claypan	64	Mundoolin-Colosseum-Rodds
Little Keppel Creek sandbar	C20	Fitzroy Estuary-North Curtis Island
Friend Point claypan	7	Port Curtis
Facing Island sandbar	GH2	Port Curtis
Mud Island east point	PA5	Fitzroy Estuary-North Curtis Island
Mundoolin Rocks north beach	65	Mundoolin-Colosseum-Rodds
Shell Point south east	PA8	Fitzroy Estuary-North Curtis Island

Figure 5-1 Roost GH10, Curtis Island Southend claypan
Survey points GH10, GH10A and 2 reference different locations at which migratory shorebirds roost within the same claypan. The data indicate that occupation of the sites is mutually exclusive so they were aggregated for this analysis. Image from Google Maps.

Figure 5-2 Roost C13 Yellow Patch sandbar

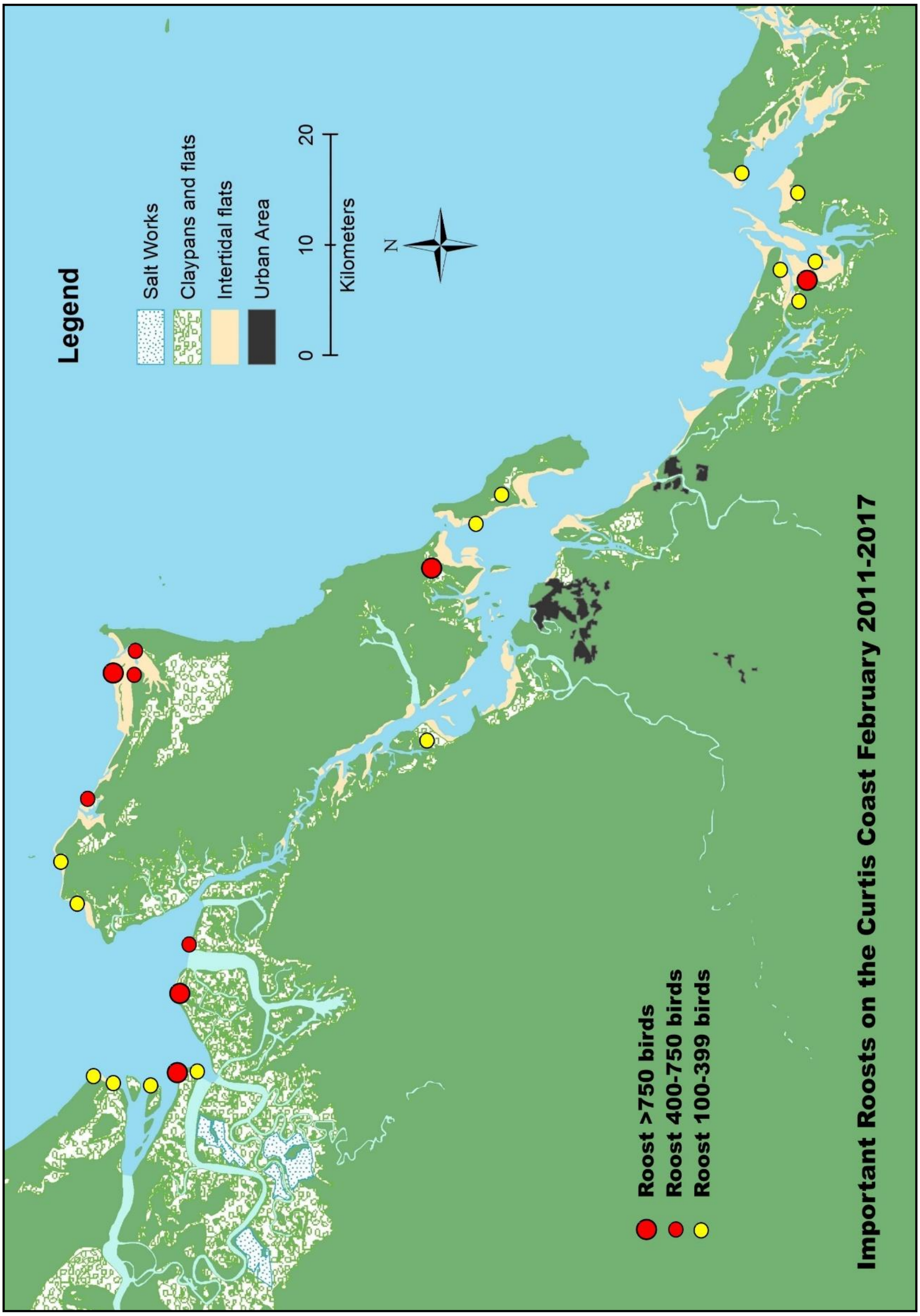
Survey point C13 was not aggregated with other nearby migratory shorebird locations because it represented a distinct feature. Image from Google Maps.

Figure 5-3 Roost 67 Mundoolin Rocks claypan
Survey points 67 and 67B reference different locations at which migratory shorebirds roost within the same claypan. Early surveys differentiated between the survey points, but while migratory shorebirds appear to prefer the location marked by survey point 67, they have been observed across most of the feature. The two locations were aggregated for this analysis. Image from Google Maps.

Table 5-2 Roosts with a mean abundance >100 during February high tide surveys 2011-2017

Roost name	Mean Abundance	Species Richness Mean (Total)	Min	Max	Roost type
Yellow Patch sandbar	1221	10.7 (15)	0	3090	Sandbar
Curtis Island Southend claypan	1049	7.0 (14)	0	1347	Claypan
Shell Point north east	913	7.6 (13)	2	2362	Claypan
Mundoolin Rocks claypan	833	8.3 (15)	492	1494	Claypan
Curlew Spit	751	8.6 (15)	103	1830	Claypan, mangroves
Deception Point	499	7.3 (11)	145	956	Sandbar
Mud Bay	495	5.6 (14)	179	1059	Sandbar
Keppel Creek sandbar	455	6.7 (14)	158	575	Sandbar
Yellow Patch entrance mangrove	413	3.8 (5)	104	1355	Mangrove
Spit End	380	6.3 (9)	136	927	Sandbar
Williams Bay	371	7.0 (12)	259	534	Claypan
Mundoolin central mangrove island	316	3.7 (5)	47	518	Mangrove
Station Point	269	4.9 (10)	0	658	Sandbar
Cattle Point	251	4.7 (13)	0	672	Sandbar
Rundle Beach	234	3.8 (10)	1	551	Sandbar
Facing Island claypan	202	5.7 (12)	10	332	Claypan
Mundoolin Rocks West Claypan	172	4.6 (13)	4	690	Claypan
Little Keppel Creek sandbar	168	3.3 (9)	7	620	Sandbar
Friend Point claypan	160	4.4 (8)	57	267	Claypan
Facing Island sandbar	121	3.6 (9)	4	358	Sandbar
Mud Island east point	116	2 (3)	25	193	Mangrove
Mundoolin Rocks north beach	108	6.2 (12)	0	251	Sandbar
Shell Point south east	106	2.3 (6)	1	688	Sandbar

Figure 5-4 Roosts with a mean abundance >100 during February high tide surveys 2011-2017



6 DISCUSSION

6.1 Summer 2017 – Results in Context

Migratory shorebird populations are in decline in the East Asian-Australasian Flyway and it is strongly suspected that this is due to transformative land use change of coastal areas particularly in the Yellow Sea (MacKinnon et al., 2012; Ma et al., 2014; Murray et al., 2015; Wetlands International, 2015; Piersma et al., 2016; Studds et al., 2017). This evidence is reflected in the Australian Government Wildlife Protection Plan for Migratory Shorebirds which lists coastal development particularly in Asia, as the most serious threat to migratory shorebirds (DoE, 2015). However, the second most serious threat is coastal development in Australia and nine further threats are listed. The occurrence of the ongoing declines and multiple threats in highly mobile species across the flyway presents a complex background against which to assess the effects of development on the Curtis Coast. Any changes noted on the Curtis Coast throughout the life of this project need to be assessed in relation to changes elsewhere in the flyway (Clemens et al., 2010; Minton et al., 2012; Ma et al., 2014; Murray et al., 2015; Piersma et al., 2016; Studds et al., 2017).

Migratory shorebird populations in Australia are in flux with many in decline (Clemens et al., 2016). Analyses of a 30-year-old citizen science dataset spanning the years 1973-2014 shows that of 19 species for which data were available, 12 have declined continent-wide. These were (in decreasing order of the magnitude of the decline): Curlew Sandpiper; Lesser Sand Plover; Sharp-tailed Sandpiper; Terek Sandpiper; Black-tailed Godwit; Red-necked Stint; Bar-tailed Godwit; Ruddy Turnstone; Eastern Curlew; Pacific Golden Plover; Grey Plover and Common Greenshank. No change was detected in Red Knot, Marsh Sandpiper, Sanderling, Greater Sand Plover, Whimbrel, Great Knot or Grey-tailed Tattler. Three species, Grey-tailed Tattler, Great Knot and Whimbrel showed increases north of 27.8°S (i.e. an area which includes the Curtis Coast) over a 15-year subset of the data spanning 1996-2014. Another 15-year dataset (1996-2014) consisting of an expanded set of sites showed declines north of 27.8°S in five species (Black-tailed Godwit, Lesser Sand Plover, Terek Sandpiper, Bar-tailed Godwit and Eastern Curlew) and increases in three (Sharp-tailed Sandpiper, Sanderling and Grey-tailed Tattler). Taken together, these data suggest migratory shorebird populations on the Curtis Coast may have been in flux prior to the commencement of construction of the WBDDP.

Interannual variability in migratory shorebird populations is high and this makes the detection of trends in the data difficult (DEWHA, 2009b; Wilson et al., 2011; Minton et al., 2012; IMEMS, 2013; Appendix 5). The problem is described by Wilson et al. (2011) who analysed trends in data collected in southern Queensland at Moreton Bay (Wilson et al., 2011).

> "Abundances and estimates of abundances of migratory species may be expected to be particularly variable because the animals are highly mobile, different stages of their life cycle occur in different places, and their wide spatial extent and high abundance create logistical difficulties in coordinating abundance estimation and monitoring (Piersma & Baker, 2000; Piersma, 2007). All these sources of variability make the robust detection of trends difficult because it is challenging to eliminate noise, and unless monitoring or analysis methods account for this variability, changes in abundance may go undetected. When the abundance of different species in an assemblage of both migrants and nonmigrants has different sources of variability, identifying trends can be extremely difficult."

The variability in migratory shorebird populations is demonstrated in a paper which presented 30 years of data from Corner Inlet in Victoria (Minton et al., 2012). The average total abundance of migratory shorebirds was 31,493 birds but the range was 22,065 - 43,041 (79 percent – 137 percent of the average). Species abundances also exhibited high variability. For example, the Bar-tailed Godwit had an average summer abundance of 10,080 and a range of 6951 - 13,139 (69 percent –

130 percent of the average). Other species which were less abundant at Corner Inlet had even larger fluctuations in numbers throughout the period (Appendix 6). In general, to overcome this level of variability requires an intensive survey effort over at least a decade and this is expected to be the case on the Curtis Coast (IMEMS, 2013).

The total abundance recorded for the Curtis Coast February 2017 summer survey was 21 percent more than the 2016 survey (Wildlife Unlimited, 2016). This was the greatest total abundance recorded during the project (Figure 4-1). The figure is 15 percent greater than the summer mean for the project, 12,285. The increase in total abundance was mainly due to a 229 percent increase in the number of Terek Sandpipers recorded. But other abundant species also showed increases: Sand Plover species (71 percent), Red-necked Stint (24 percent) and Whimbrel (21 percent); while Grey-tailed Tattler abundance remained at the top of the range following a big increase in 2016. The increases were partly offset by a substantial decrease in the number of Great Knots (48 percent).

Conditions for shorebird counting were good during the survey. Winds were generally light for the first two days but increased a little bit for the final three days. The general effect of windy conditions is to reduce detectability causing a tendency to record fewer birds and fewer species (Rogers et al., 2006b). This can particularly be an issue for differentiating Sand Plovers in large flocks, but there were no difficulties this year.

Tides during the 2017 survey were at the top of the predicted range for 2017 and predicted to be higher than during the 2016 survey when the Yellow Patch sandbar was under water. Despite the predicted tide height, the top of the tide was noticeably lower than 2016 (Figure 6-1) so that Yellow Patch sandbar was available to birds. The contrast in the actual tide height between years may have been due to the difference in recent rain; 2016 was a wet year in Gladstone, while 2017 was dry.

Figure 6-1 Thornton Creek Island roost was inundated in 2016 but exposed in 2017
Birds were present on the sandbar (Adam Leavesley, Wildlife Unlimited).

6.2 The Effects of Construction on Migratory Shorebirds

Anthropogenic activity in the upper harbour of Port Curtis appeared markedly reduced compared to previous years. The second LNG train at the GLNG plant was commissioned on 26 May 2016 and at the APLNG plant on 10 October 2016. Local news reports say that the construction workforce has been reduced to 15, down from 14,500 at the peak. We presume that activity associated with the

LNG plants will now mostly consist of berthing and loading of ships (Figure 6-2), transport of the plant staff and equipment (Figure 6-3, Figure 6-4) and maintenance of the port infrastructure.

The effect of construction in Port Curtis on migratory shorebirds appears to have varied from place-to-place. Previous reports have documented the apparent displacement and change in migratory shorebird populations at two roosts, one of which was within the development footprint of the new Wiggins Island Coal Export Terminal (Figure 6-5, Figure 6-6) and the other at Clinton Ash Ponds (Figure 6-7) a facility in near constant use adjacent to the R.G. Tanna Coal Terminal (Wildlife Unlimited, 2016). One of the Calliope River roosts which is within a few hundred metres of the Clinton Ash Ponds appears to be experiencing increased use. This roost may now be preferred by birds which feed on the Wiggins Island tidal flat but no longer appear to roost at the ash ponds.

In the upper harbour, a gas pipeline was constructed adjacent to the roost at Friend Point shoreline. Prior to construction in January 2011, 188 birds were recorded at the site. In comparison, seven birds were recorded during the 2015 survey, eight in 2016 and 5 in 2017. While this may suggest a lasting effect of development, it is probable that birds which use Friend Point shoreline also use the nearby Friend Point claypan particularly during the highest tides when the shoreline site was inundated (Wildlife Unlimited, 2016). During this year's survey it was noted that birds were flying further west down the alignment of the pipeline and settling near the shoreline. This appears to be another option if Friend Point shoreline is unavailable (Figure 6-8).

The roosts at North and South Passage Islands appear to be subject to reduced shipping traffic following the completion of construction of the LNG plants. The South Passage Island roost returned a count of 235 in January 2011 but only 59 birds in February 2015, 23 birds in 2016 and 39 in 2017. If the reduction in use of the roost by migratory shorebirds was associated with the amount of shipping traffic in the area and there is a sustained reduction in this traffic, then the numbers of migratory shorebirds at the roost may change again. With the completion of the LNG plants the roosts will now potentially be subject to disturbance from LNG export shipping.

Roost sites that have been taken over for development constitute a long-term loss of habitat and therefore may lead to a reduction in the shorebird carrying capacity of the study site (DEWHA, 2009b). However, while it appears that proximity to construction activity has disturbed migratory shorebirds, the effect is variable. With construction very nearly complete, there are likely to be other sources of disturbance associated with the new infrastructure such as light spill (Figure 6-9), disturbance from port facilities that existed prior to the WBDDP (Figure 6-10) and other unrelated sources of disturbance (Figure 6-11) including recreational fishers (Figure 6-12, Figure 6-13) and natural predators (Figure 6-14, Figure 6-15).

Another potential cause of migratory shorebird decline in the upper harbour of Port Curtis is a reduction in foraging habitat. Dredging may cause changes in the distribution of the tidal flats on which shorebirds feed. Hydrological modelling predicts some loss of tidal flats within the Western Basin associated with dredging (GHD, 2011c) and in our view the tidal flats surrounding North Passage Island may have changed (Figure 6-16). A reduction in the area of foraging habitat associated with the WBDDP will affect the foraging density estimates produced for this report. Updated estimates of the foraging area are required to maintain confidence in the density estimates.

Differentiating between the various activities associated with construction was difficult because all the specified activities were occurring in the area surrounding the roosts and in close proximity to the intertidal foraging areas. The cessation of construction activities presents an opportunity to assess the response of migratory shorebird populations at roosts in close proximity. But the likelihood is slim that robust evidence linking changes in migratory shorebird populations to specific construction activities can be obtained using the present methods. Similarly, the present methods offer little scope for determining the relative effects of aspects of construction such as noise compared to light spill or water quality. Conclusions on this topic are therefore likely to be speculative and generalised. In addition, it remains possible that the cause of the reduction in the number of migratory shorebirds recorded in the upper harbour of Port Curtis was habitat alteration (DEWHA, 2009b). An example of habitat alteration would be changes in prey type and abundance or changes in the size and composition of the substrate (Colwell, 2010). Such changes could affect shorebird populations but would not be directly detectable using the *Shorebird 2020* method.

Figure 6-2 LNG export vessel in close proximity to South Passage Island, February 2016
The roost at South Passage Island no longer appears to be subject to shipping traffic associated with construction; 39 birds were recorded (Adam Leavesley, Wildlife Unlimited).

Figure 6-3 Passenger transport vessel in the upper harbour of Port Curtis, February 2017
(Adam Leavesley, Wildlife Unlimited)

Figure 6-4 Shipping traffic in the upper harbour of Port Curtis
Commercial shipping traffic appeared much reduced in the upper harbour of Port Curtis during the 2017 survey (Adam Leavesley, Wildlife Unlimited).

Figure 6-5 The WICET extends over the tidal flat at Wiggins Island.
The terminal was constructed close to the QGC1 roost. Migratory shorebirds forage on the tidal flat below the conveyor at low tide (Amanda Lilleyman, Wildlife Unlimited).

Figure 6-6 A roost on the Calliope River directly adjacent to the WICET, February 2017.
A group of Whimbrel were present (Adam Leavesley, Wildlife Unlimited).

Figure 6-7 Clinton Ash Ponds, February 2017
The site was subject to works during the 2017 survey (Adam Leavesley, Wildlife Unlimited).

Figure 6-8 A newly detected roost site adjacent to Friend Point claypan, February 2017
The photo is looking west along the alignment of the gas pipeline to the shoreline adjacent to Targinnie boat ramp. Birds were observed flying from the roost at Friend Point claypan over the mangroves into this location (Adam Leavesley, Wildlife Unlimited).

Figure 6-9 Light spill from an LNG plant at Port Curtis, February 2017
(Inka Veltheim, Wildlife Unlimited)

Figure 6-10 Berths at Fisherman's Landing, February 2017
These berths in the Western Basin of Port Curtis were in operation prior to the construction of the WBRA (Adam Leavesley, Wildlife Unlimited)

Figure 6-11 Horticultural maintenance equipment, February 2017
Machinery observed near a roost at lower Port Curtis (Jim Reside, Wildlife Unlimited).

Figure 6-12 Recreational boat in the upper harbour of Port Curtis, February 2017.
(Adam Leavesley, Wildlife Unlimited).

Figure 6-13 Boats at Yellow Patch, February 2017
The main sandbar roost is in the background. The boat to the right was contracted for the migratory shorebird survey (Inka Veltheim, Wildlife Unlimited).

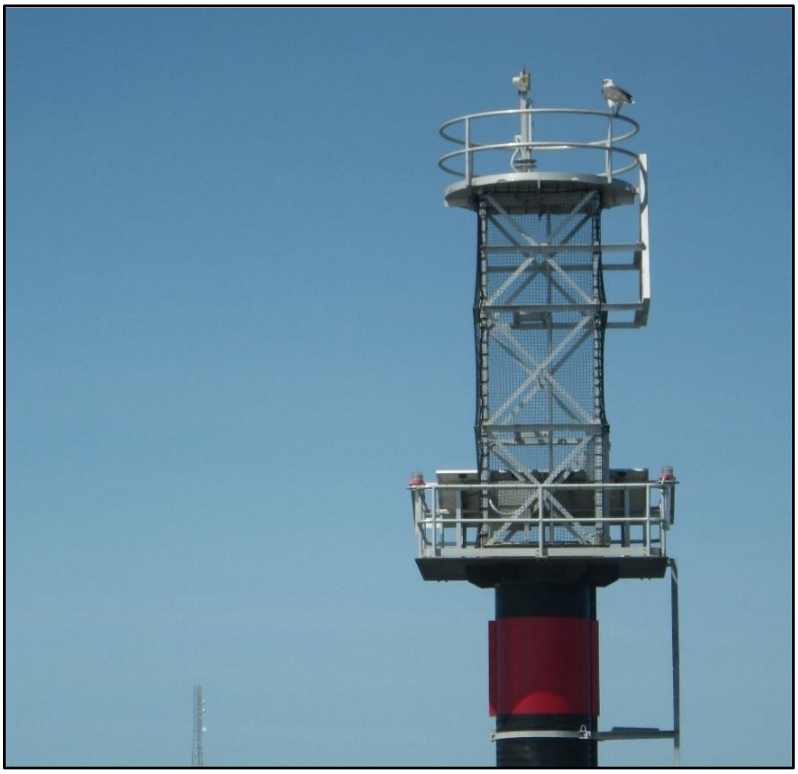


Figure 6-14 A predatory bird in the upper harbour of Port Curtis, February 2017
A White-bellied Sea-eagle on a navigation aid (Adam Leavesley, Wildlife Unlimited).

Figure 6-15 A White-bellied Sea-eagle at North Curtis Island, February 2017
(Adam Leavesley, Wildlife Unlimited)

Figure 6-16 The tidal flat at South Passage Island, February 2017.

The tidal flat around South Passage may have changed. Mapping of the tidal flat by GHD (2011c) shows a single mass. In February 2017, near to the bottom of the tide, the flat appeared U-shaped, raising the possibility that change may have occurred.

6.3 Survey Coverage and Inference

The geographical coverage and duration of this project appears suitable to meet the primary aim of monitoring the migratory shorebird populations of the Curtis Coast during a major construction phase and in the period of increased human utilisation after. The project area allows for comparison of the main work site in the Western Basin with the rest of Port Curtis. Assuming no significant change occurs to the conditions for migratory shorebirds on the eastern side of Port Curtis, inference may be drawn about the effects of the construction work and the subsequent increase in human activity in the Western Basin. Should the increase in port capacity also affect shorebirds in the lower harbour of Port Curtis, the inclusion of Fitzroy Estuary, Mundoolin Inlet, Colosseum Inlet and Rodds Peninsula allows a further comparison to be made because any effects on shorebirds in these locations are expected to be attenuated. Survey of the wider Curtis Coast also provides baseline information for other areas that may be subject to future development.

The use of the *Shorebird 2020* method allows comparison with other regularly counted sites on the Queensland coast such as Moreton Bay and other sites across Australia, New Zealand and the whole EAAF. This is important because migratory shorebird populations along the EAAF are declining (MacKinnon et al., 2012; Murray et al., 2015; Piersma et al., 2016, Clemens et al.,2016).

During the 2017 survey, construction activity associated with LNG production was in its final stages and the upper harbour of Port Curtis appeared subject to less human activity than observed during previous surveys. Previous reports have documented a snap shot of construction activity that occurred during the shorebird surveys and the project database holds the disturbance records. During construction, the effects of the various activities specified in the ERMP (Gladstone Ports Corporation, 2016) could not be easily separated from each other (Section 6.2). The reason was that most of the construction work was happening in the same place and at the same time. For the purposes of the survey the ERMP conditions were interpreted to mean that all effects of the construction work were to be considered and documented. Detailed investigation of habitat utilisation is also difficult to achieve during monitoring survey. Nonetheless, aspects noted by survey staff for their potential effect, such as tide height, have been entered into the project database and documented in reports (GHD, 2011c; Sandpiper Ecological Surveys, 2012b).

6.4 The Western Basin Reclamation Area

A total of four migratory shorebirds, three Curlew Sandpiper and one Whimbrel were recorded at the WBRA at high tide. In comparison, 327 Red-necked Stints were recorded during the high tide surveys in 2016 and three Eastern Curlew in 2015. The Curlew Sandpiper record was the first from the WBRA and the birds were observed foraging in the western pond (Figure 6-17). To date the use of the WBRA by migratory shorebirds has involved small numbers of large birds such as Eastern Curlew and Whimbrel, and Red-necked Stints in a range of flock sizes. Most of the birds have been recorded from the southern ponds. The large birds were all observed roosting; however the stints, when present have been feeding in shallow pools.

Figure 6-17 Curlew Sandpiper at the WBRA, February 2017
(Adam Leavesley, Wildlife Unlimited).

6.5 Conclusion

Survey coverage was comparable to February 2016 and previous summer surveys. Therefore, the results meet a key objective of the ERMP that populations of migratory shorebirds across the Curtis Coast are monitored annually between October and March (Gladstone Ports Corporation, 2016).

The total abundance of migratory shorebirds does not appear to have declined since the program began in 2011. The program has provided valuable knowledge about the distribution of migratory shorebirds on the Curtis Coast however population dynamics are not well enough understood to draw firm conclusions about the trajectories of the constituent species. Many migratory shorebird species on the Curtis Coast have exhibited considerable variation in their distribution in time and space and it is not safe to assume that stability in total migratory shorebird abundance indicates that all migratory shorebird populations are stable. It is an intriguing question why the total migratory shorebird abundance is apparently relatively stable when the constituent populations appear to vary so much in time and space. Understanding this issue may assist with future management.

Shorebird abundance at sites that were subject to construction disturbance generally appeared lower than at the beginning of the project but: 1) few data were collected prior to the commencement of construction; and 2) the effect was not uniform. It remains unclear whether the WBDDP activities have caused significant habitat change or long-term decline to migratory shorebird abundance in the upper harbour. It is also difficult using present methods to determine the differential effects (if any) of the various projects underway in Port Curtis such as WICET, the Curtis Island LNG developments or any other changes in patterns of use of Port Curtis that have occurred since migratory shorebird monitoring began.

The site of the WBDDP in Port Curtis appears to continue to experience a localised reduction or re-distribution of migratory shorebird numbers similar to that documented in previous reports. The completion of major construction works may change the patterns of disturbance in the upper harbour of Port Curtis and this may be reflected in the abundance and distribution of migratory shorebirds.

The Cheetham Salt Works was surveyed during the mainland shoreline survey on day 5. The results were consistent with previous findings, that the site supports an assemblage of migratory shorebirds that are relatively rare elsewhere on the Curtis Coast.

High tide surveys at the WBRA revealed 3 Curlew Sandpipers and one Whimbrel on the western pond. Surveys targeting the bund wall did not detect any birds and it appears that this feature is unsuitable for roosting. The rest of the WBRA area appears to be used intermittently by migratory shorebirds.

6.6 Recommendations

1. Following the agreed scheduling guidelines, the next annual summer survey is due on the new moon high tide from Wednesday 31 January to Sunday 4 February 2018.

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Appendix 1: EPBC Act Listed Migratory Shorebirds

Scientific name	Common name	Abbreviation
Scolopacidae		
Gallinago hardwickii	Latham's Snipe	LS
Gallinago stenura	Pin-tailed Snipe	PtS
Gallinago megala	Swinhoe's Snipe	SS
Limosa limosa	Black-tailed Godwit	BltG
Limosa lapponica	Bar-tailed Godwit	BtG
Numenius minutus	Little Curlew	LC
Numenius phaeopus	Whimbrel	W
Numenius madagascariensis	Eastern Curlew	EC
Tringa totanus	Common Redshank	CR
Tringa stagnatilis	Marsh Sandpiper	MS
Tringa nebularia	Common Greenshank	CG
Tringa glareola	Wood Sandpiper	WS
Xenus cinereus	Terek Sandpiper	TS
Actitis hypoleucos	Common Sandpiper	CS
Tringa brevipes	Grey-tailed Tattler	GtT
Tringa incana	Wandering Tattler	WT
Arenaria interpres	Ruddy Turnstone	RT
Limnodromus semipalmatus	Asian Dowitcher	AD
Calidris tenuirostris	Great Knot	GK
Calidris canutus	Red Knot	RK
Calidris alba	Sanderling	San
Calidris ruficollis	Red-necked Stint	RnS
Calidris subminuta	Long-toed Stint	LtS
Calidris melanotus	Pectoral Sandpiper	PS
Calidris acuminata	Sharp-tailed Sandpiper	StS
Calidris ferruginea	Curlew Sandpiper	CuS
Limocola falcinellus	Broad-billed Sandpiper	BbS
Philomachus pugnax	Ruff	R
Phalaropus lobatus	Red-necked Phalarope	RnP
Glareolidae		
Glareola maldivarum	Oriental Pratincole	OPc
Charadriidae		
Pluvialis fulva	Pacific Golden Plover	PGP
Pluvialis squatorola	Grey Plover	GP
Charadrius dubius	Little Ringed Plover	LRP
Charadrius bicinctus	Double-banded Plover	DbP
Charadrius mongolus	Lesser Sand Plover	LSP
Charadrius veredus	Greater Sand Plover	GSP
Charadrius leschenaultii	Oriental Plover	OP

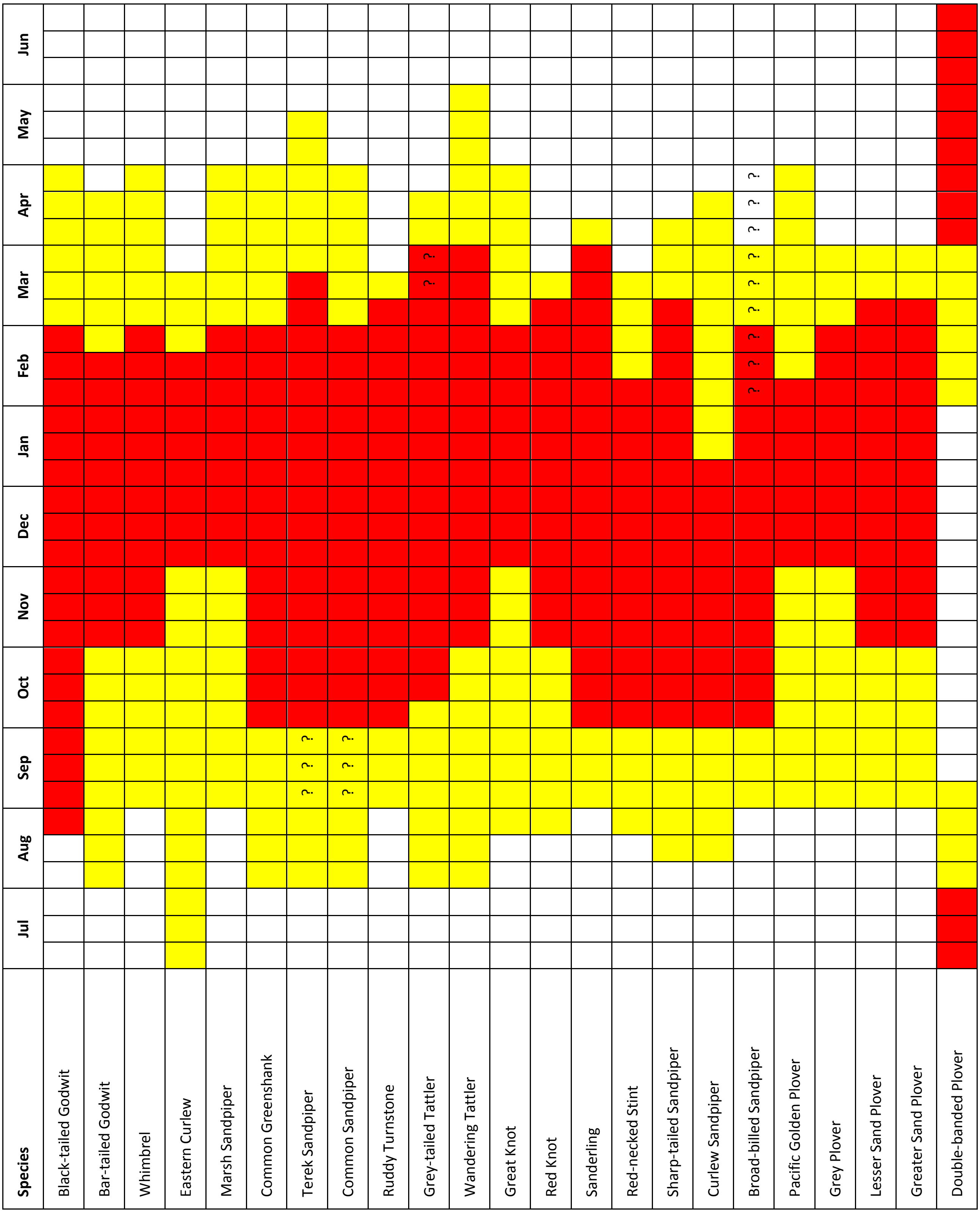
Appendix 2: EAAF Population Estimates

Common name (sub-species)	Bamford *et. al*. 2008	Wetlands International 2017	
Scolopacidae			
Latham's Snipe	36,000	25,000-100,000	Declining
Pin-tailed Snipe	25,000-1,000,000	25,000-1,000,000	Unknown
Swinhoe's Snipe	25,000-100,000	25,000-100,000	Unknown
Black-tailed Godwit	160,000	139,000	Declining
Bar-tailed Godwit (*menzbieri*)	325,000	146,000	Declining
Bar-tailed Godwit (*baueri*)		133,000	Declining
Little Curlew	180,000	180,000	Unknown
Whimbrel	100,000	55,000	Declining
Eastern Curlew	38,000	32,000	Declining
Common Redshank	75,000	10,000-100,000	Unknown
Marsh Sandpiper	100,000-1,000,000	100,000-1,000,000	Unknown
Common Greenshank	60,000	100,000	Unknown
Wood Sandpiper	100,000-1000,000	100,000	Unknown
Terek Sandpiper	60,000	50,000	Unknown
Common Sandpiper	25,000-100,000	50,000	Unknown
Grey-tailed Tattler	50,000	44,000	Declining
Wandering Tattler	—	10,000-25,000*	Unknown
Ruddy Turnstone	35,000	28,500	Declining
Asian Dowitcher	24,000	23,000	Declining
Great Knot	375,000	290,000	Declining
Red Knot (*piersmai*)	220,000	50,500-62,000	Declining
Red Knot (*rogersi*)		48,500-60,000	Declining
Sanderling	22,000	22,000	Unknown
Red-necked Stint	325,000	315,000	Unknown
Long-toed Stint	25,000	25,000	Unknown
Pectoral Sandpiper	—	1,220,000-1,930,000*	Declining
Sharp-tailed Sandpiper	160,000	160,000	Unknown
Curlew Sandpiper	180,000	135,000	Declining
Broad-billed Sandpiper	25,000	25,000	Unknown
Ruff	—	25,000-100,000*	Unknown
Red-necked Phalarope	100,000-1,000,000	100,000-1,000,000	Declining
Glareolidae			
Oriental Pratincole	2,880,000	2,880,000	Unknown
Charadriidae			
Pacific Golden Plover	100,000-1,000,000	100,000	Unknown
Grey Plover	125,000	104,000	Declining
Little Ringed Plover	25,000	25,000	Unknown
Double-banded Plover (*bicinctus*)	50,000	50,000	Declining
Double-banded Plover (*exilis*)		730	Increasing?
Lesser Sand Plover (*mongolus*)	140,000	25,500	Declining
Lesser Sand Plover (*schaeferi*)		30,000	Unknown
Lesser Sand Plover (*stegmanni*)		13,000	Declining
Greater Sand Plover	110,000	79,000	Declining
Oriental Plover	70,000	145,000-155,000	Unknown

* Only a small proportion of the population is present in the EAAF.

Appendix 3: Timing of Migration

Timing of migration for 23 species of migratory shorebirds in central Queensland following Marchant and Higgins (1993) and Higgins and Davies (1996).
Yellow: periods when the population is believed to be in flux; Red: periods when the population is present with numbers potentially at a maximum. ? = migration behaviour described as unclear.



Appendix 4: Non-migratory Shorebirds

Scientific name	Common name	Abbreviation
Burhinidae		
Burhinus grallarius	Bush Stone-curlew	BSc
Esacus magnirostris	Beach Stone-curlew	BeSc
Haematopodidae		
Haematopus longirostris	Australian Pied Oystercatcher	APO
Haematopus himantopus	Sooty Oystercatcher	SO
Charadriidae		
Erythrogobus cinctus	Red-kneed Dotterel	RkD
Charadrius ruficapillus	Red-capped Plover	RcP
Elseyornis melanops	Black-fronted Dotterel	BfD
Vanellus miles	Masked Lapwing	ML
Recurvirostridae		
Himantopus himantopus	Black-winged Stilt	BwS
Recurvirostra novaehollandiae	Red-necked Avocet	RnA

Appendix 5: Species time-series 2011-2014

Monitoring the Curtis Coast Shorebird Populations

After a series of 10 surveys on the Curtis Coast, the opportunity arises to assess the patterns of occurrence of the EPBC Act-listed migratory shorebirds. The short period over which the surveys have occurred means that few firm conclusions may be drawn, but nonetheless the information obtained is likely to be valuable for planning and contextualising future work.

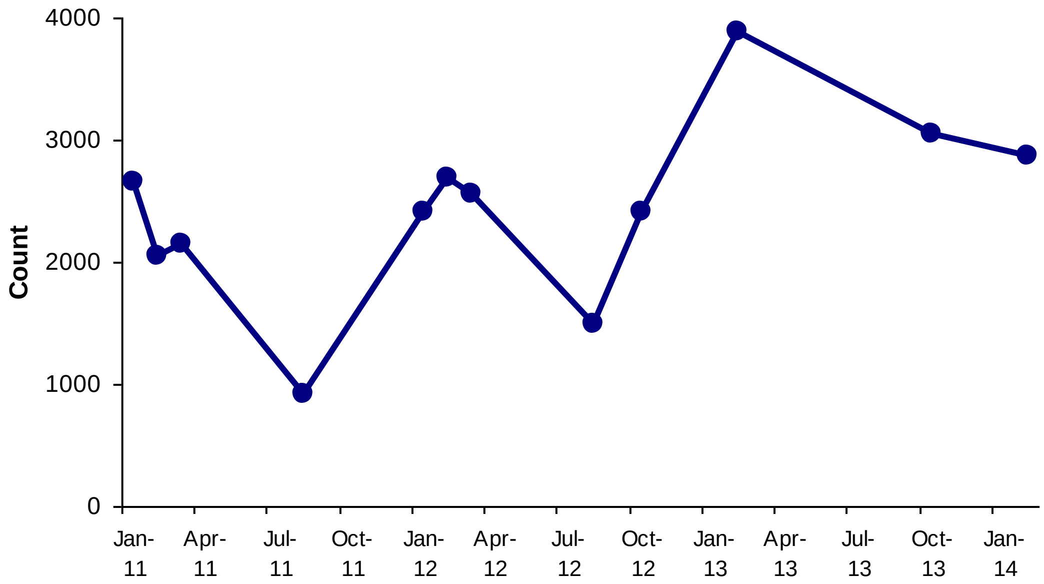
To this point, reports have focussed on the total number of birds present at the study site however this is not the key issue. In a technical sense, the term population applies to a species. It does not apply to a group of species or a community – such as the shorebirds of the Curtis Coast. It is therefore the intent of the conditions set by the regulator in the ERMP, that monitoring address the health of the populations of each of the constituent species of the Curtis Coast migratory shorebird community.

Ten species of EPBC Act-listed migratory shorebirds are present in sufficient numbers to justify an exploration of the data and speculative characterisation of their population dynamics on the Curtis Coast. These species are: Bar-tailed Godwit, Whimbrel, Eastern Curlew, Terek Sandpiper, Grey-tailed Tattler, Great Knot, Red-necked Stint, Grey Plover, Lesser Sand Plover and Greater Sand Plover.

A set of time-series for these species may potentially shed some light on a number of questions. 1) The size of the population. 2) The variation in the size of the population between years – i.e. the long term trend in numbers. 3) The variation in the size of the population within a season or a year – the timing of migration and the context of figures obtained in particular months.

The single species time-series show that the relatively stable counts obtained for the Curtis Coast are concealing considerable variation from species to species. A stable total count does not signal that the populations of all the constituent species are also stable.

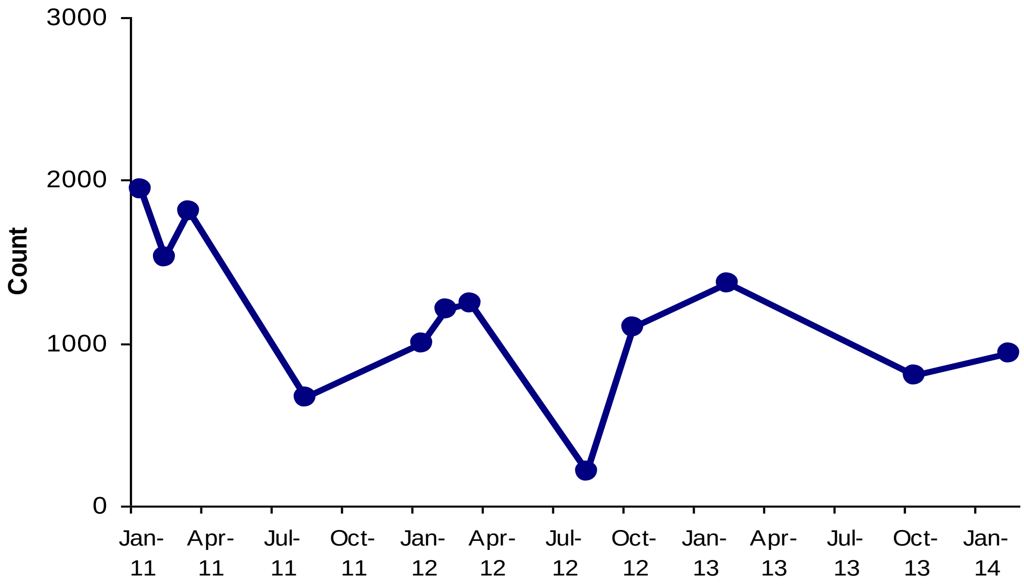
Bar-tailed Godwit



Bar-tailed Godwit time series at the Curtis Coast from January 2011 to February 2014.

Peak numbers of Bar-tailed Godwits appeared to occur in summer. The August 2012 and February 2013 surveys showed an increase from their respective months in the previous year suggesting that the species may have experienced successful breeding seasons (Minton et al., 2012). The northward migration did not appear to make a difference to godwit numbers in March however the possibility that birds moving north were being replaced by others from further south could not be ruled out. Abundance in October 2012 was considerably lower than February 2016 suggesting that godwits may not have staged at the Curtis Coast during the southward migration. However the October 2013 figure was greater than the February 2014 figure, suggesting that staging may have occurred.

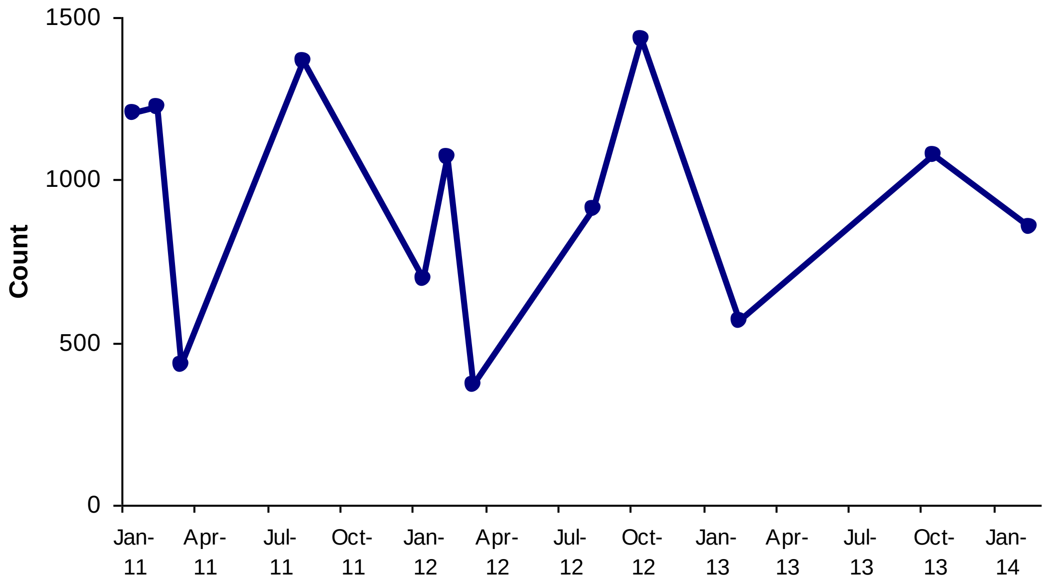
Whimbrel



Whimbrel time series at the Curtis Coast from January 2011 to February 2014.

Whimbrel numbers appeared to peak on the Curtis Coast in the Austral summer and during the study period, the summer figure was reasonably stable. Migration did not appear to make a difference to Whimbrel numbers in March however this did not rule out that birds moving north were being replaced by others from further south. October abundances were consistently lower than the February abundances. The decrease in numbers between August 2011 and August 2012 may have reflected a poor 2011 Arctic breeding season.

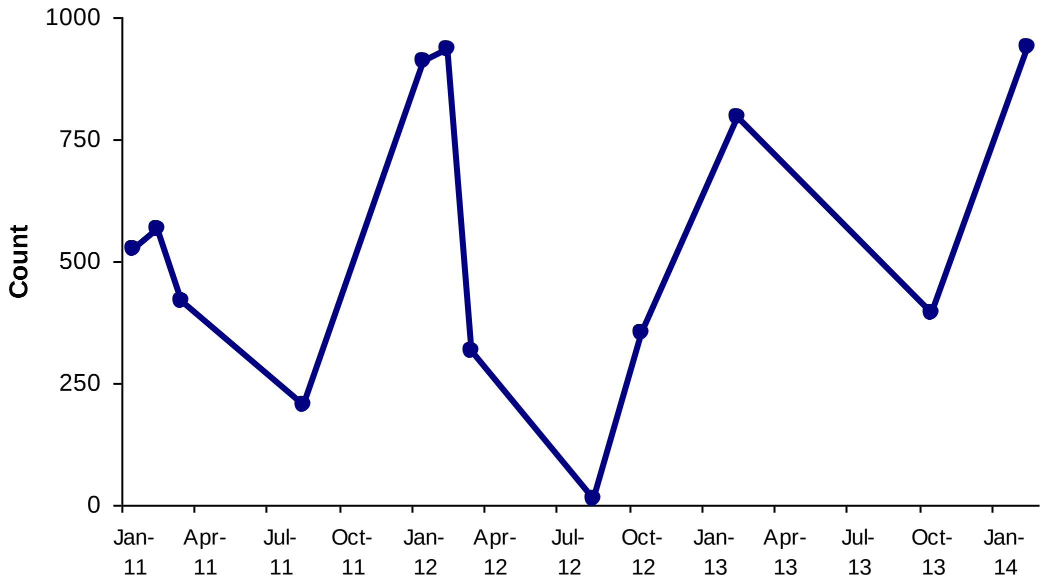
Eastern Curlew



Eastern Curlew time series at the Curtis Coast from January 2011 to February 2014

Eastern Curlew showed an atypical annual pattern of abundance. Numbers were unusually high in August and this may have been due to the movement of young birds north along the Australian coast during the Austral winter (Wilson, 2000; Minton et al., 2011). These birds are then believed to migrate south again during the Austral summer. Numbers were considerably lower in March than they were in January and February. This may reflect the commencement of the northward migration by breeding birds that would appear to have begun in mid-February. This is consistent with Higgins and Davies (1996) but appears to contradict more recent work (Minton et al., 2011). The high counts in October compared to February suggests that birds may have staged through the Curtis Coast on the southward migration.

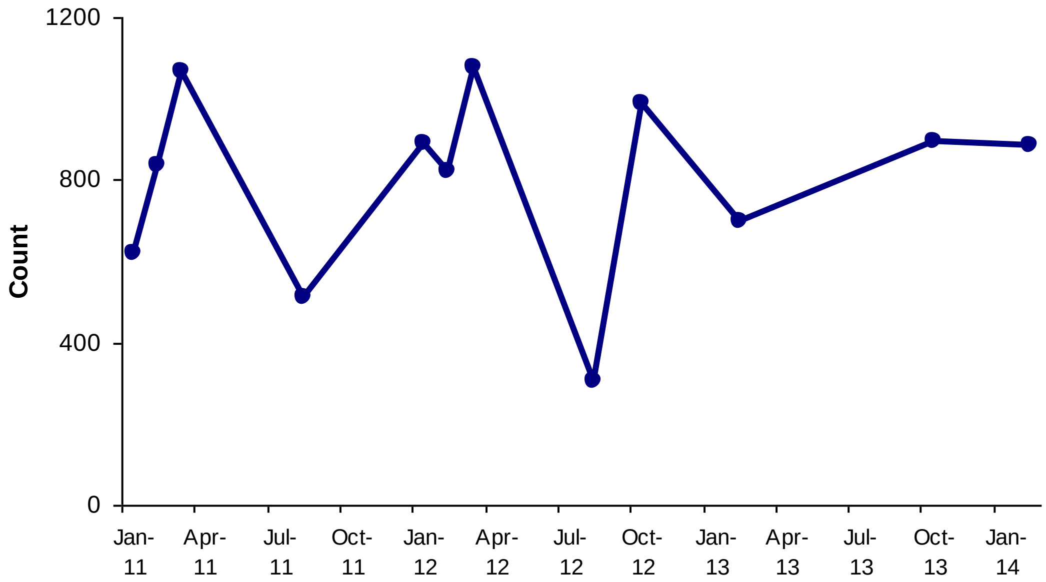
Terek Sandpiper



Terek Sandpiper time series at the Curtis Coast from January 2011 to February 2014

The peak abundance for Terek Sandpiper appeared to be January and February. Numbers declined in March suggesting that birds may have commenced the northward migration sometime in the second half of February. The relatively low counts in October compared to February suggested that numbers were still building throughout October. It may also indicate that the species did not stage through the Curtis Coast during the southward migration. The August 2012 count appeared considerably lower than the August 2011 count which may indicate that the 2011 Arctic breeding season was not very successful.

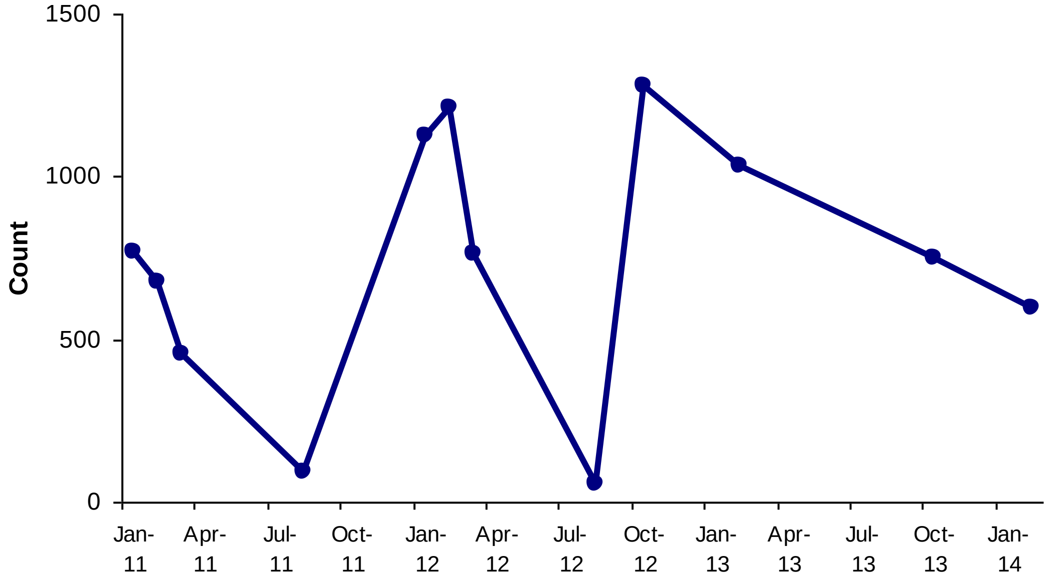
Grey-tailed Tattler



Grey-tailed Tattler time series at the Curtis Coast from January 2011 to February 2014

Grey-tailed Tattler showed an increase in numbers from January and February to March. This may indicate that birds moved into the Curtis Coast from further south at a greater rate than the summer residents were departing. The high figures in October compared to February 2014 may indicate that the Curtis Coast was used as a staging area for the southward migration.

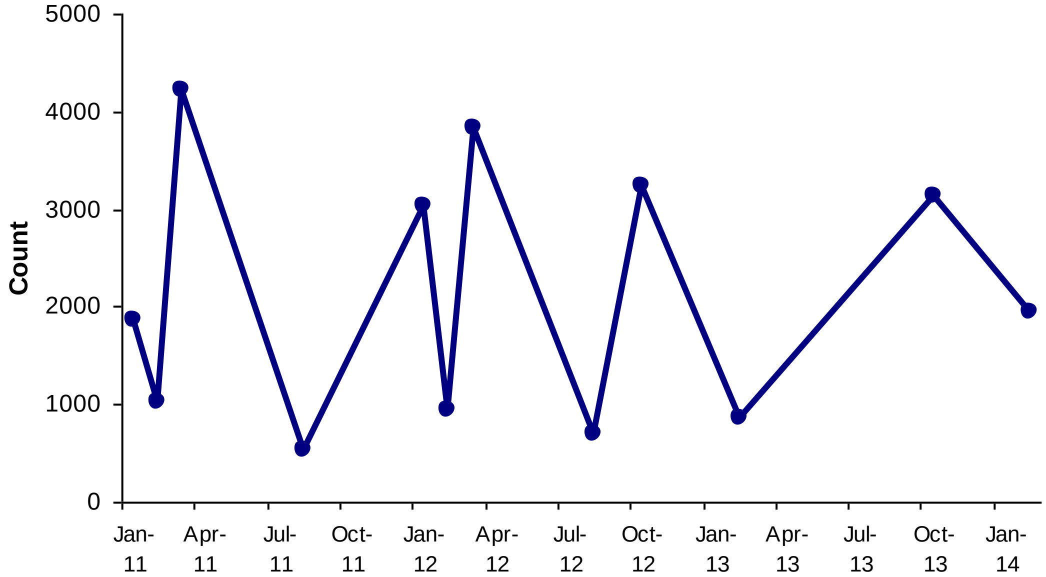
Great Knot



Great Knot time series at the Curtis Coast from January 2011 to February 2014

The annual peak in abundance for the Great Knot appears to be January and February. Numbers declined in March suggesting that birds may commence the northward migration sometime in the second half of February. The relatively high counts in October compared to February suggests that birds may stage through the Curtis Coast on the southward migration. Numbers in August were low in both years suggesting that few birds winter on the Curtis Coast.

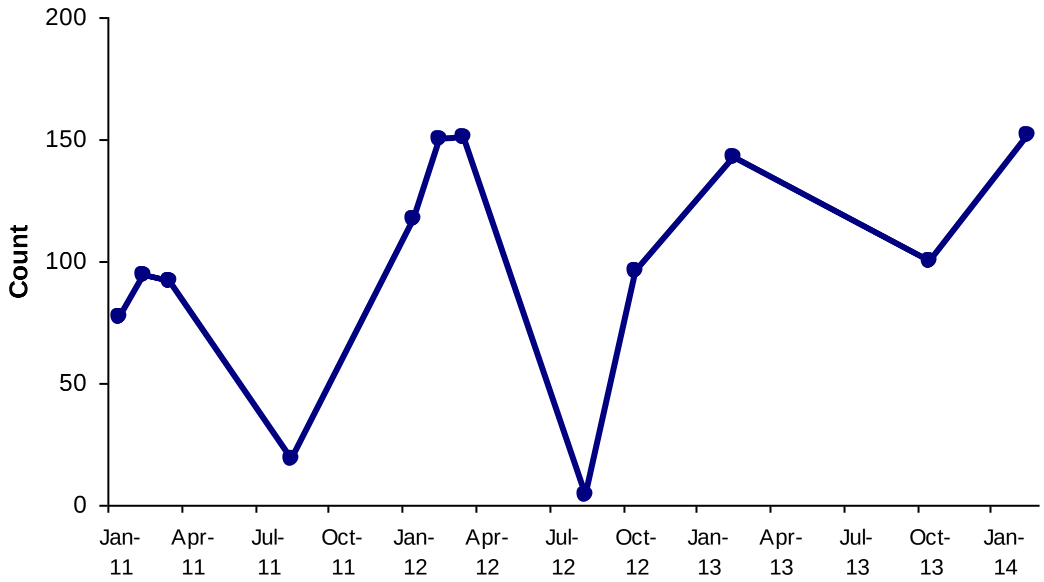
Red-necked Stint



Red-necked Stint time series at the Curtis Coast from January 2011 to February 2014

Red-necked Stint showed a rapid intra-annual rise and fall in numbers on the Curtis Coast. Maximum numbers were recorded in March suggesting that birds stage through the Curtis Coast on the northward migration. Another smaller peak occurred in January, but three of the four February surveys returned relatively low numbers. A potential explanation for this pattern is that stints may migrate northward in two groups perhaps determined by age or sex. One group appeared to leave the Curtis Coast in the second half of January or early February, while the second group staged through the region in March. The estimates from October were relatively high compared to the following February. This may indicate that stint numbers approach their summer maximum in October or perhaps stage through the Curtis Coast during the southward migration. No October-January comparison was collected and that would be useful. Records from the Cheetham Salt Works which were collected at a higher frequency than this survey are consistent with the staging suggestion (Houston et al., 2012).

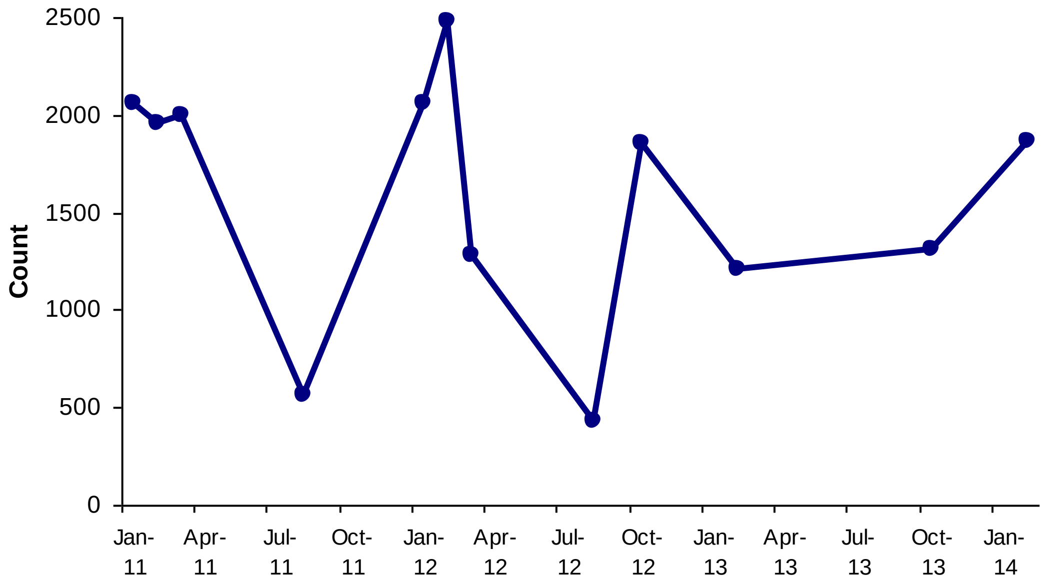
Grey Plover



Grey Plover time series at the Curtis Coast from January 2011 to February 2014

The numbers of Grey Plover on the Curtis Coast may not be sufficient to generate a consistent pattern over a longer time period. For the present however, numbers appeared to peak in February and March. This may indicate that the Grey Plover northward migration did not occur until April, or alternatively, that as the summer residents migrate northward, their numbers were replaced by birds from further south. The August surveys recorded very few birds and the October surveys returned a figure considerably lower than that recorded the following February. This suggests that the southward migration may have still been underway in October.

Sand Plover species



Sand Plover species time series at the Curtis Coast from January 2011 to February 2014

Sand Plover numbers were inconsistent across the Curtis Coast during the study period. The first two years suggested a January-February annual peak in abundance however the October 2012 survey returned a higher figure than the February 2013 survey, which suggested that southward staging may have occurred. The following year, the October abundance estimate was lower than the February estimate. The timing of the northward migration in 2012 was also inconsistent. The 2011 data suggested a late March departure but the 2012 data suggested a late February departure. Potential reasons for the inconsistencies were: 1) the birds may not follow a strict timetable; 2) the apparent effects may have been an artefact of the survey timing; 3) the combination of two species may have confounded the pattern; and 4) the floods in January 2014 associated with TC Oswald may have affected the abundance of one or both species on the Curtis Coast. The information obtainable will be improved if the proportion of birds not identifiable to species level is reduced.

Appendix 6: Variation in Summer Migratory Shorebird Counts at Corner Inlet, Victoria

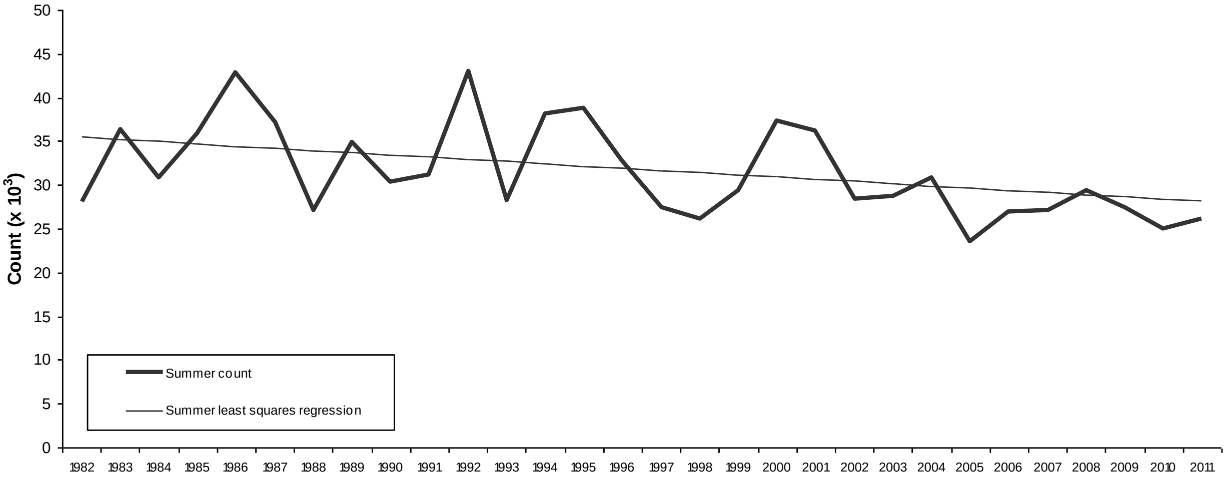


Figure A6.1 Migratory Shorebird Count at Corner Inlet from 1982-2011, reproduced from Minton *et al*. (2012). A standardised method was used throughout the period.