Gladstone Ports Corporation

Report for Migratory Shorebird Monitoring

Port Curtis and the Curtis Coast

Annual Summer Survey - 2018

Report prepared for Gladstone Ports Corporation

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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 2018 annual shorebird monitoring summer survey was carried out on the full moon spring tide over five days from 31 January - 5 February. Poor weather forced a stand down day on 4 February. A total of 150 roosts were surveyed over six days in the order of Port Curtis; Rodds Peninsula; Mainland Shoreline and the Western Basin Reclamation Area; North Curtis Island; Fitzroy Estuary; Mundoolin Rocks and Colosseum Inlet.

- The Cheetham salt works at Bajool were surveyed on a falling high tide. Six sites were surveyed from the road on 1 February.

- Weather conditions for the survey were good for the first two days but winds intensified over the last four days with strong wind warnings declared for the Capricorn Coast. There were also periods of rain and mist. The survey team stood down on 4 February due to a strong wind warning.

- Predicted tide heights were at the top of the range for Gladstone for 2018 – up to 4.80m on 2 February - due to the coincidence of the moon's perigee with the spring tide, i.e. a super moon.

- Survey coverage was similar to the 2017 and previous summer surveys except that one large roost in Colosseum Inlet with a 2011-2017 mean abundance of 108 birds could not be surveyed due to safety considerations. This figure is 0.8 percent of the summer average calculated from 10 surveys conducted in January and February over the life of the project (2011-2018).

- A total of 12,986 migratory shorebirds consisting of 19 species was recorded during the high tide roost surveys. This was 8 percent fewer than the equivalent figure from February 2017 but 5 percent more than the summer average.

- The slight change in the total abundance of migratory shorebirds compared to the previous year was due to substantially lower abundances of six species: Terek Sandpiper, Greater Sand Plover, Bar-tailed Godwit, Whimbrel, Great Knot and Broad-billed Sandpiper. All of these species remained within the range of previous summer surveys except the Great Knot which returned the lowest summer abundance of the project.

- Substantially higher abundances were recorded of Red-necked Stint, Grey-tailed Tattler and small waders that were not able to be identified to species. The Grey-tailed Tattler abundance was the highest for the project for the third year in a row.

- The 10 most abundant species accounted for 97 percent of the records and this is comparable with previous surveys. The composition of the 10 most abundant species changed slightly, returning to the combination recorded every year except 2017 when an unusually high number of Curlew Sandpipers and Broad-billed Sandpipers were recorded.

- A total of 707 Red-necked Stints, four Whimbrel and three Eastern Curlew were recorded on the WBRA during the high tide survey. The Red-necked Stints were observed feeding. Two Whimbrel were recorded roosting on the bund wall, the first occasion on which this has been observed.

- Shorebird abundance was relatively evenly spread across the four management units: Port Curtis (3256), Fitzroy Estuary (3701 birds), North Curtis Island (3153) and Mundoolin-Colosseum-Rodds (2876 birds).

- Two roosts were recorded with >1000 shorebirds, both of which were in the Fitzroy Estuary. Four roosts were recorded with 500-1000 shorebirds, two each at North Curtis Island and Port Curtis. There were 18 roosts in the 100-500 class, eight of which were in the Mundoolin-Colosseum-Rodds management unit.

- 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 of this variation may be explained by migration dynamics described by Choi et al. (2017) that were not understood at the commencement of the project.

- Some migratory shorebird roosts in Upper Gladstone Harbour appear to continue to experience a redistribution of migratory shorebirds and possibly a localised reduction compared with surveys conducted in 2011. This situation has been documented in previous reports.

- Activities that may have caused changes include: works at the Clinton Ash Ponds; works associated with the Wiggins Island Coal Export Terminal and disturbance due to increased maritime traffic around North and South Passage Islands.

- We have adopted the recommendation of Choi et al. (2017) that the most appropriate management units for migratory shorebirds on the Curtis Coast are: Port Curtis, Fitzroy Estuary, North Curtis Island and Mundoolin-Colosseum-Rodds.

- We have updated the migratory shorebird migration timing table we developed in 2012, with information published by Choi et al. 2017.

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 (GPC) (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 LNG plant on Curtis Island, February 2018
South Passage Island, a mangrove roost, is in the foreground (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 sixth 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 sixth annual summer survey – February 2018 – following the established methods.

Figure 1-2 The swing basin at the Wiggins Island Coal Export Terminal (WICET), February 2018
The vessel is the Big Fish, a 177,662 dwt Capesize bulk carrier registered in the Marshall Islands. Capesize ships are so named because they are too big to traverse the Panama Canal (Adam Leavesley, Wildlife Unlimited).

Figure 1-3 LNG vessel berthing in Gladstone, February 2018
There were three LNG vessels in Port Curtis during the 2018 survey. Pictured is the YK Sovereign, a 72,020 dwt Korean-registered vessel bound for Pyeongtaek in South Korea. Also present was the BW Pavilion Vanda, a 91,515 dwt Singapore-registered vessel bound for Yeosu in South Korea; and the Methane Alison Victoria, a 79,058 dwt Bermuda-registered ship bound for Himeji in Japan (Adam Leavesley, 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 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 included 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; 2017).

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.

2.3 Migratory Shorebirds on the Curtis Coast

A thorough investigation of migratory shorebird habitat and patterns of use on the Curtis Coast conducted under the auspices of the ERMPAP (Choi et al. 2017) has markedly increased understanding of the carrying capacity of the study area and the patterns of use by migratory shorebirds. The study combined bird counts, prey sampling and radio tracking of birds. The total number of migratory shorebirds that use the Curtis Coast annually was found to be about 20,000. Of these, 44 percent stopover in the area on their journey to foraging grounds further south. For species such as Curlew Sandpiper, Red Knot, Broad-billed Sandpiper, Sharp-tailed Sandpiper and Ruddy Turnstone, which have been recorded in low numbers over summer, the Curtis Coast is more important as a staging area.

A study of the migratory shorebird movement on the Curtis Coast, including radio tracking indicated that birds have high site fidelity, returning to the same roosts and foraging grounds each year and remaining mostly at those sites throughout the Austral summer. There are three key ramifications associated with this finding. 1) It provides support for a key assumption of the five-day survey method because the likelihood of double counting of birds in different regions of the Curtis Coast on different days is low. 2) The movement patterns suggest that the region be divided into four migratory shorebird management units in the Fitzroy Estuary, North Curtis Island, Port Curtis and Mundoolin-Colosseum-Rodds Peninsula. 3) The small amount of movement that does occur within the region means that loss or degradation of habitat affects more animals than may be typically present at a site and this needs to be taken into account when development decisions are made. This issue is even more important when considering the needs of the birds which stopover on migration. 4) A related finding was that the diurnal and nocturnal movement patterns were strikingly different. This means that daytime surveys are not sufficient to understand all the habitat requirements of the birds.

Migratory shorebird food is present on the Curtis Coast at low density by international standards. In addition, the prey has low digestible content and is patchy across the tidal flats and across the tidal cycle. Many of the best foraging areas are only exposed at the lowest tides for a short period of time. Taking into account these factors, it appears that the Curtis Coast is close to carrying capacity, that is the number of birds present is roughly in line with the number able to be supported by the amount of food.

The overall conclusion of Choi et al. (2017) was that the migratory shorebird ecosystems on the Curtis Coast were healthy, but vulnerable to further loss of habitat or a reduction in habitat quality. The appropriate scale for shorebird management is smaller than the study area (the Curtis Coast), but point locations are too small. Hence the recommendation of management units at a scale commensurate with the observed movement of birds and defined by breaks in contiguous habitat.

A number of other findings from the study are relevant to the annual shorebird count and this report.

- The study produced estimates of the migration timing for 16 migratory shorebird species including the 10 most abundant during surveys in early February. This is important information for understanding the data collected during this project. It can also be used to determine the best timing for surveys.
- The estimated daily mean tidal flat exposure on the Curtis Coast varied from 8,900ha to 12,400ha. This compares with an estimate of 10,067ha produced by GHD (2011c).

Figure 2-1 Migratory shorebirds roosting at Deception Point, February 2018
Pictured are Bar-tailed Godwits, Greater Sand Plover, Lesser Sand Plover and Red-capped Plover (Adam Leavesley, Wildlife Unlimited).

Figure 2-2 A large flock of Red-necked Stints at Deception Point, February 2018
More than 2000 Red-necked Stints were roosting at Deception Point. Also pictured are Lesser Sand Plover and Red-capped Plover (Adam Leavesley, Wildlife Unlimited).

Figure 2-3 The roost at Yellow patch sandbar, February 2018
Pictured are Bar-tailed Godwits, Great Knots and Lesser Sand Plovers which are all migratory shorebirds. Also present is a non-migratory shorebird, the Australian Pied Oystercatcher and two seabird species (Adam Leavesley, Wildlife Unlimited).

Figure 2-4 Lesser Sand Plovers and Ruddy Turnstones at Tannum Sands, February 2018.
(Adam Leavesley, Wildlife Unlimited)

Figure 2-5 A Black-winged Stilt at Clinton Ash Ponds, February 2018.
The species is non-migratory and breeds at the site (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 were expected to be present by the beginning of December (Appendix 3). One of these species, the Curlew Sandpiper, was expected to begin its northward migration in mid-January but no other species was believed to leave before mid-February. This left 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, the longer daylight hours of August are more desirable then

June and July 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.

Recent work by Choi et al. (2017) indicates that migratory shorebirds present on the Curtis Coast can be classified to one of three classes relating to the timing of their migration in comparison with the early February survey date (Table 3-1). The classes are: 1) summer resident, not migrating; 2) summer resident, migrating; and 3) Not-resident. The survey date is suitable to deliver an accurate estimate of summer abundance for species in class 1 and this includes seven of the 10 most abundant species from the February surveys during the project. Estimates for species in class 2 are likely to be subject to the effects of migration and this includes three species of the 10 which are most abundant in February. Species in class 3 are predominantly in transit on the Curtis Coast and return the highest counts at other times of year. An updated summary of migration dates, including the work of Choi et al. (2017) is at Table 3-5.

Table 3-1 The migration status of migratory shorebird species on the Curtis Coast in early February
The table was compiled following Choi et al. (2017).

Resident, not migrating	Bar-tailed Godwit, Common Greenshank, Eastern Curlew, Great Knot, Grey Plover, Greater Sand Plover, Grey-tailed Tattler, Whimbrel
Resident, migrating	Lesser Sand Plover, Red-necked Stint, Terek Sandpiper
Non-resident	Broad-billed Sandpiper, Curlew Sandpiper, Red Knot, Ruddy Turnstone, Sharp-tailed Sandpiper

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 four management units following the method of Choi et al. (2017). The management units are: Port Curtis incorporating the mainland

foreshore (Figure 3-1); Fitzroy Estuary (Figure 3-2); North Curtis Island; and Mundoolin-Colosseum-Rodds (Figure 3-3). Data from the Cheetham Salt Works at Bajool has been excluded from analyses using the putative management 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; 2017). 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 amplitude than average due to high tides being higher and low tides being lower. Predicted tide heights for the 2018 survey were at the top of the range for the Curtis Coast because the moon's perigee – closest point to earth – coincided with the spring tide. The event was reported in the media as a 'super blue blood moon'. The standard survey path was followed and counting was conducted from the standard survey points.

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 scheduled to be conducted for five consecutive days coinciding with a full moon spring tide, from 31 January - 4 February. However, a low-pressure system lying east of the central Queensland coast brought strong south-easterly winds leading the Bureau of Meteorology to issue a series of strong wind warnings (30-40 knots) for the Capricorn Coast commencing on 1 February. The survey schedule was consequently adjusted in consultation with the boat operator to maintain operational safety (Table 3-2). Nonetheless, a stand down day was required on 4 February when wind observations at Rundle Island exceeded 40 knots; i.e. reached gale force. The final day of the survey was completed on 5 February with a strong wind warning current.

Table 3-2 Survey schedule for February 2018

Date	Scheduled locations
31 January	Port Curtis
1 February	Rodds Peninsula, Mainland Shore, Cheetham Salt Works
2 February	North Curtis Island
3 February	Fitzroy Estuary
4 February	Stand-down
5 February	Colosseum Inlet and Mundoolin Rocks

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 3-3). The procedure largely follows Australian Government guidelines (DEWHA, 2009b) and is commonly used around Australia.

Table 3-3 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 3-4). 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. 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.

Table 3-4 Bureau of Meteorology predicted tide heights and times at Gladstone
The survey was not conducted on 4 February because the weather was unsuitable

Date	High tide		Low tide	
	Time	Height	Time	Height
31 January	09:05	4.77m	15:31	0.47m
1 February	09:51	4.80m	16:15	0.42m
2 February	10:37	4.72m	16:58	0.48m
3 February	11:21	4.53m	17:39	0.64m
4 February	12:05	4.26m	18:19	0.87m
5 February	12:47	3.93m	18:59	1.13m

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 at 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 two. 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; 2017).

The salt works were surveyed on 1 February 2018 during the mainland shoreline schedule. The sites surveyed were those accessible from the road.

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 2018 survey and the area of intertidal flat as determined by GHD (2011c). The GHD data have been superseded by Choi et al. (2017) who accounted for variation in the tidal range. However, the

established method has been retained for this report because: 1) the GHD value falls within the range of values calculated by Choi et al. (2017); and 2) to maintain continuity between reports. The established method is a blunt tool which does not take into account the tidal range or the foraging preferences of each species (Colwell, 2010). It does however, serve two useful functions: 1) provides a standardised comparison between management units; and 2) helps to contextualise changes in shorebird community composition in Port Curtis through time. This may be helpful if the area of foraging habitat in Port Curtis was reduced by the WBDDP. If the area of foraging habitat in Port Curtis was adjusted for any changes, these analyses may assist in determining whether the quality of shorebird foraging habitat had changed (i.e. habitat alteration; DEWHA, 2009b) or whether birds subject to disturbance had become habituated to disturbance as discussed by GHD (2011a; 2011c).

The summer average total abundance of migratory shorebirds was calculated using January and February surveys conducted for this project from 2011-2018. The surveys were conducted in January 2011-2012, and February 2011-2018.

This report presents some single species comparisons between management units between years. This approach has been taken because: 1) it is 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 Survey sites in the Port Curtis management unit.

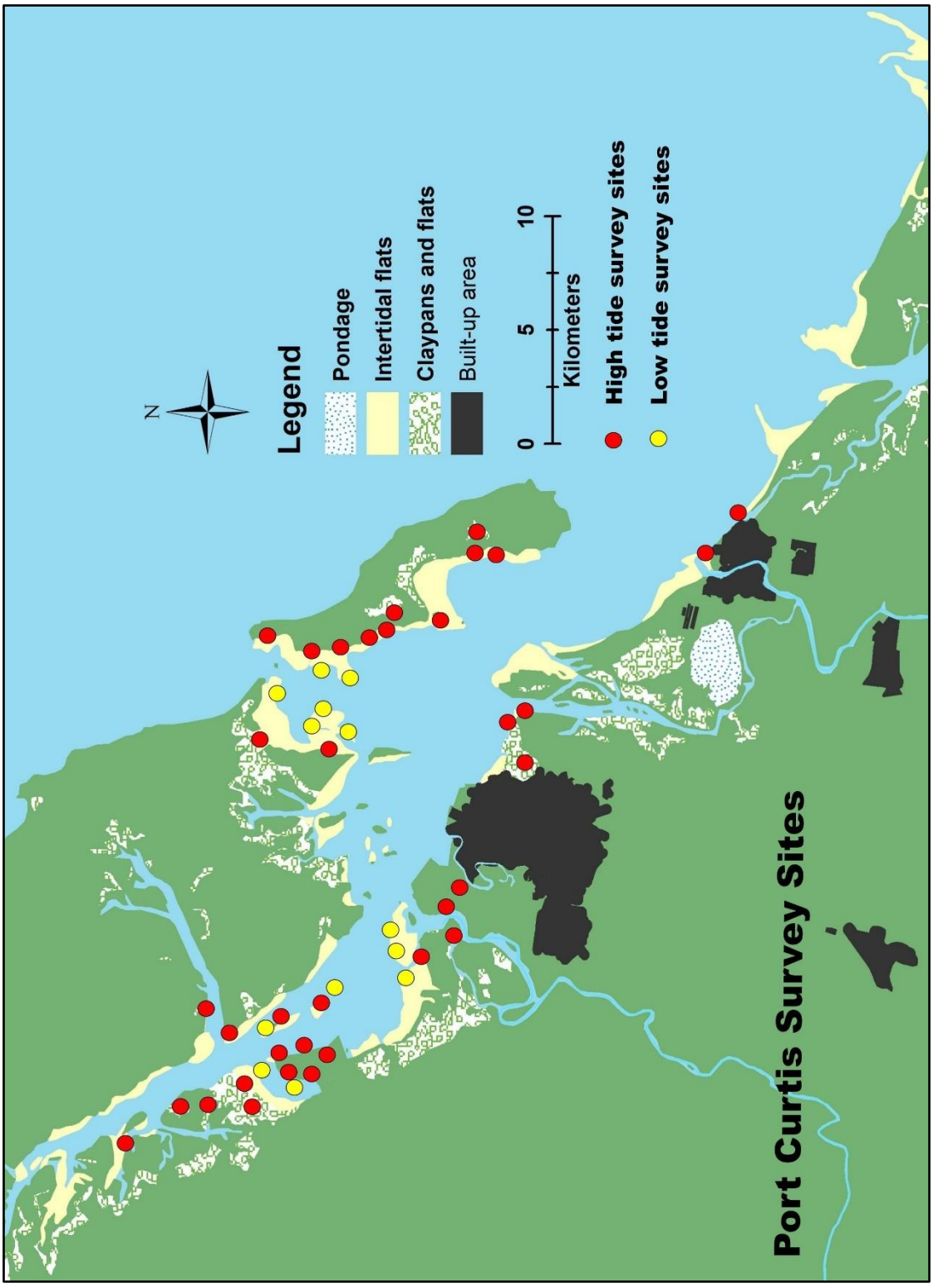


Figure 3-2 Survey sites in the Fitzroy Estuary and North Curtis Island management units.

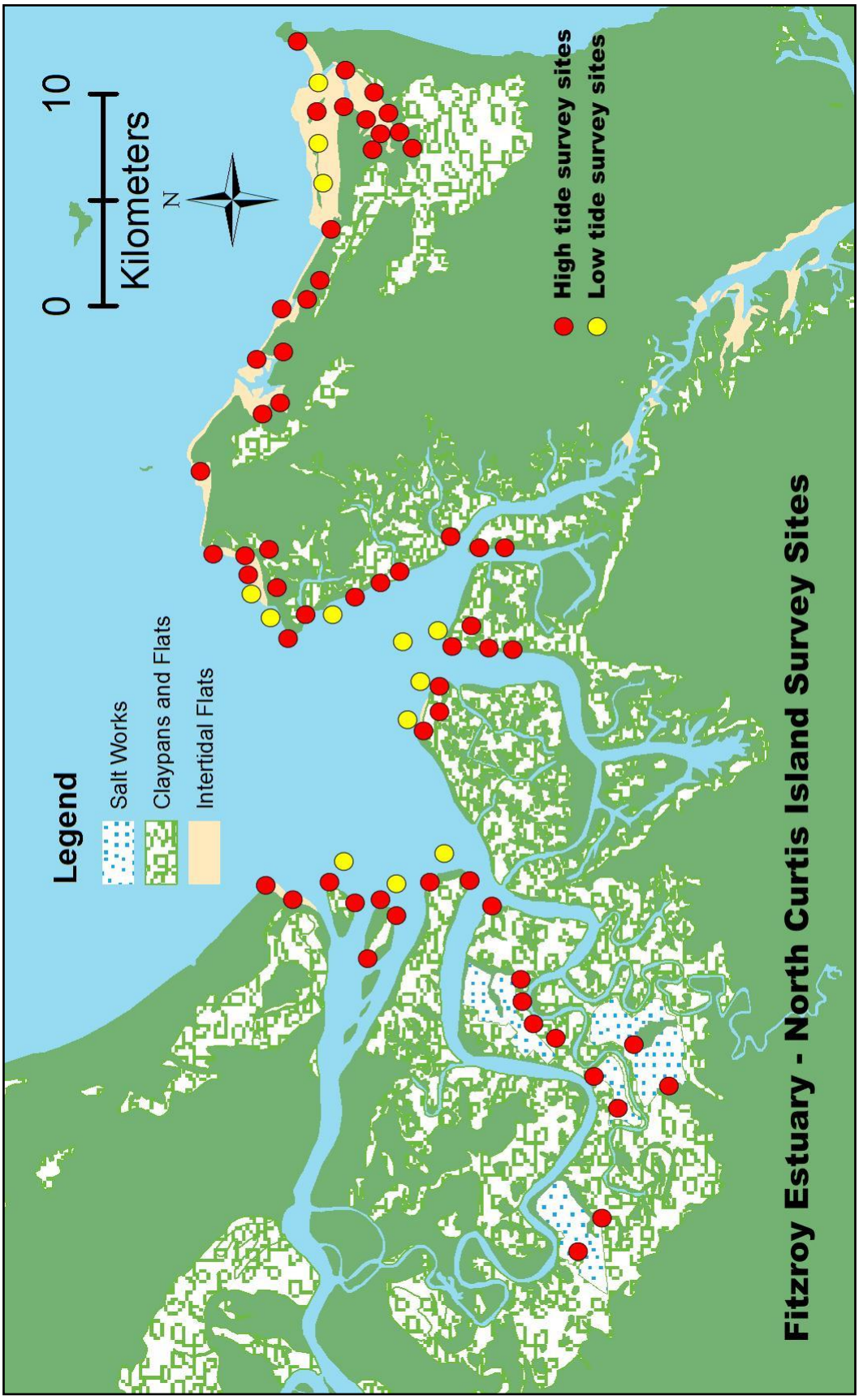


Figure 3-3 Survey sites in the Mundoolin-Colosseum-Rodds management unit.

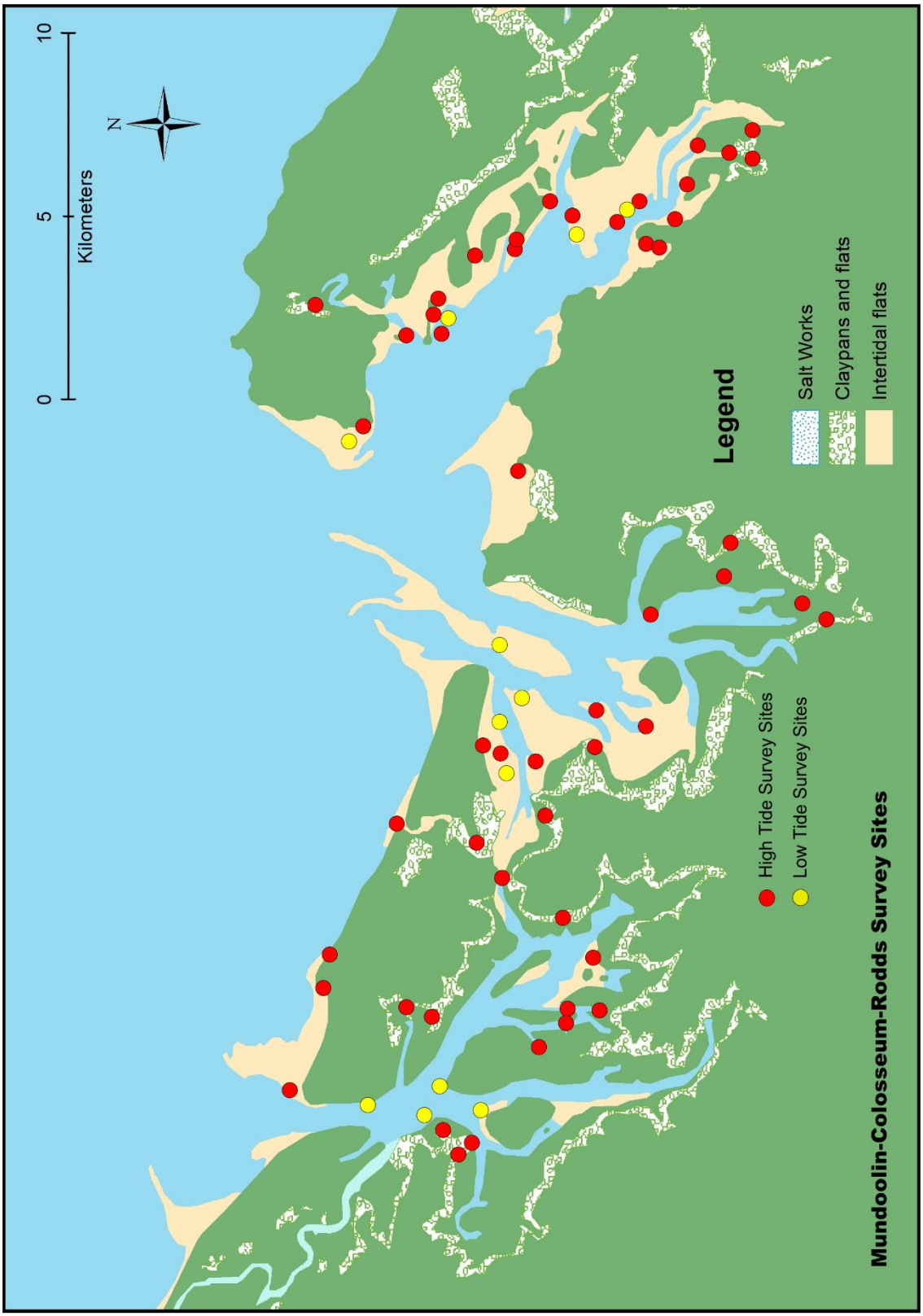
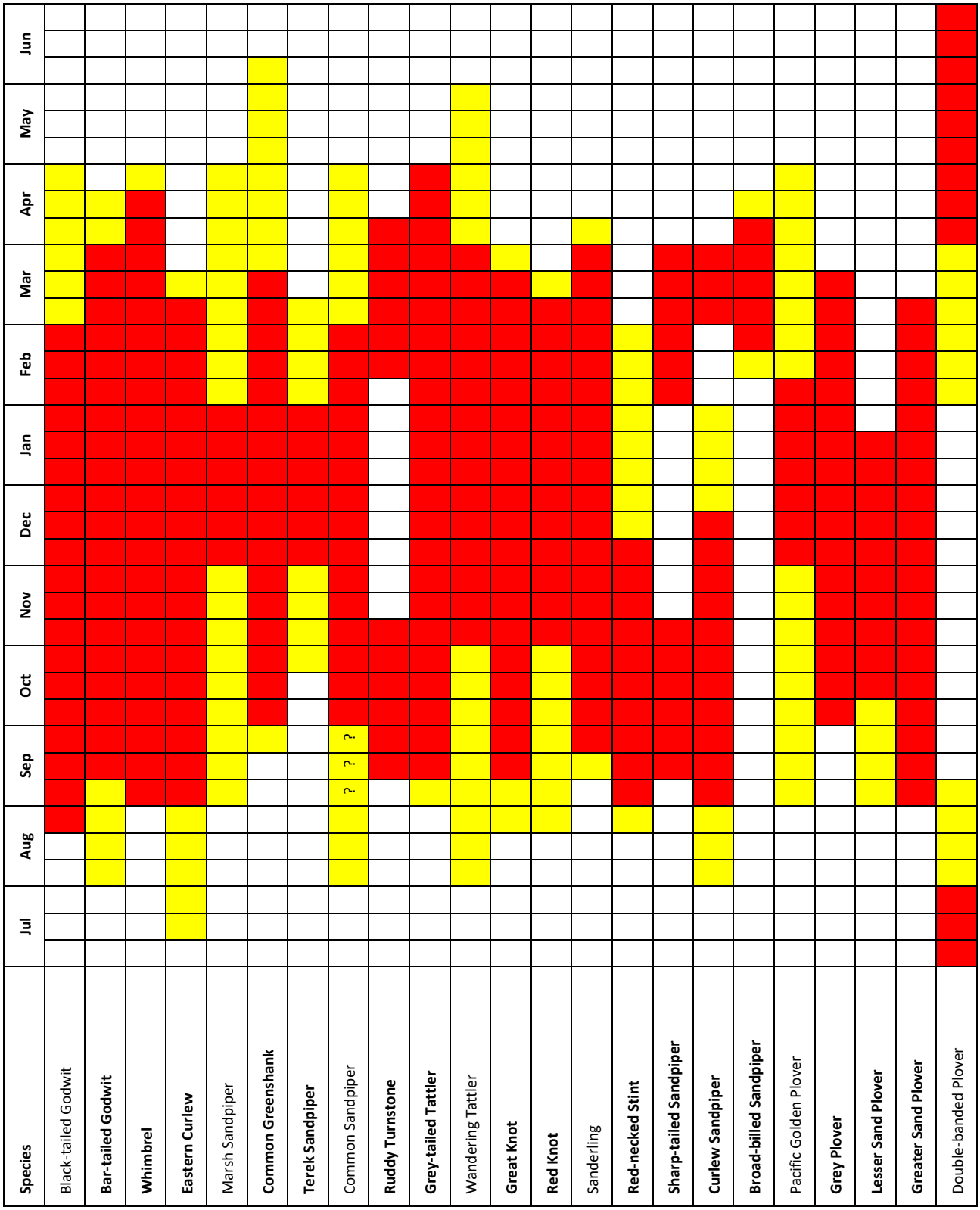


Table 3-5 Updated timing of migration for 23 species of migratory shorebirds on the Curtis Coast. Timing of migration for 16 species of migratory shorebirds on the Curtis Coast following Choi *et al*. (2017; species names in bold). Migration timing for the remaining seven species on the central Queensland coast follows Marchant and Higgins (1993) and Higgins and Davies (1996). Yellow signifies when the population is in flux, red signifies the peak of a species presence and a "?" indicates uncertainty.



4 RESULTS

4.1 Survey coverage

The coverage of this high tide roost survey was comparable with that of previous years, though it should be noted that a single site, Mundoolin Rocks north beach (site 65), with a mean abundance of 108 birds during February surveys 2011-2017 (Wildlife Unlimited, 2017; Appendix 5) was unable to be counted due to safety considerations. A total of 150 high tide surveys were completed (Table 4-1) which was four fewer than February 2017. The total survey time at high tide was 1328 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.

The coverage of the low tide survey was affected by the weather conditions. The planned survey schedule was completed at Port Curtis and Rodds Peninsula on the first and second days and some work was completed at North Curtis Island on the third day. However, no work was possible in the Fitzroy Estuary on day four or in Mundoolin Rocks-Colosseum Inlet on day six. A total of 19 sites were surveyed at low tide for a duration of 325 minutes. This was 13 sites fewer than was surveyed in February 2017.

The weather during the high tide roost survey was good for the first two days but sub-optimal for the remaining four days. The wind strength was generally good with 67 percent of sites counted in winds estimated to be <20km/h. Conversely four sites were counted during winds >29km/h. However, surveys were affected by periods of rain and mist on the third and fourth days. Weather conditions were generally worse during low tide with only 37 percent of surveys occurring during winds <20km/h. Rain and mist curtailed low tide surveys on day three.

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	43	451	14	175
Fitzroy Estuary	23	263	0	0
North Curtis Island	37	238	3	117
Mundoolin-Colosseum	22	219	0	0
Rodds Peninsula	19	134	2	33
Cheetham Salt Works	6	23	0	0
Total	**150**	**1328**	**19**	**325**

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 2018 was 12,986 (Table 4-14, Figure 4-1) consisting of 19 species (Figure 4-2). This figure is 7.3 percent fewer than was recorded in February 2017 (14,003 birds). Two species recorded last year were not recorded this year. These were Broad-billed Sandpiper and Double-banded Plover. The composition of the 10 most abundant species differed from last year with the Grey Plover replacing the Curlew Sandpiper at number 10. The 10 most abundant species listed in descending order were Red-necked Stint, Bar-tailed Godwit, Grey-tailed Tattler, Terek Sandpiper, Whimbrel, Lesser Sand Plover, Eastern Curlew, Great Knot, Greater Sand Plover and Grey Plover. The foraging density of migratory shorebirds across the Curtis Coast was 1.29 birds/ha compared to 1.39 birds/ha last year. At the Fitzroy Estuary the foraging density was 1.56 birds/ha compared to 1.66 birds/ha last year, at North Curtis Island the foraging density was 1.60 birds/ha compared to 2.28 birds/ha last year, at Mundoolin-Colosseum-Rodds it was 0.87 birds/ha compared to 0.89 birds/ha last year and at Port Curtis was 1.35 birds/ha compared to 1.09 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.

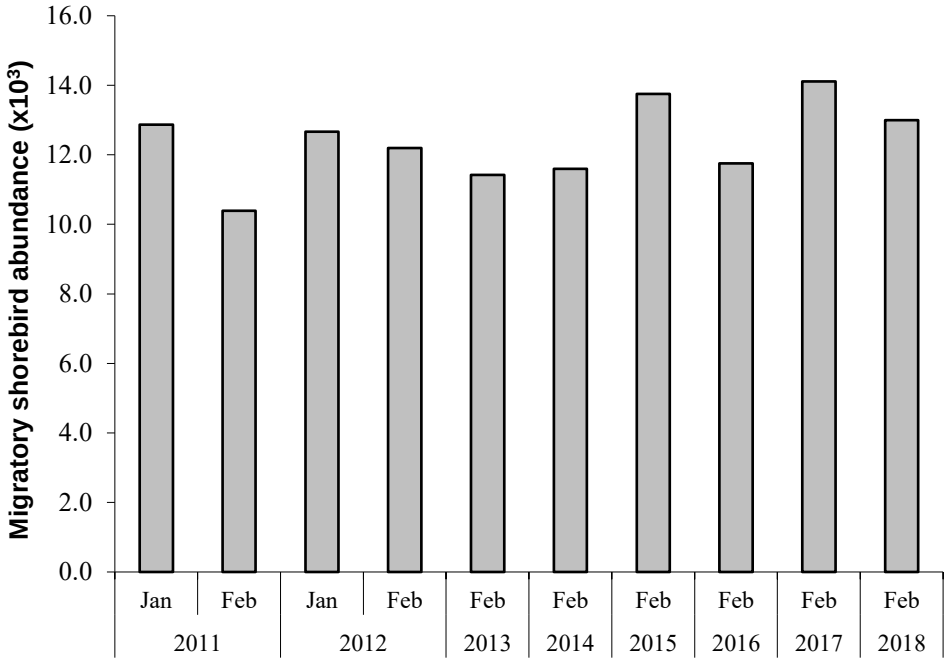


Figure 4-1 Total abundance of migratory shorebirds in summer on the Curtis Coast
Cheetham Salt Works counts have been excluded due to variability of access over the period of the study.

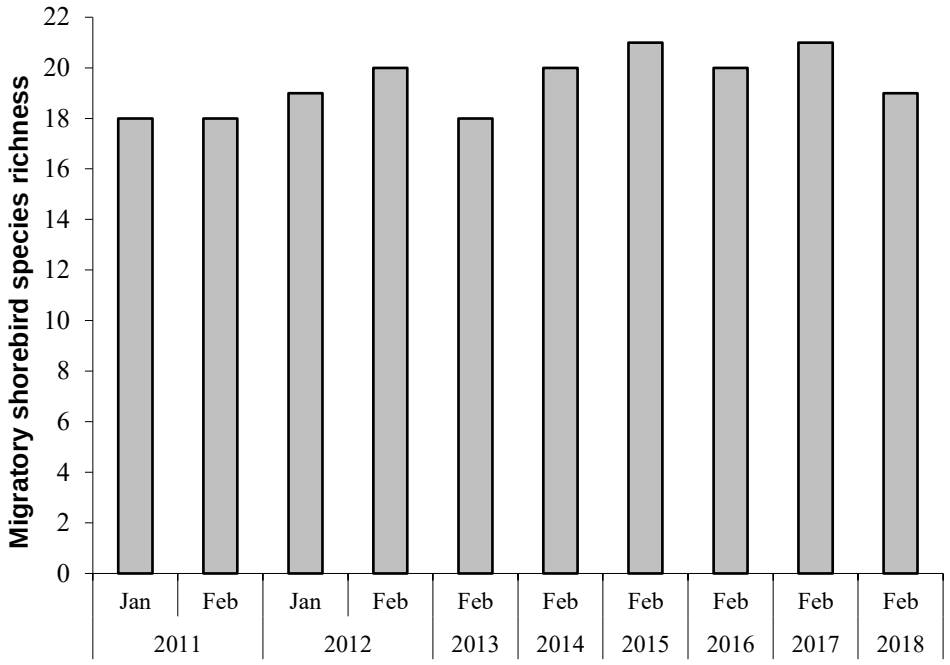


Figure 4-2 Species richness of migratory shorebirds in summer on the Curtis Coast
Cheetham Salt Works counts have been excluded due to variability of access over the period of the study.

The distribution of large roosts across the Curtis Coast was skewed to the north (Table 4-2, Figure 4-13). There were two roosts with >1000 birds. These were Deception Point (2236 birds) and Shell Point (1018 birds) both in the Fitzroy Estuary. There were four roosts in the 500-999 birds class. These were Yellow Patch sandbar (962 birds) and Yellow Patch entrance mangrove (603 birds) at North Curtis Island; and Curtis Island Southend claypan (767 birds) and the Western Basin Reclamation Area (708 birds) both in Port Curtis. There were a further 18 roosts with 100-499 birds: eight in Mundoolin-Colosseum-Rodds, four each at North Curtis Island and Port Curtis and two in the Fitzroy Estuary.

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

Location	Abundance	Roost
Fitzroy Estuary	>1000	1. Deception Point 2. Shell Point
	500-999	1. Nil
	100-499	1. Curlew Spit 2. Mud Island east point
North Curtis Island	>1000	1. Nil
	500-999	1. Yellow Patch sandbar 2. Yellow Patch sandbar mangrove
	100-499	1. Mud Bay 2. Keppel Creek entrance 3. Yellow Patch mangrove 4. Note Creek entrance
Port Curtis	>1000	1. Nil
	500-999	1. Curtis Island Southend claypan 2. Western Basin Reclamation Area
	100-499	1. Facing Island claypan 2. Friend Point claypan 3. Facing Island sandbar 4. Calliope River
Mundoolin-Colosseum-Rodds	>1000	1. Nil
	500-999	1. Nil
	100-499	1. Mundoolin central mangrove island 2. Mundoolin Rocks east claypan 3. Mundoolin Rocks west claypan 4. Williams Bay 5. Mundoolin Rocks mangrove 6. Spit End 7. Morris Creek claypan 8. Turkey Beach mangrove island

A total of 731 migratory shorebirds, consisting of five species (Red-necked Stint, Lesser Sand Plover, Eastern Curlew, Whimbrel and Ruddy Turnstone) were recorded during high tide counts on the mainland shoreline including the WBRA. A total of 707 of these were Red-necked Stints recorded from the WBRA.

The Cheetham Salt Works was surveyed from the road during a falling high tide. No migratory shorebirds were recorded.

The mean abundance of migratory shorebirds on the Curtis Coast in summer calculated from the 10 surveys in January and February 2011-2018 was 12,355 birds with a range of 10,387 to 14,003 (GHD, 2011b; Sandpiper Ecological Surveys 2012a; Wildlife Unlimited 2013a; 2014; 2015; 2016; 2017). The lower bound of the range is 84 percent of the mean and the upper bound is 114 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.

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 second most abundant species in the 2018 summer survey with 2444 birds recorded at roosts during high tide (Table 4-3; Figure 4-3; Figure 4-14). This figure was 12 percent fewer than recorded during the survey in February 2017 (2783 birds). The figure was <1 percent of both the official Australian Government EAAF population estimate (Bamford et al., 2008) and the more recent Wetlands International (2015) population estimate. Bar-tailed Godwits were recorded at 23 roosts, two of which were ≥0.1 percent of the official EAAF population estimate. These were Yellow Patch sandbar (390 birds) in the North Curtis Island management unit, and Curtis Island Southend west claypan (370 birds) at Port Curtis. The foraging density of Bar-tailed Godwits was greatest in North Curtis Island and Port Curtis. 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 four management units in February 2018

Location	Roosts	Total	Density[1]
Port Curtis	6	742	0.31
Fitzroy Estuary	5	232	0.10
North Curtis Island	5	769	0.39
Mundoolin-Colosseum-Rodds	7	701	0.21
Total	**23**	**2444**	**0.24**

1 Foraging density (birds/ha)

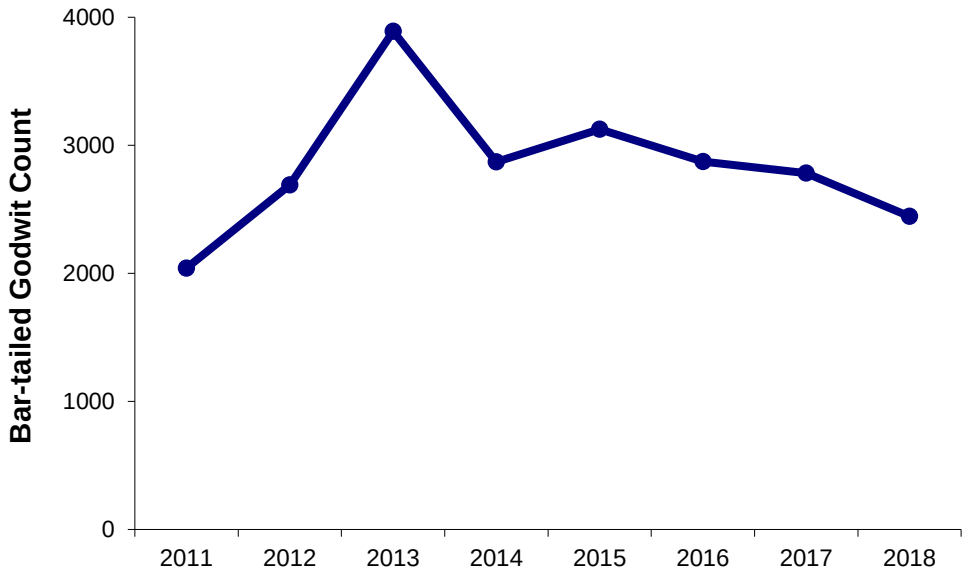


Figure 4-3 Counts of Bar-tailed Godwits on the Curtis Coast, February 2011-2018.

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 1093 Whimbrels was recorded on the Curtis Coast in February 2018 (Table 4-4; Figure 4-15). This was 18 percent fewer birds than recorded in February 2017 (1334 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 4-4). Whimbrels were present at 57 roosts with the largest at Keppel Creek entrance (215 birds) in the North Curtis Island management unit and Curtis Island Southend claypan (160 birds) in the Port Curtis management unit. The 0.1 percent threshold for sites of national significance was exceeded at these two roosts. Foraging density was greatest in the North Curtis Island and Port Curtis management units. 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	19	428	0.18
Fitzroy Estuary	5	14	0.01
North Curtis Island	18	516	0.26
Mundoolin-Colosseum-Rodds	15	135	0.04
Total	**57**	**1093**	**0.11**

1 Foraging density (birds/ha)

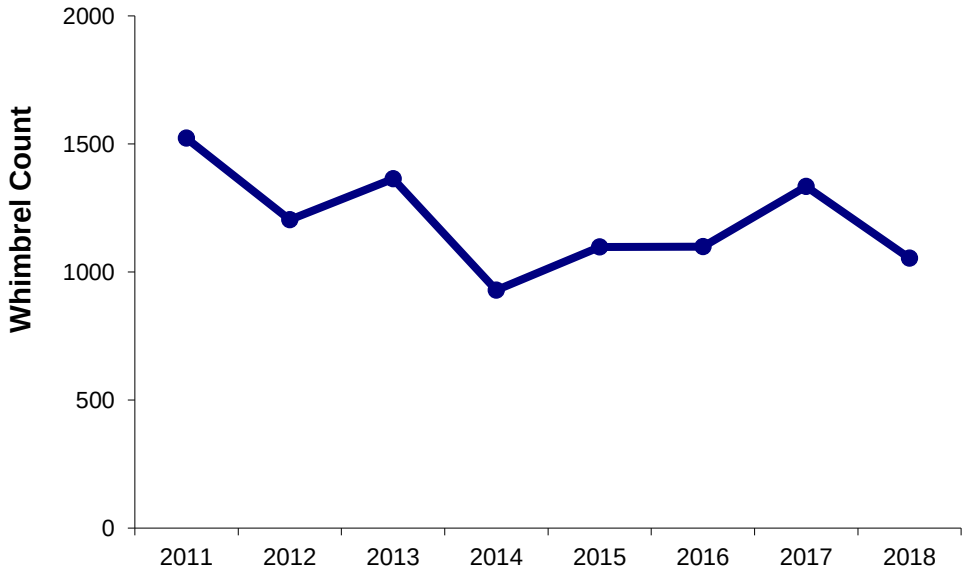


Figure 4-4 Counts of Whimbrels on the Curtis Coast, February 2011-2018.

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 744 Eastern Curlews was recorded on the Curtis Coast in February 2018 (Table 4-5; Figure 4-16). This was five percent fewer than was recorded in February 2017 (785 birds). The number of Eastern Curlews on the Curtis Coast has exceeded the 1 percent population threshold of the official Australian Government population estimate (Bamford et al., 2008) on each of the past eight summers (Figure 4-5). Eastern Curlews were present at 25 roosts with the largest at Curtis Island Southend claypan (152 birds), Facing Island claypan (97 birds) and Friend Point claypan (41 birds) in the Port Curtis management unit; and Morris Creek claypan (101 birds) Mundoolin Rocks east claypan (75 birds), Williams Bay (63 birds), Mangrove Creek saltpan (48 birds) and Spit End (47 birds) in the Mundoolin-Colosseum-Rodds management 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 management units. The Eastern Curlew is considered to be in decline across the EAAF (Wetlands International, 2015) and also on the Australian continent particularly south of 27.8°S and east of 129°E (Clemens et al., 2016).

Table 4-5 Comparison of the number of birds, number of roosts occupied and foraging density of Eastern Curlews between four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	6	305	0.13
Fitzroy Estuary	2	8	0.00
North Curtis Island	8	89	0.05
Mundoolin-Colosseum-Rodds	9	342	0.10
Total	**25**	**744**	**0.07**

1 Foraging density (birds/ha)

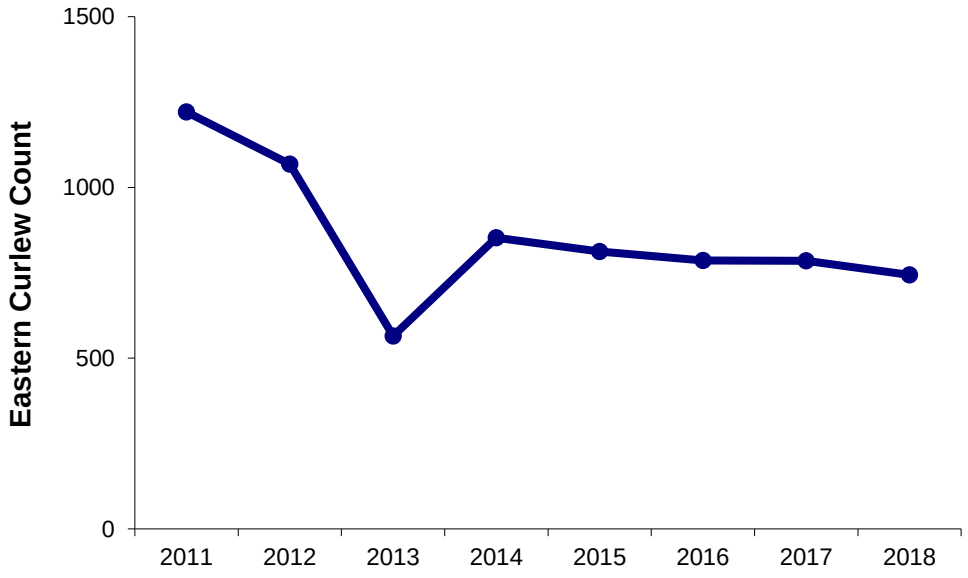


Figure 4-5 Counts of Eastern Curlews on the Curtis Coast, February 2011-2018.

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 1216 Terek Sandpipers was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-6, Figure 4-17). This was 39 percent fewer than was recorded the previous February (1982 birds) but remained the second highest February count for the project. The greater numbers recorded in 2017 and 2018 reflect greater numbers recorded at large roosts and we assume these are new birds in the study area. 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 4-6). Terek Sandpipers were present at 30 roosts the largest of which were Mundoolin central mangrove island (190 birds), Mundoolin Rocks mangrove (120 birds), Mundoolin Rocks west (92 birds), Bird Island (80 birds) and Turkey Beach mangrove island in the Mundoolin-Colosseum-Rodds management unit; Facing Island sandbar mangrove (107 birds) in the Port Curtis management unit; Mud Island mangrove (120 birds) in the Fitzroy Estuary management unit; and Yellow Patch sandbar mangrove (70 birds) in the North Curtis Island management unit. These eight 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 greatest in the Mundoolin-Colosseum-Rodds management unit. It is unclear whether the number of Terek Sandpipers in the EAAF population is changing (Wetlands International, 2015). However Australian data suggest the species 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	9	236	0.10
Fitzroy Estuary	6	162	0.07
North Curtis Island	8	210	0.11
Mundoolin-Colosseum-Rodds	7	608	0.18
Total	**30**	**1216**	**0.12**

1 Foraging density (birds/ha)

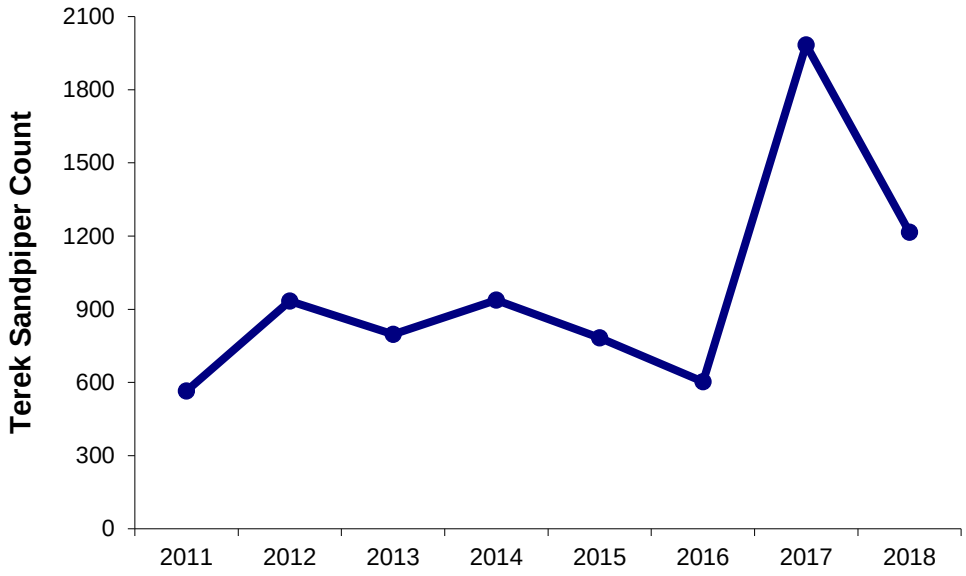


Figure 4-6 Counts of Terek Sandpipers on the Curtis Coast, February 2011-2018.

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 1465 Grey-tailed Tattlers was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-7, Figure 4-18). This was 20 percent more birds than was recorded at roosts the previous February and the 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 4-7). Grey-tailed Tattlers were present at 34 roosts across the study area. The largest roosts were Yellow Patch sandbar mangrove (527 birds) and Yellow Patch mangrove in the North Curtis Island management unit; Mundoolin central mangrove island (230 birds), Mundoolin Rocks mangrove (200 birds) and Turkey Beach mangrove island in the Mundoolin-Colosseum-Rodds management unit. 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 in the North Curtis Island management unit and least in the Fitzroy Estuary management 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	9	176	0.07
Fitzroy Estuary	5	16	0.01
North Curtis Island	11	734	0.37
Mundoolin-Colosseum-Rodds	9	539	0.16
Total	**34**	**1465**	**0.15**

1 Foraging density (birds/ha)

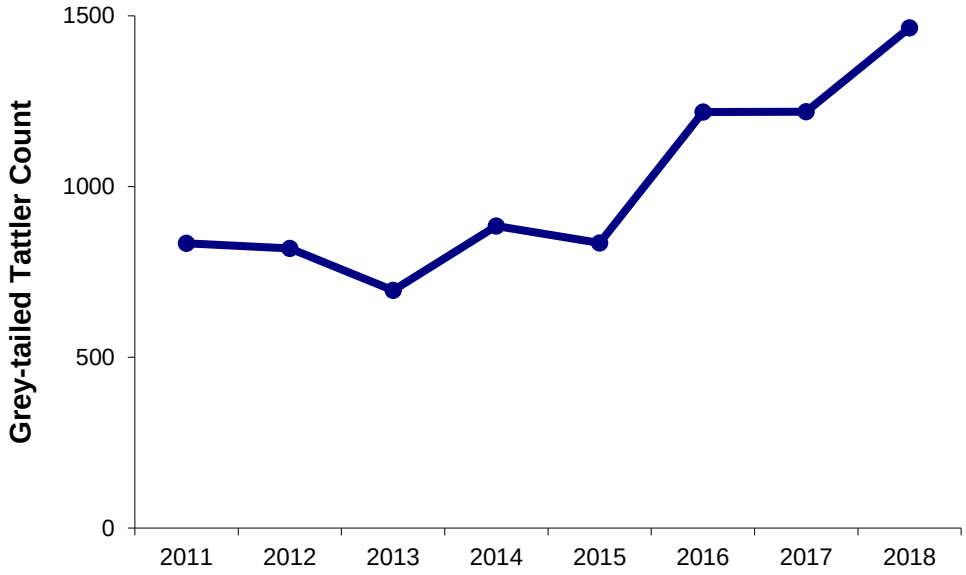


Figure 4-7 Counts of Grey-tailed Tattlers on the Curtis Coast, February 2011-2018.

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 353 Great Knots was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-8, Figure 4-19). This was 38 percent fewer than was recorded at roosts in February 2017 (571 birds) and the lowest summer count for the project. 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 4-8). Great Knots were present at nine roosts, the largest of which were Yellow Patch sandbar (125 birds) in the North Curtis Island management unit and Curtis Island Southend claypan (56 birds) in the Port Curtis management unit. 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 they 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	2	60	0.02
Fitzroy Estuary	1	44	0.02
North Curtis Island	3	174	0.09
Mundoolin-Colosseum-Rodds	3	75	0.02
Total	**9**	**353**	**0.04**

1 Foraging density (birds/ha)

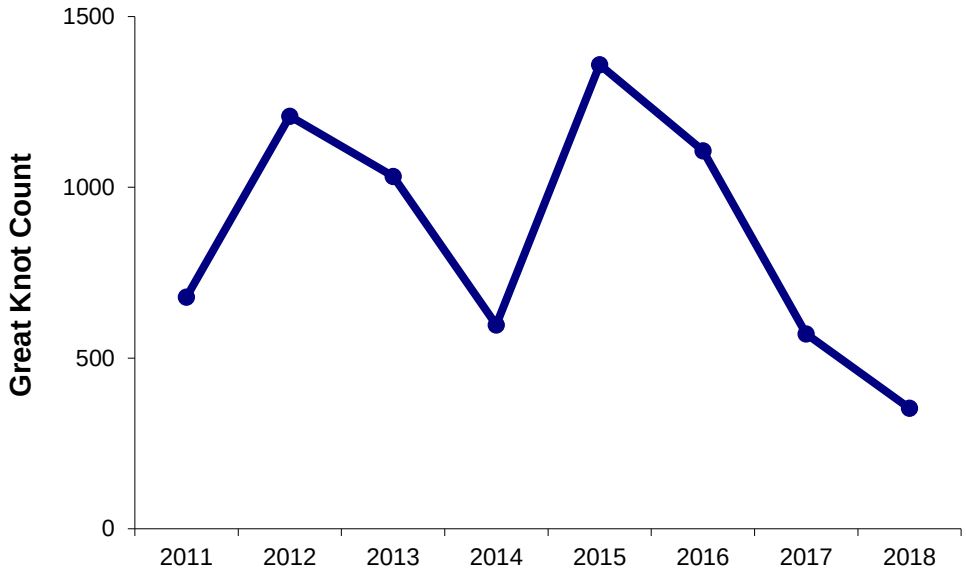


Figure 4-8 Counts of Great Knots on the Curtis Coast, February 2011-2018.

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 3435 Red-necked Stints was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-9, Figure 4-20). This was 24 percent more than was recorded at roosts the previous February (2780 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 in 2015 and this year (Figure 4-9). Red-necked Stints were present at 19 roosts, the biggest of which were Deception Point claypan (2035 birds) in the Fitzroy Estuary management unit and the WBRA (707 birds). 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 greatest in the Fitzroy Estuary management unit. 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 the species 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	7	907	0.38
Fitzroy Estuary	4	2407	1.02
North Curtis Island	2	20	0.01
Mundoolin-Colosseum-Rodds	6	101	0.03
Total	**19**	**3435**	**0.34**

1 Foraging density (birds/ha)

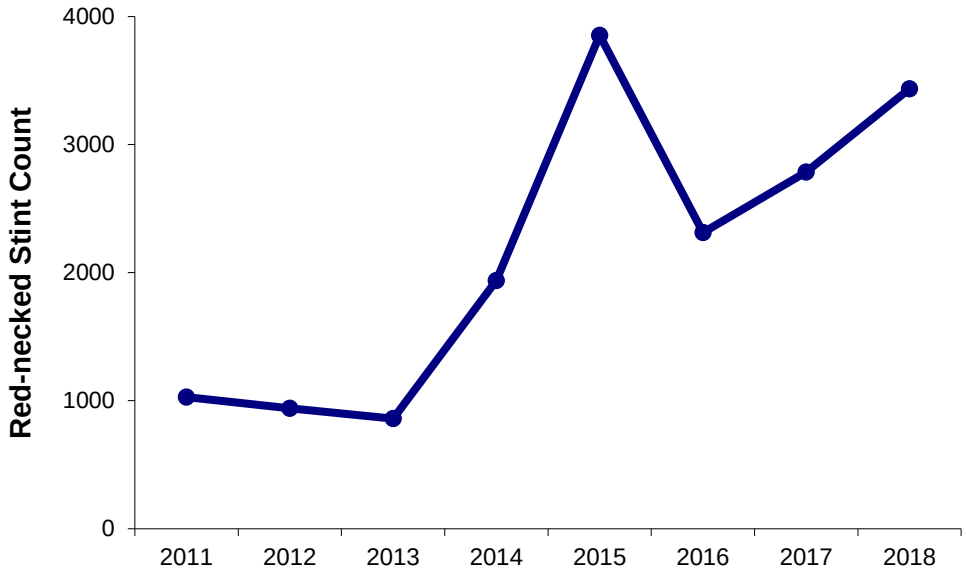


Figure 4-9 Counts of Red-necked Stints on the Curtis Coast, February 2011-2018.

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 133 Grey Plovers was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-10, Figure 4-21). This was 45 percent more birds than was recorded at roosts the previous February (92 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 4-10). Grey Plovers were present at seven roosts with the largest at Yellow Patch sandbar (67 birds) in the North Curtis Island management unit and Mundoolin Rocks claypan (49 birds) in the Mundoolin-Colosseum-Rodds management unit. Foraging density was greatest in the North Curtis Island management 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	1	7	0.00
Fitzroy Estuary	1	3	0.01
North Curtis Island	3	73	0.04
Mundoolin-Colosseum-Rodds	2	50	0.02
Total	**7**	**133**	**0.01**

1 Foraging density (birds/ha)

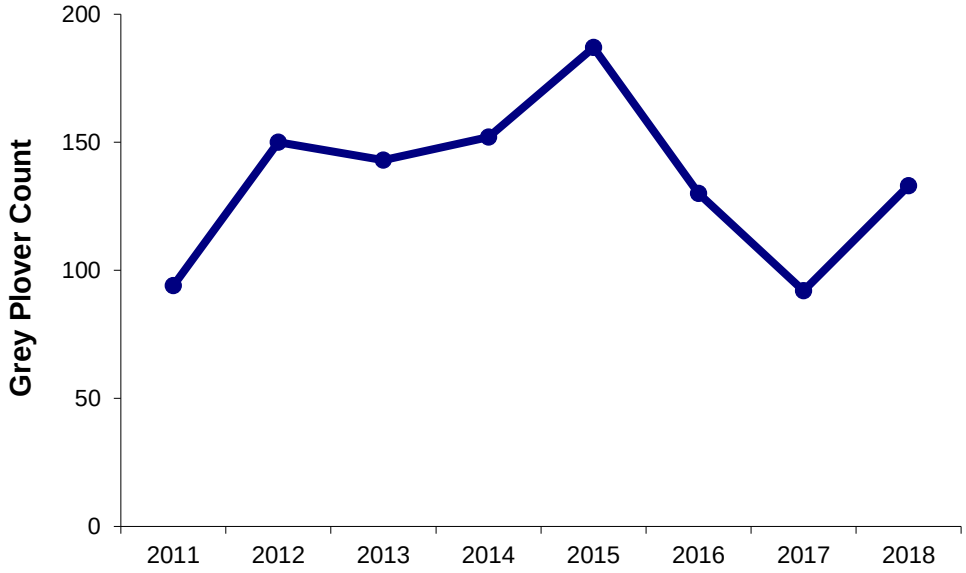


Figure 4-10 Counts of Grey Plovers on the Curtis Coast, February 2011-2018.

4.2.10 Sand Plover Species

A total of 1419 Sand Plovers was recorded at high tide roosts on the Curtis Coast in February 2018 (Figure 4.25). This was 28 percent fewer than the February 2017 survey (1982 birds). The 2018 total comprised 961 Lesser Sand Plovers, 322 Greater Sand Plovers and 136 birds which could not be identified to species level. The proportion of birds that cannot be distinguished is influenced 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 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 961 Lesser Sand Plovers was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-11). 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 14 roosts, the largest of which were Shell Point (220 birds) in the Fitzroy Estuary management unit; Yellow Patch sandbar (160 birds) in the North Curtis Island management unit; and Mundoolin Rocks claypan in the Mundoolin-Colosseum-Rodds management 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 North Curtis island and Fitzroy Estuary management 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 four management units in February 2018.

Location	Roosts	Total	Density[1]
Port Curtis	4	137	0.06
Fitzroy Estuary	2	293	0.12
North Curtis Island	4	314	0.16
Mundoolin-Colosseum-Rodds	4	217	0.07
Total	**14**	**961**	**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 322 Greater Sand Plovers was recorded at high tide roosts on the Curtis Coast in February 2018 (Table 4-12). 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) or the more recent Wetlands International (2015) estimate. Greater Sand Plovers were recorded at 9 roosts, the largest of which were Yellow Patch sandbar (162 birds) in the North Curtis management unit. The count at

this sites was >0.1 percent of the EAAF population estimate indicating that it may be of national significance. The greatest foraging density occurred in the North Curtis Island management 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 four management units in February 2018

Location	Roosts	Total	Density[1]
Port Curtis	3	87	0.04
Fitzroy Estuary	2	24	0.01
North Curtis Island	2	205	0.10
Mundoolin-Colosseum-Rodds	2	6	0.00
Total	**9**	**322**	**0.03**

1 Foraging density (birds/ha)

4.3 Other Migratory Shorebird Species

The composition of the 10 most abundant species in 2018 changed from 2017 due to an increase in the abundance of Grey Plovers (133 birds) and decreases in the abundance of Curlew Sandpiper (75 birds) and Broad-billed Sandpiper (0 birds).

The 10 most abundant species accounted for 97 percent of the migratory shorebirds recorded at high tide roosts in February 2018. Of the remaining nine species, the counts for two were >40. These were Curlew Sandpiper and Common Greenshank (61 birds).

The distribution of the rarer species was relatively restricted. Curlew Sandpipers were recorded at three roosts with most birds recorded at Shell Point in the Fitzroy Estuary. Common Greenshanks were recorded at six roosts, Ruddy Turnstones at 10 and Pacific Golden Plovers at five 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 19 low tide surveys were completed in February 2018, 13 fewer than in the 2017 survey due to unsuitable weather (Figure 4-11) and safety considerations. The duration of the low tide surveys was 325 minutes (Table 4-1). A total of 531 birds comprising 10 species was counted at low tide (Table 4-15). No additional migratory shorebird species were recorded. 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.

Figure 4-11 The Yellow Patch tidal flat during low tide surveys, February 2018.
The weather conditions precluded a reliable count (Adam Leavesley, Wildlife Unlimited).

4.5 Non-migratory Species

A total of 696 non-migratory birds of eight species was recorded during the high tide roost counts (Table 4-13). This compares with 1223 birds of eight species recorded in February 2017. The same species were recorded this year as last.

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.

Species	PC	FE	NC	M-C	RP	SW	Total
Beach Stone-curlew	2	0	5	2	0	0	**9**
Bush Stone-curlew	0	0	0	0	0	0	**0**
Pied Oystercatcher	30	3	41	55	108	0	**237**
Sooty Oystercatcher	14	0	1	0	4	0	**19**
Black-winged Stilt	20	0	0	0	0	0	**20**
Red-necked Avocet	27	0	0	0	0	0	**27**
Red-capped Plover	175	96	39	22	16	14	**362**
Black-fronted Dotterel	5	0	0	0	0	0	**5**
Red-kneed Dotterel	0	0	0	0	0	0	**0**
Masked Lapwing	16	0	1	0	0	0	**17**
Total abundance	289	99	87	79	128	14	**696**
Total species	**8**	**2**	**5**	**3**	**3**	**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

Six surveys were completed at Cheetham Salt Works at high tide on 1 February for a duration of 23 minutes. All sites were accessible from the road. No migratory shorebirds were recorded which was 24 fewer than the previous year when a count was made of a single internal site. A total of 14 non-migratory shorebirds was recorded all of which were Red-capped Plovers. An account of monthly surveys at the Cheetham Salt Works (Houston et al., 2012) assists in better understanding the contribution that the facility makes to migratory shorebird diversity on the Curtis Coast and the population dynamics of some of the species which are rare elsewhere.

4.7 Western Basin Reclamation Area

A thorough survey of the WBRA at high tide was conducted on 1 February 2018. 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 68 minutes which was 30 minutes longer than 2017. The duration represents the time spent surveying at each site and does not include time driving between sites. A total of 714 migratory shorebirds consisting of 707 Red-necked Stint, four Whimbrel and three Eastern Curlew were recorded at the WBRA. This is the highest count from the WBRA during the project. Two non-migratory shorebird species were recorded. These were the Red-necked Avocet (27 birds) and the Red-capped Plover (64 birds).

Figure 4-12 Red-necked Stints foraging in the WBRA in February 2018.
The birds were recorded from three of the ponds (Adam Leavesley, Wildlife Unlimited).

Table 4-14 Summary of the roost counts for migratory shorebirds at each survey location.

	PC	FE	NC	M-C	RP	SW	Total
Pacific Golden Plover	13	3	2	0	3	0	**21**
Grey Plover	7	3	73	50	0	0	**133**
Double-banded Plover	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lesser Sand Plover	137	293	314	189	28	0	**961**
Greater Sand Plover	87	24	205	6	0	0	**322**
Latham's Snipe	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Black-tailed Godwit	0	0	1	0	0	0	**1**
Bar-tailed Godwit	742	232	769	521	180	0	**2444**
Little Curlew	0	0	0	0	0	0	**0**
Whimbrel	428	14	516	98	37	0	**1093**
Eastern Curlew	305	8	89	190	152	0	**744**
Terek Sandpiper	236	162	210	402	206	0	**1216**
Common Sandpiper	0	0	0	0	0	0	**0**
Grey-tailed Tattler	176	16	734	442	97	0	**1465**
Common Greenshank	11	0	29	21	0	0	**61**
Marsh Sandpiper	0	5	0	0	0	0	**5**
Ruddy Turnstone	8	0	1	25	0	0	**34**
Great Knot	60	44	174	72	3	0	**353**
Red Knot	4	0	6	0	0	0	**10**
Sanderling	0	0	5	0	0	0	**5**
Red-necked Stint	907	2407	20	72	29	0	**3435**
Sharp-tailed Sandpiper	5	10	5	0	0	0	**20**
Curlew Sandpiper	0	74	0	1	0	0	**75**
Broad-billed Sandpiper	0	0	0	0	0	0	**0**
Sand Plover spp.*	100	36	0	0	0	0	**136**
Tattler/Terek spp.*	30	0	0	0	0	0	**30**
Unidentified small wader*	0	370	0	0	52	0	**422**
Total abundance	**3256**	**3701**	**3153**	**2089**	**787**	**0**	**12986**
Total species	**15**	**14**	**17**	**13**	**9**	**0**	**19**

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

*This class represents multiple species so is not reflected in the count of total species.

Figure 4-13 Important roosts on the Curtis Coast, February 2018.

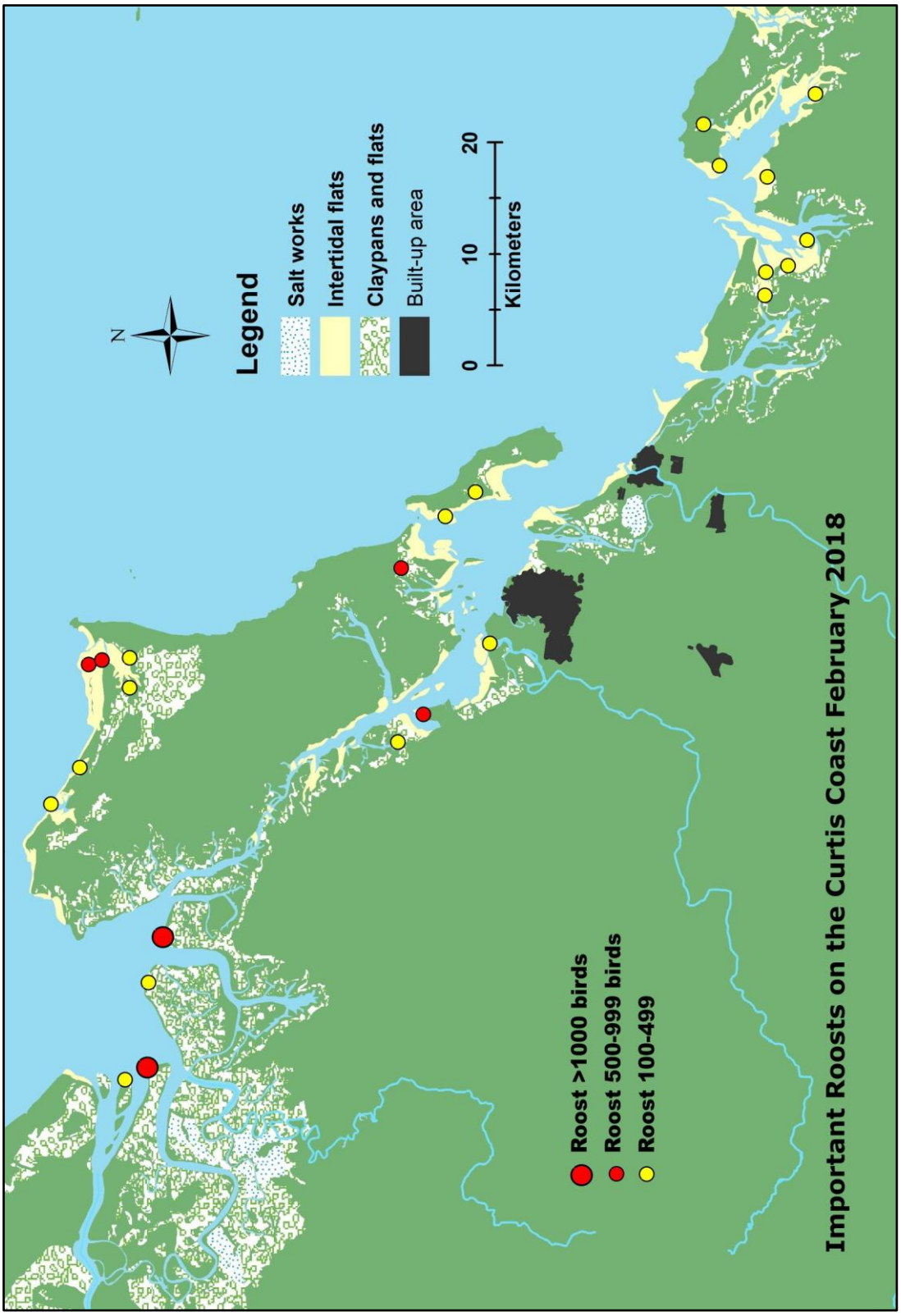


Figure 4-14 Bar-tailed Godwit roosts on the Curtis Coast, February 2018.

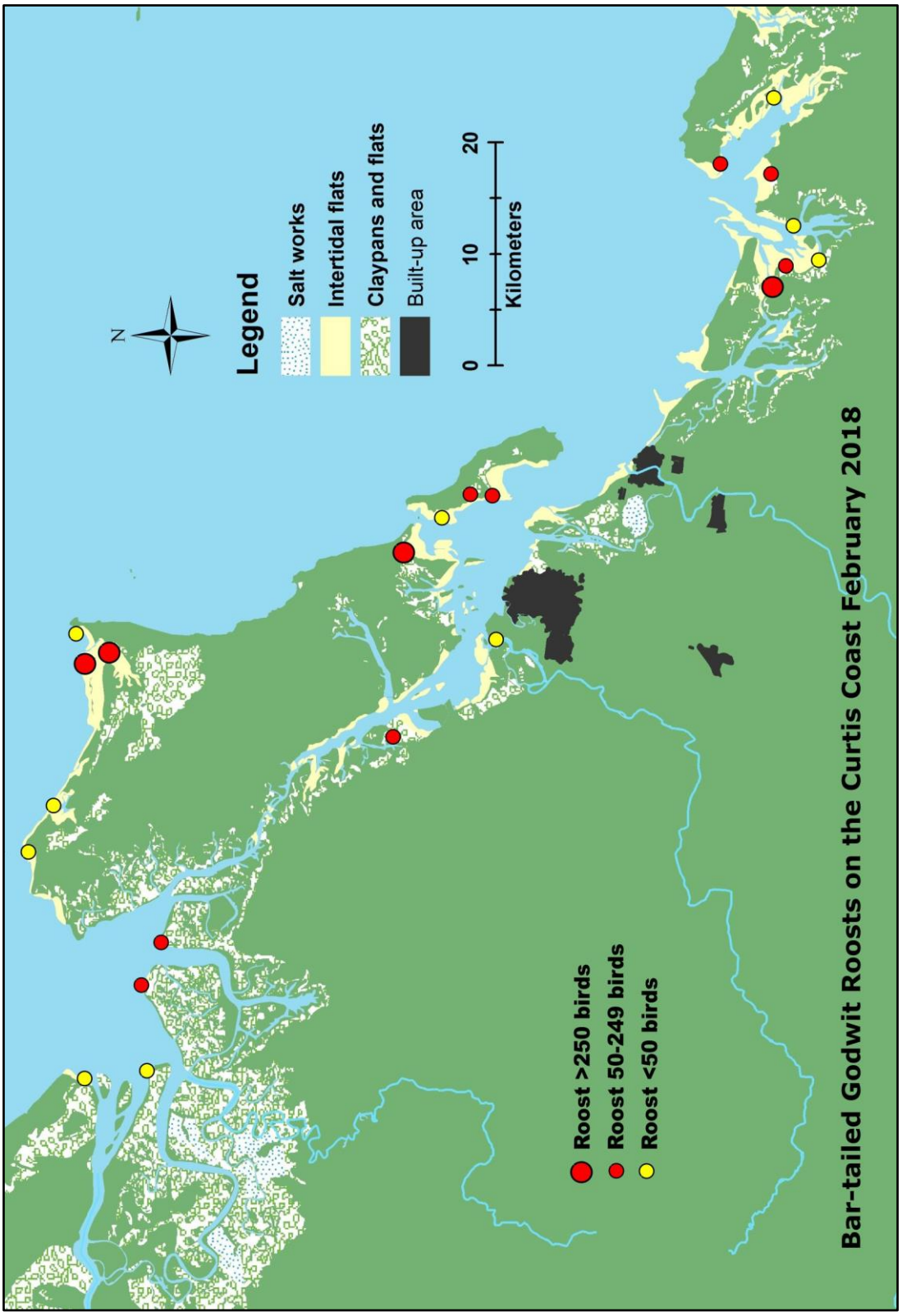


Figure 4-15 Whimbrel roosts on the Curtis Coast, February 2018.

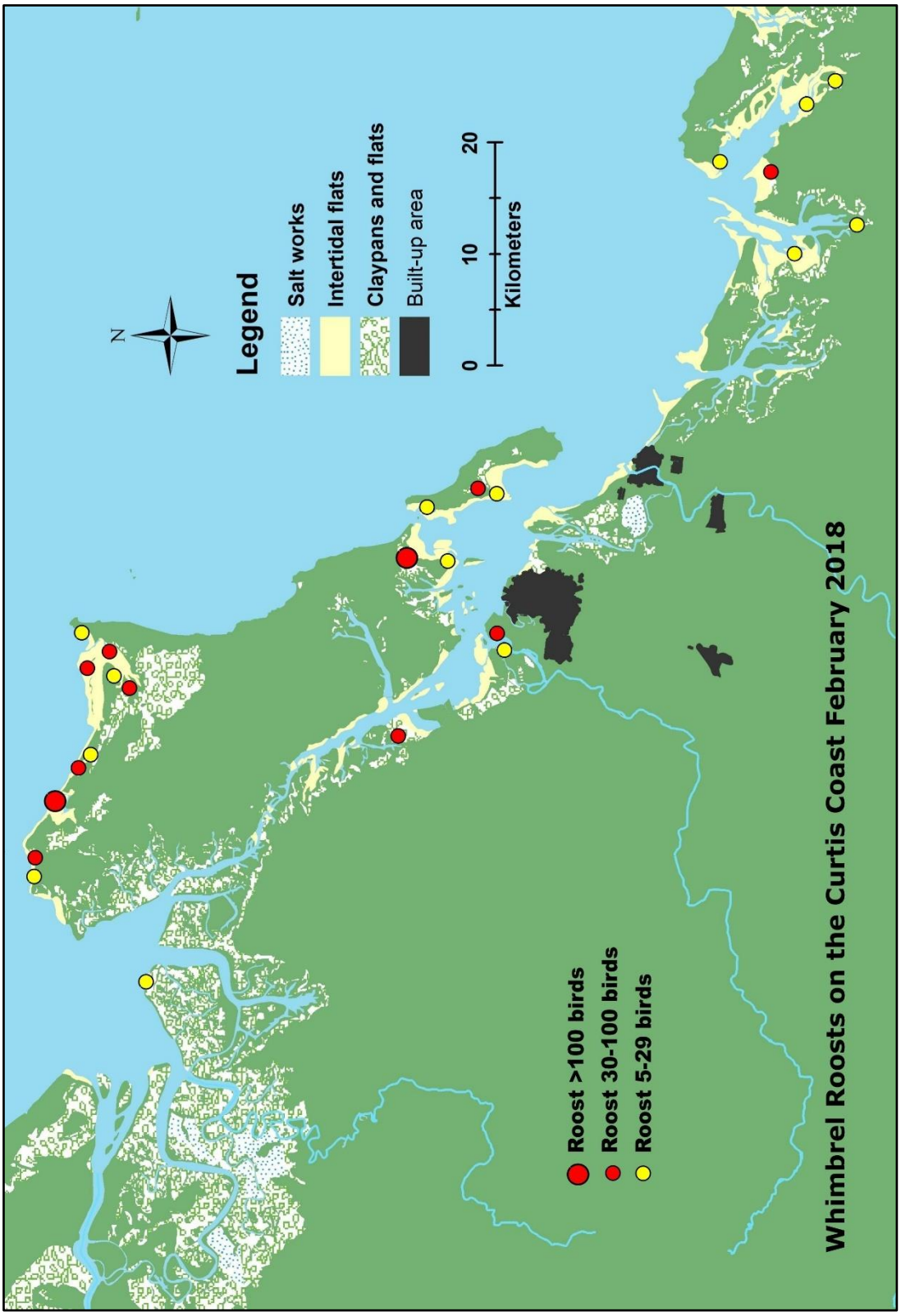


Figure 4-16 Eastern Curlew roosts on the Curtis Coast, February 2018.

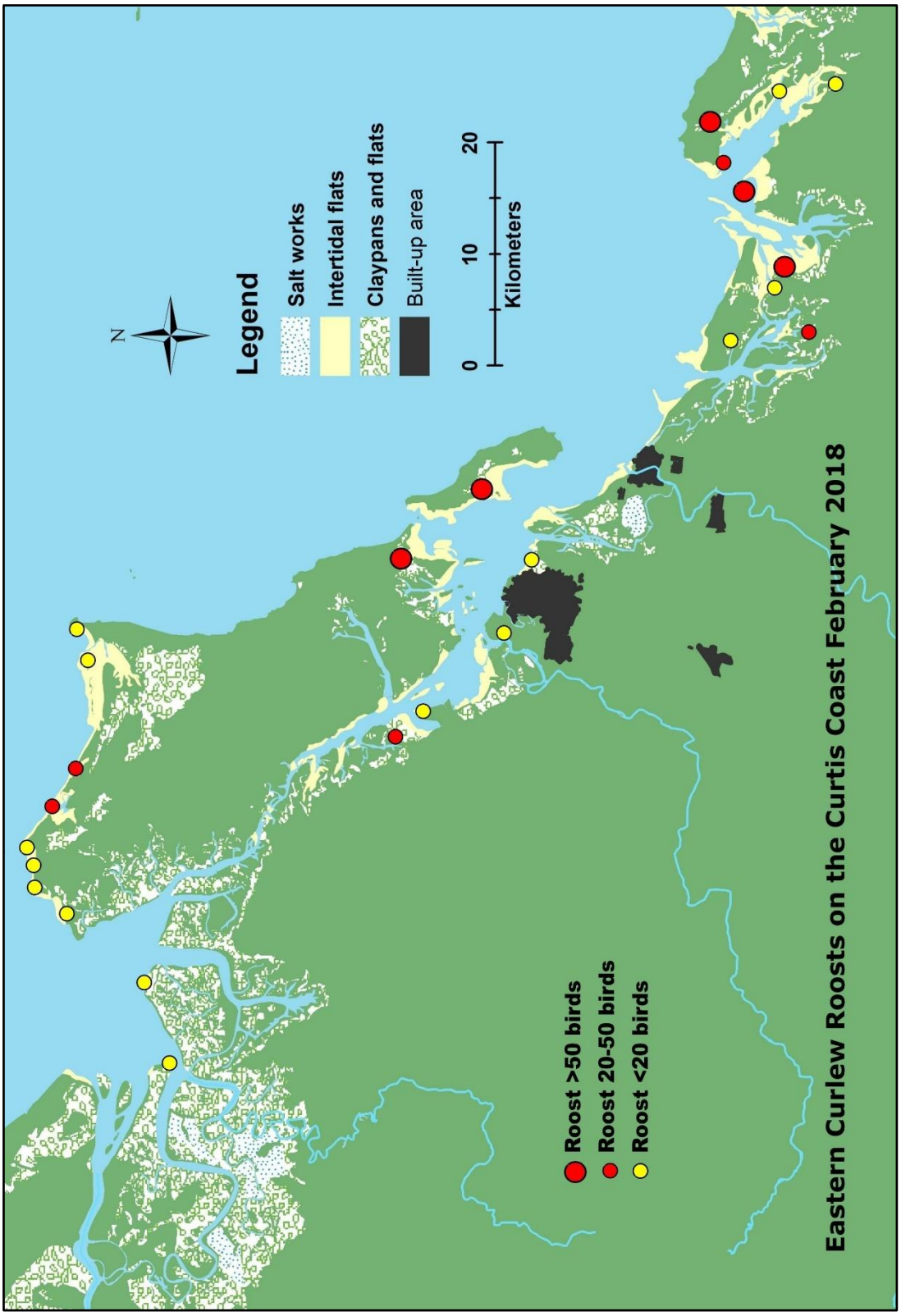


Figure 4-17 Terek Sandpiper roosts on the Curtis Coast, February 2018.

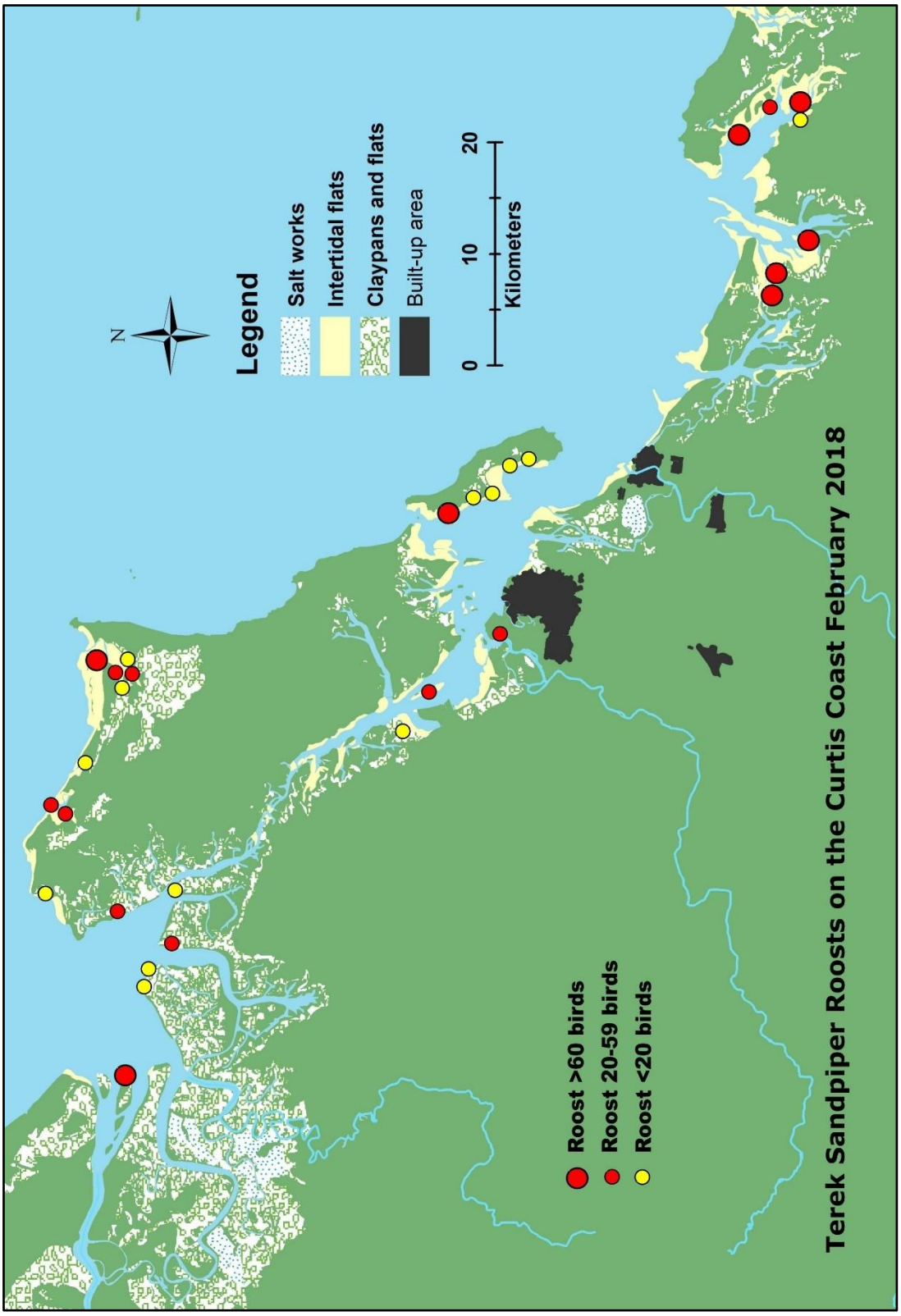


Figure 4-18 Grey-tailed Tattler roosts on the Curtis Coast, February 2018.

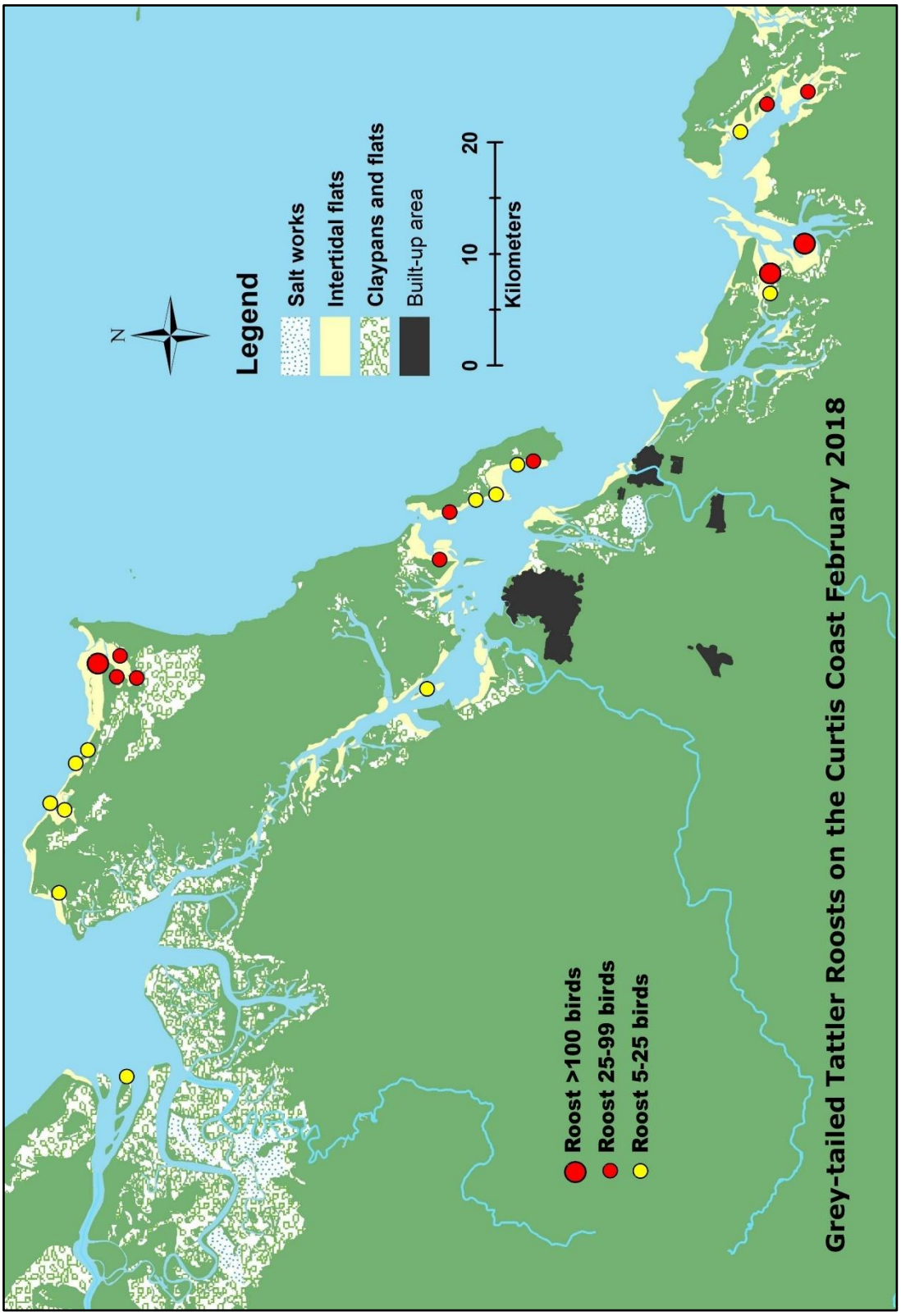


Figure 4-19 Great Knot roosts on the Curtis Coast, February 2018.

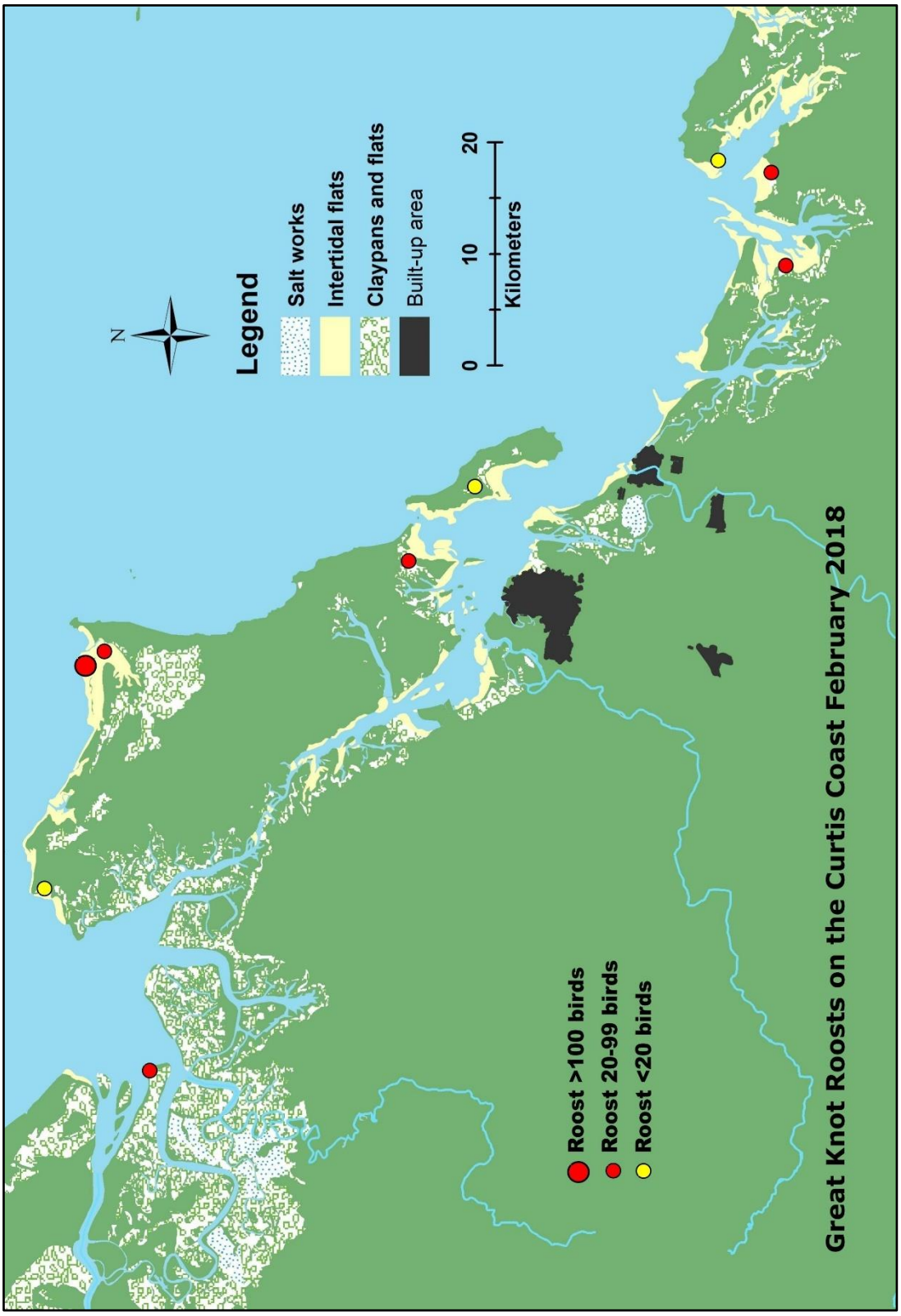


Figure 4-20 Red-necked Stint roosts on the Curtis Coast, February 2018.

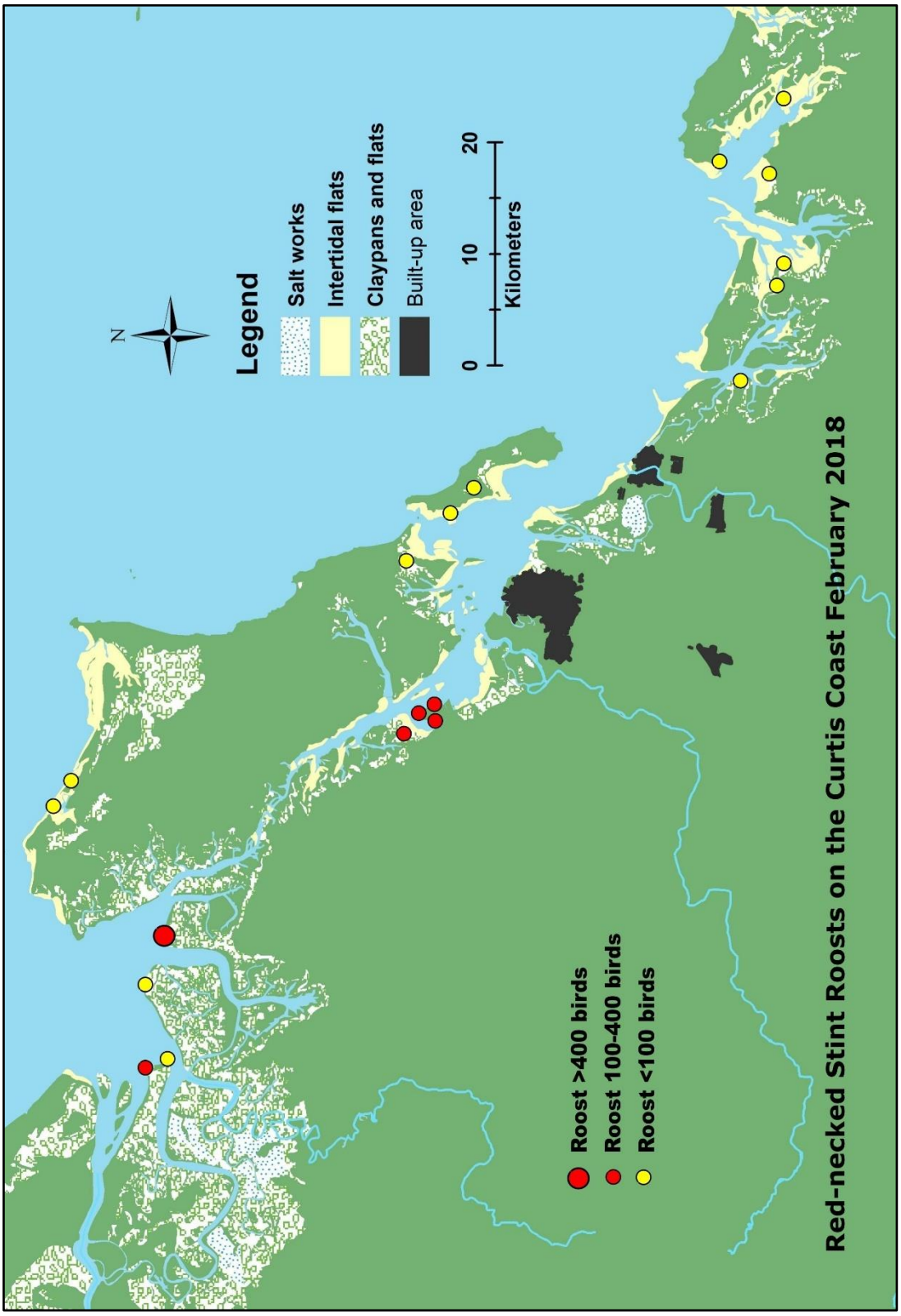


Figure 4-21 Grey Plover roosts on the Curtis Coast, February 2018.

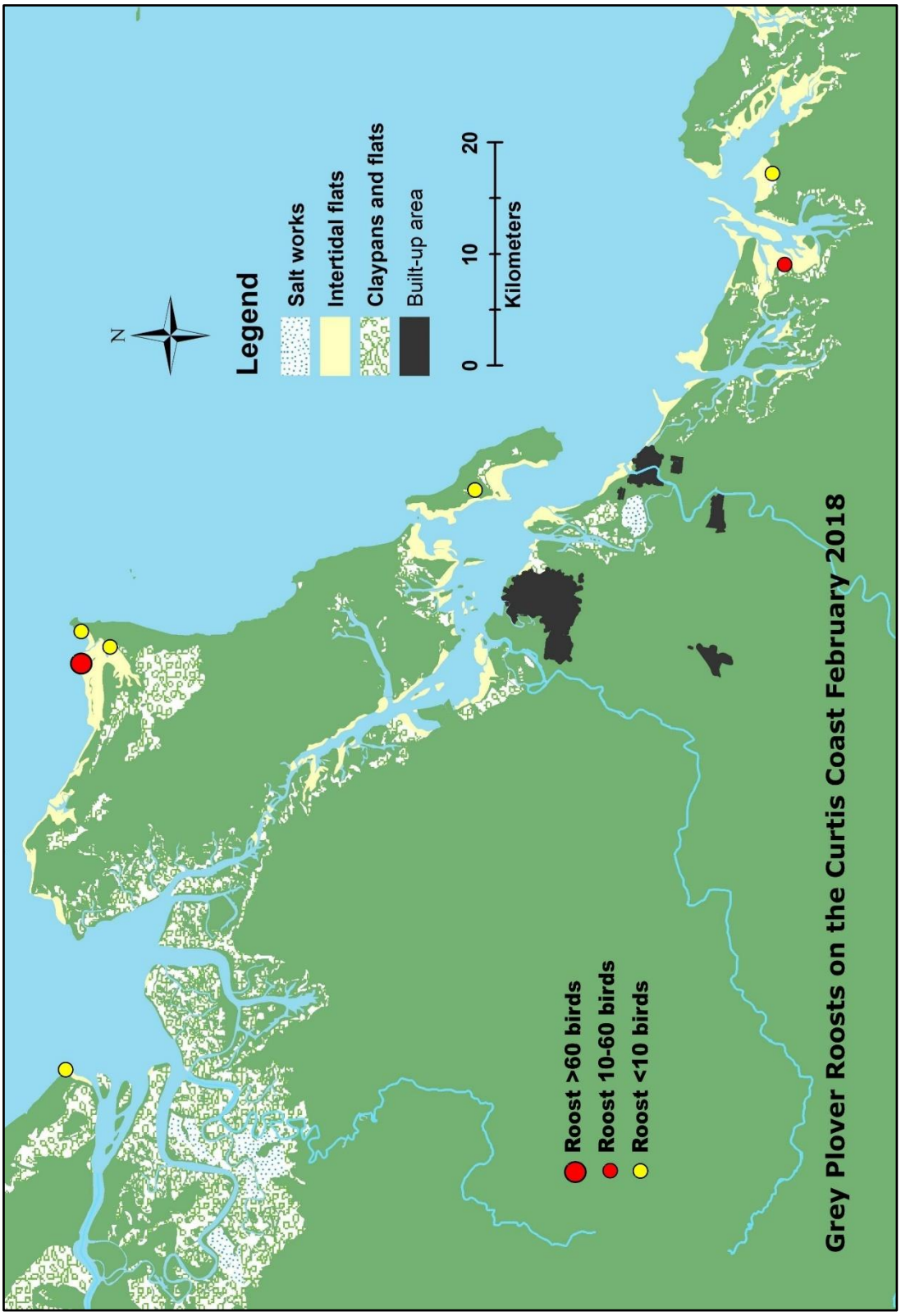


Figure 4-22 Sand Plover roosts on the Curtis Coast, February 2018.

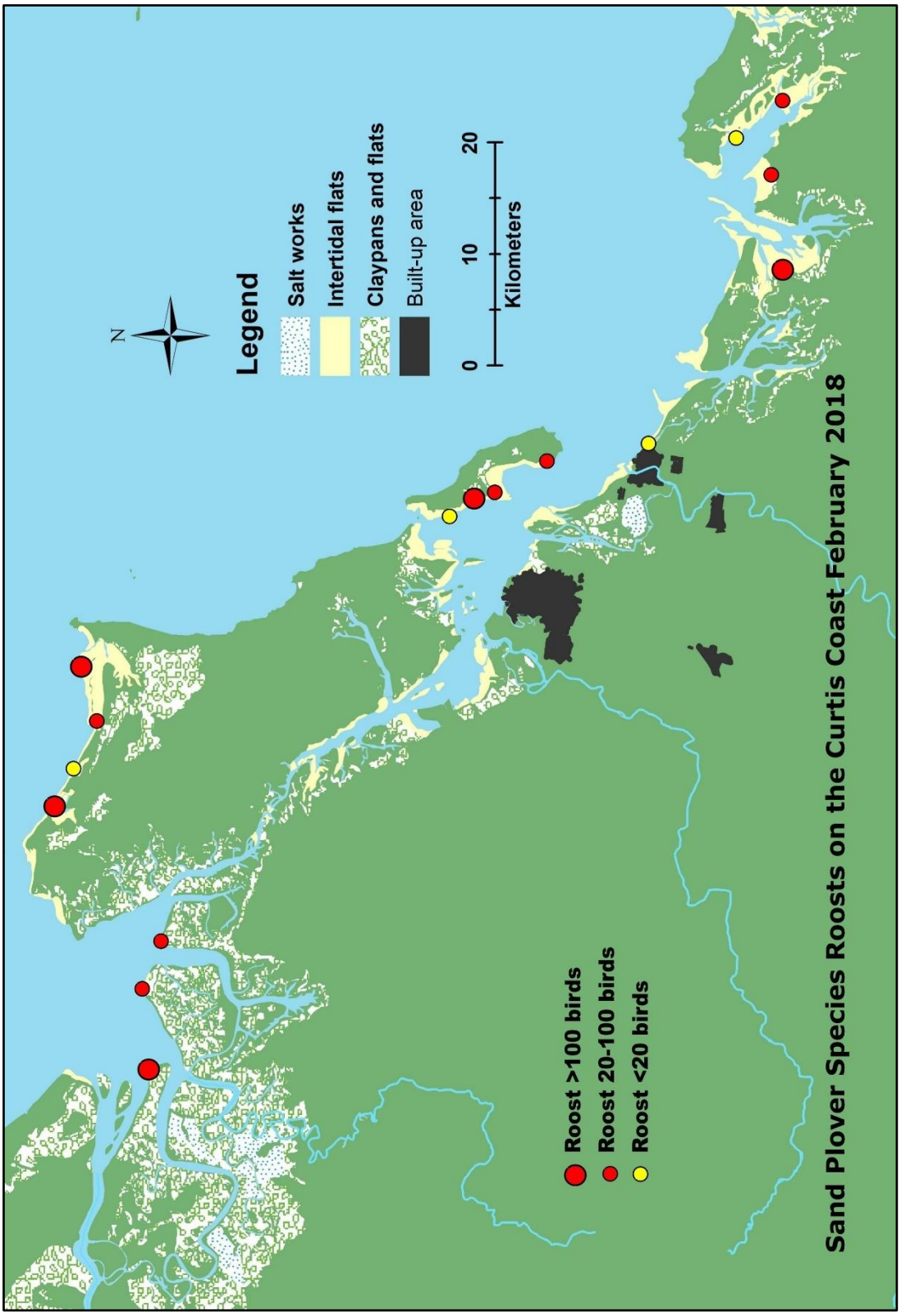


Table 4-15 Summary of low tide foraging counts for migratory shorebirds at each survey location.

The counts at North Curtis Island were curtailed due to unsuitable weather conditions. The scheduled counts at Fitzroy Estuary and Mundoolin-Colosseum could not be completed due to safety considerations.

	PC	NC	RP	Total
Lesser Sand Plover	6	14	1	**21**
Greater Sand Plover	10	2	0	**12**
Bar-tailed Godwit	84	22	0	**106**
Whimbrel	28	10	2	**40**
Eastern Curlew	70	1	33	**104**
Great Knot	8	0	0	**8**
Terek Sandpiper	3	0	0	**3**
Grey-tailed Tattler	23	8	0	**31**
Common Greenshank	0	6	0	**6**
Red-necked Stint	176	10	1	**187**
Sand Plover spp.*	0	13	0	**13**
Total abundance	**408**	**86**	**37**	**531**
Total species	**9**	**8**	**4**	**10**

PC = Port Curtis including the mainland foreshore, NC = North Curtis Island, RP = Rodds Peninsula

*This class represents multiple species so is not represented in the count of total species

Eastern Curlew on the Friend Point tidal flat, February 2018
(Adam Leavesley, Wildlife Unlimited).

5 DISCUSSION

5.1 Summer 2018 – 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). Announcements by the Chinese Government reported in the South China Morning Post on 2 January 2018 have said that land reclamation for commercial purposes will no longer be approved. The ban would not be expected to reverse migratory shorebird decline but maybe halt them.

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). 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 5). 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).

A migratory shorebird monitoring program on the Curtis Coast timed for early February is likely to produce good estimates of the abundance of eight species residing over summer. These are Bar-tailed Godwit, Common Greenshank, Eastern Curlew, Great Knot, Grey Plover, Greater Sand Plover, Grey-tailed Tattler and Whimbrel (Choi et al. 2017). These data are appropriate for detection of changes in the abundance of summer residents. Three species which reside on the Curtis Coast over summer have commenced northward migration in February. These are Lesser Sand Plover, Red-necked Stint and Terek Sandpiper. Detection of changes in abundance of summer residents of these species is confounded by the migrants. A number of species use the Curtis Coast in transit, to and from foraging areas further south. Species in this category include: Broad-billed Sandpiper, Curlew Sandpiper, Red Knot, Ruddy Turnstone and Sharp-tailed Sandpiper (Choi et al. 2017). Summer counts of these species may not adequately reflect their use of the Curtis Coast.

The total abundance recorded for the Curtis Coast February 2018 summer survey was 7 percent fewer than the 2017 survey which was the highest figure recorded for the project (Wildlife Unlimited, 2017). The 2018 figure was still 5 percent greater than the summer mean for the project, 12,355. The abundances of six species were substantially lower than recorded in 2017. These were: Terek Sandpiper (-39 percent), Greater Sand Plover (-69 percent), Bar-tailed Godwit (-12 percent), Whimbrel (-18 percent), Great Knot (-38 percent), Broad-billed Sandpiper (-100 percent). The abundance of all these species except the Great Knot, was within the range previously recorded during this project. It is also important to note that: 1) Terek Sandpiper and Broad-billed Sandpiper counts may have been affected by migratory behaviour (Choi et al. 2017); and 2) the count of Sand Plover spp. and small shorebirds not identifiable to species was greater than 2017 and this may have contributed to the magnitude of the decrease in the Greater Sand Plover and Broad-billed Sandpiper counts.

Two species exhibited substantial increases from 2017. These were the Red-necked Stint (24 percent) and Grey-tailed Tattler (20 percent). Red-necked Stint counts have exhibited the greatest range of any species during the project (860-3854). This has been attributed to the possibility that birds were not roosting at high tide but instead feeding across coastal salt marshes (e.g. Wildlife Unlimited, 2017). But the counts are also likely to have been affected by migratory movements (Choi et al. 2017). Grey-tailed Tattler abundance remained at the top of the range for the third year in a row following a big increase in 2016.

Conditions for shorebird counting during the survey were sub-optimal. Winds were generally light to moderate for the first two days but increased substantially for the final four days which included a stand-down day. 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. Due to safety considerations, one roost with an average abundance >100 could not be surveyed this year. In comparing the 2018 results with the previous year the contrast in weather conditions should be taken into account.

Tides during the 2018 survey were at the top of the predicted range for 2018 due to the coincidence of the moon's perigee with the spring tide. The event was reported in the media as a 'super blue blood moon'.

5.2 The Effects of Construction on Migratory Shorebirds

There was no construction activity apparent in the upper harbour of Port Curtis during the 2018 survey. The last of the six LNG trains was commissioned at the APLNG plant in October 2016 and local news reports said that the workforce of the construction contractor Bechtel, was reduced to a warranty team soon after. In contrast, activity associated with the berthing and loading of LNG ships appeared to have increased with three vessels present and near-constant tug operations (Figure 5-1, Figure 5-4). Vessels transporting plant staff and equipment were also observed (Figure 5-3, Figure 5-3) but there was apparently no port infrastructure maintenance underway (Figure 5-5).

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 5-6) and the other at Clinton Ash Ponds (Figure 5-7,) 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 (Figure 5-8). 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. The Gladstone Marina Ponds, which are adjacent to the Clinton Ash Ponds and treated as the same site, have been subject to works since the 2017 survey. The works have reduced the area of shorebird habitat (Figure 5-9).

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, five in 2017 and four in 2018. 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 again 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.

The roosts at North and South Passage Islands appear to be subject to reduced shipping construction traffic following the completion of construction of the LNG plants. However, activity associated with berthing and loading of LNG ships appears to have increased. The South Passage Island roost returned a count of 235 in January 2011, consisting of seven species. A total of 59 birds of three species were recorded in February 2015, 23 birds in 2016, 39 in 2017 and 30 in 2018. Species present in 2011 that have not been recorded since are the Bar-tailed Godwit, Eastern Curlew, Lesser Sand Plover and Red-necked Stint. In addition, Whimbrel numbers have been greatly reduced. The two species regularly recorded since 2011 are the mangrove-roosting Grey-tailed Tattler and Terek Sandpiper.

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 complete, there are likely to be other sources of disturbance associated with the new infrastructure such as light spill, disturbance from port facilities that existed prior to the WBDDP (Figure 5-10) and other unrelated sources of disturbance including recreational fishers (Figure 5-11, Figure 5-12) and natural predators (Figure 5-13).

Another potential cause of migratory shorebird decline in the upper harbour of Port Curtis is a reduction in foraging habitat. The dredging associated with the LNG plants may cause some loss (GHD, 2011c). Recent work on the Curtis Coast concluded that the migratory shorebirds have strong site fidelity and that the foraging grounds are at carrying capacity (Choi et al. 2017). Losses of foraging habitat are therefore likely to negatively impact migratory shorebirds.

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 apparent changes in the distribution of migratory shorebirds in the upper harbour of Port Curtis were caused by 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.

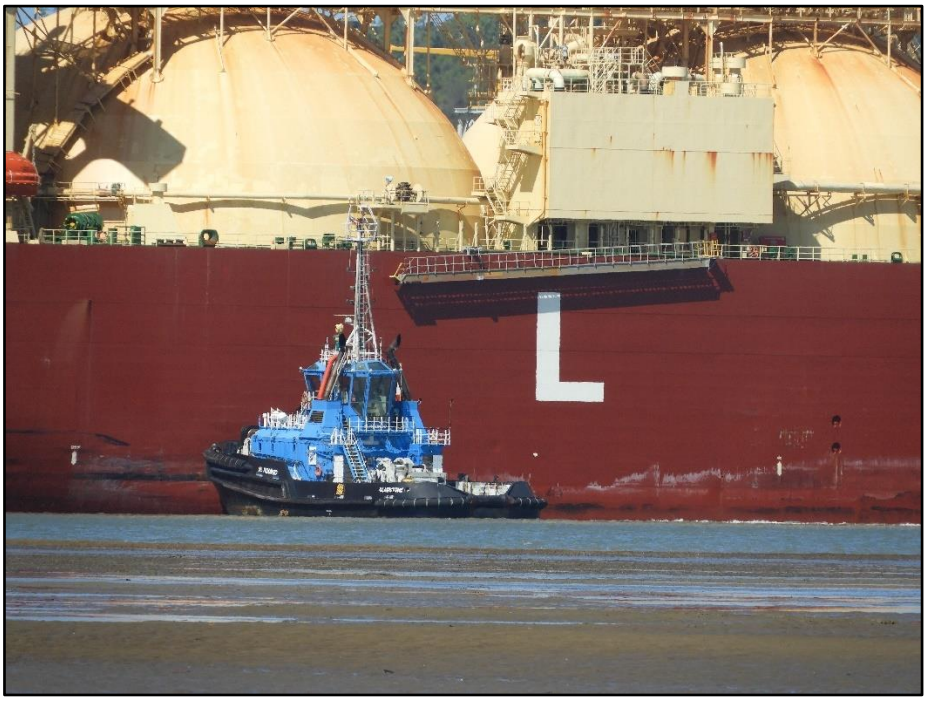


Figure 5-1 LNG export vessel in close proximity to South Passage Island, February 2018.
There was more shipping activity associated with LNG export than during previous surveys (Adam Leavesley, Wildlife Unlimited).

Figure 5-2 Tug boats were a common sight in the upper harbour of Port Curtis, February 2018.
These two boats are moored adjacent to an LNG plant (Adam Leavesley, Wildlife Unlimited).

Figure 5-3 Shipping traffic adjacent to an LNG plant in Port Curtis, February 2018.
Commercial shipping traffic appeared much reduced in the upper harbour of Port Curtis during the 2018 survey (Adam Leavesley, Wildlife Unlimited).

Figure 5-4 Vessels in the upper harbour of Port Curtis, February 2018.
(Adam Leavesley, Wildlife Unlimited)

Figure 5-5 A dredge channel maintenance vessel in Gladstone Marina, February 2018.
The blade on the stern of the vessel is deployed in the dredge channels a bit like a grader blade (Adam Leavesley, Wildlife Unlimited).

Figure 5-6 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 5-7 Clinton Ash Ponds, February 2017.
The site was subject to works during the 2017 survey but supported abundant wetland plants in 2018, see figure 2.5 (Adam Leavesley, Wildlife Unlimited).

Figure 5-8 A roost on the Calliope River directly adjacent to the WICET, February 2018.
A group of Whimbrel were present (Adam Leavesley, Wildlife Unlimited).

Figure 5-9 The Marina Ponds, February 2018.
The site has been subject to works which have reduced the area of shorebird habitat (Adam Leavesley, Wildlife Unlimited).

Figure 5-10 Berths at Fisherman's Landing, February 2018.
Berths in use in the Port of Gladstone (Adam Leavesley, Wildlife Unlimited).

Figure 5-11 Recreational fishers near roosting sites on the WBRA, February 2018.
(Adam Leavesley, Wildlife Unlimited).

Figure 5-12 Recreational boat in Targinnie Creek, February 2018.
Birds roost in mangroves along the edge of waterways. One tinnie was observed to put 320 mangrove roosting shorebirds to flight at a site near Mundoolin Rocks (Adam Leavesley, Wildlife Unlimited).

Figure 5-13 A predatory bird in the upper harbour of Port Curtis, February 2018.
A White-bellied Sea-eagle on a navigation aid (Adam Leavesley, Wildlife Unlimited).

5.3 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 2018 survey, construction activity associated with LNG production appeared complete. 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 5.2). 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 a 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).

5.4 The Western Basin Reclamation Area

A total of 714 migratory shorebirds consisting of 707 Red-necked Stint (Figure 5-14), four Whimbrel and three Eastern Curlew were recorded at the WBRA at high tide. This is the highest count from the WBRA during the project. In comparison, three Curlew Sandpiper and one Whimbrel were recorded during the high tide survey in 2017, 327 Red-necked Stints were recorded in 2016 and three Eastern Curlew in 2015. The Red-necked Stints were recorded foraging in three of the ponds, while the Eastern Curlews and Whimbrels were roosting. Two of the Whimbrels were observed using the bund wall which is the first record of this behaviour (Figure 5-15). The pattern of use of the WBRA by migratory shorebirds was consistent with previous surveys involving small numbers of large birds at rest and Red-necked Stints in a range of flock sizes, feeding on the edge of the shallow pools.

Figure 5-14 Red-necked Stints at the WBRA, February 2018.
(Adam Leavesley, Wildlife Unlimited)

Figure 5-15 A Whimbrel on the bund wall of the WBRA at high tide, February 2018.
(Adam Leavesley, Wildlife Unlimited)

5.5 Conclusion

Survey coverage was comparable to February 2017 and previous summer surveys. It should however be noted that: 1) The schedule was completed over a six-day period with a single stand down day due to unsuitable weather; and 2) a single roost with an average abundance >100 could not be surveyed due to safety considerations. Nonetheless, 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 present on the Curtis Coast in early February does not appear to have declined since the program began in 2011. However recent work shows that a proportion of these birds are not summer residents but passage migrants heading northward (Choi et al. 2017). Stability in the annual count of migratory shorebirds on the Curtis Coast is positive, however it is not directly relevant to the health of the constituent species which need to be treated separately. 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.

Eight species of migratory shorebirds are resident on the Curtis Coast in summer, display high site fidelity and have not commenced migratory movements prior to February 15 (Choi et al. 2017). Of these, seven are amongst the 10 most abundant species on the Curtis Coast in early February. Of these seven species, the counts recorded in 2018 are within the range recorded previously during this project. The two species that have extended the range of recorded values are the Grey-tailed

Tattler which returned the highest count of the project for the third year in a row and the Great Knot which returned the lowest count of the project for the second year in a row.

Three species of migratory shorebird are resident on the Curtis Coast in summer, but have commenced migratory movements in the first half of February. Two of these species have exhibited considerable variation in abundance between years. The third species, the Lesser Sand Plover cannot always be distinguished from the Greater Sand Plover and this further confounds the counts. The 2018 counts for all three species were within the range recorded in previous years.

High tide surveys at the WBRA revealed 707 Red-necked Stints, four Whimbrels and three eastern Curlew. Surveys targeting the bund wall detected two Whimbrels. This is the first time this behaviour has been detected. This general pattern of use of the WBRA is of small numbers of Whimbrel and Eastern Curlew roosting; and flocks of Red-necked Stints of various sizes feeding.

Shorebird abundance at sites that were subject to construction disturbance generally appeared lower than at the beginning of the project but few data were collected prior to the commencement of construction. There appear to be changes in the distribution of birds at roosts in the upper harbour and the use of the WBRA by large flocks of Red-necked Stints is new. It is 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.

5.6 Recommendations

1. This survey was the final annual summer survey required for the project. If a survey is to be conducted in early February 2019 according to the guidelines agreed for the annual summer survey, it will commence on the new moon on Monday 4 February and run to Friday 8 February.

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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

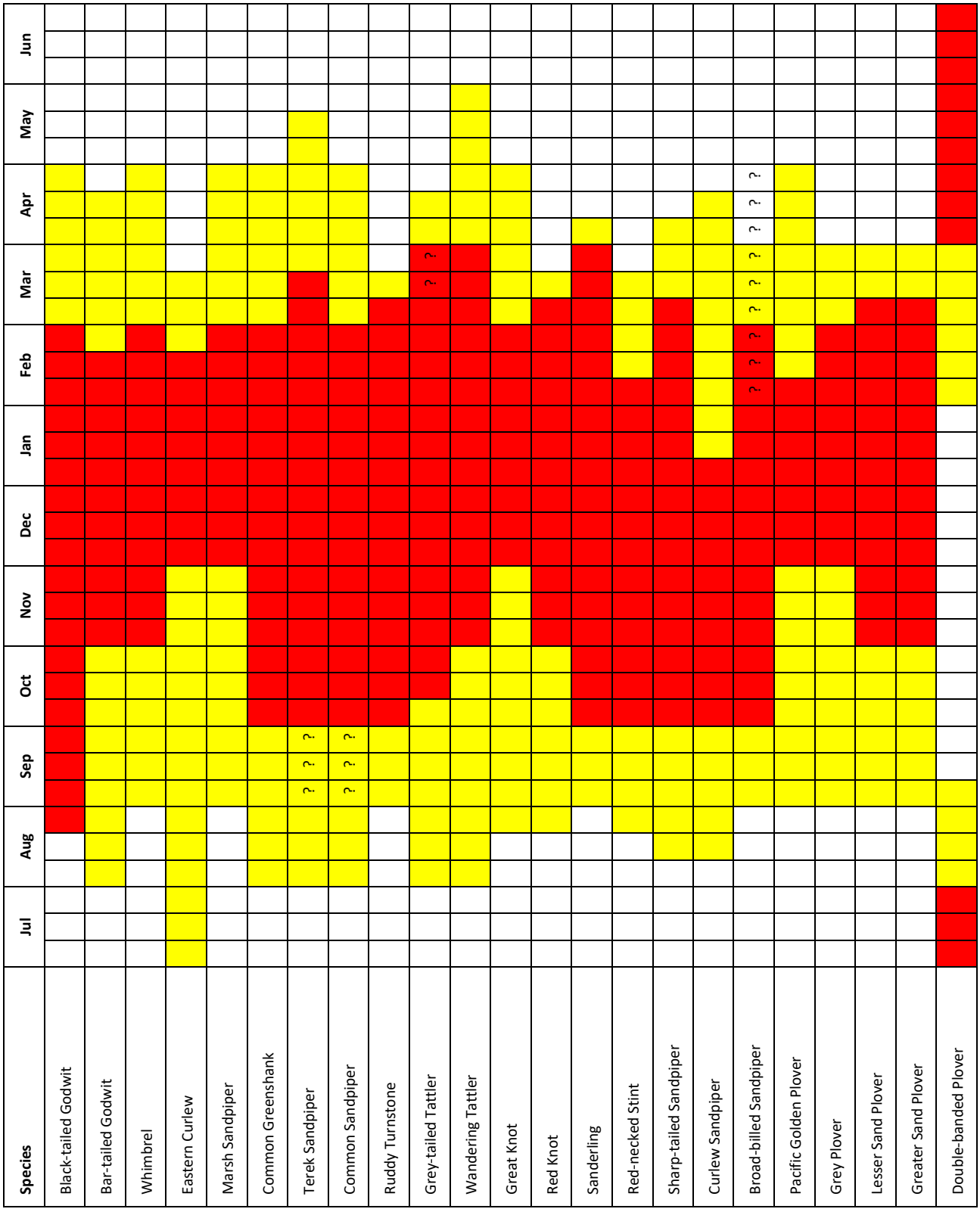
* Only a small proportion of the population is present in the EAAF.

? indicates uncertainty about the population trajectory

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

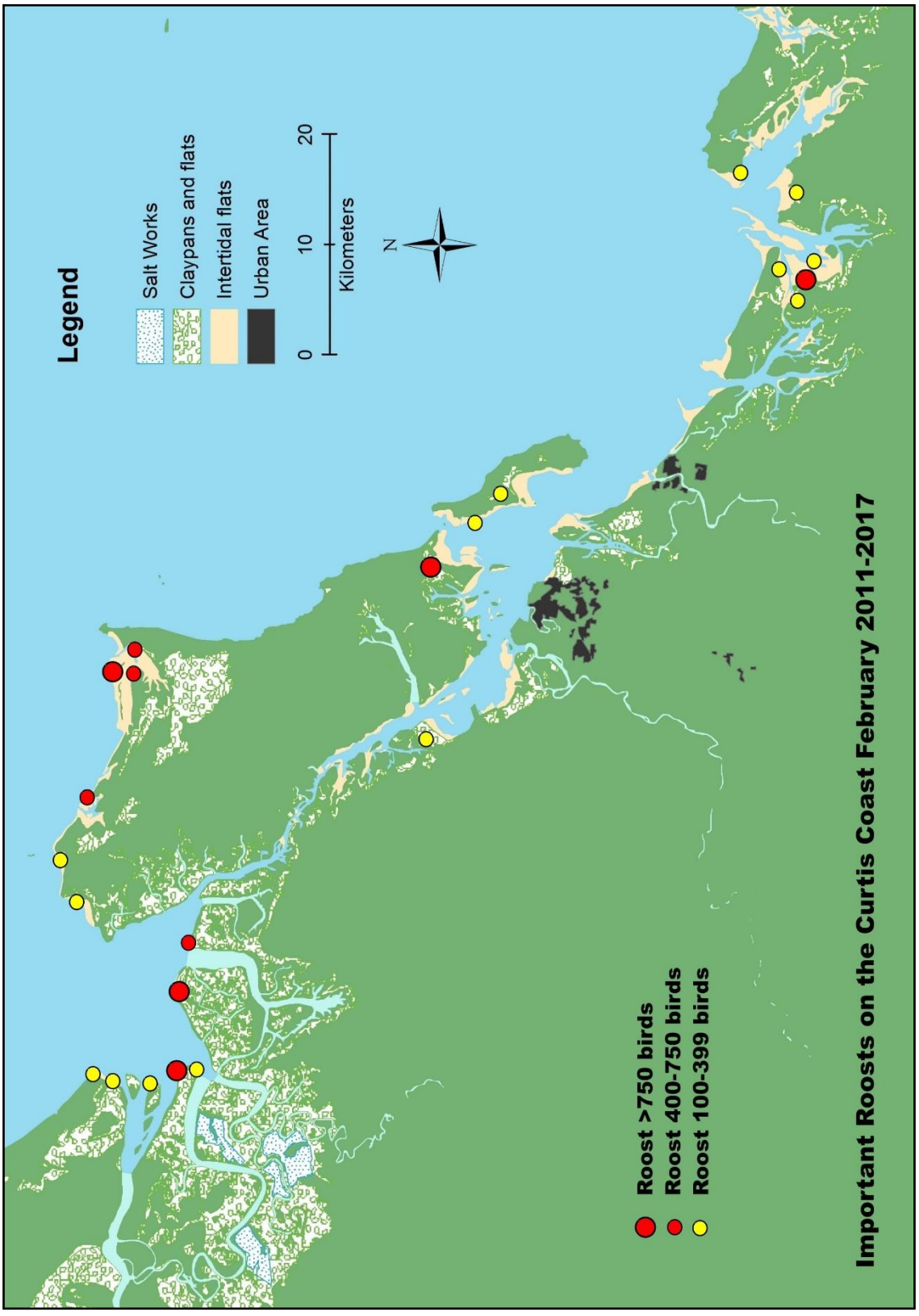
Scientific name	Common name	Abbreviation
Burhinidae		
Burhinus grallarius	Bush Stone-curlew	BSc
Esacus magnirostris	Beach Stone-curlew	BeSc
Haematopodidae		
Haematopus longirostris	Australian Pied Oystercatcher	APO
Haematopus himantopus	Sooty Oystercatcher	SO
Charadriidae		
Erythrogobus cinctus	Red-kneed 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: Important Summer Roosts 2011-2017

Table A5.1 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 A5.1 Roosts with a mean abundance >100 during February high tide surveys 2011-2017



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

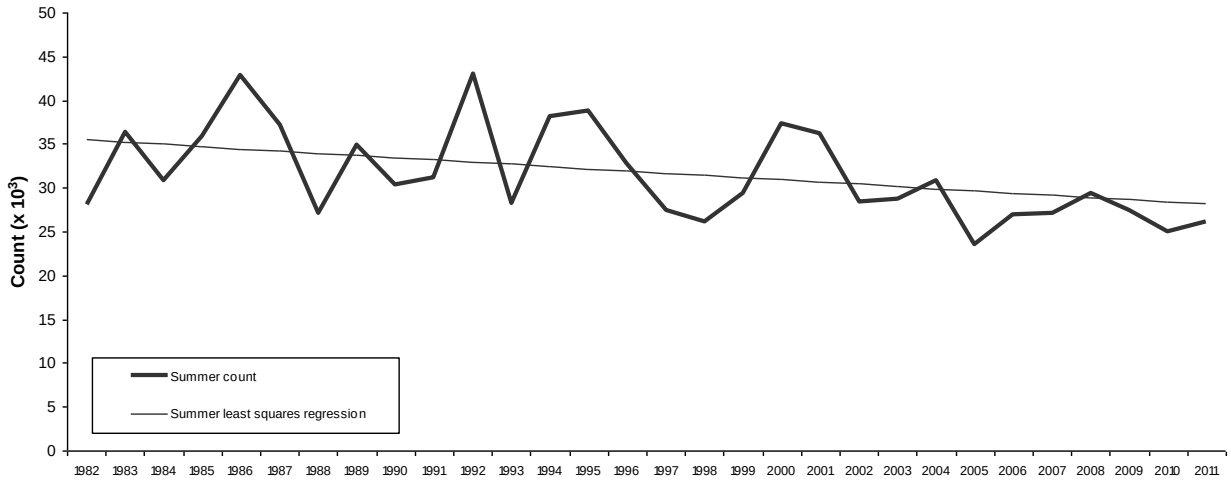


Figure A6.1 Migratory Shorebird Count at Corner Inlet from 1982-2011, reproduced from Minton et al. (2012). A standardised method was used throughout the period.