# Growing capacity to support migratory shorebird resilience at three of Queensland's coastal Ramsar sites: A two year volunteer-led field project

*Final report for the Queensland Government*
*Community Sustainability Action grant project CSAT20034*

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**Acknowledgement of Country**

We acknowledge the Traditional Owners of the land on which we conducted our activities and pay our respects to Elders past, present and future. We value and care for the country which we now enjoy through the custodianship and nurturing of Australia's First Peoples over tens of millennia.

**Acknowledgements**

We acknowledge the support of the Queensland State Government through the award of a Queensland State Community Sustainability Action Grant and express our gratitude to the grant team for their understanding when we needed to change timelines and funding allocations to address restrictions due to the Covid-19 pandemic.

The Department of Environment and Science provided relevant permits to conduct our field work. The Australian Bird and Bat Banding Scheme supplied metal bands for shorebirds as part of the catching program on the Great Sandy and Moreton Bay field work sites. Platform Terminal Transmitters (PTT) were purchased through the grant. Additional PTTs were donated by Charles Darwin University which allowed us to expand the satellite tracking program. The Queensland Wader Study Group provided funding for leg flags and other ancillary costs.

Brisbane City Council, Redland City Council, Fraser Coast Council and the Port of Brisbane provided access to public and private lands to catch birds at high tide roosts. The Gudjuda Aboriginal Reference Corporation and its land and sea rangers provided the overwater transport support for the surveys at Bowling Green Bay. At Great Sandy Strait, members of the Butchulla Aboriginal Corporation attended a pre-fieldwork shorebird training workshop. At Moreton Bay, the Quandamooka Yoolooburrabee Aboriginal Corporation agreed to a joint field work training initiative that unfortunately could not go ahead due to Covid restrictions. We look forward to building on these initiatives into the future.

More than 60 members of Queensland Wader Study Group (QWSG), a special interest group of the Queensland Ornithological Society, and other local volunteers took part in the field work at the Bowling Green Bay, Great Sandy Strait and Moreton Bay Ramsar sites. Volunteers ranged from experienced counters and bird banders to trainees from across Queensland, New South Wales and the Australian Capital Territory, with representatives from the University of Queensland and Newcastle University, as well as from local industry, including the Port of Brisbane. We would especially like to acknowledge the efforts to establish local support at Great Sandy Strait by Cecile Espigole and Will Price who conducted reconnaissance surveys ahead of the catching expeditions.

We also acknowledge the collaboration of the Bird Education Group (recently renamed the Bird Learning Group), a joint initiative of Birds Queensland and Birdlife (Southern Queensland) in the development of STEM materials on Shorebirds for Schools and also the Moreton Bay Discovery Centre, who funded and supported the establishment of a permanent Shorebird display which incorporates findings from shorebird satellite tracking.

We thank our expert panel members, Professor Richard Fuller from the University of Queensland and Mike Ronan from the Wetlands Team in the Department of Environment and Science for their support during the project.

**Data availability**

Data generated through this project is uploaded to Wildnet through an existing agreement between the Queensland Government and QWSG. Shorebird count, leg-flag, and tracking data can also be requested from QWSG.

**Recommended citation: this title will need to change if we use the current suggested title**

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**Author contributions:**

RAB coordinated production of the overall report and led the writing of Chapter 1 (Introduction) and the Addendum. PVD and BKW led the writing of Chapter 2 (Bowling Green Bay surveys). JTC, RAB, LAC led the writing of Chapter 3 (Great Sandy Strait and Moreton Bay tracking and leg-flagging study), and LAC conducted spatial analysis of tracking data. BKW led the writing of Chapter 4 (General Discussion). All authors reviewed and edited drafts of the report.

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LIST OF ABBREVIATIONS

**PTT** - Platform Terminal Transmitter (satellite-communication devices to track shorebirds)
**QWSG** - Queensland Wader Study Group
**STEM** - Science, technology, engineering, and mathematics
**EPBC -** Environment Protection and Biodiversity Conservation Act
**TMR** - Department of Transport and main Roads

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EXECUTIVE SUMMARY

*Background and aims.* Queensland's coastal Ramsar wetlands provide critical habitat to many thousands of threatened migratory shorebirds, yet information and resources available to support migratory shorebird conservation and management varies among sites and is primarily concentrated in the south. To address information gaps, enhance capacity for shorebird monitoring, and improve education and public awareness, QWSG undertook a community-led field project in and adjacent to the Bowling Green Bay, Great Sandy Strait, and Moreton Bay Ramsar wetlands between December 2019 and October 2022. The project was supported by a Queensland Government Community Sustainability Action Grant (Project CSAT20034).

*Bowling Green Bay.* At the Bowling Green Bay Ramsar site, two comprehensive shorebird surveys were conducted in late February / early March in 2021 and 2022 to fill gaps in shorebird monitoring in the region. During these surveys, we counted an average of 12,163 migratory shorebirds of 21 species from 29 sites extending from the Ross River mouth southwards through Bowling Green Bay to the Burdekin River mouth. Community-level and species-specific abundances varied across the region, and when combined with historical data, painted a picture of the relative importance of these areas to shorebirds. Notably, the part of the coastline given the least attention over the years around the mouth of the Burdekin, consistently holds high numbers of shorebirds. The roost site at the mouth of the Ross River in Cleveland Bay (south side of Townsville and adjacent to the Port development) has been sampled more than any other site in the region. The coastline of Bowling Green Bay has overall shorebird numbers that appear similar to the Burdekin delta, but not exceptional numbers of any particular species. Despite more intensive sampling on the wide intertidal areas north of Townsville, fewer shorebirds occurred than elsewhere.

*Great Sandy Strait and Moreton Bay.* At the Great Sandy Strait and Moreton Bay Ramsar sites, engraved leg flags and tracking devices were attached to migratory shorebirds to enhance capacity to understand local shorebird movements and home ranges, and to set the stage for measuring connectivity within and between Ramsar wetlands and across the East Asian Australasian Flyway. Across both Ramsar sites, a total of 466 shorebirds of 20 species were caught, banded, and leg-flagged, contributing to a total of 5,362 leg flag resightings from 1,171 individuals in Moreton Bay and 50 resightings of 39 individuals in Great Sandy Strait during the study period. In addition, 11 tracking devices were fitted to Bar-tailed Godwits, with further data received from previously fitted devices (1 Eurasian Whimbrel and 3 Far Eastern Curlew). Combined, leg flag resightings and satellite telemetry have revealed high degrees of site fidelity in both study sites; key feeding and roosting habitats; seasonal differences in habitat use; use of both protected areas and adjacent non-protected areas; and linkages between all three Ramsar wetlands that were the focus of this project.

*Education and capacity building.* During the two-year study period, we involved more than 60 volunteers in fieldwork and sought to engage the public and increase awareness of

threatened migratory shorebirds through endorsed social media postings that reached a cumulative audience of 193,000. To improve public awareness, education, and capacity over the long-term, we further began a process of strengthening relationships with Traditional Owner organisations; developed a permanent public shorebird display at the Moreton Bay Discovery Centre; and co-developed curriculum resources about shorebirds for schools in partnership with Birds Queensland and Birdlife Southern Queensland.

*Implications.* Activities undertaken by the project will help to support migratory shorebird conservation and management throughout Queensland now and into the future. New and forthcoming information about migratory shorebird movements, connectivity, distribution, and abundance within and across three of Queensland's Ramsar wetlands that can support coastal management planning at multiple Ramsar wetlands and marine parks. Further, education, volunteer engagement, and relationship-building initiatives undertaken will help to increase capacity for monitoring and conserving shorebirds and their habitats over the longer-term. With continued funding and support, we are hopeful that outcomes from this project will help to secure a stable future for threatened migratory shorebirds and healthy coastal environments across Queensland as the climate undergoes change.

# CHAPTER 1 – INTRODUCTION

## 1.1 Summary

Queensland's coastal Ramsar wetlands provide critical habitat to many thousands of threatened migratory shorebirds, yet information needed to conserve, manage, and assess impacts of climate change and other threats on migratory shorebirds varies widely across sites and is lacking in many areas. This report details a two-year, volunteer-led project across three of the four Queensland coastal Ramsar wetlands that begins to address this limitation. The project was designed to enhance capacity to monitor, conserve, and manage migratory shorebirds across Ramsar sites under a changing climate. The project ran from December 2019 to October 2022 and was led by the Queensland Wader Study Group, a special interest group of the Queensland Ornithological Society. The project was supported by a Queensland Government Community Sustainability Action Grant (project CSAT20034).

## 1.2 Addressing Threatened Migratory Shorebirds

Queensland's migratory shorebird community is in decline (Clemens et al. 2016), with 7 species listed as threatened under the Commonwealth Government's Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) and Queensland Government's Nature Conservation Act 1992 (Table 1.1).

To address these declines, conservation action plans for individual species have been developed at the national and international level (Commonwealth of Australia (2015), Threatened Species Scientific Committee (2015, 2016), East Asian Australasian Flyway Partnership (2012)). The action plans list key threats and broad strategies for mitigating these threats. These have been used to guide this project's design.

A requirement of the Community Sustainability Action Grant is that listed threatened species conservation be addressed as part of the field project. The field work design addresses this specifically through a focus on the Far Eastern Curlew and the Bar-tailed Godwit. Field work approaches are aimed to address knowledge gaps at key coastal Ramsar sites and adjacent surrounds. While in the past greater attention has been placed on discovering the migration routes from the Queensland coast to the breeding grounds, in this project the focus is on local conditions.

**Table 1.1.** Migratory shorebird species listed as threatened under the EPBC Act (1999).

| **Common name** | **Scientific name** | **National status** | **Queensland status** |
|---|---|---|---|
| Far Eastern Curlew | Numenius madagascariensis | Critically Endangered | Endangered |
| Bar-tailed Godwit | Limosa lapponica baueri | Vulnerable | Vulnerable |
| | Limosa lapponica | Critically Endangered | Endangered |

| Common name | Scientific name | National status | Queensland status |
|---|---|---|---|
| | menzbieri | | |
| Curlew Sandpiper | Calidris ferruginea | Critically Endangered | Critically Endangered |
| Great Knot | Calidris tenuirostris | Critically Endangered | Critically Endangered |
| Red Knot | Calidris canutus | Endangered | Endangered |
| Lesser Sand Plover | Charadrius mongolus | Endangered | Endangered |
| Greater Sand Plover | Charadrius leschenaultii | Vulnerable | Vulnerable |

1.3 Queensland's Coastal Ramsar Sites

During the 1990s four coastal Ramsar sites were established along Queensland's extensive east coast. In October 1993, Bowling Green Bay National Park, with an area in excess of 35,000 hectares was established south of Townsville, achieving Ramsar listing in 1996. In October 1993, Moreton Bay in south-eastern Queensland was listed as a Ramsar site with a total area in excess of 120,000 hectares. Three years later, parts of Great Sandy Strait with an area of 93,160 hectares as well as the Shoalwater and Corio Bay area with an area of 239,100 hectares were listed as Ramsar sites. Both of these additional sites are on the central Queensland coast and complete a chain of four internationally recognised coastal wetlands interspersed along almost 2000 kilometres of Queensland's east coast. This chain of Ramsar sites follows the routes taken by many migratory shorebirds to and from their breeding grounds in the northern hemisphere. The realisation that these four Ramsar sites are a key coastal environmental asset that could potentially support climate change resilience in threatened migratory shorebirds provided a rationale for this project.

The fieldwork took place at the Bowling Green Bay, Great Sandy Strait and Moreton Bay Ramsar sites. The Shoalwater and Corio Bays Ramsar site is within an Australian Defence Force training area and managed though the Commonwealth Department of Defence. The site was not included in this project because it was beyond the resources of QWSG to do so, but including this site in future field projects would be a worthwhile addition to support climate change resilience in migratory shorebirds along the Queensland coast.

Migratory shorebirds are a climate sensitive species (Watson et al. 2013). Iwamura et al. (2013) developed models to determine the impact of habitat loss in key coastal sites from sea level rise across the East Asian-Australian Flyway and estimated that sea level rise would inundate between 23-40% of intertidal habit. This would lead to a population reduction of up to 72% of 10 long-distance migrant shorebirds. However, it is probable that Queensland's coastal Ramsar sites are playing an important role in shielding migratory shorebirds from some impacts of climate change, coastal development and a range of other threats. Yet, regular surveying of migratory shorebirds and the mapping of these threats has been heavily concentrated around the southernmost of the four Ramsar sites, Moreton Bay.

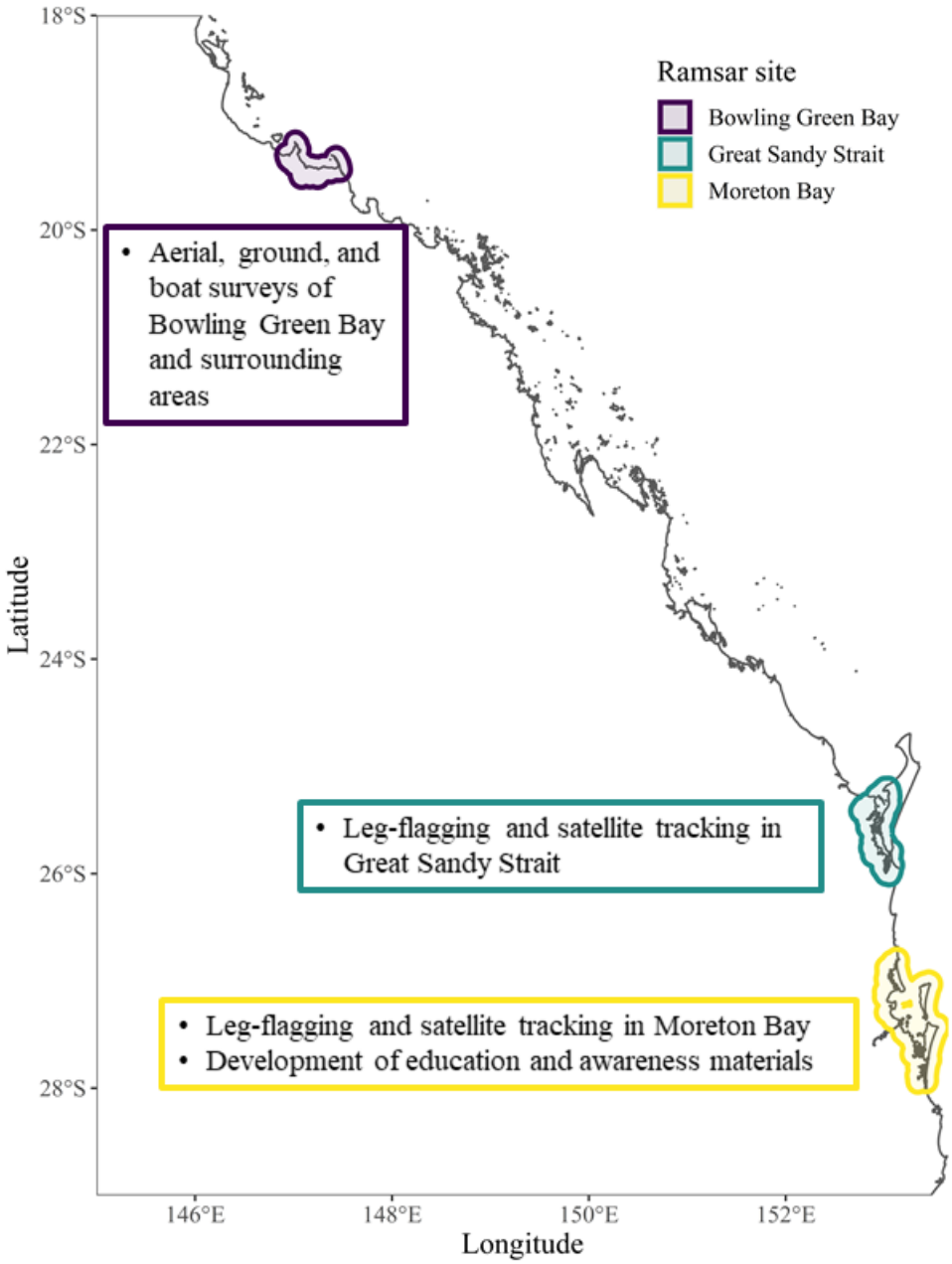


**Figure 1.1.** Map of the three coastal Ramsar wetlands in Queensland (Bowling Green Bay, Great Sandy Strait, and Moreton Bay) and project activities that occurred in each.

1.4 Project Purpose and Aims

To account for this historical bias the project adopted different aims for each site so that there would eventually be an increased capacity for shorebird monitoring, conservation, and management across all three sites. Likewise, the methods deployed across each site were different and designed to achieve these different aims.

*Aim: Bowling Green Bay*

Prior to its Ramsar listing in 1996, information about shorebird populations was limited for Bowling Green Bay (Kelly and Lee Long, 2011). Following a period of field work over one year at Bowling Green and surrounding areas, Driscoll et al. (2012) reported that, amongst other significant characteristics, the site supported greater than 1% of the flyway population of migratory shorebirds. Their report stressed that the area surrounding the Ramsar site had significant flocks of migratory shorebirds as well as within the site itself.

There has only been this single attempt to comprehensively estimate the abundance of shorebirds and their species diversity over the full site and surrounding area in more than 25 years since the site's Ramsar declaration. This has limited the capacity to establish management plans for migratory shorebirds at this, the most northerly Ramsar site on the Queensland east coast.

Accordingly, at Bowling Green Bay we aimed to fill critical knowledge gaps by conducting ground, over water and aerial community lead surveys repeated consecutively over two years. Through repeat surveys of shorebird populations we aimed to fill recent gaps in shorebird monitoring in the region to fulfill international obligations under the Ramsar Convention and three bilateral migratory species agreements. The data gathered will support management planning for shorebird climate change resilience.

*Aim: Great Sandy Strait*

QWSG has conducted regular biennial surveys of shorebird populations at roosting sites in the region since 1996. These surveys have established that significant populations of migratory shorebirds are present in the Great Sandy Strait and surrounding areas during the Austral summer and that there are greater than 1% of the flyway population of the Far Eastern Curlew at the site, among other threatened and non-threatened species. However, our knowledge of how shorebirds use the site, the interconnectivity between roosting and feeding areas remains largely unknown.

Accordingly, at the Great Sandy Strait Ramsar site and surrounding areas we conducted the first shorebird catching program using cannon nets to place engraved leg flags on a variety of species including Bar-tailed Godwit. Shorebirds with engraved leg flags will enable local shorebird citizen scientists to observe movements of identifiable birds and begin the task of establishing the interconnectivity between roosting and foraging areas in and around Great Sandy Strait.

*Aim: Moreton Bay*

Since the early 1990s QWSG has conducted monthly counts at key roosting sites of shorebirds. This extensive data set has provided important information for local management of shorebirds within the Bay and has contributed towards assessments of species abundance and the declaration of a number of species as threatened under the EPBC Act.

Since 2007 engraved leg flags have been attached to a variety of migratory shorebirds resulting in some analysis of shorebird movements within the Bay (Coleman et al. 2012). Since 2016, Platform terminal Transmitters (PTTs) have been attached to several species, in particular the Far Eastern Curlew as part of the National Eastern Curlew Project (Lilleyman et al. 2020, Morrick et al. 2022). We will take the local movement data from this previous study and combine this with local tracking data from Bar-tailed Godwits with attached PTTs from this field work project to discover in a more comprehensive manner the home range of Far Eastern Curlew and Bar-tailed Godwit within Moreton Bay.

In Moreton Bay our aim was to advance understanding of at least two species of threatened migratory shorebirds, Far Eastern Curlew and Bar-tailed Godwit, by shifting from our current capacity to define local movements to documenting this species home ranges and the significant habitat features within these ranges.

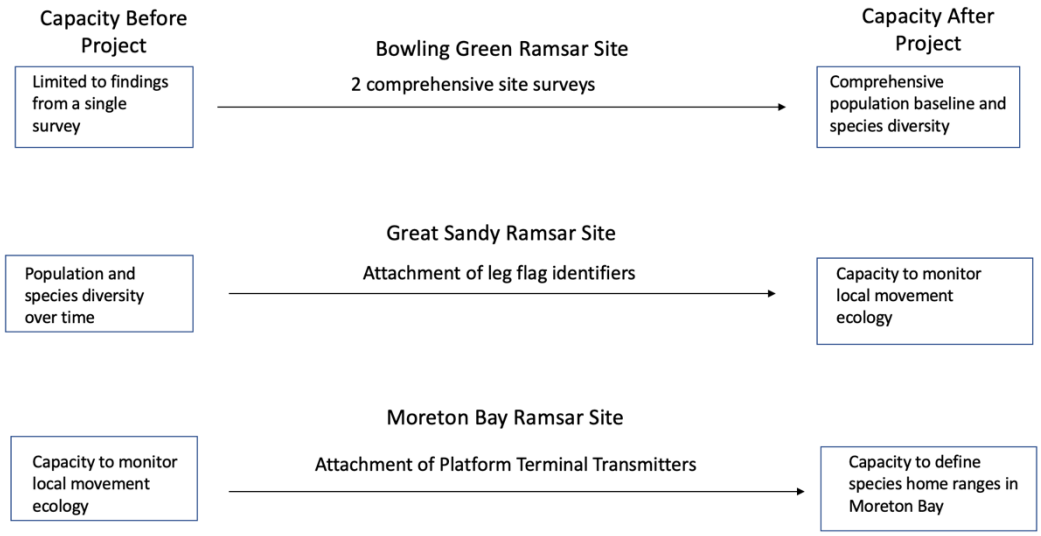


**Figure 1.2.** Project capacity building at three coastal Ramsar sites.

## 1.5 Engagement, Education Dissemination and Data Sharing

A requirement of the Sustainability Action Grant is that the activities involve volunteers, engage with Traditional Owner organisations, contribute to education initiatives, and that the data obtained is made available to the public and to organisations for planning and management purposes.

The engagement strategy involved supporting local citizen scientists through an invitation to join field work teams at the three field sites. We also began the process of relationship building with traditional owners through their local Aboriginal organisations and ranger services. We recognised that the eventual establishment of partnerships with traditional

owners and the sharing of traditional knowledge and citizen science initiatives can build a sustainable pathway in conservation of migratory shorebirds (Lilleyman et al. 2022).

We also recognized that social media can be a powerful tool in the dissemination of information about findings from field work. We therefore undertook to provide regular updates of the project to the public and to monitor the reach of information to a wider audience.

Past experience has demonstrated the engagement potential of using satellite tracking information in education programs about shorebird conservation. We planned to incorporate this and other shorebird conservation findings into both public and school-based education programs. We therefore worked to develop the new Shorebird display at the Moreton Bay Discovery Centre on the shores of Moreton Bay at Manly and also to provide STEM materials on shorebirds for schools through an initiative of the Bird Education Group, a project of Birds Queensland and Birdlife (Southern Queensland). The completed STEM learning and teaching packages are to be made widely available and specifically through the Moreton Bay Environmental Education Centre.

### 1.6 Report Structure

The remainder of the report is structured as follows. Chapter 2 reports on field activities and findings from surveys of shorebird abundance and distribution within and surrounding the Bowling Green Bay Ramsar wetland. Chapter 3 reports on the field activities and findings from the deployment of tracking devices and leg flags at the Great Sandy Strait and Moreton Bay Ramsar wetlands. Chapter 4 draws on findings from Chapters 2 and 3 to explore issues concerning climate change resilience of threatened migratory shorebirds at and surrounding Queensland's coastal Ramsar wetlands. Capacity-building initiatives undertaken to engage volunteers and provide educational resources are included in the Addendum.

# CHAPTER 2 – SURVEYS OF BOWLING GREEN BAY AND SURROUNDING AREAS

## 2.1 Background and objectives

Shorebird monitoring in the Bowling Green Bay region has been patchy both spatially and temporally over the last 42 years (Table 2.1). Since 1981 shorebird surveys have been conducted at 92 sites in the region, extending from Balgal Beach 50 km northwest of Townsville to Molongle Creek 60 km southeast of Bowling Green Bay (Fig. 2.1). Initiated by Birdlife Australia (RAOU), the five sites in the region regularly counted by volunteers throughout the 1980s were Alva Beach, Blakey's Crossing Townsville, Bolger Bay Magnetic Island, Bushland Beach East to the Bohle River, and the Ross River mouth sandspit. Then there was a lapse in sampling until 1994 and early 1995 when three of the original sites plus five others north of Townsville and another in Cleveland Bay were sampled, but not intensively. Late in 1995 a QWSG-led shorebird survey extended the geographic range of surveys in the area to include Bowling Green Bay and the Burdekin River mouth. Later in the 1990s more regular surveys were recommenced north of Townsville. During the 2000s nearly 40 sites were sampled, some very regularly such as the Ross River mouth, and several in Bowling Green Bay, including the tip of Cape Bowling Green, where, on four occasions well over 2000 shorebirds were counted. There has been limited regular sampling of the Burdekin River mouth after 2010. Driscoll et al. (2012) details the last known comprehensive surveys of the coastline between Cleveland Bay and the Burdekin River between 2010 and 2012, although some Burdekin River sites were revisited in 2016.

*Objectives*: Given recent gaps in shorebird monitoring in the Bowling Green Bay region, this project sought to collect new data and combine it with past survey data from the region to provide an updated picture of migratory shorebird abundance and distribution in and around Queensland's northernmost Ramsar wetland. While surveys conducted as part of this project did not include the area north of Townsville shown in Fig. 2.1, this area is where shorebird monitoring began in the region and is thus included to better represent the region as a whole.

**Table 2.1.** Summary of the number of sites surveyed and shorebird counts conducted in the Bowling Green Bay region (Fig. 1) in 5-year intervals from 1981 to present.

| 5 yr period: | *1981-85* | *1986-90* | *1991-95* | *1996-2000* | *2001-05* | *2006-10* | *2011-15* | *2016-20* | *2021-22* |
|---|---|---|---|---|---|---|---|---|---|
| Numer of counts: | 114 | 82 | 77 | 216 | 189 | 193 | 126 | 6 | 100 |
| Number of sites: | 5 | 3 | 45 | 24 | 21 | 32 | 39 | 6 | 29 |

**Figure 2.1.** Map of regional shorebird survey sites showing the boundary of the Bowling Green Bay Ramsar site (yellow lines). The sites have been grouped spatially by colour and are identified on the basis of whether a maximum of more (A) or less than (B) 100 migratory shorebirds have ever been recorded at the site. The 29 ground / boat survey sites visited in Feb/Mar 2021 and 2022 are a subset of these sites and are shown in Figure 2.


**Figure 2.2.** Map of the 29 project survey sites for Cleveland Bay (purple), Bowling Green Bay (yellow), the Alva area (red) and Burdekin area (blue). The Ramsar boundary is in yellow. The size of the dots is indicative of the relative average number of migratory

shorebirds on a logarithmic scale. Some sites averaged less than 20. Alva claypan (ALVC) recorded 4102.

## 2.2 Methods

Surveys were conducted between 08-14 March 2021 and 26 February to 03 March 2022. Surveys targeted coastal habitats of threatened migratory shorebirds. Counts were primarily conducted at roost sites at high tide, with low / rising tide counts conducted at Cleveland Bay, Cungulla and Wunjunga Wetlands. High tide roost site counts were either ground counts or boat counts and all low / rising tide counts were ground counts. The site locations are shown in Figure 2.2 and the number of visits to each site during the two-year sampling period are presented in Table 2.3. In both years, an aerial reconnaissance survey was flown along the coastline from the Ross River mouth southwards to the Burdekin River mouth to gain a preliminary assessment of the distribution of migratory shorebirds to inform subsequent boat and ground surveys. No shorebirds were observed at the tip of Cape Bowling Green during aerial reconnaissance surveys. Consequently, we did not travel to the tip of Cape Bowling Green by boat to conduct ground counts, choosing instead to prioritize boat travel to sample areas with greater concentrations of shorebirds.

## 2.3 Results

During the 2021 and 2022 surveys, we counted an average of 12,163 migratory shorebirds of 21 species from 29 sites extending from the Ross River mouth southwards through Bowling Green Bay to the Burdekin River mouth (Fig. 2.2). Community-level and species-specific abundances were not evenly distributed across the region (Table 2.3). When combined with all available data for each of the five coastal areas (Fig. 2.1), they paint a picture of the relative importance of these areas to shorebirds (Table 2.2, Fig. 2.3).

Despite more intensive sampling on the wide intertidal areas along the open coastline north of Townsville, this area holds fewer shorebirds than elsewhere (Fig. 2.3). It is notable, however, that despite the relatively low numbers of migratory species, the area has had good counts of non-migratory species over the years (Table 2.2), and large flocks of migratory Great Knot and Red Knot periodically occur in the area. To the south, the roost site at the mouth of the Ross River in Cleveland Bay has been sampled more than any other site in the region (149 times). It consistently holds good numbers of shorebirds, especially Great Knot, as well as Red Knot at certain times of the year (Table 2.2) Shorebirds that forage on the western side of Cleveland Bay use this high tide roost, whereas there are far fewer birds using the eastern side of Cleveland Bay, where there is no known high tide roost site.

The part of the coastline given the least attention over the years around the mouth of the Burdekin, consistently holds high numbers of shorebirds (Fig. 2.3). The Burdekin River mouth also supports the highest diversity of shorebirds, with 12 of the 21 listed species ranked highest for the Burdekin (Table 2.2). The Alva claypan is notable for a very high count

of Broad-billed Sandpiper, Sharp-tailed Sandpiper, Curlew Sandpiper and Marsh Sandpiper during the 2021 survey, which is reflected in the rankings in Table2.1. This was accompanied by a high count of Pied Stilt, whereas the high ranking of Pacific Golden Plover for the Alva area results from the discovery of a flock of over 400 birds in an isolated location behind a coastal dune at the mouth of Plantation Creek (between Alva and the Burdekin mouth).

Bowling Green Bay has only received attention over the last 25 years since being designated as a Ramsar site. Prior to this, the coastline between Bowling Green Bay and the Burdekin River mouth was virtually unknown for shorebirds. Monitoring that has since taken place, has revealed that the coastline of Bowling Green Bay has good representation of a range of shorebirds but not exceptional numbers of any particular species, except perhaps for the Black-tailed Godwit and Red-necked Stint (Table 2.2). Despite this, the overall shorebird numbers appear similar to the Burdekin River mouth (Fig. 2.2). It is likely many of the same shorebirds that feed on tidal flats in Bowling Green Bay also roost or feed on the Alva claypan, which gives greater importance to Bowling Green Bay than is indicated in Table 2.2. Although Alva is given separate status as an area, it lies just outside the Ramsar boundary and functions as an important habitat component to the broader Bowling Green Bay wetland complex. Another important aspect of Bowling Green Bay is the vast freshwater wetlands that lie to the south of the coastal strip, just beyond the Ramsar boundary, which were given attention in Driscoll et al. 2012.

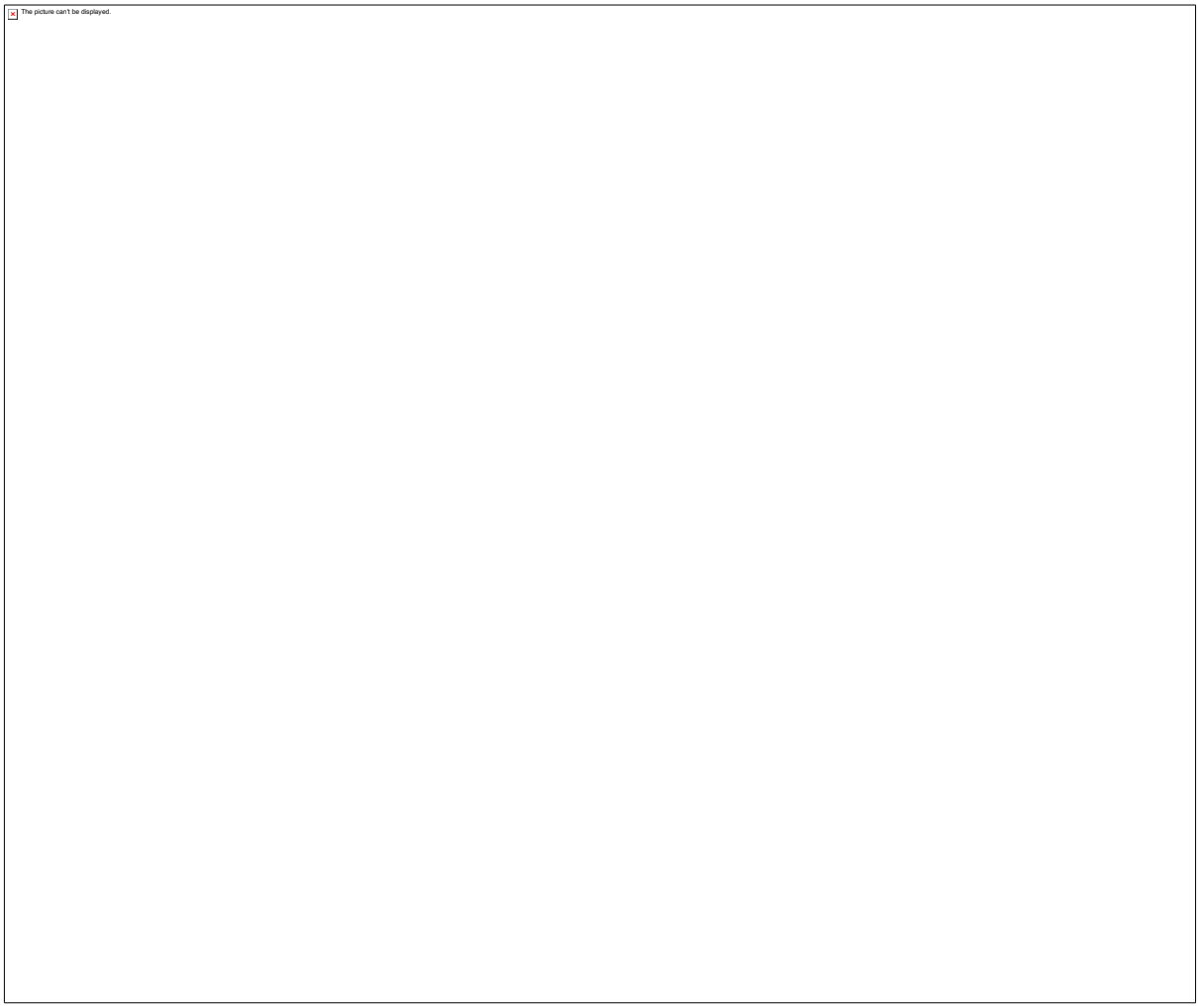


**Figure 2.3:** Relative migratory shorebird abundance (dark blue bars) and sampling effort (light blue bars) across survey areas since 1981. Relative abundance was calculated as the sum of average site counts of migratory shorebirds for each area. Sampling effort was calculated as the average of two parameters: the percentage of the overall number of sites in each area and the percentage of the overall number of site visits made. Both metrics use data from the 2021/22 surveys and data collected in earlier years.

**Table 2.2:** The summed, average site counts of each migratory and non-migratory shorebird species for each area, given as a percentage of the species total value (values in 2nd column). More intense colour equates to a higher percentage.

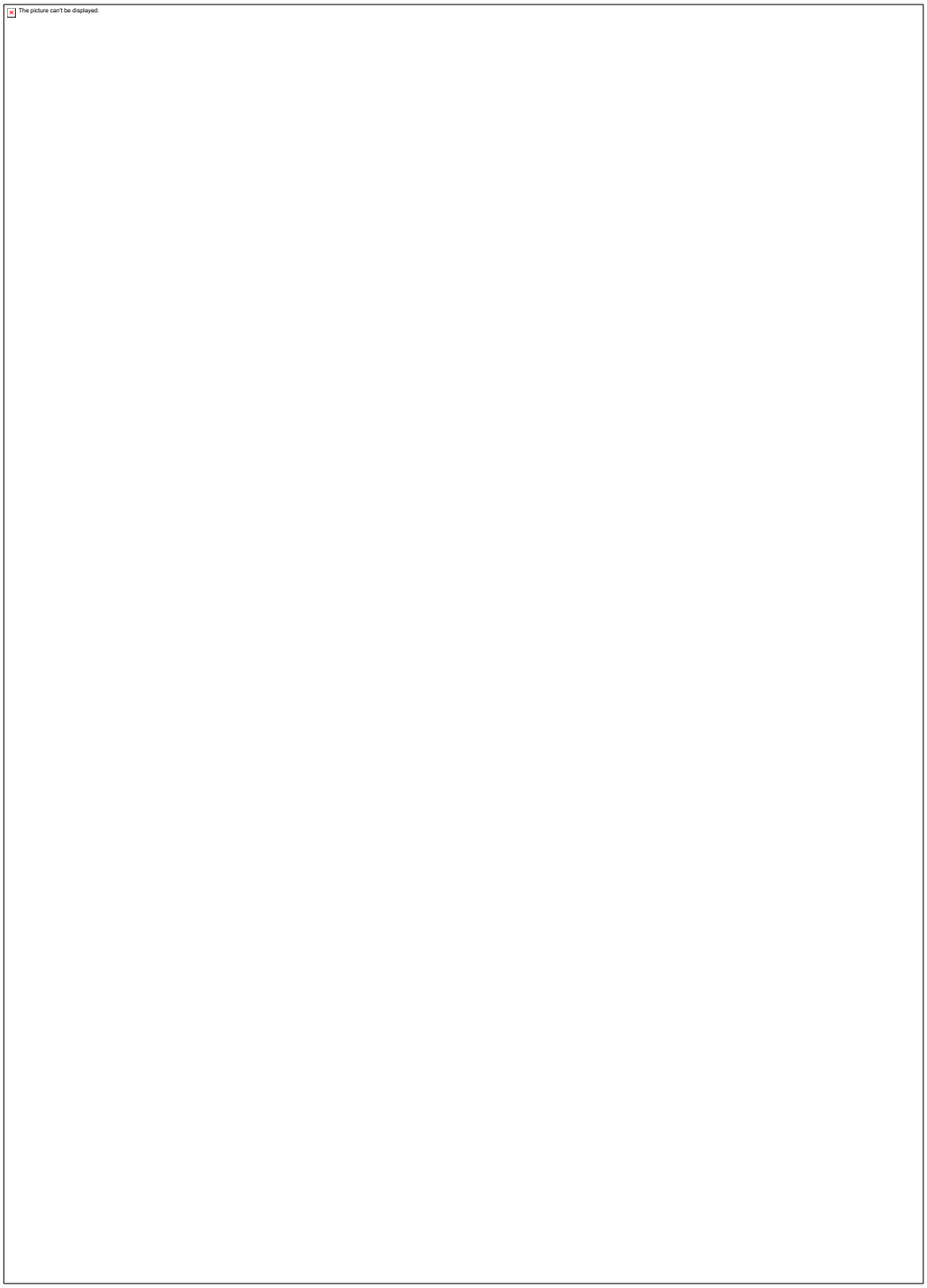

**Table 2.3:** Summary data from ground and boat surveys of the Bowling Green Bay Ramsar wetland and surrounding areas in Feb/Mar 2021 and Feb/Mar 2022.


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# CHAPTER 3 – LEG FLAGGING AND SATELLITE TRACKING OF SHOREBIRDS CAUGHT IN AND ADJACENT TO MORETON BAY AND GREAT SANDY STRAIT

## 3.1 Background and objectives

Shorebirds have been monitored throughout Queensland by QWSG since its inception in 1992, which has included a regular shorebird catching and banding program in Moreton Bay. This catching program has resulted in 5,701 individuals of 29 shorebird species caught and fitted with plain green leg flags which signify that the birds were caught and banded in the state of Queensland. The data from resightings of these individuals have allowed migration routes and stopover sites for birds spending the non-breeding season in Queensland to be identified. Combining leg flag data from all banding locations throughout the flyway has allowed further analysis identifying important locations throughout the flyway for migratory shorebirds with results summarised in Minton et. al. (2006).

Since 2006 engraved leg flags have been used in Moreton Bay allowing individual movements to be tracked and data on return rates and fidelity to feeding and roosting sites to be collected (e.g. Coleman and Milton 2012). Advances in technology led to the use of geolocators on Grey-tailed Tattlers in Moreton Bay which reduced observer biases in resightings and led to the identification of new sites used by this species on migration, as well as providing specific information on the breeding locations for this species (Coleman et. al. 2018). Satellite telemetry has also provided far more accurate data on migration with pioneering work led by the QWSG on the Far eastern Curlew (Driscoll and Ueta 2002). Advances in this technology to reduce the size and improve longevity of data provision has allowed this technology to be used on other smaller species with further insights provided into the migration of Eurasian Whimbrel (Kuang et al 2020), Far Eastern Curlew (Morrick et al. 2021) and Pacific Golden Plover (Coleman and Bush 2020) using Moreton Bay in the non-breeding season.

Increasingly, the detailed information on local movements, the interconnectivity between feeding and roosting sites and the relationship between different locations, both protected and unprotected for shorebirds has become important in understanding the threats they face. The use of PTTs to provide this level of information is essential in providing unbiased data throughout the life cycle of shorebirds. The opportunities provided by this grant allowed QWSG to fit additional PTTs to Bar-tailed Godwit to answer questions in relation to local movements, interactions between east coast Australian Ramsar sites as well as providing funds to fit PTTs and leg flags to shorebirds in Great Sandy Strait.

*Objectives*: This study sought to fill knowledge gaps in relation to habitat use and connectivity within and among Ramsar wetlands by:

1. Measuring and mapping migratory shorebird habitat use within and among Queensland's Ramsar sites by deploying tracking devices and engraved leg-flags on Far Eastern Curlew and Bar-tailed godwit in the Moreton Bay and Great Sandy Strait

Ramsar wetlands. The data collected built on previous tracking efforts revealing critical roosting and foraging habitat requirements and population connectivity in Moreton Bay, Great Sandy Strait, and along Queensland's coastline.

2. Adding engraved leg flags to a range of shorebird species to better understand movement patterns of the shorebird community as a whole and to encourage members of the public to look for these birds, improving awareness of shorebird issues. Particular focus was given to Endangered or Vulnerable species including Curlew Sandpiper, Great Knot, Lesser Sand Plover, Greater Sand Plover and Red Knot.

3.2 Methods

Birds were captured using two primary methods in Moreton Bay, mist and cannon netting, with only cannon netting used to capture birds in Great Sandy Strait. Mist netting involves capturing shorebirds at night by setting fine nets to catch birds as they fly into high tide roosts (Fig. 3.1). Cannon netting involves setting nets during the daytime at high tide roost sites at points where birds are expected to roost. The nets are furled into a narrow line of net and fired over the top of the birds when they are stationary at the roost (Fig. 3.2).

**Figure 3.1:** A line of mist nets set at dusk to capture shorebirds at the high tide roost at Geoff Skinner Reserve, Wellington Point, Moreton Bay Marine Park on 5th March 2022.

Every bird caught was banded with a uniquely coded metal band issued by the Australian Bird and Bat Banding Scheme on the left tarsus and fitted with an engraved green leg flag on the right tibia. The leg flag can be read in the field without the need to recapture the bird allowing multiple resightings to be collected with minimal disturbance to the bird. Birds were aged on

their plumage and moult cycle identifying juveniles from adults and a series of morphological measurements were taken, including body mass allowing condition to be assessed for birds caught. The length of the bill in some species also allowed the sex of the individual to be established with females typically being larger and longer billed in a number of species.

Platform Terminal Transmitters (PTT) were purchased from Microwave Telemetry in the USA, a company specialising in lightweight miniaturised transmitters designed for research of this nature. The devices purchased for use were primarily 5 gram solar powered devices (6 units) but five, 2 gram solar powered devices were also donated to this study by Charles Darwin University. In addition, a number of 5 and 7.5 gram devices used in prior tracking initiatives were also transmitting during this study and their data are included in this report.

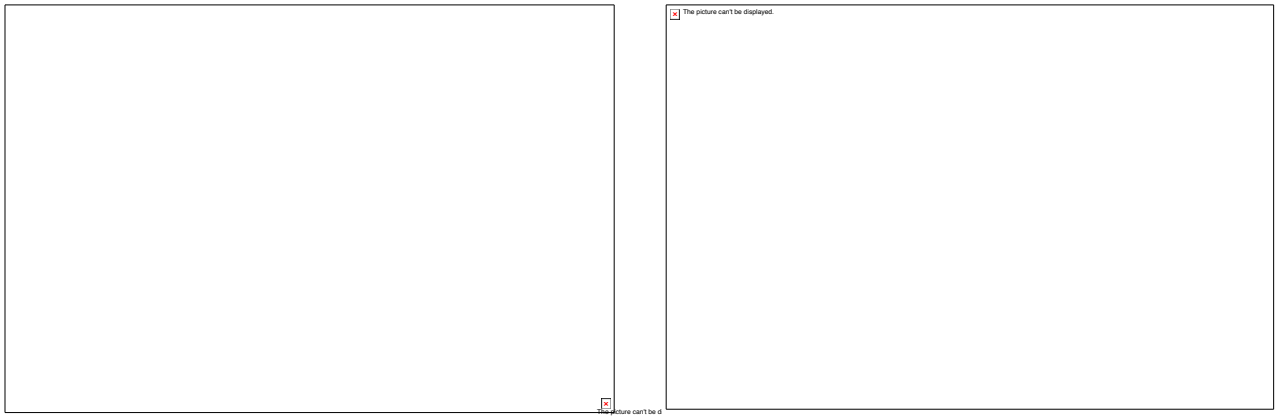


**Figure 3.2:** Setting (left) and firing (right) a cannon net at Maaroom, Great Sandy Strait Marine Park on 23rd January 2022.

Birds were caught at both the Moreton Bay Marine Park and within the Great Sandy Marine Park areas (Figs. 3.3, 3.4) during a total of 18 catching attempts across both study areas (Table 3.1). Catches were made at four locations within Moreton Bay the furthest north being at the Port of Brisbane with the most southerly birds caught at Geoff Skinner Reserve near Wellington Point. Lytton and Geoff Skinner are open claypan sites behind Mangroves which birds use at high tide for roosting. Manly is an artificially created roost site at the mouth of Manly Marina and the Port of Brisbane site is a high tide roost site within the land reclamation area at the mouth of the Brisbane River (Fig. 3.3). In the Great Sandy Strait, birds were caught at three sites, two within the Marine Park and one slightly north of the Park at Toogoom (Fig. 3.4). The Toogoom site is an open sandy beach to the west of Hervey Bay with the other two sites being within the Great Sandy Strait area. The most southerly location at Boonooroo is a series of open claypans surrounded by mangroves with the site at Maaroom being on a sandy beach with a large open claypan behind which birds also use at high tide.

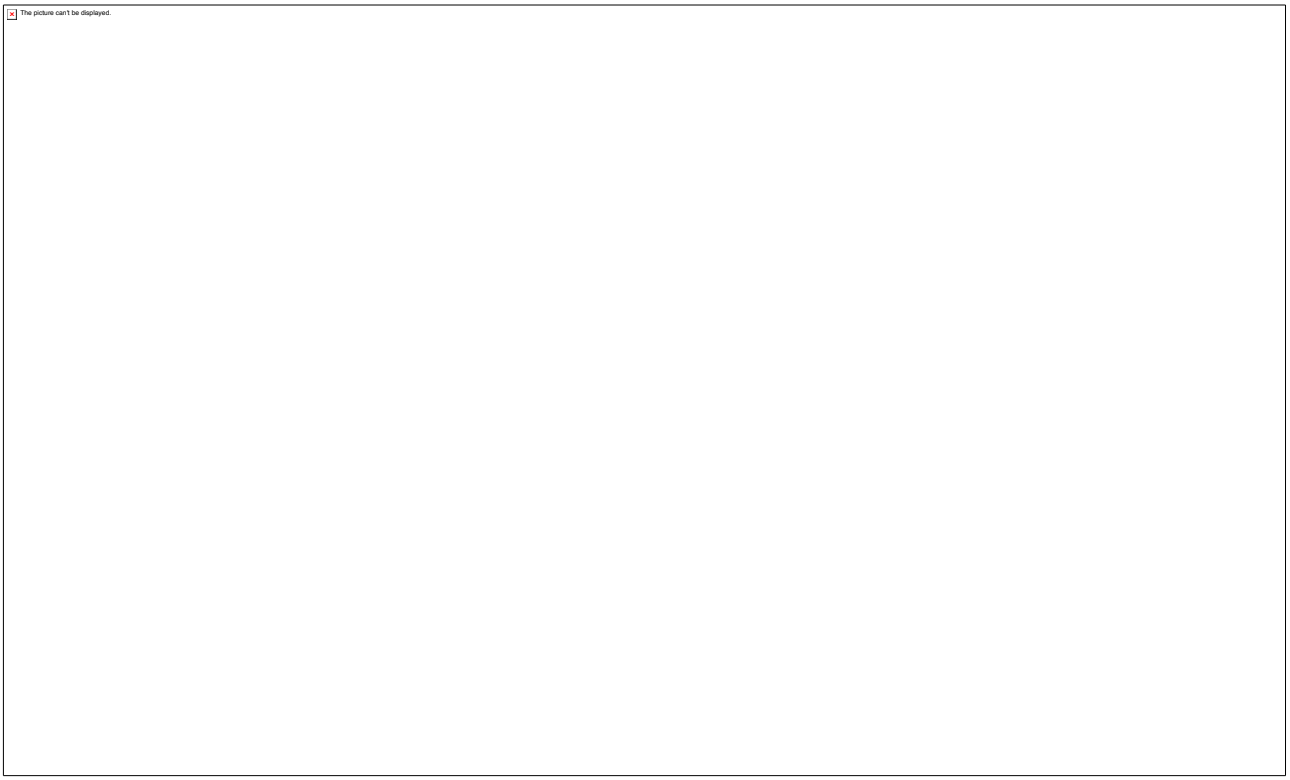


**Figure 3.3:** Shorebird catching locations used within the Moreton Bay Marine Park and immediate environs.

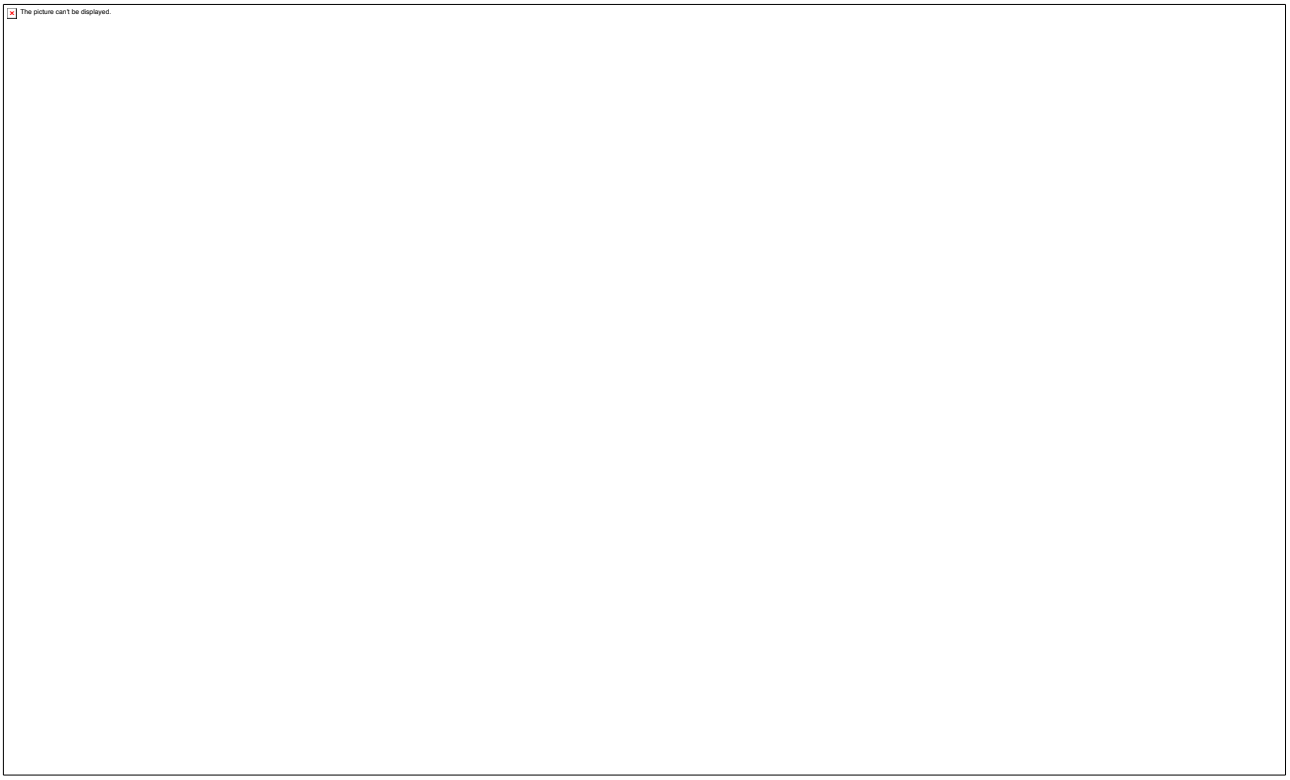

**Figure 3.4:** Shorebird catching locations used within the Great Sandy Marine Park and immediate environs.

**Table 3.1.** Catch dates and locations at which birds were caught during the project period.

| Catching Location | Date | Method | Number of birds Caught | Number of Species Caught |
|---|---|---|---|---|
| Manly Marina, MBMP | 30/12/2020 | Mist-Netting | 28 | 9 |
| Geoff Skinner, MBMP | 16/01/2021 | Mist-Netting | 2 | 1 |
| Port of Brisbane, MBMP | 23/01/2021 | Cannon-Netting | 41 | 6 |
| Geoff Skinner, MBMP | 13/02/2021 | Mist-Netting | 7 | 4 |
| Lytton Roost, MBMP | 27/02/2021 | Mist-Netting | 20 | 4 |
| Geoff Skinner, MBMP | 28/02/2021 | Mist Netting | 5 | 1 |
| Manly Marina, MBMP | 01/05/2021 | Mist-Netting | 29 | 3 |
| Geoff Skinner, MBMP | 08/10/2021 | Mist-Netting | 34 | 7 |
| Manly Marina, MBMP | 24/10/2021 | Cannon-Netting | 15 | 4 |
| Manly Marina, MBMP | 06/12/2021 | Mist-Netting | 3 | 3 |
| Toogoom, GSMP | 21/01/2022 | Cannon-Netting | 90 | 9 |
| Boonooroo, GSMP | 22/01/2022 | Cannon-Netting | 46 | 3 |
| Maaroom, GSMP | 23/01/2022 | Cannon-Netting | 0 | 0 |
| Manly Marina, MBMP | 18/02/2022 | Mist-Netting | 17 | 6 |
| Geoff Skinner, MBMP | 19/02/2022 | Mist-Netting | 4 | 1 |
| Geoff Skinner, MBMP | 05/03/2022 | Mist-Netting | 16 | 1 |
| Manly Marina, MBMP | 29/05/2022 | Mist-Netting | 6 | 5 |
| Maaroom GSMP | 28/08/2022 | Cannon-netting | 112 | 4 |

PTT data were analysed using Kernel Density Analysis to identify home ranges and create the home range maps presented in this report. The kernel utilisation distributions were calculated

using the R package adehabitatHR, using both the least squares cross validation method, indicated by the shaded areas, and the reference bandwidth, indicated by the lines, for the smoothing parameter.. The home range was defined as the 90% utilisation distribution which found the smallest area where the probability of relocating the bird was equal to 0.9 (shaded area) with the full home range boundary encompassed within the boundary lines.

*Permits and approvals.* All QWSG field activities were carried out in accordance with scientific purposes permits WISP16744415 and WA0032220, Moreton Bay Marine Park Permit QS2007/CVL1337A and MPP-100037264 and Animal Ethics Approvals CA 2018-02-1159 and CA 2020-11-1435.

3.3 Results

Numbers of birds banded and fitted with transmitters

Between December 2020 and August 2022, a total of 466 birds of 20 species of bird were caught (Table 3.2). Of these, with the exception of the Red-necked Stint, Silver Gull and White-faced Heron, all were fitted with leg flags, although 6 of the Red-necked Stints caught at Boonooroo were also fitted with leg flags. Given the targeted nature of the catching it was unsurprising that Bar-tailed Godwit were the most frequently caught species, but despite significant efforts no Far Eastern Curlew were captured in this period.

**Table 3.2:** Numbers of shorebirds caught and banded at Great Sandy Strait and Moreton Bay between December 2020 and August 2022.

| Species | Number of birds Banded/ Flagged MBMP | Number of birds Banded/ Flagged GSMP | Number of Transmitters Deployed MBMP | Number of Transmitters Deployed GSMP |
|---|---|---|---|---|
| Australian Tern | 2 | 2 | 0 | 0 |
| Bar-tailed Godwit | 58 | 95 | 10 | 2 |
| Broad-billed Sandpiper | 1 | 0 | 0 | 0 |
| Curlew Sandpiper | 21 | 21 | 0 | 0 |
| Great Knot | 2 | 62 | 0 | 0 |
| Greater Sandplover | 1 | 26 | 0 | 0 |
| Grey-tailed Tattler | 38 | 0 | 0 | 0 |
| Lesser Sandplover | 34 | 30 | 0 | 0 |
| Little Tern | 0 | 1 | 0 | 0 |
| Pacific Golden Plover | 11 | 0 | 0 | 0 |
| Pied Oystercatcher | 7 | 1 | 0 | 0 |
| Pied Stilt | 4 | 0 | 0 | 0 |
| Red Knot | 0 | 3 | 0 | 0 |

| Species | Number of birds Banded/ Flagged MBMP | Number of birds Banded/ Flagged GSMP | Number of Transmitters Deployed MBMP | Number of Transmitters Deployed GSMP |
|---|---|---|---|---|
| Red-necked Stint | 12 | 6 | 0 | 0 |
| Ruddy Turnstone | 12 | 0 | 0 | 0 |
| Sharp-tailed Sandpiper | 7 | 0 | 0 | 0 |
| Silver Gull | 4 | 0 | 0 | 0 |
| Terek Sandpiper | 2 | 0 | 0 | 0 |
| Whimbrel | 1 | 0 | 0 | 0 |
| White-faced Heron | 2 | 0 | 0 | 0 |

Eleven PTTs were fitted during the survey period all except one of these were fitted at Geoff Skinner Wetland, Wellington Point in Moreton Bay with the remaining device fitted at Toogoom, just outside the western boundary of the Great Sandy Marine Park (Table 3.3). All the devices were fitted to Bar-tailed Godwits. Prior to this survey period previous work on Far Eastern Curlew and Whimbrel

**Table 3.3.** *Number of PTTs fitted, and the species, application dates and locations.*

| Species | PTT | Leg Flag | Deployment Date | Deployment Location |
|---|---|---|---|---|
| Bar-tailed Godwit | 208304 – 5g | BVH | 16/01/2021 | Geoff Skinner |
| Bar-tailed Godwit | 208305 – 5g | BVJ | 16/01/2021 | Geoff Skinner |
| Bar-tailed Godwit | 207723 - 2g | BVK | 13/02/2021 | Geoff Skinner |
| Bar-tailed Godwit | 207725 - 2g | BVN | 13/02/2021 | Geoff Skinner |
| Bar-tailed Godwit | 207724 - 2g | BYZ | 27/02/2021 | Lytton Roost |
| Bar-tailed Godwit | 207722 - 2g | BYX | 27/02/2021 | Lytton Roost |
| Bar-tailed Godwit | 207721 – 2g | BWV | 08/10/2021 | Geoff Skinner |
| Bar-tailed Godwit | 208302 – 5g | HND | 21/01/2022 | Toogoom |
| Bar-tailed Godwit | 208300 – 5g | CDS | 19/02/2022 | Geoff Skinner |
| Bar-tailed Godwit | 5DF2EA – 5g | CDT | 19/02/2022 | Geoff Skinner |
| Bar-tailed Godwit | 5C5B1B – 5g | FPB | 05/03/2022 | Geoff Skinner |
| Bar-tailed Godwit | 208301 - 5g | FDJ | 28/08/2022 | Maaroom |
| Whimbrel | 43576 – 5g | DBC | **24/11/2017 | Geoff Skinner |
| Far Eastern Curlew | 40965 – 12g | AAK | **03/03/2018 | Geoff Skinner |
| Far Eastern Curlew | 40963 – 12g | AAD | **26/11/2017 | Toorbul |

<u>Leg flag resightings of birds banded in Moreton Bay</u>

A total of 5,362 engraved leg flag resightings of 1,171 individual birds were made between December 2020 and August 2022 of which 5,042 records of 1,109 individuals related to local green leg flagged birds, the remainder birds flagged overseas or interstate.

Overseas and interstate birds recorded in Moreton Bay originated from a number of locations. Seven interstate birds were from Victoria and comprised six Bar-tailed Godwit and one Curlew Sandpiper. These birds were only recorded briefly, presumably staging in Moreton Bay as a precursor to their final migration leg. A further four interstate birds were Pied Oystercatchers from New South Wales which frequently range up and down the east coast, often reaching Moreton Bay.

Overseas birds came from New Zealand (9), Russia (1), China (5), Taiwan (2) and Japan (3). Most birds were recorded multiple times, suggesting that Moreton Bay was their final destination for their non-breeding season. The exception were the birds originally banded in New Zealand which were typically only seen early in the season, presumably using Moreton Bay as a final fuelling stop en-route to New Zealand non-breeding sites.

The many leg flag re-sightings of green flagged birds originally captured in Moreton Bay came from sites throughout the bay. While most resightings were of birds at high tide roost sites some were of birds feeding on mudflats. Most high tide resightings were at the same roost sites where the bird was originally banded but there was some movement between adjacent roost sites. There was almost no interchange between birds originally banded in the north of Moreton Bay with those in the south of the bay. This indicates that birds are not only site faithful to the general location (e.g. Moreton Bay) but very strongly associate with specific roosting and feeding sites within the Ramsar site.

Leg flag resightings of birds banded in Great Sandy Strait

As a result of the field trips to Great Sandy Marine Park in January and August 2022 a total of 146 birds of 8 species were fitted with individually engraved leg flags. These have resulted in a total of 40 resightings of 34 individuals. During the survey period a further 10 resightings involving 5 foreign or non-local Australian leg flagged birds resighted in the Great Sandy region were also received.

Of the birds not originally leg flagged in the Great Sandy region two involved Bar-tailed Godwits fitted with orange leg flags in Victoria, both seen in September 2021 at Maaroom. Given their brief time at Maaroom these birds were presumably refuelling on their migration to Victoria. Both of these individuals were also seen briefly in September 2018 at the same stopover location indicating repeated use of these staging sites.

One Bar-tailed Godwit carrying a green leg flag was originally banded at Toorbul, in northern Moreton Bay, and was seen at Urangan in February 2022. Interestingly, this bird was also recorded at sites in the Pumicestone Passage near Toorbul both before and after the Urangan sighting.

The remaining two individuals were both birds banded overseas in Taiwan. The first, a Terek Sandpiper, banded in April 2019 has been seen at Maaroom during the Australian Summer

at dates from January 2020 to March 2022 showing that many shorebirds remain faithful to their non-breeding locations between years. The second, a Lesser Sandplover banded in May 2019 was resighted at Urangan Boat Harbour roost in February 2021.

For birds banded at sites in the Great Sandy region in January 2022 12 (28.2%) of the 40 resightings involved birds recorded at different locations with the remainder being of birds recorded at the same high tide roost site they were originally captured at. All resightings of birds away from their original banding location except for one, involved 32 individuals banded at Toogoom. All resightings, with one exception, for birds flagged at Boonooroo were at the same location.

Five individuals from Toogoom were recorded at the high tide roost at Urangan Boat Harbour (19km ESE) on one or more occasions with a further four individuals recorded at a roost site near Point Vernon (8.5km E). The Urangan resightings involved both Greater and Lesser Sandplover while the Point Vernon resightings were mainly Bar-tailed Godwit, with one Greater Sandplover.

Two individual Great Knot from Toogoom were recorded at Toorbul, northern Moreton Bay in April and July 2022 respectively. Finally, the one Boonooroo resighting away from the banding site involved a Lesser Sandplover, resighted on the 25th July 2022 in Chiba, Japan and in Tokyo Bay on the 6th August 2022. This bird either partially migrated, remaining in Japan or was a bird returning from breeding grounds further north.

These data already indicate evidence of linkage between Great Sandy and Moreton Bay Marine Parks as well as evidence of sites being used as staging sites for migrating birds. Perhaps of more importance is noting that key shorebird roosting and feeding habitat exists outside of the Great Sandy Marine Park, particularly in the Hervey Bay to Toogoom area and consideration should be given to management of these areas and their importance to adjacent protected areas.

<u>Results from birds fitted with PTTs in Moreton Bay</u>

Three Far Eastern Curlew with PTT's provided data during the period of this study. Two flagged in the southern Moreton Bay area (Figure 6) and one in northern Moreton Bay, originally captured at Toorbul in the Pumicestone Passage (Figure 7).

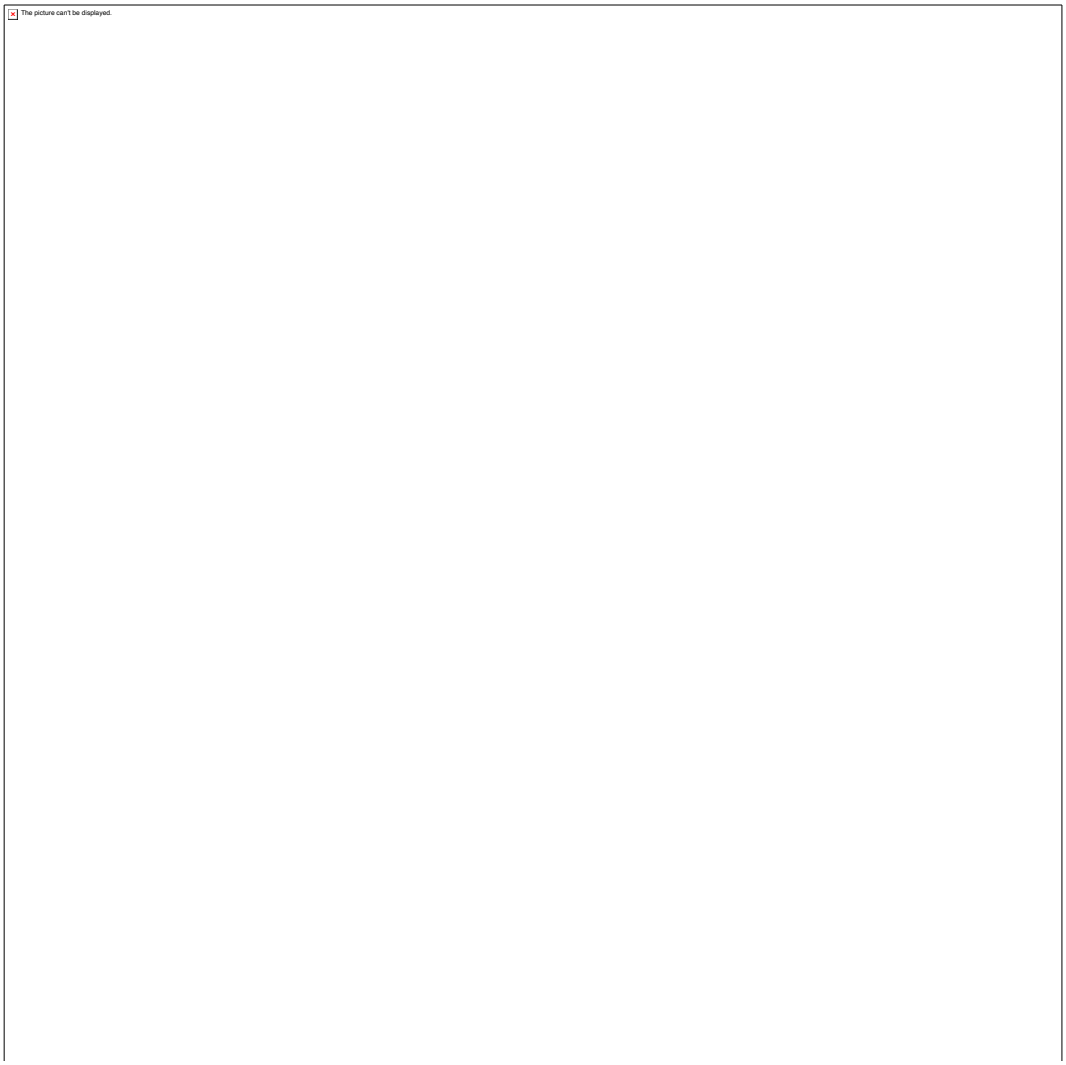


**Figure 3.5:** Far Eastern Curlew kernel density analysis showing favoured areas utilised between 2020 and 2022 in the Austral Summer, southern Moreton Bay.

Both birds in southern Moreton Bay were originally banded at Geoff Skinner Reserve, Wellington Point with kernel density analysis demonstrating that this area remained popular with both birds as a roost site. Feeding locations were also immediately adjacent to the high tide roost site with birds frequently using the general area for both activities.
However, the tracking data also highlighted other important locations used by this species with regular feeding areas around Peel Island and on the adjacent shoreline of North Stradbroke Island. There was evidence of secondary roosting sites in those areas too. The kernel density and satellite tracks indicated significant movement between these sites demonstrating the importance of all three locations for these birds (Figure 6) for both feeding and roosting along with the transition routes between them.
For the individual in northern Moreton Bay the vast majority of activity was in the area of the Toorbul Artificial Roost site with feeding primarily on the adjacent mud flats (Figure 7). However, there was evidence of secondary roosting sites in the mangroves to the northwest of Toorbul and to the southwest with some movements to the roost site at Kakadu Beach on

Bribie Island. Again, the interconnectivity between these sites, as well as the locations themselves are important considerations in conserving appropriate habitat for this species. In all cases there is clear evidence of both primary and alternate feeding and roosting locations indicating a degree of complexity in home ranges previously undescribed. This requires consideration in the management and zoning of marine parks for this critically endangered species. It is also notable that two of the roosting sites most frequently used in northern Moreton Bay are above the mean annual high tide mark and therefore technically outside of the protected area.

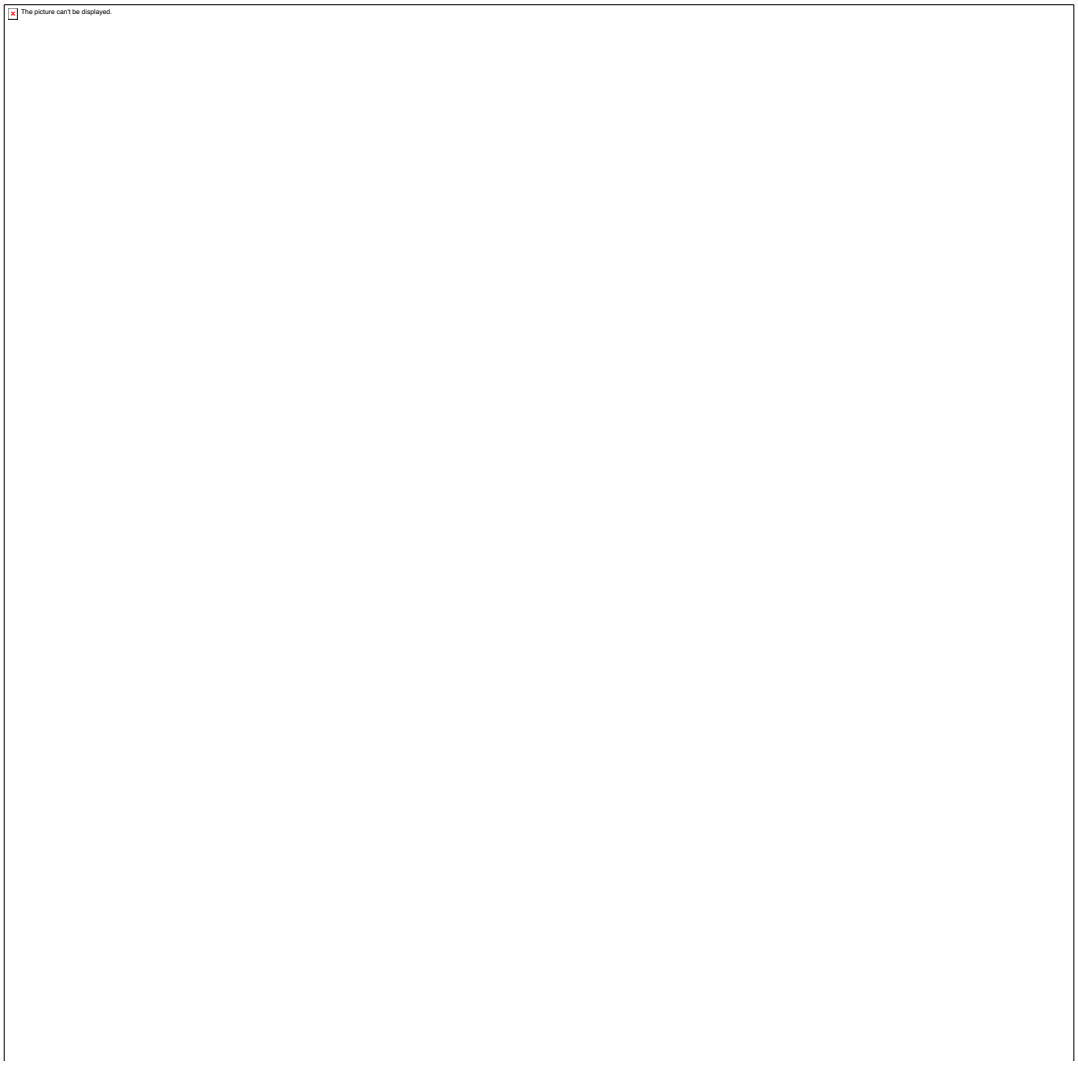


**Figure 3.6:** Far Eastern Curlew kernel density analysis showing favoured areas utilised between 2020 and 2022 in the Austral Summer, northern Moreton Bay.

All the Bar-tailed Godwit tracked as part of these studies were captured and fitted with PTTs in the southern Moreton Bay region with seven individuals fitted with PTTs (Figure 8). With one exception, key feeding and roosting areas were restricted to the mainland coast with only one individual using the North Stradbroke and Moreton Island coastlines.

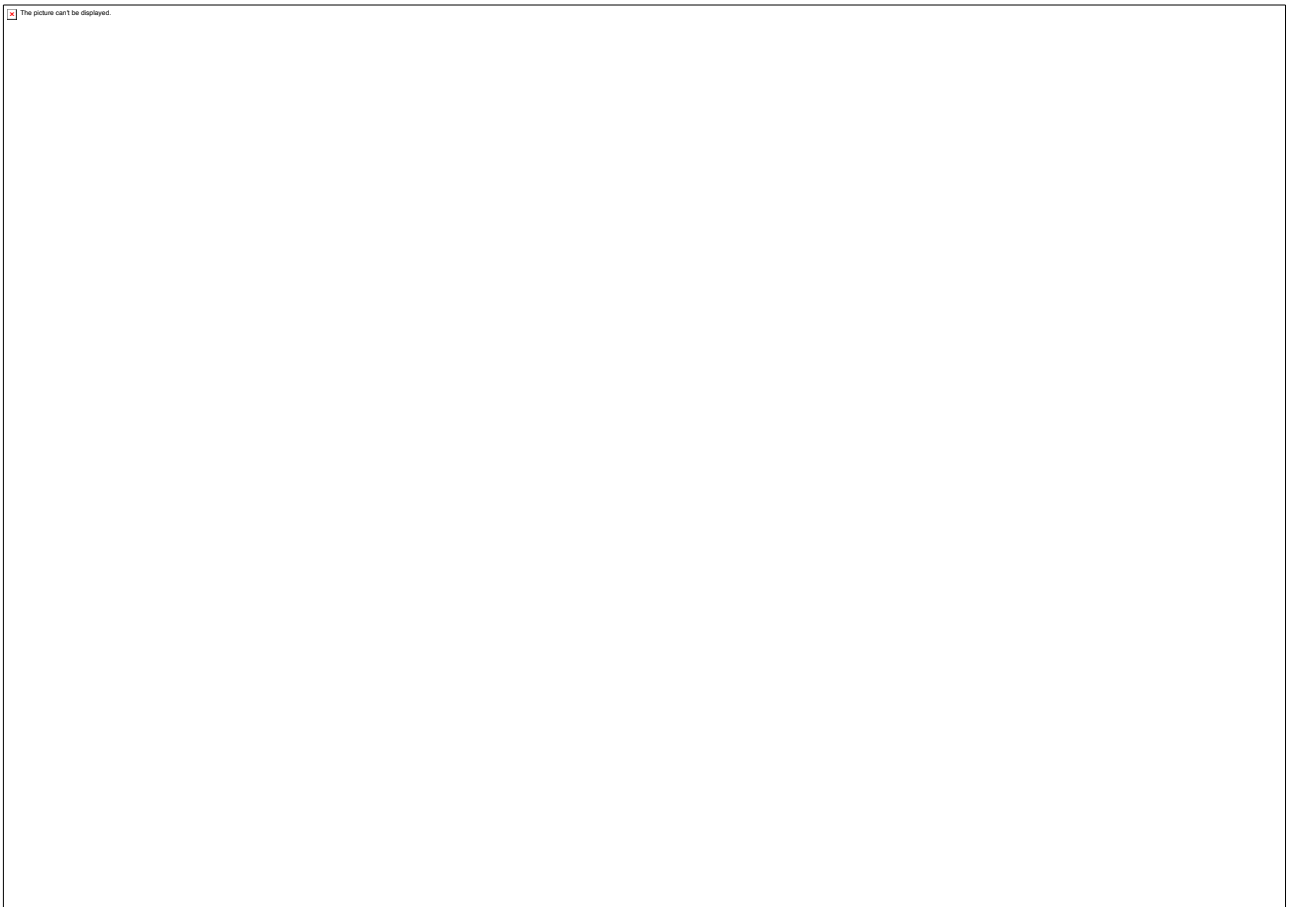


**Figure 3.7:** Bar-tailed Godwit kernel density analysis showing favoured areas utilised between 2020 and 2022, all seasons, southern Moreton Bay.

Three immature Bar-tailed godwit fitted with PTTs did not migrate and provided evidence of changed feeding areas in the Austral winter. Immature birds typically do not migrate north for 2-3 years after arriving in Australia and have to compete for resources with an influx of adult birds in the summer months. In the case of BVJ , the only bird of this species to utilise some of the important feeding locations on the east of Moreton Bay, a wider range of sites were used in the winter months (Figure 9). These additional sites may well represent optimal feeding sites denied to immature birds in the summer months due to increased competition for resources.

For the two immature birds that utilised sites only on the mainland coast of Moreton Bay both birds fed mainly in the Thorneside area of Moreton Bay in the Austral Summer but in the Austral Winter, both birds also utilised the Wynnum and Lytton areas far more for both feeding and roosting. The Wynnum area has several nearby roost sites (Wynnum Roost, Lytton Claypan and the Port of Brisbane) with birds from Manly also recorded feeding in that area. This suggests that the Wynnum mudflats are a particularly important feeding area within Moreton Bay and it is likely that immature birds are excluded from these prime locations in the Austral summer through increased competition. The importance of protecting marginal feeding locations as well as optimal sites is therefore equally important. These more marginal sites appear to be important in hosting future recruits to the breeding

population. Figure 10 shows the changes described for Bar-tailed Godwit BVN, banded at Wellington Point, in its home range behaviour between Summer and Winter. The data for BYZ, banded at Lytton Roost showed similar behaviour with the bird often feeding as far away as the Manly area before settling into a smaller home range, similar to that shown for BVN centred on the Wynnum mudflats

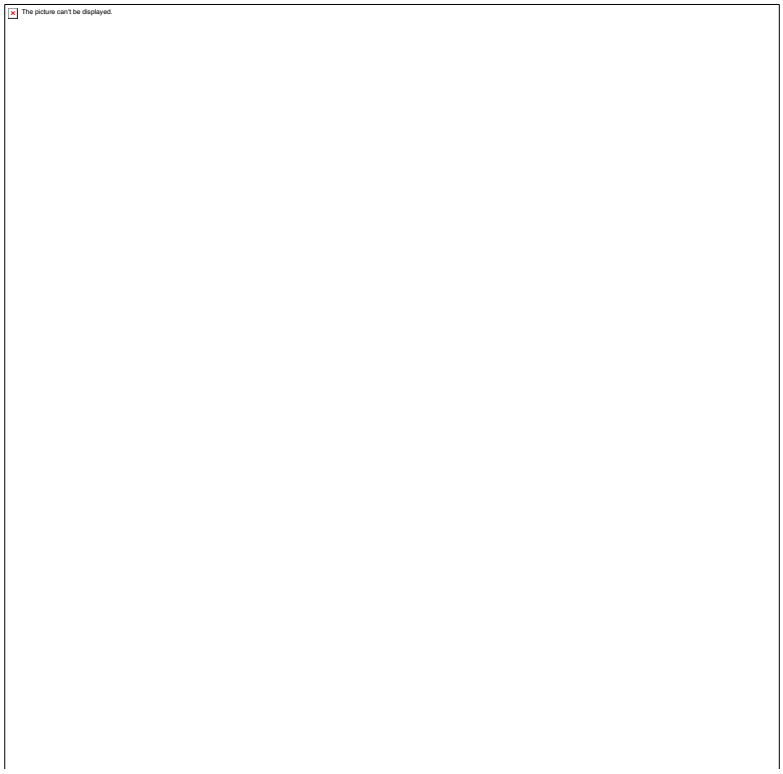


**Figure 3.8:** Bar-tailed Godwit kernel density analysis showing favoured areas utilised between 2020 and 2022 in the Austral Summer, and Winter for Bar-tailed Godwit BVJ, southern Moreton Bay.

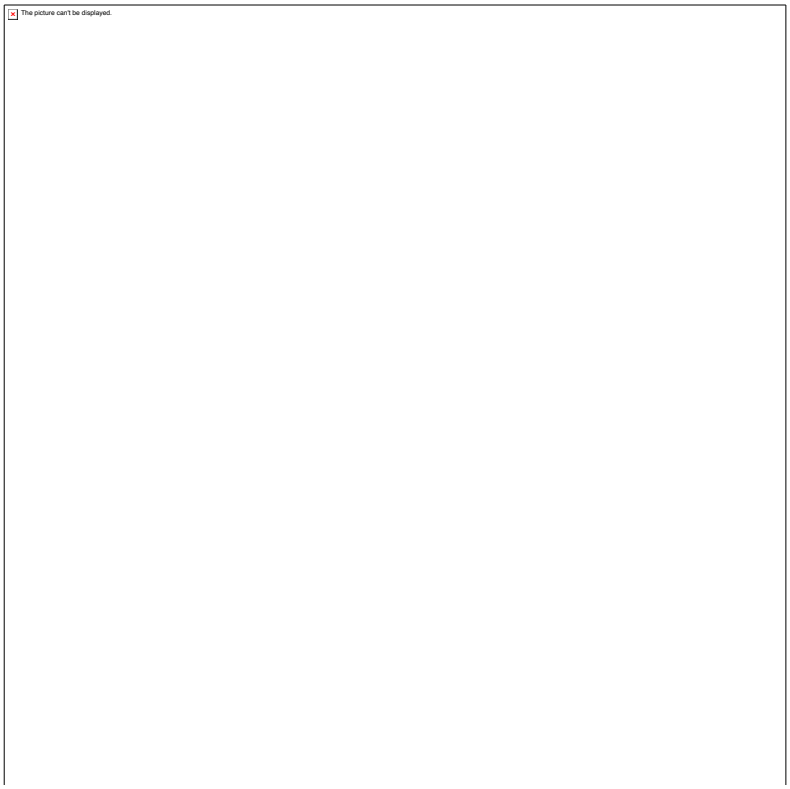


**Figure 3.9**: Bar-tailed Godwit kernel density analysis showing favoured areas utilised between 2020 and 2022 in the Austral Summer, and Winter for Bar-tailed Godwit BVN, southern Moreton Bay.

One Eurasian Whimbrel banded in the south of Moreton Bay at Wellington Point transmitted data during this study period and showed this species maintained a far more localised range than those of the Bar-tailed Godwit and Far Eastern Curlew described earlier. The home range was centred around Wellington Point with the range extending north to Green Island and south to Ormiston. This species is more tolerant of Mangroves, frequently roosting in them and feeding on claypans within areas of Mangrove growth. This area of the coast has extensive mangrove habitat suggesting the birds in this area may not need to disperse long distances for feeding.

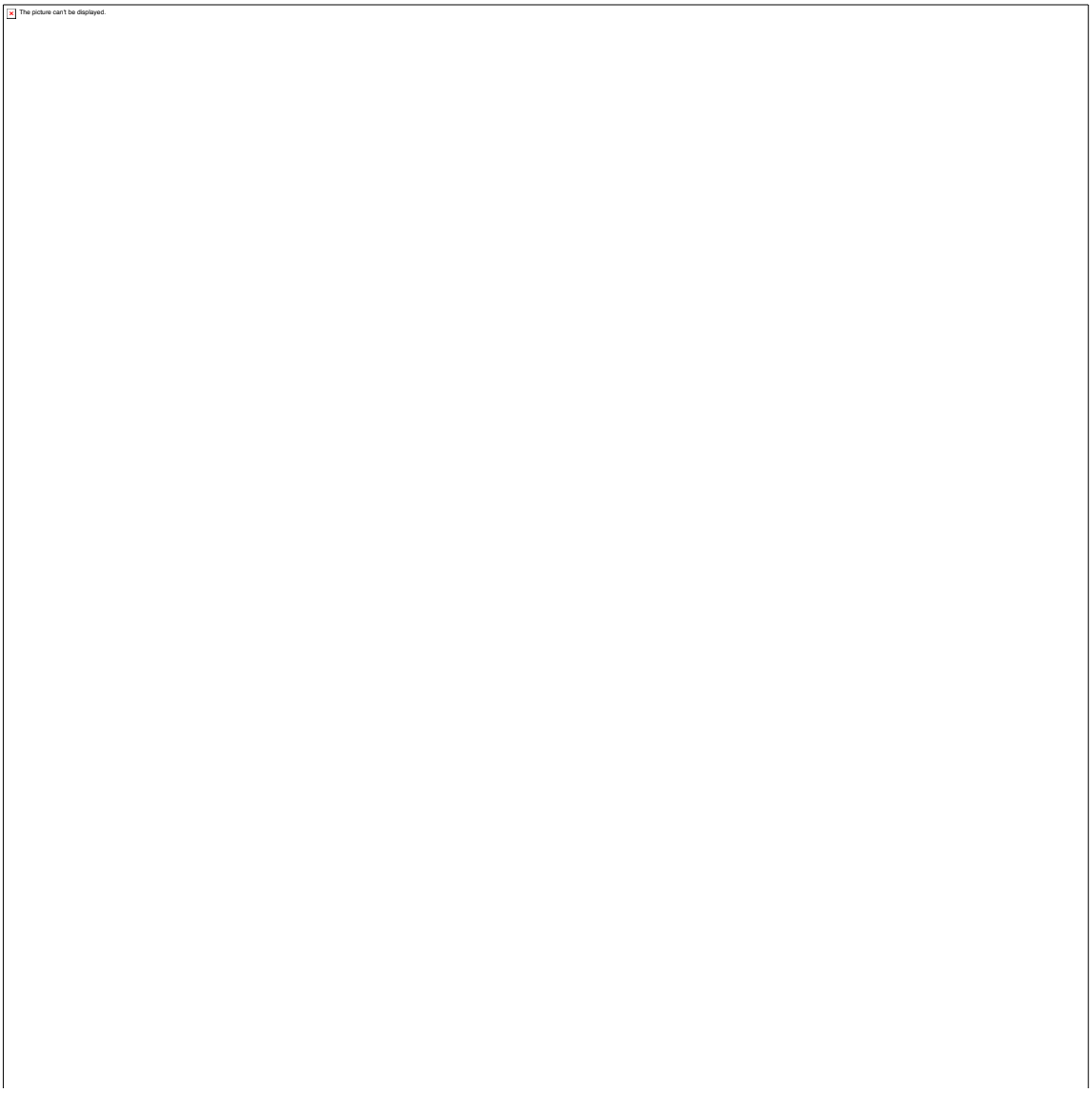


**Figure 3.10:** Eurasian Whimbrel kernel density analysis showing favoured areas utilised between 2020 and 2022, in the Austral summer, southern Moreton Bay

Data for the two Whimbrel fitted with transmitters to the north at Toorbul showed a similar story with almost all activity centred around the Toorbul Artificial Roost and adjacent foreshore. This is another area with extensive Mangrove habitat providing ideal roosting and feeding sites for this species although many other shorebird species prefer more open areas for feeding and roosting.

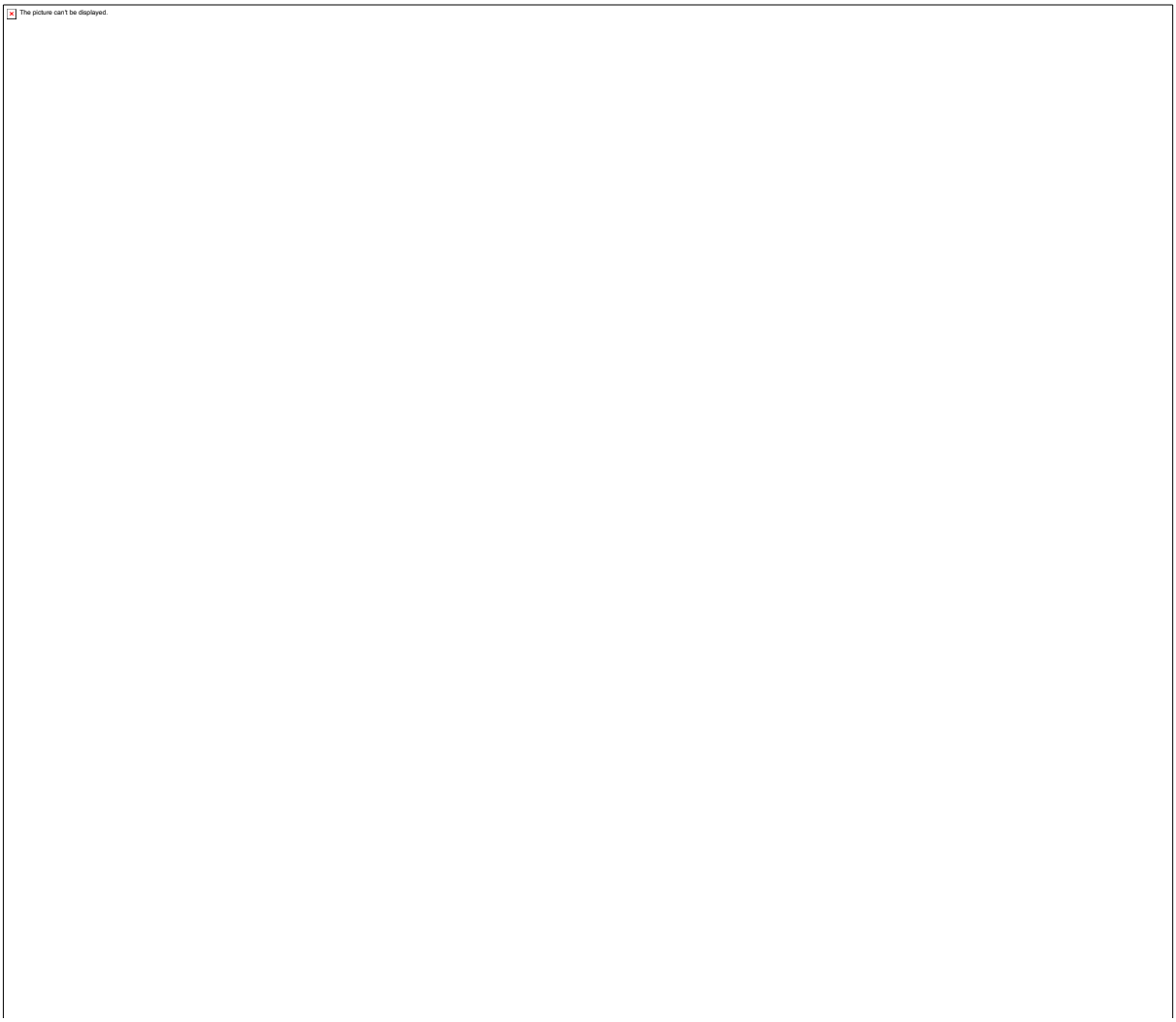


**Figure 3.11:** Eurasian Whimbrel kernel density analysis showing favoured areas utilised between 2020 and 2022, in the Austral summer, northern Moreton Bay.

Results from birds fitted with PTTs in Great Sandy Strait

One Bar-tailed Godwit was fitted with a PTT at O'Regan's Creek near Toogoom on the 21st January 2022. Although the bird was an immature bird and did not migrate to the breeding grounds it provided the opportunity to see in detail the local movements of birds in that area. During the non-breeding season, the bird favoured locations in the Point Vernon area with limited movements back to Toogoom and one record further east. This represented an overall range of 17km between Burrum Heads and Point Vernon but with almost all activity (98%) within a 5km$^2$ area to the west of Point Vernon (Figure 13).

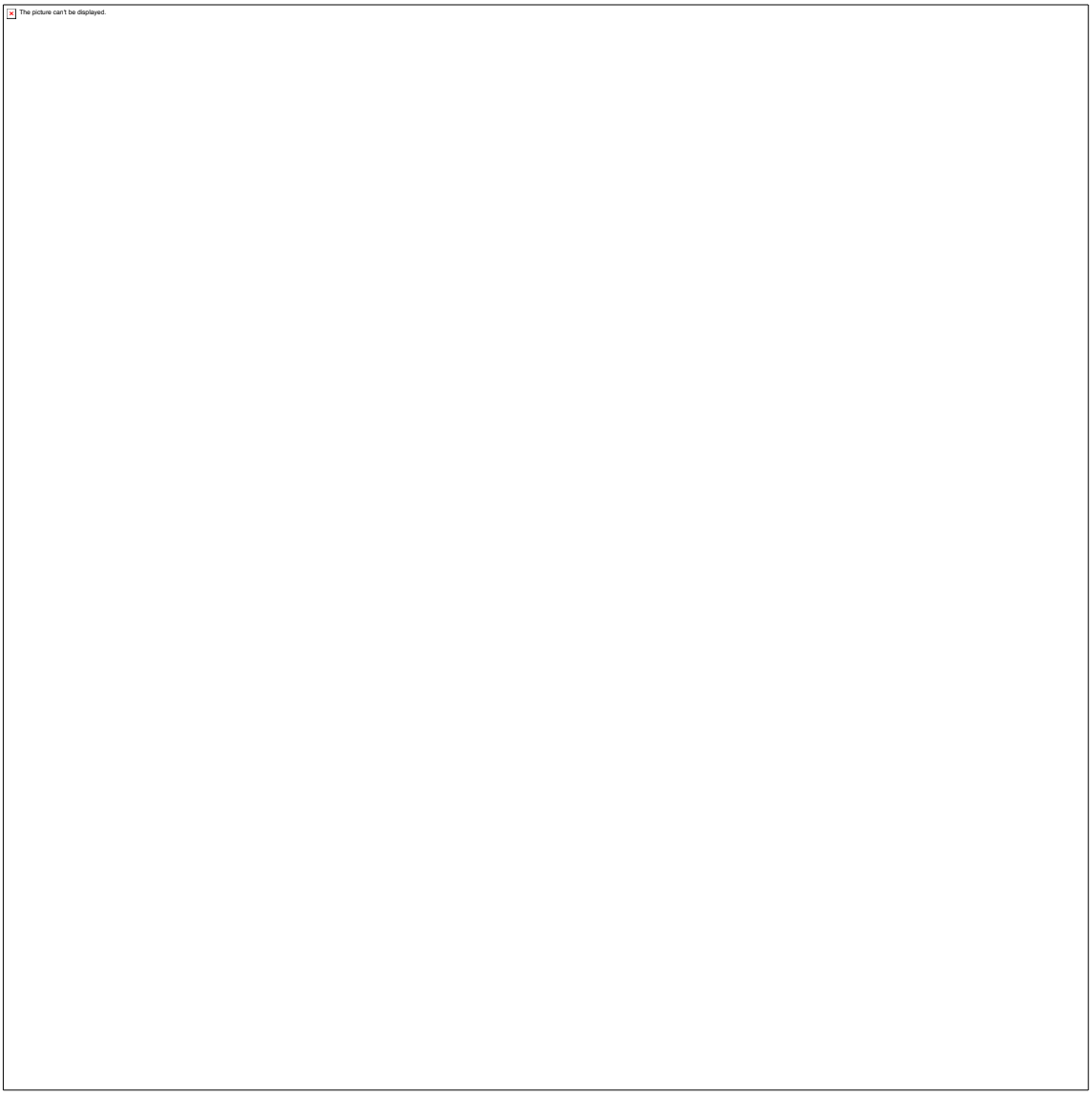


**Figure 3.12:** Bar-tailed Godwit kernel density analysis showing favoured areas utilised in 2022 in the Austral summer, and winter for Bar-tailed Godwit HND in the Great Sandy region.

In the breeding season, when the majority of birds had left for their northern breeding grounds the feeding locations and range of the individual increased (Figure 13). While some time was spent in the Point Vernon area the majority of time was spent on the western Fraser Island coast with some movements further south into the Great Sandy Strait. This increased ranging again may reflect a decrease in competition as a result of more dominant adult birds being absent. The findings may also be identifying prime feeding habitat, not previously described due to their isolated location. This would merit further investigation to identify not only the number of birds utilising these feeding areas in the summer but also to identify roost sites in that area that may not already be known or quantified.

Evidence from PTTs of linkages between Ramsar sites

While the data collected provided significant insights into the spatial utilisation and habits for three species of shorebird fitted with PTTs, these, along with leg flag sightings also provided data on the importance of interconnectivity of these protected areas. Leg flag resightings in the 2021/22 season provided evidence of one Bar-tailed Godwit moving north from Moreton Bay to Great Sandy and back to Moreton Bay and two Great Knot, moving south from Great Sandy to Moreton Bay.

However, PTT data provided further evidence of the importance of these protected areas as a network of refuges for migrating birds rather than just standalone sites. Figure 14 shows the southward migration of Far Eastern Curlew AAK on its journey along the Australian coast. After leaving the Yellow Sea the bird first made landfall in Australia on the 25th of July 2022 in Great Sandy Marine Park where the bird remained, feeding post migration, until the 30th July. The bird utilised a number of sites from River Heads to the north, south to the Maaroom area. On leaving Great Sandy the bird arrived back in Moreton Bay on the 2nd of August 2022.

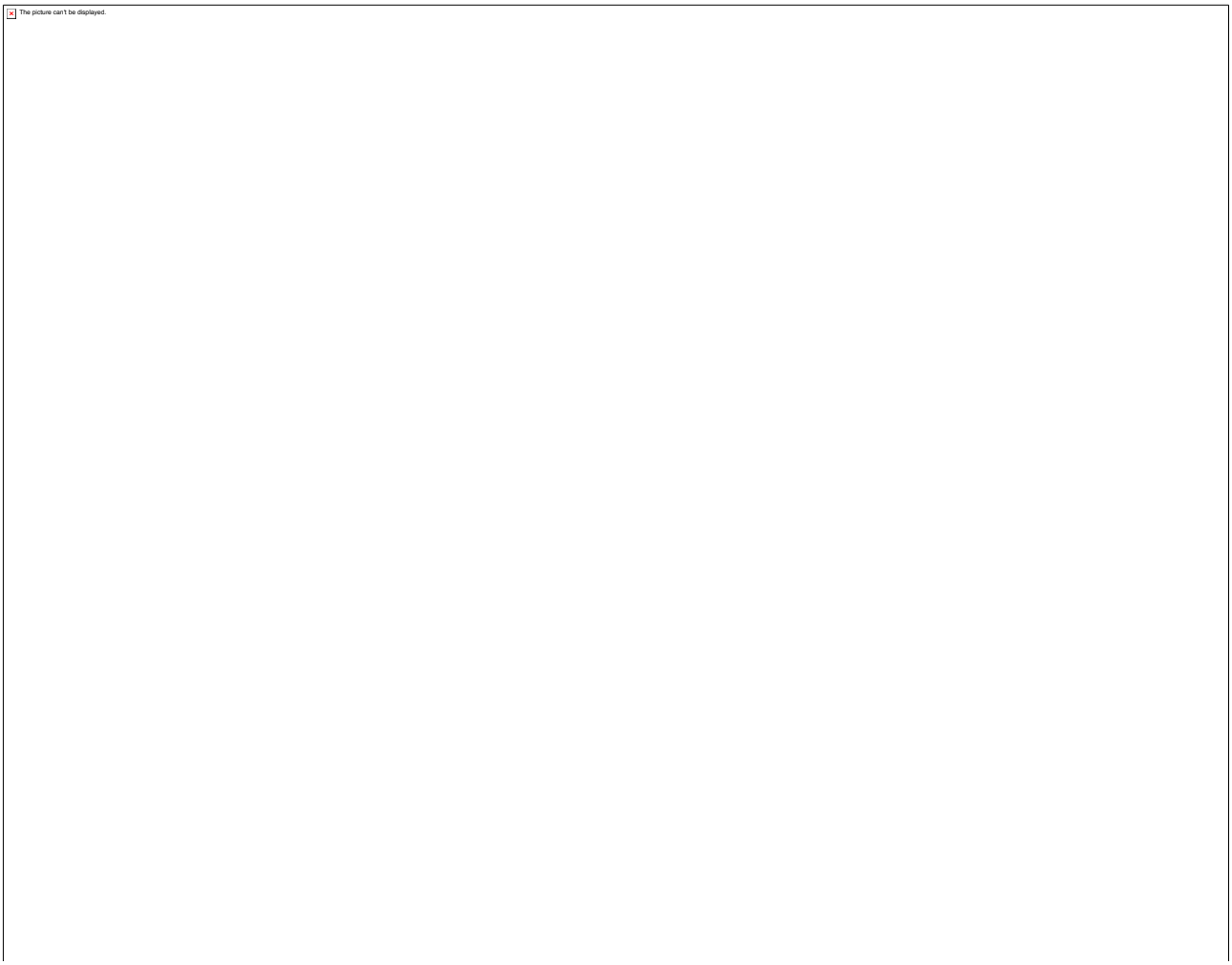


**Figure 3.13:** Southward Migration of Far Eastern Curlew AAK in 2022 staging in Great Sandy Ramsar site en-route to Moreton Bay Ramsar site.

Bar-tailed Godwit CDS failed to complete its northward migration, turning south after passing Papua New Guinea and returning to Australia after spending several weeks on the southern coast of New Guinea. The bird spent from the 7th of May to the 23rd of July in the Townsville region at Bushland Beach (Figure 15). Despite Bowling Green being only 30km away this individual was not recorded at all within that protected area. However, in previous years returning Bar-tailed Godwit have been recorded at Bowling Green on their way back to Moreton Bay indicating the sites use as a staging location for birds travelling further south as well as a site for over-summering birds.

On leaving Townsville the individual moved to Rockhampton where the bird remained from 23rd July 2022 until the 5th of August, spending its time in the Port Alma area. The bird then completed its migration, arriving back in Moreton Bay on the 6th of August.

In contrast to the Far Eastern Curlew breaking its migration with a stopover in Great Sandy this Godwit did not utilise any protected areas on its southward migration but did utilise other sites known to be important for shorebirds in the austral Summer. This again highlights the complex and important interactions between sites used by migratory shorebirds with a combination of both protected and unprotected areas proving important as interconnected refuelling locations for these species.

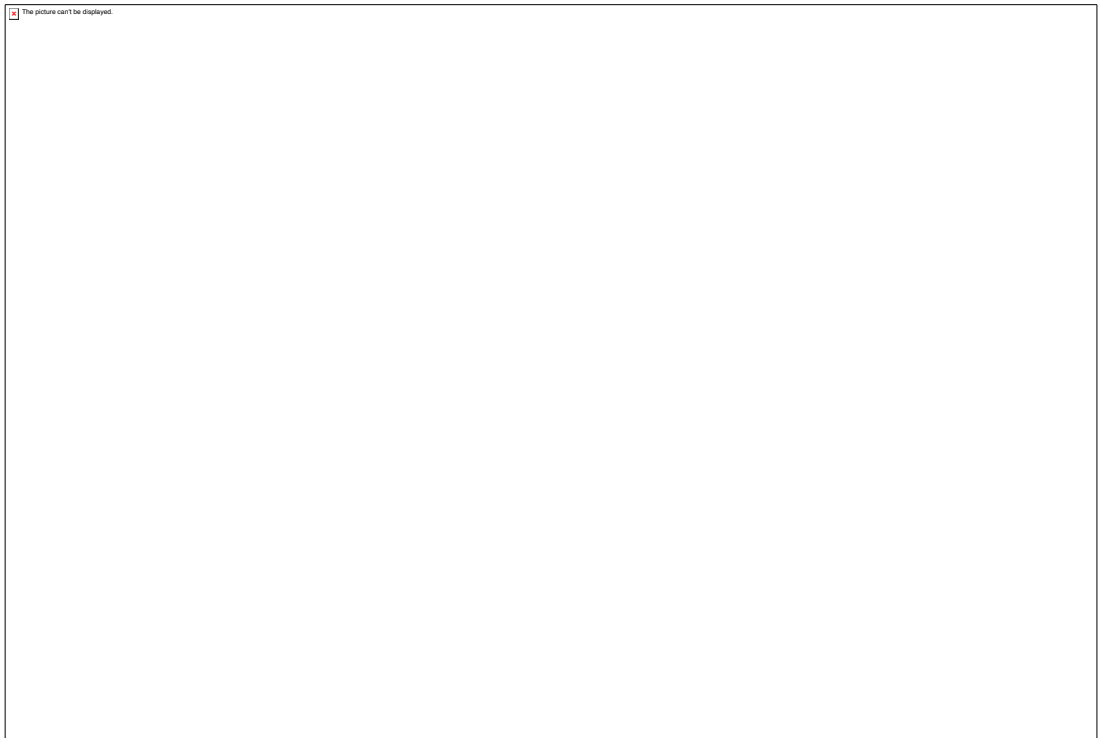


**Figure 3.14:** Southward migration of Bar-tailed Godwit CDS in 2022 staging in Bowling Green Bay en route to Moreton Bay via Gladstone.

# CHAPTER 4 – GENERAL DISCUSSION

Volunteer-led surveys and education materials developed under this project have provided new, updated, and forthcoming data about migratory shorebird movements, connectivity, distribution, and abundance across three of Queensland's coastal Ramsar wetlands, while simultaneously increasing public awareness of migratory shorebirds, their ecology, threats they face, and steps everyone can take to help protect them. It is our hope that activities undertaken as part of this project will help to support migratory shorebird conservation and management throughout Queensland now and into the future as the climate changes.

Migratory shorebirds, like all wildlife, are facing unprecedented environmental changes, both through climate change and other forms of human pressure on coastal landscapes and habitats. During the non-breeding season and migration in Australia, migratory shorebirds, including all seven of the threatened species that were the focus of this project, primarily occupy coastal habitats that includes intertidal mudflats, claypans, beaches, and mangroves. Bordering on the ocean and situated within and adjacent to the intertidal zone, these habitats are naturally dynamic and variable in terms of their suitability as roosting and foraging habitats for migratory shorebirds. They are also limited in extent, consisting of a relatively narrow strip of habitat at the terrestrial-marine boundary (Murray et al. 2019). Sea-level rise and increases in ocean acidification and extreme weather events are all known and predicted impacts of climate change that could further limit the availability of these habitats and impact their suitability through, for example, coastal erosion, variable water levels in claypans, and mangrove dieback or encroachment.

Predicting the impacts of climate change on coastal habitats at local or regional levels, and how individual species and the migratory shorebird community more broadly will respond to those changes, is a persistent challenge. Consequently, three key approaches to support species' ability to adapt to climate change are (i) to ensure sufficient space for species to flexibly adjust their habitat use in response to long-term shifts in habitat availability and quality (i.e., protect more than the minimum), (ii) protect a diverse suite of habitat types, and (iii) maintain landscape connectivity to allow species to move between critical habitats. For migratory shorebirds, connectivity matters both at a local scale (i.e. a network of supratidal roosting habitats and nearby intertidal foraging habitats) and broad scale (i.e., a network of migratory stopover habitats connecting breeding and non-breeding habitats). Protecting more than the minimum and maintaining connected networks of habitats may be especially important for migratory shorebirds, whose habitat is limited in extent to begin with (Murray et al. 2019) and which often show high levels of site fidelity, a potentially maladaptive trait in periods of rapid environmental change (Merkle et al. 2022).

Our findings from surveys of Bowling Green Bay and tracking and leg-flag re-sightings in Great Sandy Strait and Moreton Bay Ramsar wetlands both provided evidence in support of the approaches outlined above to help to conserve Queensland's threatened migratory shorebird community during the current period of rapid environmental change.

Observations from all three Ramsar sites revealed considerable temporal and spatial variation in habitat use, supporting the need to conserve ample space and a diverse suite of habitats. A notable example from Bowling Green Bay surveys was the variation in numbers observed at the Alva claypan, which had the highest count of any site in 2021 (4102) and much lower counts the following year. This variability is further seen when comparing surveys of the Bowling Green Bay region conducted under this project to surveys conducted in previous years. Large flocks of shorebirds have been counted at the sandspit at the tip of Cape Bowling Green in previous years, but none were observed during aerial reconnaissance surveys in 2021 and 2022. Movement data from Moreton Bay and Great Sandy Strait also showed variable site use throughout the study period. For example, tracking data from the immature Bar-tailed Godwit in Great Sandy Strait revealed a relatively restricted home range during the Austral summer compared to much wider-ranging movements in the Austral winter (Fig. 3.13). Similar inter-seasonal movements have been observed for juvenile Far Eastern Curlew in Moreton Bay (Lilleyman et al. 2021). There are numerous factors that can contribute to spatial variability in site and habitat use within and across seasons. While we can undertake studies or speculate on the reasons why, it nonetheless shows that habitat use can vary widely and not always for obvious reasons. It is therefore necessary for coastal management planning to ensure large areas of diverse habitats are given ample protection to allow species to move among habitat types as conditions change, either seasonally, annually, or longer term with climate change.

Despite examples of spatial and temporal variability in habitat use, there are also habitats and areas that consistently support large numbers of migratory shorebirds, and these areas require extra protection (e.g., Table 2.2). While many such sites in Moreton Bay (e.g., Manly Harbour Marina, Geoff Skinner Reserve, and Toorbul) and Great Sandy Strait (e.g., Turtle Cove claypan, Boonooroo, Maaroom, and Inskip Point) have been documented through decades of monitoring by QWSG and other organisations, monitoring of and awareness of such sites in the Bowling Green Bay Ramsar wetland and surrounds has been more limited. One such site is the Burdekin River mouth and the sandbars, beaches, and mangrove forests that make up the river delta. Based on current and historical survey data, this area supports the highest relative abundance of most shorebird species, including 6 of the 7 threatened migratory shorebird species (Table 2.3; Far Eastern Curlew, Bar-tailed Godwit, Great Knot, Red Knot, Lesser Sand Plover, Greater Sand Plover), of any coastal area in the Townsville - Bowling Green Bay - Burdekin River region. Based on the numbers of migratory shorebirds that use this habitat, the Burdekin River mouth ranks among the most numerically important sites along the eastern coast of Queensland (QWSG 2022).

The importance of the Burdekin River mouth coupled with findings from tracking data from Great Sandy and Moreton Bay highlights another key theme of our findings: the importance of conserving a connected network of habitats, both inside and outside of protected areas. Many sites that support large numbers of shorebirds and that are used frequently, sit at the fringes of or entirely outside of Ramsar wetlands, marine parks, and other protected areas. While the Burdekin River delta is an example of an entire estuary system lacking protection, smaller-scale examples are equally important to consider, particularly in areas under more

direct and intense human pressure. For example, movement data collected in Great Sandy Strait and Moreton Bay show that shorebirds rely on both protected and adjacent non-protected areas for feeding and roosting on a daily basis (Figs. 3.6-3.13). Consideration of how those unprotected areas can be managed to ensure sufficient habitat availability for shorebirds is needed. Specifically, many roosting habitats are situated above the high tide mark and outside the boundaries of marine parks and Ramsar wetlands where they have low levels or no forms of protection, leaving them susceptible to disturbance and development. Management plans for coastal environments should ensure these sites are clearly identified as essential shorebird habitat and steps taken to ensure their protection.

While field studies from the three Ramsar wetlands generated new and forthcoming data about migratory shorebird habitat use, distribution, and abundance that can be used to inform conservation and management planning for Ramsar wetlands, marine parks, and coastal landscapes more broadly, securing a future for migratory shorebirds will depend on responsible stewardship of coastal environments by society as a whole. For this reason, the education, public awareness, and relationship-building initiatives could represent the most significant and long-lasting outcomes from this project. During the two-year project period, we involved more than 60 volunteers in fieldwork and reached a cumulative audience of 193,425 with endorsed social media posts about threatened migratory shorebirds, climate change, and Ramsar wetlands. We further began a process of strengthening relationships between QWSG and Traditional Owner organisations, developed a public shorebird display at the Moreton Bay Discovery Centre, and co-developed curriculum resources about shorebirds for schools in partnership with Birds Queensland and Birdlife Southern Queensland. It is our hope that through these education, capacity-building, and monitoring initiatives, that this project will contribute to a more sustainable future for migratory shorebirds in Queensland and throughout the East Asian-Australasian Flyway.

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ADDENDUM

A1. Capacity-building Through Volunteering And Engaging With Traditional Owners

We engaged more than 60 volunteers at the Bowling Green Bay, Great Sandy Strait and Moreton Bay Ramsar sites. Core teams from the QWSG worked with local volunteers in the survey work at Bowling Green and integrated local volunteers into the catching, banding and PTT program at Great Sandy Strait and in Moreton Bay. We took this approach to support the eventual development and sustainability of local expertise in shorebird field work skills for the future. The list of participants is in Table A1 below.

**Table A1:** Volunteers and others that contributed to fieldwork at the three coastal Ramsar sites.

| **Bowling Green Bay (N = 12)** | |
|---|---|
| Martin Cachard | Rob Kernot |
| Peter Driscoll | Sally Sheldon |
| Paul Fisk | Brad Woodworth |
| Denise Holder | Eddie Smallwood* |
| Graham Holder | James Gaston* |
| Arthur Keates | Shayleen Beer* |

*Gudjuda Land and Sea Rangers / Gudjuda Aboriginal Reference Group

| **Great Sandy Strait (N = 32)** | |
|---|---|
| Chris Barnes | Cecile Espigole |
| John Bell | Richard Fuller |
| Don Bradley | Ofalia Ho |
| Lesley Bradley | Gabrielle Hunt |
| Robert Bush | Greg Little |
| Deirdre Chrzescijanski | Judy Little |
| Jon Coleman | Stephen Macdonald |
| Lucy Coleman | Gillian Matthew |
| Marilyn Connell | Kelly Matthews |
| Laura Dee | Brendan Doohan |

| | |
|---|---|
| David Edwards | Rebecca McElroy |
| Alice Ekin | Ross McMillan |
| Frank Ekin | Alan Pilkington |
| Wendy Pilkington | Mattea Taylor |
| Louise Williams | Randall Wood |
| Jack Worcester | Maria Zann |

**Moreton Bay (N = 34)**

| | |
|---|---|
| Aaron Bean | David Braithwaite |
| Miriam Braithwaite | Robert Bush |
| Deirdre Chrzescijanski | Jon Coleman |
| Lucy Coleman | Amelia Cook |
| Emily Davies | Laura Dee |
| Brendan Doonhan | David Edwards |
| Richard Fuller | Ofalia Ho |
| Gabrielle Hunt | Roxanne Ives |
| Greg Little | Michael Linde (Port of Brisbane) |
| Judy Little | Eva Lloyd |
| Penn Lloyd | Stephen Macdonald |
| Gillian Matthew | Kelly Matthews |
| Rebecca McElroy | Ross McMillan |
| Joel Moore | Zaine Morrick |
| Alan Pilkington | Wendy Pilkington |
| Keith Rigby | Craig Wilson (Port of Brisbane) |
| Randall Wood | Brad Woodworth |

**Statement of Aboriginal Engagement**

We set out to establish relationships with Traditional Owners of the lands on which this project took place by engaging with local Indigenous organisations. First, at the Bowling Green Bay Ramsar site we established a working relationship with the Gudjuda Aboriginal Reference Corporation and its Land and Sea Rangers who provided overwater transport support for the surveys. Second, at the Great Sandy Strait Ramsar site, we built on a pre-fieldwork shorebird training workshop held in the region that was attended by members of the Butchulla Aboriginal Corporation, by continuing to inform and invite members to our activities. In March 2022, a further training event was organised by QWSG on the Fraser Coast and the Butchulla Aboriginal Corporation were invited to take part. Thirdly, at the Moreton Bay Ramsar site we engaged with the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC) and their rangers to jointly run a training event organised through the QWSG education officer Sheryl Keates. Unfortunately COVID-19 restrictions led to the cancellation of this event and subsequent mentored field practice. We have since continued attempts to keep open dialogue with QYAC about future training opportunities (post-COVID restrictions) and are currently working in collaboration with the Healthy Land and Water Inc. on training initiatives in support of the Land and Sea Ranger program.

A2. Social Media Dissemination

We implemented a social media strategy through the course of the project to engage with the public about the project, its aims and findings. We primarily used the QWSG Facebook platform to communicate about the project. Over the course of the project, we made 20 posts that, based on Facebook's analytics, reached an overall audience of 193425. URL address analysis suggested that about 70% of views were within Australia and about 30% were worldwide. The postings are listed below.

**Table A2:** Project social media posts and reach (derived from Facebook Analytics)

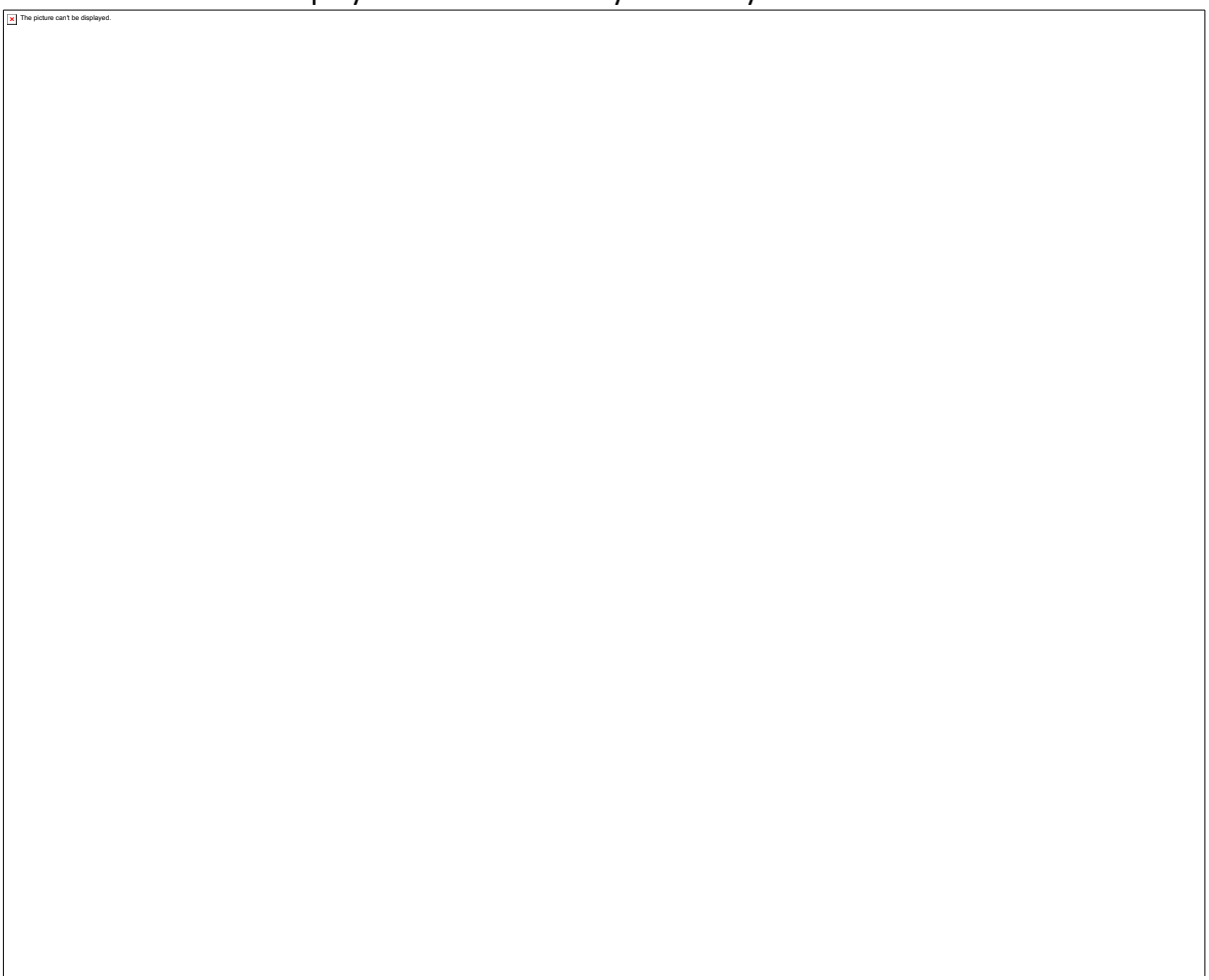
| Platform and date | Subject | Reach* |
|---|---|---|
| QWSG webpage (www.waders.org.au) | Grant briefing | |
| Facebook: January 2021 | QWSG Begins the Year with a Major Grant Announcement: 'Climate Change Resilience of Threatened Shorebirds in Queensland's Ramsar Wetlands | 3521 |
| Facebook: January 2021 | First Transmitters Deployed on Bar-tailed Godwits Under the QWSG Community Action Sustainability Grant | 2187 |

| | | |
|---|---|---|
| Facebook: February 2021 | Update: Tracking Bar-Tailed Godwits Around Moreton Bay | 4082 |
| Facebook: March 2021 | A Stint in Bowling Green Bay – Well, More Like a Few Thousand Stint at this Little Explored Ramsar Site in North Queensland | 2434 |
| Birds Queensland Newsletter: March 2021 | Queensland Government: Community Sustainability Action: Climate change resilience of threatened shorebirds in Queensland's Ramsar wetlands | 800 |
| Facebook: April 2021 | Moreton Bay Bar-tailed Godwits on the move | 8030 |
| Facebook: April 2021 | Toorbul's Best Know Eastern Curlew 'AAD' Arrives in Taiwan | 5353 |
| Facebook: September 2021 | Extreme Athletes: Bar-tailed Godwit BXY Returns from Alaska | 106679 |
| Facebook: October 2021 | QWSG Commences Summer Catching Program for the Study of Shorebirds in Moreton Bay | 4848 |
| Facebook: October 2021 | Goat Island in Moreton Bay: a Most Unusual Shorebird Roost | 3371 |
| Facebook: November 2021 | NZ Travel Bubble Open for Godwits | 1943 |
| Facebook: January 2022 | QWSG Completes Its First Expedition to Band Shorebirds in the Great Sandy Marine Park | 5249 |
| Facebook: March 2022 | One Week in the Life of a Bar-Tailed Godwit in Moreton Bay: How Satellite Tracking is Beginning to Tell us about the Interconnections between Roosting and Foraging Sites | 7927 |
| Facebook: March 2022 | Another Stint in Bowling Green Bay | 1380 |

| | | |
|---|---|---|
| Facebook: May 2022 | Satellite Tracking Shows Moreton Bay Shorebirds on the Move | 7559 |
| Facebook: June 2022 | What Happens to Young Shorebirds That Don't Migrate: Following a Young Bar-Tailed Godwit on the Fraser Coast, Queensland | 2501 |
| Facebook: July 2022 | Bar-Tailed Godwit with Satellite Tracker Photographed on Bushland Beach, Townsville, Queensland, Australia | 1995 |
| Facebook: July 2022 | QWSG Joins National Winter Shorebirds Count Joining Up Count Information with Other Data can Advance Shorebird Conservation | 8364 |
| Facebook: September 2022 | With Your Help We Can Discover Shorebird Movements Around One of Australia's Most Important Ramsar Sites – The Great Sandy National Park on The Fraser Coast, Queensland | 2178 |

**Total Posts = 20**
**Total Reach = 193425**

A3. Public Shorebird Display at the Moreton Bay Discovery Centre




**The display at the Moreton Bay Discovery Centre**

Following advice from the QWSG the Moreton Bay Discovery Centre Inc. management committee determined that the first display to be developed would be about migratory shorebirds. The rationale for this decision is as follows:

> Moreton Bay is designated under the Ramsar Convention as a wetland of international significance. Australia is a signatory to the Ramsar Convention and so committed to the protection of the Bay's wetlands. Moreton Bay's wetlands are a world-renowned destination of Arctic and Sub-Arctic migratory shorebirds.

What follows is a description of the contributions of the business sector, community organisations and university research organisations as well as other government contributions to develop the display. The description also shows the steps undertaken to develop the shorebird display to world class standard.

1. **Setting the benchmark for innovation and world best practice in shorebird displays**

Early in the development of the Discovery Centre, the management committee took the decision that displays should be of a high standard, involve state-of-the-art interactive and electronic innovation that would meet both local, national and international contemporary expectations. The committee had in mind that the Discovery Centre would attract both educational as well as tourist interest as a public asset.

Accordingly, the Shorebird display was benchmarked against the **Scottish Seabird Centre** outside Edinburgh in Scotland. This Centre has developed an international reputation for its educational displays and in particular the use of remote camera technology at bird colonies to provide live nature experiences for the public. The Scottish Seabird Centre provides expert advice to other centres on using this technology (see for example cameras on the Galapagos Islands). This benchmarking access was provided pro bono.

**2. Securing start-up funds**

Manly Harbour Village traders (approximately one hundred in number) through their **Manly Chamber of Commerce** supported the early development of the Discovery Centre through the provision of a funding loan. A substantial donation was also received from the **David Farley Family Trust.**

A portion of these funds enabled the work to commence on the display.

**3. Creating the intellectual and material assets for the shorebird display**

We engaged both national and Queensland based organisations to build the intellectual and material assets to create the shorebird display. We sought collaboration from **Birdlife Australia**, the national peak body and its local sub-branch, **Birdlife Southern Queensl**and. We also engaged with **Birds Queensland,** the peak state NGO. Two specialist shorebird groups also agreed to share resources, the **Australasian Wader Study Group and the Queensland Wader Study Group (QWSG)**. We negotiated the handover of material resources such as text based descriptive accounts, video, photographs and research discoveries about shorebirds in Moreton Bay. We secured agreements to use these materials with these organisations with them waiving their rights to copyright.

**4. Building in innovation by linking bird movements and migration with advances in satellite telemetry**

To establish a point of difference we built in new technologies that can track bird movements across the globe using satellite tracking devices. We considered that the linking of bird ecology with innovations in satellite telemetry would potentially introduce novel and futuristic learning experiences, especially for young people and school groups.

The QWSG was a participant in a nationwide project to use this technology to track the world's largest migratory shorebird, the Eastern Curlew as well as the Bar-tailed Godwit. We negotiated the release of tracking data from the **Northern Threatened Species Recovery Hub, part of the National Environmental Science programme for Far Eastern Curlew and other data from the QWSG**. A donation of trackers from **Charles Darwin University** and a successful application for a Sustainability Action Grant from the **Queensland Department of Environment and Science** was used to purchase more satellite trackers and access the **Argos Satellite System** (this is the worldwide animal tracking satellite system). The QWSG attached these trackers to birds in Moreton Bay and provided the information generated free of charge for the display development.

**The Fuller Lab at the University of Queensland** provided pro bono, the work required to download and convert the satellite data into maps displaying tracks and other information; such as, for example, the impact of weather patterns, flight duration and speed. We used these maps and information to create storyboards of individual birds that are resident in Moreton Bay. Information presented in this way had not been produced for education and public display purposes before and enabled live storytelling to be part of the public experience when viewing the display.

### 5. Assuring the displays are designed for children, young people and schools and acknowledges the history of shorebirds and Indigenous peoples

We addressed the issue of ensuring the content and delivery of materials about shorebirds is appropriate for children and young people and would complement the school science curriculum requirements. To do this an App was developed and integrated as a downloadable education tool built into the display.

To assure quality, the **Moreton Bay Environmental Education Centre, a facility of Education Queensland**, provided guidance and review on the App content and learning features. A Brisbane based technology start-up company**, Aktura technology Pty. Ltd.** was engaged to build the app platform. The **Port of Brisbane Pty. Ltd** was approached to fund the app and agreed to do so. The scientific assurance for the App content was undertaken by QWSG, pro bono.

To make the App 'My Shorebird watcher' accessible, we applied for it to be included on the **Apple Store and Google Play** platforms. To make it available free on these platforms requires certification that the material is designed and suitable for children of different ages. It also requires releasing the coding and technical design aspects for assessment by these companies to assure the App is safe for children to download and use (for example that a child's details can't be accessed by a third party). The work of certification was undertaken by QWSG in partnership with Aktura Technology and the cost was covered by private donation.

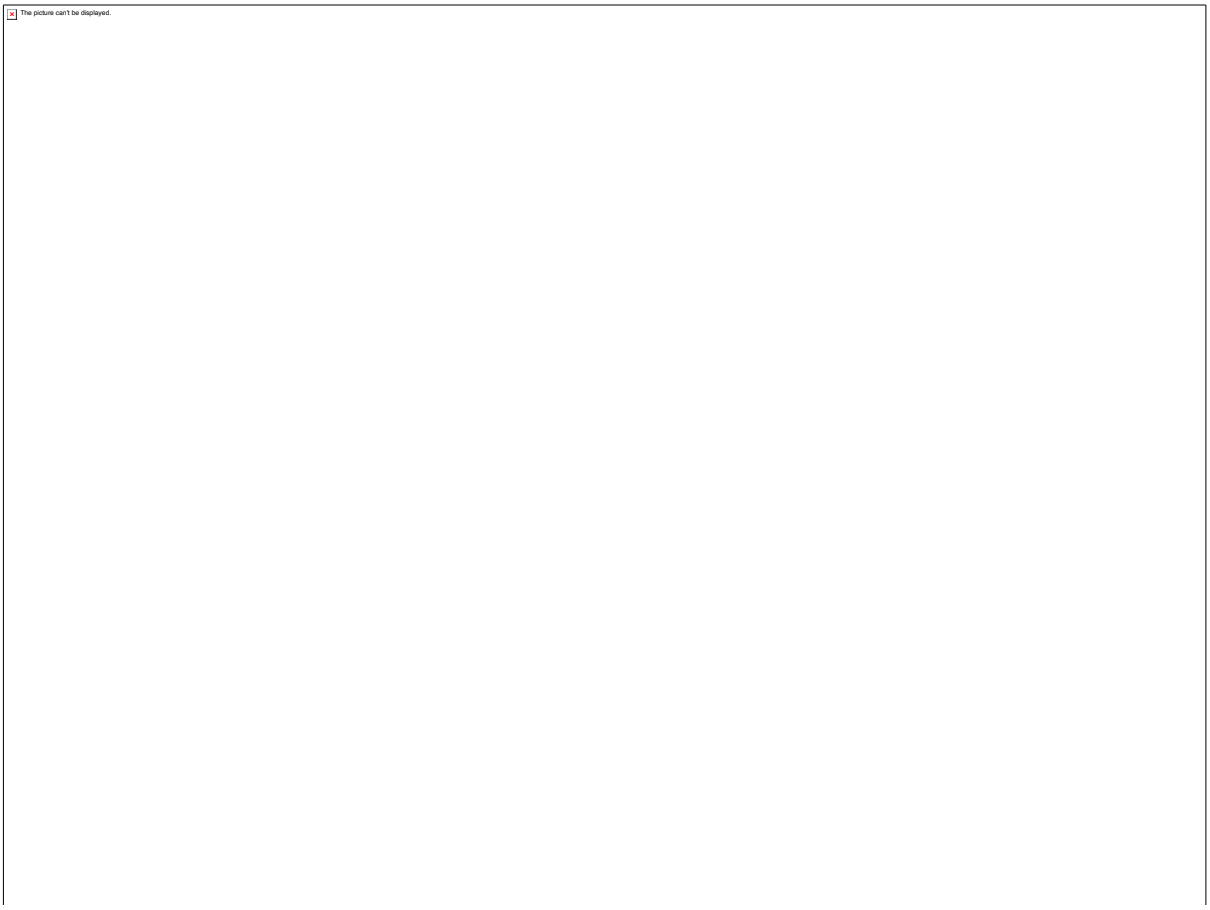
We sought the services of the **Queensland Museum** to establish the historical relationships and cultural heritage of Indigenous peoples with shorebirds and incorporated this into the storyboards.

### 6. Building in live access to birds through remote camera technology

Manly Boat Harbour has within its precinct an above-high-tide shorebird roost designed to provide a safe haven for shorebirds during high tides. This is a unique aspect of the harbour design and is a successful demonstration of the integration of nature conservation needs for local and migratory bird life with a working recreational boat harbour. The roost is off limits to the public to protect resting shorebirds.

Parts of the Harbour Precinct, which includes the roost site, are a government entity managed by **TMR**. We negotiated an access agreement with TMR to set up a fixed camera with a dedicated signal to relay images to the display at the Discovery Centre. The achieve a dedicated signal between the camera and the Discovery Centre we worked with the **Royal Queensland Yacht Squadron** to piggyback a repeater station within the harbour. Tests were conducted to ensure the signal did not interfere with ship-to-shore communication and navigation.

To ensure that the camera mount and roost access did not harm or disturb roosting birds, the QWSG was engaged as consultants and their recommendations then included into the access agreement. This consultancy was undertaken pro bono.




**Solar powered remote camera at the Manly Boat Harbour Roost – A world first initiative**

## 7. Establishing the display at the Discovery Centre

The materials and intellectual property accumulated through these collaborations formed the basis for constructing the shorebird display that could meet our world class benchmark partner expectations.

The Moreton Bay Discovery Centre engaged three local south-east Queensland companies to construct the shorebird display. Invited Shorebird experts undertook quality assurance of the display materials and interactive components as these came online. The camera now provides a real time live link to shorebirds at the roost.

1. **Moreton Bay Systems Pty. Ltd**.

**Moreton Bay Systems** supplied and installed the camera at the Manly Harbour roost site in accordance with the bird safety requirements in the TMR access agreement. The Company provided free follow up advice to improve the quality of the camera performance.

**2. Telco Antennas Pty Ltd.**

**Telco Antennas** installed the communications links, repeater station and image download software to link the camera images to the display screens. The company worked with the **Royal Queensland Yacht Squadron** (QRYS) management to secure the links and repeater station sites within the harbour compound. Tests were conducted to assure that the installation did not interfere with ship-to-shore communication and navigation. The QRYS have provided their access and services free of charge.

**3. Xibit Pty. Ltd.**

**Xibit** worked with the Discovery Centre extensively over a two-year period to develop and install the fixed, electronic and interactive displays and adapt the camera imagery to touch screen technology. This allows a member of the public to use a touch screen to move and zoom in on shorebirds using the remote camera at the roost.

Xibit were supplied with materials, videos, diagrams, maps, story boards and scripts to create the display. They did this in four ways:

First, they created the fixed story displays guided by science driven criteria about the key education messages about shorebirds in Moreton Bay and their conservation.

Second, they programmed the interactive displays using sub-themes pertinent to greater depth of learning and investigation and adapted these to interactive screen capability.

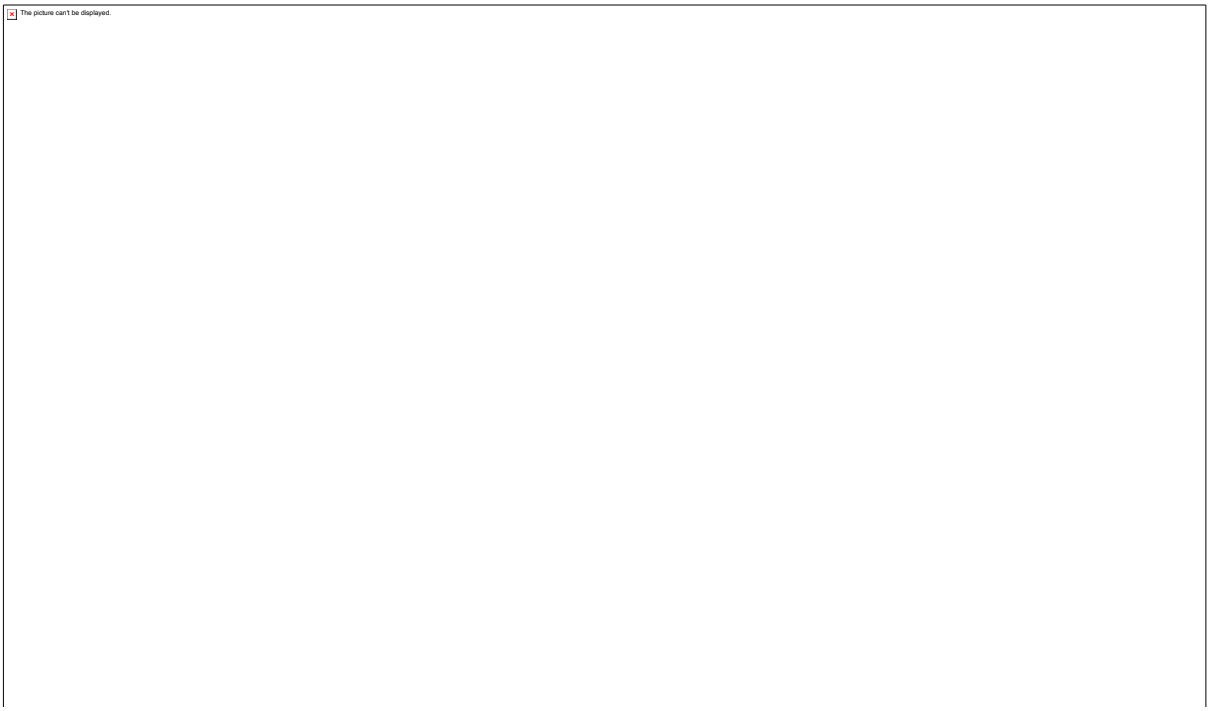
Third, they used animation software to convert shorebird local and migratory flight paths into moving animations for public exploration using interactive screen technology.

Finally, they wrote and installed the program to allow the public to use the remote camera at the Discovery Centre.

A series of trials and early user feedback was used to make fine adjustments to the Shorebird display. Organisations involved in the display development were invited to view, interact, comment and assess the display. Their feedback will guide future improvements.

**List of Contributors**

The Scottish Seabird Centre
The Manly Harbour Village traders through their Chamber of Commerce
The David Farley Family Trust
Birdlife Australia
Birdlife Southern Queensland
Birds Queensland
Australasian Wader Study Group
Queensland Wader Study Group
Northern Threatened Species Recovery Hub - National Environmental Science Programme
Charles Darwin University
Queensland Department of Environment and Science
Argos Satellite Systems Ltd.
The Fuller Lab at the University of Queensland
Moreton Bay Environmental Education Centre, a facility of Education Queensland
Aktura technology Pty. Ltd.
The Port of Brisbane Pty. Ltd
Apple Store Developer Platform Services
Google Play Developer Platform Services
Queensland Department of Transport and Main Roads
The Queensland Museum
Moreton Bay Systems Pty. Ltd.
Telco Antennas Pty Ltd.
Royal Queensland Yacht Squadron
Xibit Pty. Ltd.




**Interactive touch screens**

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A4. School-based Education Resources

We worked with the Bird Education Group, an initiative of Birds Queensland and Birdlife (Southern Queensland) to develop shorebird education materials over the course of the project.

The extraordinary story of migratory shorebirds is ideal real-world material for the study of school STEM subjects, especially science and technology. However, common practice for many school students is to learn about shorebirds at a one-off opportunistic event, such as an organised school field visit to a wetland or a classroom talk from an enthusiastic birdwatcher.

'Learn About Birds' (an initiative of Birds Queensland and Birdlife-Southern Queensland) aims to encourage a more educationally sound approach through linking shorebirds to the Australian STEM curriculum. This is achieved by resourcing both teachers and students with material that links to the STEM curriculum guidelines (See: https://www.australiancurriculum.edu.au/resources/stem)

Working with the Queensland Wader Study Group, curriculum content and resources about local migratory shorebirds were developed by educators from the Learn About Birds group (See: https://www.ourlocalbirds.com/about) to support the study of Migration by Year 6 students (11 year olds) within the Australian Science Curriculum. This provided an opportunity to integrate many aspects of STEM. For example, in the case of the Bar-tailed

Godwit the following topics are presented: Taxonomy and species identification, feeding ecology and evolved species' anatomy and physiology, behavioural ecology and habitat assessment, conservation and bird-human interaction, as well as some field study methods. And, from the technology curriculum, an introduction to satellite telemetry.

The teaching resources and school student material can be viewed here:
https://www.ourlocalbirds.com/year6

The key learning video material based on the project is available here:
https://vimeo.com/394819136

These learning materials have been circulated widely, including to the Moreton Bay Environmental Education Centre.