

Distribution and abundance of migratory shorebirds in Darwin Harbour, Northern Territory, Australia

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Abstract

Here we report the results of an aerial survey of migratory shorebirds in Darwin Harbour, Northern Territory, Australia, as part of a new project on strategic planning for the Far Eastern Curlew (*Numenius madagascarensis*). On one day in January 2017 we surveyed the intertidal zone of a large part of upper and middle Darwin Harbour at low tide and counted all shorebirds and waterbirds present, and then we also surveyed all salt pans and potential roosting areas at high tide. There were 724 birds of 19 species recorded during the low tidal survey and 789 birds from 13 species recorded during the high tidal survey (i.e. a total of 24 species for the day). We found a total of 329 Far Eastern Curlews during the high tide survey, an increase in the Darwin Harbour maximum previously recorded. We will use these results to guide future monitoring work on the Far Eastern Curlew in Darwin Harbour, and to help mitigate the effects of coastal developments on shorebirds.

Introduction

Most shorebirds in Australia are long-distance migrants that breed in Siberia, Alaska or China, and visit Australasian shores during the austral summer. These shorebirds migrate between hemispheres along the East Asian-Australasian Flyway (hereafter the EAAF), but habitat destruction in the Yellow Sea region is driving population decline for many species (Szabo *et al.* 2012; Murray *et al.* 2014; Clemens *et al.* 2016; Conklin *et al.* 2016; Piersma *et al.* 2016). Once in Australia, shorebirds spend the duration of the austral summer seeking out high quality food resources. As most coastal shorebirds feed on benthic invertebrates on exposed mudflats during low tide, foraging and roosting times are dictated by tidal cycles. At high tide, when the foraging grounds are submerged, shorebirds retreat to roosts on sandy beaches, rocky reefs, dykes and ponds, where they preen or rest.



Figure 1 (above). Far Eastern Curlews (*Numenius madagascariensis*) in flight. (Amanda Lilleyman)

Figure 2 (inset right). A male Far Eastern Curlew in flight. (Amanda Lilleyman)

There are 37 species of migratory shorebirds that regularly visit Australia (Commonwealth of Australia 2015), and 25 of them occur along the coastlines of Darwin Harbour in the Northern Territory (A. Lilleyman, unpubl. data). There are seven species of shorebirds classified as Threatened under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act); all occur in Darwin Harbour. The focal species of this study is one of them, the Far Eastern Curlew (*Numenius madagascariensis*) (Figures 1 and 2). In fact its conservation status was recently upgraded to Critically Endangered under the EPBC Act due to reported population declines over the last thirty years from monitoring sites around Australia (Department of the Environment and Energy 2015). Internationally it is listed as Endangered (BirdLife International 2016). It is the largest of the annual migrant shorebirds that travel along the EAAF, to which it is endemic (Higgins & Davies 1996).

Darwin Harbour has a variety of coastal habitats that migratory shorebirds use during the non-breeding season. This includes natural sites such as beaches, rocky reefs, intertidal sand and mud flats, but also an artificial site – the dredge ponds at Darwin Port's East Arm Wharf (Figure 3). This site regularly provides safe roosting habitat for over 1000 shorebirds of 25 species plus 45 species of other waterbirds or water-associated birds (Lilleyman 2016). In contrast to the rest of the species' range (Clemens *et al.* 2016;

Studds *et al.* 2017), the Far Eastern Curlew has been counted in increasing numbers in the Darwin region – at Lee Point in Darwin’s northern suburbs – over the last 30 years, and at East Arm Wharf since 2009 (Lilleyman *et al.* 2016b).

In Australia, the key threats to migratory shorebirds are coastal development that destroys habitat and disturbance that disrupts their normal activities (Harding *et al.* 2007). These threats are both present in the Darwin region and the effects of anthropogenic disturbance to shorebirds have been documented (Lilleyman *et al.* 2016a). Safe roosting sites are critically important for shorebirds that feed on coastal intertidal zones that become inundated by the tide twice a day. East Arm Wharf provides secure and safe roosting habitat for shorebirds because human access to the site is restricted. Far Eastern Curlews regularly occur at the site in nationally important numbers (criterion: 0.1% of the EAAF population) during spring high tides (Lilleyman *et al.* 2016b), suggesting that a large proportion of the population uses this site when other roosting sites are not available. The connectivity and availability of these sites at various tide cycles is crucial for managing the shorebird populations in Darwin Harbour.

Migratory shorebirds select roosting sites that are close to feeding grounds to allow short commutes twice a day. In tropical locations, both roosting and feeding sites need to be in areas where birds can thermoregulate to avoid heat stress (Rogers *et al.* 2006; Rosa *et al.* 2006; Zharikov & Milton 2009). Shorebirds will often use a network of sites in a region for roosting and feeding to ensure that there is always one site available at which they can forage. Far Eastern Curlews are solitary foragers and defend small territories across intertidal mudflats (Jackson 2017). On Stradbroke Island, in southern Queensland, territory size varies from 0.22–0.85 ha, depending on densities of favoured prey (Zharikov & Skilleter 2004) and in Moreton Bay, also in southern Queensland, the Curlews operate daily at scales of 5–10 km (Finn *et al.* 2002). Prey abundance and thus territory size are yet to be measured in Darwin Harbour but will affect both the abundance and dispersion of Curlews across the Darwin Harbour intertidal zone.

Darwin Harbour is likely to undergo substantial development over coming decades. Under the *EPBC Act*, new developments need to take the needs of protected threatened species into account. This can only be done if there is a greater understanding of how the different species use the available habitat and the extent to which sites are connected. This project on the Far Eastern Curlew will contribute to this understanding so the deleterious effects of coastal development can be minimised. This preliminary survey builds on an intensive monitoring program for shorebirds at the Port of Darwin. The aim of the aerial survey was to record all migratory shorebirds and other waterbirds observed in the study area. While our main focus was on Far Eastern Curlews, we took the opportunity to survey all other bird species that utilise the intertidal zone. The result is a detailed survey of shorebird abundance and distribution at low and high tide during the core non-breeding period in Darwin Harbour. We also present the first full count of Far Eastern Curlew numbers in the Harbour.

An additional factor in the research of which this survey forms part, is that it is a partnership between researchers at Charles Darwin University and the Larrakia people, the Traditional Owners of the habitat where the Curlew occurs. Far Eastern Curlews and other shorebird species have been recorded at the Larrakia sacred site Yirra (Catalina Island) to the east of East Arm Wharf. There is extensive overlap between the habitat used by Far Eastern Curlews and areas that are culturally important to Larrakia people. Extensive middens around the fringes of Darwin Harbour attest to a long and continuing history of use of the mangroves and mudflats around the edges of the Harbour that are non-breeding habitats for the Far Eastern Curlew. Such resource use, however, can only continue if the environment remains in a healthy and productive state. Larrakia people are already working with university researchers to monitor pollution levels in shellfish around the Harbour. The current project will allow us to understand how the resources are being used by the threatened birds that also use Larrakia's land and sea areas.

The Darwin Port corporation, a major stakeholder in the long-term planning of Darwin Harbour and the associated coastline, is a partner in this project and aims to assist in the management of globally-threatened shorebirds through appropriate and sustainable decision-making. The Port of Darwin corporation currently manages the nationally important habitat for the Far Eastern Curlew at East Arm Wharf and will seek to understand how the species uses other feeding and roosting habitats in Darwin Harbour as a contribution to long-term strategic planning.

Methods

We conducted an aerial survey of Darwin Harbour using a helicopter on Thursday 12 January 2017 during low tide (10.15 hr to 12.15 hr) and then again at high tide (17.00 hr to 18.30 hr). Low tide (0.75 m) occurred at 12.09 hr and high tide (7.63 m) occurred at 18.44 hr that day. An aerial survey allowed full coverage of Darwin Harbour during one full tidal cycle and gave us access to saltpan habitat that would otherwise be inaccessible by road.

During the low tidal phase of the survey, we flew over the intertidal zone along the edge of the mangroves starting from Dinah Beach Boat Ramp (12.44°S, 130.85°E) through to Mandorah Wharf (12.44°S, 130.76°E) (Figure 3). We circumnavigated all the small islets and flew over exposed sandbars. During the high tidal phase of the survey, when the intertidal zone was covered, we flew low over mangroves and supratidal salt pans where, from experience, we expected shorebirds to be roosting (Figure 4). This meant that we omitted the southern ends of the three arms of the Harbour because there are no salt pans behind the mangroves where roosting birds were likely to be visible from the air. For surveying, A. Lilleyman and S. Garnett called out counts of all shorebirds and waterbirds, and A. Lilleyman recorded all birds observed and made notes on habitats into a hand-held voice recorder (Sony ICD-PX440). Survey personnel avoided duplicating observations by making counts from different sides of the helicopter. When shorebirds



Figure 3. Far Eastern Curlews roosting with other waterbirds in a dredge pond at Darwin Port's East Arm Wharf. This photo alone yields a count of Far Eastern Curlews that exceeds the national threshold for that species of bird. (Amanda Lilleyman)

were not easily identified from the air, they were classed as either 'Small' or 'Medium' based on their size. The recording data were later transcribed into a database.

During the high tidal phase of the survey, an experienced shorebird counter (G. O'Brien) was stationed at East Arm Wharf roost to count all birds present at the site, while A. Lilleyman and S. Garnett surveyed additional sites in the region. This on-ground survey was conducted between 16.00 hr and 19.00 hr. Once all high tidal sites had been surveyed, we flew over East Arm Wharf to count shorebirds at the Darwin Port corporation's ponds and later ground-truthed this by comparing with the East Arm Wharf on-ground count. The timing of arrival of birds at the Port's ponds was recorded and this was checked against records of birds away from the site to avoid duplication in the final estimate of birds.

Results

Abundance of migratory shorebirds in Darwin Harbour

We recorded 724 individuals of 19 species of bird during the low tidal phase of the survey (Table 1) including 160 Far Eastern Curlews. All the Curlews were feeding on the exposed intertidal mud alone or in loosely associated pairs. At the lowest tide they were commonly feeding in the middle of the mudflat, often along small drainage channels, though this was difficult to quantify.

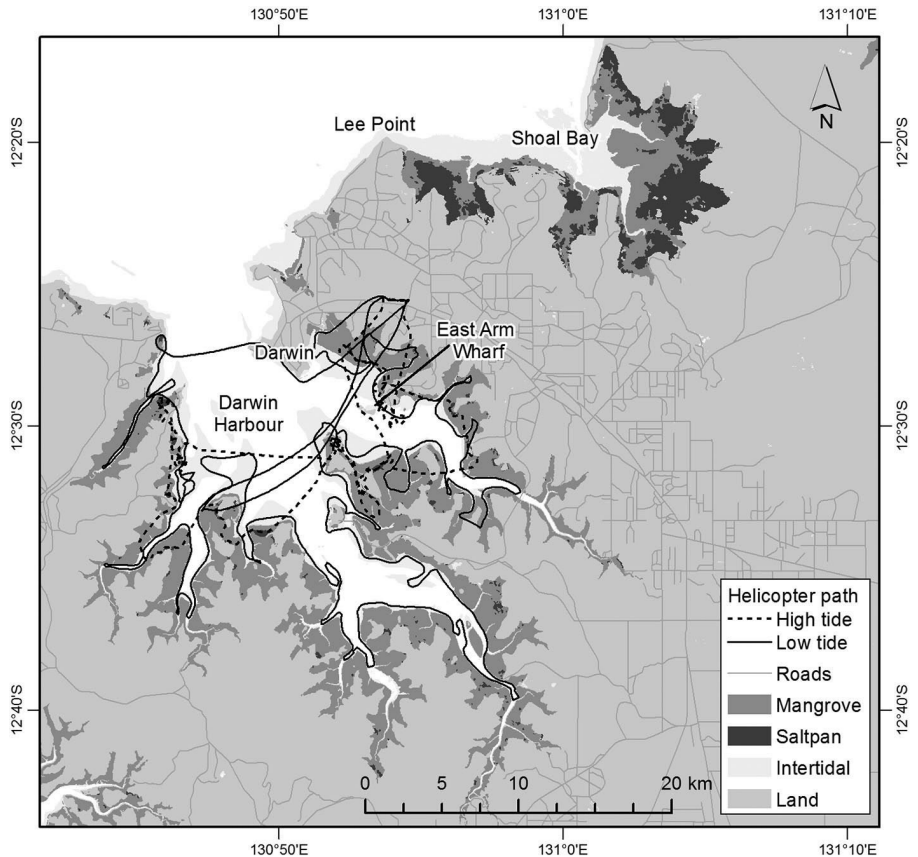


Figure 4. Map of the survey area in Darwin Harbour and the path flown during high tide and low tide.

At high tide we located 789 individual shorebirds belonging to 13 species (i.e. a total of 24 species for the day), including 185 Far Eastern Curlews. Many of the Curlews were roosting in small flocks with a median group size of 2 individuals, a mean group size of 7 and a maximum of 60.

At East Arm Wharf, 388 individuals from 14 species were counted from the ground (Table 2). This included 144 Far Eastern Curlews. These individuals were in addition to the 185 Far Eastern Curlews that we recorded in Darwin Harbour during the high tidal survey. The total population of Far Eastern Curlews in Darwin Harbour on 12 January 2017 was therefore 329 individuals. This is greater than the previously recorded maximum count of Far Eastern Curlews for the East Arm Wharf site (264 individuals recorded during the December monthly high tide count).

Table 1. Total count of migratory shorebirds recorded in Darwin Harbour during low tide and high tide on 12 January 2017.

Species	Low tide	High tide
Grey Plover	0	3
Bar-tailed Godwit	0	30
Whimbrel	104	344
Far Eastern Curlew	160	329
Terek Sandpiper	2	0
Common Sandpiper	42	0
Grey-tailed Tattler	14	0
Common Greenshank	46	16
Small	167	66
Medium	118	13

Note: The ‘Small’ component of this count comprises Red-necked Stint, Common Sandpiper, Terek Sandpiper, Grey-tailed Tattler, Red Knot, Great Knot, Ruddy Turnstone, Sharp-tailed Sandpiper, Greater Sand Plover, and Lesser Sand Plover. The ‘Medium’ component of this count comprises Common Greenshank, Grey Plover, and Bar-tailed Godwit.

Table 2. Count of migratory shorebirds from East Arm Wharf (on-ground count) during the high tidal survey of 12 January 2017.

Species	Total count
Grey Plover	6
Bar-tailed Godwit	3
Whimbrel	116
Far Eastern Curlew	144
Common Greenshank	50
Marsh Sandpiper	2
Sharp-tailed Sandpiper	8

Distribution of the Far Eastern Curlew in Darwin Harbour

Far Eastern Curlews were found to be widely distributed throughout Darwin Harbour during the aerial survey conducted at low tide (Figure 5). Most were recorded foraging on the inner section of the mud flats closer to the mangroves than the outer section of the mud flats towards the lowest tide height (see ‘Intertidal’ layer on map of Figure 5). They were recorded in small flocks during the high tidal period when they were roosting, primarily in supratidal salt pans, above the high-water mark (Figure 6). Shorebirds were forced out of these salt pans once the tide had reached its peak height and they flew to roosts on islands, in mangroves, or on beaches. Some shorebirds, including Far Eastern Curlews, roosted at the East Arm Wharf site, and even when perturbed at the site during the aerial survey, they returned to roost in the artificial dredge ponds.

Curlews recorded during the low tidal survey had to fly from different parts of the Harbour to roost at East Arm Wharf. The straight line distance between foraging sites at low tide and the East Arm Wharf roost site varied from 2.5 to 19.6 km, with an average of 9.7 km. Although birds recorded on the intertidal zone at low tide were always close

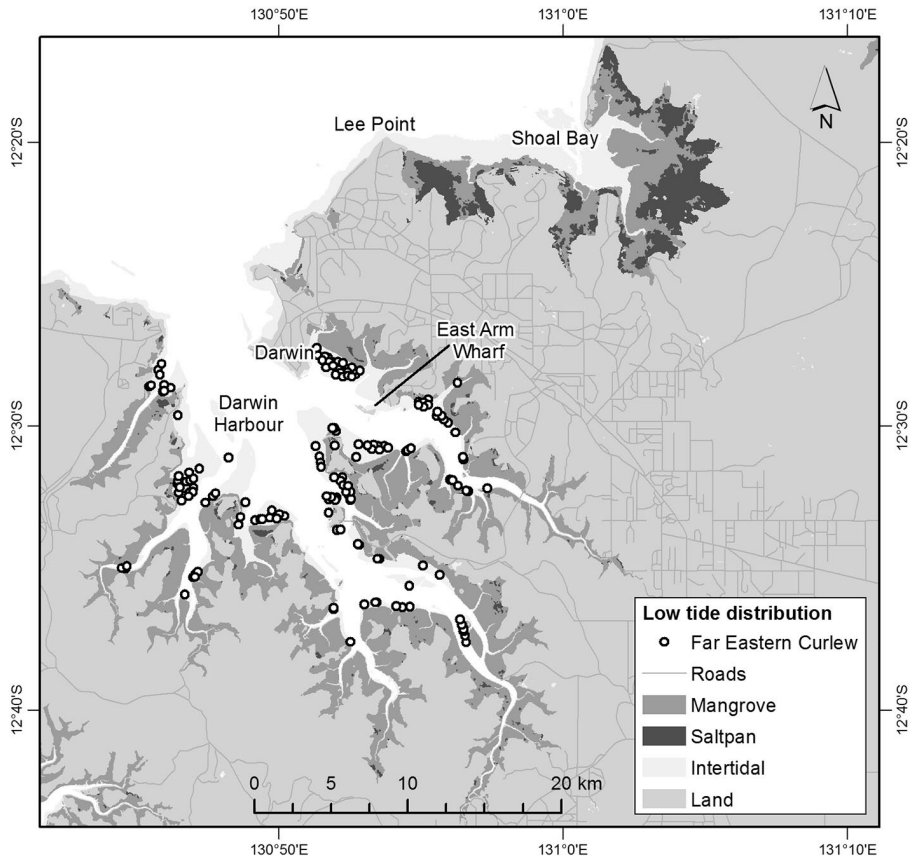


Figure 5. Distribution of Far Eastern Curlews recorded during low tide in Darwin Harbour.

to supratidal saltpans, these are not available during high spring tide heights because they are covered in deep water. At such times we believe that most, if not all, the Curlews around the Harbour roost at East Arm Wharf, although other roosting sites may be important on lower high tides or as staging posts while the tide is rising.

Nationally important roosting sites

During the count of high tidal roosts, we recorded two locations where flocks of Far Eastern Curlews had more than 31 individuals (Figures 3, 6). This meets the threshold for protection of threatened shorebirds under the EPBC Act, which is 0.1% of the flyway population. One flock was recorded at East Arm Wharf, where large congregations of greater than or equal to 31 individuals assemble frequently. The other flock was at the saltpan, south-east of East Arm Wharf, adjacent to the ConocoPhillips LNG Plant, although this roosting site may not be available at the highest tides.

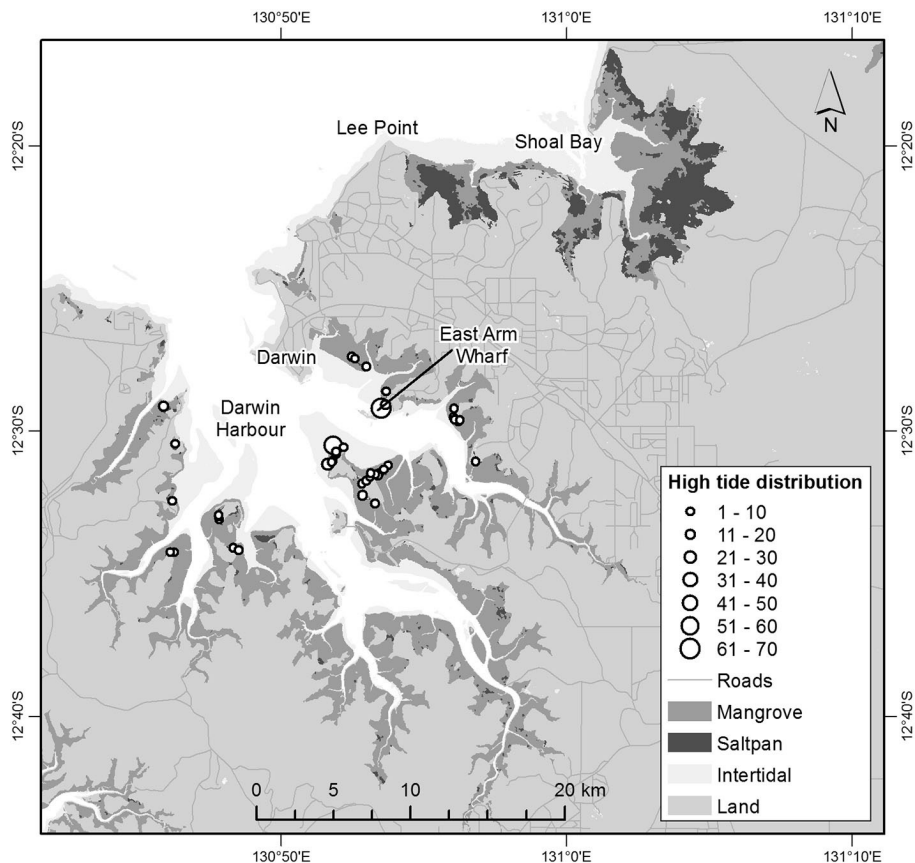


Figure 6. Distribution of Far Eastern Curlews recorded during high tide in Darwin Harbour. Legend shows count size classifications. Flocks of this species greater than or equal to 31 individuals indicate representation at sites considered as nationally important under the *Environmental Protection and Biodiversity Conservation Act 1999*.

Discussion

Distribution and abundance

Most migratory shorebirds observed in this study were sparsely distributed over the intertidal mudflats of Darwin Harbour during low tide. Some areas were devoid of birds, whilst at others individuals had congregated in small feeding flocks. Most Curlews were feeding on the upper half of the mudflat exposed at low tide during which we surveyed from near the mangroves to half way out to the sea with only a few at the edge of the water. This suggests that Far Eastern Curlews may not strictly follow the tide when foraging. We observed high abundances of crabs in the middle of the exposed areas at low tide and this might influence where Far Eastern Curlews forage, as crustaceans are

its preferred prey (Finn *et al.* 2008). Also, if Curlews are defending territories, they may only defend mudflats exposed at most tides and not those exposed only at the lowest spring low tides (the timing of the current survey).

The abundance and distribution data reported from this aerial survey will be used to guide the fieldwork program for the strategic planning project on the Far Eastern Curlew, including the benthic invertebrate monitoring component which will examine the availability of food for Curlews. Understanding the types of prey and how much of it is available to shorebirds will help determine the habitat requirements of these birds in Darwin Harbour. Prey distribution influences shorebird distribution across the intertidal habitat (Ponsero *et al.* 2016), and tidal cycles constrain both the movement of benthic invertebrates and the available time for shorebirds to forage (Kraan *et al.* 2009). Our aerial survey has shown where Far Eastern Curlews forage during low tide, but it has not shown the distances these birds move within the Harbour during a complete tidal (high to low) cycle. Our next project is to examine the movement of individuals in Darwin Harbour to explore the connectivity within the region. Migratory shorebirds require a network of high-quality sites at both a flyway scale and at a local regional scale to migrate and breed successfully each year (Aharon-Rotman *et al.* 2016).

Understanding habitat choice of shorebirds allows informed management of important habitat, which in turn can secure the protection of these birds. Migratory shorebirds will require a range of roosting and feeding sites in Darwin Harbour so they can move between sites if the optimal habitat is disturbed or unavailable due to tidal conditions. It will be important to ensure there is an adequate array of roosting sites for shorebirds as a reduction in these may lead to increased competition for resources (Goss-Custard *et al.* 2002) or, in extreme circumstances, a population crash if suitable habitats are not available (Burton *et al.* 2006).

The use of the East Arm Wharf site by Far Eastern Curlews (and many other species of shorebirds) (Figure 3) documented during the survey reported here suggests an ongoing attraction to this artificial habitat. The high count from the current survey represents a substantial increase in Curlews for the Darwin Harbour area compared to those reported previously (Chatto 2003). The results from this study coupled with the local-scale increases as reported by Lilleyman *et al.* (2016b) show that this species can adapt to local habitat changes if the alterations to the environment provide a net increase in habitat availability. The East Arm Wharf site is evidently now providing high quality roosting habitat for Far Eastern Curlews and other shorebirds and waterbirds. These birds roost there in preference of all other roosting sites in Darwin Harbour, as evidenced by the large number of birds at the site, relative to the total Darwin Harbour population.

In Darwin Harbour, shorebird numbers may be constrained by the availability of roosting sites. Feeding grounds appear to be widely available with extensive intertidal areas within the region, although the quality of these mudflats is yet to be tested.

Although Far Eastern Curlews were always close to potential saltpan roost sites when they were feeding at low tide, the saltpans are inundated at the highest tides. The birds can then roost in mangroves or fly to East Arm Wharf. This latter site is apparently being adopted by increasing numbers of migratory shorebirds, including the Curlews. Indeed, the increasing numbers counted at East Arm Wharf may be because the availability of the roosting site there is allowing more birds to feed in Darwin Harbour. Given the length of time over which the increases have been sustained, this seems a more probable explanation than the alternative explanation, which is that birds traditionally using the Harbour have only gradually come to know the quality of the East Arm Wharf roosting site. However, the distance the Curlews appear to be travelling to East Arm Wharf from feeding areas is longer than is usual among shorebirds (Jackson 2017). This in turn implies that the creation of additional roosting sites could further increase the quality of the Harbour to migratory shorebirds if food is available.

Conclusion

The low tidal survey revealed a high level of usage of mudflats by the Far Eastern Curlew with birds feeding on mudflats around almost all the Harbour, particularly on the broader tidal flats. Roosting occurred on saltpans but, when these were inundated, many birds moved to East Arm Wharf. The survey confirmed that the artificial East Arm Wharf site has become the most important roosting site for the Far Eastern Curlew within Darwin Harbour. The site is also particularly important for other species of migratory shorebirds throughout the austral summer. The new maximum count for the Far Eastern Curlew of 329 birds is an increase in the population estimate for this species and shows that there are more birds in the Darwin region than previously recorded. This study, along with recent research (Lilleyman *et al.* 2016b), provides an opportunity to further manage an artificial site for positive conservation outcomes for migratory shorebirds. Management of the Far Eastern Curlew in Darwin Harbour requires a holistic approach so that the species, and other migratory shorebirds, are adequately protected against the potential impacts of coastal development.

Acknowledgements

We acknowledge Darwin Harbour's Traditional Owners, the Larrakia people, and their elders past and present. We thank our project partners the Darwin Port corporation. Thanks are also extended to the Threatened Species Recovery Hub, National Environmental Science Program for funding this project on the Far Eastern Curlew (Project 5.1.1). Thanks also to Airborne Solutions for providing expert helicopter assistance during the aerial survey and to the Larrakia Rangers for their involvement in the field survey. We are grateful to Ian Leiper for providing the maps for this paper. Figures 4–6 incorporate topographic map data which are copyright to the Commonwealth of Australia (Geoscience Australia) and the vegetation mapping data supplied by the Department of Land Resource Management, Northern Territory of Australia, are also subject to copyright. Thanks also to the reviewer who provided useful comments on this manuscript.

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