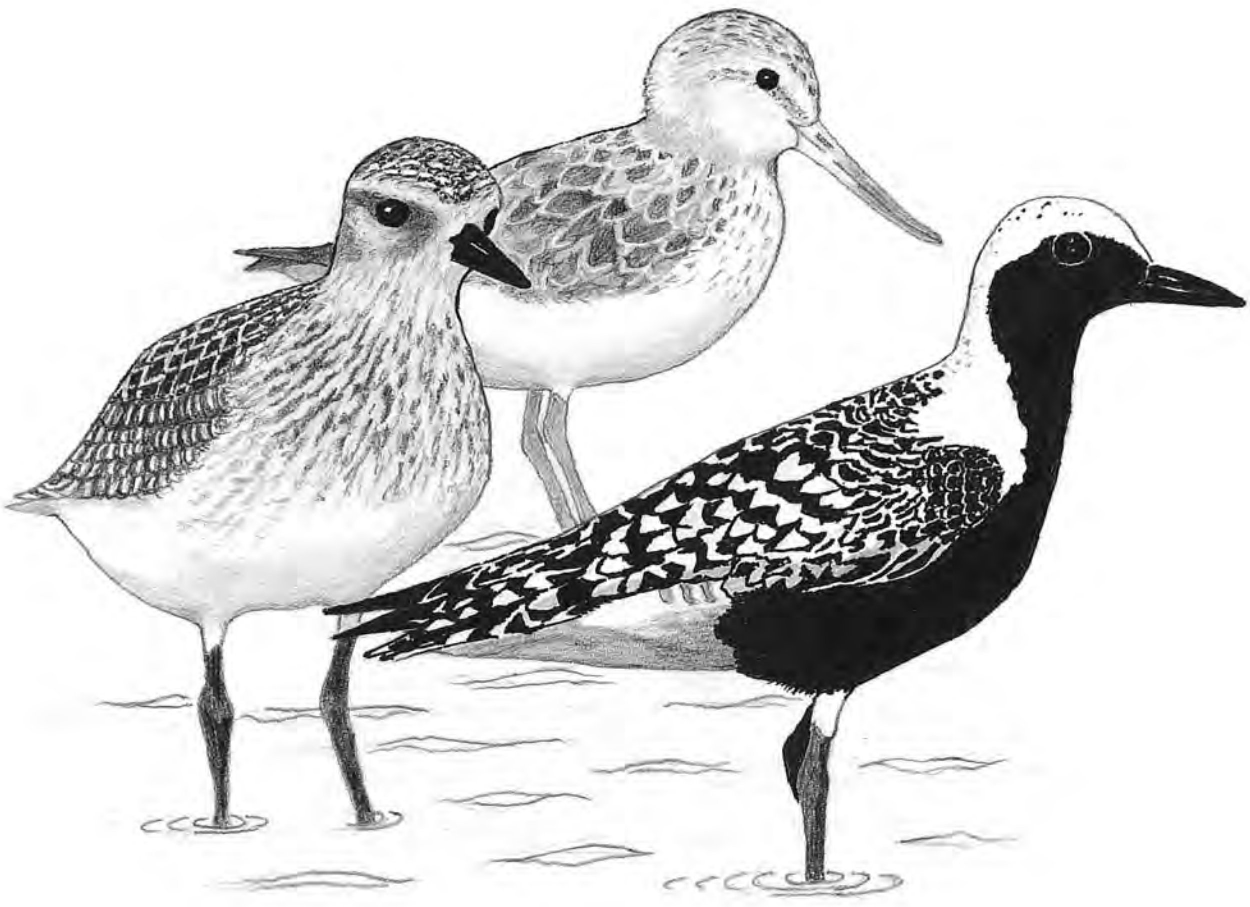
Stilt

The Journal for the East Asian-Australasian Flyway



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AWSG
Australasian Wader Studies Group

Stilt

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MISSION STATEMENT
To ensure the future of waders and their habitats in Australia through research and conservation programmes, and to encourage and assist similar programmes in the rest of the East Asian–Australasian Flyway.

OBJECTIVES
- To monitor wader populations through a programme of counting and banding in order to collect data on changes on a local, national and international basis.
- To study the migrations of waders through a programme of counting, banding, colour flagging and collection of biometric data.
- To instigate and encourage other scientific studies of waders such as feeding and breeding studies.
- To communicate the results of these studies to a wide audience through *Stilt*, the *Tattler*, other journals, the internet, the media, conferences and lectures.
- To formulate and promote policies for the conservation of waders and their habitat, and to make available information to local and national governmental conservation bodies and other organisations to encourage and assist them in pursuing this objective.
- To encourage and promote the involvement of a large band of amateurs, as well as professionals, to achieve these objectives.

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MEMBERSHIP OF THE AUSTRALASIAN WADER STUDIES GROUP
Membership of the AWSG is open to anyone interested in the conservation and research of waders (shorebirds) in the East Asian–Australasian Flyway. Members receive the twice yearly bulletin *Stilt*, and the quarterly newsletter *Tattler*. Please direct all membership enquiries to the Membership Manager at BirdLife Australia, Suite 2-05, 60 Leicester St, Carlton Vic 3053, AUSTRALIA.
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EDITORIAL

This is the first of two consecutive issues that feature contributions on the issue of declining populations of waders in the East Asian-Australasian Flyway. This has been an ambitious move on my part to, in a very short time, encourage the publication or updating of information from migratory wader monitoring in Australia relevant to the theme "Waders in Decline". I have not been as successful as I would have liked, and thus, this issue comes to you later than usual and missing several important contributions, which are still in the production process. Nevertheless, I have pressed on, feeling that the need was urgent to go ahead with this issue and the tight deadlines necessary to start accumulating in one place up-to-date information demonstrating what most of the shorebird community already knows - that populations of migratory wader species in the EAAF are declining. Later I provide a brief overview of the Australian wader literature that relates to the issue of declining populations of waders.

At this dark hour of wader conservation, we find it darkened even further by the loss of one of our great champions of wader studies and international collaboration, Mark Barter. Mark's contribution to wader research and conservation in the EAAF has been substantial. Ken Gosbell and Doug Watkins provide us with a heart-felt obituary to Mark, which follows this editorial. A summary of just some of his research achievements in developing and maintaining strong ties between Australasian and Asian wader researchers is at the end of the obituary.

It should be of considerable concern to the Australian government to lose someone of Mark's calibre in addition to the burgeoning wader conservation crisis. Up until now, Australian Governments have paid lip service to the international treaties for the protection of migratory birds they have signed and are obliged to uphold. Coastal industrial development in Asia has been shown to be one of the greatest threats to migratory waders in the EAAF. However, the government selectively prioritises support of such development whilst seemingly ignoring the resultant biodiversity losses that they have responsibility to prevent.

In this issue of *Stilt* there are three research papers that provide reports on declining populations of waders. Two reports on populations in New South Wales, the first providing an account of the status of Curlew Sandpiper by Dawes (which has just been accepted for listing under the NSW Threatened Species Conservation Act) and the second presenting the results of a long-term wader survey from Port Stephens by Stuart. The third paper reports on the loss of waders from an important high-tide roost in Queensland due to disturbance from human recreation, an issue plaguing wader populations throughout built-up coastal areas in Australia.

Following the special section on Waders in Decline, there are four research contributions that provide a more positive story for waders. There are two reports of new species' records: a potential range expansion of Grey-headed Lapwing in northern Sumatra by Crossland & Sitorus, and a first over-summering record of Spoon-billed Sandpiper from Thailand by Eiam-Ampei and colleagues. Newman and Park present their research from a long-term study of shorebirds at Morpeth Wastewater Treatment Works in NSW, and new shorebird data for Barrow Island, an Important Bird Area off the coast of WA, is presented by Bamford and Moro. I hope readers are refreshed by these accounts after the grim tales presented in the previous section.

We can only hope that the continued accumulation and publication of research based upon decades of monitoring, plus the passionate people that strive to collect and publish data, collaborate interstate and overseas, and lobby governments to sit up and pay attention, may alleviate the crisis unfolding. I would encourage all our readers to do what they can to make our political leaders understand and respond to this conservation issue before we experience more preventable extinctions like the loss of the Christmas Island Pipistrelle in 2010 (Lunney *et al*. 2011. *Australian Zoologist* 35 [special issue]: 485–498) and the need for expensive captive breeding programs such as the current Spoon-billed Sandpiper program.

Birgita Hansen

A TRIBUTE TO MARK BARTER (9.6.1940 – 21.11.2011)

Ken Gosbell and Doug Watkins

Our friend and colleague Mark Barter passed away at his home on 21st November, 2011 after a battle with cancer. Mark will be remembered for his untiring work over many years in almost all countries of the East Asian - Australasian Flyway, where he worked with and trained so many people. His contribution and dedication to the AWSG was extensive and a great example to many.

In order to recognize the enormous contribution that Mark had made to waterbird research and conservation in Australia and throughout the Flyway he was presented with a letter of recognition several weeks before he died. This letter was signed by 59 people representing birding and conservation organizations around the globe; a very fitting tribute. In order to recognize the achievements of Mark, we can no better than reproduce the letter below. The accompanying Citation outlines the numerous elements of

his contribution. You will note that we committed to develop an Award program in Mark's honour focusing on the conservation of migratory waterbirds in the Flyway.

Expressions of sympathy and thanks for his contribution in so many ways were received from his many friends and colleagues from around the world. Perhaps this note from Cao Lei with whom Mark worked so closely in China in recent years summarises these thoughts:... "Today is Thanks Giving day, in memory of Mark, our group stayed together in the Lab this morning. We summarised what he has achieved with us in the last eight years, and looked at some nice photos of him. We thank God for creating Mark to love the waterbirds in China! We thank Mark for what he has done for birds and wetlands, for us, for China and the planet!"

Mark was an amazing man, a great scientist, practical conservationist, dedicated teacher and sincere friend. He will be sadly missed but his legacy and example will live on. Our thoughts are with his wife Terry and the family at this time.

An abridged bibliography of Mark's more recent research contributions is provided at the end.

A LETTER OF RECOGNITION

Dear Mark,

We are writing to formally recognise your outstanding contribution to migratory waterbird research and conservation in the East Asian – Australasian Flyway and to express our great appreciation for your efforts in raising awareness globally about the importance of protecting and maintaining migratory waterbird populations.

Over the past 3 decades your contribution has been instrumental to:

- the development of the Australasian Wader Studies Group and its conservation activities (Chair 1987–1997).
- the development and oversight of the East Asian – Australasian Action Plan (1997-2001) and your role as Chair of the Shorebird Working Group during this time.
- conducting a program to train Nature Reserve staff in bird recognition and survey methods at various wetland sites and, with them, undertake surveys of tidal flats from Fujian in southern China to the border with North Korea.
- promoting global recognition of the critical importance of the Yellow Sea for migratory shorebirds in the East Asian – Australasian Flyway.
- advancing our understanding of the importance of the Middle and Lower Yangtze wetlands for Anatidae, establishing a waterbird monitoring program for the Yangtze wetlands, encouraging and supporting the waterbirds and wetland group University of Science and Technology of China in Hefei to focus on conservation orientated Anatidae research.
- facilitating the development of international collaborative waterbird research programs that linked scientists in Asia, Europe and North America.

Your achievements would be outstanding for any full time ecologist. But you have done this as a volunteer, initially in your spare time and then in your retirement, often at your own expense. This selfless model will hopefully inspire others to contribute in a similar way.

We greatly value your contribution as a leader, a scientist and as a trainer and mentor. Your work in the flyway has established a greatly expanded body of researchers, site managers and community members with a passion for waterbirds and their conservation. These in turn will motivate others and collectively ensure a lasting legacy built on your foundational work.

We also know that, as a person of action, you will expect us to match our fine words with something more substantial. Accordingly, in this letter we are committing ourselves to developing an award program for the conservation of migratory waterbirds in the East Asian – Australasian

Mark with Wangxin, a PhD studying White-fronted Geese, at Dongting Lake, China.

Flyway.

The shape and scope of this award require further discussion but it would be open to individuals and non-government organisations. Also, it would aim to continue and build on the efforts you have contributed to the conservation of migratory waterbirds and build greater awareness of waterbirds and the challenges they face, among government agencies and local communities. Priority may be assigned to key regions in which you have worked, including the Yellow Sea and Yangtze floodplain.

In conclusion, we salute your great contribution to migratory waterbird conservation and commit to using the award and other means to provide a major incentive for this work to continue.

We would also like to thank your wife, Terry, for her years of understanding!

Your friends and colleagues [the signatures and logos of 59 organisations was attached]

CITATION

Key elements of the contribution made by Mark Barter to migratory waterbird research and conservation in the East Asian – Australian Flyway are captured in the points listed below:

1. **Development of the Australasian Wader Studies Group**
   - Mark was the second Chairman of the Australasian Wader Studies Group (AWSG) and held this responsibility from 1987 to 1997. He did an excellent job in every way and was particularly responsible for expanding AWSG's horizons of interest and activity outside Australasia and throughout the Flyway.
   - Mark was the real instigator of shorebird research and conservation activities in China and did a very large part of the initial monitoring of shorebird populations on the coast of the Yellow Sea himself. This culminated in his publication of 2002 detailing the results of shorebird population monitoring over the whole of the Yellow Sea, which has formed the basis of conservation strategies since that time.
   - Overseas Mark was also greatly involved in the education of people in shorebird identification and counting and he made the first attempts to impress upon people in China and elsewhere the need for conservation actions in critical locations.
   - Mark also was very active in shorebird banding fieldwork in Tasmania and then Victoria.
   - During his term as Chair, Mark provided extensive guidance, mentoring and support in the development of the “National Plan for Shorebird Conservation in Australia (1987)”. The approach developed in this work provided a template for subsequent transformations of shorebird count data into conservation advocacy tools for the flyway.

2. **Data management (Victorian and Australasian Wader Studies Group Banding Data Base), analysis and publication**
   - A particularly onerous task that Mark carried out single-handedly with the help of his wife Terry for more than 10 years was the collation and computerisation of VWSG and AWSG banding data and its transmission to the Banding Office in Canberra. This was a thankless task which demanded impeccable accuracy. The fact that today we have an excellent comprehensive, accurate and up to date database is because of the foundations that Mark laid.
   - Mark personally took a major role in analysing and publishing data emerging from shorebird studies by AWSG and VWSG in Australia.
   - Most of the species of migratory shorebird occurring in Australia have been the subject of, or a component of, some form of publication by Mark. The subjects of these publications range from biometric and moult analysis to movement data and population information. He promulgated strongly the need for data analysis and publication and his endeavours have directly borne fruit in the wide acceptance of this need today.

3. **Development of frameworks for conservation of migratory waterbirds in the East Asian – Australasian Flyway**
   - Mark took an active role in the inception and development of the Asia-Pacific Migratory Waterbird Conservation Strategy (1996). He was very influential in focusing efforts on the desired conservation outcomes.
   - Mark’s contribution was strongest in the development and implementation of the Asia-Pacific Shorebird Action Plan 1996-2001. During this time he was Chair of the Shorebird Working Group and a member of the Asia-Pacific Migratory Waterbird Conservation Committee.
   - Mark gave close attention to succession planning for leadership roles. He was not only an excellent Chair but also ensured that there was a suitable replacement when he stepped down.

4. **Yellow Sea Waterbird surveys, capacity building and publications**
   - Not content to just be the Chair of the Asia-Pacific Shorebird Working Group, Mark stepped up to deliver on a core part of the Shorebird Action Plan. This involved building capacity at Nature Reserves around the coasts of the Yellow Sea in China and, at the same time, to conduct a series of surveys of this complete coast. The Yellow Sea training and surveys involved two periods of field work a year from 1996 to 2002.
   - The Yellow Sea work culminated in the 2002 publication of the benchmark report “Shorebirds of the Yellow Sea”. To make this report comprehensive Mark networked with Government and non-government organisations in South Korea

and obtained their support for the inclusion of their shorebird count data.

5. **Middle Yangtze waterbird surveys and capacity building**
   - In 2004 and 2005 Mark was instrumental in organising the WWFwaterbird surveys of the Middle and Lower Yangtze River Floodplain. As a mentor, Mark made great contributions by developing survey methods, training survey staff and compiling reports. During this work, Mark made two comprehensive surveys of the wetlands in Anhui province. Based on this foundation, Mark developed a robust program of support and research activities with the University of Science and Technology of China in Hefei (USTC) and in recognition of his major contribution was awarded a Visiting Professorship at USTC. From 2005 to 2007 Mark led USTC teams conducting wintering waterbird surveys of the Huai River Floodplain and coastal areas from Shandong to Fujian province. This extensive field work resulted in over 10 papers and reports, presenting new population estimates and distributional information for Anatidae, shorebirds and globally threatened species. These publications confirmed that the Yangtze River Floodplain is the most important area for non-breeding Anatidae in the whole of China, but documented large population declines and ranges contractions.
   - Mark made a major contribution by establishing the first ongoing site monitoring program for waterbirds in China in 2008 (a systematic program of waterbird monitoring at Shengjin Lake). He continues to be instrumental in applying this model to other lakes and key sites in the Yangtze River Floodplain with the USTC group. Based on his rigorous approach to integrated monitoring, dramatic changes in the distribution and abundance of key species have been detected since 2004 and 2005.
   - With encouragement and assistance from Mark, a waterbirds and wetland research group was established at USTC to focus on understanding the causes of wetland degradation and their impact on Anatidae in the Yangtze River Floodplain.
   - Mark has conducted waterbird ecology, identification and counting training courses for National Nature Reserve staff and members from NGOs as well as undergraduate and graduate students from universities. His friendly and engaging manner and ability to communicate with all ages have made him a well-loved and inspiring teacher and mentor and his work has crafted a sound educational base for further research and conservation.

6. International collaborative waterbird research programs (Asia and Europe)
   - Mark was not only active but highly focused in facilitating information exchange and collaborative research between scientists in Europe (e.g. from Aarhus University, Denmark and the Wildfowl & Wetlands Trust, UK) and scientists developing ecological research programs in China (including students and the next generation of ecologists!).
   - Fundamental in his encouragement has been the integration of rigorous monitoring programs to determine “pattern” with ecological studies to understand underlying “process”, a construction that has combined efforts of ecologists from Europe, North America and Australia to bring best experience to bear on the problems of these globally important Chinese wetland systems.
   - In particular, his drive and determination led to multi-national fieldwork being undertaken in China and, in due course, to numerous papers (many of which he was co-author) being published in scientific peer-reviewed journals.
   - This East-West communication and exchange of knowledge engendered by Mark, and the comparative research programs resulting from this communication, has been, and continues to be, crucial for understanding variation in the trends, distribution and site-use by birds migrating along different flyways.

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Mark with Ken Gosbel in China, at the Yalu River crossing into North Korea, May 2005.

A BRIEF OVERVIEW OF LITERATURE ON WADERS IN DECLINE

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One of the earliest publications of declining populations of waders was in 1984 by Close and Newman, where they reported decreases in Eastern Curlew in Tasmania. Eastern Curlew declines have continued to be reported in Tasmania since that time, and reports have recently started emerging from Victoria, New South Wales and Queensland (Gosbell & Clemens 2006, Hansen *et al.* 2011, Wilson *et al.* 2011). This has contributed to this species being upgraded to 'vulnerable' on the IUCN's Red List in 2011.

Curlew Sandpiper is another species that has been flagged as a potentially declining species for almost as long as the Eastern Curlew. Reports of declining populations of Curlew Sandpiper have been emerging from southern Australia for at least 20 years (Barter 1992, Creed & Bailey 1998, Wilson 2001, Gosbell & Clemens 2006, Close 2008, Singor 2009, Creed & Bailey 2009, Hansen *et al.* 2011, Dawes this volume).

Reports on other declining species have been very much dependent on location (Table 1). Declines appear definitive in south-eastern Australia where many sites are considered to be the terminus for migration but also most sensitive to changes in population sizes by virtue of their largest transit distance from breeding grounds. Species showing decreases in this region, in addition to Eastern Curlew and Curlew Sandpiper, were Red-necked Stint, Sharp-tailed Sandpiper, Pacific Golden Plover and Grey-tailed Tattler (Table 1). However, trends in species like Red-necked Stint and Sharp-tailed Sandpiper are difficult to generalise because they can be highly variable depending on site and regional environmental conditions, for example, inland water availability (Nebel *et al.* 2008).

In 1993, the National Shorebird Plan was produced in order to set a benchmark against which subsequent changes in populations of waders could be assessed (Watkins 1993). Some decreases were noted in several resident and migratory species, notably Curlew Sandpiper (particularly in Tasmania), Eastern Curlew (in South Australia and Tasmania) and Painted Snipe. A subsequent report commissioned by Environment Australia on the AWSG Population Monitoring Project highlighted the potential for declines in waders but noted that due to count inconsistency, actual decreases versus changes in numbers due to increased detection probability (resulting from increased count effort) could not be reliably de-coupled (Driscoll 1997). In light of this limitation, data inspection to look for longitudinal trends in shorebird species was restricted to Victoria, which was considered to have the most consistent count coverage. This inspection revealed a decrease in eight species over the data reporting period (approximately 10 years): Curlew Sandpiper, Eastern Curlew, Great Knot, Grey-tailed Tattler, Latham's Snipe, Pacific Golden Plover, Red-necked Stint and Sharp-tailed Sandpiper (Driscoll 1997).

At the present time, it would seem almost certain that Curlew Sandpiper and Eastern Curlew are among the worst affected of Australia's migratory species. Bamford *et al.* (2008) highlighted in their summary of changes in population estimates that Curlew Sandpiper was a species of concern due to a decrease in estimates of around 40% over a decade, despite an increase in count effort.

Sophisticated modelling techniques have been recently employed to investigate trends in wader populations in Moreton Bay (Wilson *et al.* 2011) and further abroad (Amano *et al*. 2010). The results of these more rigorous statistical investigations were yet another confirmation of population declines, seven species locally (Wilson et al. 2011) and three species in the "Oceania" region (Amano *et al*. 2010) (Table 1). It is clear from this accumulating data, especially where analytical techniques are applied to control for variability due to count effort and coverage, that declines are occurring across much of Australia and are exacerbated by the rapidly expanding tidal flat destruction taking place in the critical Yellow Sea region. Thus, the problem appears to be "spreading", and theoretical predictions of population collapses are starting to be realised in this and other flyways (Stroud 2006).

Threats to waders have been repeatedly highlighted for nearly 20 years, starting with Mark Barter's report in *Stilt* 22 about the importance of population monitoring (Barter 1993). These threats, which include habitat loss (particularly at staging sites in the Yellow Sea) and pressure from hunting, continue to be emphasised time and again in research and reports on wader conservation from the EAAF (Straw 1997, Barter 2002, 2003, Lane 1987, IWSG 2003, Straw 2004, Bamford *et al.* 2008, Rogers *et al*. 2010). Local conservation issues have also featured more prominently in the wader literature in recent years, indicating that problems for migratory waders *en route* are being compounded by regional issues like modification to natural flow and flooding regimes (Gosbell & Greer 2004, Rogers *et al.* 2005, Nebel *et al*. 2008).

The next issue of Stilt will contain several more contributions relating to the theme "Waders in Decline". Further contributions are invited now for this upcoming issue, but must be received no later than March 1, 2012.

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Table 1. Summary of publications reporting declines in migratory waders in the East Asian – Australasian Flyway.

Year	Author(s)	Species*	Location	Site
1984	Close & Newman	Eastern Curlew	SA TAS	multiple
1992	Barter	Curlew Sandpiper Great Knot	VIC	Swan Bay
1998	Creed & Bailey	Bar-tailed Godwit Curlew Sandpiper Red-necked Stint	WA	Pelican Point
2001	Wilson	Curlew Sandpiper Eastern Curlew Pacific Golden Plover	VIC TAS VIC	multiple south-east multiple
2003	Reid & Park	Eastern Curlew	TAS	multiple
2006	Gosbell & Clemens	Curlew Sandpiper Eastern Curlew Red-necked Stint Sharp-tailed Sandpiper	NSW VIC TAS NSW VIC TAS NSW TAS SE AUS	multiple multiple multiple
2008	Close	Bar-tailed Godwit Black-tailed Godwit Curlew Sandpiper Grey Plover Grey-tailed Tattler Sharp-tailed Sandpiper	SA	Gulf St Vincent
2008	Nebel *et al.*	small shorebirds	MDB	
2009	Singor	Bar-tailed Godwit Curlew Sandpiper Great Knot Grey Plover Red Knot Red-necked Stint Sharp-tailed Sandpiper	WA	Alfred Cove, Swan River
2009	Creed & Bailey	Bar-tailed Godwit Curlew Sandpiper Grey Plover Red Knot Red-necked Stint	WA	Pelican Point
2010	Amano *et al*.	Bar-tailed Godwit Red Knot Ruddy Turnstone	Oceania	
2010	Rogers *et al*.	Red Knot	AUS & NZ	
2011	Wilson *et al.*	Common Greenshank Eastern Curlew Greater Sand Plover Great Knot Red Knot Ruddy Turnstone Whimbrel	QLD	Moreton Bay
2011	Hansen *et al.*	Curlew Sandpiper Eastern Curlew Grey-tailed Tattler Pacific Golden Plover	VIC	Western Port

* where multiple species' accounts are published, only those reported to have the substantial (or significant) declines are given here
MDB = Murray-Darling Basin

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THE DECLINING POPULATION OF CURLEW SANDPIPER *CALIDRIS FERRUGINEA* INDICATES THAT IT MAY NOW BE ENDANGERED IN NEW SOUTH WALES

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A detailed analysis was conducted of New South Wales (NSW) counts of Curlew Sandpiper *Calidris ferruginea* recorded between 1981 and 2010 at sites featured on the Shorebirds 2020 database. The distribution of Curlew Sandpiper during this period has not changed markedly, but the average maximum population during the 2001-10 decade was only 23 % of that in 1981-90. The Hunter Estuary remains the most important site in NSW for Curlew Sandpiper. Botany Bay and the Parramatta River, which supported 29 % of the NSW population of Curlew Sandpiper in 1981-90, now account for <2 % of the State population. Based both on the rate of decline in the overall abundance of this species from 1981-2010 and the estimated current number of mature individuals, Curlew Sandpiper fulfils the criteria for listing as Endangered in NSW and a preliminary determination by the NSW Scientific Committee has recommended its listing under the NSW Threatened Species Act (1995).

INTRODUCTION

The Curlew Sandpiper *Calidris ferruginea* breeds in the high arctic coastal tundra from Alaska to North-Eastern Siberia. During the non-breeding period it is widespread in Africa, and in Asia occurs along the coast from the Arabian Peninsula to China as well as in Australasia. Most birds that migrate to Australia travel south via an overland route across Siberia and China, then through India, Burma, Malaysia, Thailand and Indonesia in July and August, arriving in Australia from August to December. Many birds arrive first in north-western Australia, then move overland to the south and south-east. Adult birds start to leave in March, and most have gone by mid-April. First-year birds do not appear to migrate, though some do disperse to other sites, and it seems that winter counts can be used as an indication of the previous season's breeding success (Minton *et al*. 2005). In Australia the species mainly inhabits intertidal mudflats around the continent, as well as ponds at saltworks and sewage farms and less frequently on inland freshwater wetlands (Geering *et al.* 2007, Higgins & Davies 1996).

The global population of Curlew Sandpiper has been estimated at 1,800,000-1,900,000 (BirdLife International 2011). The extensive review by Bamford *et al.* (2008) of over 100,000 count records of shorebirds in the East Asian-Australasian Flyway, estimated the Flyway population of Curlew Sandpipers to be 180,000 and the Australian population to be 118,000; which represents 6.4 % of the global population and 66 % of the East Asian-Australasian Flyway population. In NSW the Curlew Sandpiper typically occurs on the coast but has also been recorded west of the Great Divide in the Riverina and South-West slopes, with occasional records from the Tablelands and scattered sightings in other parts of the State (Higgins & Davies 1996). The most important site for Curlew Sandpipers in NSW, and the only identified site of international significance for the species in NSW, is the Hunter River Estuary, where the maximum summer count recorded has 4,000 birds (Bamford *et al.* 2008).

Anecdotal reports from the birding community suggest that the number of Curlew Sandpiper in NSW has declined dramatically in recent years. This paper examines reported numbers of this species from 1981 to 2010 using counts recorded on the Shorebirds 2020 database, the most comprehensive dataset available for the analysis of shorebird populations in NSW during this period. Shorebirds 2020 (http://www.shorebirds.org.au) is a program designed to coordinate national shorebird monitoring in Australia in order to detect population trends nationally and at individual areas. It is a collaborative enterprise between Birds Australia, the Australasian Wader Studies Group, World Wildlife Fund-Australia and the Australian Government's Natural Heritage Trust.

METHODS

A detailed analysis was conducted of NSW counts of Curlew Sandpiper recorded between 1981 and 2010 at sites featured on the Shorebirds 2020 database, listed in Table 1. Mature and immature individuals were not differentiated in the counts. All NSW sites at which Curlew Sandpiper were present have been included in the analysis, except where no counts have been recorded since 2000 and recent populations could not therefore be determined. Statistical analyses were carried out manually from first principles (Griffiths *et al.*1998). A simple linear regression was used to determine the overall decline in maximum annual counts of the NSW population between 1982 and 2010 and the Fisher test to determine p-values.

RESULTS

During the period 1981 to 2010, Curlew Sandpiper were reported at the 22 sites in NSW listed (Table 1). In addition, the species was recorded at Parkes Sewage Works (maximum count 6 birds) and an unidentified Riverine wetland (maximum count 58). Maximum state-wide numbers, calculated as the sum of the maximum count at each site, were regularly >1,500 birds until 1997-98 (Figure 1). Since that time there has been only one instance (2002-03) of a maximum state-wide count exceeding 1,000 birds. The trend towards declining numbers of Curlew Sandpiper in NSW from 1998 onwards continued in 2000-10; despite extensive and intensive surveys, the maximum summer count since 2005-06 has been <400 birds. There was no significant difference (P=0.6) between maximum counts for

Table 1. Locations of 22 Shorebird 2020 sites at which Curlew Sandpiper have been reported in NSW, and maximum counts recorded at each site.

Shorebird area	Latitude*	Longitude*	Coastal/ Inland	Max count	Year of max count
Barren Box Swamp	34° 15' S	145° 25' E	Inland	45	2008-09
Botany Bay	34° 00' S	151° 10' E	Coastal	610	1984-85
Clarence River	29° 28' S	153° 20' E	Coastal	193	1994-95
Fivebough Swamp	34°30' S	146°25' E	Inland	13	1986-87
Fletcher's Lake^	34° 00' S	142° 00' E	Inland	670	1983-84
Hastings River	31° 25' S	152° 50' E	Coastal	2	1994-95
Hunter Estuary	32° 45' S	151° 40' E	Coastal	2,600	1995-96
Lake Bathurst^	35° 00' S	149° 40' E	Inland	450	1983-84
Lake Illawarra	34° 30' S	150° 50' E	Coastal	78	1983-84
Lake Macquarie Entrance	33° 05' S	151° 40' E	Coastal	146	1984-85
Manning River Estuary	31° 50' S	152° 40' E	Coastal	2	1983-84
Lowbidgee Floodplain^	34° 35' S	144° 00' E	Inland	35	1996-97
Moruya Estuary^	35° 55' S	150° 10' E	Coastal	4	1993-94
Nericon Swamp^	34° 15' S	146° 00' E	Inland	7	1987-88
Parramatta River	33° 50' S	151° 00' E	Coastal	860	1983-84 1985-86
Port Stephens	32° 40' S	152° 10' E	Coastal	30	1981-82
Richmond River Estuary	28° 55' S	153° 30' E	Coastal	247	1994-95
Shoalhaven Estuary	34° 50' S	150° 40' E	Coastal	77	2006-07
Tuggerah Lakes	33° 20' S	151° 25' E	Coastal	1,315	1991-92
Tullakool Saltworks	35° 20' S	144° 10' E	Inland	400	1995-96
Tweed Estuary	28° 10' S	153° 30' E	Coastal	122	1997-98
Yantara Lake^	29° 53' S	142° 17' E	Inland	47	1984-85

*Given to the nearest 5'.

^ Omitted from the analysis (no counts since 2000).

the first (1981/82-1990/91) and second decades (1991/92-2000/01), but maximum numbers for 2001/2 to 2009/10 were highly significantly lower ($P<0.001$) than in either of the preceding two decades. Linear regression analysis of these data indicates that there has been a 94% decline in maximum annual counts of the NSW population of Curlew Sandpiper between 1982 and 2010 ($r^2 = 0.35$). However, the distribution of Curlew Sandpiper during this period has apparently not been greatly affected (data not shown).

For 21 of the 30 years for which counts were analysed, the Hunter Estuary, Parramatta River and Botany Bay together supported >80% of the Curlew Sandpipers recorded in NSW. The importance of the Hunter Estuary as the main site in NSW for this species has not changed over this period. In contrast, the Parramatta River and Botany Bay together supported an average of 29 % of the State's Curlew Sandpiper in 1981-90, but in the 2001-10 period only 6 % of birds were found in these areas.

Figure 2 shows the 10 year mean of the maximum count in NSW and in three sites at which the Curlew Sandpiper has been found in greatest numbers, as a percentage of the mean maximum count from 1981-1990. In the 10 years from 1991 to 2000, the mean maximum count of Curlew Sandpiper in NSW fell by 39 % compared to the mean maximum count for 1981 - 1990. In the 2001-10 period, the mean maximum count was 62 % less than the numbers recorded in 1991-

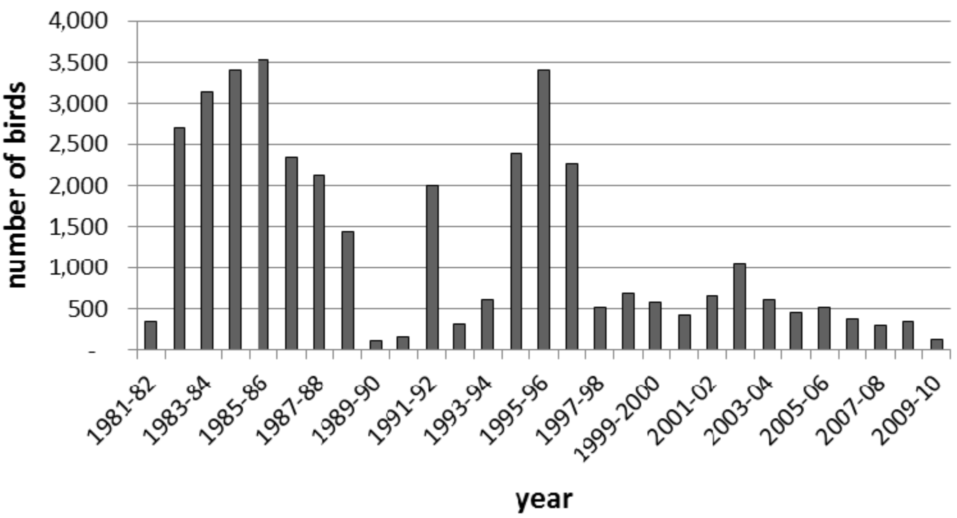

Figure 1. Maximum counts for Curlew Sandpiper in NSW (1981-2010).

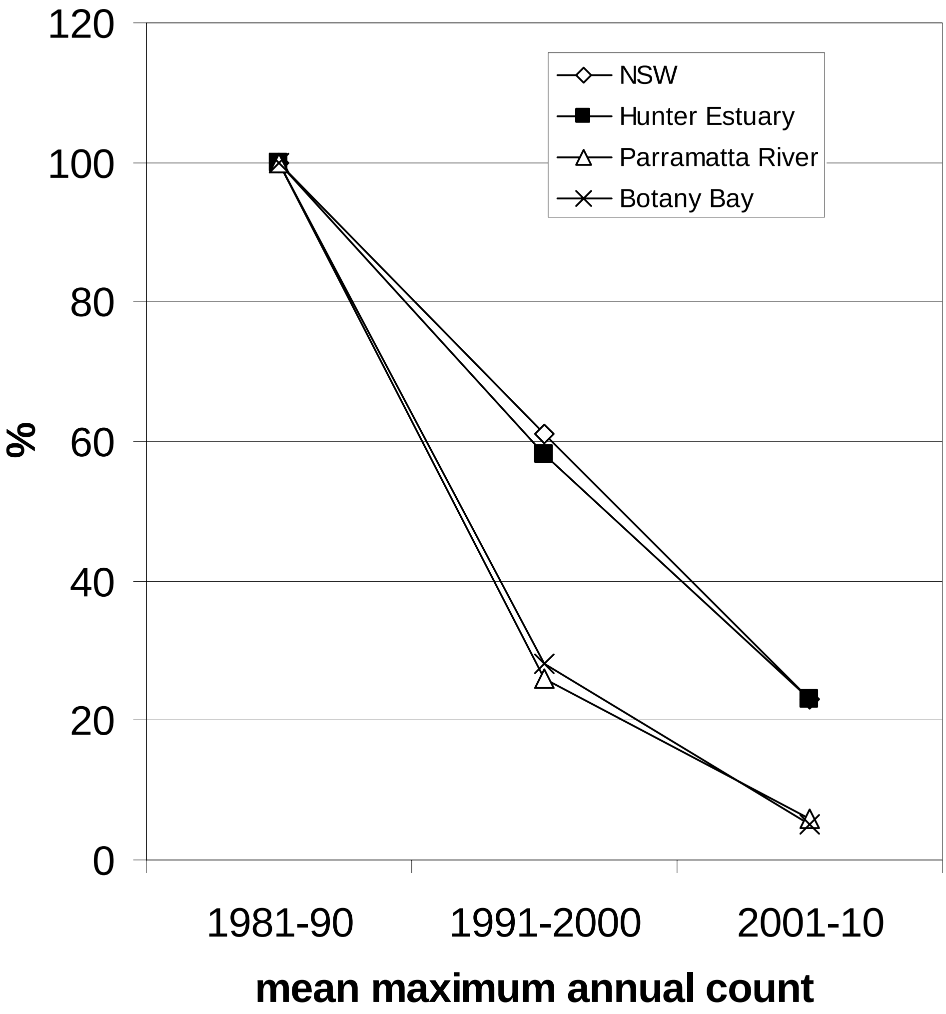

Figure 2. Curlew Sandpiper counts in NSW and major NSW habitats (% of mean maximum count 1981-90).

2000, and 77 % less than counts in 1981-90. Comparing the mean maximum count for each 10 year period against the previous period reduces the "noise" created by variability in annual counts. Linear regression of this data set gives $r^2 >$ 0.99. The decline of the Curlew Sandpiper population in the Hunter Estuary reflected the pattern of decline observed in NSW as a whole. In the Parramatta River and Botany Bay however, a much greater decline was observed, with numbers recorded in 2001-10 being only 6% and 5%, respectively of counts observed in 1981-90. This represented <2 % of the NSW population of Curlew Sandpipers.

DISCUSSION

The Curlew Sandpiper is listed as of Least Concern by the IUCN on a global scale, as it has an extremely large range and population, and there is no current evidence of a population decline (BirdLife International 2011). In sharp contrast to reported global data, there is strong evidence of a national population decline in the number of Curlew Sandpiper in Australia, where counts have fallen sharply in recent years (Olsen & Weston 2004, Olsen 2008). There was a 26 % decline in the reporting rate of the species to the New Atlas of Australian Birds (1998-2002) compared with the Atlas of Australian Birds (1977-1981) (Barrett *et al*. 2003). However, the geographical distribution of the Curlew Sandpiper did not change significantly over this period. In 2006 a review of the Australasian Wader Studies Group's Population Monitoring Programme indicated that between 1980 and 2005 there was a clear declining trend in the national Curlew Sandpiper population (Gosbell & Clemens 2006). This was evident no matter how the data were examined, and there were declines at all 11 sites tested (Gosbell & Clemens 2006). When in 2009 the 49 sites with the best data recorded in the National Shorebird Database were analysed, it was found that the average number of this species in 1981-85 was 74,327 and in 2005-09 had dropped to 13,432, a highly significant decline of 82% (Rob Clemens, *pers. comm.*).

In NSW, Gosbell and Clemens (2006) found that there were significant average declines of 3-4% per annum in Curlew Sandpiper abundance at all three sites examined. In the Botany Bay, Parramatta River and Shoalhaven River regions, declines were highly significant (Gosbell & Clemens 2006). A significant decline in the numbers of Curlew Sandpiper between 1987 and 2003 has also been reported in the Tweed Estuary (Rohweder 2007).

The present analysis confirms a major and continuing decline in the population of Curlew Sandpiper in NSW since 1981. Such a decline is probably the result of a combination of factors. First, Curlew Sandpipers experienced a succession of very poor breeding seasons in the Arctic in the decade preceding 2002 (Minton *et al.* 2010). In the last 12 years, however, their breeding success seems to have fluctuated between particularly good and particularly bad years (Minton *et al.* 2010). In 2001-02, 2005-06 and 2009-10 juveniles made up 27% of the Curlew Sandpiper counted in south-east Australia, and in 2007-08 it was 33%. This measure of breeding success averaged 16.8% over the period (Minton *et al.* 2010). Prospects of improved breeding success appear poor as two different models predict a 40-70% loss of breeding area habitat across the entire breeding range for the species by the end of this century (Callaghan *et al.* 2010).

Secondly, this species is thought to have lost vital intertidal habitats necessary for successful migration along the East Asian-Australasian Flyway, particularly through the reclamation, pollution and environmental destruction of inter-tidal mudflats in its staging areas. In Bohai Bay, China, one third of the original tidal area has been reclaimed and northward migrants have become concentrated in an ever smaller remaining area. The spring peak numbers of Curlew Sandpiper at this site have increased from 3% of the Flyway population in 2007 to 23% in 2010 (Yang *et al*. 2011).

Thirdly, in Australia, and particularly in states such as NSW with a high and increasing coastal human population, migratory shorebird habitat is threatened by extensive coastal development including drainage of preferred littoral and estuarine habitats. The removal and fragmentation of habitat and the associated increased disturbance of both feeding and roosting sites as a result of the presence of walkers, dogs and other recreational activity are likely to be a major cause for the decline of this species in Australia (Milton & Harding, this volume).

The results of this analysis were submitted to the NSW Scientific Committee in an application to list the Curlew Sandpiper as Endangered in NSW, under the NSW Threatened Species Conservation Act 1995 and Threatened Species Conservation Regulation 2002 Clause 16 which states that: (b) *the estimated total number of mature individuals of the species is low*, and (d) (i) *a continuing decline is observed in an index of abundance appropriate to the taxon.*

The analysis reported here shows that the Curlew Sandpiper meets both of the above criteria for being considered endangered in NSW. Since 1997-98 the total number of Curlew Sandpipers counted in NSW has been much less than 2500, the number at which a species is considered Endangered.

Reductions in population size must be assessed over a time frame appropriate to the life cycle of the species, which is currently regarded as three generation lengths or 10 years, whichever is the longer (IUCN 2001). Generation length is defined as the average age of parents of the current cohort (NSW Scientific Committee 2010). It is difficult to calculate the generation length of the Curlew Sandpiper without published data on typical lifespan or the survival of juveniles or adults, though some analysis indicates that adult survival rates are probably in the 75-80 % range (Clive Minton, *pers. comm.*). Curlew Sandpiper first breed at two years old, and the oldest recorded bird is 19 years old though very few will survive to this age (Australian Bird and Bat Banding Scheme (http://www.environment.gov.au/cgi-bin/biodiversity/abbbs, accessed September 2011). The mean elapsed time of recovery of 5,544 individuals recorded in the Australian Bird and Bat Banding Scheme is 32.3 months, but as many of these birds are banded as adults the generation length will be greater than this. The best estimate available is derived from data from 30 years of catching Curlew Sandpiper in south-east and north-west Australia. These indicate that the average age of recapture is three to five years (Clive Minton, *pers. comm.*), and the generation length of the Curlew Sandpiper is probably similar. The appropriate time period over which to assess a reduction in population is therefore nine to 15 years (three generation lengths). Given the uncertainties involved in this calculation, the alternative of 10 years, which falls within this time frame, was used here. In the 10 years from 2001-2010 the mean maximum count of Curlew Sandpiper fell by >50%, meeting the threshold under Criterion 3 for classification as Endangered.

The NSW Scientific Committee has now made a Preliminary Determination to support this proposal to list the Curlew Sandpiper *Calidris ferruginea* as an Endangered Species in NSW (NSW Office of Environment and Heritage, http://www.environment.nsw.gov.au/determinations/curlewsandpiperPD.htm, accessed 17 June 2011).

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SHOREBIRD SURVEYS AT PORT STEPHENS, NEW SOUTH WALES, 2004–2011 AND COMPARISONS WITH RESULTS FROM PREVIOUS SURVEYS

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Twenty-one shorebird species have been recorded in regular surveys at Port Stephens over 2004–2011, with mean counts of 1564 birds present in summer and 650 birds in winter. When compared with survey results from 20-30 years previously, Port Stephens was shown to be an internationally important site for Eastern Curlew *Numenius madagascariensis* for at least three decades. However, there has been at least a 32% decline in the numbers of Eastern Curlew over that time. The numbers of most small and medium sized shorebirds have also declined substantially. Sandpiper numbers collectively are 88% lower than were recorded in the 1980's. The Sharp-tailed Sandpiper *Calidris acuminata* is now rare and the Curlew Sandpiper *Calidris ferruginea* has not been recorded in eight years of summer surveys. There have also been large percentage decreases in the counts of species such as Red-necked Stint *Calidris ruficollis*, Lesser Sand Plover *Charadrius mongolus*, Pacific Golden Plover *Pluvialis fulva*, Double-banded Plover *Charadrius bicinctus* and Red-capped Plover *Charadrius ruficapillus*, which previously were all present in moderate numbers. Many other small and medium sized shorebirds that used to occur in Port Stephens in small numbers have not been recorded at all during the 2004-2011 surveys. A few shorebird species have increased in numbers, in particular Australian Pied Oystercatcher *Haematopus longirostris*, Sooty Oystercatcher *Haematopus fuliginosus*, Bar-tailed Godwit *Limosa lapponica* and Whimbrel *Numenius phaeopus*. The 2004-2011 surveys have established that Port Stephens is an internationally important site for Australian Pied Oystercatcher.

INTRODUCTION

Although Bamford *et al.* (2008) recognised Port Stephens as a site of international importance for Eastern Curlew *Numenius madagascariensis*, the value of Port Stephens (Figure 1) for shorebirds in New South Wales is sometimes over-looked. Port Stephens, situated approximately 200 km north of Sydney, is a popular tourist and recreational area and the south-eastern section in particular has undergone substantial development while the north-eastern part has also seen considerable growth in holiday and retirement housing. However, there are many areas of Port Stephens which remain relatively undisturbed and have suitable habitat for shorebirds. The Port Stephens environs include two reserves – Gir-um-bit National Park (32° 42', 151° 58', formerly known as Worimi Nature Reserve) and Corrie Island Nature Reserve (32° 40', 152° 08'). All of the Port Stephens waters, to the high tide shoreline, are part of the Port Stephens-Great Lakes Marine Park; this includes some small islands and sand banks exposed at low tide and used by waders for roosting or foraging.

During 1982-1984, as part of national shorebirds surveys conducted by the Australasian Wader Studies Group (AWSG), summer and winter surveys were carried out at the known land-accessible roost sites in Port Stephens. Some of the now-known roost sites (for example, Corrie Island NR, and oyster beds located off Swan Bay) are not readily accessible by land and were not surveyed. The three AWSG summer surveys revealed 707 to 1700+ birds, and the winter surveys 339 to 450 birds (Stuart 2005). The variability in the

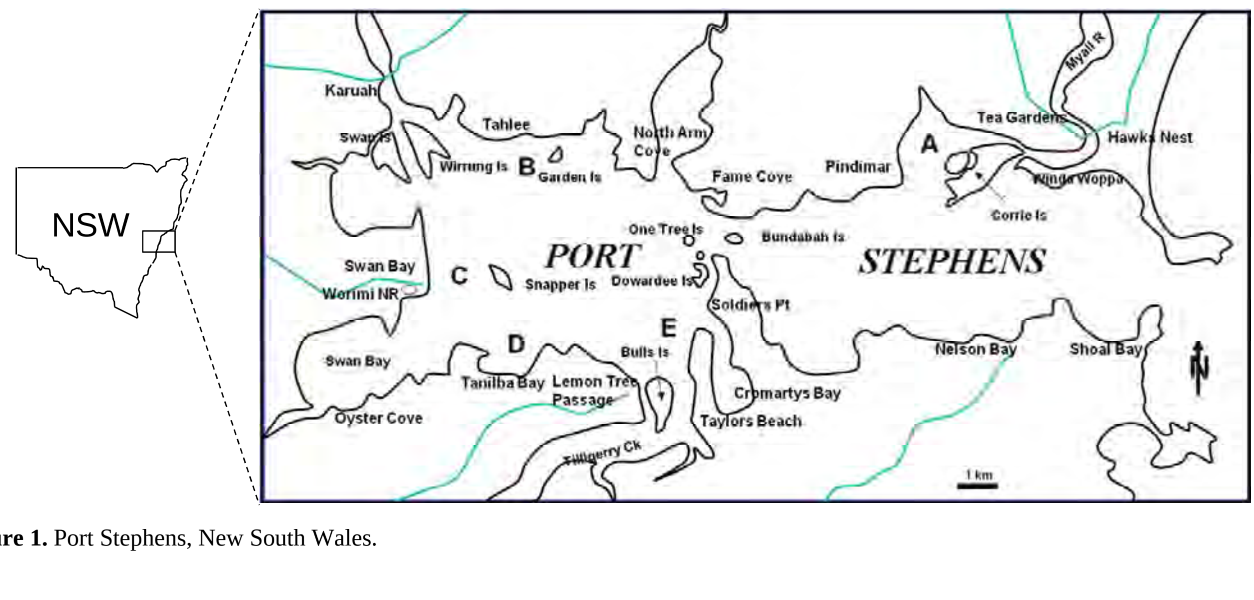

Figure 1. Port Stephens, New South Wales.

counts especially for the summer surveys was probably due to the incompleteness of coverage of all potential Port Stephens habitat; in particular, fewer sites were visited in 1983-84 compared to 1982 (Stuart 2004).

Lane (1987) analysed the AWSG data and other available records and rated Port Stephens as a top 20 site in Australia for four species – Pacific Golden Plover *Pluvialis fulva*, Lesser Sand Plover *Charadrius mongolus,* Whimbrel *Numenius phaeopus* and Eastern Curlew. That is, for those four species, the peak count was amongst the 20 largest peak counts for the species across all sites for which data were available in 1987.

Smith (1991) extended the AWSG data with later records of *ad hoc* observations by visitors to Port Stephens. He ranked Port Stephens as a Priority 2 site for shorebirds in NSW based on the high counts of Whimbrel, Eastern Curlew and Pacific Golden Plover, all of which were present there at greater than 1% of their then-estimated Australian population (Smith 1991). Smith's criteria for evaluating the sites was different from that now used whereby the population in the Flyway is taken into account, not simply the Australian population (Bamford *et al.* 2008).

Between 1985 and 2003, our knowledge about shorebirds in Port Stephens came solely from opportunistic observations (as published, for example, in the annual bird reports for the Hunter Region and for NSW). Those reports suggested that Port Stephens had remained an important shorebird site in NSW; however, the absence of any ongoing systematic surveying made it difficult to support such a conclusion. The aim of this study is to provide a revised estimate of the Port Stephens shorebird population and to document major trends in key shorebird species.

METHODS

In February 2004, annual boat-based summer surveys of Port Stephens commenced. Similar winter surveys commenced from July 2008. The surveys involved volunteers from Hunter Bird Observers Club (HBOC) and are organised jointly with NSW National Parks and Wildlife Service. The general methodology for the surveys has been described previously (Stuart 2005); in essence, five teams in boats simultaneously survey sub-areas of Port Stephens at high tide, recording the numbers of all shorebirds and any other waterbirds seen. In recent years, a supplementary shallow-drafted support vessel has been used to allow sufficiently close approach to the area around Winda Woppa Point (Figure 1) where small shorebirds sometimes roost in the dunes. The south-eastern section of the Port Stephens coastline is heavily disturbed (from leisure and tourism activities and the associated infrastructure) and is not surveyed.

RESULTS & DISCUSSION

Twenty-one shorebird species have been recorded in Port Stephens in the boat-based surveys from 2004 (21 species in the summer surveys, average total of 1564 birds; 11 species in the winter surveys, average total of 650 birds). The results are summarised in Table 1. With the exception of the March 2005 survey, the summer counts have been reasonably consistent and they align with the best result from the AWSG surveys, when around 1700 birds were recorded (in 1982). The three winter counts have produced much greater totals (nearly double) than were achieved in the AWSG surveys in the 1980s. This change in winter numbers reflects an increase in the numbers of four species and a marked decline in the numbers of almost all other species.

Four species – the Australian Pied Oystercatcher *Haematopus longirostris*, Bar-tailed Godwit *Limosa lapponica*, Eastern Curlew, and Whimbrel – have been recorded in counts of >100 birds in most summer surveys.

Table 1. Details of annual shorebird counts in Port Stephens, 2004-2011.

	Summer surveys										Winter surveys					
	'04	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**Mean**	**SD**	**'08**	**'09**	**'10**	**'11**	**Mean**	**SD**
Beach Stone-curlew			1											2		
Australian Pied Oystercatcher	112	30	77	108	107	134	144	166	110	42	154	122	148	142	141	14
Sooty Oystercatcher	18	5	9	11	10	13	19	19	13	5	14	9	24	15	15	6
Pacific Golden Plover			38			28	7	23	12	15						
Grey Plover			1													
Red-capped Plover			26	41	10	37	20		17	17		3	3	5	2.8	2.1
Double-banded Plover			15				1		2	5				35	9	17
Lesser Sand Plover	5	4		3	2	1			2	2						
Masked Lapwing	33	15	11	50	46	29	24	54	33	16	23	16	51	22	28	16
Black-tailed Godwit	51			1		6			7	18						
Bar-tailed Godwit	888	268	515	809	886	641	876	511	674	229	354	340	424	227	336	82
Whimbrel	218	248	424	215	261	40	271	240	239	104	10	24	27	36	24	11
Eastern Curlew	649	80	303	329	320	551	376	342	369	171	52	223	14	36	81	96
Terek Sandpiper	6		4	6	5		2	1	3	3	11			1	3	5
Common Sandpiper	1		1		1		1		1	1						
Grey-tailed Tattler	44	9	32	100	37	18	22	51	39	28	1	1	7	23	8	10
Common Greenshank		8	15	13	5	13		2	7	6						
Ruddy Turnstone	8	20	9	5	5	2	5		7	6						
Red Knot							1									
Red-necked Stint	20	2	6	59	0	41	43	22	24	22						
Sharp-tailed Sandpiper			40						5	14						
Total number of birds	2053	689	1527	1750	1695	1554	1812	1431			619	738	701	544		
Number of species	13	11	18	14	13	14	15	15			8	8	6	11		
Seasonal mean									1564	403					650	86

For all other species, the counts have been much smaller and several species have not been recorded every year. Individual species accounts are provided below.

Australian Pied Oystercatcher *Haematopus longirostris*

Port Stephens has emerged as the stronghold for Australian Pied Oystercatcher in NSW. In 10 of the 12 surveys, >100 birds have been present (Table 1) and the low count of just 30 birds in March 2005 was from a survey that produced anomalous results for almost all species. The average numbers are 110 birds in summer and 142 birds in winter. These represent 1-1.5% of the estimated 11,000 Australian population and >40% of the previously estimated NSW population (Watkins 1993, Owner & Rowheder 2003) although the present NSW population is probably larger than those earlier estimates (Stuart 2010).

These results were unexpected. Although Lane (1987) and Smith (1991) noted that there had been peak counts of 60-63 birds in the 1980s, the species was only recorded once in the AWSG surveys – four birds at Taylors Beach in July 1982. Opportunistic records from the intervening period are scant and there are only two known records of 10 or more birds – 18 birds were recorded at Corrie Island in August 2001 and 10 birds at Oyster Cove in 1998 (Stuart 2004). The AWSG surveys did not include Corrie Island and Winda Woppa Point, two important roost sites recently identified for Australian Pied Oystercatcher. Several other of the now known roost sites are not fully accessible from land and probably were not surveyed comprehensively in the 1980s. High numbers of Australian Pied Oystercatcher might always have been present in Port Stephens but this cannot be confirmed. Alternatively, high numbers might be a recent phenomenon. Their numbers are known to be increasing at other sites, for example in Sydney (P. Straw *pers. comm.*) and this might be indicative of a broader trend.

There is only one known breeding record from Port Stephens, at Orobillah Island about 10 years ago (G. Little *pers. comm.*), and there are very few suitable locations for pairs to establish breeding territories (M. Newman *pers. comm.*). Thus, it may be that most of the birds that are recorded in Port Stephens are from breeding sites elsewhere and that they only spend some of their life cycle in Port Stephens. Given that the species is classified as Endangered in NSW under the Threatened Species Conservation Act 1995 (NSW Scientific Committee 2010), it seems important to gain better understandings about this.

Bar-tailed Godwit *Limosa lapponica*

Eight hundred to nine hundred birds have been recorded several times in the summer surveys since 2004, and with >500 birds present most years (Table 1). These counts represent >0.5% of the sub-species *baueri* population that visits Australia (Bamford *et al.* 2008). As there were >600 birds present in the 1982 AWSG survey (Table 2), it seems probable that Port Stephens has supported good numbers of Bar-tailed Godwit for at least three decades.

The winter surveys have yielded an average of 336 birds – much greater counts than the ~150 birds that were recorded in the 1980's (Smith 1991) and rather higher than the corresponding winter counts in the Hunter Estuary (for example see Table 3). Thus, Port Stephens has emerged as the most important site in NSW nowadays for over-wintering Bar-tailed Godwits.

Eastern Curlew *Numenius madagascariensis*

The first summer boat-based survey produced the second-highest known count for Eastern Curlew in Port Stephens, after the count of 960 birds in 1982 (Smith 1991). The 649 birds recorded in 2004 (Table 1) were 1.7% of the Flyway population and Port Stephens very clearly is an internationally important location for Eastern Curlew. The post-2004 summer counts have mostly been 350±25 birds, but with a much larger count (551 birds; 1.45% of the Flyway population) in February 2009 and a very low count (80 birds) in March 2005.

Although only modest numbers have been present in three of the four winter surveys, there were 223 birds present in July 2009. The 1983 and 1984 AWSG surveys also recorded 105 and 152 over-wintering birds, respectively. These results suggest that Port Stephens has been an important NSW site for over-wintering Eastern Curlews for at least three decades.

Whimbrel *Numenius phaeopus*

Two hundred and twenty birds on average have been present in the summer surveys, with the peak count 424 birds in February 2006 (Table 1). However, the very low count of just 40 birds in February 2009 suggests that in some years the conditions in Port Stephens are less favourable for Whimbrel. Only small numbers of birds over-winter (Table 1).

Sooty Oystercatcher *Haematopus fuliginosus*

Small numbers occur regularly, with a peak count of 24 birds in July 2010. Although some young birds are usually present, there are no known breeding records. As for the Australian Pied Oystercatcher, there seem to be very few suitable locations for pairs to establish breeding territories (M. Newman *pers. comm.*) and it may be that the birds in Port Stephens are from breeding sites elsewhere and that

Table 2. Comparison of 1982 and 2004-11 summer surveys

Species	1982	2004-11 mean (SD)
Australian Pied Oystercatcher	0	110 (42)
Sooty Oystercatcher	0	13 (5)
Black-winged Stilt	4	0
Red-capped Plover	70+	17 (17)
Lesser Sand Plover	0	2 (2)
Masked Lapwing	16	33 (16)
Black-tailed Godwit	0	7 (18)
Bar-tailed Godwit	600+	674 (229)
Whimbrel	27	239 (104)
Eastern Curlew	800+	369 (171)
Terek Sandpiper	0	3 (3)
Common Sandpiper	0	1 (1)
Grey-tailed Tattler	21	39 (28)
Ruddy Turnstone	0	7 (6)
Red-necked Stint	150+	24 (22)
Sharp-tailed Sandpiper	42	5 (14)
Curlew Sandpiper	30	0

Table 3. Comparisons of mean counts at Port Stephens and the Hunter Estuary during February and July, for the main species occuring in Port Stephens.

Species	Feb 2004-11		July 2008-11	
	Port St	Hunter	Port St	Hunter
Australian Pied Oystercatcher	110	8	142	11
Sooty Oystercatcher	13	5	15	7
Pacific Golden Plover	12	163	0	0
Bar-tailed Godwit	674	977	336	228
Whimbrel	240	31	24	10
Eastern Curlew	369	397	81	53
Grey-tailed Tattler	39	13	8	0

they only spend some of their life cycle in Port Stephens.

Grey-tailed Tattler *Tringa brevipes*

Although the peak count from the surveys is 100 birds in February 2007, the numbers have varied considerably (mean of 39 birds, standard deviation 28; see Table 1). Due to the roosting preference for mangrove areas, the counts may be under-estimates. For example, in December 2004, the western side of Pindimar Bay was surveyed by foot and 75+ birds were recorded in that limited area – a higher number than the counts for all of Port Stephens in February 2004 and March 2005.

Pacific Golden Plover *Pluvialis fulva*

Birds have only been recorded in half of the summer surveys (and no winter surveys). However, birds have now been present each summer over 2009-2011 and perhaps a modest recovery is underway. The peak count of 38 birds in February 2006 is a 50% decline in the previous peak count (Table 4). Although Lane (1987) rated Port Stephens in the top 20 of sites in Australia for Pacific Golden Plover, his conclusion can no longer be considered valid.

Other shorebirds

A feature of the 2004-2011 surveys is the general absence or low counts of small and medium sized shorebirds. Red-necked Stint *Calidris ruficollis*, Common Greenshank *Tringa nebularia*, Lesser Sand Plover and Red-capped Plovers *Charadrius ruficapillus* have been present most summers but in low to modest numbers (Table 1). All other species have only been recorded intermittently. These results are discussed in more detail in a later section, where the counts are compared with those from the 1980's.

Limitations of surveys

The boat-based methodology used since 2004 means that all potential roost sites are surveyed, and therefore the overall counts provide a more accurate estimate of the Port Stephens shorebird population than the land-based surveys of the 1980s. However, the numbers of Whimbrel, Grey-tailed Tattler *Tringa brevipes* and Terek Sandpiper *Xenus cinereus* are potentially under-estimated by both methodologies. This is because these species are known to sometimes roost in areas which are less accessible, such as in mangroves or at rocky shorelines. For example, far greater counts of Grey-tailed Tattler were found foraging and roosting in the mangrove fringed northern shores in January 1980 than ever were recorded in any of the formal AWSG surveys (Pegler 1982).

It is not clear why the March 2005 survey yielded such low counts compared to all other summer surveys. Although there were some operational issues, about 70% of the targeted area was surveyed. Two hundred and forty-eight Whimbrel were recorded which was about average (Table 1), but all the other shorebirds which are present in good numbers most years had March 2005 counts which were only 20-40% of their average for 2004-2011. At the time of the March 2005 survey, migratory shorebirds had not departed from the Hunter Estuary which is only ~50km to the south; the counts for the Hunter Estuary for February and March 2005 were essentially unchanged (HBOC unpublished results). The Port Stephens survey took place just one day after the March Hunter Estuary survey, and therefore it seems unlikely that there had been a significant departure of migratory shorebirds from Port Stephens. All waterbird numbers, not just shorebirds, were substantially lower in the three sub-sections that were surveyed normally. It may have been the case that foraging and/or roosting conditions were unsuitable in Port Stephens in March 2005. This is partially confirmed by counts of Australian Pied Oystercatcher further north, at Forster/Tuncurry and Manning Estuary, were unusually high in that month (Stuart 2010).

Comparisons with the Hunter Estuary

Smith (1991) recognised the Hunter Estuary as the premier

Table 4. Percentage change in peak counts for some Port Stephens shorebirds. 1980's peak counts are from those reported in 1982-84 AWSG surveys and additional data presented by Lane (1987) and Smith (1991)

Species	Change since the 1980's
Australian Pied Oystercatcher	+163%
Sooty Oystercatcher	+500%
Pacific Golden Plover	-50%
Bar-tailed Godwit	+48%
Whimbrel	+63%
Eastern Curlew	-32%
Grey-tailed Tattler	-59%
Pacific Golden Plover	-50%
Ruddy Turnstone	+400%
Sandpipers	-88%
Stint, small plovers	-69%
Other medium/small waders	-74%

site in NSW for shorebirds and this undoubtedly remains the case based on the total numbers of shorebirds that are recorded there. Most summer counts for the Hunter Estuary are of many thousands of birds (HBOC unpublished results). However, it is interesting to compare the situations at the two sites for shorebirds which are common in Port Stephens. Table 3 shows the average counts for those seven species for the February surveys at both locations over 2004-2011, and for the July counts for 2008-2011. In summer, Port Stephens is far more important for Australian Pied Oystercatcher and Whimbrel than is the Hunter Estuary, and about as important for Bar-tailed Godwit and Eastern Curlew. In winter, it remains far more important for Australian Pied Oystercatcher and also hosts a considerably greater number of over-wintering Bar-tailed Godwit.

Comparisons with earlier records

Lane (1987) and Smith (1991) both summarised the available shorebird count data for Port Stephens. Their peak counts for each species are shown in Table 5, with the peak count for 2004-2011 also presented. It should be pointed out that both Lane and Smith did not take into account some of the results from the February 1982 AWSG survey. That survey recorded 600+ Bar-tailed Godwit and 150+ Red-necked Stint (Stuart 2004). Smith and Lane both cited lower peak counts for these two species for the period covered in their reviews. There has been a decline in Eastern Curlew numbers, with the 2004-2011 peak count of 649 birds in this study being much lower than the peak count of 960 birds reported by Smith (1991) (Table 5). The comparison presented in Table 5 also highlights the decline in numbers of many small and medium sized shorebirds in Port Stephens. For example, the Sharp-tailed Sandpiper *Calidris acuminata* had a peak count of just 40 birds in the 2004-2011 surveys and the Curlew Sandpiper *Calidris ferruginea* was not recorded at all in those surveys. There were also substantial decreases in the peak counts of species such as Red-necked Stint, Lesser Sand Plover, Pacific Golden Plover, Double-banded Plover *Charadrius bicinctus* and Red-capped Plover which previously all were present in moderate numbers. Many other small and medium sized shorebirds that used to occur in Port Stephens in small numbers have not been recorded at all during the 2004-2011 surveys. Only a few shorebird species have increased in numbers; most notably Australian Pied Oystercatcher, Sooty Oystercatcher, Bar-tailed Godwit and Whimbrel.

The use of peak counts for comparisons between two sets of surveys potentially could mislead since they do not necessarily indicate the typical situation, but instead the extreme. For this reason, it is interesting to also compare the results from the 1982 AWSG survey with the averaged results from the 2004-2011 surveys (see Table 2). Since more Port Stephens sites were visited in 1982 than was the case in the 1983-84 AWSG surveys, the 1982 survey is a more relevant benchmark (but noting that the land based survey could not cover all of the now known roost sites). In Table 2, the decline in numbers of many small and medium sized shorebirds in Port Stephens is very clear: for example, Red-necked Stint, Red-capped Plover and Sharp-tailed Sandpiper are now uncommon and Curlew Sandpiper has not been recorded in any of the 2004-2011 surveys. In contrast, the numbers for Whimbrel and Australian Pied Oystercatcher are much higher. It is not clear though whether this is because of an actual increase in their local populations or because of the more effective survey methodology which is now being used.

Results presented in Figures 2 and 3 highlight the decline that has occurred in the numbers of small and medium sized shorebirds. Figure 2 compares the peak counts for large shorebirds for the two periods (the Figure uses the count data from Smith (1991), but also includes the higher 1982 AWSG peak count for Bar-tailed Godwit). The peak counts for both godwit species and Whimbrel are higher now, but there has been a 32% decrease in the peak count for Eastern Curlew. It is possible that the counts for the other species are higher because of the more comprehensive survey method; for the same reason, the decrease in Eastern Curlew numbers may be larger than the available data indicate. Figure 3 shows the corresponding situation for small and medium sized waders. To simplify the analysis, all of the sandpiper species (Terek, Sharp-tailed, Curlew, Common *Actitis hypoleucos*, Pectoral *Calidris melanotos* and Wood *Tringa glareola*) have been grouped together, as have Red-necked Stint and the small plovers (Red-capped, Double-banded, both Sand Plovers) and then all the other waders are grouped (for example, Black-fronted *Elseyornis melanops* and Red-kneed Dotterel *Erythrogonys cinctus*, Common Greenshank). The changes

Table 5. Comparisons of 2004-2011 peak counts with previously published peak counts (Lane 1987, Smith 1991).

Species	Lane	Smith	2004-11
Beach Stone-curlew	0	0	2
Australian Pied Oystercatcher	60	63	166
Sooty Oystercatcher	4	4	24
Black-winged Stilt	16	16	0
Red-necked Avocet	0	1	0
Pacific Golden Plover	70	76	38
Grey Plover	0	1	1
Red-capped Plover	60	120	41
Double-banded Plover	50	69	35
Lesser Sand Plover	40	101	5
Greater Sand Plover	0	6	0
Masked Lapwing	*	27	54
Black-tailed Godwit	0	1	51
Bar-tailed Godwit	370	370	888
Whimbrel	30	260	424
Eastern Curlew	530	960	649
Terek Sandpiper	0	2	11
Common Sandpiper	0	2	1
Grey-tailed Tattler	70	245	100
Common Greenshank	14	14	15
Marsh Sandpiper	1	1	0
Ruddy Turnstone	2	4	20
Red Knot	0	3	1
Red-necked Stint	110	116	59
Sanderling	0	1	0
Sharp-tailed Sandpiper	260	406	40
Pectoral Sandpiper	0	1	0
Wood Sandpiper	0	1	0
Curlew Sandpiper	30	30	0
Red-kneed Dotterel	15	15	0
Black-fronted Dotterel	14	14	0

* Masked Lapwing was not reviewed by Lane

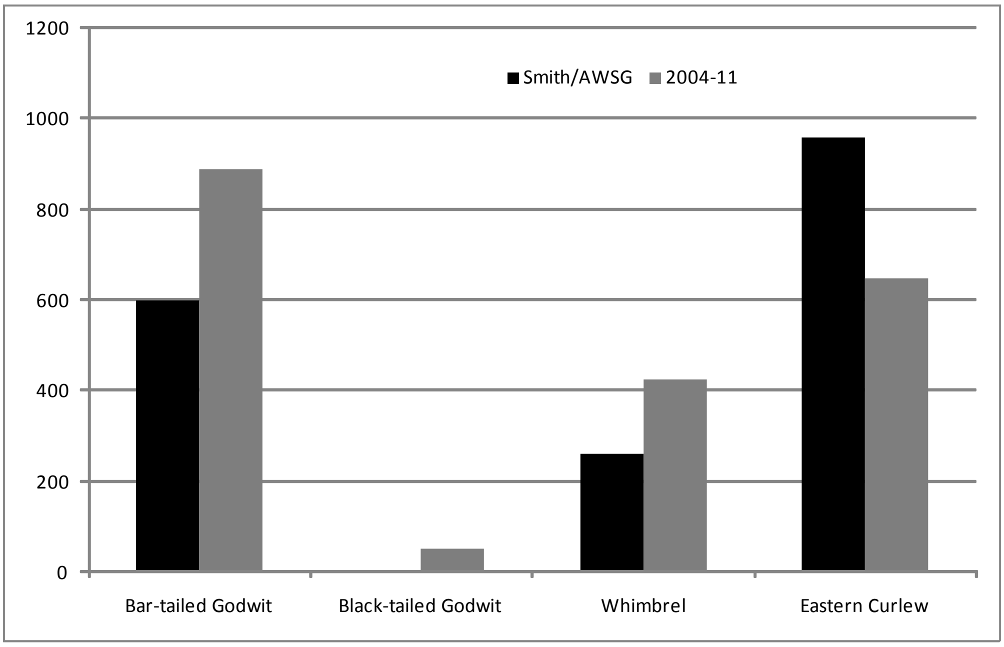

Figure 2. Comparisons of the recent and historical peak counts – large shorebirds.

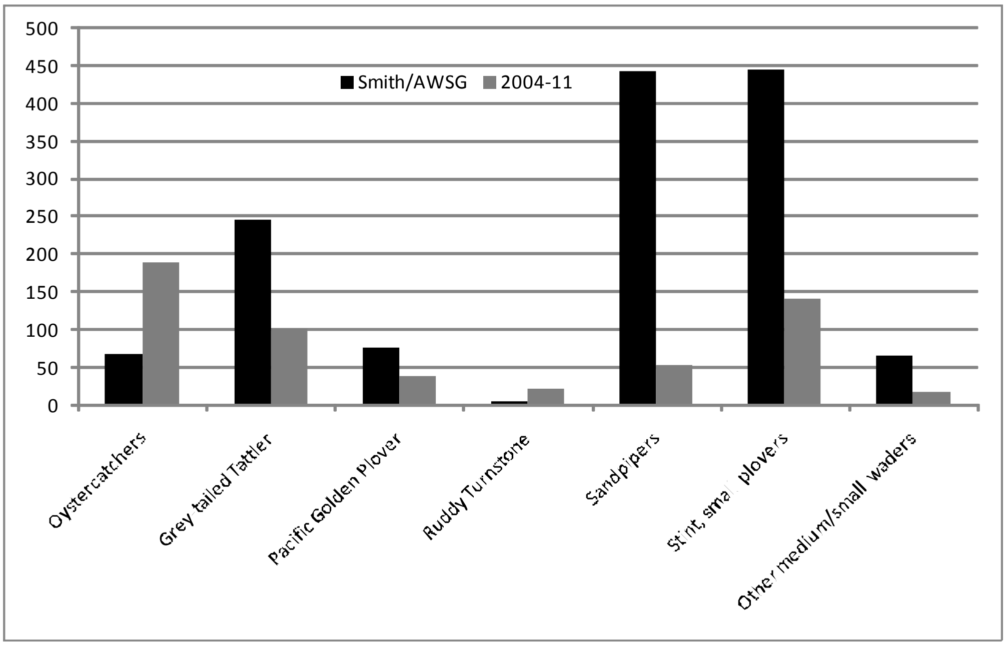

Figure 3. Comparisons of the recent and historical peak counts – medium and small shorebirds.

are also expressed as percentages in Table 4. There has been an 88% decline in the counts of sandpipers (considering all of these species combined) and approximately 70% decline in the numbers of many other small to medium sized waders. The decreases might actually be even larger than this, since the survey methodology now allows a more comprehensive coverage of all of the roost sites than was possible in the earlier surveys.

Many of these findings echo the decline in shorebird numbers identified elsewhere in Australia (Gosbell & Clemens 2006). In the case of Red-necked Stint, Gosbell and Clemens concluded that numbers in SE Australia are increasing in some areas but decreasing in other ones. Port Stephens therefore is another site where the numbers are decreasing. Conversely, the numbers of Bar-tailed Godwit are higher now in Port Stephens than were recorded in the 1980's, which is contrary to the general decline in their numbers in SE Australia (Gosbell & Clemens 2006). One can speculate that an increase in the Port Stephens Bar-tailed Godwit population is an artefact of the more effective boat-based survey method now in use and that the numbers present in the 1980's were higher than the land-based surveys had indicated. This may also explain the increases in the numbers of Australian Pied Oystercatcher, Sooty Oystercatcher and Whimbrel in the 2004-2011 surveys compared to the 1980's.

The decline in shorebird numbers is also very clear from comparisons of winter count data from 2008-2011 and 1982-84. The comparisons of mean counts and peak counts for the two periods are presented in Table 6. The 1982-84 data are from AWSG surveys in June of each year at just two sites in Port Stephens (Taylors Beach, Swan Bay) and therefore are likely to be an under-estimate of how many shorebirds were present in the entirety of Port Stephens. The winter counts for four species increased: Australian Pied Oystercatcher, Sooty Oystercatcher, Bar-tailed Godwit and Whimbrel. At the very least, this reflects the more effective surveying that now takes place. The counts for all other species have declined, in most cases very markedly. Four small shorebirds, Red-capped Plover, Double-banded Plover, Grey-tailed Tattler and Red-necked Stint, which were present in moderate numbers in Port Stephens in the 1980's have collectively declined by 86% based on mean counts (140 birds then, 20 birds now). Shorebirds present in low numbers in winter, such as Pacific Golden Plover, Black-winged Stilt *Himantopus himantopus*, and Ruddy Turnstone *Arenaria interpres*, have not been recorded at all during 2008-2011.

Factors like loss of habitat at staging sites on migration are thought to be contributing to declines in many migratory species (Rogers *et al.* 2010). However, the decreases in non-migratory species such as Red-capped Plover suggest that local factors may also be contributing to declines. Geering *et al.* (2007) summarised the main threats to shorebirds; the only threat they identified which seems obviously to apply for Port Stephens is disturbance. Port Stephens is one of the fastest population growth centres in NSW (Australian Bureau of Statistics 2011, accessed 5/12/2011). Many more people now live in the area and it has also become a very popular holiday destination. Geering *et al.* (2007) cite human activity, habitat modification, and predation of eggs and chicks by feral and domestic animals as disturbances which impact shorebirds. All of these disturbances are presumed to have increased as a result of the population growth around Port Stephens. However, the conditions prevailing there in the 1980's are not well documented, precluding a formal analysis of the impact of disturbance in Port Stephens.

CONCLUSIONS

Port Stephens has been a site of international importance for Eastern Curlew for at least three decades and is a site of international importance for Australian Pied Oystercatcher. Up to 1.7% of the Flyway population of Eastern Curlew has been present in Port Stephens in the 2004-2011 surveys and up to 1.4% of the world population of Australian Pied Oystercatcher. For the latter, a very large proportion of the NSW population seems to be present in both summer and winter, although further study is needed to determine if they reside in Port Stephens for the whole of the year.

Eastern Curlew numbers have decreased by 32% since the 1980's based on comparisons of peak counts. The land-based surveys of the 1980's very likely under-estimated the total population present, whereas the modern survey methodology allows coverage of all the potential roost sites. Therefore, the real decline in Eastern Curlew numbers probably is much more than 32%.

There has been a substantial decline in the numbers of most small and medium sized shorebirds when compared with the data from the 1980's. Many species which occurred in low numbers in the 1980's have not been recorded at all during the 2004-2011 surveys. Species which previously were present in moderate numbers have declined, by up to 90% from direct comparisons of the data and possibly by even higher percentages given that the modern survey methodology is more effective.

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Table 6. Comparison of 1982-84 (AWSG) and 2004-11 (this study) winter surveys

Species	**Mean counts**		**Winter peak counts**	
	1982-4	**2004-11**	**1982-4**	**2004-11**
Australian Pied Oystercatcher	1	142	4	154
Sooty Oystercatcher	0	16	0	24
Black-winged Stilt	4	0	13	0
Pacific Golden Plover	3	0	0	0
Red-capped Plover	54	3	64	5
Double-banded Plover	42	9	69	35
Red-kneed Dotterel	5	0	15	0
Masked Lapwing	22	28	33	51
Bar-tailed Godwit	98	336	114	424
Whimbrel	13	24	25	36
Eastern Curlew	100	81	152	223
Terek Sandpiper	0	3	0	11
Grey-tailed Tattler	21	8	37	23
Common Greenshank	<1	0	1	0
Ruddy Turnstone	8	0	20	0
Red-necked Stint	23	0	33	0
Curlew Sandpiper	<1	0	1	0

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DEATH BY A THOUSAND CUTS – THE INCREMENTAL LOSS OF COASTAL HIGH TIDE ROOSTS FOR SHOREBIRDS IN AUSTRALIA: SANDFLY CREEK ENVIRONMENTAL RESERVE, CENTRAL QUEENSLAND

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The Sandfly Creek Environmental Reserve is a 750 ha parcel of state land on the south bank of the mouth of the Pioneer River in central Queensland. The reserve is in the eastern suburbs of the rapidly growing city of Mackay and administered by the Mackay Regional Council as trustee on behalf of the Queensland government. It has two shorebird roosts that can support upwards of 4,000 shorebirds and other waterbirds during high tide. In early 2007, the council decided to construct a pedestrian and cycle path along a raised bund wall that passes around the northern and eastern sides of the reserve. This route passes close by both of the shorebird roosts within the reserve. The local Queensland Wader Study Group (QWSG) counter noticed a reduction in shorebird numbers at high tide roosts within the reserve almost immediately construction commenced. We examine the QWSG counts at these roosts since 1998 and compare the abundance and frequency of occurrence of all shorebirds and other waterbirds between the pre- and post- construction periods. A total of 135 spring tide surveys (95 prior to construction) identified 55 species of waterbird at the two roosts, including 28 species of shorebird. The mean diversity of waterbirds dropped dramatically after construction of the path from 16 to 4 species per count. Prior to construction of the path, internationally-significant numbers of Lesser Sand Plover and Eastern Curlew and nationally-significant Red-capped Plover were counted. The mean count of each of these species and the total count were significantly lower after the path was constructed ($P<0.001$). Five species of shorebird also significantly reduced their frequency of use of these roosts ($P<0.001$). Shorebird counts were also significantly correlated with tide height ($r^2 = 0.37$; $P<0.001$) as these roosts had highest counts during extreme spring tides. Concerned local conservationists brought the decline in use of the roosts to the attention of the Mackay Regional Council and the Queensland Department of Environment and Resource Management (DERM). DERM established a reserve advisory committee that recommended closing the path and establishing an alternate public route well away from the two roosts. The council refused to close the path, but agreed to construct the alternate route when a budget became available. Signage at the two entrances to the reserve was modified to show the new route and encourage visitors to avoid using the pedestrian and cycle path through the reserve. Compliance monitoring in March – April 2011 showed poor compliance with the signage requests by people undertaking most recreational activities. Of the mean 38.3 recreational users who entered the reserve around high tide each day, only 34% used the alternate route. The group with the highest compliance were walkers (42%). Shorebird counts have also remained low since the opening of the alternate route and numbers at nearby roosts have not increased. This study highlights the effects of persistent disturbance on shorebird use of high tide roosts and the difficulties in managing its impacts. The overall effect of persistent daily disturbance on less tolerant shorebird species appears to be that they have abandoned the area.

INTRODUCTION

The high demand for coastal waterfront land in Australia and elsewhere in the East Asian-Australasian Flyway (EAAF) inevitably leads to conflicts in land use between development and the environment. In Australia, many areas of coastal habitat are lost each year to housing, recreational and industrial uses. These incremental losses are rarely ecologically-significant in isolation and rarely reach the scale being reclaimed in the staging areas in the Yellow Sea (Barter 2002, Rogers *et al.* 2010). However, their cumulative effects on available roosting and feeding habitat for shorebirds can be substantial in many regions of the Australian coast near large population centres.

In recognition of the significance of this incremental loss of habitat, the federal government has sought to develop more sensitive indicators of high quality habitat that can be used to identify and better protect regionally important areas (Clemens *et al.* 2010). The intention is to introduce a new criterion of "national-significance" under the Environmental Protection and Biodiversity Conservation (EPBC) Act for high tide roosts where 0.1% of the flyway population of a migratory species occur. Clemens *et al.* (2010) showed that if this criterion is applied, substantial additional areas of wader habitat will be identified as important. This additional criterion will be useful to improve and strengthen the conservation of coastal wader habitats where these habitats are being modified or lost. However, they are unlikely to help manage the effect of regular roost disturbance from high human recreational use of coastal habitats.

There have been many studies of the effects of human disturbance on roosting and feeding shorebirds (Burton *et al.* 1996, Burger *et al.* 2004, Chan & Dening 2007). In extreme cases, roosts will be abandoned if the intensity of disturbance is sufficient (Burton *et al.* 1996). In this paper, we document the pattern of use by shorebirds, waterbirds and people at two important high tide roosts at Sandfly Creek

Environmental Reserve in the mouth of the Pioneer River, Mackay, central Queensland. Counts of upwards of 4,000 shorebirds and terns have been made at Sandfly Creek since monitoring began in 1998, including internationally-significant numbers of Lesser Sand Plover and Eastern Curlew (Harding & Milton 2003). The roosts are part of an environmental reserve administered by the Mackay City Council as trustee on behalf of the Queensland government. In early 2007, the Mackay Regional Council decided to build a public walkway and cycle path on the road reserve that ran through the environmental reserve to improve recreational opportunities to residents (Figure 1). The aim of this paper is to (1) examine the trend in wader counts at Sandfly Creek Environmental Reserve and nearby roosts to assess whether the dramatic declines in shorebird numbers at this site merely reflect a shift in roosting pattern or a loss from the region and (2) to discuss management actions being undertaken to reduce disturbance and maintain the viability of the roosts.

METHODS

Shoirebirds and other waterbirds have been counted monthly at the two Sandfly Creek Environmental Reserve roosts by Les Thyer since 1998. Les has also counted the nearby roost at Shellgrit Creek, about 2 km further south (Figure 1). In late 2002, the Queensland Wader Study Group (QWSG) obtained funding under the WWF-led National Shorebird Project to undertake comprehensive surveys of shorebirds in the Mackay region. During the project, a total of five complete surveys were made of the 200 km stretch of coast from Repulse Bay, near Airlie Beach (-20.4486° S, 148.7875°E) to Cape Palmerston, south of Sarina (-21.5195° S, 149.4738° E). All surveys were made during the non-breeding period when shorebird numbers were highest (October – April). Since the completion of that project, QWSG have funded an additional four complete surveys in the November – January period. The last QWSG survey was made in November 2010. During each of these surveys all 38 known high tide roosts were counted at least once. Besides these surveys, additional *ad hoc* counts of nearby (< 2 km) roosts were made by other QWSG members. Count frequency increased after 2003 when QWSG actively recruited new members to their program.

The Mackay Regional Council began construction of the cycle path through the Sandfly Creek Environmental Reserve in early 2007. The QWSG counter, Les Thyer noticed that shorebird numbers at the roost started to drop almost immediately and alerted local conservationists and QWSG. Regular monthly counts of other roosts in the region were made by other QWSG members and the trends in abundance at these will be compared with that found at Sandfly Creek.

Following concern from local conservationists and the setting up of a Sandfly Creek Environmental Reserve Advisory Committee, the Mackay Regional Council

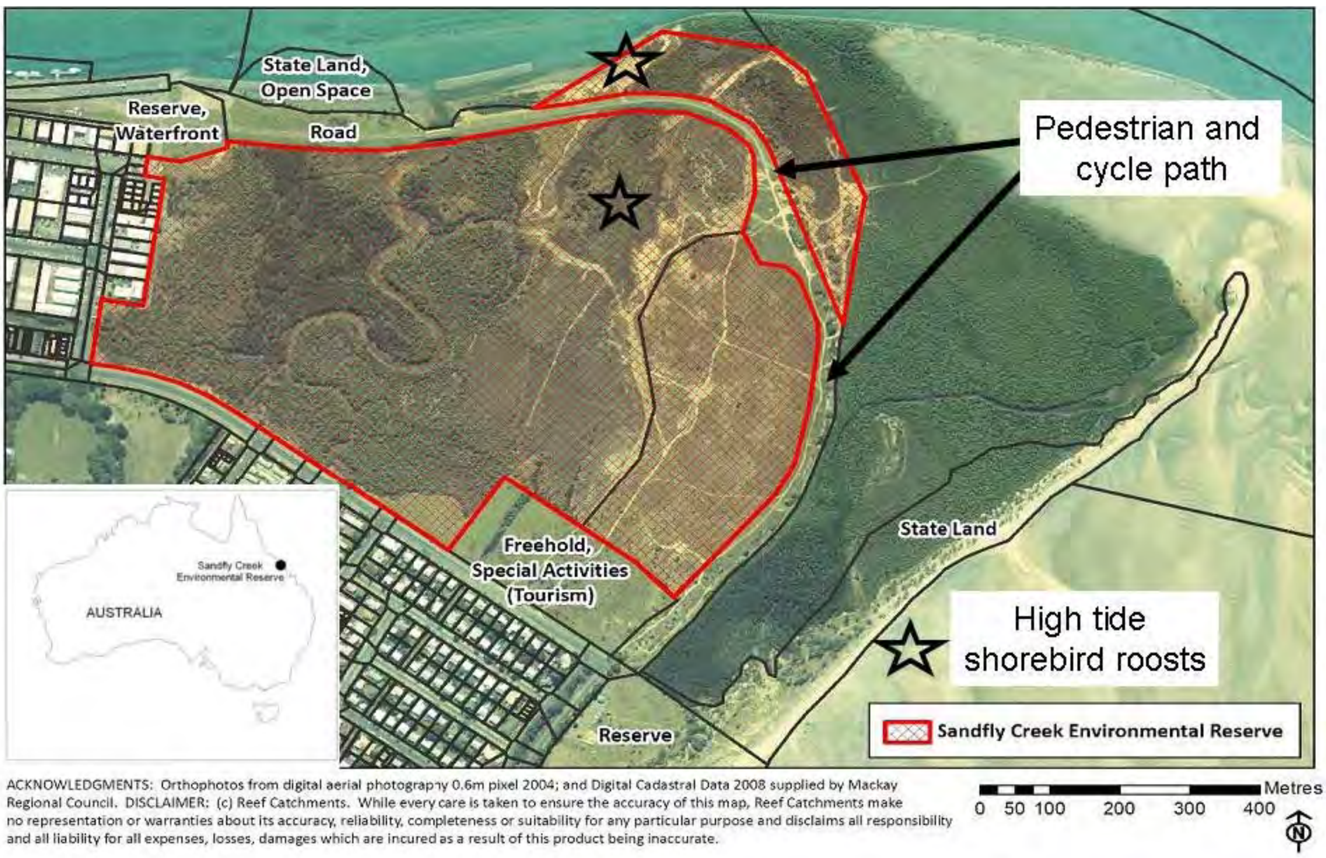

Figure 1. Map of the Sandfly Creek Environmental Reserve showing the location of the two high tide shorebird roosts and the pedestrian and cycle path through the Reserve. Inset shows the location of the Reserve in eastern Australia.

eventually proposed an alternative walking and cycle path away from the roosts in 2010. This path could be used during the summer non-breeding season to reduce disturbance. Signage at the Reserve entrances was modified in late 2010 to alert users to the changed routing and the need to minimise shorebird disturbance. Observers monitored the effectiveness of these changes to the signage in March – April 2011 to assess the level of voluntary compliance. Daily observations were made from the two entrances to pedestrian and cycle paths in the Sandfly Creek Environmental Reserve (Figure 1) during the high tide period (4 hrs). The activity of all people entering the Reserve was classified into one of eight categories.

The shorebird and waterbird count data were analysed by a two-way analysis of covariance with period (pre- or post-construction) and month as main effects. Tide height was treated as a covariate as preliminary analysis showed that it was highly correlated with the natural logarithm of the total count (r^2 = 0.37; P<0.001). Total count and species that varied significantly between periods (based on simple *t*-tests) were analysed by ANCOVA with SAS 9.2 statistical software.

RESULTS

Overall shorebird numbers

A total of 55 species of shorebird and waterbird were counted at the two roosts at Sandfly Creek Environmental Reserve before the pedestrian and cycle path was built (Table 1). Since the construction of the pathway, 36 species have continued to use the roosts, but in significantly lower numbers (Table 1; P<0.001). The number of shorebird species found on the two roosts within the Sandfly Creek Environmental Reserve started to decline rapidly after the construction of the cycle and pedestrian path began in January 2007 (Figure 2). Before the path was constructed, a mean of between eight to 12 shorebird species were seen on the roosts. After 2007, the number of species fell steadily to only four to five shorebird species by the summer of 2009/2010. Besides shorebirds, the roosts regularly supported eight to 11 species of waterbird during the summer non-breeding season prior to the construction of the pedestrian and cycle path (Figure 2).

The mean number of birds counted on the two roosts dropped by 34% from that counted prior to the construction of the path (Table 1). Prior to the construction of the path, the roosts regularly held over 1000 birds on several occasions during the non-breeding period (October – March) (Figure 3). Following the construction, the roosts still held over 1000 birds, but on only four visits over three years. These were all on tides well above the mean high water spring tides (5.28 m) when there were few alternative roosts nearby (Figure 3).

Counts at the five roosts within 2 km of Sandfly Creek Environmental Reserve, showed no significant declines in both the number of species and the total number of birds at the roost since monthly counts began in 1988 (both P>0.4; Figure 4). Counts varied seasonally, but there was no trend

Table 1. The mean ± SE and proportion of bird counts Pre-construction (n = 95) or Post-construction (n = 34) of the Sandfly Creek Environmental Reserve cycle path in December 2006. Significant differences in the mean or proportions of any species (P<0.05) are shown in **bold**.

Common name	Pre-construction			Post-construction		
	Mean ± SE*	No. counts	Proportion	Mean ± SE*	No. counts	Proportion
Australian Darter	1.2 ± 0.2	6	0.06	1.4 ± 0.4	7	0.21
Australian Pelican	14.5 ± 2.0	44	0.46	16.4 ± 2.9	20	0.59
Australian Pied Oystercatcher	3.7 ± 0.4	85	0.89	4.8 ± 0.9	30	0.88
Australian White Ibis	6.0 ± 0.6	55	0.58	4.6 ± 1.0	18	0.53
Bar-tailed Godwit	97.7 ± 9.8	58	0.61	127.5 ± 31.5	18	0.53
Beach Thick-knee	2.1 ± 0.2	23	0.24	1.3 ± 0.3	3	0.09
Black Swan	1.0	1	0.01	-	-	-
Black-necked Stork	1.0	8	0.08	1.0	1	0.03
Black-tailed Godwit	80.0 ± 30.0	2	0.02	-	-	-
Black-winged Stilt	2.0	1	0.01	-	-	-
Brahminy Kite	6.6 ± 5.4	13	0.14	1.0	4	0.12
Broad-billed Sandpiper	6.5 ± 3.5	2	0.02	-	-	-
Bush Stone-Curlew	5.0 ± 0.5	69	**0.73**	4.2 ± 0.8	15	**0.44**
Caspian Tern	10.9 ± 1.0	60	**0.63**	8.6 ± 2.7	11	**0.32**
Common Greenshank	13.0 ± 2.7	28	0.29	13.8 ± 2.8	17	0.50
Common Sandpiper	1.6 ± 0.4	5	0.05	1.0	2	0.06
Crested Tern	10.1 ± 0.9	79	0.83	10.9 ± 1.7	28	0.82

Table 1 continued

Common name	Pre-construction			Post-construction		
	Mean ± SE*	No. counts	Proportion	Mean ± SE*	No. counts	Proportion
Curlew Sandpiper	12.3 ± 4.0	15	0.16	60.9 ± 25.7	7	0.21
Double-banded Plover	12.0 ± 8.0	2	0.02	-	-	-
Eastern Curlew	111.8 ± 9.5	90	**0.96**	115.5 ± 17.0	21	**0.62**
Great Egret	1.4 ± 0.3	28	0.29	1.8 ± 0.3	4	0.12
Great Knot	66.4 ± 11.3	36	0.38	97.6 ± 39.1	7	0.21
Greater Sand Plover	**94.3 ± 20.9**	23	0.24	**14.2 ± 3.1**	6	0.18
Grey Plover	15.0	1	0.01	-	-	-
Grey-tailed Tattler	73.7 ± 11.7	58	0.61	113.2 ± 30.6	16	0.47
Gull-billed Tern	21.9 ± 4.8	42	0.44	17.3 ± 4.7	10	0.29
Intermediate Egret	1.3 ± 0.3	9	0.09	1.0	2	0.06
Lesser Crested Tern	14.0	1	0.01	-	-	-
Lesser Sand Plover	**343.2 ± 68.5**	38	0.40	**117.3 ± 50.3**	7	0.21
Little Black Cormorant	2.3 ± 0.6	14	0.15	4.4 ± 2.5	8	0.24
Little Egret	1.5 ± 0.2	24	0.25	2.0 ± 1.0	2	0.06
Little Pied Cormorant	1.2 ± 0.1	18	0.19	-	-	-
Little Tern	36.4 ± 8.1	16	0.17	27.8 ± 12.8	5	0.15
Marsh Sandpiper	4.0	2	0.02	21.0	1	0.03
Masked Lapwing	4.6 ± 0.5	52	0.55	3.9 ± 0.9	11	0.32
Osprey	1.0	3	0.03	1.0	1	0.03
Pacific Black Duck	3.8 ± 0.7	14	0.15	4.0 ± 1.0	5	0.15
Pacific Golden Plover	38.3 ± 6.2	27	0.28	38.2 ± 18.3	9	0.26
Pied Cormorant	1.5 ± 0.2	22	0.23	1.9 ± 0.4	15	0.44
Plumed Whistling-Duck	-	-	-	2.0	1	0.03
Red Knot	12.0 ± 8.0	2	0.02	-	-	-
Red-capped Plover	**24.9** ± **2.8**	71	**0.75**	**10.5** ± **3.4**	12	**0.35**
Red-necked Stint	147.6 ± 19.5	55	**0.58**	101.9 ± 29.1	9	**0.26**
Royal Spoonbill	4.0 ± 1.5	4	0.04	71.0	1	0.03
Ruddy Turnstone	9.1 ± 1.5	36	0.38	16.3 ± 8.5	6	0.17
Sharp-tailed Sandpiper	30.4 ± 4.0	30	0.32	79.4 ± 23.4	8	0.24
Silver Gull	47.2 ± 9.5	75	0.79	42.9 ± 6.3	26	0.76
Sooty Oystercatcher	2.0 ± 0.2	25	0.26	2.1 ± 0.3	9	0.26
Straw-necked Ibis	3.8 ± 0.8	6	0.06	5.8 ± 1.7	4	0.12
Striated Heron	1.3 ± 0.2	11	0.12	1.2 ± 0.2	5	0.15
Terek Sandpiper	36.2 ± 7.3	32	0.34	34.7 ± 12.5	9	0.26
Whimbrel	66.9 ± 6.7	78	0.82	84.1 ± 15.7	25	0.74
Whistling Kite	1.0	1	0.01	2.0	1	0.03
White-bellied Sea-Eagle	1.0	5	0.05	-	-	-
White-faced Heron	2.0 ± 0.2	58	0.61	1.5 ± 0.3	11	0.32
White-winged Black Tern	42.0	1	0.01	-	-	-
TOTAL	**737.2 ± 15.8**	95		**471.8 ± 35.2**	34	

* Where the sample size was very small, no error estimate could be generated

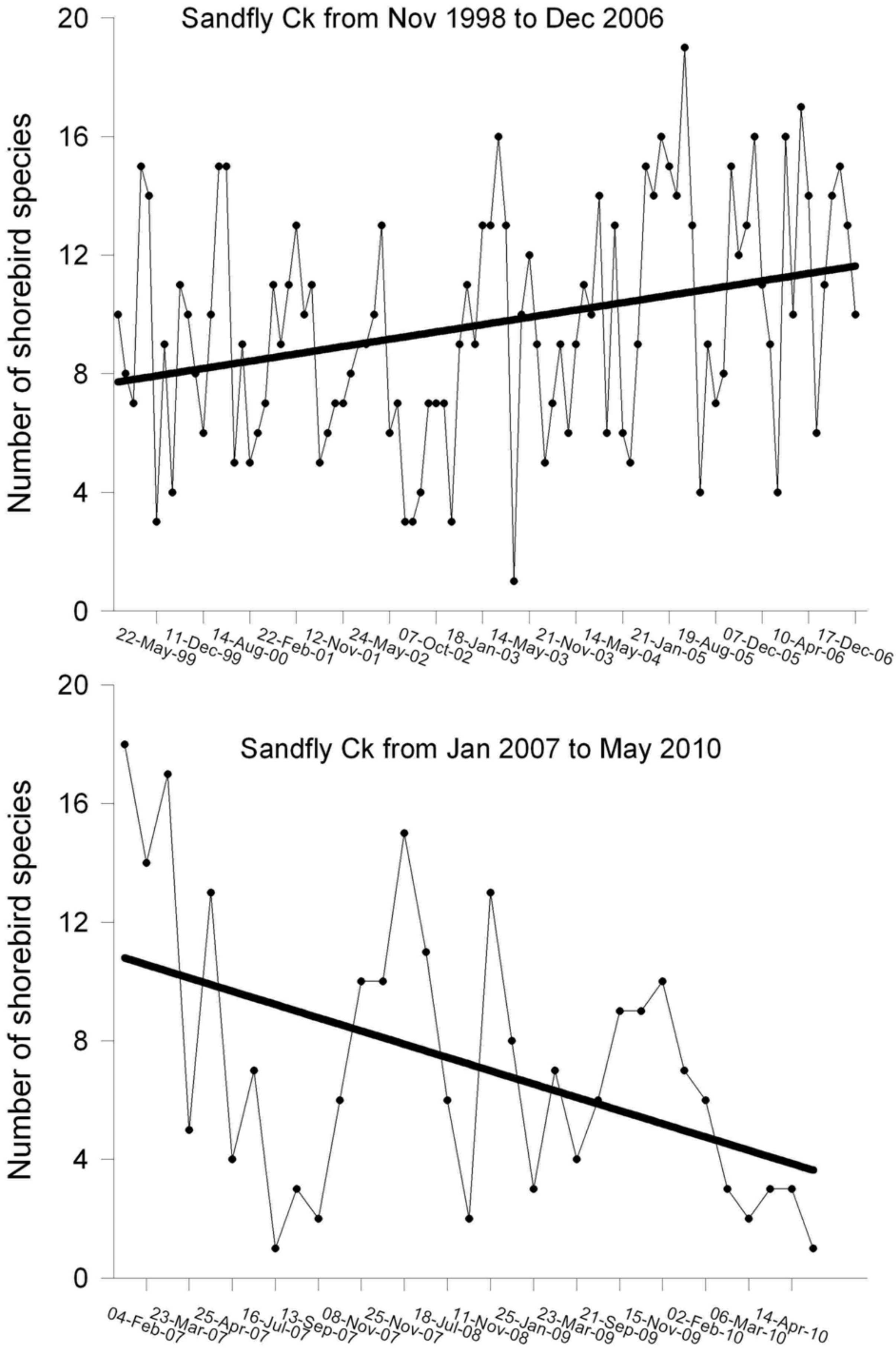

Figure 2. The number of shorebird species identified during regular monthly counts at the two Sandfly Creek high tide roosts between December 1998 and May 2010. The trend in the mean number of species using the roosts is also shown.

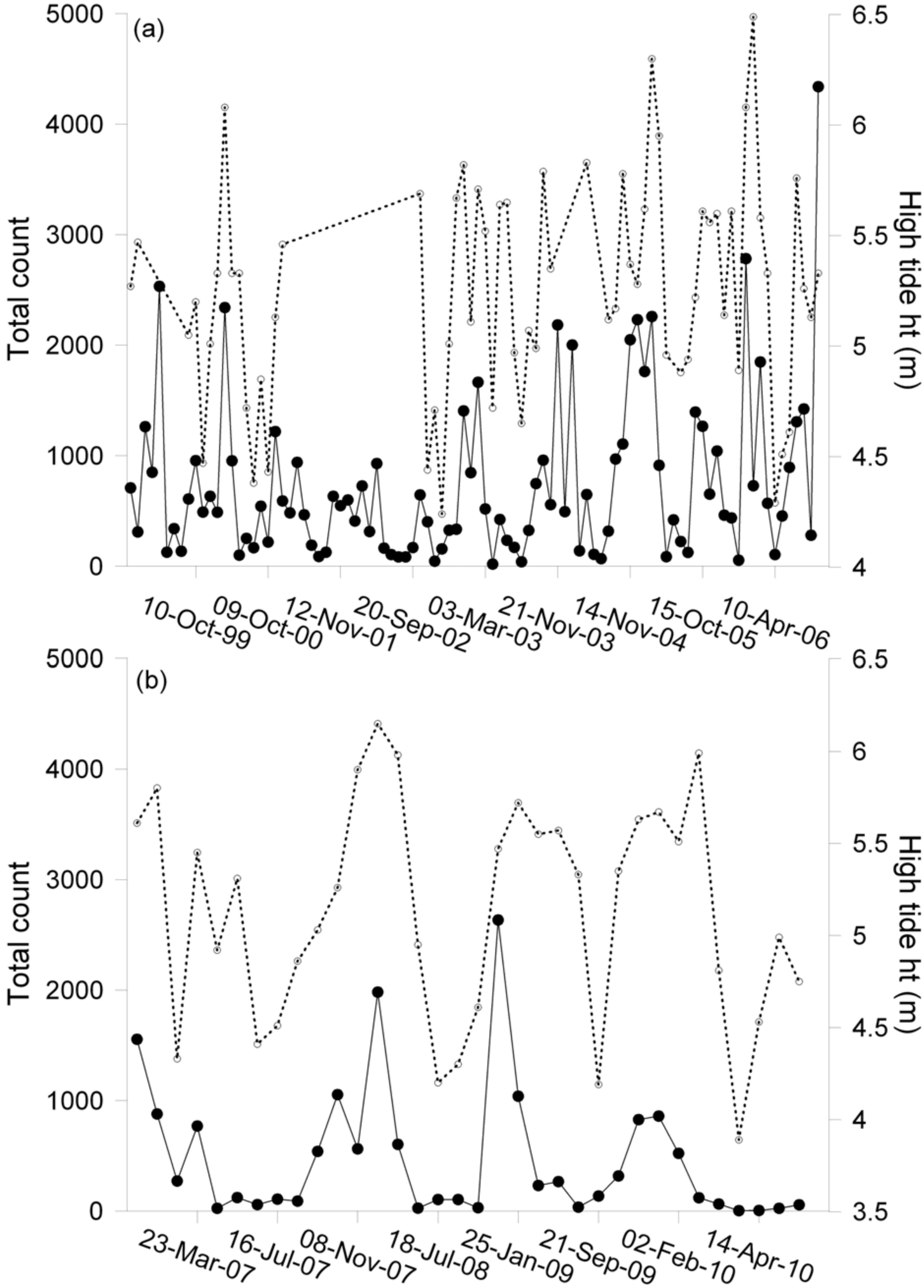

Figure 3. The total count of birds (closed symbols) and tide ht (m) during regular monthly counts at the two Sandfly Creek Environmental Reserve (a) pre-construction and (b) post-construction of the pedestrian and cycle path.

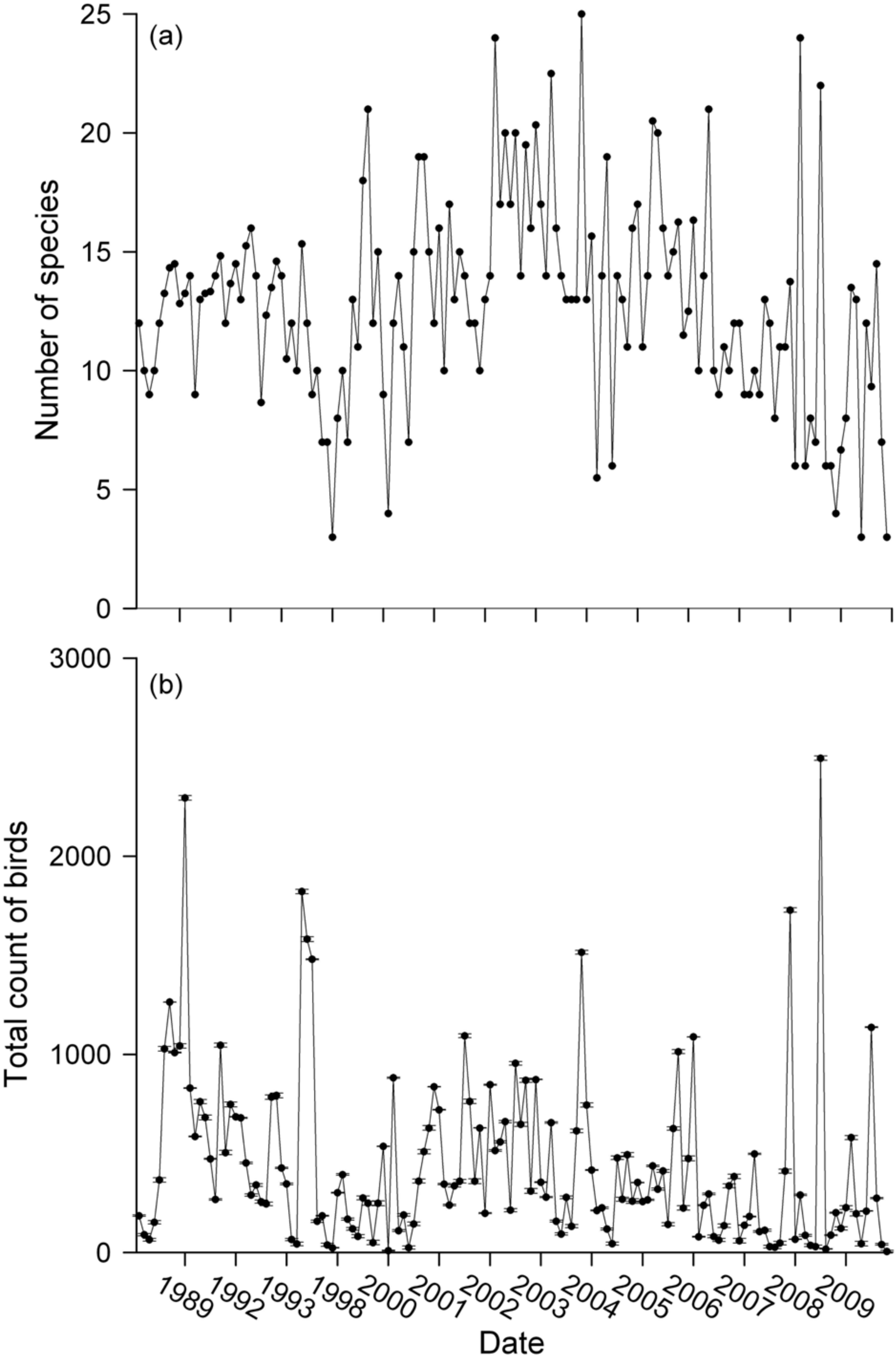

Figure 4. The number of species (a) and the total number of shorebirds (b) counted at the five nearby roosts during spring high tide surveys from April 1988 to May 2010.

in the overall number of birds or an increase since the construction of the pedestrian and cycle path in early 2007. The species at these roosts were similar to those seen at Sandfly Creek Environmental Reserve with Bar-tailed Godwit, Eastern Curlew, Lesser Sand Plover and Red-necked Stint being the most abundant species.

Changes in species occurrence and abundance

The mean counts and frequency of occurrence of several species declined between the pre- and post construction periods (Table 1). No species increased significantly in abundance after the construction, although one new species was seen (Plumed Whistling-duck). Five species roosted at the site significantly less frequently (all $P<0.05$) (Bush Stone-curlew, Caspian Tern, Eastern Curlew, Red-capped Plover and Red-necked Stint). In the case of Eastern Curlew, a similar number of birds roosted in the same part of the reserve on almost every visit (96%) before the construction of the path. Since the construction, the same flock has only roosted there on 62% of visits. Many other species also roosted at Sandfly Creek Environmental Reserve less frequently, but the results were not significant.

Three species of shorebird were less abundant at the roosts after the construction of the path (Lesser and Greater Sand Plover and Red-capped Plover). Counts of these species declined by 58 – 85% after the path was constructed (Table 1). Results of the ANCOVA showed that counts of all species were significantly different between periods and among months (all $P<0.05$). Tide height also significantly correlated with counts of all species ($P<0.05$) (Figure 5). All species had higher counts on dates when the tides were higher than the median high water springs (5.28 m). Count data for Eastern Curlew were also analysed by ANCOVA and this showed that the mean count was also highly significantly different between periods when tide height and month were taken into account ($P<0.01$) (Figure 5).

Use of the alternate access route in March – April 2011

The use of the existing pedestrian and cycle path and the alternate route was monitored for 10 days between 21 March and 5 April 2011. During that period 365 people were counted in the Reserve during the four hours around high tide. The most common use of the Reserve was for walking or cycling (Figure 6). Most users continued to use the constructed pedestrian and cycle path. The proportion of walkers was higher on the alternate route than for other activities. The alternate route was not formed and thus made other activities such as roller-skating and skateboarding difficult to undertake along this path.

DISCUSSION

The construction of the pedestrian and cycle path through Sandfly Creek Environmental Reserve in early 2007 has caused a detectable reduction in the number of shorebirds that roost at the site. The response by different species has varied, depending on their preferred roosting habitat, tide height and the availability of alternative roosts nearby with similar habitats. Sandfly Creek is a king tide roost that stays viable at all tides. There are no alternative roosts for many species within five km of the site. Thus, although similar numbers of many species, such as Eastern Curlew have continued to use the site after the construction of the pathway, their frequency of use has declined. This is because they can use other nearby roosting sites that are available on lower high tides (Harding & Milton 2003).

The initial response from most shorebird and waterbird species to the increased perceived predation risk from disturbers has been to roost elsewhere. As the frequency of disturbance increased, more species stopped consistently roosting at Sandfly Creek. Only five species of the 55 seen at the reserve had detectable differences in their frequency of occurrence. However, another seven species that used the site regularly (> 15% of visits) began roosting there less frequently. These differences were not significant due to the low power of the sampling design. Visits were only made on spring tides each month when most alternative roosts were flooded. Thus, the reduction in use by shorebirds is probably much greater than these data indicate.

It is also worth noting that there were only three species (Eastern Curlew, Red-capped Plover and Whimbrel) that routinely used the roosts at the reserve (frequency of occurrence > 75%). Of these Eastern Curlew and Red-capped Plover have both declined significantly in both the frequency of use and the number of birds present when they do use the site. Prior to the construction of the pedestrian and cycle path, the site was internationally-significant for Eastern Curlew (Bamford *et al.* 2008) and nationally-significant for Red-capped Plover. For Whimbrel, their preferred roosting habitat included bare branches in mangroves. In the reserve, this habitat is remote from the pedestrian and cycle path and thus Whimbrels were disturbed less frequently than the other two species. The other 52 species detected at the roosts mostly used the site on fewer than half the visits, even before the construction of the pathway.

Understanding roost choice by shorebirds is complex and involves the trade-off between predation risk (including disturbance) and the energetic costs of flight to alternate roosts (Rogers *et. al.* 2006a, b). The Sandfly Creek Environmental Reserve roosts are at the mouth of the Pioneer River. This area is adjacent to extensive intertidal flats that receive nutrient-rich waters from the river. This makes Sandfly Creek Environmental Reserve an attractive roost location for many species as it is near more productive feeding habitats than other roosts on the exposed coast north or south of the Pioneer River. Thus, one of the important features of the roost is the fact that it is used by so many species compared with other high tide roosts in the region (Harding & Milton 2003).

Our data suggest that some species such as Eastern Curlew and Red-capped Plover have high individual fidelity to these roosts. Constant disturbance appears to have forced these species to abandon the roost except on extreme high tides when alternative roosts are unavailable. This highlights the value of those roosts that remain available on extreme (king) high tides in all coastal areas in the EAAF. There are usually few of these roosts in any section of coast and they are often widely dispersed. In the 200 km of coast in the

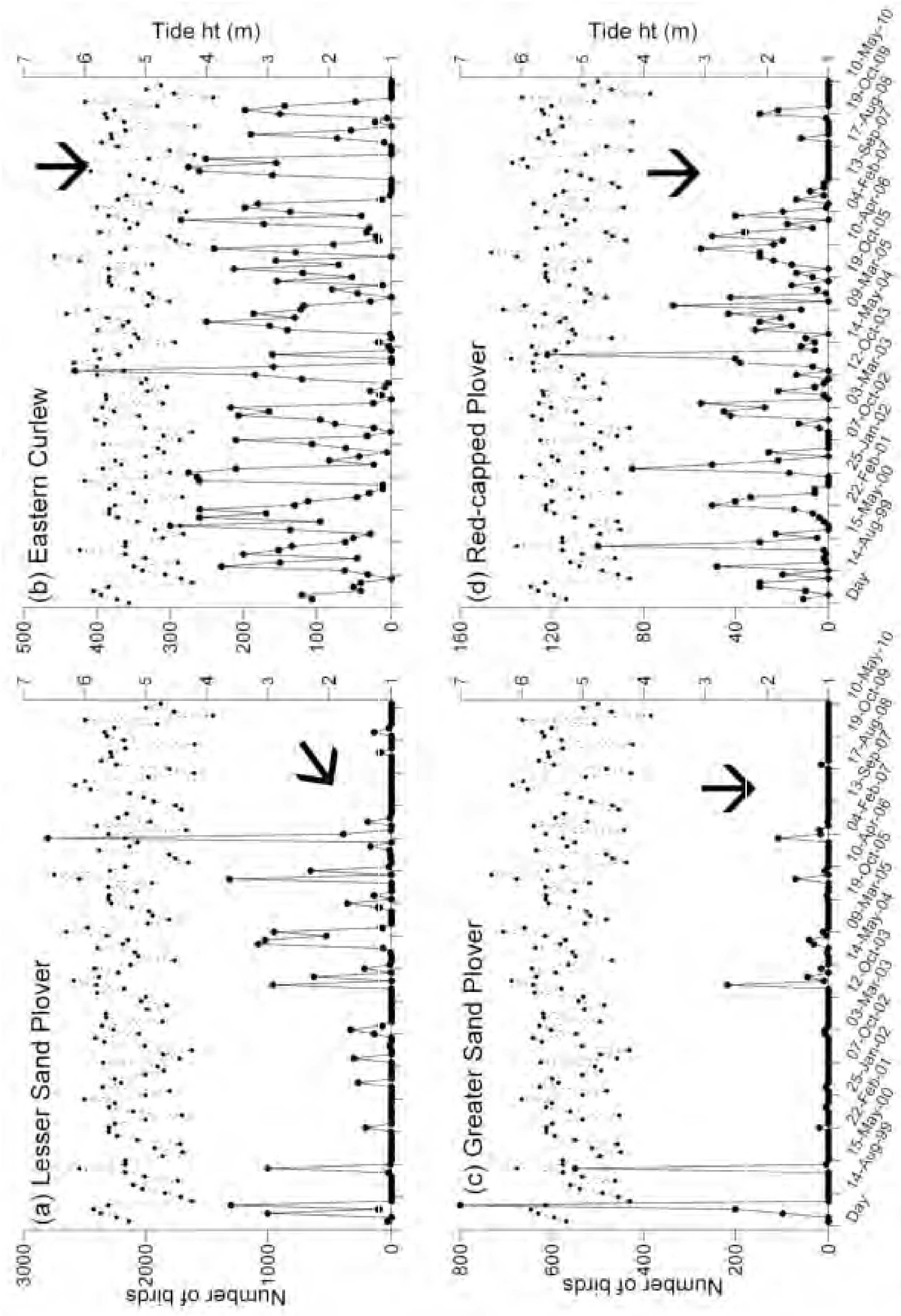

Figure 5. Trends in the abundance of four species (closed symbols) that showed declines in counts between the pre- and post-construction of the Sandfly Creek Environmental Reserve pedestrian and cycle path. Tide heights (m) are shown for each count.

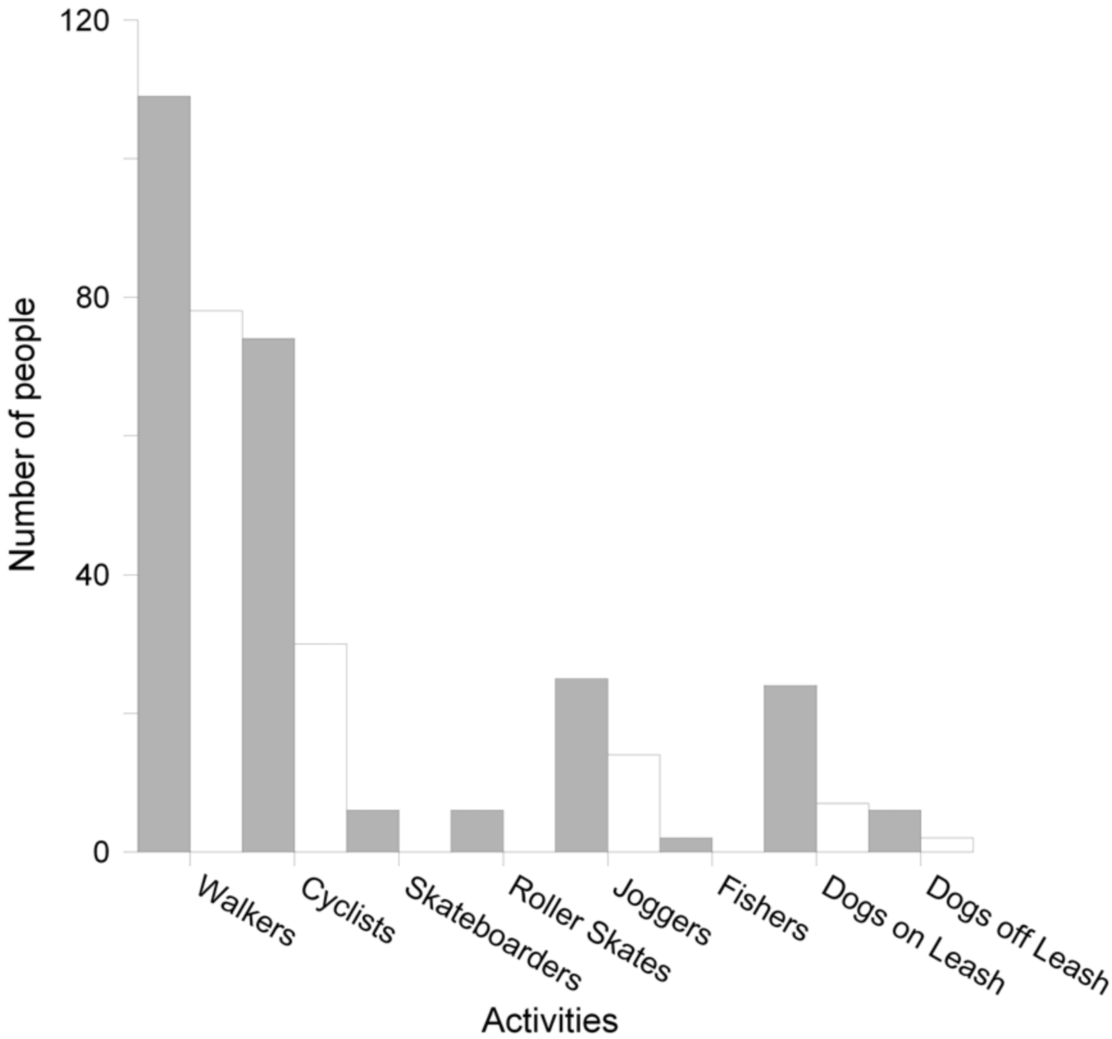

Figure 6. The number of people undertaking different types of activity within the Sandfly Creek Environmental Reserve in the 4 hr period around high tide on 10 days during March – April 2011. Shaded columns represent users of the pedestrian and cycle path. Open columns show the number of users of the alternate route away from the high tide roosts.

Mackay region regularly surveyed by QWSG, Harding and Milton (2003) only identified seven king tide roosts of 38 visited. The roosts at Sandfly Creek Environmental Reserve were the only king tide roosts within 10 km of the mouth of the Pioneer River. Predation threats (or disturbance) that force shorebirds to abandon roosts adjacent to profitable feeding grounds can place energetic constraints on feeding distribution if they have to fly long distances to roost at high tide (Rogers *et al.* 2006b). Our data from less disturbed roosts nearby (within 2 km) showed that shorebird counts of most species were stable. Thus, the shorebirds that have stopped roosting at Sandfly Creek Environmental Reserve do not appear to have relocated nearby. These data suggest that the frequency of disturbance was sufficient for many individuals of the more sensitive species to abandon the area altogether (Burton *et al.* 1996). It also indicates that the Reserve is not maintaining the biodiversity values that contributed to the justification for its creation.

Management actions

Management of public access and use of wetland habitats near large coastal urban centres can be challenging (Antos *et al.* 2007). Shorebirds appear to be more easily disturbed than other species and are the first group of waterbirds to reduce their use of wetland habitats after frequent disturbance (Cardoni *et al.* 2008). We found no detectable changes in the number or frequency of visits that terns, gulls, raptors or other waterbirds used the Sandfly Creek Environmental Reserve. Thus, shorebirds need to be the focus of any interventions to reduce disturbance by human recreation to roosting birds.

In recognition of the concerns by local conservationists about the level of disturbance at Sandfly Creek Environmental Reserve, Mackay Regional Council commissioned Reef Catchments NRM to develop a management plan for the reserve. This plan was finalised in December 2010 and proposed revegetation screening of shorebird roosts, closing the area adjacent to the roost beside the Pioneer River and exclusion of domestic animals between October and April as means of reducing disturbance. Several hundred trees were planted along the northern side of the path to screen the riverside roost from path users. However, regular uncontrolled grass fires within the reserve have killed almost all the trees making the screening ineffective.

In recognition of the lack of effective management of the reserve by the council, DERM set up a Reserve Management Advisory Committee in early 2010. The composition of the committee included representatives of the major stakeholder groups: the council, the reserve owners (DERM), Mackay Conservation Group, Bird Observers Club, Reef Catchments NRM (developers of the management plan), Pioneer Catchments Landcare Group and QWSG (SH). This committee met several times during 2010 to discuss practical measures to reduce the disturbance. Local conservationists were pushing hard for the pedestrian and cycle path to be permanently closed. However, the council was resistant for several reasons, including the popularity of the path among residents, the loss of public use of expensive infrastructure and lack of concern about the effects on shorebirds.

As a compromise, the council agreed to a proposal from the committee to develop an alternate route through the reserve to be available when the migratory shorebirds returned in September 2010. This route was not a formed path, but followed the western and southern boundaries of the reserve remote from where shorebirds roosted (Figure 7). Council insisted that public compliance should be voluntary, but agreed to amend existing signage to show the route and reasons for its development. The signs state that the new route should be used during the period that migratory shorebirds were in greatest abundance (September – April). Our public usage data from March – April 2011 shows that these efforts have been somewhat successful. Almost half of the walkers that used the reserve had used the alternate route. However, compliance from other user groups was much poorer. This is hardly surprising when the alternate route remains unformed and the surface is rough. A sealed surface would be strongly preferred for the activities being undertaken by almost all other user groups identified. Unless this alternate route is sealed, the only effective measure to reduce disturbance appears to be closing the pedestrian and cycle path.

ACKNOWLEDGEMENTS

We thank Les Thyer for his regular counts at the Sandfly Creek roosts since 1989 that have enabled this analysis to be undertaken. Maureen Cooper and Patricia Julien have both worked tirelessly over many years to try and improve the conservation of shorebirds and coastal habitats in the region. Their efforts to force the Mackay Regional Council to take their Sandfly Creek Environmental Reserve responsibilities seriously have been instrumental in the actions taken by council to date. We also thank an anonymous reviewer for comments on an earlier version of this manuscript.

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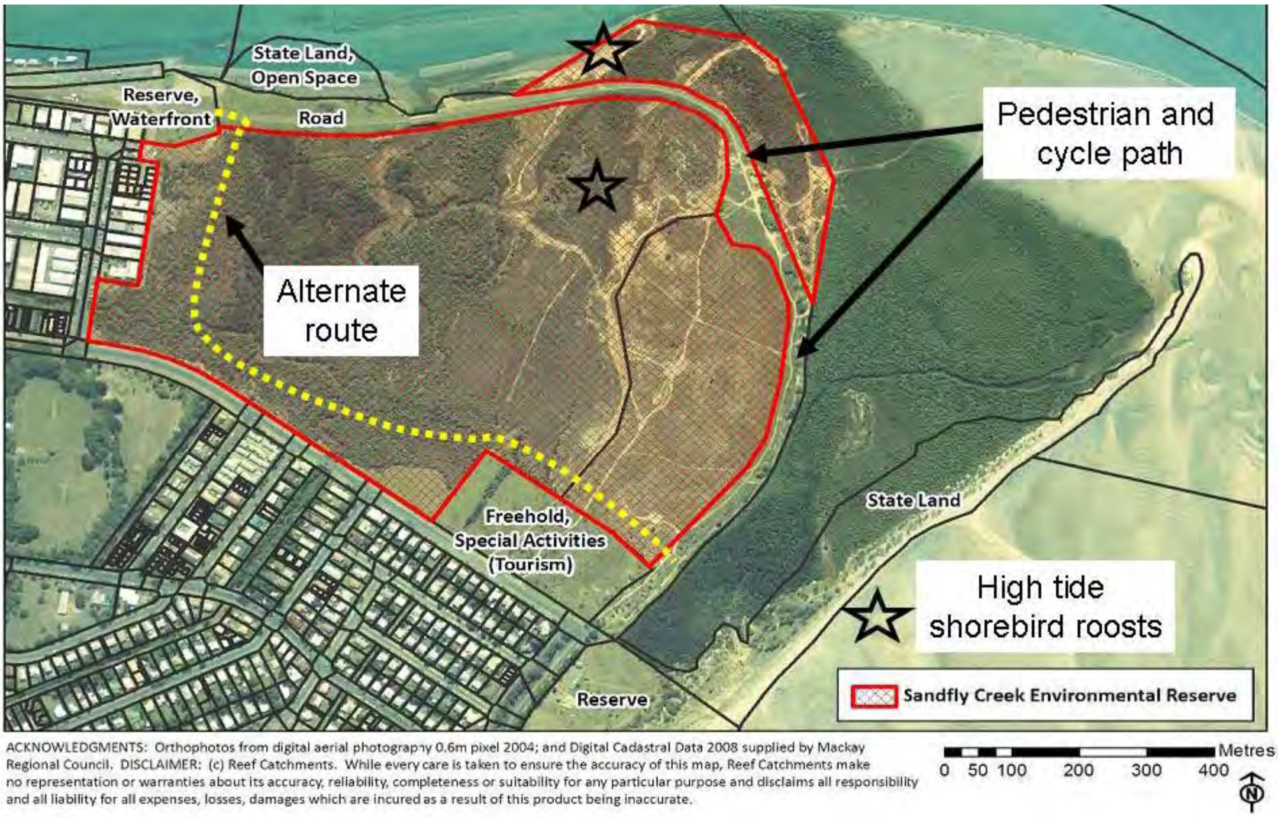

Figure 7. Map of the Sandfly Creek Environmental Reserve showing the new alternate route (dashed line) developed for use during the migratory shorebird non-breeding season in late 2010 (September – April).

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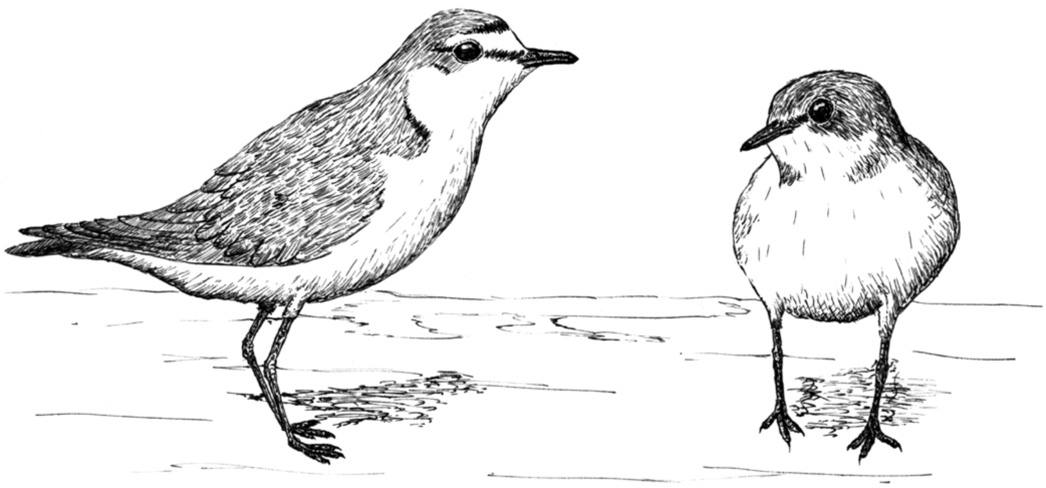

MORE GREY-HEADED LAPWINGS *VANELLUS CINEREUS* IN NORTHERN SUMATRA – VAGRANTS OR AN EXTENSION OF WINTERING RANGE?

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The occurrence of 29 Grey-headed Lapwings at four sites in North Sumatra Province, Indonesia, during October 2010 is put into the context of 20 birds observed in Aceh in 2008, a substantial increase in numbers visiting Peninsular Malaysia since 2000 and the recent occurrence of this species as a vagrant to Australia. The evidence suggests that the Grey-headed Lapwing has recently expanded its winter range to include Peninsular Malaysia and northern Sumatra.

INTRODUCTION

The Grey-headed Lapwing *Vanellus cinereus* has two breeding populations - a sedentary population in Japan and a larger migratory population breeding in north-eastern China (Central Manchuria and Inner Mongolia) and wintering in southern China, Indochina, Myanmar, Bangladesh, India, Nepal and parts of mainland South-East Asia (Robson 2000, Bamford *et al.* 2008). The species is estimated to number 25,000 - 100,000 individuals (Delany & Scott 2006), with the largest wintering concentrations found in Bangladesh and China (Lopez & Mundkur 1997, Bamford *et al*. 2008, Li *et al*. 2009).

Prior to 2010, Grey-headed Lapwing had only been recorded twice in Indonesia. The first record was in Gorontalo Province, northern Sulawesi in 1869, and the second (involving 20 birds) was at Alui Putih, Aceh Province in northern Sumatra on 31 December 2008 (Sukmantoro *et al.* 2007, Iqbal *et al.* 2009, 2010). The 139 years between these first and second occurrences, plus the fact that Sumatra is 1200 km south of the main wintering range, led Iqbal *et al.* (2009) to describe Grey-headed Lapwing as a vagrant to Sumatra and the Indonesian archipelago.

METHODS

In September and October 2010 we surveyed the central east coastline of North Sumatra Province, visiting 40 coastal wetlands and counting 60,000+ waterbirds (Crossland & Sitorus *in prep*.). We were aware of the 2008 record of Grey-headed Lapwing in Aceh and scrutinised congregations of waterbirds for any further evidence of this species.

RESULTS

During our 2010 surveys we found Grey-headed Lapwing at 4 sites - Pantai Sejara (7 birds), Pantai Labu Baru (3), Pantai Ancol Indah West (14) and Bagan Serdang (5), totalling a minimum 29 individuals (Table 1). All observations were on inter-tidal mudflats, a non-typical habitat for a species that usually prefers rice-fields, marshes, wet grassland and riverbeds (Sonobe & Usui 1993, Rosair & Cottridge 1995).

Most birds were adults in non-breeding plumage with at least one juvenile in the company of two adults at Pantai Labu Baru. Grey-headed Lapwing were observed roosting and foraging together in loose groups and freely mingled with other shorebirds, particularly Black-tailed Godwit *Limosa limosa*, Common Redshank *Tringa totanus*, and Asian Dowitcher *Limnodromus semipalmatus*. They were shy when approached and readily took flight, circling as a tight flock before alighting again a short distance away.

We are confident that the three sightings on 14 October 2010 involved separate groups and were not components of the same flock moving along the shoreline ahead of us. The Pantai Labu Baru birds were not disturbed and were still feeding when we left at 13:00 hrs. The flock of 14 at Pantai Ancol Indah West (*c*.3 km north-west of Pantai Labu Baru) flew in at 14:20 hrs from the direction of inland aquaculture ponds and eventually settled about 500 m to the south-east (see Figure 1). The five birds at Bagan Serdang (*c*.4.5 km north-west of Pantai Ancol Indah West) were first observed at 16:30 hrs and flew in from unsurveyed areas to the west.

DISCUSSION

Iqbal *et al.* (2009) noted that vagrancy over large distances usually involves individuals rather than flocks and described the occurrence of a flock of 20 Grey-headed Lapwing in Aceh as a mystery. They also made comment that as far as they were aware, there is no current evidence of range expansion for this species. However, closer examination of recent reports from mainland South East Asia, particularly from Peninsular Malaysia, indicate that this conclusion appears incorrect.

Until recently, the Grey-headed Lapwing has been considered a vagrant or scarce migrant in Malaysia (Wells

Table 1. Counts of Grey-headed Lapwing, North Sumatra, October 2010.

Date	Location	Lat/long	Count
08/10/10	Pantai Sejara	3°15’N, 99°32’E	7
14/10/10	Pantai Labu Baru	3°40’N, 98°54’E	3
14/10/10	Pantai Ancol Indah West	3°41’N, 98°51’E	14
14/10/10	Bagan Serdang	3°42’N, 98°50’E	5
Total			**29**

Figure 1. 12 of 14 Grey-headed Lapwings at Pantai Ancol Indah West, North Sumatra, 14 October 2010

1999, Strange 2000), but this has changed in the last decade with a marked increase in wintering numbers and a southwards expansion in range (D. Bakewell *pers. comm.*). The Malaysian i-witness online bird database (http://www.worldbirds.org/v3/malaysia.php) has 107 reports of Grey-headed Lapwing in Peninsular Malaysia for the period 1996 to the end of 2010. Reports of the species generally involved individuals or groups smaller than 10 until 2004, then double figures in 2005-2006, and now flocks as large as 100+ birds. This increase is also evident in Asian Waterbid Census (AWC) data for Malaysia (Li *et al.* 2009) where census numbers increased from zero in 1989 to totals of 52 in 2006 and 33 in 2007 (Table 2). Subsequent to the AWC census period analysed by Li *et al.* (2009), one key site, Chikus Wetlands in Perak, have shown an impressive build up in Grey-headed Lapwing numbers – from 11 birds in January 2009 to 175 in January 2010 and 407 in January 2011 (AWC counts reported by N. Cheung, C. Ho, S.S. Khoo and D. Lai in http://www.worldbirds.org/v3/malaysia.php).

Our 2010 sightings of Grey-headed Lapwing in Sumatra represent the 3rd to 6th records for Indonesia. Although such scarcity usually assigns a species to the "rare vagrant" category, in this case a different status would now seem appropriate. Within the context of a clear increase in wintering numbers in Peninsular Malaysia and the recent observations of flocks of 20, 14, seven, five and three Grey-headed Lapwings in Aceh and North Sumatra Provinces, a more likely interpretation is that this species is now expanding its wintering range to include Sumatra.

The occurrence of a Grey-headed Lapwing in New South Wales in June 2006 (Clarke *et al.* 2008) - a first record for Australia – would appear to be part of this range expansion and could well be repeated in the future. If recent trends continue then non-breeding flocks of Grey-headed Lapwings can be expected to become more common in Sumatra over coming years and we may see further expansion into other parts of western Indonesia such as Java and Borneo.

Table 2. AWC data showing the increasing totals for Grey-headed Lapwing in Malaysia (after Li *et al.* 2009)

Year	Total
1989-99	0
2000	2
2001	0
2002	12
2003	1
2004	16
2005	32
2006	52
2007	33

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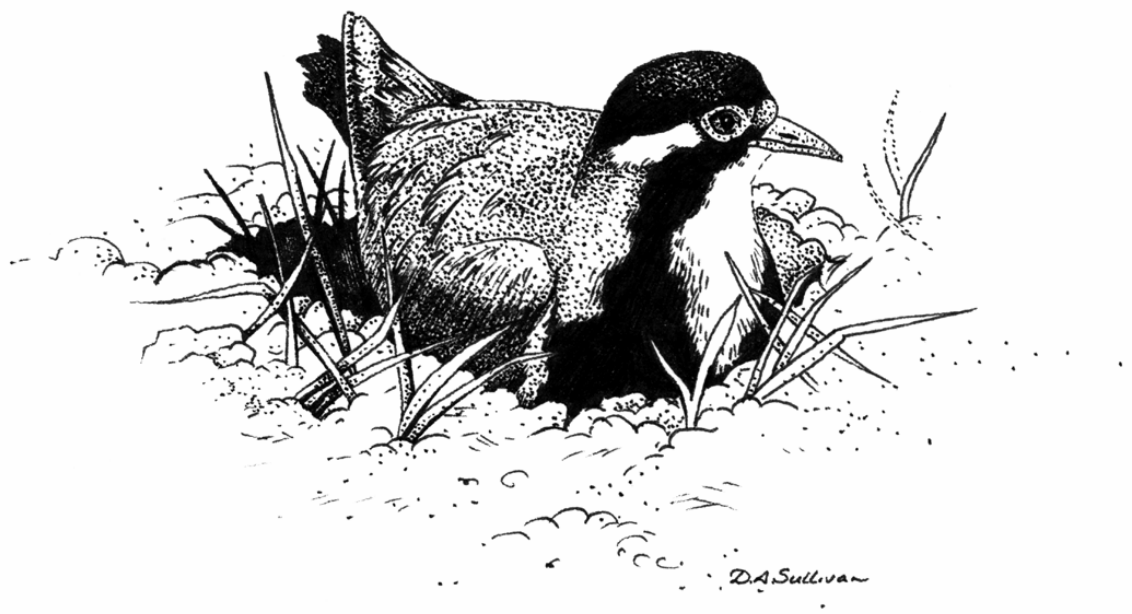

A TEN-YEAR STUDY OF SHOREBIRDS AT THE MORPETH WASTEWATER TREATMENT WORKS NEAR MAITLAND IN NEW SOUTH WALES

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Sixteen species of shorebird were recorded at the Morpeth Wastewater Treatment Works (MWTW) in the Hunter Region of NSW between 2001 and 2010. Only one species, the Sharp-tailed Sandpiper *Calidris acuminata*, occurred in sufficient numbers for MWTW to be considered an internationally important site. The Masked Lapwing *Vanellus miles* and Black-winged Stilt *Himantopus himantopus* occurred annually in regionally significant numbers. Another three species, the Marsh Sandpiper *Tringa stagnatilis*, Red-necked Avocet *Recurvirostra novaehollandiae* and Black-fronted Dotterel *Elseyornis melanops* occurred irregularly, but were numerous at times. Two of the above species breed in the northern hemisphere and the other four breed in Australia.

Shorebirds predominantly use the MWTW for feeding and the three species which bred at MWTW did so only to a limited extent. Feeding primarily occurs on ephemeral wetlands, particularly the muddy edges formed as water meadow dries out in spring and summer. For short periods the muddy edges can become a preferred foraging area in the Lower Hunter Valley for Sharp-tailed Sandpipers, Marsh Sandpipers and Black-winged Stilts.

Over the ten-year period there was a decline in both the reporting rate (i.e. the frequency of occurrence) and the abundance of some of the smaller species of shorebird, particularly the Red-capped Plover *Charadrius ruficapillus* and the dotterels. Reasons for these trends are uncertain, but may be an indication of a local population decline. The fall in Red-capped Plover reporting rate and abundance is of particular concern because this species has a distribution which is restricted to coastal areas in the Hunter Region, where its breeding habitat is increasingly disturbed by recreational activities and threatened by development.

MWTW intermittently provides important foraging opportunities for shorebirds favouring fresh water habitats, particularly when drought conditions prevail in eastern Australia.

INTRODUCTION

MWTW owned and operated by Hunter Water Corporation (HWC) is located (32°44'31"S, 151°37'24"E) about 10 km north-east of Maitland in NSW and covers an area of 72 ha. The original plant, decommissioned in 2000, was a biological filter works constructed in 1936.

It was recognised that the maturation pond system associated with the original MWTW constitutes an important wetland habitat with local, regional and state significance. As a condition of the Minister’s Approval, for decommissioning the plant, the HWC was required to manage the ponds so as “to provide enhancement of wetland and riparian habitats and encourage their use by indigenous and migratory species.”(Anon. 1999).

The MWTW site (Figure 1) is comprised of four ponds where water is permanent (A), a sludge pond which occasionally dries out (B) and a larger ephemeral wetland, which although bunded, is subject to a wetting and drying regime (C). On the southern and western sides of MWTW privately owned ephemeral wetlands are immediately adjacent (D). The southern wetland on occasions receives top-up water from the permanent ponds (A). To the east is an ephemeral wetland, again privately owned, which is wet only after heavy rain. This wetland was however modified in 2008 and a channel on the southern side now exists which often contains water (E).

HWC invited Hunter Bird Observers Club (HBOC) to take part in developing the management plan and as a result members commenced monthly surveys of all bird species in February 2001. Ten years of surveys have been completed. This paper deals with the shorebirds which occur at the MWTW. A previous paper (Lindsey & Newman 2002) reported the results of surveys in 2001, the first year of the study, which aimed to monitor long term fluctuations in the size of the bird populations using the wetlands after decommissioning. A further aim was to understand how different species utilised the various parts of the wetland complex. A recent closely-related paper (Newman & Lindsey 2011) discusses the occurrence of herons, spoonbills and ibis over the ten year period.

The Hunter Estuary, the most important area for shorebirds in NSW (Straw 1999), was also surveyed monthly over the same period, but the timing of the two sets of surveys was not synchronised.

METHODS

Surveys were conducted monthly commencing in February 2001. Over a ten year period 120 have been completed including two in November 2001, the second of which was carried out immediately after heavy rain which caused flooding on sub-area D. The mean of these two November 2001 counts was used during data analysis. As will be discussed, sites B, C and D are important shorebird habitat.

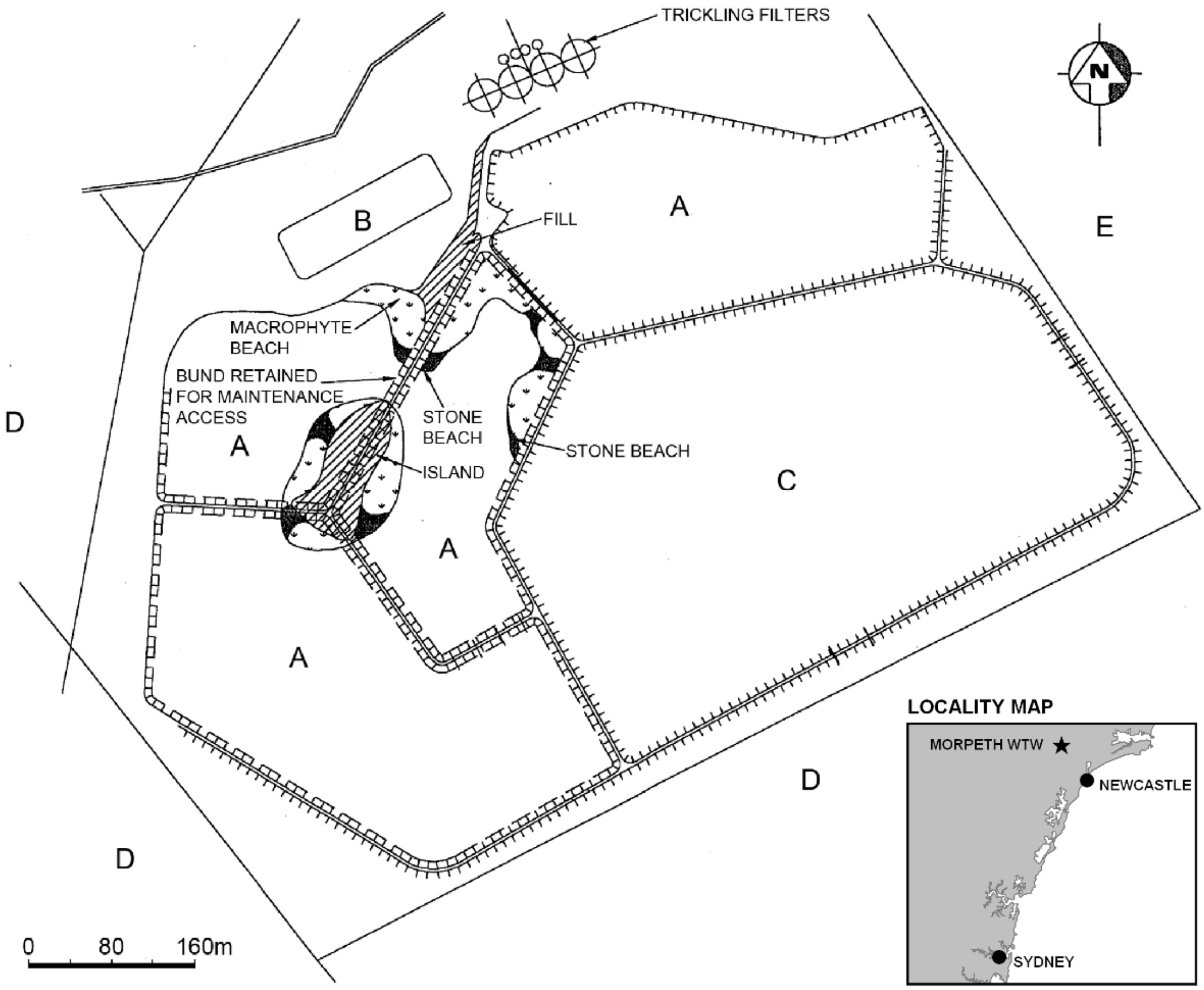

Figure 1. Morpeth Wastewater Treatment Works.

A – Ponds with permanent water; **B** – Sludge pond which occasionally dries out; **C** – Ephemeral wetland in bunded area which intermittently floods; **D** & **E** – Privately owned ephemeral wetlands.

They are often flooded during the winter months and dry out in spring creating water meadow conditions and, during the drying out period, muddy edges. These conditions provide ideal foraging habitat for shorebirds. It was important to determine how spontaneously the birds responded to changed conditions on these ephemeral sites; hence the second count in November 2001.

Surveys typically took three hours and involved two observers driving a fixed route around the maturation ponds, commencing two hours after sunrise. All species were recorded. Observations were made outside the vehicle using binoculars and telescope. Figure 1 provides details of the features of the area. The distribution of shorebirds between the different sub-areas was recorded.

To minimize the risk of double counting, birds that moved between the different sub-areas were noted and an estimate was made of the total number of birds in the area. This number was used as a check against the sum of the numbers of individual species counted in the sub-areas. In most instances the number of shorebirds present was not large and there was little difficulty with movement other than when large flocks of Sharp-tailed Sandpipers were disturbed by raptors.

Nine years of the ten years of the study, from July 2001 to June 2010, were subjected to intensive analysis. Variations in the reporting rate (i.e. the frequency of occurrence) of shorebird species were determined by comparing the count data for three equal periods, each of three years duration commencing July 2001. The chi-square statistic was used to test the significance of differences between the periods. Variations in abundance between these periods were also evaluated. The significance of differences in mean abundance was evaluated using the *z*-test provided that the data first passed the *F*-ratio test (Fowler & Cohen 1986). For data sets failing the *F*-ratio test the non-parametric Mann-Whitney *U*-test was used to compare median values, but no statistically significant differences were found.

RESULTS AND DISCUSSION

Sixteen species of shorebird were recorded. For shorebirds breeding in the northern hemisphere, the numbers of which peak in the summer months in southern Australia, the analysis of results for the period July to June is more meaningful than comparing calendar years. This approach is taken in the following discussion. Of the sixteen species, nine were migrants which breed in the northern hemisphere and one which breeds in New Zealand. The other six species breed in Australia. The study area is however not important breeding habitat for any of these species.

The occurrence of shorebirds is summarized in Table 1. While only the Masked Lapwing and the Black-winged Stilt are regularly present, it is apparent that MWTW is at times extremely important to other species, particularly the Sharp-tailed Sandpiper. A more detailed discussion of the occurrence of the individual species follows.

Black-winged Stilt *Himantopus himantopus*

The Black-winged Stilt is a numerous species frequenting both saline and freshwater habitats in the Hunter Estuary (Stuart 1994–2010). It was present on 81% of the surveys, often in large numbers (Tables 1 and 2). Indeed the maximum count of 504 in November 2004 was comparable to that for the whole of the Hunter Estuary in November 2004 (Herbert 2007) and it appears that on occasions MWTW may be the preferred location for Black-winged Stilts with freshwater habitat being preferred to saline.

Black-winged Stilt breed in Australia, but not extensively in the Hunter Region. It has attempted to breed at MWTW (nest with eggs in sub-area B), apparently unsuccessfully. Although very young fledged juveniles are sometimes present, they are thought to have been bred elsewhere.

This long-legged shorebird, which forages primarily in the ephemeral flooded areas, is able to exploit feeding opportunities over a greater range of water levels than is possible for shorter-legged species, which favour the muddy margins. Table 2 shows that the species is usually present except in February, March and June when there is a tendency for the ephemeral wetlands to dry out.

Red-necked Avocet *Recurvirostra novaehollandiae*

The Red-necked Avocet breeds inland and uses the Hunter Region as a drought refuge when conditions are unsuitable further west. This study corresponded with a period of inland drought and Red-necked Avocet numbers in the Hunter Estuary progressively built up to around 7000 (Lindsey 2008). Intuitively, one might expect the use of MWTW by this species to correspond to that of the similar-sized and long-legged Black-winged Stilt. However, this is not the case with the avocet being recorded on only 12% of the surveys

Table 1. Summary of shorebird data for MWTW July 2001 to June 2010

		Reporting rate[1] (%)	Mean number[2]	Standard error[3]	Maximum number
Black-winged Stilt	*Himantopus himantopus*	80.6	83.7	10.1	504
Red-necked Avocet	*Recurvirostra novaehollandiae*	12	51.2	21.9	230
Pacific Golden Plover	*Pluvialis fulva*	6.5	3.1	1.4	11
Red-capped Plover	*Charadrius ruficapillus*	9.3	3.2	0.6	7
Double-banded Plover	*Charadrius bicinctus*	3.7	3.8	2.2	10
Black-fronted Dotterel	*Elseyornis melanops*	31.5	15	4.9	131
Red-kneed Dotterel	*Erythrogonys cinctus*	21.3	3.1	0.5	10
Masked Lapwing	*Vanellus miles*	100	53.6	2.9	174
Latham's Snipe	*Gallinago hardwickii*	13.9	1.7	0.2	3
Bar-tailed Godwit	*Limosa lapponica*	1.9	3.5	1.5	5
Common Greenshank	*Tringa nebularia*	6.5	1.4	0.3	3
Marsh Sandpiper	*Tringa stagnatilis*	13	7.6	3.0	43
Red-necked Stint	*Calidris ruficollis*	5.6	7.8	5.8	37
Pectoral Sandpiper	*Calidris melanotos*	1.9	1	0.0	1
Sharp-tailed Sandpiper	*Calidris acuminata*	33.3	157.6	70.2	2460
Curlew Sandpiper	*Calidris ferruginea*	8.3	5	1.8	13

[1] Reporting rate - the percent occurrence of a species during 108 surveys.
[2] Mean number of a species when present (i.e. ignoring surveys when absent).
[3] Standard error may not be a meaningful statistic for some species, particularly those occurring infrequently, irregularly and in widely fluctuating numbers.

Table 2. Variation in Black-winged Stilt numbers at MWTW between 2001 and 2010.

Period	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
2001/02	73	87	140	149	52	16	8	81	161	24	171	61
2002/03	38	9	28	113	7	35	25	3			113	
2003/04	14	160	122		50		44			3	92	65
2004/05	101	83	230	394	504	97	58		2	120		83
2005/06	73	90	35	6		203	1			20	10	
2006/07	7		7	26	225	105	20		25	41	32	
2007/08		29	13	65	72	4	11	5		67	66	119
2008/09	134	73	42	295	152	27	60		91	107	66	63
2009/10	52	203	186	255	424	2	32	3		2	19	

compared with 81% for the stilt. However, when present, the avocet can be quite numerous at MWTW with a maximum count of 230 as shown in Table 3.

With exception of one record in June, all occurrences of the avocet were between October and December, and in three of the nine years there were no records. Perhaps the greatest contrast is for September when Black-winged Stilt was present (in every year) but there were no avocet records. These findings suggest that the avocet favours saline estuarine habitats and is infrequent at the freshwater wetlands of the lower Hunter Region. High numbers of avocets at Deep Pond, a freshwater habitat on Kooragang Island in the Hunter Estuary (e.g. 2000 in January 2006: Lindsey 2008), may reflect the use of that area as a roost rather than primarily for feeding. Comparison of the records for the two species at MWTW suggests that avocets were often present when there were higher than average numbers of stilt.

Pacific Golden Plover *Pluvialis fulva*

The Pacific Golden Plover occurred in five years with records in spring between September and December. Most records involved either one or two birds, which were present on a single occasion in each year. The exception was in 2008, when the species was present in three successive months, with a maximum of 11 birds in October.

Small plovers and dotterels

The Double-banded Plover is a trans-Tasman migrant to the east coast of Australia during the winter months. There were only five records of this species, all occurring during the first three years of the study, with six birds in June 2001, one, three and ten birds present in May, June and July 2002 and a single bird in June 2003. These birds were found in the ephemeral wetland areas, often in the company of other species of plover.

In the Hunter Region of NSW the Red-capped Plover is primarily restricted to coastal and estuarine areas (Stuart 1994–2010) and records at MWTW are consequently at the inland limit of its local range. There were 11 records, all in the first three years of the study. The records were evenly spread across the months May to November with a peak count of seven birds. The birds foraged on the ephemeral wetlands and there was no evidence of breeding.

The Black-fronted Dotterel was the most common of this group of species being recorded on 32% of the counts with a peak number of 131. The greater abundance of this species is not unexpected as it is widely distributed in the Hunter Region. However, the high numbers seen in 2001 and 2002 are unusual (Stuart 2010). The variation in numbers of Black-fronted Dotterel is complex as shown in Table 4. Numbers peaked between May and August and there were few records in the summer months between January and April. The other feature is the fall off in numbers from the peaks in the period 2001 to 2003 with only two records, each of a single bird, in a 43 month period between September 2004 and March 2008. Numbers then increased with this species present for nine consecutive months from October 2008, involving peak winter numbers of up to 22 birds. This renewed presence of Black-fronted Dotterel appears to have been catalysed by construction works at the eastern boundary of the plant, where the installation of a new pipeline generated areas of water with muddy islands. At other times the Black-fronted Dotterel predominantly foraged on the drying ephemeral wetlands.

Although it was recorded nearly twice as often, the pattern of occurrence of the Red-kneed Dotterel was very similar to that of the Red-capped Plover. The majority of the records were in 2001 and 2002, when it was recorded in all months except October. It was never numerous with a maximum count of 10. In the six years since January 2005 there have been only five records involving either one or two

Table 3. Variation in Red-necked Avocet numbers at MWTW between 2001 and 2010.

Period	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
2001/02												
2002/03				15								
2003/04												
2004/05						3	28					4
2005/06						230	2					
2006/07					3	187	1					
2007/08												
2008/09				2			2					
2009/10				64	124							

Table 4. Variation in Black-fronted Dotterel numbers at MWTW between 2001 and 2010.

Period	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
2001/02	41				1	2	1			1	60	29
2002/03	131	15	16	3								1
2003/04		10				1					22	12
2004/05	20	5					1					
2005/06												
2006/07						1						
2007/08										7	8	5
2008/09	19	5	11	3	7	8					14	8
2009/10	22	19			1							

birds. When the surveys commenced Red-kneed Dotterel were often encountered on the muddy margins of one of the ponds in sub-area A. However these margins have become increasingly weed covered and unsuitable for shorebirds. The occasional ongoing records occur on the ephemeral wetlands when they are drying out.

Across these four species there is a consistent trend for the species to have been most numerous during the first two years of the study followed by a substantial decline in both the frequency of occurrence and numbers of birds present. However, the Black-fronted Dotterel is to some extent the exception, making a recovery after the installation of a pipeline temporarily created beneficial habitat.

Masked Lapwing V*anellus miles*

The Masked Lapwing is a resident in the Hunter Region and is widely and commonly recorded usually in counts of up to 20 birds (Stuart 2009). Masked Lapwing were present on every survey. The magnitudes of the mean 53.6 and maximum 174 counts clearly demonstrate that MWTW is an important area at which Masked Lapwing congregate. The trend in monthly numbers shown in Figure 2 indicates a gradual build up through spring and summer followed by a marked increase in March. This is attributed to a post-breeding season influx of birds. There is little evidence of successful breeding at MWTW. Foxes, which breed in the area and the regular presence of raptors, would be expected to be detrimental to breeding.

Latham's Snipe *Gallinago hardwickii*

Latham's Snipe breeds in Japan and migrates to south-eastern Australia, arriving in August and departing around March. It favours marshy habitat and was predominantly recorded at edges of the permanent ponds in sub-area A and on sub-area C, when it contained water meadow. Except for 2010 it was present every year in small numbers, with a maximum count of three. However, it is a cryptic species and was probably under-recorded. There is some evidence that it declined during the study as in the first four years it was recorded on two or more surveys, but only once annually since 2005/06. It occurred from August to January, with most records in October. The lack of records in late summer is consistent with the drying out of its favoured water meadow habitat.

Red-necked Stint *Calidris ruficollis* and Curlew Sandpiper *Calidris ferruginea*

The Red-necked Stint and Curlew Sandpiper are occasional visitors to MWTW having occurred on six and nine occasions respectively. Usually they occur separately as either one or two birds during spring and often in consecutive months. The occurrence in November 2006 of 37 Red-necked Stints and 10 Curlew Sandpipers were exceptions. Between September and November 2009 both species were present with a maximum of two Red-necked Stints and 13 Curlew Sandpiper. At that time unprecedented numbers of Sharp-tailed Sandpipers were present with 2460 in November. The Red-necked Stints and Curlew Sandpipers tended to forage on the edge of the Sharp-tailed Sandpiper flocks and consequently were more vulnerable to predation, with one of the Curlew Sandpipers being taken by a Black Falcon *Falco subniger* (Newman & Lindsey 2009).

Bar-tailed Godwit *Limosa lapponica* and Pectoral Sandpiper *Calidris melanotos*

Both these species were recorded on two occasions. Five Bar-tailed Godwits were present in September and two in December 2006. Single Pectoral Sandpipers were present in December 2001 and 2009, on both occasions in association with Sharp-tailed Sandpipers. Bar-tailed Godwits are among

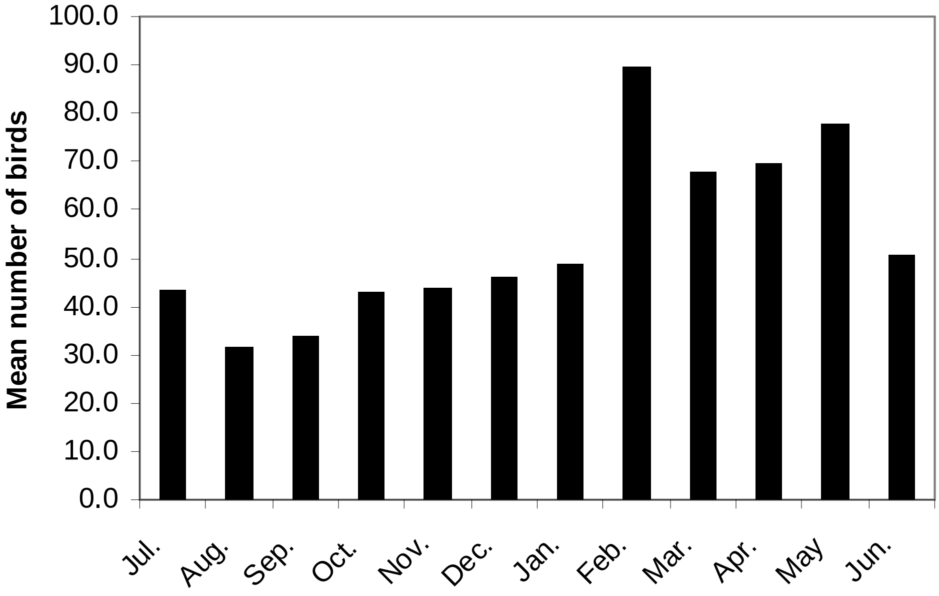

Figure 2. Variation in mean monthly numbers of Masked Lapwing at MWTW from July 2001 to June 2010.

the most numerous of the migrant waders visiting the Hunter Estuary (Herbert 2007). In contrast the Pectoral Sandpiper is rare, being recorded in small numbers in some years (Herbert 2007). Black-tailed Godwit was not recorded at MWTW during the study period.

Marsh Sandpiper *Tringa stagnatilis* and Common Greenshank *Tringa nebularia*

Marsh Sandpipers were recorded more frequently and in greater numbers than Common Greenshank (Table 1). Contemporaneous counts in the nearby Hunter Estuary suggest a typical maximum summer population of between 100 and 200 birds for each species with the Common Greenshank being slightly more numerous (Herbert 2007). While both species are found in saline and freshwater habitats, the Common Greenshank records indicated a preference for saline habitat. The predominance of Marsh Sandpipers at MWTW, an exclusively freshwater habitat, is consistent with this proposition.

Both species were predominantly recorded on the ephemeral wetlands in sub-area D, as they dried out in spring and summer. While most Marsh Sandpiper records are from September and October, the suitability of the area varies with differences in seasonal rainfall patterns. This is well exemplified by the data for 2001 when 4, 12, 43 and 13 Marsh Sandpipers were present during counts spanning the months September to December. However, the birds were not constantly present as the area dried out in early November and Marsh Sandpipers were absent on the 18th, but 43 were present on the 23rd of November following heavy rain which inundated the area. Thirteen were present on the 7th December and this was the next highest count during the nine year study. These records suggest that Marsh Sandpipers are highly opportunistic and seek out freshwater foraging opportunities following favourable climatic events. The maximum count of 43 was approximately 25% of the total Hunter Estuary population at that time (Herbert 2007).

Marsh Sandpipers were not recorded in three of the last five years of the study and in 2008/2009 when the species was present during four successive surveys from October to January the maximum count was only three. There are no records after January other than one record of a single Marsh Sandpiper in June 2002.

Most (75%) of the Common Greenshank records coincided with the presence of Marsh Sandpipers, but as the maximum count for this species was three it clearly prefers the saline habitat of the Hunter Estuary.

Sharp-tailed Sandpiper *Calidris acuminata*

In Australia the migratory Sharp-tailed Sandpiper occurs on both inland and coastal (Geering *et al.* 2007), fresh or saline swamps and estuaries (Stuart 1994-2010). At MWTW it occurred every year in each of the nine years included in the intensive analysis (Table 5), and in 2004/5 was present during seven months of the year. The most important months are from September to January. The annual maximum numbers mostly ranged between 100 and 400 until 2009/10, when 2460 birds were present in November. However, no Sharp-tailed Sandpipers were recorded in the second half of 2010 (i.e. during 2010/2011, subsequent to the period covered by the data in Table 5). This is attributed to abnormally wet conditions in inland Australia.

The importance of MWTW to Sharp-tailed Sandpiper depends on water levels providing suitable conditions. Conditions may change both annually and from month to month. For instance the highest annual numbers occurred in 2006/07 and 2009/10, which were particularly wet years in the Hunter Region and the wetlands were full and deeper than usual. In December 2006 however, water levels had dropped sufficiently and the ephemeral wetlands presented ideal conditions with shallow water and broad muddy edges and 394 birds were present. In March 2009, 250 mm of rain had fallen and all wetlands in the area were filled and remained at capacity during the winter. No rain at all fell in August and by September the ephemeral wetlands were covered in shallow water with exposed broad, muddy edges/margins. Numbers had built up from 152 in September to 880 in October and 2460 in November. Again hot weather and a lack of rain caused the wetlands to dry out quickly so that by the 17 December only 5% of the ephemeral wetlands had surface water and only 26 birds were present.

Trends in shorebird numbers

The results of a statistical analysis to determine periods when shorebird species reporting rates and abundance were abnormal are shown in Table 6. The analysis was limited to those species which were recorded sufficiently frequently for meaningful analysis. The results highlight the contrast between species like the Black-winged Stilt and Sharp-tailed Sandpiper, where there was no statistically significant variation and smaller species like the Red-capped Plover and dotterels where variation occurred. However, even when

Table 5. Annual variations in Sharp-tailed Sandpiper numbers at MWTW from 2001 to 2010.

Period	Maximum count for period	Month of peak numbers	Number of months recorded[1]
2001/02	220	Nov.	6
2002/03	250	Oct.	3
2003/04	100	Sep.	3
2004//05	151	Dec.	7
2005/06	141	Oct.	2
2006/07	394	Dec.	3
2007/08	17	Nov.	2
2008/09	102	Jan.	5
2009/10	2460	Nov.	5

[1] Twelve surveys during each period.

Table 6. Results of statistical tests to determine whether either reporting rates or abundance of shorebirds were abnormal during successive three year periods.[1]

Species	n [2]	2001/02 - 2003/04 Period 1	2004/05 - 2006/07 Period 2	2007/08 - 2009/10 Period 3
Black-winged Stilt	87			
Red-necked Avocet [3]	13			
Red-capped Plover	10	Reporting rate high [4] χ^2=8.1 (*P*<0.01)	Absent	Absent
Black-fronted Dotterel	34		Reporting rate low χ^2=13.0 (*P*<0.01)	
Red-kneed Dotterel	23	Reporting rate high χ^2=17.0 (*P*<0.01)		
Masked Lapwing	108	Abundance low *Z*=16.2 (*P*<0.01) [5]		
Marsh Sandpiper [3]	14			
Sharp-tailed Sandpiper	36			

[1] Unless stated there was no statistically significant difference in reporting rate or abundance.
[2] Number of surveys during which the species was recorded.
[3] Analysis limited by low number of records: Chi-Square test invalid.
[4] Based on comparison of periods 1 and 2 using chi-square test with a Yates Correction (Fowler & Cohen 1986).
[5] Comparison of means using the *z*-test.

variation occurred the trend was not consistent, as indicated by the results for the Black-fronted Dotterel compared with the Red-kneed Dotterel and the Red-capped Plover.

The importance of MWTW to shorebirds

The numbers of Sharp-tailed Sandpiper recorded in 2009/10 exceeded the internationally significant threshold value of 1600 based on 1% of the flyway population (Bamford *et al*. 2008). At the recently proposed lower threshold of 160 birds or 0.1% of the flyway population (Anon. 2009) the numbers of Sharp-tailed Sandpiper at MWTW met the criteria in two successive seasons (2001/02 and 2002/2003) and also qualify on the basis of the five-year average of 623 for the period 2005/06 to 2009/10). On this basis MWTW qualifies as a nationally significant site for Sharp-tailed Sandpiper.

Only two species, Masked Lapwing and Black-winged Stilt, occurred annually in significant numbers. The Sharp-tailed Sandpiper occurred every year except at the end of the study in 2010 when conditions were particularly favourable in inland Australia as will be discussed further. The attributes of MWTW attracting these species are different in each case and in no instance is the availability of breeding habitat important.

As an example, although the locally resident Masked Lapwing is always present and forms flocks which are unusually large by local standards (Stuart 2009), it disperses to breed elsewhere. Consequently the function of MWTW is to provide foraging and roosting opportunities for non-breeding birds and birds during non-breeding periods. Superficially the same argument applies for the Black-winged Stilt, except that its foraging requirements are more specialized than the Masked Lapwing. The stilt is found in sub-areas B, C, and D feeding in shallow water and is usually present except, when these areas are either full or dry. As discussed previously the Black-winged Stilt does not breed extensively in the Hunter Region. Its annual occurrence in substantial numbers at near coastal locations like MWTW, even when conditions are suitable inland (the second half of 2010 when most birds left was an exception), suggests that the function of these areas is more than that of a drought refuge. This conclusion is supported by comparison with the disappearance of the entire population of Red-necked Avocet from the Hunter Region when inland conditions are suitable for breeding (Stuart 2009).

The numbers of Sharp-tailed Sandpiper, a migrant breeding in the northern hemisphere, are internationally significant, but fluctuate widely between years. It favours the muddy edges of sub-areas B, C, and D (see Figure 1). Because it is a shorter-legged species than the Black-winged Stilt MWTW is only suitable when it is drying out. The wide fluctuations in annual numbers reflect the importance of the lower Hunter Region as a drought refuge for this species when conditions are unsuitable inland. MWTW is one of a number of coastal foraging options for Sharp-tailed Sandpiper, which include the Hexham Swamp, the Stockton Borehole at Cockle Creek and Ash Island (Stuart 1994–2010). The sequence in which these areas dry out probably influences their relative importance at any given time. In this respect the tidal areas of Ash Island probably represent the most reliable area, but not necessarily the most productive area with respect to food availability. Clearly MWTW is favoured when conditions are suitable not only by Sharp-tailed Sandpiper but also by Marsh Sandpiper another migrant shorebird which appears to exploit freshwater foraging opportunities under favourable conditions.

The four species of small plovers and dotterels occurred predominantly in sub-area D when extensive areas of mud become available as the water meadow dried out. Hence their occurrence is mainly opportunistic. However, the Black-fronted Dotterel at times occurs in flocks which are unusually large for the Hunter Region. Of particular interest was the exploitation of broken ground with pools of water following construction work to install a pipeline. It is possible that in addition to providing foraging opportunities the rutted terrain provided shelter and increased protection from predators for this cryptic species.

The progressive growth and dying off of herbaceous weeds is a feature of the flooded pond (sub-area C). At times dead stalks in areas of shallow water and drying out mud briefly provide the unique opportunity for birds like Sharp-tailed Sandpiper to feed inconspicuously and this area may be exploited in preference to more open areas, presumably as a predator defence mechanism.

The ponds in sub-area A, have little importance to shorebirds. Initially Red-kneed Dotterel regularly and Latham's Snipe occasionally, occurred on the muddy margins of one of the ponds. However, a combination of increased water levels and the growth of vegetation have removed this feeding habitat.

Limitations of monthly surveys

The monthly surveys were conducted on a day selected on the basis that weather conditions were favourable and it was convenient to the observers. The two surveys in November 2001 indicated that shorebird numbers fluctuated rapidly in response to changing conditions, particularly to the water level in sub-area D and to a lesser extent in sub-area C. The drying out process in spring and early summer is gradual and in the absence of significant rainfall monthly surveys probably give a realistic indication of the use of MWTW by shorebirds. This proposition is supported by steady trends in numbers over consecutive months, although peak numbers were probably missed. The impression gained is that birds use the area continuously until it dries out. However, when it is re-inundated as in November 2001 the birds may return and briefly exploit the area for a period which is shorter than the interval between surveys. Hence these short term occurrences may be missed.

MWTW is approximately 20 km from the main shorebird foraging and roosting areas in the Hunter Estuary. When this study commenced the regular exchange of birds between these areas was not considered important. Consequently, it was not deemed important to synchronise the monthly counts in the two areas and this was not practical as the same observers were involved in both studies. Results reported in this paper generally support this conclusion, but it may need to be reconsidered for some species on occasions.

The use of MWTW by shorebirds appears to be driven by both local and external factors. The most important local factor involves the existence of flooded wetlands with shallow water, particularly when muddy edges are formed as they dry out. The timing and the extent of these conditions vary between years driven by climate changes such as the El Niño/La Niña – Southern Oscillation. In other respects conditions at MWTW changed little during the study other than some loss of muddy margins on the ponds in area A. While a decrease in nutrient level entering the ponds (sub-area A) might be expected to impact on the availability of food, this is not considered to be an important factor for two reasons. Firstly shorebirds predominantly use sub-areas C, D and E, which did not receive nutrients before decommissioning and secondly Sharp-tailed Sandpiper numbers peaked at the end of the study, nearly a decade after nutrient discharge ceased. The external factors involve the availability of other foraging opportunities elsewhere, especially the influence of drought conditions inland, which may drive shorebirds to coastal areas like the Hunter Region. Cumulatively these factors explain the sporadic occurrence of shorebirds at MWTW as exemplified by the fluctuations in Sharp-tailed Sandpiper numbers.

The intermittent importance of MWTW to shorebirds and the complexity of the underlying causes of this variability militate against establishing long-term trends which reflect population trends. However, the decrease in the occurrence of the Red-capped Plover, for which all eleven records were in the first three years of the study, may be significant. MWTW is at the inland limit of the local range of this species, which has a strictly coastal range in central NSW. The coastal and estuarine habitats in which this species breeds have been increasingly threatened by a combination of recreational and development pressures in recent decades. The loss of this species from areas like MWTW, which are at the limit of its range, is consistent with hypothesis that this species may be experiencing a population decline. Hence trends in the occurrence of Red-capped Plover at MWTW may be a litmus test for the viability of the local population.

Many of the migrants from the northern hemisphere have been experiencing long term population declines both in the Hunter Region and throughout Australia (Geering *et al.* 2007). Numerous factors both local and external to Australia, such as the loss of feeding grounds on stop over foraging habitat along the shores of the Yellow Sea, in China and the Republic of South Korea are thought to have contributed to the decline. In the Hunter Region the loss of small wader species like the Red-necked Stint and the Curlew Sandpiper has been particularly dramatic. The general decline of these species in the Hunter Region would be expected to impact adversely on the frequency and numbers occasionally visiting MWTW. Our observations are consistent with this expectation, but as stated earlier the data were too sparse to quantify population trends rigorously.

CONCLUSIONS

The MWTW and the immediate surrounding area provide an important freshwater foraging opportunity for a number of shorebird species. Sharp-tailed Sandpiper numbers are sufficient to make MWTW an internationally important site for migratory shorebirds.

For several species the suitability of the area depends upon the existence of shallow water with muddy edges in low lying surrounding areas, which are intermittently flooded. The MWTW ponds are of minor importance to shorebirds and excess water flowing from the ponds has little impact on the extent of flooding in the external areas, which is primarily a consequence of run off following rainfall.

Our results suggest that in the Lower Hunter Region some shorebird species opportunistically exploit a mosaic of freshwater habitats, which other than MWTW are poorly monitored. Even the monthly surveys at MWTW are of inadequate frequency to track the dynamic response of the birds to rapid changes in the suitability of habitat, particularly in late spring and summer when flash flooding followed by rapid drying out occur.

When there are droughts in inland Australia, near-coastal localities in the Lower Hunter Region become extremely important drought refuges for species like the Sharp-tailed

Sandpiper, which occurs at internationally significant numbers. The importance of areas like MWTW as an integral part of that refuge system, where the occurrence of a species is episodic, can only be appreciated when long term studies like the one reported in this paper are conducted. Within the Hunter Region there are a number of flood plain basins which flood and dry out. With the exception of ephemeral water meadows between Lenaghans Drive at Minmi and the Hexham Swamp, an area also known to act as a drought refuge for Sharp-tailed Sandpiper (Stuart 1994-2010), these areas are not monitored. The function of these areas as shorebird habitat needs to be better understood because they are an important resource, which needs to be appropriately managed.

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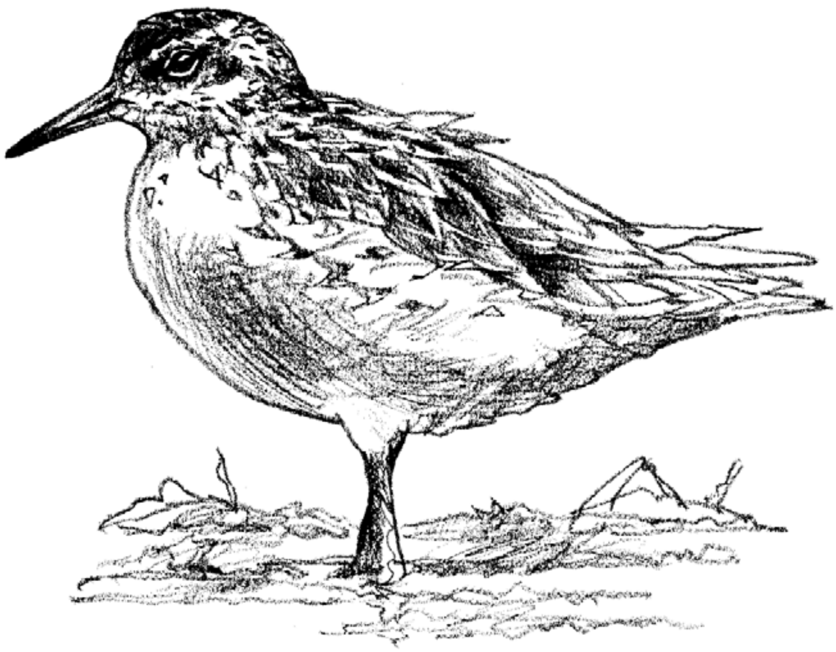

BARROW ISLAND AS AN IMPORTANT BIRD AREA FOR MIGRATORY WADERS IN THE EAST ASIAN-AUSTRALASIAN FLYWAY

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Little is known of the importance of continental islands to migratory birds off western Australia because few long-term studies on transequatorial migrants have been conducted in this region. In this study we report on the temporal and spatial use of a large offshore island off north-western Australia, Barrow Island, by migratory waders. While Barrow Island is a designated International Bird Area (IBA), little is known about the long-term seasonal abundance and distribution of waders using the island. The results of a three-year study lead us to propose that continental islands such as Barrow Island are important not just as staging sites but also as destination sites for four international migratory species. Twenty-two species of Holarctic-breeding waders and four species of migratory larids, among other non-migratory species, were recorded. Counts were highest during the southward migration and non-breeding periods in contrast to other island sites in northern Australia. Counts during the breeding period, when migrants move to northern latitudes, remained higher than has been recorded before, suggesting the island offers important "winter" habitat for non-breeding migratory waders. Our study suggests that the use of continental islands off north-western Australia by international migrants has been underestimated because the intra-annual and inter-annual records of island usage had not been recorded. The importance of Barrow Island within the East Asian-Australasian Flyway as an IBA can now be justified, based on the IBA criterion for congregations of Red-necked Stint *Calidris ruficollis*, and more than 1% of a biogeographic population of Red-necked Stint, Grey-tailed Tattler *Tringa brevipes*, Ruddy Turnstone *Arenaria interpres*, and Greater Sand Plover *Charadrius leschenaultii*. Our work also highlights the importance of seasonal observations of international migrants in the region, the role that continental island may play in this context, and potentially their importance in the East Asian-Australasian Flyway off north-western Australia.

INTRODUCTION

Recently there has been international recognition that many waders (or shorebirds) are experiencing global declines (International Wader Study Group 2003). A specific area of concern has been the East Asian-Australasian Flyway (EAAF), which covers more than 20 countries from northern Siberia to southern Australia and New Zealand. Scientists estimate this flyway supports more than eight million migratory waders annually (Bamford *et al.* 2008), yet relative to other global flyway systems, only little information on the status and migration routes of wader populations is known (International Wader Study Group 2003, Milton 2003). In addition, within these flyways, Important Bird Areas (IBAs), identified through the BirdLife International programme, provide a focus for the effective identification of habitats worth recognising for many migratory birds, yet the data to support their designation, based upon IBA recognition critertia, often remain limited (Dutson *et al.* 2009). While populated regions of Australia have good survey records for waders (Clemens *et al. in prep*), and with the exception of some records such as those from Roebuck Bay and Eighty Mile Beach, fewer records exist for remote, less populated regions in north-western Australia, and particularly for offshore continental islands. Waders commonly use coastal habitats, yet the importance of offshore islands with suitable habitat for these international migrants remains scarce.

The within- and between-year use of coastal habitats on offshore islands remains unclear because there have been few long-term studies on how frequently transequatorial migrants use these areas. Offshore islands, particularly across north and north-western Australia, are remote locations, limiting the survey capacity to collect systematic count data on the diversity and abundance of migratory species which use these areas during their breeding and non-breeding seasons. Consequently, data are often limited to support the significance of offshore islands as Important Bird Areas for migratory waders in the EAAF. Collecting information on the numbers of waders at a site over time, including their spatial abundance at a local scale, can facilitate the identification and protection of sites such as those designated as IBAs.

In Western Australia, Barrow Island is one of five islands or reefs offering suitable offshore habitats for trans-equatorial migrants (Bamford *et al*. 2008). It is relatively close to other continental island archipelagos in the area. Barrow Island has been designated an IBA, but little is known about the seasonal patterns of waders using the island. Historical island surveys recorded high numbers of resident and migratory species (Sedgwick 1978, Bamford & Bamford 2005). However, it remains unclear how migratory waders, as well as migratory larids, vary in abundance across the year or around the island. Previous studies by Sedgwick (1978) were limited to 10 days, although he noted over-wintering by 14 migrant species on Barrow Island.

While part of a larger study on waders and waterbirds around Barrow Island, this study aims to expand our knowledge of the long-term use of Barrow Island by migratory waders and migratory larids, and particularly transequatorial migrants, to address a lack of seasonal and spatial information on the use of this offshore island in the north west of Australia by this group of birds. To provide contextual information to count data, the variation in counts around the island is also included. The intent of this work is to expand on the information available for migrants using Barrow Island, and to also provide better evidence for the current recognition of Barrow Island as an IBA (Dutson *et al.* 2009).

METHODS

Study site

Barrow Island (20.82 °S, 115.39 °E) is Western Australia's second largest island (approximately 234 km^2, excluding the intertidal area), and is located off the Pilbara coast about 85 km north of the town of Onslow. It is the largest of a group of islands on Western Australia's north-west region which were separated from the mainland *ca*. 8000 years ago by rising sea levels (Chevron Australia 2005). The island was proclaimed as a Class A nature reserve in 1910, the most protected type of Crown (public) land designation in Western Australia, in recognition of its rich terrestrial ecosystems (Chevron Australia 2005).

Barrow Island has a semi-arid tropical climate which experiences two main seasons throughout the year: the hot, humid summer is characterized by high temperatures (20°C - 34°C daily average) and sporadic rainfall from tropical storms, while the warm, dry winters are typically cooler (17°C - 26°C daily average), with occasional rainfall from cold fronts (Chevron Australia 2005). As rainfall is highly variable between years and seasons, the flora of the island has affiliations with that of the arid parts of Western Australia's Carnarvon Basin and Pilbara regions (Mattiske 2005). Barrow Island's vertebrate fauna (including birdlife) is unusually rich and abundant, due to an absence of introduced predators and competitors (Chevron Australia 2005).

Field surveys

The study was conducted as part of a larger study of seasonal waders and waterbirds using Barrow Island. The study supported an environmental impact assessment for a liquefied natural gas (LNG) development on Barrow Island, with the aim of providing baseline information for any future actions in support of an island ecological monitoring program. Surveys of waders and waterbirds were undertaken monthly for 13 months, from September 2003 to September 2004, and additionally during October 2005 and February/March 2006 to coincide with the non-breeding period when migratory waders and migratory larids were present in the area. Surveys were based upon monthly high tide roost counts of as much of the shoreline as possible, and were conducted over five, rarely four days by experienced counters using binoculars and telescopes. Counts were carried out during high tide and on days when the maximum tide was at least 2.7 m (WAPET Landing datum). Birds were counted individually, where possible, but when large flocks were encountered, standard approaches of estimation were used, such as block counting and using the proportion of each species determined from a detailed count to estimate the number of that species present in a mixed flock (Lane 1987). Due to different flocking behaviours of waders, count data remain biased towards those species that roost in flocks and which utilise tidal shore-lines during high tides. Those species that do not flock are likely to be overlooked or under-surveyed. Nomenclature and taxonomy follows that of Christidis & Boles (2008).

For the purposes of the survey, Barrow Island was divided into 12 regions, each consisting of individual bays, beaches and headlands (Figure 1). Within each region, birds were recorded as being located at a roost where ten or more birds were concentrated. The co-ordinates of each roost (WGS84 datum) were recorded using a hand-held GPS unit. All survey regions were visited from January to September 2004, and in October 2004 and February/March 2006. Coverage was less complete in September 2003 (six regions visited), October and December 2003 (10 regions visited) and November 2003 (11 regions visited). However, those regions where waders were concentrated (South, South-East and Lower East regions) were visited on all surveys. To facilitate comparison of island-wide abundance between months, abundances at coastal regions that were unsurveyed were estimated for the September to December 2003 period using data from January to March 2004. This estimation was considered valid as the proportional distribution of birds around the coastline was consistent across seasons during those periods when complete surveys were conducted.

Reporting of count observations was stratified into the annual life history breeding and migration cycles for waders following Bamford *et al.* (2008): breeding (June-August, equivalent to the Austral Winter), southward migration (September to November, equivalent to the Austral Spring), non-breeding (December to February, equivalent to the Austral Summer), northward migration (March to May, equivalent to the Austral Autumn). Seasonal terms such as winter and spring are preferentially avoided where possible.

Aside from migratory species, we also provide contextual information on total counts of waders and waterbirds, and limited information on Australian (non-migratory) waders and waterbirds that allows us to compare migrant counts with non-migrant counts across the seasons. Complete species lists can be found in Chevron Australia (2005).

RESULTS

Total counts of waders and waterbirds

Counts of waders and waterbirds on Barrow Island varied seasonally and annually. Total monthly counts (all species pooled) in each of the surveys on Barrow Island are presented in Figure 2. Time-series data show that over 200,000 individual wader records were made during the survey period. These included 48 species representing six major guilds: 22 species of Holarctic-breeding waders, four species of migratory larids, four species of Australian-breeding waders, eight species of non-migratory larids, pelican and cormorants, and six species of herons, egrets and ibis. The highest monthly count of all birds was 20,428 in September 2004, although high counts (>15,000 birds) were also recorded from October 2003 through to March 2004, and in February 2006 (Figure 2).

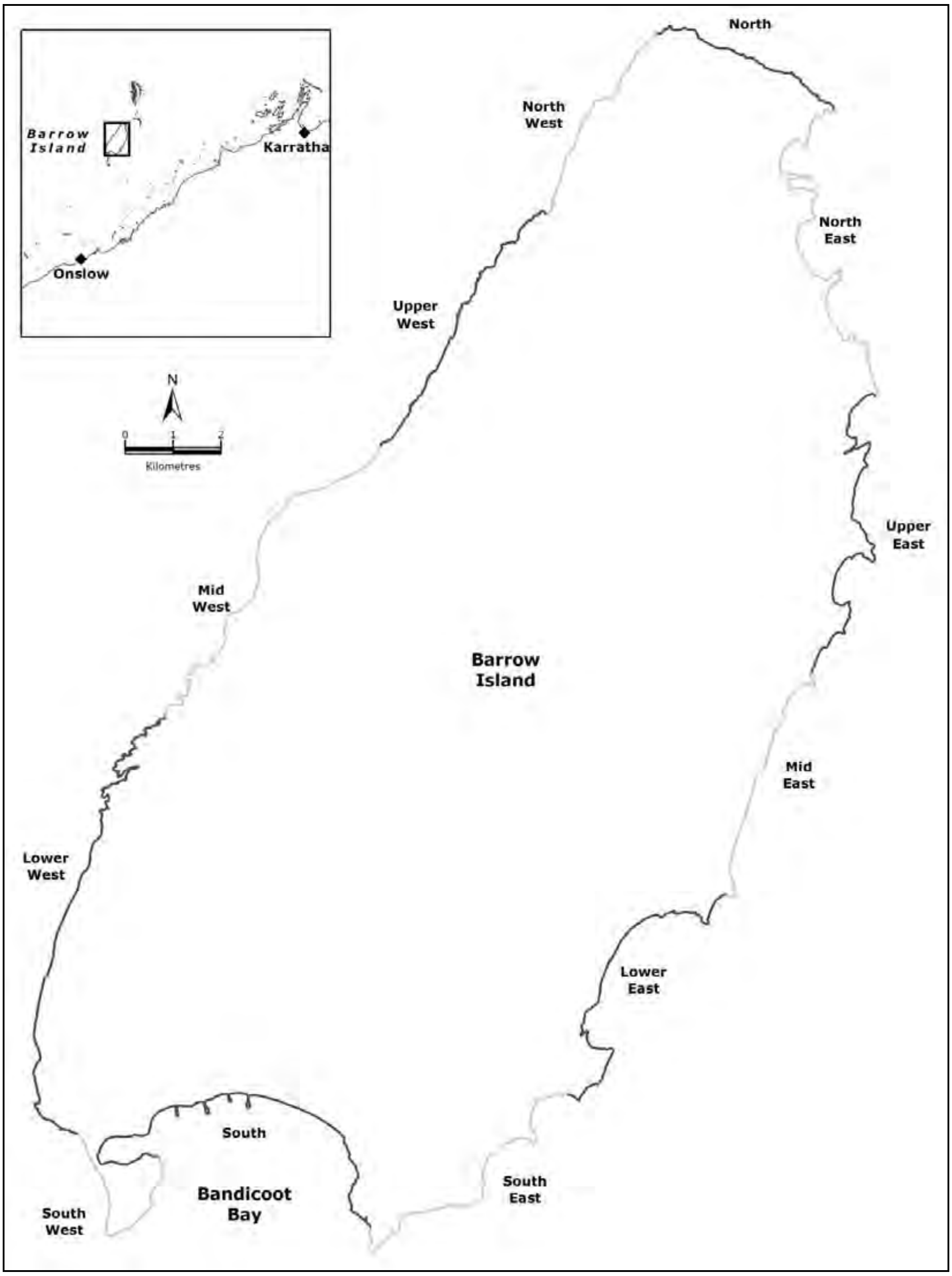

Figure 1. Wader and waterbird survey regions around Barrow Island. Survey regions around the island are indicated with different shades of grey and have been named for the purposes of this survey.

Holarctic-breeding (migratory) waders

Twenty-two species of Holarctic-breeding wader were recorded on Barrow Island (Table 1), of which five species were recorded with high (>1000) maximum monthly counts at least once during the survey: Bar-tailed Godwit *Limosa lapponica*, Grey-tailed Tattler *Tringa brevipes*, Ruddy Turnstone *Arenaria interpres*, Red-necked Stint *Calidris ruficollis* and Greater Sand Plover *Charadrius leschenaultii*. Numbers of species increased during the southward migration months (18 species), remained at a high level during the non-breeding months (18 species), declined during the northward migration (17 species) and were at a lower level during the breeding months (13 species) (Figure 3). Transequatorial migrants such as Bar-tailed Godwit, Grey-tailed Tattler, Ruddy Turnstone, Red-necked Stint and Greater Sand Plover in particular followed this general pattern (Figure 4). However, numbers of Bar-tailed Godwit were consistently high over the non-breeding period, then peaked (counts > 1000 birds) during the early period of their northward migration in March 2004 before declining in

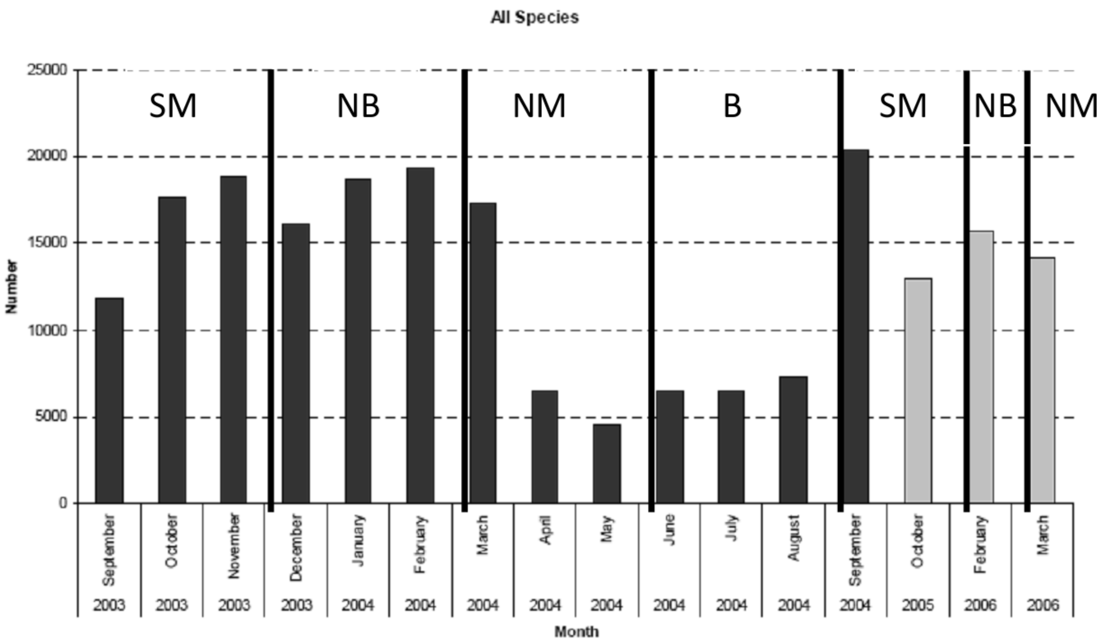

Figure 2. Total monthly counts of waders and waterbirds on Barrow Island September 2003-March 2006. Consecutive monthly counts are represented by black bars, additional monthly counts are represented by grey bars. Counts from September 2003 to December 2003 include numbers that were estimated based on proportions in complete counts. Months are separated into the four life history periods for waders (following Bamford *et al.* 2008): NB, non-breeding; NM, northward migration; B, breeding; SM, southward migration.

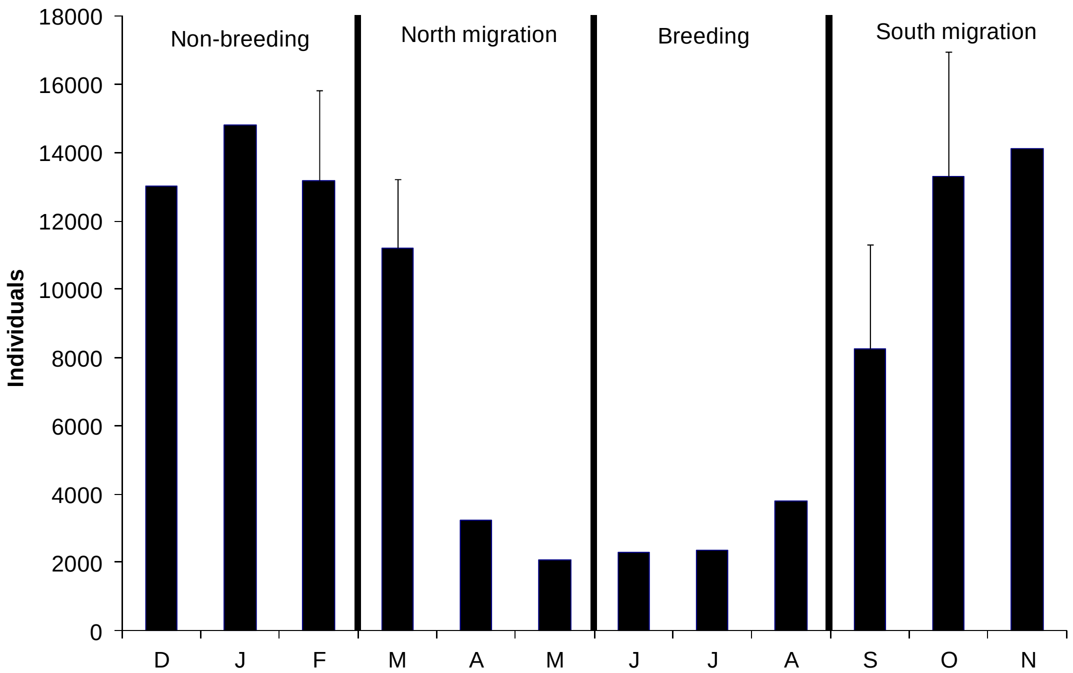

Figure 3. Total (or mean ±SD, where there was more than one survey) monthly counts for Holarctic-breeding waders on Barrow Island September 2003-March 2006. Life history periods as for Figure 2.

numbers rapidly later during this period (Figure 4a). Grey-tailed Tattler and Ruddy Turnstone counts were similar (Figure 4b, 4c, respectively) whereas counts of Red-necked Stint and Greater Sand Plover showed variation between months (Figure 4d, 4e, respectively). The presence of these five migrants during the Austral winter, representing approximately 10 % of the non-breeding period population on Barrow Island, suggests the island supports non-breeding individuals throughout the whole year.

Nine species (Eastern Curlew *Numenius madagascariensis*, Terek Sandpiper *Xenus cinereus*, Common Sandpiper *Actitis hypoleucos*, Red Knot *Calidris canutus*, Sanderling *Calidris alba*, Sharp-tailed Sandpiper *Calidris acuminata*, Curlew Sandpiper *Calidris ferruginea*,

Table 1. Holarctic-breeding waders and migratory larids recorded during the survey period on Barrow Island, September 2003-March 2006. Numbers are seasonal averages (standard error in brackets) separated into life-history periods: NB, non-breeding; NM, northward migration; B, breeding; SM, southward migration.

Species	2003	2003/04			2005	2006		Max[a]
	SM	NB	NM	B	SM	NB	NM	
Waders								
Bar-tailed Godwit	706 (264)	956 (12)	462 (527)	95 (21)	818 (25)	768	700	1070
Little Curlew	0 (1)	0 (1)	0	0	0	0	0	1
Whimbrel	65 (27)	70 (27)	63 (31)	32 (10)	75 (13)	64	59	97
Eastern Curlew	5 (3)	4 (2)	3 (2)	1 (1)	4 (1)	1	2	8
Marsh Sandpiper	0 (1)	0	0	0	0	0	0	1
Common Greenshank	159 (78)	239 (23)	63 (40)	38 (20)	179 (13)	228	86	266
Terek Sandpiper	8 (7)	10 (7)	7 (3)	1 (1)	5 (4)	5	9	16
Common Sandpiper	43 (5)	36 (5)	8 (11)	13 (16)	35 (1)	41	20	47
Grey-tailed Tattler	2040 (695)	2511 (136)	1354 (1082)	490 (90)	1770 (197)	2188	2361	2719
Ruddy Turnstone	1759 (361)	1696 (32)	658 (931)	148 (68)	1451 (35)	1712	1429	2173
Great Knot	348 (73)	366 (44)	139 (222)	40 (44)	298 (68)	179	114	432
Red Knot	12 (12)	6 (1)	5 (9)	0	5 (4)	0	3	23
Sanderling	94 (124)	86 (37)	40 (50)	11 (15)	91 (3)	97	54	235
Red-necked Stint	6500 (1845)	6682 (824)	2275 (2232)	1181 (194)	4198 (259)	4447	3697	7933
Sharp-tailed Sandpiper	3 (2)	4 (4)	0	0	5 (3)	4	1	9
Curlew Sandpiper	168 (88)	147 (20)	32 (46)	21 (29)	92 (18)	58	49	268
Pacific Golden Plover	28 (27)	24 (3)	10 (17)	1 (1)	16 (17)	23	24	53
Grey Plover	117 (38)	168 (24)	65 (98)	13 (6)	126 (47)	113	88	188
Lesser Sand Plover	554 (310)	617 (59)	482 (364)	351 (32)	407 (215)	246	538	902
Greater Sand Plover	732 (379)	661 (159)	313 (162)	384 (341)	1003 (141)	1158	562	1158
Oriental Plover	0	0 (1)	0	0	0	0	0	1
Oriental Pratincole	0	0	2 (3)	0	0	0	0	5
Larids								
Roseate Tern	15 (27)	3 (5)	0 (1)	461 (356)	3675 (5127)	0	0	7300
Common Tern	609 (1047)	759 (193)	268 (429)	0	131 (166)	634	735	1818
Little Tern	22 (19)	7 (10)	15 (14)	0	36 (50)	8	27	71
White-winged Black Tern	105 (181)	62 (79)	47 (81)	0	0	0	0	314

Pacific Golden Plover *Pluvialis fulva*, and Grey Plover *Pluvialis squatarola*) showed limited or no evidence of over-wintering on Barrow Island during their breeding period (Table 1). In contrast to the seasonal patterns of Holarctic-breeding wader counts, non-migrant wader and larid counts show consistent abundances across the year (Figure 5), suggesting that counts of migrants reflected true variation rather than any bias in survey methodology.

Migratory waders were widely distributed around the shoreline of Barrow Island (Figure 6). These areas coincided with shallow intertidal rock platforms. More than two-thirds of the Holarctic-breeding waders were concentrated in the south and south-east of Barrow Island across seasons (Figure 6), where there are extensive tidal mudflats. In addition, one area in the north-east of the Island recorded high numbers, in particular, for Grey-tailed Tattler and Ruddy Turnstone (Figure 6b, 6c, respectively). Among the less abundant species, the Sanderling was recorded mainly in the south-west region. There was little evidence of seasonal variation in distribution of Holarctic-breeding waders between eastern and western regions of the Barrow Island shoreline

Migratory larids

Four species of migratory larids were recorded (Table 1): Common Tern *Sterna hirundo* (1818 maximum monthly count), Little Tern *Sternula albifrons* (71), White-winged Black Tern *Chlidonias leucopterus* (314), and most abundant the Roseate Tern *Sterna dougallii* (7300). Unlike Holarctic-breeding waders, the maximum counts of migratory larids occurred during the southward migration, where a pulse increase of larids were recorded during this period in 2005 commensurate with an influx of Roseate Tern to the island (Figure 7). The Common Tern contributed significantly to the overall southward migration peak, with a maximum count of 1818 birds recorded during November 2003. White-winged Black Tern were highest in numbers during the late southward migration and during the non-breeding periods. Only Roseate Tern remained on Barrow Island during the breeding period (Table 1), but were not recorded breeding there. Migratory larids were distributed around Barrow Island with the north of the island hosting the highest numbers during southward migration (Figure 8).

DISCUSSION

Barrow Island supports large numbers of waders and waterbirds, with over 214,000 individuals comprising 51 species recorded during the survey period. Holarctic migrants utilising the EAAF represented 53 % (27, or 28 if Roseate Tern are included) of these species. Maximum monthly counts peaked seasonally, with almost 20,500 waders and larids recorded during the southward migration in 2005, including 3675 Roseate Tern. Other abundant species were the Red-necked Stint, Grey-tailed Tattler, and

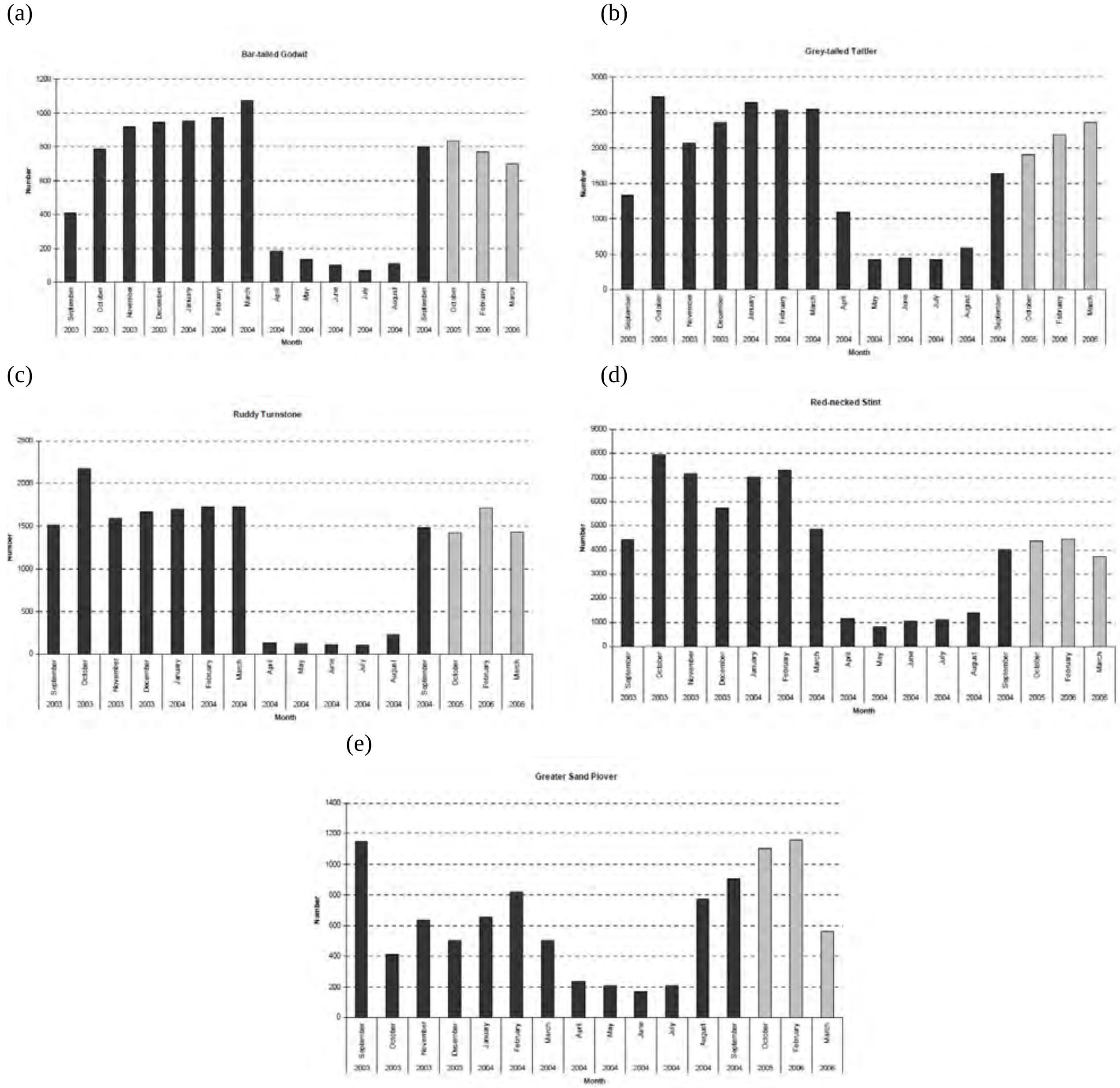

Figure 4. Total monthly counts of a) Bar-tailed Godwit, b) Grey-tailed Tattler, c) Ruddy Turnstone, d) Red-necked Stint, e) Greater Sand Plover on Barrow Island September 2003-March 2006. Consecutive monthly counts are represented by black bars, additional monthly counts are represented by grey bars.

Ruddy Turnstone; all three species have been recorded historically on Barrow Island during their southward migration and at similar proportions (Sedgwick 1978) to the current study. Interestingly, Black-tailed Godwit were also recorded historically (Sedgwick 1978), however they were a species not seen during the current study. Among non-migratory waders and other waterbird species, historical counts were broadly similar (Sedgwick 1978) to those obtained in the present study. Barrow Island is also significant for the Sooty Oystercatcher *Haematopus fuliginosus ophthalmicus* (Christidis & Boles 2008).

Overall, wader abundances were lower in the 2005 and 2006 survey months compared with corresponding surveys the previous years. This decline may have been influenced by the creation of inland wetlands to which some species like Red-necked Stint may respond to and move (Higgins & Davies 1996). Summer rainfall was heavy and extensive across the mainland Pilbara and nearby regions following five cyclones during 2005 to 2006, with flooding of massive ephemeral wetlands creating alternative habitat for many waterbirds in the region.

One notable finding from this survey was the large numbers of Holarctic-breeding waders that remained on Barrow Island over their non-breeding period during both the 2003/2004 and 2005/2006 survey months. This pattern contrasts to that observed at some nearby mainland sites in the Pilbara where species tend to use shorelines largely as staging areas as they migrate further south (Bamford *et al.* 2008). While southward migration on Barrow Island was evident for Greater Sand Plover in September 2003, and Sanderling and Lesser Sand Plover *Charadrius mongolus* in October 2003, the abundance of other species (e.g. Grey-

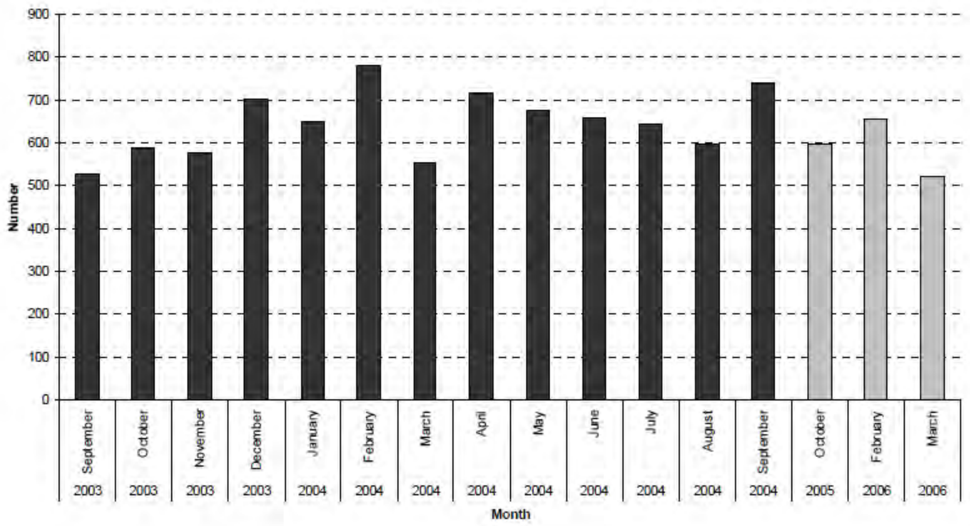

Figure 5. Total monthly counts of Australian-breeding waders and larids (combined) sighted on Barrow Island, September 2003-March 2006. Consecutive monthly counts are represented by black bars, additional monthly counts are represented by grey bars. Counts from September 2003 to December 2003 include numbers that were estimated based on proportions in complete counts.

tailed Tattler *Heteroscelus brevipes*, Ruddy Turnstone, Bar-tailed Godwit) varied little between the southward migration and non-breeding periods. Some migrants stayed on the island following their arrival in September, suggesting the island serves as an important destination site during their non-breeding period. Sites such as Barrow Island, and potentially other continental islands in the region, are therefore important for Ruddy Turnstone and Bar-tailed Godwit in particular, because recent population trend information over 30 years suggests these species show consistent declines (Amano *et al*. 2010).

During the northern breeding period, and aligned to historical observations during August 1976 (Sedgwick 1978), Barrow Island remained an important site hosting large numbers of non-breeding migratory waders. Elsewhere in northern Australia, Chatto (2003) and Bamford *et al*. (2008) made similar observations of significant numbers of wader species which remained at several mainland sites during their (northern hemisphere) breeding period. While Barrow Island effectively acts as an important staging and non-breeding site for some migratory species, our survey found that it is also an important site for non-breeding – and presumably immature - birds (in particular, Red-necked Stint, Grey-tailed Tattler, Ruddy Turnstone and Greater Sand Plover) that do not migrate to the northern hemisphere in the Austral autumn. Islands, such as Barrow Island, that provide habitat either for different age cohorts, or for adult individuals who skip a breeding season, are important because these sites support potential recruits into the breeding population for some wader species.

The importance of sites in the north-west of Australia during the northward migration remains unclear. While the Bar-tailed Godwit increased slightly in abundance in March 2004, most species declined in numbers. Observations of count data suggest that Barrow Island is of minor importance, however there is only one year of observations available and in that year there was a cyclone that could have had a significant influence on the presence of waders.

High counts of Roseate Tern on Barrow Island, and recorded previously on the adjacent coastline (Astron Environmental 2002), may be significant for this migratory species. It remains unclear whether individuals represented the east Asian race of Roseate Tern (*S. dougallii bangsi*): the Roseate Tern on Barrow Island may include birds dispersing from southern breeding areas (e.g. the Abrolhos, which includes Austral autumn-winter breeding populations as well as spring-summer breeders), or birds dispersing from breeding sites in the Pilbara and Kimberley in northern Australia, where breeding occurs in Austral autumn-winter (Higgins & Davies 1996, Johnstone & Storr 1998). A November peak of Common Terns, followed months later by a decline in their abundance, is consistent with their southward movement through Barrow Island. Population estimates for Common Terns in the north-west of Australia are uncertain and therefore the regional significance of over 1708 Common Terns in November 2003 is interesting but remains unclear. Barrow Island is also significant for Fairy Terns (8.3 % of the estimated population in the EAAF).

While Barrow Island is listed as an IBA because of its importance for waders, our current information extends our understanding of the significance of this site. Monthly counts of four species (Red-necked Stint, Grey-tailed Tattler, Ruddy Turnstone and Greater Sand Plover) qualify Barrow Island as an internationally-significant migratory wader site under the Ramsar Convention for supporting >1 % of a species' population in the EAAF (Ramsar Convention Bureau 2000) (Table 2). Furthermore, counts of seven species using Barrow Island (Red-necked Stint, Bar-tailed Godwit, Grey-tailed Tattler, Ruddy Turnstone, Greater Sand Plover, Common Greenshank, Lesser Sand Plover) during their southward or northward migration periods met the staging criterion (at least 0.25 % of a species' population) of the

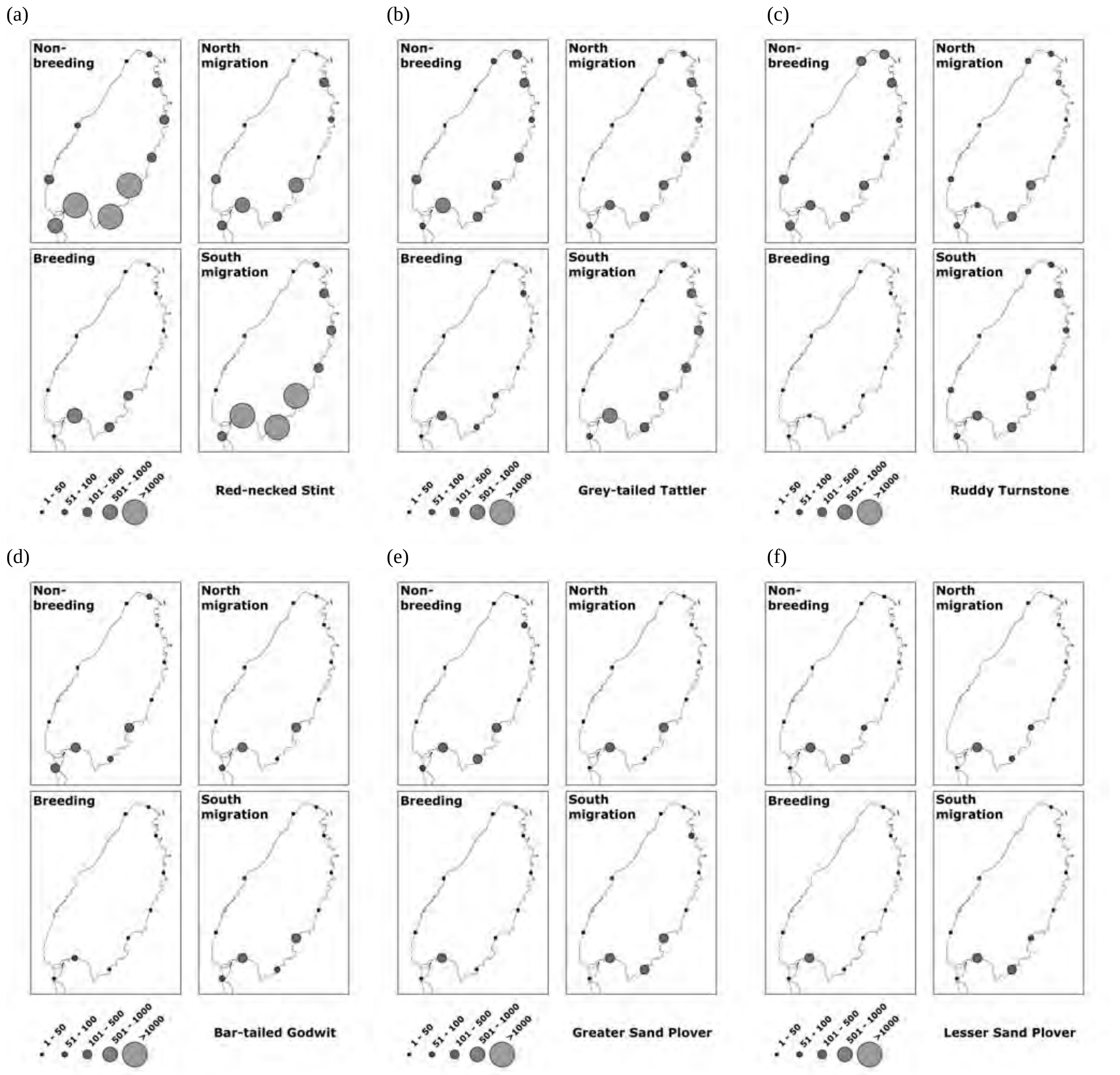

Figure 6. Seasonal distribution of Holarctic-breeding waders sighted around Barrow Island, September 2003-March 2006. Circles represent monthly average counts of birds per season. Life history periods as for Figure 2.

Ramsar Convention (Table 2). On the basis of the importance of Barrow Island for seven migratory waders, Barrow Island is equal tenth among the 147 important sites for migratory waders in Australia (Bamford *et al.* 2008). For the Grey-tailed Tattler and Ruddy Turnstone, it is the fifth and fourth-most important site in Australia, respectively

The highest abundances of migratory waders (over two-thirds of records of most species) were concentrated in the extensive tidal mudflats in the south and southeast of the Island. These areas are important for roosting and foraging and the birds appear to roost close to their foraging sites. The habitat in Bandicoot Bay in the south of Barrow Island offers a large intertidal reef for waders and is protected as part of the Bandicoot Bay Conservation Area (Department of Environment and Conservation 2007).

The broader implications of our study are that the importance of continental islands off north-western Australia during the year may be underestimated, and we encourage the collection and reporting of seasonal data on waders at additional offshore locations to identify site fidelity to non-breeding and staging sites which can give indications on the importance and potentially quality of these sites (Piersma & Lindström 2004). To function effectively to protect transequatorial migrants, offshore islands as Important Bird Areas need the appropriate level of temporal and spatial data to allow informed decisions to be made about their protection or their use. With mainland sites experiencing pressures from a variety of threats (such as non-indigenous species and land clearing), islands that support significant numbers of migratory birds are therefore extremely

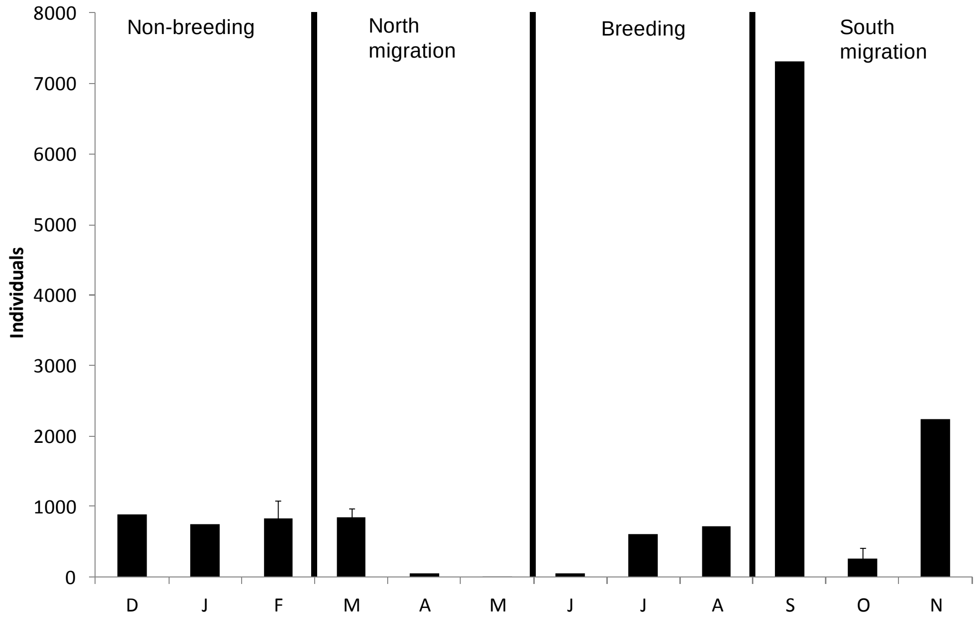

Figure 7. Total (or mean ±SD, where there was more than one survey) monthly counts for migratory larids on Barrow Island September 2003-March 2006. Life history periods as for Figure 2.

important in their own right, as well as being potential refugia for immature birds of some species of global significance. Specifically, the importance of Barrow Island within the EAAF is greater than previously suggested (Bamford *et al*. 2008). Conservation of key sites, such as islands, is important to maintain the migration of many wader populations in the EAAF.

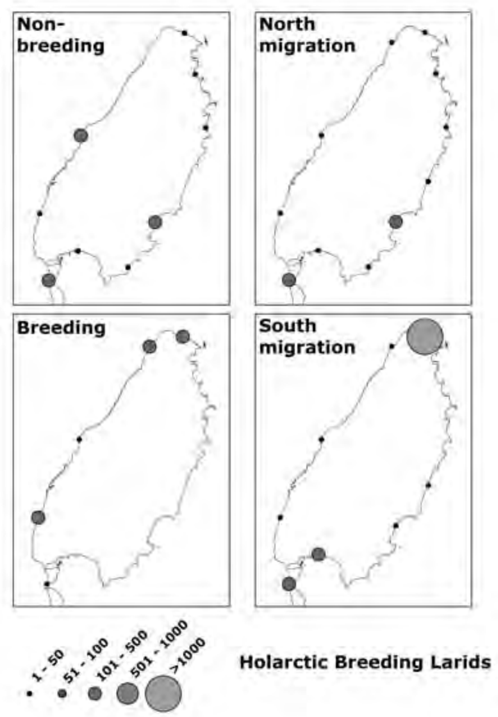

Figure 8. Distribution of migratory larids sighted around Barrow Island, September 2003-March 2006. Circles represent monthly average counts of birds per season. Life history periods as for Figure 2.

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Table 2. Holarctic-breeding waders that were well-represented during the survey period on Barrow Island, September 2003-March 2006. (Shading represents species that meet a population threshold for important sites nationally and internationally. Counts are separated into the four life history periods for waders [following Bamford *et al.* 2008]: NB, non-breeding; NM, northward migration; B, breeding; SM, southward migration.)

Species	Maximum monthly count	EAA Flyway population estimate*	1% of EAA Flyway population threshold*	Staging threshold (0.25% of flyway)*	Global population estimate (minimum)**	1% of global population threshold
Red-necked Stint	7933 (SM) 7291 (NB) 4845 (NM) 1400 (B)	325,000	3250	813	315,000	3150
Bar-tailed Godwit	917 (SM) 970 (NB) 1070 (NM) 110 (B)	160,000	1600	400	1,060,000	10,600
Grey-tailed Tattler	2719 (SM) 2634 (NB) 2543 (NM) 594 (B)	50,000	500	125	40,000	4000
Ruddy Turnstone	2173 (SM) 1725 (NB) 1733 (NM) 227 (B)	35,000	350	88	475,000	4750
Greater Sand Plover	1151 (SM) 1158 (NB) 562 (NM) 777 (B)	110,000	1100	275	175,000	1750
Common Greenshank	212 (SM) 266 (NB) 108 (NM) 59 (B)	60,000	600	150	399,000	3990
Lesser Sand Plover	838 (SM) 654 (NB) 902 (NM) 388 (B)	140,000	1400	350	130,000	1300

*Adopted from Bamford *et al.* (2008)
** Adopted from Delany and Scott (2006)

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THE FIRST RECORD OF OVER-SUMMERING SPOON-BILLED SANDPIPER *EURYNORHYNCHUS PYGMEUS* IN THAILAND

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During routine monthly surveys of over-summering shorebirds and other waterbirds conducted by the Wildlife Research Division of the Department of National Parks, Wildlife and Plants Conservation of the Thai government, a single Spoon-billed Sandpiper *Eurynorhynchus pygmeus* was found feeding among Red-necked Stints *Calidris ruficollis* on newly accreting intertidal mudflats at Khok Kham, Samut Sakhon Province, Thailand (*c.* 13° 31’ N; 100° 19’ E) on 19 July 2010. Many shorebirds display delayed maturity, not returning to natal sites until their second or third year (Loftin 1962, Summers *et al*. 1995, Rogers *et al*. 2006) and it has long been assumed that first-year Spoon-billed Sandpipers do likewise (Tomkovich 1995, Zöckler *et al*. 2010a). This appears to be the first documented record of a Spoon-billed Sandpiper over-summering in the non-breeding grounds. Given the critically endangered status and ongoing rapid population decline of Spoon-billed Sandpipers (Zöckler *et al*. 2010a, b), this over-summering record is highly significant.

The same individual was photographed by SS almost one month later, on 16 August 2010, when it roosted on salt-pans. Its primaries were in active moult, with score being “555554[1 or 2] 000” and the tertials had been dropped or were growing. A few black-centred, breeding plumage feathers were visible in the mantle and scapulars, but the bird was otherwise in grey, non-breeding plumage (Figures 1 and 2).

The outermost three (unmoulted) primaries were extremely bleached, brownish and pointed, supporting the supposition that this was a first-summer bird. Although first-year shorebirds frequently renew a few outer primaries in a partial post-juvenile moult, some do not, and there are many species in which only a proportion of the population undergoes such a moult (Higgins & Davies 1996, Marchant & Higgins 1993, D. Rogers, *in litt*.). While the detailed ontogeny of the moult of Spoon-billed Sandpiper appears to be unreported, the extreme wear and bleaching of the outer primaries of the present individual was thought typical among unmoulted first-summer shorebirds. Additionally, the primary moult (more than 50% completed by mid-August) was too advanced to indicate normal post-breeding moult of an adult (C.D.T. Minton, *in litt*., D. Rogers, *in litt*.).

What was thought to be the same bird was seen on 17 and 21 September when its stage of moult had progressed to the extent that it more or less resembled “typical” non-breeding adults (S. Daengphayon, *pers. comm.*). The latter sightings still pre-dated the arrival of non-breeding Spoon-billed Sandpipers in the Thai Gulf, usually occurring in October (Round & Gardner 2008).

Khok Kham and nearby sites in Samut Sakhon Province constitute one of two major clusters of sites in the Thai Inner Gulf where about 10–20 Spoon-billed Sandpipers regularly winter (Nimnuan & Daengphayon 2008, Round & Gardner 2008). The initial sighting, on newly accreting mudflats, may be highly relevant to the habitat preference of Spoon-billed Sandpipers which, in some parts of their non-breeding range (especially the Meghna Delta of Bangladesh), appear to

Figure 1. Over-summering Spoon-billed Sandpiper with wing extended, enabling determination of primary moult status. Khok Kham, Samut Sakhon Province, Thailand, 16 August 2010 (Photo: *Smith Sutibut*)

Figure 2. Over-summing Spoon-billed Sandpiper showing upperparts feathering. Khok Kham, Samut Sakhon Province, Thailand, 16 August 2010 (Photo: *Smith Sutibut*).

favour accreting shorelines. (Enam ul-Haque, *in litt*.). The observation was made at the site of a conservation project which is successfully reversing coastal erosion using traditional methods (bamboo stakes) instead of intrusive concrete sea-walls, administered by the Department of Marine and Coastal Resources, in collaboration with the local community. Such accreting sites may be a valuable though highly transient resource for Spoon-billed Sandpipers. Experience in Bangladesh shows that as the substrate stabilises and compacts, Spoon-billed Sandpipers are among the first shorebirds to disappear, presumably moving elsewhere (Enam ul-Haque, *in litt.).* In Thailand, more coastline is eroding rather than accreting, and erosion is worsened by subsidence (caused by the unregulated extraction of ground water), reduced sediment inflow due to dam construction on rivers, and unzoned developments in the coastal zone. At least 130 sq km in 18 Thai coastal provinces were planted with mangroves during 1998–2003 (Round & Gardner 2008) to offset erosion. Since provincial and national authorities frequently choose to plant mangrove seedlings on mudflats, overtaking the process of natural succession, this could further deprive Spoon-billed Sandpipers and other shorebirds of key intertidal feeding areas. Integrated management and zoning of the both onshore and offshore habitats along the Inner Gulf coast should be adopted so as to restrict inappropriate developments, reduce erosion, and rehabilitate both onshore and offshore habitats. This would safeguard both shorebirds and other biodiversity values, and sustain the traditional (salt-farming and inshore fishing) lifestyles of the human inhabitants.

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WADER BREEDING SUCCESS IN THE 2010 ARCTIC SUMMER, BASED ON JUVENILE RATIOS OF BIRDS WHICH SPEND THE NON-BREEDING SEASON IN AUSTRALIA

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INTRODUCTION

This paper gives the results for 2010/2011 of the “percentage juvenile sampling” carried out in south-east Australia and in north-west Australia during the November 2010 to March 2011 wader non-breeding season. This is the time when wader populations in Australia are relatively stable, with all juvenile birds having arrived and before northward migration of adults has commenced. The percentage of juveniles in these catches is an indication of breeding success in the previous Arctic summer (in this case 2010). It is intended to provide an index and is not necessarily an absolute measurement of breeding success for the whole population.

Percentage juvenile data has now been systematically collected over 33 seasons for some species in south-east Australia and for 13 years in north-west Australia. Since 2000, the results have been published annually in Arctic Birds and in *Stilt* (Minton *et al*. 2000, 2009, 2010). The long series of data now enables each year’s activity to be viewed in context and periods of above or below average breeding success to be identified. Breeding productivity measured this way is a key parameter to monitor, especially at a time when many wader populations in the East Asian-Australasian Flyway are declining rapidly (Stroud *et al.* 2006).

METHODS

Data was collected in 2010/2011 using standard cannon-netting techniques (Minton *et al.* 2005). Median counts were generated from previously published data contained within Minton *et al.* (2005), and data reported in this study. All birds included in the analysis were generally caught at the same range of sites as for previous years. The timing of catches is also similar in most years, although in this last season the main catching in north-west Australia was carried out in the second half of February/early March rather than the usual November/early December period. Also the results of Ruddy Turnstone catching in King Island in the period 5–12 April are included in the south-east Australia analysis because no adult birds had yet departed and because King Island birds were a significant part of the sample in other recent years.

RESULTS AND DISCUSSION

The data is presented in a range of tables (Tables 1 to 4), consistent with previous studies (Minton *et al.* 2009, 2010).

South-east Australia

In south-east Australia it was not possible, for the first time ever, to obtain samples of Curlew Sandpiper (*Calidirs ferruginea*) and Sharp-tailed Sandpiper (*Calidris acuminata*). Sampling of Red-necked Stint (*Calidris ruficollis*) was also reduced compared to recent years. This is attributed to exceptional circumstances whereby regular heavy rainfall across the whole of inland Australia occurred in almost every month from April 2010 up to the present time (May 2011). The net result was large numbers of ephemeral wetlands across inland Australia providing alternative suitable wader habitat. We believe that Sharp-tailed Sandpiper, which prefer inland freshwater habitats if available, and many Curlew Sandpiper and Red-necked Stint, stop at these wetlands during southward migration across the continent. Small waders have often been reported using temporary inland wetlands but most of these normally dry up during the hot December to February period each year forcing waders to continue on to the coastal non-breeding areas. Ongoing inland rains meant that they did not reach our main catch sites on the Victorian coast in the 2010/2011 sampling period.

Good catching success was nevertheless achieved on

Table 1. Percentage of juvenile/first year waders in cannon-net catches in south-east Australia in 2010/2011

Species	No. of catches		Total caught	Juv/1st year		Long term median* % juvenile (years)	Assessment of 2010 breeding success
	Large (>50)	Small (<50)		No.	%		
Red-necked Stint *Calidris ruficollis*	6	5	1219	249	**20.4**	14.1 (32)	Good
Curlew Sandpiper *C. ferruginea*	0	0	0	0	-	10.6 (31)	-
Bar-tailed Godwit *Limosa lapponica*	3	0	284	29	**10.2**	19.4 (21)	Poor
Red Knot *C. Canutus*	0	4	63	49	**77.8**	52.1 (17)	Very good
Ruddy Turnstone *Arenaria intepres*	1	17	446	114	**25.6**	9.8 (20)	Very good
Sanderling *C.Alba*	1	0	70	15	**21.4**	12.6 (19)	Good
Sharp-tailed Sandpiper *C. Acuminata*	0	0	0	0	-	11.6 (29)	-

All birds cannon-netted in period 15 November to 28 February except for Red-necked Stint, Ruddy Turnstone, and Sanderling, for which catches up to 25 March are included.
* Does **not** include the 2010/2011 figures

Table 2. Percentage of juvenile/first year waders in cannon-net catches in north-west Australia in 2010/2011

Species	No. of catches Large (>50)	No. of catches Small (<50)	Total caught	Juv/1st year No.	Juv/1st year %	ASSESSMENT OF 2010 breeding success
Great Knot *Calidris tenuirostris*	8	4	1166	279	**23.9**	Excellent
Bar-tailed Godwit *Limosa lapponica*	3	5	365	78	**21.3**	Excellent
Red-necked Stint *C. ruficollis*	2	4	432	80	**18.5**	Average
Red Knot *C. canutus*	2	7	210	34	**16.2**	Average
Curlew Sandpiper *C. ferruginea*	0	6	82	20	**24.4**	Good
Ruddy Turnstone *Arenaria intepres*	0	4	4	1	-	-
Sanderling C. *alba*	0	3	3	1	-	-
Sharp-tailed Sandpiper *C. acuminata*	0	0	0	0	-	-
Non-arctic northern migrants						
Greater Sand Plover *Charadrius leschenaultii*	4	6	586	100	**17.1**	Poor
Terek Sandpiper *Xenus cinereus*	1	6	151	38	**25.2**	Very good
Grey-tailed Tattler *Heteroscelus brevipes*	1	10	130	41	**31.5**	Very good
Broad-billed Sandpiper *Limicola falcinellus*	0	2	29	17	**58.6**	Very good

All birds cannon-netted in period 1 November to mid-March

Table 3. Percentage of first year birds in wader catches in south-east Australia 1998/1999 to 2010/2011

Species	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	*Average (12 yrs)*
Ruddy Turnstone	6.2	29	10	9.3	17	6.7	12	28	1.3	19	0.7	19	26	*13.2*
Red-necked Stint	32	23	13	35	13	23	10	7.4	14	10	15	12	20	*17.0*
Curlew Sandpiper	4.1	20	6.8	27	15	15	22	27	4.9	33	10	27	-	*17.6*
Sharp-tailed Sandpiper	11	10	16	7.9	20	39	42	27	12	20	3.6	32	-	*20.0*
Sanderling	10	13	2.9	10	43	2.7	16	62	0.5	14	2.9	19	21	*16.3*
Red Knot	(2.8)	38	52	69	(92)	(86)	29	73	58	(75)	(-)	(-)	78	*53.1*
Bar-tailed Godwit	41	19	3.6	1.4	16	2.3	38	40	26	56	29	31	10	*25.1*

All birds cannon-netted between mid November and 25 March (except Sharp-tailed Sandpiper and Curlew Sandpiper to end February only). Averages (for previous 12 years) exclude figures in brackets (small samples) and **exclude** 2010/2011 figures

Table 4. Percentage of first year birds in wader catches in north-west Australia 1998/1999 to 2010/2011

Species	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	*Average (12 yrs)*
Red-necked Stint	26	46	15	17	41	10	13	20	21	20	10	17	18	*21.3*
Curlew Sandpiper	9.3	22	11	19	15	7.4	21	37	11	29	10	35	24	*19.0*
Great Knot	2.4	4.8	18	5.2	17	16	3.2	12	9.2	12	6	41	24	*12.2*
Red Knot	3.3	14	9.6	5.4	32	3.2	(12)	57	11	23	12	52	16	*20.2*
Bar-tailed Godwit	2.0	10	4.8	15	13	9.0	6.7	11	8.5	8	4	28	21	*10.0*
Non-arctic northern migrants														
Greater Sand Plover	25	33	22	13	32	24	21	9.5	21	27	27	35	17	*24.2*
Terek Sandpiper	12	(0)	8.5	12	11	19	14	13	11	13	15	19	25	*13.4*
Grey-tailed Tattler	26	(44)	17	17	9.0	14	11	15	28	25	38	24	31	*20.4*

All birds cannon-netted in the period 1 November to mid-March. Averages (for previous 12 years) exclude figures in brackets (small samples) and **exclude** 2010/2011 figures

those species having strong coastal habitat preferences. It is particularly pleasing that some small catches of Red Knot (*Calidris canutus*) were obtained in the sampling season for the first time since 2006/07. This was mainly because numbers increased as a result of a very good breeding season (*rogersi* sub-species from Chukotka in north-east Siberia).

Most of the wader populations in south-east Australia had a good or very good breeding season during the Arctic summer of 2010 (Table 1), and this was the second successive above average breeding season for two species, Ruddy Turnstone (*Arenaria intepres*) and Sanderling (*Calidris alba*) (Minton *et al.* 2010). Although the percentage juvenile figure for Red-necked Stint was only marginally above the average for the last 12 years, this was the first time since the 2003 breeding season that this has occurred (Minton *et al*. 2010). Only Bar-tailed Godwit (*Limosa lapponica*) had a poor breeding year. The population in south-east Australia is mainly the *baueri* sub-species, which breeds in Alaska (compared to the other species which breed on the Asian continent) where conditions may well have been markedly different from those of northern Siberia during the 2010 Arctic summer.

North-west Australia

The results for north-west Australia wader populations are given in Table 2. There was no indication in the data that the later sampling during the non-breeding season (compared to other years) had an effect on the juvenile percentage figures. All Arctic-breeding waders for which adequate samples were obtained had average or above average breeding success in 2010. Great Knot (*Calidris tenuirostris*) and Bar-tailed Godwit (*menzbieri* sub-species) had excellent breeding outcomes, which is consistent with breeding success in 2009/2010 (Minton *et al.* 2010). Curlew Sandpiper had good breeding success, which is similar to the previous year (Minton *et al.* 2010). Unfortunately, no measure of the breeding success of Sanderling and Ruddy Turnstone could be obtained due to insufficient captures.

Three of four wader species that breed at slightly lower latitudes in Siberia, Terek Sandpiper (*Xenus cinereus*), Grey-tailed Tattler (*Heteroscelus brevipes*) and Broad-billed Sandpiper (*Limicola falcinellus*), also had very good breeding success. Only the most southerly breeding of those regularly monitored, Greater Sand Plover (*Charadrius leschenaultii*), had poor breeding success. This suggests that weather conditions (early snowmelt, above average temperatures, no late snowfall at the time of chick hatching etc.) and predation pressures (high Lemming numbers, low numbers of adult predators) may have been favourable for wader breeding over wide areas of northern and central Siberia during the 2010 June/July breeding season.

As in south-east Australia, numbers of Red-necked Stint and Curlew Sandpiper were reduced probably for similar reasons, that is, some birds moving inland to feed in the extensive freshwater habitats present during sampling. A similar reason probably accounts for a complete lack of Sharp-tailed Sandpipers on the shore and, for the first time ever, no Sharp-tailed Sandpipers being cannon-netted either at Roebuck Bay (Broome) nor at 80 Mile Beach.

CONCLUSION

It is particularly pleasing to have now had two successive good breeding seasons in (2009 and 2010) seven of the 10 northern hemisphere migrants for which sufficient captures were made in 2010/2011. With so many wader populations in marked decline in the East Asian-Australasian Flyway, good breeding success will be of particular benefit in offsetting these losses. Hopefully wader migration patterns within Australia will return to normal in the 2011/2012 season thereby enabling population counts to be more realistic indicators of population trends. Monitoring of the juvenile content of wader populations in south-east Australia and north-west Australia will be continued in the 2011/12 season.

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All members of the VWSG and participants in the North-west Australia AWSG Wader Expeditions are thanked for their enormous efforts in the field in collecting this data during the 2010/2011 non-breeding season in Australia. The physical effort of making catches and the need to band and process birds within a reasonable time scale after capture mean that large teams are necessary for cannon-netting operations. This is especially so in north-west Australia where protective shade has to be erected to keep birds cool in the generally hot and sunny conditions. Heather Gibbs is thanked for typing this year's update of Tables 1 to 4.

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Stilt 60 – October 2011
Table of Contents