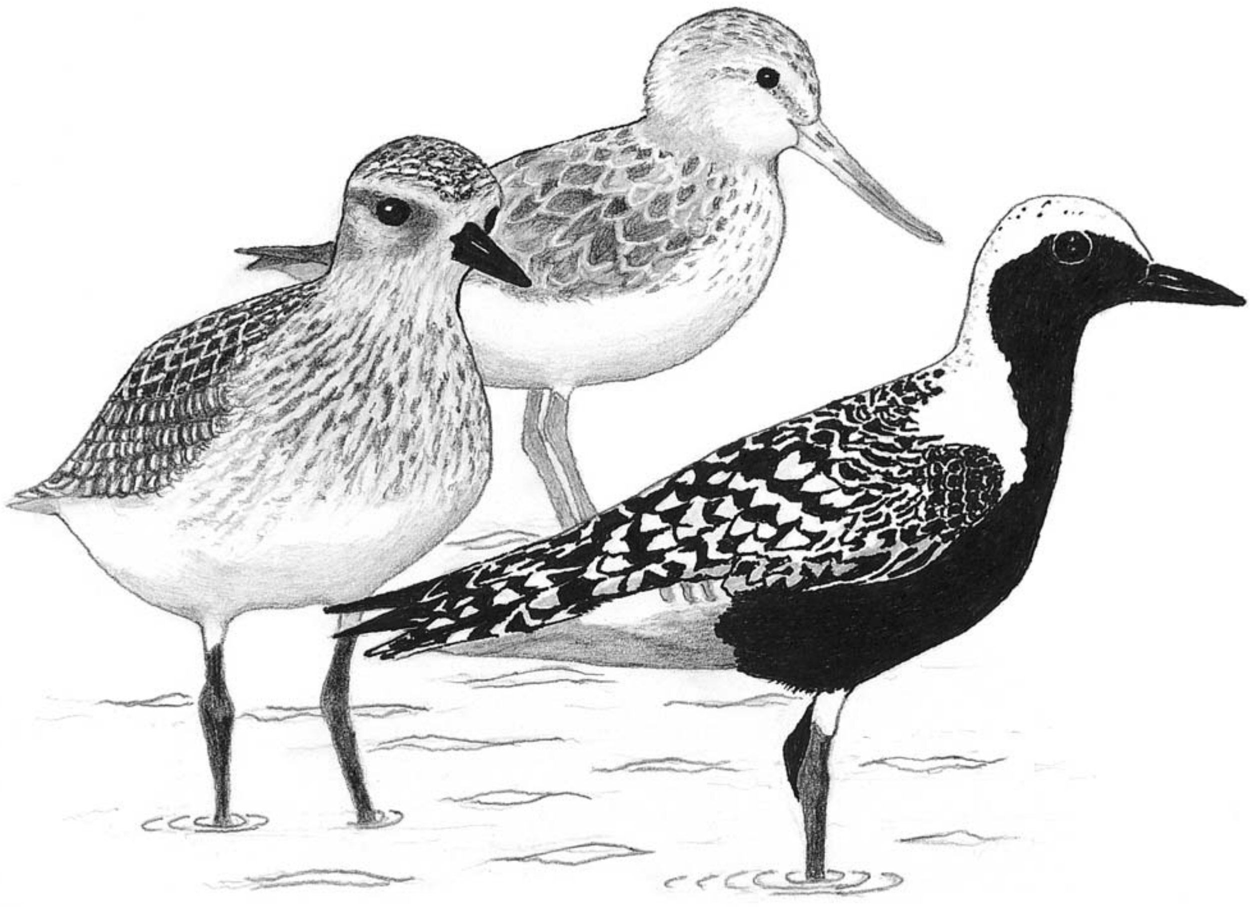
Stilt

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.

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.
Ph: 1300 730 075, fax: (03) 9347 9323.
Email: membership@birdlife.org.au

Annual Subscriptions:	Australia & New Zealand	A$40.00
	Overseas	A$45.00
	Institutions	A$50.00

ELECTIONS FOR 2012 – 2014 AWSG COMMITTEE

Under the Rules of the AWSG, which is a Special Interest Group of BirdLife Australia, all positions on the Committee are open and nominations are sought for the following:

- Chair
- Vice-Chair
- Scientific Committee Chair
- Editor of Stilt
- Secretary
- Treasurer
- Conservation Officer
- Communications Officer
- Up to 8 Committee Members

Nominations for the above positions, seconded by a Member of the Group should be sent to the Secretary by 20 July 2012. Should an election be necessary ballot papers will be sent out with the July 2012 *Tattler.*

John Renowden, *Secretary*

EDITORIAL

I am very pleased to report that *Stilt* has recently been accepted for listing on Scopus, which is the largest abstract and citation database of research literature. Scopus covers nearly 18,000 titles from more than 5,000 publishers and is the primary citation data provider for the Australian federal government's Excellence in Research for Australia (ERA) initiative. The ERA assesses research quality within Australia's higher education institutions using a combination of indicators and internationally-recognised expert review. The listing of *Stilt* on Scopus will increase the dissemination of the outcomes of wader monitoring, as well as raising the profile of wader research from the East Asian-Australasian Flyway.

This is the second consecutive issue featuring contributions on the issue of declining populations of waders in the EAAF. We are fortunate to feature two contributions that provide results from some of the longest-running surveys in Australia. The first (Minton *et al.*) originates from Corner Inlet, one of the three most important sites for waterbirds in Victoria, where continuous counts have been running since 1981. The second (Cooper *et al.*) is from north-east Tasmania (George Town and Cape Portland), where counting began in 1974 and has continued on a monthly basis since then. This is one of the most comprehensive surveys of its kind in Australia.

In both Corner Inlet and north-east Tasmania, Curlew Sandpiper, Eastern Curlew and Ruddy Turnstone have declined. In addition, regional declines have occurred in a further seven species in Corner Inlet (Grey Plover, Greater Sand Plover, Lesser Sand Plover, Common Greenshank, Red Knot, Great Knot and Sharp-tailed Sandpiper), and one in north-east Tasmania (Bar-tailed Godwit). Furthermore, six species that historically were present rarely in north-east Tasmania (Red Knot, Lesser Sand Plover, Greater Sand Plover, Grey-tailed Tattler, Terek Sandpiper and Grey Plover), are no longer recorded. This may represent a range contraction from the most distal regions in the flyway, as species decrease in both abundance and distribution.

The remainder of *Stilt* 61 is devoted to research papers from elsewhere in the flyway. The researchers and counters in Indonesia have been busy in areas that are under-counted. Muhammed Iqbal and colleagues provide information from Jambi Province and Bangka Island, and Adhy Maruly reports on new records of Australian Pratincole from East Java. From North Sumatra, Andrew Crossland and colleagues summarise 12 years of wader monitoring along the Deli-Serdang coastline. These results have substantially increased population estimates for the region and highlight the importance of this coastline. Wader research is also alive and well in Bangladesh: Sayam Chowdhury reports on one of few over-summering (May and June) wader surveys from Sonadia Island, in Cox's Bazar. In the same district, Phil Round and colleagues have been undertaking mist-netting of waders. The capture of several Little and Red-necked Stint provides the first evidence of the species' co-occurrence during the winter for the country. Information from these regions of the flyway is particularly critical given the wader losses at more southerly sites. It remains to be seen if south-east Asian wader sites increase in their relative importance to declining species.

From Australasia, Andrew Crossland details the counting of exceptional numbers of Wrybill during their 2009 southward migration between the North and South Islands of New Zealand. *Stilt* 61 finishes with the 2012 North-west Australia Wader and Tern expedition report.

A reminder that the 2012 Australasian Shorebird Conference is being held at the University of Adelaide on September 29th and 30th. The conference theme this year is the "Role of Science in the Conservation of Shorebirds". Conference presenters can apply for financial support to attend, courtesy of the Shorebirds 2020 Conference Scholarship. Volunteer members are particularly encouraged to apply. Registration for ASC closes on Friday 14th September.

I would just like to finish by saying a huge thank you to Andrew Dunn, the production editor of *Stilt*. Andrew works tirelessly (and largely thanklessly) in the background, forcing the mismatch of contribution styles into the correct format for publication. Without his input, *Stilt* would be in a much sorrier state!

Birgita Hansen

ERRATA

An error appeared in the Editorial in *Stilt* 60. The seventh line of the second-last paragraph should have read "Newman and Lindsey present their research..." rather than Newman and Park. The editor apologises for this oversight.

An error in authorship was also detected in *Stilt* 60 after publication. A third contributor, Michael D. Craig, was omitted from the authorship list on the article "Barrow Island as an Important Bird Area for migratory waders in the East Asian-Australasian Flyway" The original authors apologise for this oversight and agree to his inclusion as a co-author.

The new citation for this article is:

Bamford, M., D. Moro & M.D. Craig. 2011. Barrow Island as an Important Bird Area for migratory waders in the East Asian-Australasian Flyway. *Stilt* 60: 46-55.

The contact addresses for Michael Craig are:

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TREASURER'S REPORT FOR 2011

Total receipts exceeded payments by $22,455 during 2011.
The non-contract surplus was $10,382 for the year.
The balance of $68,858.35 carried forward at 31 December 2011 includes commitments for future expenditure on contracts of $10,372.97.
General accumulated funds were $58,485.38 at year-end.

Australasian Wader Studies Group
Receipts and Payments
1 January 2011 - 31 December 2011

RECEIPTS			**PAYMENTS**		
Item	**2011** **$**	**2010** **$**	**Item**	**2011** **$**	**2010** **$**
Balance brought forward	46,403.00	13 70,830.77	Stationery/Printing	4,614.34	3,077.33
Subscriptions	8,471.11	7,996.01	Postage/Courier	626.55	751.59
Contracts - Federal Govt.	20,000.00	0.00	Consultants	22,863.66	37,889.77
Contracts - State Govts.	8,000.00	8,000.00	Field expenses	48,013.21	1,869.73
Contracts - Other	95,190.40	15,000.00	Conferences/Meetings	174.95	414.48
Sales		-120.00	Phone/Fax	0.00	190.00
Grants and Donations	26,563.03	1,210.00	Donations	16,100.00	
BA adjustment		126.22	Travel & accommodation	8,988.49	11,446.97
			Equipment consumable	33,389.12	0.00
			Admin fee (BA)	999.00	1,000.00
Total income	158,224.54	32,212.23	Total expenses	135,769.32	56,639.87
			Balance carried forward	**68,858.35**	**46,403.13**
	204,627.67	**103,043.00**		**204,627.67**	**103,043.00**

Membership Statistics for 2011:

The membership at the end of the year was:	**2011**	**2010**
Australia/New Zealand	220	235
Overseas (excl. NZ)	27	28
Institutions	14	14
Complimentary	16	56
Total	**277**	**333**

This summary of receipts and payments for the past year is not an audited statement. It has been prepared for the information of AWSG members from records of transactions provided by BirdLife Australia relating to the Australasian Wader Studies Group.

The AWSG is a special interest group of BirdLife Australia and members who wish to see the audited accounts of Birds Australia should refer to the Concise Financial Report included in the Birds Australia Annual Report 2011.

TRENDS OF SHOREBIRDS IN CORNER INLET, VICTORIA, 1982–2011

CLIVE MINTON [A], PETER DANN [B], ALICE EWING [A], SUSAN TAYLOR [CA], ROZ JESSOP[BA], PETER ANTON [A], AND ROBERT CLEMENS [DA]

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Corner Inlet, Victoria, provides habitat for one of the largest and most diverse assemblages of shorebirds in southern Australia. Systematic counting commenced in 1981 and has continued, uninterrupted, to the present (2011). Standardised counts, along fixed boat routes, indicate that numbers in summer of all species combined have declined by 23% over the 30 year count period, from typically 35-40,000 in the earlier years to 25-30,000 in recent times. Ten species – Grey Plover *Pluvialis squatarola*, Ruddy Turnstone *Arenaria interpres*, Eastern Curlew *Numenius madagascariensis*, Red Knot *Calidris canutus*, Great Knot *Calidris tenuirostris,* Curlew Sandpiper *Calidris ferruginea,* Sharp-tailed Sandpiper *Calidus acuminata,* Common Greenshank *Tringa nebularia*, Greater Sand Plover *Charadrius leschenaulti,* and Lesser Sand Plover *C. mongolus* - have declined, while Sooty Oystercatcher *Haematopus fuliginosus*, has increased. Numbers of five other migratory species –Bar-tailed Godwit *Limosa lapponica,* Whimbrel *Numenius phaepus,* Red-necked Stint *Calidris ruficollis,* Sanderling *C. alba* and Double-banded Plover *Charadrius bicinctus* and one resident, species, Australian Pied Oystercatcher *Haematopus longirostris* – have not shown any significant change. Estimated declines in the abundance of individual species ranged from 47% to 95%. In contrast there was a significant increase in Sooty Oystercatchers of between 1.5 fold (winter) and 3.5 fold (summer). Numbers counted varied widely between years, most likely due to a combination of annual variation in demographic parameters, and possibly detection rates. The cause of long-term changes in abundance at Corner Inlet is not certain, but habitat destruction in staging areas, notably the Yellow Sea regions of China and Korea, is suggested as the main contributor with related changes in adult survival rates a more likely mechanism than changes in breeding success. Interestingly, declines in several species were most pronounced over one or two years. This study emphasises the benefit of using the same route and observers over long periods to identify trends in abundance.

INTRODUCTION

Declines in the abundance of some migratory shorebirds (waders) were reported in south-east Australia nearly 20 years ago (Barter 1992, Dann *et al.* 1994) and recently, evidence of declines in numbers of migratory shorebirds have increased in Australia (Creed & Bailey 1998, Wilson 2001, Olsen *et al.* 2003, Reid & Park 2003, Gosbell & Clemens 2006, Nebel *et al.* 2008), and throughout the globe (Howe *et al.* 1989, Delany 2003, IWSG 2003, CHASM 2004, Amano *et al.* 2010, Barshep *et al.* 2011). Unfortunately, there are few places in the East Asian-Australasian Flyway where data have been collected systematically on shorebird abundance over long time periods. Surveys of shorebirds at Corner Inlet, Victoria, have been on-going since 1981, and the consistent methods used by the same personnel over that period have resulted in an informative and rare dataset. While, monitoring on a consistent and long-term basis to detect trends in shorebird population levels presents practical problems (Driscoll 1997), consistent survey methodology used when collecting these data will provide some of the best evidence available of assessing changes in shorebird trends.

Knowledge of the abundance of birds, and changes in these over time, are a fundamental basis for conservation of species and their habitats (Furness & Greenwood 1993). For shorebirds it is generally most practical to count them when they are gathered in flocks in their non-breeding areas. This is especially important for migratory shorebirds, which form the majority of Australian assemblages (Watkins 1993). On their Northern Hemisphere breeding grounds they are too spread out to census, on large temporal and geographical scales, and they only occur as transient birds at migratory stopover locations.

Preliminary counts of Corner Inlet were initiated as part of the first Victoria-wide shorebird survey in 1979 (Dann 1994) and the Inlet was subsequently one of the original sites selected for monitoring when the Australasian Wader Studies Group (AWSG) initiated its fieldwork programme in 1981 (Lane 1987). It has the largest number, and greatest diversity of shorebirds of any of the 25 sites at which counts have been regularly made (Gosbell & Clemens 2006). The only other areas that have been consistently counted for a longer period are Western Port, from 1973 (Dann *et al.* 1994), the area around Hobart, from 1964 (Thomas 1970), and areas in north-east Tasmania (Cooper *et al.* 2012). In spite of major decreases in recent years (Wainwright & Christie 2008, K. Gosbell *pers. comm.*), the Coorong still holds the greatest population of migratory shorebirds in the southern half of Australia. As Corner Inlet has higher diversity it is therefore a particularly important location for monitoring population levels of a wide range of species, both migratory and resident.

Monitoring is especially relevant at the present time when major losses of habitat, due to reclamation (Moores

2006, Rogers *et al.* 2006), are occurring in migratory stopover areas in the East Asian-Australasian Flyway (Xie *et al.* 2010). This paper examines the population trends of migratory and resident shorebirds over 30 years in Corner Inlet in south-eastern Australia.

METHODS

Study area

Corner Inlet is a large, complex, intertidal area in South Gippsland, Victoria, and is situated just to the east of Wilsons Promontory (Figure 1). The principal component of the western section is the Corner Inlet Basin, some 15 km in diameter. The main feature of the eastern section is a string of four barrier islands, with only four relatively small entrances to the open sea between them. Inside these sandy islands are a myriad of large and small islands, mostly mangrove-fringed, and waterways. Overall there are approximately 65 islands in the complex, mostly in the eastern section.

There are five habitations along the mainland coast in the eastern part – two small ports and a number of places with recreational boat access. Most of the rest of the mainland coast in the east is mangrove-lined. In the western section, saltmarsh is much more extensive but there are also long stretches of fairly narrow sandy beach including some that are small, isolated and secluded. The western part of Corner Inlet forms part of the Wilsons Promontory Marine Park and the eastern half is the Nooramunga National Park. The majority of the area is a Ramsar-listed site. The tidal range in Corner Inlet is quite small, at peak springs up to 2.6m but at neaps only 0.8m (annual Victorian Tide Tables). The total area of water is around 360 sq. km (Martindale 1982) with some three quarters of that being exposed at low spring tides. Only five small rivers flow into the complex and these have had only a minor influence on the topography. However they have facilitated large accumulations of mud, particularly in the more sheltered eastern section. Seagrass, mainly *Posidonia australis,* covers some of the mudflats, particularly in the Corner Inlet Basin in the west.

Count surveys

Counts were carried out twice each year. The summer count was usually in late January or the first half of February, at a time when local shorebird movements appear to be at a minimum (Dann 1994). Many resident shorebird species have also flocked by then, following their main breeding season in September to January. The winter count was undertaken between mid-June and mid-July (usually late June) when only non-breeding migratory shorebirds were present. Most resident species were also still in flocks at that time, with adult birds not usually dispersing to take up their

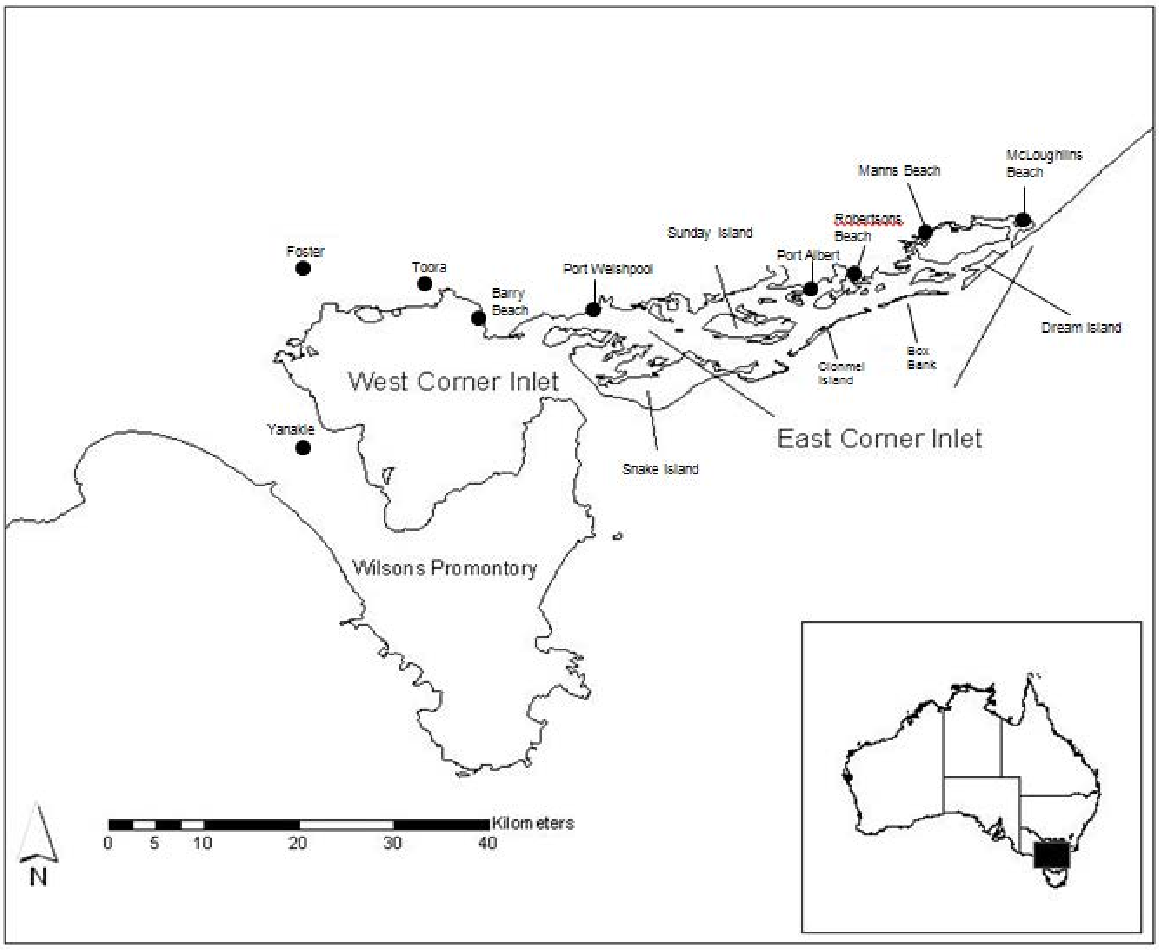

Figure 1. Location of Corner Inlet, Victoria, Australia

breeding territories until late July or August (VWSG *unpub. data*).

Counts were made at high tide roosts. Medium to high spring tides were selected (>2.3 m. at Rabbit Island, off Port Welshpool) so that birds were concentrated and also because this depth of water was required to enable boat access all roost locations. The duration of each count was around five hours in either west or east sections and these sections were usually counted on consecutive days. The Corner Inlet complex was split into two sections for the purpose of the count, with a small uncounted section in between. The East Corner Inlet section (mostly the Nooramunga National Park) covered from the Port Albert/east Sunday Island/east Snake Island area to the north-east end of the complex (Figure 1). Most roosting birds were located on the sandy points and inner shores of the barrier islands–Clonmel Island, Box Bank and Dream Island (between Box Bank and the mainland in the far north-east; Figure 1). However the largely mangrove-fringed inner islands were also surveyed, with Mangrove Root Island (a small mud island off Robertsons Beach) being the most regular location of a high tide roost on the inner islands.

The West Corner Inlet count section covered from Port Welshpool (near Sunday Island) and the west end of Snake Island right around the Corner Inlet basin. This included the northern shores of Wilsons Promontory, the eastern shores of the isthmus connecting the promontory to the mainland, and the northern and eastern shores of the inlet near Foster, Toora and Barry Beach (Figure 1). Shorebirds roosted in a variety of habitats ranging from small, low, mainly mangrove-fringed islands, through saltmarsh areas, to small sheltered sandy beaches and a larger more exposed shell beach (at Barry Beach). Australian Pied and Sooty Oystercatchers also used scattered monolithic rock formations just off the Wilsons Promontory coast, especially Camel Rocks and Millers Landing (at the extreme southern end of west Corner Inlet).

The section between Port Albert and Port Welshpool was not counted. This section included the inner, saltmarsh shores of Snake Island, Little Snake Island, most of Sunday Island and the largely mangrove-fringed mainland coastline between the two ports. This is the shallowest region of the complex and is only accessible by the boats used for counts for a limited period around high tide. It was thus impractical to incorporate this area into either of the two main count sections. Occasional counts, by small boat and from the air, have shown that the shorebird numbers in the uncounted section is normally only a few hundred birds, small in relation to the total Corner Inlet population.

Each counting team usually consisted of two or three people plus the boat driver. Throughout the 30 year period CM was almost always present in the East Corner Inlet team and PD in that for West Corner Inlet. Most counts were made from the boat, stationary offshore but as close as possible to each roost. Where flocks required more detailed examination, counters were put ashore for a period. Changes to the roosting areas at Barry Beach in the latter part of the survey meant that shore counts were necessary as the entire roost could not be seen from a boat.

The route followed by the boats for counting was the same throughout the 30 year period except when weather conditions dictated otherwise. East Corner Inlet was usually counted from west to east and West Corner Inlet in a clockwise manner. Approximately 55-65 km was covered by the boats during each count. Weather conditions occasionally caused postponement of a count and it was usually rescheduled within two weeks. There were no winter counts in 1981 (both sections) and in the West Corner Inlet section in 1982. Apart from these omissions only one of the remaining 116 planned counts could not be completed. In winter 1990 scheduled counts for West Corner Inlet were repeatedly prevented by unsuitable weather conditions. The figures in the tables and graphs for this missing count were obtained by averaging the two preceding and two subsequent winter counts for this area (Underhill & Prys-Jones 1994).

Shorebird species

Fourteen out of the 20 migratory species regularly monitored in Corner Inlet were selected for analyses on the basis of having a yearly average of more than 20 birds over the 30 year period. Those not analysed included: Greater Sand Plover *Charadrius leschenaultii*, Pacific Golden Plover *Pluvialis fulva*, Grey-tailed Tattler *Heteroscelus brevipes*, Marsh Sandpiper *Tringa stagnatilis*, Terek Sandpiper *Tringa cinereus*, and one record of two Black-tailed Godwit *Limosa limosa*. Thirteen qualified on the basis of summer counts but for Double-banded Plover, a migrant to Australia from New Zealand, winter counts were used. Data on only two resident species were analysed as the other five were only recorded in small numbers. These five were Masked Lapwing *Vanellus miles*, Hooded Plover *Charadrius rubricollis*, Red-capped Plover *Charadrius ruficapillus*, Black-winged Stilt *Himantopus himantopus* and one record of a Banded Stilt *Cladorhynchus leucocephalus*.

Statistical analyses

Diagnostic tests were conducted on each species' time series of maximum summer counts, including scatter plots, box plots, autocorrelation plots, and Yule-Walker autocorrelation estimates. The data collected in 1981 were thought to represent an incomplete count and were therefore excluded from all analyses. Therefore, analyses were conducted for count data available from 1982-2011. Further, diagnostics indicated that the assumptions of linear regression were all violated to some degree in most data, with a lack of linearity between counts and year, a lack of independence in the errors over time, a lack of homoscedasticity (evenly distributed errors over time), and occasionally a lack of normality in the distribution of the error terms. Initial attempts were made to use polynomial regressions, negative binomial Generalised linear models, and Generalised additive models using optimally selected smoothing (penalty-modified) thin plate regression splines (which optimise the amount of smoothing or "wiggliness" of the best fitting line). However, residual plots from all these techniques indicated over-fitting, and a lack of homogenous variance of errors over time.

Two types of statistical testing were ultimately employed. For those species with sufficient data, a

Generalised Least Squares (GLS) regression analysis was run to produce a reasonable index of population change over time. This could identify if long term changes were greater than we would have expected by chance, and to deliver estimates of the magnitude of change. In GLS analyses, year was transformed into an ordinal variable with the first year in the time series set as year one, and used as an independent variable to predict the number counted. Zero values were retained in all regressions, and *t*-tests used to assess the significance of the estimated parameters including slope (which indicated long term changes in abundance). In order to overcome violations in the linear regression assumptions mentioned above, GLS terms were added to models.

For each species in each area seven candidate GLS models were tested. The first model corresponded to a simple linear regression model with year used to predict maximum summer or winter abundance for each species. In three of the remaining six models a term was added implementing a residual correlation structure of an auto-regressive model of order 1 (AR1). In all of the (remaining) six models three pairs were differentiated, with one model in each pair including an AR1 term, and one not. In addition, one of three types of weighting terms was added to each of the three pairs of models: (1)a weighting term that assumed the spread in residuals was different in each 5 year period, (2) a weighting term that assumed an exponential relationship between year and the spread of residuals, and (3) a weighting term that combined exponential and 5 year period terms. These additional terms were all thought to represent the kind of variation we'd expect in shorebird abundance data.

The optimal of these seven models was selected based on the lowest AIC value. The model was then assessed with residual plots. If residual plots revealed assumptions were met, and if the additional term(s) made sense biologically, the model with the lowest AIC value was selected in each case, and estimated parameters were summarised.

All statistical analyses related to GLS were conducted in the R software program (R Development Core Team 2011), with use of the 'nlme' library in R for generalised least squares analysis (Pinheiro *et al.* 2011), and the 'mgcv' library in R for general additive models (Wood 2003, Wood 2004, Wood 2006). Statistical analyses followed demonstrated procedures (Zuur *et al.* 2009).

The second type of testing was done for just those species which appeared to show a discontinuity, with a stepped change in count levels, where a comparison was made of average population levels before and after this break. Mann-Whitney U tests were run to determine if the number of birds were significantly different on either side of this visually identified break. Further tests were then run in SegReg software (www.waterlog.info/segreg.html). The SegReg program essentially tests a series of different linear and non-linear models, and then selects the best fitting model based on the model with the lowest AIC value. The models tested in each run included: a linear model with no slope, a linear model with slope significantly different than zero, a piecewise regression with one turning point or knot between two connected straight lines with varied slopes, a non-linear 'broken regression' where two unconnected non-overlapping horizontal lines are fit to the data, and a non-linear 'broken regression' where two unconnected non-overlapping lines with varying slopes are fit to the data. Algorithms within the software iteratively tested different break points with a view toward maximising fit (or maximising the coefficient of explanation denoted by r^2) and were used to identify optimal knots or break points.

Additional GLS analyses were also carried out to summarise the rate and estimated magnitude of declines over selected periods for some of the species which appeared to show periods of steeper declines over these shorter periods.

RESULTS

Total population

Twenty-seven shorebird species were recorded during surveys, including 20 migratory species and seven residents (Appendix 1 & 2). A single Semipalmated Plover *Charadrius semipalmatus* was found on Clonmel Island during the winter 2010 count, which is the first record for the inlet and only the third for Australia.

In summer, the total count of all shorebirds averaged 33,425 birds over the 30 year period 1982 – 2011 (Appendix 1). In most years, counts were between 28,000 and 39,000, with marked peaks of around 44,000 in 1986 and 1992. The lowest summer count was 24,624 in 2005. The winter total count of all shorebirds has mostly ranged between 3,000 and 9,000 birds with an average of 5,532 for the 29 years from 1983 to 2011 (Appendix 2). The winter shorebird count total was 16.7% of the summer population, on average. Peak winter numbers of just over 10,000 were reached in 1992 and 2000, and the winter total count total was also close to this level in 1989. The lowest winter count was 1,997 in 1993. Proportionately, winter counts were more variable from year to year than the summer counts.

Migratory shorebirds account for 94% of the summer counts but this reduced to 79% in winter, when the resident Australian Pied and Sooty Oystercatchers form a more significant component. The total average summer count of migratory shorebirds was 31,493 compared with 1,173 for resident species. In winter an average of 4,731 migratory shorebirds was present with 1,161 resident shorebirds. In summer 85%, and in winter 76% of the shorebirds counted were in the East Corner Inlet section .

Population trends

The summer total shorebird count has shown a 23% decline over the 30 year count period (Table 1), though with marked year to year fluctuations (Figure 2). In contrast the winter total shorebird counts have not changed significantly.

The trends for individual species showed some marked differences (Figures 3 – 19). Ten migratory species showed some evidence of long term declines in abundance: Curlew Sandpiper, Great Knot, Red Knot, Ruddy Turnstone, Grey Plover, Eastern Curlew, Common Greenshank, Greater Sand Plover, Sharp-tailed Sandpiper and Lesser Sand Plover (Table 1 & 2). In seven of those species, significant declines were evident across all statistical techniques and models attempted. Greater Sand Plover, Sharp-tailed Sandpiper and Lesser Sand Plover were the three species for which

Table 1. Change in abundance of selected species over selected time periods from Corner Inlet, Victoria, estimated from Generalised Least Squares. Bold font indicates species that have changed significantly in abundance, or when a subset of the total years were tested.

Species	Time period	Mean abundance	Av. change[1]	%change/yr[1]	*P*-value[2]	AR1[3]	Variation weight[4]
Sooty Oystercatcher	Summers 1982 - 2011	249	100-394	+10.1%	0.000	No	expon.
Sooty Oystercatcher	Winters 1982 - 2011	289	158-420	+5.7%	0.000	No	None
Whimbrel	Summers 1982 - 2011	31	3-27	+22.1%	0.001	No	5 year
Red-necked Stint	Winters 1982 - 2011	1,205	618-1015	+2.2%	0.195	No	5 year
Bar-tailed Godwit	Winters 1982 - 2011	1,513	1085-1890	+2.6%	0.423	Yes	None
Double-banded Plover	Winters 1982 - 2011	552	424-587	+1.3%	0.169	No	5 year
Red-necked Stint	Summers 1982 - 2011	14,046	12685-15153	+0.7%	0.583	Yes	None
Bar-tailed Godwit	Summers 1982 - 2011	10,080	9019-10824	+0.7%	0.486	Yes	None
Sanderling	Summers 1982 - 2011	116	107-125	+0.6%	0.704	No	None
Pied Oystercatcher	Summers 1982 - 2011	882	849-915	+0.3%	0.452	No	None
Pied Oystercatcher	Winters 1982 - 2011	787	823-149	-0.3%	0.450	No	expon.
Lesser Sand Plover	Summers 1982 - 2011	39	10-0	-3.4%	0.259	Yes	expon. & 5 year
Sharp-tailed Sandpiper	Summers 1982 - 2011	73	98-19	-2.8%	0.017	No	5 year
Greater Sand Plover	Summers 1982 - 2011	11	18-3	-2.9%	0.012	Yes	5 year
Common Greenshank	Summers **1990** - 2011	173	359-2	-3.4%	0.001	Yes	None
Common Greenshank	Summers 1982 - 2011	169	257-67	-2.6%	0.006	Yes	5 year
Eastern Curlew	Summers 1982 - 2011	1,196	1528-619	-2.1%	0.000	No	5 year
Grey Plover	Summers 1982 - 2011	475	648-235	-2.2%	0.000	No	5 year
Ruddy Turnstone	Summers 1982 - 2011	71	130-8	-3.2%	0.029	Yes	None
Red Knot	Summers **1985** - 2011	2681	4863-258	-3.3%	0.000	Yes	expon.
Red Knot	Summers 1982 - 2011	2666	4952-342	-3.2%	0.000	Yes	expon.
Great Knot	Summers **1986** - 2011	240	253-33	-3.4%	0.034	Yes	5 year
Great Knot	Summers 1982 - 2011	240	306-23	-3.2%	0.004	Yes	5 year
Curlew Sandpiper	Summers 1982 - 2011	2,257	3075-0	-3.4%	0.000	Yes	expon. & 5 year
Total of all species	Summers 1982 - 2011	33,425	38413-27408	-1.0%	0.000	No	expon.

[1] changes estimated from GLS predicted values, should be viewed as rough approximations
[2] p-value of T-test on slope coefficient
[3] a term added to GLS regressions to account for a residual correlation structure of an auto-regressive model of order 1
[4] weighting term used to address problems in heterogeneity, expon = exponential, 5 yr = periods with variation allowed to vary within each 5 yr period something that allows for periodic "good years" and subsequent time lags, in two instances a combination of the weighting terms was used

indications of declines varied depending on the error terms in GLS employed, or the kinds of statistical tests used. In Lesser Sand Plover, simple linear regression indicated significant declines as did three other GLS models but assumptions were not met for these tests, and the best fitting GLS and GLS zero-inflated models (Zuur *et al.* 2009) did not indicate a significant decline. While most assumptions were met for the optimal GLS model, there was still an indication of unequal distribution of errors above and below the best fitting line, suggesting GLS was not able to sufficiently address the variation in these data. Comparison of mean abundance in 1981-1999 to 2000-2011 did suggest far fewer Lesser Sand Plover have been seen in the last decade (Table 2). Results for Greater Sand Plover and Sharp-tailed Sandpiper showed similar sensitivity to the kinds of GLS error terms employed, but data also appeared to meet assumptions in the optimal selected statistically significant model. Sharp-tailed Sandpiper declines (Table 1) were perhaps the least compelling of these identified declines, as there was only ever a modest number of birds seen, and this species has been known to wander widely into and out of areas in response to better conditions elsewhere. Therefore, the apparent decline from higher counts in the 1980's may simply reflect a modest movement of birds out of the area. In each of these three species it is worth noting that the numbers are relatively small.

Of the ten species showing evidence of decreases over time, all but Sharp-tailed Sandpiper showed evidence of a sudden stepped drop in abundance. This abrupt reduction generally appeared to take place over only one or two years. The graphs of summer counts for each of the nine species (Figures 4, 5, 7, 9, 11, 12, 13, 15, 16) do not suggest a linear trend over the whole period and instead all appear to show signs of this stepped drop in abundance. In most species the counts after the discontinuity are almost all below the level of the individual annual summer counts in the earlier period, in spite of marked year to year variations throughout the whole count period. One way of representing the population change therefore is to compare the means before and after sudden breaks. These means are shown as dashed lines on the graphs and are the place where data were divided into two sections for further comparisons (Table 2). Species' population reductions derived from the means were between 47% (Eastern Curlew) and 95% (Lesser Sand Plover). Six species showed declines between 69% and 82%. Minimum population reductions derived from differences in the 95% confidence intervals around the means ranged from 31% (Eastern Curlew) to 81% (Lesser Sand Plover), while maximum differences ranged from 61% to 99% (Table 2).

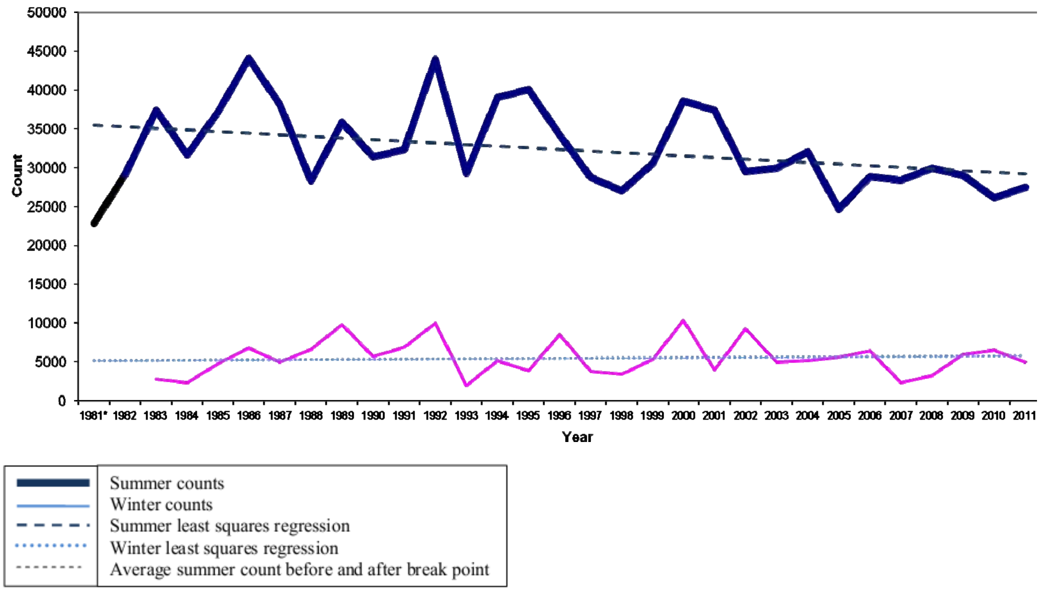

Figure 2. Corner Inlet Total - Summer and Winter Wader Counts - 1982-2011

Results from analyses in SegReg software indicated that for seven of the nine species for which stepped declines were tested, a model with a break point had more support than a linear model. Break points identified using this statistical method were similar to those selected visually (Table 2). For the Curlew Sandpiper data, SegReg software suggested that no model provided a good fit. Similarly, SegReg software indicated that piecewise regression with two segments, one that went up until just after 1993 then went down, provided the best fit to those data. Again, GLS appeared to meet assumptions while piecewise did not.

GLS analyses were also carried out on three species where the graphs suggested a possibly larger linear decline for part of the count period (Table 1). Statistically significant rates of decline were apparent for Red Knot (3.3% per year), Great Knot (3.4% per year) and Common Greenshank (3.4% per year) over selected periods.

In three of the migratory species, Bar-tailed Godwit, Red-necked Stint, and Sanderling, a significant change in the summer numbers was not identified with GLS (Table 1). Similarly, no significant change in abundance was detected (Figure 17 & Table 1) in Double-banded Plover abundance in winter. For the Double-banded Plover winter count numbers were used because only a few of these migrants from New Zealand had arrived in Corner Inlet at the time of the summer counts.

There were marked year-to-year differences in most species, and the counts in three species, Bar-tailed Godwit, Red-necked Stint and Sharp-tailed Sandpiper, gave the appearance of periods of sustained growth and decline over the 30 years. In Bar-tailed Godwit and Red-necked Stint overwintering numbers (immature birds) were also sufficient for analysis. These data also showed no long-term significant population change.

Both summer and winter count data were used for the two resident shorebird species analysed. Australian Pied Oystercatcher showed no significant long-term population trend (Figure 18). However Sooty Oystercatcher exhibited a sustained growth which resulted in a 1.5-fold increase of the winter population and a 3.5-fold increase of the summer population over the 30 year count period.

In the migratory Whimbrel there is some evidence of a significant long-term increase in numbers. However, numbers of Whimbrel were modest, and there was substantial scatter in these data. Detection rates are also expected to vary substantially for this species, and therefore the evidence of increase reported here was thought to relate more to detection rates than real changes in the numbers found in Corner Inlet during summer.

DISCUSSION

Total population numbers (summer and winter)

The 23% decline in the total summer shorebird population in Corner Inlet, from counts typically around 35-40,000 to current levels of just under 30,000, is the net result of marked reductions in the numbers of seven species and an increase in one species. The decline in the winter population was relatively small. However, Australian Pied and Sooty Oystercatchers, whose numbers are similar in both summer and winter, form almost 20% of the winter population and provide a stabilising effect, diluting the effect of the reductions which have taken place in many of the migratory shorebird species.

Population changes and potential drivers

The declines in summer count numbers have two noticeable features. Firstly, the sizes of the measured decreases in seven species of migratory shorebirds are large, ranging from 47 to

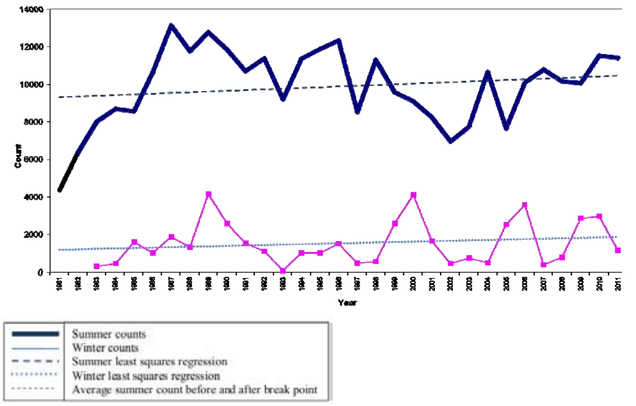

Figure 3. Bar-tailed Godwit - Corner Inlet Counts 1982-2011

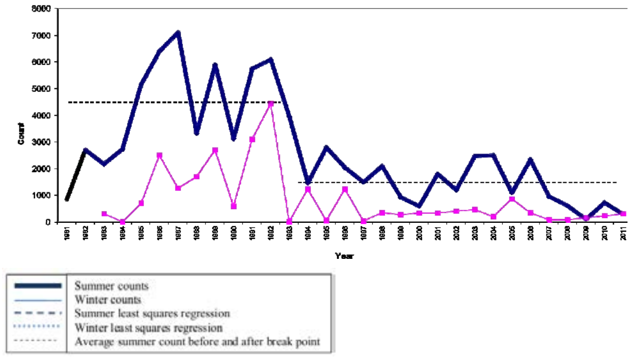

Figure 4. Red Knot - Corner Inlet Totals 1982-2011

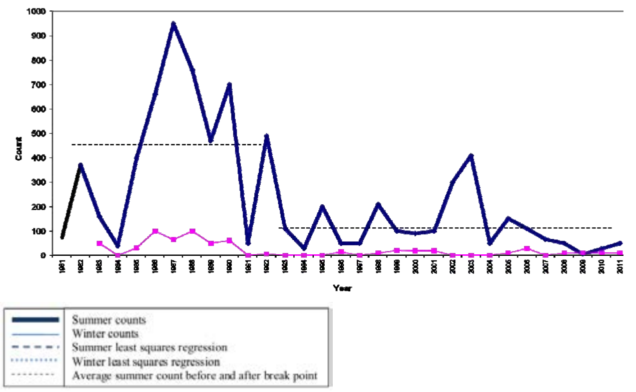

Figure 5. Great Knot - Corner Inlet Total 1982-2011

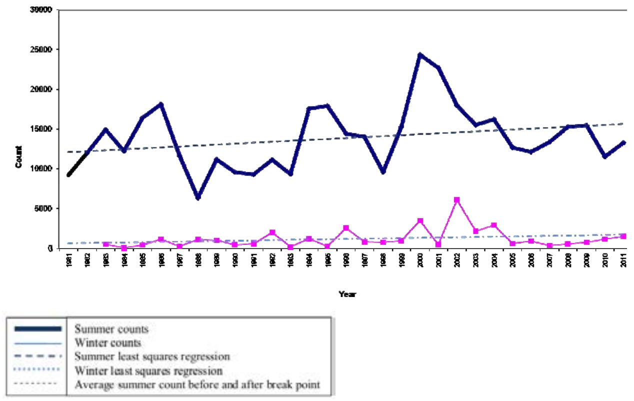

Figure 6. Red-necked Stint - Corner Inlet Total 1982-2011

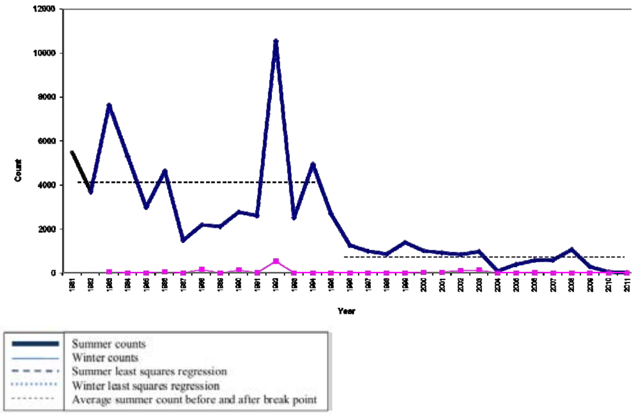

Figure 7. Curlew Sandpiper - Corner Inlet Total 1982-2011

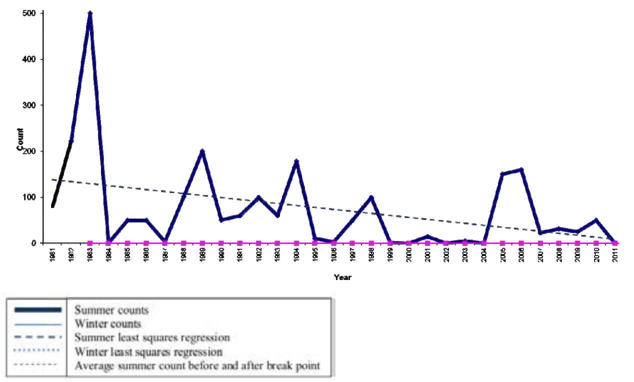

Figure 8. Sharp-tailed Sandpiper - Corner Inlet Total 1982-2011

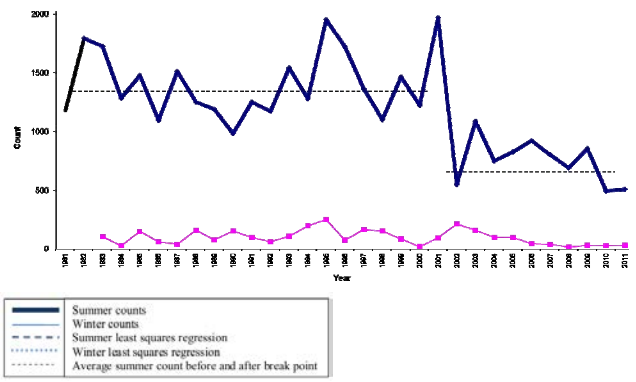

Figure 9. Eastern Curlew - Corner Inlet Total 1982-2011

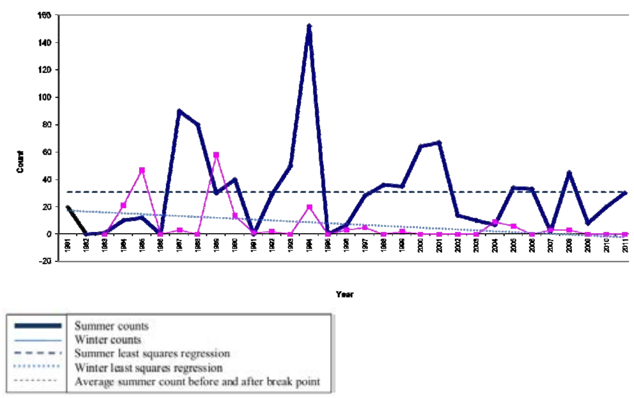

Figure 10. Whimbrel - Corner Inlet Total 1982-2011

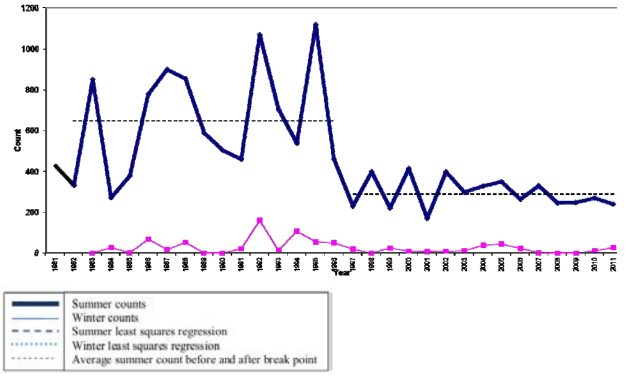

Figure 11. Grey Plover - Corner Inlet Total 1982-2011

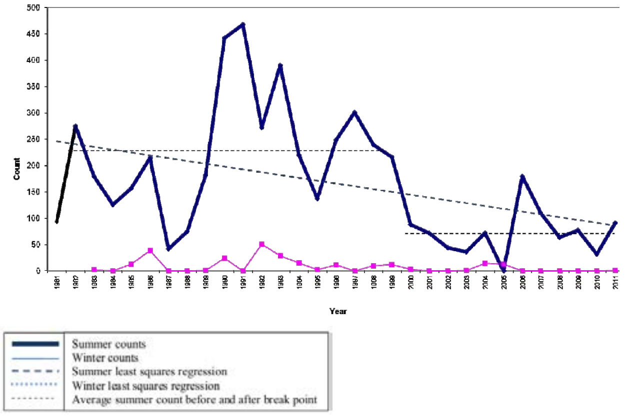

Figure 12. Common Greenshank - Corner Inlet Total 1982-2011

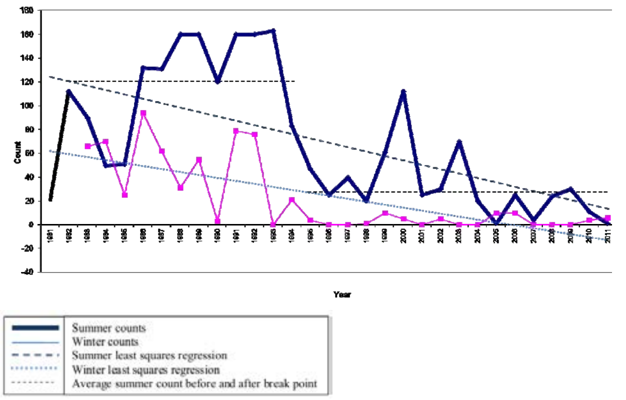

Figure 13. Ruddy Turnstone - Corner Inlet Total 1982-2011

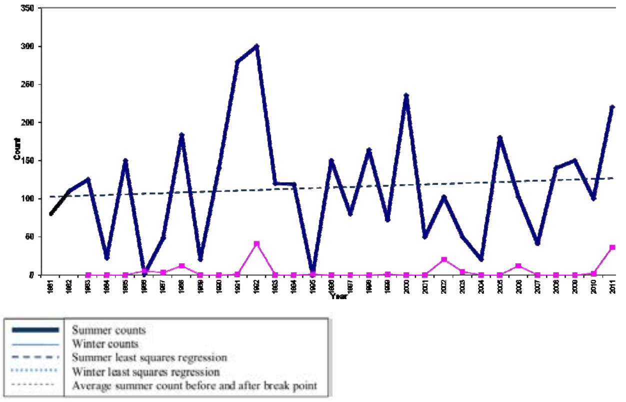

Figure 14. Sanderling - Corner Inlet Total 1982-2011

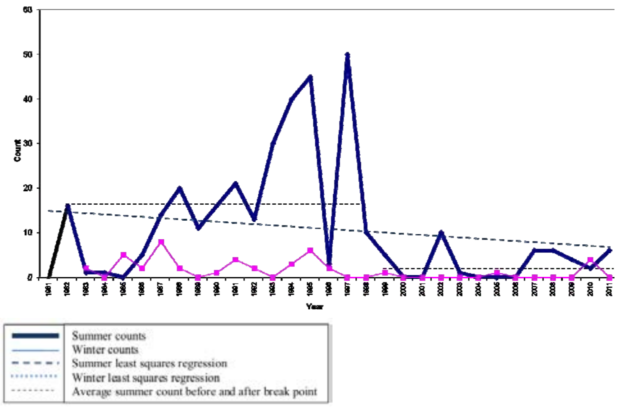

Figure 15. Greater Sand Plover - Corner Inlet Total 1982-2011

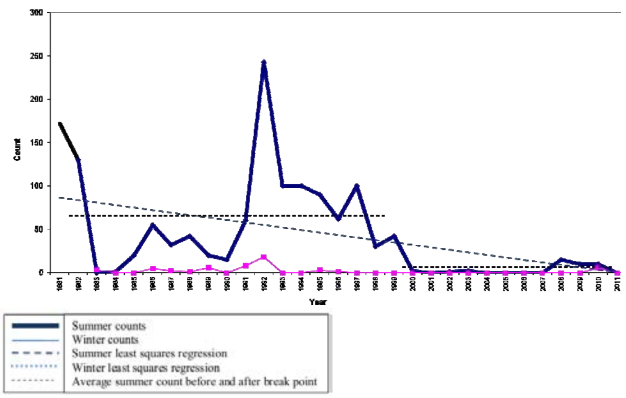

Figure 16. Lesser Sand Plover - Corner Inlet Total 1982-2011

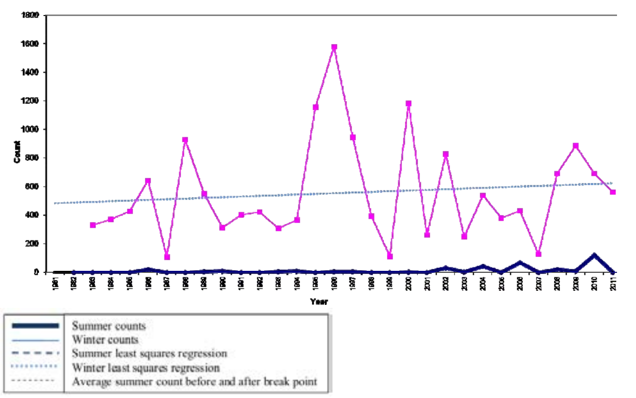

Figure 17. Double-banded Plover - Corner Inlet Total 1982-2011

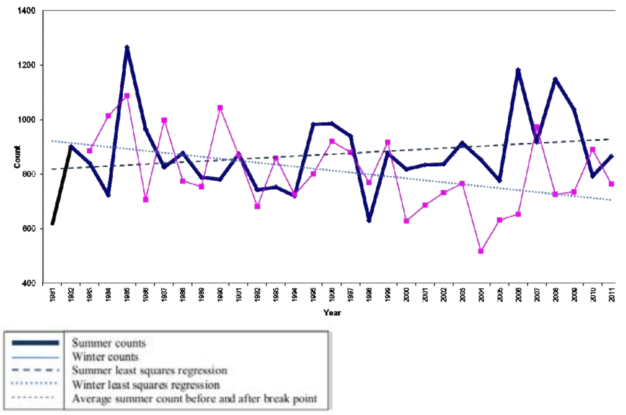

Figure 18. Australian Pied Oystercatcher - Corner Inlet 1982-2011

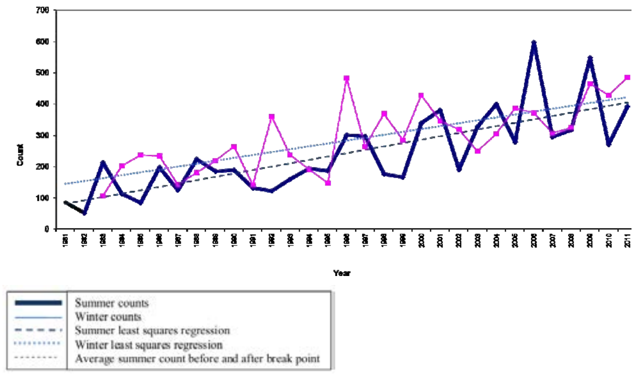

Figure 19. Sooty Oystercatcher - Corner Inlet Total 1982-2011

nearly 100% (Tables 1 & 2), and there is evidence of decline in another three species of migratory shorebird. Secondly, most of these declining species show strong evidence of a step-wise sudden decrease in numbers rather than a gradual decline. The timing of these decreases has varied between species, with most of the major changes occurring in the 1992 to 2000 period. It is also notable that counts of five migratory shorebird species (Red-necked Stint, Bar-tailed Godwit, Whimbrel, Sanderling and Double-banded Plover) have not declined over the count period and neither have resident shorebird species. Of the major residents, Australian Pied Oystercatchers have maintained their numbers and Sooty Oystercatchers have increased between 1.5-fold and 3.5-fold, the only species to have recorded a substantial population increase.

The lack of consistency between migratory and resident species in the alterations in numbers suggests that the main cause(s) are not to be found in Corner Inlet. This is further suggested by similar changes in some species being reported more widely in Australia (Creed & Bailey 1998, Wilson 2001, Olsen *et al.* 2003, Reid & Park 2003, Gosbell & Clemens 2006, Nebel *et al.* 2008, Wilson *et al.* 2011). Further, there have been no major anthropogenic changes obvious in the whole complex during the survey. There does not appear to have been any loss of roosting sites or feeding areas, and human disturbance levels remain relatively low in both feeding and roosting areas. This suggests that neither loss of habitat in Corner Inlet nor disturbance are the cause of changes in abundance.

Previously reported correlations between count totals and an index of annual breeding success suggest that annual counts are influenced by breeding success (Minton *et al.* 2005). An index of breeding success for the more numerous and regularly caught shorebird species in Victoria has been obtained annually by the VWSG. This index was created by measuring the proportion of first year birds caught in the non-breeding flocks in Victoria between mid-November and March, a period when the population of adults and first year birds should be relatively stable (Minton *et al.* 2005, Minton *et al.* in press). A good breeding season should lead to an increase in the non-breeding population counted in the following austral summer relative to other years and, if the species is one in which first year birds do not migrate northwards to breed, an even more noticeable increase in the following austral winter would be expected. One of the two peaks (44,000) in the summer shorebird population in Corner Inlet was in 1992, immediately following what appears to have been the exceptionally successful breeding season, which occurred right across the Siberian arctic in June/July

Table 2. Population changes in summer counts of selected species which show a stepped reduction in count numbers in Corner Inlet, Victoria

Species	Time Period	Mean Abundance	SE	*P*-value	% Decrease in Abundance	Min. – Max. change[1]	SegReg Break?[2]
Red Knot	1982-1993	4536	494.6	0.000	-69%	-47% to -82%	Yes 1992↑ | 1993↓
	1994-2011	1419	193.2				
Great Knot	1982-1992	459	89.2	0.000	-75%	-37% to -90%	Yes 1989↑ | 1990↓
	1993-2011	114	23.6				
Curlew Sandpiper	1982-1995	4013	664.2	0.000	-82%	-63% to -91%	No, linear ↓
	1996-2011	720	108.4				
Eastern Curlew	1982-2001	1419	64.6	0.000	-47%	-31% to -61%	Yes 2001→ | 2002 →
	2002-2011	751	60.6				
Grey Plover	1982-1996	655	68.5	0.000	-55%	-34% to -68%	Yes 1995↑ | 1996↓
	1997-2011	295	19.0				
Common Greenshank	1982-1999	233	27.2	0.000	-69%	-42% to -85%	Yes 1989↓ | 1990↓
	2000-2011	72	13.1				
Ruddy Turnstone	1982-1994	121	11.5	0.000	-74%	-52% to -88%	Yes 1993↑ | 1994↓
	1995-2011	32	6.8				
Greater Sand Plover	1982-1998	17	3.8	0.001	-82%	-51% to -97%	No, 1993↑ connected piecewise 1994↓
	1999-2011	3	0.9				
Lesser Sand Plover	1982-1999	63	13.8	0.002	-95%	-81% to -99%	Yes 1997↑ | 1998↓
	2000-2011	3	1.5				

[1]% change from first to second time period, estimated from 95% confidence internals around both means

[2]Yes = SegReg software suggested best fitting model identified using AIC was two unconnected lines, the arrows indicate the slope of the lines before and after the years where SegReg identified the optimal break point. No = the best fitting model identified by SegReg was either linear or connected piecewise with one knot.

1991 (Minton *et al.* 2005). The peak winter count was also in 1992 and appears to have resulted from the high number of immature birds remaining from that breeding bonanza. Conversely the lowest winter count, in 1993, followed the reported disastrous 1992 arctic breeding season (Ganter & Boyd 2000).

Despite the annual variation in count totals, there are some obvious large long-term declines in seven shorebird species which visit the inlet. In addition, there was evidence of decline in a further three species, which occur in modest numbers, although one of these may simply be indicative of a modest movement of birds out of the study area. One of the most likely explanations of these declines has been the accelerating loss of feeding habitat at migratory stopovers in Asia (Barter 2002, Moores *et al.* 2008, Rogers *et al.* 2010). Banding and flagging has shown that almost all migratory shorebird species spending the non-breeding season in Victoria use the Yellow Sea regions of China and Korea as stopover sites, particularly on northward migration (Minton *et al.* 2006, Minton *et al.* 2011c). Huge amounts of reclamation, particularly for industrial development, have taken place all around the coasts of the Yellow Sea during the last 20 or more years (Xie *et al.* 2010). This has resulted in a major reduction in the intertidal areas available for feeding shorebirds. The loss of feeding areas and the reduction in their average quality are likely to impact negatively on the condition of birds using the area for migratory fattening (Atkinson *et al.* 2005). The timing of migratory departures from the area may have become later than the optimum and the physical condition of birds reaching their breeding areas may be poorer, resulting in negative impacts on breeding success, and even adult survival.

Differences in the timing of population declines could relate to temporal variation in the range of reclamation projects around the Yellow Sea. Some species are found in relatively restricted areas on their migratory stopovers. For example, half of the Flyway population of Red Knot are concentrated in the Hebei/Bohai area, in the north-west of the Yellow Sea, during northward migration in May (Rogers *et al.* 2010) and any changes in the availability of food in this area will have disproportionately large effects.

It is interesting that five of the six migratory species which have not shown a population decline do not use the shores of the Yellow Sea as their principal stopover site on migration. Bar-tailed Godwit is the exception, although this species only uses the area on northward migration. Bar-tailed Godwit in Victoria are all from the Alaskan breeding population (Wilson *et al.* 2007), which migrates directly across the Pacific on southward migration (Gill *et al.* 2009).

In contrast, all of the species showing marked declines, except Greater Sand Plover, make a major stopover in the Yellow Sea, usually on both northward and southward migration (Minton *et al.* 2011a, Minton *et al.* 2011c). This evidence adds support to the population declines observed being mainly associated with the loss of habitat through reclamation of intertidal areas in the Yellow Sea.

The level of decline in some species is not necessarily indicative of the size of change occurring in its whole Flyway population. Corner Inlet is at the southern end of the non-breeding range for some species, with the major numbers being located further north. When populations change, numbers in the extremities of their range are likely to be the most affected. This was seen, for example, when Red-necked Stint and Sharp-tailed Sandpiper populations expanded rapidly, following unusually good breeding seasons in the late 1990s/early 2000s and the early/mid 2000s respectively (Minton *et al.* 2005). Both species turned up in higher than normal numbers in previously little-used areas, and largely disappeared again from those areas when the populations declined to previous levels. This coincided with annual breeding success indices that returned to average, or below average, levels. Thus, Lesser Sand Plover, Greater Sand Plover and Great Knot – of which the bulk of the Flyway populations occur in the northern parts of Australia – declined at a rapid rate in Corner Inlet, compared with percentage changes in numbers in other main habitats (AWSG *unpubl. data*). Great Knot and Greater Sand Plover declines have been reported in north-western Western Australia, and Moreton Bay Queensland, although evidence for Greater Sand Plover declines was less in Moreton Bay (Rogers *et al.* 2009, Wilson *et al.* 2011). These two studies did report large declines in Bar-tailed Godwit, which contrast the findings from Corner Inlet, and highlight the need for a broad scale analysis to better determine the wider magnitude of declines in these species.

Individual patterns of abundance

Quite a number of the changes in numbers recorded for the different species in the Corner Inlet counts appear to be related to breeding productivity (percent juvenile) measurements. Bar-tailed Godwit show some signs of such a correlation although productivity data in the 1980s were not collected every year. There were two years in the early 1980s with extremely high breeding productivity indices and these may have led to the generally high summer numbers in the late 1980s (Minton *et al.* 2005). Conversely, the trough in the summer population in 2002 coincided with a period containing three of the poorest Bar-tailed Godwit breeding seasons recorded (Minton *et al.* in press). Good breeding success indices between 2004 and 2011 appears to have resulted in some improvement in the total Bar-tailed Godwit population visiting Corner Inlet.

The dramatic decline in the Red Knot abundance reported here does not seem to be directly relatable to indices of annual breeding success (Minton *et al.* 2005, Minton *et al.* in press). More likely it is a consequence of habitat losses at staging sites in the Yellow Sea, which suggests that the Flyway cannot now support the previous population level (Rogers *et al.* 2010). Red Knot numbers in north-west Australia have declined markedly also, supporting the suggestion of a Flyway-wide problem (Rogers *et al.* 2011). Count figures for the last four years in Corner Inlet even suggest that the Red Knot population may have suffered a further recent stepped reduction to a new lower average level. The situation mirrors that in Delaware Bay, USA, where a major population decline in Red Knot was directly related to a huge reduction in food availability (horseshoe crab eggs) at the key stopover site (Baker *et al.* 2004). Great Knot have followed a similar pattern to Red Knot, reaching their nadir in 2009 after four years of decline. A huge reclamation at Saemangeum in South Korea, a major stopover location for this species, was completed in 2006 and could be the major cause of this recent apparent further decline (Moores *et al.* 2008).

Red-necked Stint counts have fluctuated markedly with both summer and particularly, winter numbers correlating well with indices of breeding productivity (Minton *et al.* 2005). The huge peak in counts between 1999 and 2004 coincides with a period in which there appears to have been four very good breeding seasons (two records). Since then there were six successive breeding seasons with apparent below-average productivity (Minton *et al.* in press), and both summer and winter counts dropped to more normal levels.

Red-necked Stint is a prime example of a species in which numbers in Corner Inlet have varied markedly over the years and yet there has been no net change over the 30 year monitoring period. Red-necked Stint seem to be more flexible in the type of habitat they use than most other shorebird species. They occur widely in both tidal and freshwater habitats, and in both large and small areas of habitat, and are thus likely have a greater capacity to adapt to habitat loss than species with restricted habitat requirements. Furthermore, reclamation projects often temporarily create, during the impoundment and drying out process, areas of shallow muddy water which are ideal for Red-necked Stint feeding. One such example occurred in late July 2009 in the Bohai region of the Yellow Sea when a concentration of 50,000 Red-necked Stints was reported feeding in a recently impounded area (P. Holt, *pers. comm*.).

Curlew Sandpiper is another species in which there has been a prolonged decline. An initial decline in the 1980s was interrupted by a huge peak in the summer and winter population in 1992, following the apparent bonanza breeding season in the arctic in 1991. Breeding indices suggest that this was followed by a period of below-average breeding success with only three years being above average out of the following nine (Minton *et al.* 2005). This appears to have led to a sustained decline, but numbers have continued to remain low in spite of some improvement in breeding success indices since then, with four of the most recent six years suggesting above-average productivity (Minton *et al.* in press). A record high breeding index in 2007 resulted in a temporary population recovery in 2008, but this subsided in the following year after another apparent below-average breeding season.

Sharp-tailed Sandpipers usually prefer less saline habitats in south-east Australia (Higgins & Davies 1996), making Corner Inlet only a marginal site for this species. Nevertheless, numbers seem to mirror breeding success indices (Minton *et al.* 2005). As with Curlew Sandpipers, there was a long period when breeding output appeared to be generally poor, being below-average in all the years between 1992 and 2001. Summer Sharp-tailed Sandpiper numbers declined and reached a very low level between 1999 and 2004. This was followed by a prolonged period of above-average breeding indices in five of the six years between 2002 and 2007, with 2003 and 2004 being exceptionally good (Minton *et al.* in press). This improvement was eventually reflected in markedly increased numbers of Sharp-tailed Sandpiper in Corner Inlet in 2005 and 2006. With a return to more typical breeding success the population bulge appears to have subsided. The complete absence of Sharp-tailed Sandpiper (and Curlew Sandpiper) in summer 2011 is thought to be related to most of the population choosing to spend the non-breeding season in 2010/11 at extensive ephemeral wetlands present in inland Australia. Similarly, it seems likely that the ten years of drought which preceeded 2011, and appeared to have reduced the numbers of small shorebirds throughout much of inland eastern Australia (Nebel *et al.* 2008), may have increased the numbers of these species at areas like Corner Inlet. The declines in abundance of these small shorebird species in Corner Inlet, which use ephemeral areas, could therefore be seen as being even more striking, given that possibility.

Eastern Curlew are not caught in sufficient numbers for annual breeding success to be monitored. However, the lower proportion of birds remaining over winter in the last six years (4.2%) compared with the whole period (8.4%), suggests that poorer breeding success in recent years may be a contributor to the reduction in population. The later onset of the stepped decline (2002) may be related to habitat loss along the particular migration routes used through Asia, especially on northward migration. Banding recoveries and flag sightings indicate many Eastern Curlew use the southern half of Japan, as well as the Yellow Sea, as a stopover location (Minton *et al.* 2011b). Relatively little intertidal habitat loss has taken place in Japan in the last 20 years in comparison with the Chinese and Korean shores of the Yellow Sea.

Whimbrel, Grey Plover and Common Greenshank are three other species where the systematic collection of annual breeding productivity data has not been possible. Furthermore, there are still too few recoveries and flag sightings to quantify their distribution across the various migratory stopover locations in Asia. Whimbrel do seem to have a preference for Japan (Minton *et al.* 2011c), which is consistent with the small Corner Inlet population not decreasing significantly. Grey Plover, however, seem to more strongly favour the Yellow Sea and their population in Corner Inlet was one of the first to drop markedly, in 1996 and 1997. It is slightly surprising perhaps that Common Greenshank numbers have dropped so significantly as recoveries, flag sightings, and current knowledge of important sites, suggest they are not highly concentrated in the Yellow Sea during migration (Minton *et al.* 2006, Bamford *et al.* 2008, Minton *et al.* 2011c). They also appear to be flexible in their habitat choice, using saline and freshwater areas. Part of the very marked year to year fluctuation in numbers of Common Greenshank in Corner Inlet is likely to be related to birds sometimes choosing to roost at locations which cannot be reached during the usual boat-based count route.

The Ruddy Turnstone population in Corner Inlet is only modest but is still significant as far as the total population on the Victoria coastline is concerned. It is a species which exhibits marked fluctuations in annual breeding success (Minton *et al.* 2005, Minton *et al.* in press), but these do not seem to correlate well with summer or winter count numbers in Corner Inlet. Ruddy Turnstones seem to use a range of locations for stopovers in Asia on migration but recent results from geolocator tracking indicate that many make a stopover in the Yellow Sea area, particularly on northward migration (Minton *et al.* 2011a). Ruddy Turnstone counts are also declining in other parts of south-east Australia (VWSG *unpubl. data*, Herrod 2010, Cooper *et al.* 2012), and more widely in Australia (Rogers *et al.* 2009, Wilson *et al.* 2011).

Sanderling is another relatively marginal species in Corner Inlet. The lack of a decline may be associated with its preference for more open sandy shores, in areas like Japan, which are less likely to be reclaimed than areas like the Yellow Sea, the latter being used in higher frequencies by other species (Minton *et al.* 2011c).

Greater and Lesser Sand Plover use markedly different migration routes through Asia yet both have shown huge decreases in their small Corner Inlet numbers. It would appear that there may have been a reduction of the population of both of these species in their core non-breeding areas in the northern half of Australia (AWSG *unpubl. data*) and that this has resulted in an almost complete withdrawal from the fringe area in Corner Inlet.

Double-banded Plover numbers have fluctuated markedly from year to year but do not appear to have changed overall. Numbers present in Corner Inlet in winter are probably strongly dependent on the amount of other habitat available in south-east Australia. Many seem to prefer to feed on short, grazed, damp grassland, often well inland though rarely far from a freshwater or saline lake (Marchant & Higgins 1993). In wet winters suitable habitat abounds but in dry winters more birds remain on the coast, with many feeding entirely in intertidal habitats. The lack of change in numbers in Corner Inlet suggests that their breeding habitats in the centre of South Island, New Zealand – from where Australian-wintering birds originate – have not changed significantly during this 30 year counting period.

One of the most marked contrasts in population trajectories apparent from this study is between the Australian Pied and Sooty Oystercatcher. Summer numbers of Australian Pied Oystercatchers have remained relatively stable whereas those of the Sooty Oystercatcher have increased steadily, with the summer population increasing three-and-a-half-fold and the winter population one-and-a-half-fold.

There is no evidence for a change in flocking behaviour or distribution in the non-breeding season for Sooty Oystercatchers. The population growth is therefore likely to be the result of higher breeding productivity or a higher survival rate (or both) in Sooty Oystercatcher compared with Australian Pied Oystercatcher. Whilst limited information is available on Australian Pied Oystercatcher breeding success in Corner Inlet none is available on Sooty Oystercatcher in their main breeding habitat on the Bass Strait islands and on rocky mainland coasts. A rough comparison of the breeding productivity of the two species can be obtained from VWSG banding data (unpublished). Most birds have been caught in the February to August period while in flocks, to which some adults and most immature birds move at that time. Four thousand and sixty-nine Australian Pied Oystercatchers have been caught since 1978 and 13.9% of these have been aged as first year birds. In the 1299 Sooty Oystercatchers caught over the same period 14.8% were in their first year. The small difference in annual breeding success indices between the two species suggests that breeding productivity is not the prime cause of their different population trajectories.

Data are not available on survival rates of oystercatchers in Corner Inlet. The two species feed and roost in mixed flocks in Corner Inlet and mortality in this period appears to be very low and is unlikely to be markedly different between the two species. A more likely cause of the different population trajectories could be a difference in adult survival rates during the September to January breeding season. Australian Pied Oystercatchers mainly nest on mainland shores or on islands fairly close to land where the main introduced ground predator, Red Fox *Vulpes vulpes*, also occurs. Sooty Oystercatchers breed mostly on offshore islands where foxes and cats (another predator of ground-nesting birds) are largely absent. With no other obvious explanations for the population change differences it seems that a higher mortality of adult Australian Pied Oystercatchers during the breeding season or reduced breeding success are the most likely causes.

Winter numbers

The average winter population of migratory shorebirds is only 14% of the summer population, whereas the non-migratory (resident) shorebird numbers are similar in both seasons. Larger shorebirds had higher proportions of the summer population remaining over winter. Presumably this is because they do not migrate northwards back to their breeding grounds until they are two, three or even four years old (VWSG and AWSG *unpubl. data*). With several age classes still present in winter the proportion of young birds is relatively higher than for the medium-size and smaller shorebirds, which usually return to breed at the end of their second year. Overall, the number of migratory shorebirds expected to be found in Corner Inlet each winter relate to the assumption that most migratory shorebirds wintering in Australia are juvenile birds, that more juveniles will be present in winter for those species whose young spend more years in Australia before migrating north, that winter abundance will be similar to the percentage of juveniles identified from all the birds captured during the previous summer, and that movements of some species within Australia during winter can override these other expectations.

The estimated proportion of over-wintering Red Knot (31.3%) is higher than would be expected because many additional juvenile birds from the New Zealand Red Knot population spend their first year in south-east Australia (Minton *et al.* 2006, Minton *et al.* 2011c). In contrast the proportion of Eastern Curlew overwintering (8.4%) is rather lower than expected. Wilson (2000) showed that the winter population of Eastern Curlew was actually higher than the summer population at sites in the northern half of Australia. He explained this by a partial northward movement within Australia of immature birds. Banding data shows that this also occurs extensively in the Curlew Sandpiper and, to a much lesser extent, in the Red-necked Stint. Low numbers remaining in the winter in Corner Inlet (2.2% and 8.6% respectively) reflect this, and are much lower than the average proportion of first-year birds in summer population (17.6% and 17.0% respectively) (Minton *et al.* in press). No Sharp-tailed Sandpiper are present in winter as in this species, all immature birds migrate northwards out of Australia in their first year.

Not readily explainable is the high proportion of Ruddy Turnstone (31.0%) remaining in winter. In the south-east of South Australia, banding and engraved leg flagging has shown that the young birds from quite a wide stretch of coastline may gather together into a single flock in winter (Christie *et al.* 2009). It may well be that some of the immature Ruddy Turnstone present in Corner Inlet in winter have spent the preceding summer elsewhere on the Victorian coast.

CONCLUSIONS

Serious decreases in the populations of many species of migratory shorebirds which visit south-east Australia in their non-breeding season were revealed by the 30 year count programme in Corner Inlet. This is in line with what has also been recorded in other flyways around the world, and in other locations around Australia. Delany and Scott (2006) reported that 48% of migratory shorebird populations worldwide had undergone major reductions in the last 20 years. The likely drivers of declines are thought to be related to changes in habitat availability and quality at migratory stopover locations. Many of the declining species do appear to be more reliant on the Yellow Sea, which has experienced large losses in available habitat in recent years. In contrast, many of the species less reliant on the Yellow Sea do not show declines, with the exception of Bar-tailed Godwit which is reliant on the Yellow Sea during northward migration but does not show evidence of decline. Thus, it appears that loss of habitat in the Yellow Sea is the likely cause of most of the decreases in the Corner Inlet count numbers. A comprehensive quantitative mapping programme of invertebrates in Corner Inlet is needed to ensure the changes reported here are not related to local changes in the benthic productivity or climate. It is amazing that in this fourth largest counted shorebird area in Australia, no significant invertebrate sampling or shorebird feeding studies have ever been undertaken. It is also vital to maintain the long-term count programme, unchanged, to track shorebird population levels in the future. This is especially important given the huge shoreline reclamation projects continuing to take place in the Yellow Sea. It is also necessary in order to determine the effects of any new or emerging factors, such as climate change.

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Appendix 1. Corner Inlet Summer Count Totals 1981-2011

Species	1981*	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
MIGRATORY SHOREBIRDS																
Grey Plover	430	333	851	273	380	780	900	855	590	506	460	1070	705	538	1120	460
Pacific Golden Plover	0	1	0	0	1	0	39	0	0	0	49	55	30	0	0	0
Lesser Sand Plover	172	130	0	1	20	55	32	42	20	15	60	243	100	100	90	62
Double-banded Plover	0	0	0	0	0	17	0	0	3	8	0	0	3	6	0	4
Greater Sand Plover	0	16	1	1	0	5	14	20	11	16	21	13	30	40	45	3
Ruddy Turnstone	21	112	90	50	51	132	131	160	160	120	160	160	163	83	47	25
Eastern Curlew	1180	1795	1726	1288	1478	1098	1512	1252	1190	986	1252	1175	1544	1278	1954	1723
Whimbrel	20	0	1	10	12	0	90	80	30	40	0	29	50	152	0	7
Grey-tailed Tattler	0	4	2	1	25	0	15	0	1	14	6	0	1	11	1	0
Common Greenshank	93	275	180	126	157	215	42	75	182	442	468	272	391	220	137	249
Marsh Sandpiper	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Terek Sandpiper	0	0	1	0	0	0	3	0	0	2	0	4	1	1	2	0
Black-tailed Godwit	0	2	0	0	0	0	1	0	0	0	0	0	1	2	0	0
Bar-tailed Godwit	4365	6372	8020	8700	8560	10642	13139	11760	12767	11838	10693	11380	9190	11351	11880	12334
Red Knot	850	2700	2168	2730	5150	6410	7110	3335	5900	3130	5750	6100	3950	1470	2802	2040
Great Knot	74	370	160	40	400	660	950	760	470	700	50	490	110	30	200	50
Sharp-tailed Sandpiper	80	222	500	1	50	50	3	101	200	51	60	100	60	178	10	3
Red-necked Stint	9200	11970	14932	12220	16398	18100	11605	6351	11183	9600	9270	11110	9319	17563	17907	14415
Curlew Sandpiper	5500	3700	7625	5300	3000	4640	1500	2205	2120	2780	2620	10540	2531	4942	2680	1275
Sanderling	80	110	125	22	150	1	48	184	20	140	280	300	120	119	0	150
Migratory Total	**22065**	**28112**	**36382**	**30763**	**35832**	**42805**	**37134**	**27180**	**34847**	**30394**	**31199**	**43041**	**28299**	**38084**	**38875**	**32800**
RESIDENT SHOREBIRDS																
Australian Pied Oystercatcher	619	901	840	723	1265	965	825	878	788	781	874	742	753	720	983	985
Sooty Oystercatcher	86	52	213	113	85	198	125	224	185	189	132	123	160	194	187	302
Masked Lapwing	12	10	2	6	0	14	30	21	7	8	55	26	17	25	16	31
Hooded Plover	3	1	0	7	2	1	5	4	2	13	9	2	3	2	4	5
Red-capped Plover	1	35	0	4	30	18	7	16	25	24	13	5	25	35	11	44
Resident Total	**721**	**999**	**1055**	**853**	**1382**	**1196**	**992**	**1143**	**1007**	**1015**	**1083**	**898**	**958**	**976**	**1201**	**1367**
SUMMER TOTAL	**22786**	**29111**	**37437**	**31616**	**37214**	**44001**	**38126**	**28323**	**35854**	**31409**	**32282**	**43939**	**29257**	**39060**	**40076**	**34167**

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average 1982-2011
MIGRATORY SHOREBIRDS																
Grey Plover	231	400	221	415	171	400	300	330	350	264	331	247	250	270	242	475
Pacific Golden Plover	25	0	22	0	0	0	0	0	0	0	0	0	0	0	1	7
Lesser Sand Plover	100	30	42	2	0	1	2	0	0	0	0	15	10	10	0	39
Double-banded Plover	4	0	0	1	0	30	1	40	0	66	0	17	6	120	0	11
Greater Sand Plover	50	10	5	0	0	10	1	0	0	0	6	6	4	2	6	11
Ruddy Turnstone	40	20	61	112	25	30	70	20	1	25	4	24	30	11	1	71
Eastern Curlew	1368	1104	1467	1224	1971	552	1090	751	829	924	804	695	857	496	510	1196
Whimbrel	28	36	35	64	67	14	10	7	34	33	2	45	8	20	30	31
Grey-tailed Tattler	10	1	0	0	0	0	0	0	2	0	2	0	0	0	6	3
Common Greenshank	301	240	216	88	72	44	36	72	0	180	110	64	77	32	91	168
Marsh Sandpiper	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terek Sandpiper	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Black-tailed Godwit	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed Godwit	8519	11285	9587	9093	8251	6951	7733	10668	7660	10083	10791	10150	10070	11523	11400	10080
Red Knot	1500	2100	930	592	1800	1200	2470	2501	1098	2340	955	612	110	730	300	2666
Great Knot	50	210	100	90	100	300	410	50	152	110	66	50	5	28	50	240
Sharp-tailed Sandpiper	50	100	2	0	15	0	5	0	150	160	23	31	25	50	0	73
Red-necked Stint	14044	9600	15292	24355	22720	17970	15520	16210	12663	12146	13358	15266	15489	11544	13260	14046
Curlew Sandpiper	1005	880	1398	1028	931	859	980	102	408	580	607	1070	295	65	30	2257
Sanderling	80	164	72	236	50	102	50	20	180	102	41	140	150	100	220	116
Migratory Total	**27411**	**26181**	**29450**	**37300**	**36173**	**28463**	**28678**	**30771**	**23527**	**27013**	**27100**	**28432**	**27386**	**25001**	**26147**	**31493**
RESIDENT SHOREBIRDS																
Australian Pied Oystercatcher	940	630	878	818	835	838	914	854	777	1182	917	1148	1037	793	865	882
Sooty Oystercatcher	298	177	166	339	381	191	328	400	279	598	295	318	549	271	392	249
Masked Lapwing	42	28	22	22	14	8	25	7	26	37	35	8	5	20	19	20
Hooded Plover	2	10	9	5	6	0	0	2	5	2	2	14	7	4	8	5
Red-capped Plover	67	8	10	60	32	0	0	0	10	2	18	12	20	10	5	18
Resident Total	**1349**	**853**	**1085**	**1244**	**1268**	**1037**	**1267**	**1263**	**1097**	**1821**	**1267**	**1500**	**1618**	**1098**	**1289**	**1173**
SUMMER TOTAL	**28760**	**27034**	**30535**	**38544**	**37441**	**29500**	**29945**	**32034**	**24624**	**28834**	**28367**	**29932**	**29004**	**26099**	**27436**	**33425**

* counts from summer 1981 were not included in these analyses

Appendix 2. Corner Inlet Winter Count Totals 1982-2011

Species	1982*	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average 1983-2011
MIGRATORY SHOREBIRDS																															
Grey Plover	0	0	28	3	70	18	54	0	0	22	161	14	108	55	51	20	1	27	10	9	10	12	40	46	25	2	1	0	12	29	29
Pacific Golden Plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lesser Sand Plover	0	3	0	0	5	2	1	6	0	8	18	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2
Double-banded Plover	410	328	370	427	642	106	927	550	313	402	420	307	365	1155	1579	945	392	111	1183	260	827	248	540	380	430	125	691	885	690	560	557
Greater Sand Plover	0	2	0	5	2	8	2	0	1	4	2	0	3	6	2	0	0	1	0	0	0	0	0	1	0	0	0	0	4	0	1
Ruddy Turnstone	0	66	70	25	94	62	31	55	3	79	76	0	21	4	0	0	1	10	5	0	5	0	0	10	10	0	0	0	4	6	22
Eastern Curlew	105	107	30	153	62	42	163	81	154	100	65	112	198	252	77	170	156	88	22	97	217	162	101	100	45	42	18	33	28	32	100
Whimbrel	3	0	21	47	0	3	0	58	14	1	2	0	20	0	3	5	0	2	0	0	0	0	9	6	0	3	3	0	0	0	7
Grey-tailed Tattler	12	1	9	0	6	26	10	0	23	4	2	0	2	12	0	0	0	4	5	0	0	0	0	0	0	1	0	0	4	0	4
Common Greenshank	36	2	0	13	39	0	0	1	25	0	51	29	15	2	11	0	10	12	3	0	0	1	14	13	0	0	0	0	0	1	8
Marsh Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terek Sandpiper	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-tailed Godwit	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed Godwit	350	301	461	1597	1022	1878	1330	4157	2603	1535	1100	91	1017	1016	1507	480	552	2587	4123	1670	459	750	500	2530	3581	390	787	2870	2980	1154	1553
Red Knot	0	296	0	700	2502	1264	1700	2700	590	3101	4440	6	1240	50	1229	30	340	275	334	330	400	465	200	865	353	80	80	150	230	300	836
Great Knot	0	51	0	32	100	65	100	50	62	0	5	0	0	0	15	0	10	22	20	20	0	0	0	10	30	0	10	15	10	0	22
Red-necked Stint	1100	495	60	425	1140	227	1107	990	426	564	1982	210	1184	247	2557	820	760	938	3492	470	6084	2140	2902	585	880	372	570	748	1161	1510	1208
Curlew Sandpiper	20	62	5	9	69	0	175	1	129	30	545	0	1	7	0	0	10	0	35	50	115	126	15	0	31	0	5	6	0	0	49
Sanderling	0	0	0	0	5	3	12	0	0	1	41	0	0	1	0	0	0	1	0	0	20	4	0	0	12	0	0	0	2	36	5
unidentified *Calidris* sandpipers	0	0	0	0	0	50	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
unidentified curlews	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Migratory Total	**2038**	**1714**	**1054**	**3476**	**5758**	**3756**	**5616**	**8699**	**4343**	**5851**	**8910**	**769**	**4182**	**2810**	**7033**	**2470**	**2232**	**4080**	**9232**	**2906**	**8137**	**3908**	**4321**	**4546**	**5397**	**1015**	**2165**	**4707**	**5131**	**3628**	**4408**
RESIDENT SHOREBIRDS																															
Australian Pied Oystercatcher	200	887	1013	1087	707	999	775	754	1044	868	682	860	725	802	920	880	770	918	628	686	732	767	518	631	654	974	726	735	891	765	807
Sooty Oystercatcher	180	106	203	237	234	143	182	219	265	141	361	237	192	148	483	265	370	285	429	347	319	250	305	387	372	308	325	465	429	485	293
Masked Lapwing	0	8	2	11	26	48	22	34	23	9	30	43	15	9	21	59	10	4	10	3	4	7	8	60	10	6	9	6	18	7	18
Hooded Plover	0	4	4	0	4	15	2	0	4	16	6	7	12	3	6	0	4	5	8	1	5	5	9	0	5	2	3	7	3	5	5
Red-capped Plover	0	25	70	23	60	47	26	50	51	22	30	81	26	65	71	93	32	36	41	6	21	24	3	15	12	31	26	67	27	40	39
Banded Stilt	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-winged Stilt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Resident Total	**380**	**1030**	**1292**	**1359**	**1031**	**1252**	**1007**	**1057**	**1388**	**1056**	**1109**	**1228**	**970**	**1027**	**1501**	**1297**	**1186**	**1248**	**1116**	**1043**	**1081**	**1053**	**843**	**1093**	**1053**	**1321**	**1089**	**1280**	**1368**	**1307**	**1162**
WINTER TOTAL	**2418**	**2744**	**2346**	**4835**	**6789**	**5008**	**6623**	**9756**	**5731**	**6907**	**10019**	**1997**	**5152**	**3837**	**8534**	**3767**	**3418**	**5328**	**10348**	**3949**	**9218**	**4961**	**5164**	**5639**	**6450**	**2336**	**3254**	**5987**	**6499**	**4935**	**5570**

* counts were not conducted in the winter of 1981, and in 1982 only the eastern half of Corner Inlet was counted

LONG-TERM DECLINES IN MIGRATORY SHOREBIRD ABUNDANCE IN NORTH-EAST TASMANIA.

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Evidence of long-term declines in migratory shorebird populations is reported at two areas in north-east Tasmania. In north-east Tasmania, both George Town Reserve and Cape Portland have featured in National Wader Counts since 1981, although observations go back to the early 1970's. Compared with the extreme north-west of Tasmania and with many mainland study sites, wader numbers in north-east Tasmania are never large, which makes for relatively easier counting. At George Town, count data indicate long-term population declines from 1974 to 2011 in Eastern Curlew, (*Numenius madagascariensis*), Ruddy Turnstone (*Arenaria interpres*), Curlew Sandpiper (*Calidris ferruginea*), and Bar-tailed Godwit (*Limosa lapponica*). George Town has also seen a decrease in the number of migratory shorebird species recorded each year, a drop on average from nine to seven, while Cape Portland has seen a larger drop in migratory shorebird species richness from eleven to six. Cape Portland has also experienced long-term declines from 1981 to 2011 in Ruddy Turnstone and Curlew Sandpiper. The reduction in species richness in both areas relates to historically uncommon species no longer being recorded such as Red Knot (*Calidris canutus*), Lesser Sand Plover (*Charadrius mongolus*), Greater Sand Plover (*Charadrius leschenaultia*), Grey-tailed Tattler (*Tringa brevipes*), Terek Sandpiper (*Xenus cinereus*) and Grey Plover (*Pluvialis squatarola*). Trends derived from these two north-east Tasmanian areas are similar to those being reported more widely in Australia, with growing numbers of migratory shorebirds showing evidence of long-term population declines. Threats to the foraging areas of both study sites, which have the potential to compromise their viability, are outlined. The volume of data available from these areas will allow for more detailed analyses in future.

INTRODUCTION

Reporting the interspecific differences in the magnitude of shorebird population changes is of increasing importance as migratory shorebirds in Australia are showing growing evidence of large, widespread declines (Creed & Bailey 1998, Wilson 2001, Olsen *et al.* 2003, Reid & Park 2003, Gosbell & Clemens 2006, Nebel *et al.* 2008, Wilson *et al.* 2011, Dawes 2011, Milton & Harding 2011, Stuart 2011). These widespread declines being reported throughout Australia are concurrent with increasing large-scale loss of habitat (Moores 2006) occurring in migration stopover locations throughout the East Asian –Australasian Flyway.

The shorebird count data collected at Cape Portland and George Town in north-east Tasmania (Figure 1) are among the most intensive and long-term data sets in Australia (Gosbell & Clemens 2006). Counts were initiated in 1973 in George Town, and in 1975 at Cape Portland and on average, were conducted in seven out of 12 months each year, with counts available in most years in both summer and winter months. We are not aware of another shorebird area in Australia with more frequent surveys over a longer period. While the number of birds in these areas is modest by international standards, these data are among only a handful that can be used to report on long-term population changes in shorebirds of Australia (Gosbell & Clemens 2006, Clemens *et al.* in review). This paper reports on initial analyses of population trends in shorebirds in north-east Tasmania over a period of more than 30 years, that will ultimately aid in the identification of regional similarities and differences in the population changes being observed throughout Australia.

METHODS

Study areas

George Town Reserve (41-03-34 S ----146-47-10 E)
This study area is situated on the eastern side of the Tamar Estuary between the towns of George Town and Low Head. It lies within an area of foreshore two kilometres in extent that was declared a Wildlife Sanctuary in 1987. The southern part of the Sanctuary was not surveyed because it contains no bays or mudflats. The river flows deeply in this section and, even at low tide, there is little exposed shoreline. The study site is confined to roughly one kilometre of shoreline further north. There are several tidal islands within the study area, some of which are used regularly as roosts.

A sand / shingle bar extends out into the Tamar Estuary for some 750m. At high tide this becomes a severed peninsula, separated from the shore by a narrow channel. On a falling tide this peninsula becomes incorporated into a series of dolerite reefs covering several hectares, surrounded by extensive mudflats. A public walkway runs the length of the area but is set back far enough from the shore to cause no disturbance to birds. There are roadside dwellings at the northern end of the area but they are not on the shoreline side of the road. No dwellings are located in the central section opposite an important Eastern Curlew roost. A few houses on the southern part of the site are separated from the shore by an access road and a wide council verge. There is no evidence of trail bike or four-wheel drive activity at the site except on very rare occasions.

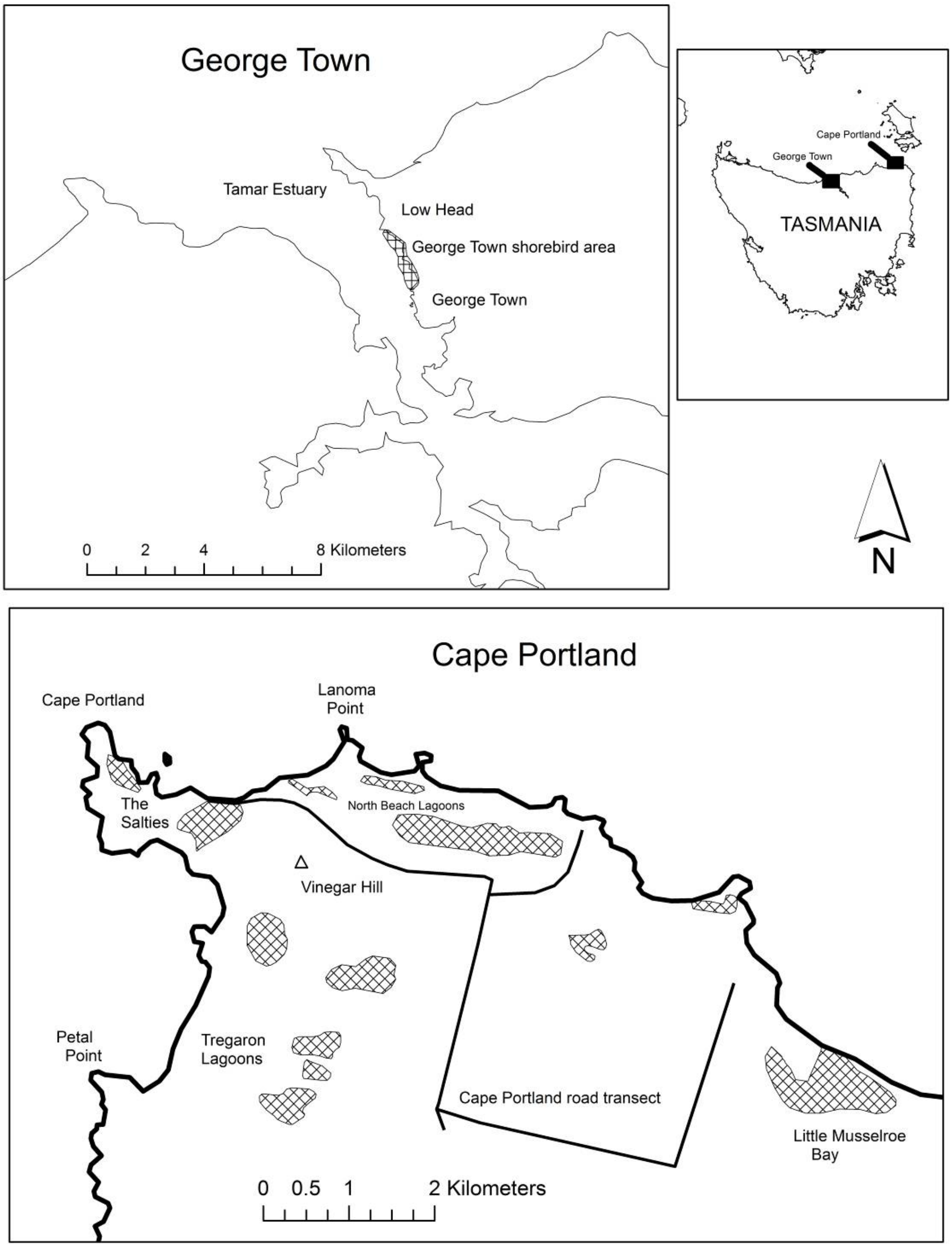

Figure 1. Map of the George Town and Cape Portland study areas in north-east Tasmania.

Cape Portland (40-45-13 S ----147-59-42 E)
This large pastoral property (>3400 ha) near the north-eastern tip of Tasmania includes areas of open pasture with many lagoons, marshes, a tidal basin, and coastal reefs along a coastline of alternatively rocky and sandy shores. The farm area is fenced with restricted access, and therefore receives little visitation, or human disturbance to the birds. The tidal basin (called Little Musselroe Bay) is a public camping area controlled by the Tasmanian Parks and Wildlife Service. Access is granted in the summer months. The tidal basin is large enough for birds to settle in quieter areas when disturbed by holiday makers. Many of the lagoons on the Cape are ephemeral, which leads to the condition of some of these habitats varying in suitability for shorebirds from one visit to the next. Over the last decade, prolonged drought has resulted in dry lagoons, greatly reducing the area's capacity to support shorebirds. Cape Portland's size and diversity of habitats present a greater challenge to counting, than the George Town area, but is still relatively easier to count than larger areas such as those found in north-west Tasmania and the Australian mainland.

Count Surveys

George Town

The small size of the George Town study site means that a complete census of the shorebirds found there can be undertaken. One person is able to cover this compact site and the majority of surveys were conducted by the same person. A total of 283 surveys were conducted at George Town between 1974 and the summer of 2011. The number of visits made in any of the 38 years from 1974 to 2011 ranged from one to 23 with summer counts available in 36 years. No summer count was recorded in 1978 or 1987, and in 1977 several species were not counted, only being recorded as present. Therefore, there were a maximum of three missing summer counts across 38 years for any one species.

Cape Portland

A total of 432 surveys were conducted between 1975 and 2011, with an average of 12 visits each year. Surveys from 1975 to 1981 often recorded both Red-necked Stint and Curlew Sandpiper as 'present' rather than as actually counted. Furthermore, counts were usually conducted by a single observer and spatial coverage varied somewhat. Therefore, counts in these early years at Cape Portland were seen as less comparable to those done more consistently from 1981-2011 and were excluded from the analyses presented here.

From 1981 surveys were conducted by the same two, occasionally three, observers. A consistent effort was made to cover all lagoon areas even when known to be dry. No water is drawn from any lagoon for agricultural purposes. This eliminates any change in lagoon levels caused by factors other than natural evaporation. Surveys were conducted by driving along the same eleven kilometres of road while leaving the vehicle at set points and walking. From the road the grassy flats were scanned for migratory shorebirds using 10x binoculars and a 20x spotting scope.

Cape Portland supports more shorebirds than George Town but it also has much greater variation in the recorded abundance between counts, with some very low counts recorded in some years. This is probably a reflection of both variation in detectability of birds across a large area, as well as potential movement of birds out of survey areas in response to the poorer condition of marshes and lagoons during persistent drought.

Some areas of coast and headland have been consistently omitted from counts allowing for concentrated effort on the better quality shorebird habitats. These omitted areas include some small steeply shelving beaches and two long sandy beaches all of which are impractical to survey in the time available. These omitted beaches have been subjected to disturbance for many years by off-road vehicles, and random surveys over the years have shown that these areas hold few, if any, migratory shorebirds.

Statistical analyses

We analysed only data from summer counts because the populations of interest for this paper were the migratory shorebirds that rely on Cape Portland during the peak of their non-breeding season (November – February). The number of summer counts conducted each year varied, and maximum summer counts were believed to represent the best estimate of the total number of birds found in each area in summer each year. In addition, these maximum summer counts were more similar across years, while using mean values increased the variation in these data. For these reasons, the maximum seasonal counts were used in analyses, but to guard against the potential bias of higher maximum counts in years with more summer surveys, the number of summer surveys conducted each year was added as a weighting term or explanatory variable in all subsequent analyses. Finally, year was transformed into an ordinal variable with the first year in the time series set as year one, and used as an independent predictor variable.

Diagnostic tests were conducted on each species' time series of maximum summer counts, including scatter plots, box plots, autocorrelation plots, and Yule-Walker autocorrelation estimates. Initial attempts were also made to use polynomial regressions, negative binomial Generalised Linear Models (GLM), and Generalised Additive Models (GAM) using penalty-modified thin plate regression splines which optimise the amount of smoothing or wiggliness of the best fitting line. However, residual plots from all these techniques indicated over-fitting, and a lack of homogenous variance of errors over time.

Diagnostic tests indicated that the assumptions of linear regression were all violated to some degree in most data, with a lack of linearity between counts and year, a lack of independence in the errors over time, a lack of homoscedasticity (evenly distributed errors over time), and occasionally a lack of normality in the distribution of the error terms. Generalized least squares (GLS) was selected as the most parsimonious technique to overcome these violations in assumptions while still resulting in a reasonable index of population change over time.

GLS regressions were run for selected species with the transformed year and the number of summer counts used as independent variables to predict the count. A *t*-test was used to assess the significance of year, indicative of a long-term trend, but the number of counts per summer was retained in the model regardless of significance. Finally, some time series had up to three missing values, which were interpolated by simply taking the average between adjacent years. Interpolated values were seen as necessary when adding autocorrelation terms, but tests indicated interpolated and non-interpolated results were nearly identical. Zero values were retained in all analyses.

For each species in each area seven candidate GLS models were tested. The first model corresponded to a simple linear regression model with year and number of surveys used to predict maximum annual summer abundance for each species. Where temporal autocorrelation in time series data was indicated by diagnostic tests, an error term was added, which implemented a residual correlation structure of an auto-regressive model of order 1 (AR1). Essentially, this term corrects for counts which are related in time, but vary somewhat randomly within constraints. This has been called 'white noise' and was thought to mirror the kind of variation we might expect to see in annual abundances of shorebird species (Colwell 2010). In all of the remaining six models three pairs were differentiated, with one model in each pair including an AR1 term, and one not. In addition, one of three types of weighting terms was added to each of the three pairs of models: (1) a weighting term that assumed the spread in residuals was different in each 5 year period, (2) a weighting term that assumed an exponential relationship between year and the spread of residuals, and (3) a weighting term that combined exponential and 5 year period terms. These additional terms were all thought to represent the kind of variation we'd expect in shorebird abundance data.

The optimal of these seven models was selected based on the model with the lowest AIC value, which was then assessed with residual plots. If residual plots revealed assumptions were met, the model with the lowest AIC value was selected in each case, and estimated parameters were summarised.

All statistical analyses were conducted in the R software program (R Development Core Team 2011), with use of the 'nlme' library in R for generalised least squares analysis (Pinheiro *et al.* 2011), and the 'mgcv' library in R for general additive models (Wood 2003, Wood 2004, Wood 2006). Statistical analyses followed demonstrated procedures (Zuur *et al.* 2009). Scatter plots of year versus maximum summer count were generated in the R software program, and a line indicating average slope was added to those species plots showing evidence of long term changes in abundance. These lines were generated by fitting least squares regressions to the predicted values of GLS models as selected above.

RESULTS

Twenty-four shorebird species were recorded in the two survey areas including 17 migratory species, and seven resident species (data not shown). Nine of the migratory shorebird species had sufficient data for analysing trends: Eastern Curlew (*Numenius madagascariensis*), Curlew Sandpiper (*Calidris ferruginea*), Ruddy Turnstone (*Arenaria interpres*), Bar-tailed Godwit (*Limosa lapponica*), Pacific Golden Plover (*Pluvialis fulva*), Common Greenshank (*Tringa nebularia*), Red-necked Stint (*Calidris ruficollis*) and Sharp-tailed Sandpiper (*Calidris acuminata*).

George Town

Generalised least squares regression indicated significant long term declines in Eastern Curlew (-2.2% per year), Ruddy Turnstone (-2.1% per year), Bar-tailed Godwit (-2.4% per year) and Curlew Sandpiper (-2.4% per year) (Figure 2). Non-significant decreases were detected in Red-necked Stint and Pacific Golden Plover (Table 1a). Common Greenshank did not show evidence of significant trends. Regressions of number of counts per year against maximum number of shorebirds produced R^2 values < 0.04 for each of the seven species. In other words, increased summer survey effort did not appear to be related to the maximum number of birds recorded in summer. Regressions of the maximum annual species richness against year, while including a weighting term for the number of counts indicated that, on average species richness at George Town declined from 9 to 7 (Table 2a). More frequent zero counts of uncommon species accounted for this change. For example, the maximum count of Grey-tailed Tattler (*Tringa brevipes*) was 16 in 1985 but

Table 1. Regression results highlighting the change in the numbers of selected shorebirds over time, listed in order of most evidence of decline to least: 1A) summer counts at George Town 1974 – 2011; 1B) summer counts at Cape Portland 1981 -2011

1A.

Species	Mean[1]	% /yr	Av. change	*P*-value[2]	Var. weight[3]	AR1[4]	YS1, YS2[5]
Eastern Curlew	59.1	-2.2%	122-19	0	5 yr	Y	1,1
Ruddy Turnstone	90.1	-2.1%	170-24	0	expon.	N	0,1
Bar-tailed Godwit	42.4	-2.4%	85-7	<0.001	none	Y	1,1
Curlew Sandpiper	82.5	-2.4%	130-2	0.003	5yr, expon.	Y	0,1
Pacific Golden Plover	9.0	-2.8%	13 to 0	0.079	expon.	Y	0,?
Red-necked Stint	156.7	-3.0%	153-0	0.084	5 yr	Y	0,1
Common Greenshank	21.3	+1.6%	17-28	0.431	expon.	Y	0,1

1B.

Species	Mean[1]	% /yr	Av. change	*P*-value[2]	Var. weight[3]	AR1[4]	YS1, YS2[5]
Ruddy Turnstone	93.8	-2.8%	194-34	0	expon	N	0,1
Curlew Sandpiper	411.2	-2.9%	528-66	0.011	5 yr, expon.	Y	0,1
Red-necked Stint	1228.9	-1.1%	1558-1053	0.221	none	N	0,1
Pacific Golden Plover	125.1	-1.7%	157-74	0.479	expon.	Y	0,?
Sharp-tailed Sandpiper	40.2	-1.7%	40-20	0.592	5 year	N	0,?

[1] Mean = average maximum number of birds; Georgetown from 1974-2011, Cape Portland 1981-2011
[2] *P*-value of *t*-test on slope coefficient
[3] weighting term used to address problems in heterogeneity, expon = exponential, 5 yr = periods with variation allowed to vary within each 5 yr period
[4] a term added to GLS regressions to account for a residual correlation structure of an auto-regressive model of order 1
[5] YS1: 1 = species thought to be extremely reliant on the Yellow Sea, 0 = other, YS2: 0 = species not reliant on Yellow Sea, 1 = a notable percent of the flyway population of this species use Yellow Sea for staging

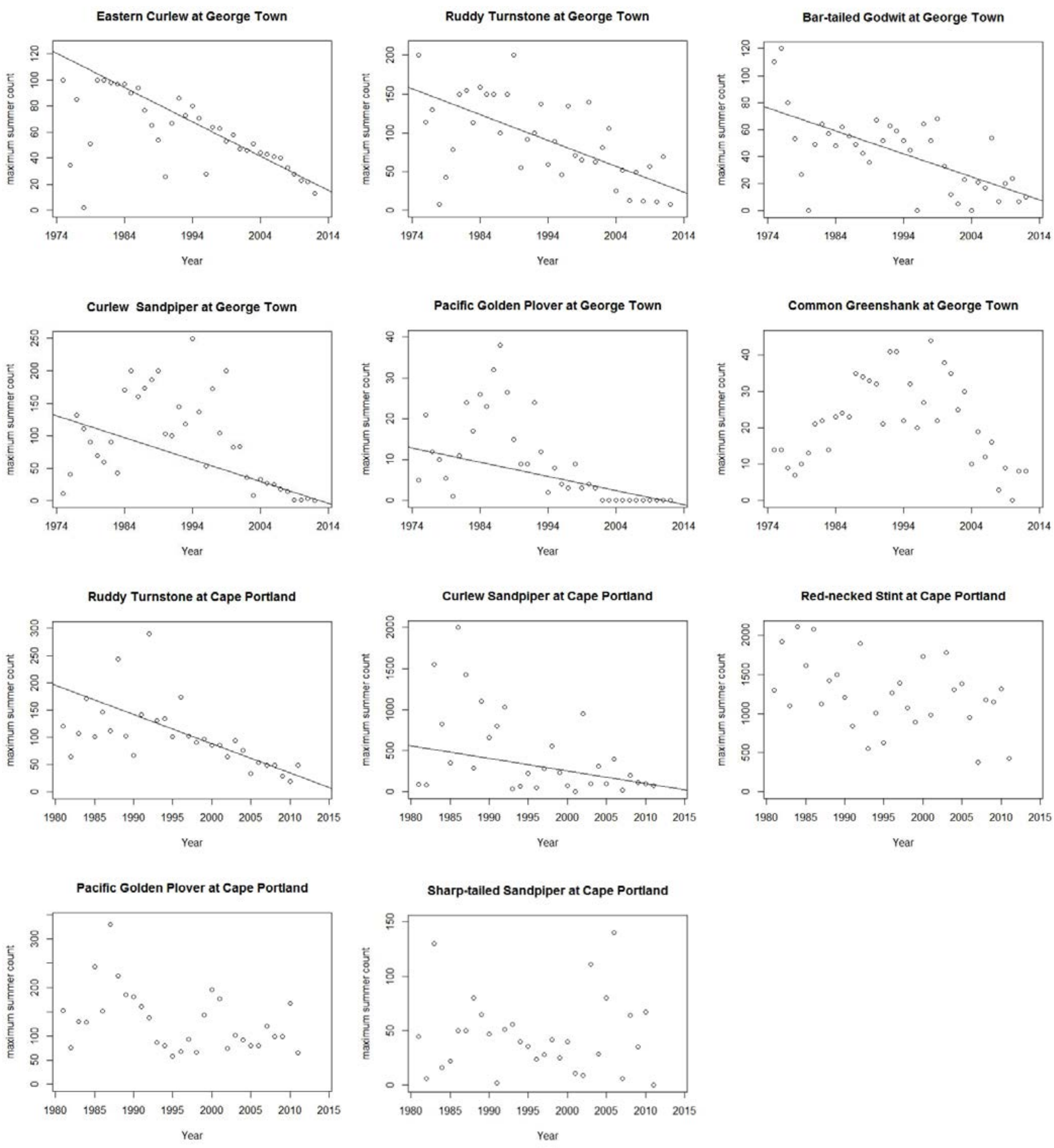

Figure 2. Scatter plots of maximum summer counts for selected shorebird species, at two areas in north-east Tasmania, Cape Portland 1981-2011 & George Town 1974-2011. Least squares regression lines of GLS predicted values are included for those species identified as having evidence of long-term changes in abundance.

none have been seen since 2005 (Table 2a). Red Knot (*Calidris canutus*) was recorded 35 times, but none since 1998. Other uncommon species like Terek Sandpiper (*Xenus cinereus*), recorded on 27 surveys, has not been recorded since 1991. Similarly, Grey Plover (*Pluvialis squatarola*) was recorded 23 times up until 1998, and Lesser Sand Plover (*Charadrius mongolus*) was recorded nine times up until 1991. Neither of these two species has been recorded since.

The summed maximum counts of all ten migratory shorebirds recorded in any summer at George Town ranged from 39 to 1171, with an average of 464. Summed maximum count totals averaged to 424 in the 1970’s, rose to 724 in the 1980’s, declined to 510 in the 1990’s, then fell again to 246 in the 2000’s, and in the last five years have

Table 2. Comparisons of maximum counts for selected species over four time periods at two areas in Northeast Tasmania: (2a) George Town and (2b) Cape Portland. Species' counts omitted due to vagrancy from each site were Lesser Sand Plover and Sharp-tailed Sandpiper (George Town), and Eastern Curlew and Whimbrel (Cape Portland).

2a) George Town.

Species	Max count 1973-1979 month/year	Max count 1980-1989 month/year	Max count 1990-1999 month/year	Max count 2006-2010 month/year
Bar-tailed Godwit	120	67	68	32
	2/75	1/89	12/95	2/06
Whimbrel	7	16	11	19
	1/74	12/85	10/97	10/02
Eastern Curlew	180	97	86	40
	3/76	2/83	2/81	1/06
Common Greenshank	18	37	44	16
	3/76	3/86	2/97	1/06
Grey-tailed Tattler	14	16	10	0
	3/77	3/85	1/96	
Ruddy Turnstone	200	200	210	69
	1/74	2/88	10/91	1/10
Red Knot	20	15	11	0
	4/77	1/86	3/91	
Red-necked Stint	200	600	295	101
	11/74	2/84	10/91	10/08
Curlew Sandpiper	100	300	324	18
	3/79	10/84	2/92	1/06
Pacific Golden Plover	27	47	24	0
	3/79	3/85	2/91	

2b) Cape Portland

Species	Max count 1975-1979 month/year	Max count 1980-1989 month/year	Max count 1990-1999 month/year	Max count 2006-2010 month/year
Bar-tailed Godwit	5	42	5	11
	11/77	11/84	11/98	10/08
Grey-tailed Tattler	6	11	7	0
	4/76	1/86	4/92	
Ruddy Turnstone	118	244	290	54
	3/79	2/88	11/91	2/06
Red Knot	16	64	26	9
	3/78	2/86	2/92	12/10
Red-necked Stint	2100	2115	1899	1314
	10/79	2/84	2/92	1/10
Sharp-tailed Sandpiper	40	130	80	67
	11/77	12/82	10/94	1/10
Curlew Sandpiper	500	2000	1032	205
	12/79	11/85	11/92	12/07
Pacific Golden Plover	200	295	169	167
	2/78	12/86	3/91	2/10
Lesser Sand Plover	12	12	9	0
	1/75	3/80	3/92	

been below 200. The lower numbers in the 1970's appear to be due mostly to lower numbers of Curlew Sandpiper and Red-necked Stint being recorded. There is no indication that lower numbers of species like the Curlew Sandpiper recorded in the 1970's related to survey methodology as the area is fairly easy to count in its entirety, and there was no relationship between numbers of counts per year and maximum counts of this species. However, a different observer did the count in the 1970's so we cannot rule out observer bias as a possible explanation entirely. By 2010, Eastern Curlew and Curlew Sandpiper counts had fallen to 22 and 3 birds, respectively. A provisional count in October 2011 (outside the analysis period) showed only 12 Eastern Curlew present.

Most of the migratory shorebirds included in analyses are thought to be somewhat dependent on the Yellow Sea in south-east Asia, with notable proportions of their flyway populations using this area as a refuelling stop during migration. There was no obvious separation in the magnitude of declines detected in north-east Tasmania between those species thought to be highly dependent on the Yellow Sea, like Bar-tailed Godwit, and those thought to be less dependent on the Yellow Sea like Ruddy Turnstone (Table 1).

Cape Portland

Generalised least squares regression indicated significant long term declines in Ruddy Turnstone (-2.8% per year), and Curlew Sandpiper (-2.9% per year; Table 1a). Red-necked Stint, Pacific Golden Plover and Sharp-tailed Sandpiper did not show evidence of significant declines. Regressions of the maximum annual species richness of migratory shorebirds with year as an independent variable, while including a weighting term for the number of counts, indicated that on average the maximum species richness at Cape Portland declined from 11.5 to 6.5. This drop in species richness related to increasing zero counts of uncommon species (Table 2b). Of the species recorded on average in numbers less than twenty, Common Greenshank, Eastern Curlew, Grey-tailed Tattler, Red Knot and Lesser Sand Plover have all been increasingly absent in summer counts. Even less common species like Great Knot (*Calidris tenuirostris*) had been recorded only on five occasions all prior to 1982.

There was some evidence that increased survey effort at Cape Portland increased the chances of observing more of the birds in the area over summer. Regressions indicated relationships between the maximum count and the number of summer surveys conducted for Curlew Sandpiper (R^2=0.34), Pacific Golden Plover (R^2=0.33), Sharp-tailed Sandpiper (R^2=0.16) and Ruddy Turnstone (R^2=0.15). The most abundant and widespread species in the area, Red-necked Stint, did not show a relationship between the number of counts and the maximum number recorded in any summer (R^2 = 0.03). Therefore, increased summer survey effort did appear to be somewhat related to the maximum number of several species recorded in summer at Cape Portland and demonstrated the importance of retaining the number of counts done each summer as an independent term in the modelling.

When we looked at the maximum summer counts of the 11 most common migratory shorebirds recorded in the Cape Portland survey site and summed those in each year, the average estimated maximum summer population was 1854 (range 135 – 4513). The patterns observed in the Cape Portland counts were similar to the George Town counts, with the lowest averages recorded in the 1970's (758), the highest in the 1980's (2657), fewer in the 1990's (1762), and somewhat fewer in the 2000's (1718). Like George Town, these lower totals in the 1970's were driven mostly by lower recorded numbers of Red-necked Stint and Curlew Sandpiper, however, in Cape Portland these lower counts were not included in analyses due to less consistent coverage of the area by one instead of two observers in the 1970's.

DISCUSSION

The long time-series count data from George Town and Cape Portland has revealed significant declines in a number of migratory shorebird species. These declines mimic declines reported more widely in Australia (Barter 1992, Creed & Bailey 1998, Wilson 2001, Olsen *et al.* 2003, Reid & Park 2003, Gosbell & Clemens 2006, Close 2008, Nebel *et al.* 2008, Creed & Bailey 2009, Singor 2009, Rogers *et al.* 2010b, Wilson *et al.* 2011, Minton *et al.* 2012). Therefore, the trends reported here are considered reliable indications of trends in north-east Tasmania more broadly, even though George Town and Cape Portland contain lower overall abundances of some species relative to other Tasmanian sites. The steepest, most consistent and catastrophic long-term declines in north-east Tasmania were observed in Eastern Curlew at George Town, but declines in Ruddy Turnstone, Bar-tailed Godwit, Curlew Sandpiper, and overall migratory shorebird species richness were clearly significant.

While the abundance of many species in both George Town and Cape Portland has always been low, the significant declines in species richness of migratory shorebirds in both areas were striking. Uncommon species including Red Knot, Lesser Sand Plover, Greater Sand Plover, Grey-tailed Tattler, Terek Sandpiper, Grey Plover, and Common Greenshank are simply no longer recorded nearly as often as they used to be in these areas.

George Town

Declines in migratory shorebird abundance and species richness have been particularly obvious at the small roost at George Town, with over 700 individuals of nine species seen in the 1980's having declined to less than 200 individuals of seven species seen today. While these declines mirror wider trends, the potential impacts on these already declining species are of concern at George Town. The George Town shorebird area is located within a relatively industrialised region and as with many survey sites that are close to industry, there is always a risk of an accident that could impact on foraging areas. Such an accident happened in July 1995 when the bulk ore carrier *Iron Baron* grounded on a reef at the mouth of the Tamar River in northern Tasmania and 325 tonnes of heavy fuel oil escaped (Holdsworth & Bryant 1995). Had the spill occurred in summer the result could have been catastrophic for shorebirds. The Australasian Wader Study Group winter count undertaken five days before the spill showed wader numbers to be low, and no oiled waders were subsequently found. An independent report commissioned by BHP, the vessel's owner, reported no significant changes in abundance of most bird species in the second year after the spill (Fairfull 1997). Initially, Ruddy Turnstones appeared to have declined by 50% (Cooper 1997) but this proved to be an inaccurate assessment of the situation as numbers increased again in subsequent years. However, an estimated 10,000+ Little Penguins died as a result of the spill (Goldsworthy *et al.* 2000) which indicates the potential risk to waders, had the timing been different.

Cape Portland

The migratory shorebirds that visit Cape Portland are more dispersed across an area with limited public access. None-the-less, declines in abundance and species richness has been striking here as well, with numbers in the 1980's of over 2500 of 11 species falling to around 1700 in recent years of only six species. While the restriction to public access and remoteness of the area reduces potential threats, a wind farm development which is currently underway, may further impact these already declining shorebird populations. On-ground work at the Musselroe Wind Farm relating to road construction and turbine hard stands is proceeding with the aim of installing turbines later in 2012 for full operation by mid-2013. Some of the fifty-six turbines are to be sited between the coastal lagoons of North Beach and lagoons near Vinegar Hill (Figure 1). Disruptions to foraging patterns on pasture habitat may occur. There is also a risk of collision of shorebirds with turbines or displacement from some habitats. Monitoring of turbines for bird mortality is a requirement of the operating licence and will be critical to investigating the potential impact of the wind farm on migratory shorebirds using the area.

Statistical approach

The use of GLS in these analyses has produced a simple yet robust estimate of population changes in migratory shorebirds by using additional terms in the modelling that make biological sense, based on what we know of shorebird count data in Australia. Further, in these data GLS assumptions were all met, a noteworthy difference to some techniques applied historically to these kinds of data, which have acknowledged violations of assumptions but sought simply to interpret results more conservatively when this happens (Gosbell & Clemens 2006). The way in which these terms overcame violations of assumptions in simple linear regression is worth highlighting. Given these data are related in time, we assume that temporal autocorrelation will be present in these data and would follow a somewhat stochastic pattern as represented by an auto-regressive model of order 1 (AR1) term. Over half the best fitting models found in these analyses used an AR1 term in the model.

The use of an exponential term in the model accounts for two likely scenarios in the distribution of residuals. First, other analyses have shown the size of errors often being proportional to the number of birds. In the declining populations observed in Australia those trends appear to be steepest in early years with slower rates of decrease in later years, as seen in exponential declines (Gosbell & Clemens 2006). So residuals are mostly dispersed in early years, and rapidly become less dispersed in later years. Second, we expect detection rates to improve over time for many species as counters get more familiar with an area, and we expect the greatest improvement in detection rates in early years. This would result in similar patterns of residuals as exponential declines would show.

The third error term allows for the spread of residuals to vary in different five-year periods. Again, if we assume variation is somewhat proportional to abundance, and we expect periodic peaks and crashes in shorebird abundance (Colwell 2010), often followed by a time-lag as populations return to equilibrium, an error term of this type would capture another kind of variation we would expect in these kinds of data.

The fact that the best fitting model employed different numbers of these error terms depending on the species raises the question: Would the error terms selected for different species be the same in other areas, or are these error terms specific to the data in north-east Tasmania? The abundant and widespread Red-necked Stint in Cape Portland was the only species in either location where simple linear regression provided the best model for these data, and additional GLS terms were not needed. It seems likely, however, if declines had been detected that an exponential term might fit these data well. This suggests, on the one hand, that the optimal selected error terms will tend to vary depending on local factors.

On the other hand, some selected error terms might be species-specific and apply across wide areas. If we assume that counts of species having high site fidelity and high detection rates will result in temporal autocorrelation which is best represented by an AR1 term, we might also expect variation in counts of species with low site fidelity or frequent movement between shorebird areas would not be well represented by an AR1 term. The was the case for Sharp-tailed Sandpiper counts in north-east Tasmania. We suspect variation in Sharp-tailed Sandpiper numbers is probably driven more by high rates of movement between areas, which may mask the detection of AR1 temporal autocorrelation between successive counts, even when it exists. Given movements of Sharp-tailed Sandpiper are well known throughout Australia (Marchant & Higgins 1993, Alcorn *et al.* 1994, Higgins & Davies 1996), we might then expect that variation in any area in Australia for this species would also be better captured by breaking the data into five year periods rather than including an AR1 term. We suggest that any species-specific similarities or differences in the GLS model terms selected here compared to model terms from analyses of species elsewhere, could help identify some of the drivers of variation in shorebird count data.

Similarities to trends reported elsewhere

The declines reported in this study match similar declines reported elsewhere in eastern Tasmania, including striking similarities in changes in annual counts between south-east and north-east Tasmania from 1981 to 1996 (Cooper *et al.* 1997). Tasmanian declines have been observed in Eastern Curlew at Port Sorell, an area 20 km further west (Britton & Hunter 2005). The numbers there were described as 'stable' with 27 to 30 birds present from 2000 to 2004, yet a summer count in 2010 could locate only 18 birds. There appears to be no interchange between the George Town and Port Sorell groups, which could account for this difference. Site fidelity seems to be high within these separate areas, with no evidence of any movement between groups, and yet the decline in numbers is evident at both sites. Eastern Curlew has also long been recorded as declining in other locations in Tasmania (Reid & Park 2003). A comprehensive review of shorebirds in Tasmania provided an overview of records to 1999 (Bryant 2002). In this review the population of Curlew Sandpipers was thought to be stable. This, however, has proved to be optimistic with increasing evidence of dramatic declines in Curlew Sandpiper throughout eastern Tasmania, where for example, Curlew Sandpiper numbers have dropped in the Derwent region around Hobart from over 1000 in the 1980's to zero in 2010 (Tas. WSG *unpubl. data*).

The declines reported here are also being reported more widely throughout Australia with notable similarities and some differences between species. Evidence of Eastern Curlew declines have increased in Victoria's Corner Inlet and Bellarine Peninsula as well as in north-western Australia (Rogers *et al.* 2009, Herrod 2010). Declines have also been highlighted in New South Wales, although in 2006 the Hunter Estuary in New South Wales was not reporting declines (Gosbell & Clemens 2006). In Moreton Bay, an area that holds far greater numbers of Eastern Curlew, there has only been slight evidence of long-term declines (Wilson *et al.* 2011). Widespread declines in Curlew Sandpiper have been evident in New South Wales, South Australia, Western Australia, and Victoria (Barter 1992, Creed & Bailey 1998, Olsen *et al.* 2003, Gosbell & Grear 2005, Gosbell & Clemens 2006, Rogers *et al.* 2009, Singor 2009, Herrod 2010, Rogers *et al.* 2010a, Minton *et al.* 2012), while Moreton Bay has only reported slight evidence of long-term declines (Wilson *et al.* 2011). Bar-tailed Godwit counts have been more variable in many areas, but non-significant negative population trajectories have been observed in many areas throughout Australia (Gosbell & Clemens 2006). More recent work has not shown significant declines in Victoria, or Moreton Bay (Singor 2009, Herrod 2010, Wilson *et al.* 2011, Minton *et al.* 2012), but declines have been reported in South Australia and Western Australia (Close 2008, Creed & Bailey 2009, Rogers *et al.* 2009). Ruddy Turnstone declines are increasingly being reported not just in Tasmania, but in Victoria, Moreton Bay, and north-western Australia (Rogers *et al.* 2009, Herrod 2010, Wilson *et al.* 2011, Minton *et al.* 2012).

More broadly 47% of intercontinental migratory shorebirds with known trends appear to be decreasing (Zöckler *et al.* 2003). In Japan similar long term declines to those reported here have been seen in Bar-tailed Godwit and Ruddy Turnstone but no declines were evident in Curlew Sandpiper or Eastern Curlew (Amano *et al.* 2010). Curlew Sandpiper has also shown evidence of declines in Africa (Delany 2003, Barshep *et al.* 2011). Finally, widespread evidence of decline in Eastern Curlew was sufficient to list this species as vulnerable under the IUCN Red List of Threatened Species (IUCN 2011), and it seems likely as available count data continue to be analysed more species will be added to the Red List.

There are probably many contributing factors leading to these widespread declines, but the most likely driver of recent declines appears to be habitat loss in staging areas. The declining species reported here are diverse in their resource requirements, varying greatly in both food preference during the non-breeding season and selection of Northern Hemisphere breeding habitats (Marchant & Higgins 1993, Higgins & Davies 1996). The most obvious and widespread shared threat that this diverse group of shorebirds face is the rapid destruction of staging intertidal habitats such as those occurring in the Yellow Sea (Barter 2005, Moores *et al.* 2008). A rough comparison between the estimated rates of declines in each species and their known degree of reliance on Yellow Sea staging habitat suggests declining species all appear to be somewhat reliant on the Yellow Sea (Table 1). This reinforces the notion that habitat losses in the Yellow Sea may be a driver of these widespread declines. Unfortunately, it is likely that other staging areas are being impacted but have yet to be documented, and shorebirds appear to be facing a host of threats throughout the flyway.

Future work

Continued on-going monitoring of these sites is important to determine if populations continue to decline as a result of continuing impacts throughout the flyway or local site-specific impacts in north-east Tasmania. This will require comparison of local trends with those being reported more widely, something which remains to be formally undertaken. When complete such analyses will provide an understanding of the interspecific differences in reported trends across Australia.

The future of monitoring shorebirds at Cape Portland will remain a challenge, but one which complements the monitoring at George Town and other sites in Tasmania. One of the challenges involves accurately recording the number of shorebirds in the area in any one count. The sequential drying out of lagoon areas has always been a feature at Cape Portland but it has often resulted in the highest numbers of some species occurring before the date of the national wader count. Therefore, repeat summer counts will need to continue to ensure that data is collected during the period when shorebirds are abundant on the lagoons. Further analyses with the full set of repeated counts rather than just maximum summer counts may uncover important seasonal patterns in these data, and greater sensitivity in results may be achieved by using other explanatory variables in models such as rainfall, or the availability of proximate suitable inland wetlands. Finally, we acknowledge that, whilst the models fitted to data here reasonably approximate species' trends, further work may improve the precision of the predicted magnitudes of decline presented in this study. This will be particularly true if that work can identify the potential drivers of change, that is, rates of reproduction, mortality, immigration and emigration, as well as detection rates and observer error.

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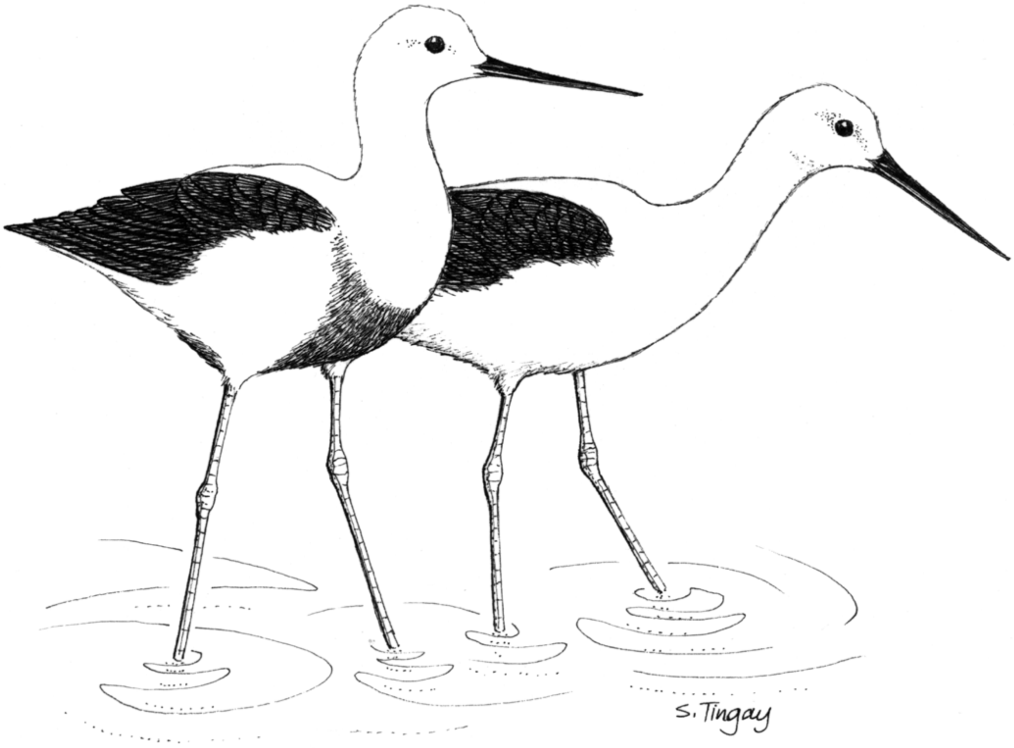

RECORD NUMBER OF WRYBILL (*ANARHYNCHUS FRONTALIS*) STAGING AT LAKE ELLESMERE ON SOUTHWARD MIGRATION

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Wrybill (*Anarhycnhus frontalis*) is a small wader endemic to New Zealand. Wrybill transit through a small number of estuarine sites on the east coast of the South Island on passage to their inland breeding grounds, but are uncommon at other times. National counts in this region typically fail to detect staging birds due to count timing. In this study, we document the passage of Wrybill at Lake Ellesmere during the August-September 2009 southward migration period. An estimated 725-750 birds were present on 31 August, representing 12-16% of the global population. The majority of these birds are thought to spend the non-breeding season in the Firth of Thames and Manukau Harbour, approximately 780 km to the north. This study confirms the importance Lake Ellesmere to migrating Wrybill and should be managed as a nationally important wader site.

INTRODUCTION

The Wrybill is a small plover endemic to New Zealand with a fluctuating population of 4500 – 5700 (Dowding & Moore 2006, Melville & Battley 2006, Southey 2009). It is listed as "vulnerable" by Birdlife International (Delany & Scott 2006) and "nationally vulnerable" by the New Zealand Department of Conservation (Miskelly *et al.* 2008). Wrybills breed on braided shingle riverbeds in Canterbury and Otago on the eastern side of the South Island, and winter primarily on inter-tidal mudflats in the upper North Island (Sagar *et al.* 1999, Riegen & Dowding 2003).

Wrybills are a rare occurrence on the eastern coastal areas of the South Island except at a small number of estuaries and lagoons adjacent to the main lowland breeding rivers – the Ashley, Waimakariri, Rakaia, Ashburton, Rangitata and Waitaki (Figure 1). Wrybills transit through these sites before and after breeding, and they also use them as temporary habitats when floods push nesting birds off riverbed breeding grounds (Dowding & Moore 2006). The most regularly used coastal wetlands are Ashley Estuary, Lake Ellesmere, Washdyke Lagoon and Lake Ki-Wainono (Figure 1). Lake Ellesmere is recognised as the most important staging site for Wrybill in the South Island (O'Donnell 1985, Dowding & Moore 2006). Flocks of 100+ are regularly observed at Ellesmere, while numbers at the other sites seldom exceed 30 birds (Ornithological Society of New Zealand *unpubl. data*).

The southward or pre-breeding, migration of Wrybill is characterised by a brief spike in numbers at eastern South Island coastal sites during August and September. This occurs as birds stop over during a 700-950 km flight from the North Island wintering grounds and before they begin their final leg of up to 200 km to inland breeding grounds. This influx is seldom reported because it lasts a short time and therefore is generally not detected. Duration of stay is thought to be short with individual birds staying on the coast one to four days (Dowding & Moore 2006).

At Lake Ellesmere the spike in numbers was not detected by O'Donnell (1985) who conducted regular counts of Wrybill from 1981 to 1983. Monthly counts by the New Zealand Wildlife Service and the Ornithological Society of New Zealand (OSNZ) also failed to detect it in 1986-87 (Department of Conservation *unpubl. data*). The OSNZ national wader counts, held in June, November/December and February, fall well outside the August/September southward migration period and therefore miss peak Wrybill numbers at the lake. Several more recent counts at Lake Ellesmere have documented the southward passage of Wrybill, including counts of 109 birds by A. Crossland on 4 September 1991 (O'Donnell & West 1994); 341 counted by C. Hill on 12 August 1998 (O'Donnell 2001); 142 on 29 August 1999 and 299 on 17 August 2003 counted by C. Hill (Dowding & Moore 2006). In this paper we report on the passage of Wrybill at Lake Ellesmere during the southward

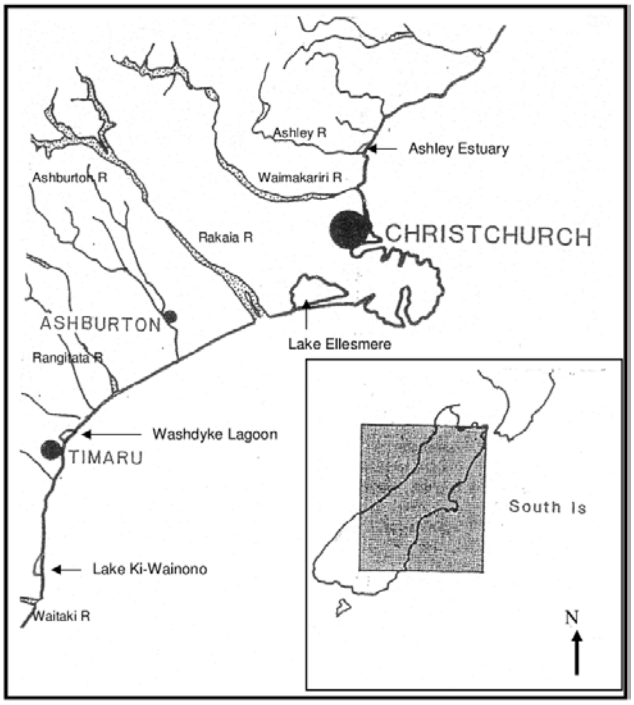

Figure 1. Location of lowland breeding rivers and wetland sites regularly used by Wrybill on the South Island's east coast.

migration period, August-September 2009.

METHODS AND RESULTS

Lake Ellesmere (20,000 ha) is the largest brackish coastal lagoon in New Zealand with a shoreline length of 58 km and a maximum depth of 3.6 m (Palmer 1983, Taylor 1996). Water levels vary on a daily basis in response to prevailing wind direction, alternately exposing and flooding large expanses of salt marsh turf and bare lake bed. Seasonal water levels are influenced by freshwater inflow from tributary rivers and from discharge of lake water via an artificial opening periodically cut through Kaitorete Spit, a 27 km long barrier which separates the lake from the Pacific Ocean. The shallow waters, extensive salt meadows and exposed mudflats of Lake Ellesmere support up to 90,000 wetland birds including 2,000-8,000 waders (O'Donnell 1985, Department of Conservation *unpubl. data*). Several sections of the lake attract concentrations of waders, particularly the north-eastern shoreline (Wolfe's Road to Greenpark Huts), the eastern shoreline (Halswell River-mouth to Kaituna Lagoon) and Kaitorete Spit (Figure 2).

On 30 August 2009 we carried out a waterbird survey along Kaitorete Spit. Toward the western end we encountered a very large congregation of Wrybill, comprising 580 birds in total. Of these, approximately 20% were feeding over mudflats and 80% were roosting in scattered formation over an adjacent area of open salt meadow. These were the first Wrybills we'd observed on the lake since April 2009. Such a large number could only represent a substantial influx of birds from the North Island wintering areas as very low numbers winter in the South Island. For example, the June/July 2009 national winter wader census recorded only 15 Wrybill for the entire South Island (OSNZ *unpubl. data*).

We returned to Lake Ellesmere the following day, 31 August 2009, and carried out a census of Wrybill along all areas of suitable habitat (mudflats and saltmeadow) on the southern, eastern and northern shorelines (Figure 2). A total of 719 birds were counted including 547 on Kaitorete Spit with smaller numbers distributed over the Wolfe's Road, Yarr's Flat and Embankment Road areas of the lake's north-eastern shoreline (Table 1).

We next surveyed Kaitorete Spit on 5 September 2009 and counted approximately 250 Wrybill. The next day, local birderwatchers Colin Hill and Steve Wratten visited the north-eastern shoreline of Lake Ellesmere (Yarr's Flat, Embankment Road, Clarks Road and Greenpark Huts areas) and recorded 102 Wrybill (C. Hill & S. Wratten *pers. comm.*). These counts on 5-6 September covered the main areas frequented by Wrybill on the lake and totalled 352 birds. Subsequent visits during late September-early October indicated that Wrybill numbers rapidly declined to much lower levels. For example, 30 Wrybill were counted at Kaitorete Spit on 24 September and just 12 birds on 11 October 2009.

DISCUSSION

The 719 Wrybill counted at Lake Ellesmere on 31 August 2009 was a minimum total for that date. Several other sections of shoreline, particularly in the north-western corner, were not covered and are likely to have held small numbers. Birdlings Lagoon, an arm of Lake Ellesmere near the base of Kaitorete Spit, was also not counted on 31 August, but was found to hold 6 birds on 2 September. It is therefore probable that total Wrybill numbers on Lake Ellesmere on 31 August was approximately 725 to 750 birds. This represents 12-16% of the world population and is more than double any count made during southward migration in previous years.

During a comprehensive study of wader populations at Lake Ellesmere from 1981 to 1983, O'Donnell (1985) observed that Wrybill numbers fluctuated markedly with annual peak numbers occurring in October and November, the period when the river breeding grounds are frequently

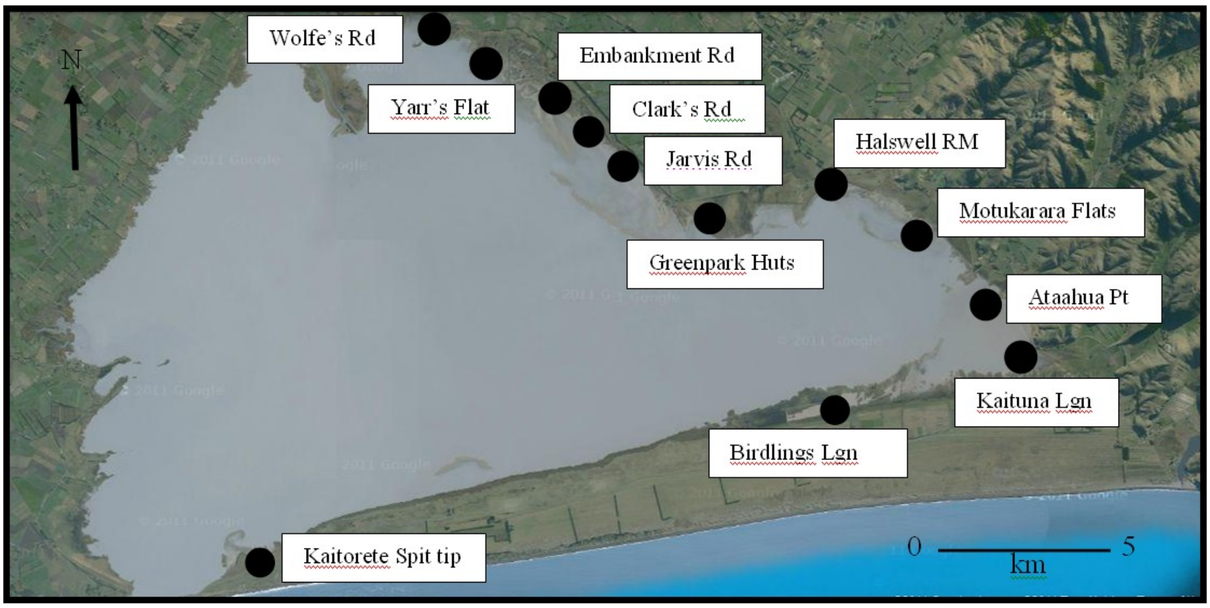

Figure 2. Map of Lake Ellesmere showing location of wader feeding/roosting areas.

Table 1. Census of Wrybill at Lake Ellesmere, 31 August 2009. See Figure 2 for location of lake shoreline sections.

Section of lake shoreline	Count
Kaitorete Spit Tip	547
Kaituna Lagoon	0
Ataahua Point	0
Motukarara Flats	3
Halswell River mouth	0
Greenpark Huts	0
Jarvis Road	0
Clarks Road	1
Embankment Road	81
Yarr's Flat	21
Wolfes Road	66
Total	719

flooded. At such times, breeding attempts are abandoned and adult birds resort to Lake Ellesmere to wait out the floods. O'Donnell (1985) reported annual peaks of approximately 400 Wrybills during this spring flooding period in October-November 1983. Allen (2001) reported a much higher peak of 701 birds on 11 October 1998. Our census total of 719 Wrybill on southward passage on 31 August 2009 marginally exceeds this previous record count for Lake Ellesmere and is almost certainly the largest congregation of Wrybill encountered anywhere in the South Island in recent decades.

The immediate source areas of most Wrybill staging at Lake Ellesmere on 30-31 August 2009 were probably the Firth of Thames (37°11'S, 175°20'E) or Manukau Harbour (37°05'S, 174° 46'E) in the Auckland Region of the North Island. We consider this likely because these two sites collectively support up to 85% of the total Wrybill population (Sagar *et al.* 1999, Riegen & Dowding 2003) and the link between these sites and Lake Ellesmere has been confirmed by previous observations of banded birds (A. Crossland, *pers. obs.*). At Miranda, on the Firth of Thames, 1000-1400 Wrybill were present during most of August 2009 (I. Southey, *pers. comm.*), until approximately 600 departed on or before 29 August (N. Milius, *pers. comm.*). The straight-line distance from Miranda to Lake Ellesmere is approximately 780 km on a SSW heading.

On both 30 and 31 August 2009 we observed two colour-banded Wrybill amongst the large flock at Kaitorete Spit. These two birds were banded as adult females on the Tasman River riverbed, M-OYR banded on 1 October 1999 and GY-BY banded on 12 October 2007 (J. Dowding, *pers. comm.*). Young Wrybills have high fidelity to natal rivers (Dowding & Moore 2006) and adults generally return close to their previous season's breeding territory (A. Crossland *pers. obs.*). The distance between the staging site at Lake Ellesmere (43°47'S, 172°29'E) and the breeding grounds on the Tasman River riverbed (43°53'S, 170°08'E) is approximately 180 km on a bearing due west (Figure 3). This is a distance that a Wrybill could cover in less than 3 hours, travelling at observed flight speeds of 60+ km/hr (A. Crossland *pers. obs.*). With such relatively short migration distances it is not known why many Wrybill stage on the South Island's east coast, but reasons could include waiting the abatement of adverse weather inland or active floods in the riverbeds.

This study has confirmed the importance Lake Ellesmere to migrating Wrybill and has produced the largest count total on record for the site. It is clear that whilst the site has low usage by Wrybill at other times, it should be managed as a nationally important wader site particularly during southward migration.

ACKNOWLEDGEMENTS

Thanks to Ian Southey, Nigel Milius, Steve Wratten and Colin Hill for access to their count data and other information. Thanks to John Dowding for information on banded birds. Many thanks to Scott Butcher for critical comments on the manuscript; to Julie Flanagan for assistance with preparation of the maps; and to Kay Holder and Liz Garson, Christchurch City Council, for publication approval. We would also like to thank an anonymous reviewer for comments on an earlier draft of this manuscript.

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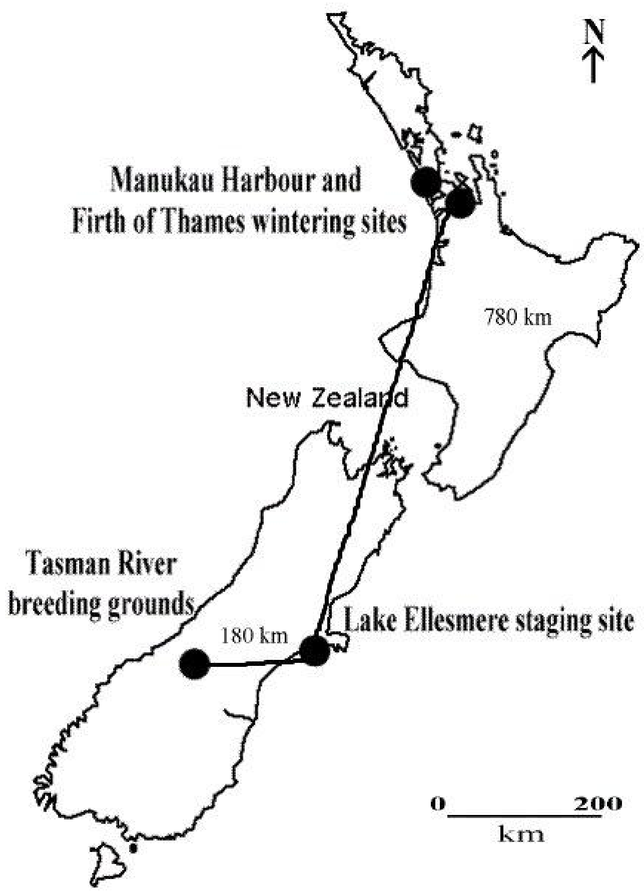

Figure 3. Presumed shortest distance migration route for two banded Wrybill observed at Lake Ellesmere on 30 & 31 August 2009.

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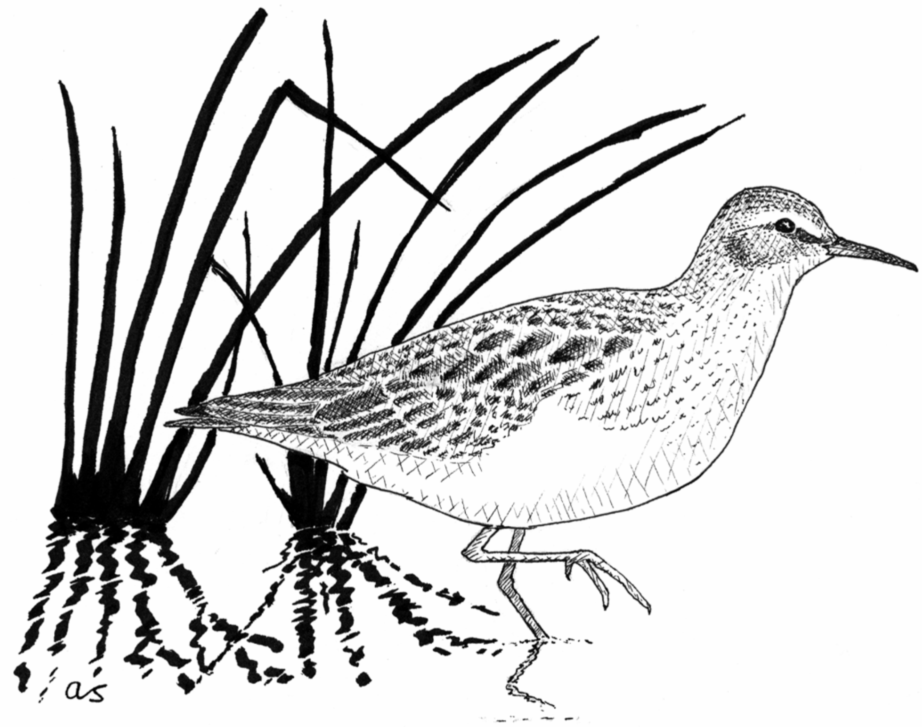

A SURVEY OF OVER-SUMMERING SHOREBIRDS AT SONADIA ISLAND, COX'S BAZAR, BANGLADESH

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An over-summering shorebird survey was carried out at Sonadia Island, Cox's Bazar, Bangladesh, in April and May 2011. A total of 16 species were recorded, comprising 285 individuals at Tajiakata and Kaladia in mid-May, and 322 individuals at Tajiataka in early-June 2011 including one globally threatened Nordmann's Greenshank *Tringa guttifer*, seven Great Knot *Calidris tenuirostris* and 27 Eurasian Curlew *Numenius arquata*. The three most abundant species were Lesser Sand Plover *Charadrius mongolus* (129 in May and 220 in June), Greater Sand Plover *Charadrius leschenaultii* (67 in May and 33 in June) and Eurasian Curlew *Numenius arquata* (27 in May). Sonadia Island is an important site in the East Asian - Australasian Flyway for at least five globally threatened shorebirds, as it supports significant numbers of adult birds in wintering, and small numbers of first-year juvenile birds in over-summering periods. Sonadia Island is declared nationally as an Ecological Critical Area (ECA) and to acquire further international focus and support, the island should be designated as Ramsar site and Important Bird Area since it fulfils the criteria for both.

INTRODUCTION

The over-summering phenomenon (birds remaining on non-breeding or wintering grounds during their breeding season) has been reported at least in some 15 families of birds but its occurrence is particularly high in Charadriidae and Scolopacidae families of shorebird (McNeil *et al.* 1994). Bangladesh is located at the junction of the Central Asia and East Asian-Australasian flyways, and offers important wintering and staging grounds for a variety of migratory shorebirds in large numbers, many of which are globally significant. Although coordinated mid-winter counts are conducted in January in Bangladesh annually, only limited information is available on the numbers and occurrence of shorebirds at other times of the year (Li *et al.* 2009).

Sonadia Island is one of the five East Asian - Australasian Flyway Site Networks in Bangladesh and identified as important habitat for migratory waterbirds by the East Asian – Australasian Flyway Partnership (EAAFP 2011). Recent surveys recorded 4,032 shorebirds of 16 species from Sonadia Island in late October 2009, 1,964 shorebirds of 23 species in early January 2010 and the 6,714 shorebirds of 26 species during northward migration in March 2011. The island also supports globally significant numbers of critically endangered Spoon-billed Sandpiper *Eurynorhynchus pygmeus* (15-20 birds in January and 20-30 birds in March), endangered Nordmann's Greenshank *Tringa guttifer* (5-10 birds in January and 5-20 birds in March) and other globally threatened and Near Threatened waders such as Great Knot, Eurasian Curlew and Black-tailed Godwit (Zöckler & Bunting 2006, Bird *et al.* 2010, Chowdhury *et al.* 2011). However, no information is available on over-summering migratory shorebirds of Sonadia Island or Bangladesh in general. Therefore, it is important to know the annual diversity and abundance of migratory waders of this site of global importance. In order to gather basic information on the occurrence and distribution of over-summering waders, I carried out surveys on Sonadia Island in May and July 2011.

METHODS

Sonadia Island is situated in Cox's Bazar district along the south-eastern coast of Bangladesh. This approximately 4,916 ha island was declared as an Ecologically Critical Area (ECA) by the Government of Bangladesh in 1999. The island holds a wide variety of habitats including intertidal mudflats, sand dunes, mangroves, sand bars, lagoons, saltpans and beaches (Coastal and Wetland Biodiversity Management Project 2006). Shorebird surveys were conducted only in Tajiakata (N21.4959°, E91.9154°) and Kaladia (N21.5512°, E91.8632°) of Sonadia Island (Figure 1). It was not possible to visit other shorebird sites due to bad weather.

Boat-based surveys for shorebirds were carried out on 15, 16 May and 3 June 2011. Roosting waders during high tide were counted in Tajiakata (1.5 km of mudflats and sand dunes) and foraging waders were counted in Kaladia (1.6 km of mudflat) during low tide (Figure 1). These are two of three most important shorebird sites on Sonadia Island. The high tide roost of birds that forage in Kaladia is unknown, therefore the site was surveyed only during low tide. Two observers carried out surveys at each site to minimize error in counting and identification. Counts were repeated in most of the occasions and the maximum number is presented here. Birds were identified using Grimmett *et al*. (1998) and Chowdhury (2011). Observations were made using 10x42 binoculars and 25-50x spotting scopes.

RESULTS

A total of 16 species were counted, comprising 285 individuals in mid-May at two sites and 322 individuals in early-June 2011 at one site (Table 1). The most abundant species was Lesser Sand Plover *Charadrius mongolus* constituting 45.26% in May and 68.32% in June, followed by Greater Sand Plover *Charadrius leschenaultii* (23.50% in May and 10.24% in June), Eurasian Curlew *Numenius arquata* (9.47% in May) and Grey Plover *Pluvialis squatarola* (12.42% in June). Three globally significant

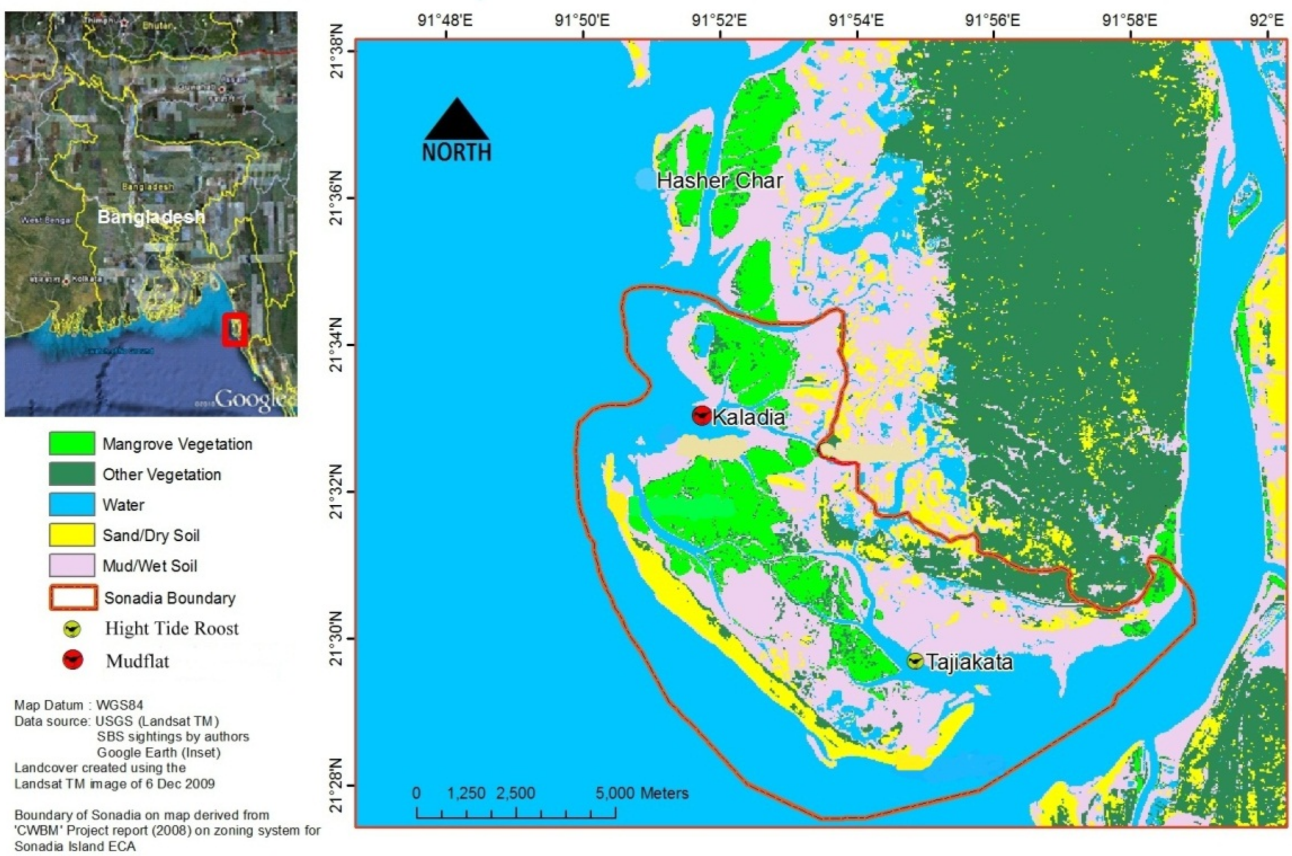

Figure 1. Sonadia Island, Cox's Bazar, Chittagong, Bangladesh. The map shows habitat characteristics of the island and surveyed sites in May – July 2011

species were observed, comprising 27 Eurasian Curlew (Neat Threatened), 7 Great Knot *Calidris tenuirostris* (Vulnerable) and 1 Nordmann's Greenshank *Tringa guttifer* (Endangered) (BirdLife International 2011). The Nordmann's Greenshank was recorded feeding with Common Greenshanks in Kaladia on 16 May 2011. Grey Plover, Lesser Sand Plover, Greater Sand Plover and Terek Sandpiper were seen on both sites. The Pacific Golden Plover was not recorded in winter during systematic shorebird survey on Sonadia Island but five were seen in Kaladia on 16 May 2011.

DISCUSSION

The status and distribution of over-summering shorebirds are largely unknown in Bangladesh and particularly at globally significant sites like Sonadia Island. Shorebirds that were observed in two sites of the island in May and June 2011 were mostly in non-breeding plumage and could possibly be sexually immature first-year birds (McNeil *et al.* 1994).

In Kaladia shorebirds occurred in higher numbers and diversity than Tajiakata, comprising 166 individuals of 13 species including three species of global concern. Tajiakata supported 119 individuals of only 5 species including one Near Threatened species in May 2011. In January 2010, Kaladia supported 235 individuals of 13 species and 2,462 individuals of 13 species in March 2012 with two species meeting the 1% Ramsar criterion. Occurrence of globally threatened species during over-summering period further reflects the importance of Kaladia for shorebirds of the East Asian-Australasian flyways. Tajiakata supported 451 individuals of 15 species in January 2010 and 172 individuals of five species in March 2010. In June 2011, the site supported 322 individuals of eight species while Kaladia left un-surveyed due to bad weather (Chowdhury *et al.* 2011, Bird *et al.* 2010).

Consistent detection of globally threatened shorebirds such as Nordmann's Greenshank and Great Knot in wintering and over-summering periods suggest that Sonadia Island is an extremely important site for at least three endangered waders throughout their migration period and provides shelter for first-year juveniles in summer. Further over-summering shorebird survey of all sites on Sonadia Island with enhanced survey effort is needed to better understand the status and distribution of shorebirds. It is important to note that Sonadia Island could support substantial number of first-year juvenile birds of globally threatened species including the Spoon-billed Sandpiper and Nordmann's Greenshank, which may provide indications on the annual recruitment of these species. Shorebird hunting has been identified as one of the key conservation issues on Sonadia Island and conservation measures are underway to mitigate the pressures of this hunting (Chowdhury 2010). A deep-water port is proposed to be built on Sonadia Island, which has the potential to largely affect the intertidal ecosystem and thus shorebirds. This area should be

Table 1: Number of shorebirds counted at two sites of Sonadia Island, Cox's Bazar, Bangladesh, during May and June 2011. The locations of these two sites are shown in Figure 1. CWV = Common Winter Visitor; RWV = Rare Winter Visitor and UWV = Uncommon Winter Visitor to Bangladesh based on Siddiqui *et al.* 2008. IUCN conservation status is given as NT (Near Threatened), VU (Vulnerable) and EN (Endangered).

Species	**National status**	**Tajiakata 15 May 2011**	**Kaladia 16 May 2011**	**Tajiakata 3 June 2011**
Pacific Golden Plover *Pluvialis fulva*	CWV	0	5	0
Grey Plover *Pluvialis squatarola*	CWV	4	1	40
Kentish Plover *Charadrius alexandrinus*	CWV	0	0	22
Lesser Sand Plover *Charadrius mongolus*	CWV	60	69	220
Greater Sand Plover *Charadrius leschenaultii*	CWV	36	31	33
Whimbrel *Numenius phaeopus*	CWV	0	0	2
Eurasian Curlew *Numenius arquata* **NT**	CWV	15	12	0
Common Redshank *Tringa totanus*	CWV	0	7	0
Marsh Sandpiper *Tringa stagnatilis*	CWV	0	1	0
Common Greenshank *Tringa nebularia*	CWV	0	8	2
Nordmann's Greenshank *Tringa guttifer* **EN**	RWV	0	1	0
Terek Sandpiper *Xenus cinereus*	CWV	4	5	2
Great Knot *Calidris tenuirostris* **VU**	RWV	0	7	0
Little Stint *Calidris minuta*	CWV	0	0	1
Curlew Sandpiper *Calidris ferruginea*	CWV	0	10	0
Broad-billed Sandpiper *Limicola falcinellus*	UWV	0	9	0
Total		119	166	322

designated as a Ramsar site and Important Bird Area (IBA) since it more than adequately fulfills criteria for both (Chowdhury *et al.* 2011). Although Sonadia Island is declared as a nationally Ecological Critical Area (ECA), designating as a Ramsar site and an IBA will get international focus and will help to ensure future protection and sustainable wetland management.

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OBSERVATIONS OF SHOREBIRDS ALONG THE DELI-SERDANG COAST, NORTH SUMATRA PROVINCE, INDONESIA: 1995–2006

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This paper reports the presence of large populations of shorebirds on the Deli-Serdang coastline of North Sumatra Province, western Indonesia. We estimate that upwards of 22,000 shorebirds of 32 species (25 waders, six terns, one gull) occurred in this area during 1995 to 2006, including internationally significant concentrations of Lesser Sand Plover, Greater Sand Plover, Asian Dowitcher, Bar-tailed Godwit, Eurasian Curlew, Common Redshank, Terek Sandpiper and Curlew Sandpiper. This confirms the international importance of this area to shorebirds and, as the area is under threat from development and other human uses, it will benefit from increased international recognition.

INTRODUCTION

For most of its length of more than 2,500 km, the eastern coastline of Sumatra is characterised by expansive inter-tidal mudflats, mangrove forests, tidal and freshwater swampland, lowland forest and low-lying swampy islands (Whitten *et al.* 2000). Although this extensive area of coastal wetlands has long been suspected to hold an abundance of waterbirds (Anderson 1826), confirmation that large numbers occur has only been obtained relatively recently (Silvius 1986, Silvius 1987, Silvius 1988, Danielsen & Skov 1989, Verheught *et al*. 1990, Verheught *et al*. 1993, Holmes 1996, Crossland *et al.* 2006, Crossland *et al.* 2009, Iqbal 2010, Iqbal *et al.* 2010, Crossland & Sitorus 2011, Iqbal *et al.* 2011).

It is now clear that the east coast of Sumatra is of particular importance to migratory waders and terns - serving as both a migration terminus for species that spend their non-breeding season in the tropics (Silvius 1987, Verheught *et al*. 1990, Crossland *et al.* 2006, Crossland & Sinambela 2009, Iqbal *et al.* 2010), a passage zone for species migrating between Northern Asia and Australia (Crossland & Sinambela 2009, Crossland & Sitorus 2011), and a summering area for non-breeders (Danielsen & Skov 1989, Iqbal & Ridwan 2009). Although the 545 km coastline of North Sumatra Province is not as swampy, nor as punctuated by large river estuaries as the three provinces to the south (Whitten *et al.* 2000), it nevertheless supports a large and diverse migratory shorebird population (Dongoran 2007, Crossland *et. al.* 2009, Iqbal *et al.* 2010).

During November-December 1995 (non-breeding "wintering" period), February-May 1997 (northward migration period), September-October 2005 (southward migration period) and August-September 2006 (southward migration period) we made observations at five river-mouth mudflat/mangrove habitats on the Deli-Serdang coastline (Bagan Percut, Bagan Serdang, Pantai Labu Baru, Sungai Ular and Pantai Cermin-Sungai Perbaungan). This paper reports on the discovery of large numbers and high species richness of migratory shorebirds (defined as waders, terns and gulls) at these sites.

STUDY AREA

North Sumatra Province is situated just north of the equator and has a human population of 12.8 million. About half live on the densely populated Deli coastal plan adjacent to the provincial capital, Medan (population 2.5 million). This region of fertile soils once supported extensive tracts of lowland rainforest but during the 19th and early 20th centuries the original vegetation cover was cleared to make way for plantation agriculture (Whitten *et al.* 2000). Present agricultural land uses include tobacco, cacao, oil palm, rubber, rice, coconut, tapioca, fruit and vegetable growing. In the immediate vicinity of the coast, aquaculture industries have expanded rapidly, pushing into the hitherto largely unmodified coastal wetland zones.

This paper focuses on the Deli-Serdang area in the central part of North Sumatra Province (Figure 1). This comprises the two administrative districts (Regencies) of Deli-Serdang (population 1,686,366; area 2,384 km^2) and Serdang-Bedagai (population 549,091; area 1,900 km^2). Located on the fringes of Medan city, these districts are currently undergoing rapid transformation from largely rural areas dominated by plantation agriculture into heavily populated suburban, peri-urban and industrial zones.

The principal study area covered approximately 35 km of coastline from 5 km south of Belawan Port to the Sungai Perbaungan river mouth (Figure 2). The total extent of inter-tidal mudflats within this area is conservatively estimated at 2,200 ha on the basis of calculations from 1:250,000 topographical maps and satellite images. This coastline mainly comprises inter-tidal mudflats between 50 m and 1,500 m in width, backed by mangrove forest, nipah palm swamp or sandy beach formations. Several rivers punctuate the otherwise largely straight coastline and small sand spits

Figure 1. Location of the Deli-Serdang area in North Sumatra Province, Indonesia.

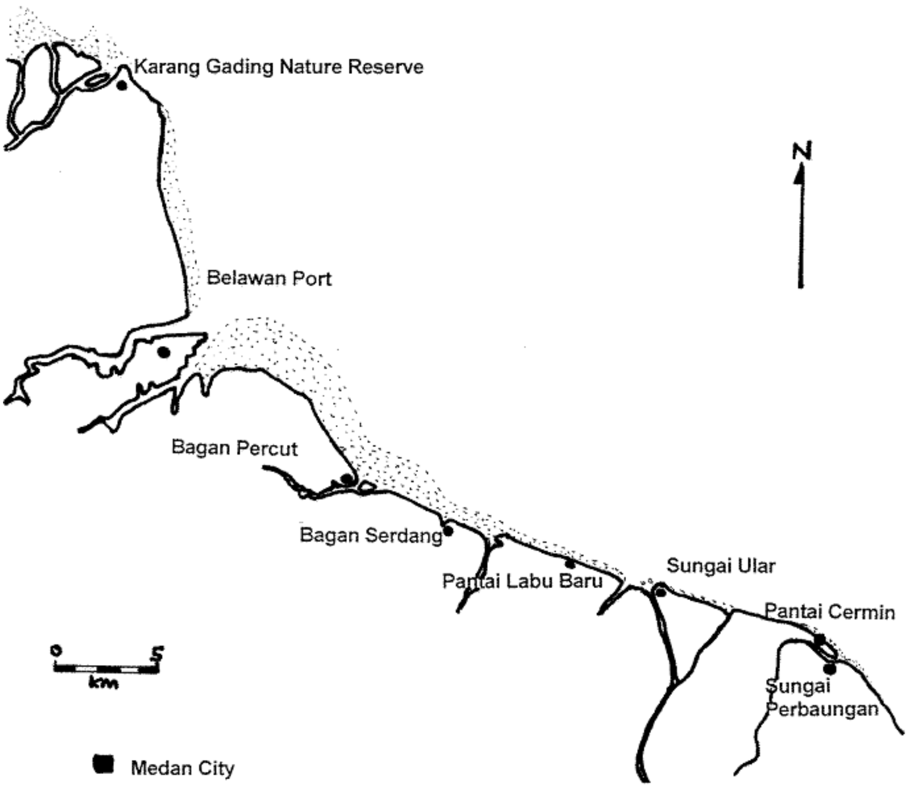

Figure 2. Principle study area, Deli-Serdang coastline, North Sumatra Province, Indonesia.

have developed where three of these (Serdang, Ular and Perbaungan) enter the sea.

In 1995, when we first investigated the study area, much of the Deli-Serdang coastline comprised a wide belt of mangrove forest and nipah swampland. Large tracts of inter-tidal mudflat lay remote from disturbance and could be reached only from the sea. Access to the shoreline was generally possible by boat from fishing villages located landward of the mangrove zone, usually a kilometre or more upriver from the mouth. Only at Pantai Cermin-Sungai Perbaungan in the southern part of our study area, was access relatively easy. This was because the site is a sandy beach with an access road servicing low-key public recreation facilities.

By 2006 the coastal landscape had changed dramatically. Roads had been constructed to previously isolated beaches, opening up several (such as Pantai Labu and an expanded area at Pantai Cermin) to new recreational development. Thousands of hectares of mangrove and coastal swampland had been converted to fish and shrimp ponds, leaving in many areas (such as east and west of Bagan Percut, east of Pantai Labu Baru and east of Sungai Perbaungan) a collapsing mangrove belt less than 50 m wide. However, despite the rapidity and enormous scale of change, large numbers of shorebirds were still present along the Deli-Serdang coastline in 2006. Mudflat feeding habitats were still intact and some species were utilising partly dry aquaculture ponds as supplementary feeding and roosting habitat.

Site Descriptions

Bagan Percut (3°43'N, 98°47'E) is a small river delta surrounded by a sizeable but shrinking patch of mangrove forest and a wide (500-1500 m) band of mudflats. The core mangrove and upper mudflat roosting habitat is effectively an island, lying between the mouths of Sungai Percut Besar and Sungai Percut Kecil. The area supports large numbers of shorebirds as well as herons, egrets and storks. Bagan Percut can be reached from Medan (via Percut village) by sealed public road.

Bagan Serdang (3°42'N, 98°50'E) is a delta comprising two small mangrove-lined river mouths with associated sand spits and inter-tidal mudflats. The site is only accessible by boat and is located 6.5 km south-east of Bagan Percut. The surrounding area comprises a wide mudflat zone, mangrove forest and aquaculture ponds on the landward side.

Pantai Labu Baru (3°40'N, 98°54'E) comprises a small river mouth (Sungai Kenang) and a short length of sandy beach adjacent to a 100-300 m wide band of mudflats. A combination of wood-cutting and coastal erosion appears to be rapidly diminishing several remnant stands of mangrove along the shoreline. The area behind the beach comprises coastal scrub and an ever-expanding zone of aquaculture ponds. Pantai Labu Baru is located 7.5 km south-east of Bagan Serdang and 5 km west of Sungai Ular river mouth. The site can be accessed by road and rough dirt track by diverting off the main north-south highway at the town of Lubuk Pakam.

Sungai Ular (3°40'N, 98°55'E) is a medium-sized river with sand spit and sandy island formations at its mouth. The site is 5 km east of Pantai Labu and 5.5 km north-west of Sungai Perbaungan. The eastern side of the river mouth comprises a scrub- and marsh-covered headland with a 1 km sand spit enclosing a narrow lagoon. Immediately inland is an extensive area of aquaculture ponds. A series of canals enter the sea about 1 km east of the river mouth and just beyond these is a sizeable stand of mangrove and nipah swampland. The east side of Sungai Ular was formerly accessible by walking 5 km along the beach from Pantai Cermin, but recent expansion of aquaculture ponds has blocked access. The west side of the river mouth is accessible by boat and comprises mainly coastal scrubland with grazing land and clusters of aquaculture ponds further inland. The adjacent sandy beach borders 100-200 m wide mudflats and these comprise the principal feeding grounds for shorebirds in the vicinity.

Pantai Cermin - Sungai Perbaungan River Mouth (3°39'N, 98°59'E) is a 1 km stretch of shoreline between the popular recreational beach at Pantai Cermin and the mouth of Sungai Perbaungan. It comprises a sandspit / mangrove association with a narrow band of mudflats exposed at low tide.

METHODS

All shorebird counts were made with 25x60 spotting scope and 10x binoculars. Usually two to four personnel were present on each survey, with one or two observers counting birds while another took notes. Survey methods closely followed those outlined in Howes & Bakewell (1989), namely they were ground-based or boat-based counts of roosting or foraging shorebirds and involved personnel scanning flocks from as close as possible without disturbing them and putting birds to flight. Where possible, birds were counted individually, but large flocks and groups of birds in flight were block counted in multiples of 10 or 50. Flocks observed at a distance were block counted in multiples of 50. Bird numbers given for Bagan Percut include a mix of full counts and estimates based on part counts. Numbers for other sites are all full counts, unless otherwise stated.

Most counts at Bagan Percut were made over two days, with a different set of species targeted each day. Shorebirds were counted from either a small boat positioned just offshore, from a standing position on mudflats, or from the balcony of a restaurant perched on stilts above the mudflats on the north side of Sungai Percut Besar. At all other sites, counts were made on foot from the shoreline over 1-3 hours. Count results are provided as total number of birds of each species observed, per site, on each survey day. In addition, density estimates were derived at Bagan Percut based on sample counts of birds in estimated 100m x 100m (1 ha) squares around the two river-mouths.

RESULTS

Bagan Percut

Shorebird (wader, tern and gull) counts were made at Bagan Percut in 1995 on 23-30 December 1995; in 1997 on 28 February - 3 March 1997, 23 March - 25 March, 31 March - 2 April, 14 April 1997 and 12 May; and in 2005 on 27 September and 8 October. This data is presented in Table 1 and although accumulated over a range of years, provides a coarse sample of seasonal abundance.

At low tide shorebirds foraged at moderate (>20 birds/ha) to very high densities (>500 birds/ha) over soft mudflats. As the incoming tide advanced, most waders congregated into mixed-species staging roosts on higher mud banks and the upper foreshore. Terns continued foraging over this period

Table 1. Shorebird counts at Bagan Percut between 1995-2005. A more recent count from 2009 is also included for comparison (Iqbal *et al.* 2010). Column headings are presented as date and year.

Species	**23/12-30/12 1995**	**28/2-3/3 1997**	**23/3-25/3 1997**	**31/3-2/4 1997**	**14/4 1997**	**12/5 1997**	**27/9 2005**	**8/10 2005**	**4/1 2009**
Oriental Pratincole *Glareola maldivarum*	58	0	0	0	0	0	0	0	0
Pacific Golden Plover *Pluvialis fulva*	200	100	100	132	100	0	146	190	150
Grey Plover *P. squatarola*	150	50	200	196	200	20	12	48	0
Kentish Plover *Charadrius alexandrinus*	10	0	0	0	0	0	0	0	0
Lesser Sand Plover *C. mongolus*	1,000	2,000	1,000	500	50	30	215	600	0
Greater Sand Plover *C. mongolus*	1,000	2,000	2,000	2,000	300	200	645	2,180	0
Asian Dowitcher *Limnodromus semipalmatus*	602	1,020	800	1,048	592	2	1,306	2,370	400
Black-tailed Godwit *Limosa limosa*	50	50	194	410	500	40	3	0	1,200
Bar-tailed Godwit *L. lapponica*	2,000	1,000	2,000	769	600	0	504	1,680	600
Whimbrel *Numenius phaeopus*	97	100	193	200	200	50	96	332	500
Eurasian Curlew *N.umenius arquata*	812	1,000	317	100	56	20	476	2,580	2,000
Eastern Curlew *N. madagascariensis*	161	50	9	10	1	0	2	40	800
Common Redshank *Tringa tetanus*	655	1,000	300	152	150	300	515	794	500
Marsh Sandpiper *T. stagnatilis*	206	200	200	100	50	0	27	32	2
Common Greenshank *T. nebularia*	130	50	50	50	36	0	15	39	0
Nordmann's Greenshank *T. guttifer*	0	0	0	0	0	0	0	6	0
Wood Sandpiper *T. glareola*	8	0	1	1	0	0	0	0	0
Terek Sandpiper *Xenus cincereus*	316	300	1,100	2,000	2,000	50	346	1,272	250
Common Sandpiper *Actitis hypoleucos*	50	50	50	50	50	10	20	15	25
Ruddy Turnstone *Arenaria interpres*	0	20	30	14	20	0	0	0	0
Great Knot *Calidris tenuirostris*	300	400	200	236	260	0	230	280	100
Red Knot *C. canutus*	0	0	0	281	400	0	13	0	0
Red-necked Stint *C. ruficollis*	50	50	50	0	30	0	0	40	0
Curlew Sandpiper *C. ferruginea*	2,000	1,000	800	1,000	500	0	1,090	1,010	5
Broad-billed Sandpiper *Limicola falcinellus*	200	50	50	96	90	0	0	0	20
unidentified small-med waders	0	0	4,000	0	0	0	600	0	1,000
Total waders	**10,055**	**10,490**	**13,644**	**9,345**	**6,185**	**722**	**6,267**	**13,502**	**7,852**
Caspian Tern *Sterna caspia*	6	0	0	0	0	0	0	0	n.c.
Gull-billed Tern *S. nilotica*	2	100	30	0	6	10	0	6	n.c.
Common Tern *S. hirundo*	10	0	0	0	0	0	75	0	n.c.
Little Tern *S. albifrons*	57	130	70	40	126	10	99	42	n.c.
Whiskered Tern *Childonias hybrida*	12	300	70	200	31	10	75	0	n.c.
White-winged Black Tern *C. leucopterus*	8	400	540	300	980	100	488	56	n.c.
Black-headed Gull *Larus ridibundus*	4	0	0	0	0	0	0	0	n.c.
Total terns and gulls	**99**	**930**	**710**	**540**	**1,143**	**130**	**737**	**104**	n.a.
Total shorebirds	**10,154**	**11,420**	**14,354**	**9,885**	**7,328**	**852**	**7,004**	**13,606**	**n.a.**

with an increasing proportion settling on the edge of the roosting wader flocks as the tide came in.

As more distant feeding grounds were inundated, groups of waders arrived from at least 3 km north and south. This incoming traffic usually lasted about 90 minutes. On smaller tides roosting shorebirds remained on the upper foreshore over high water and foraged along the receding water line as the tide turned. On big tides the birds were eventually forced from the shore and flew inland to an unknown roosting location. Their roost was formerly located in the mangrove forest, but as these had been cleared by 2005, the new site(s) was presumably within the complex of aquaculture ponds inland from the coast.

Numbers of shorebirds counted at Bagan Percut ranged from totals of 852 in mid-May 1997 (late in the northward migration period) to 13,606 in early October 2005 (southward migration period) and 14,354 in late March 1997 (northward migration period) (Table 1). A total of 10,154 shorebirds were counted in late December 1995 (Northern Hemisphere winter).

Most of the 32 shorebird species recorded were relatively common with 100 or more individuals counted for 22 species on at least one of the census dates. Nine species were recorded in numbers exceeding 500 individuals and eight species numbered 1,000 individuals or more. The most abundant species were Eurasian Curlew (highest count = 2,580); Asian Dowitcher (2,370); Greater Sand Plover (2,180); Lesser Sand Plover (2,000); Terek Sandpiper (2,000); Curlew Sandpiper (2,000); Bar-tailed Godwit (2,000); Common Redshank (1,000) and White-winged Black Tern (980). All of these species, except White-winged Black Tern, occurred in numbers that meet the 1% Ramsar criterion for international importance (Table 2).

Species occurring in moderate numbers (100+) included Pacific Golden Plover, Grey Plover, Black-tailed Godwit, Whimbrel, Eastern Curlew, Marsh Sandpiper, Common Greenshank, Great Knot, Red Knot, Broad-billed Sandpiper, Gull-billed Tern, Little Tern, and Whiskered Tern. Uncommon species (i.e. those recorded on three or more dates but in low numbers) were Wood Sandpiper, Common

Table 2. Species concentrations of international significance, according to the Ramsar criterion, on the Deli-Serdang coast.

Species	Highest count	1 % of flyway criterion*	% of flyway population	Site
Lesser Sand Plover	2,000	1,300	1.5%	Bagan Percut
Greater Sand Plover	2,180	1,000	2.2%	Bagan Percut
Asian Dowitcher	2,370	230	10.3%	Bagan Percut
Asian Dowitcher	1,410	230	6.1%	Bagan Serdang
Bar-tailed Godwit	2,000	1,700	1.2%	Bagan Percut
Eurasian Curlew	2,580	350	7.4%	Bagan Percut
Common Redshank	1,000	1,000	1.0%	Bagan Percut
Terek Sandpiper	2,000	500	4.0%	Bagan Percut
Curlew Sandpiper	2,000	1,800	1.1%	Bagan Percut

*Criterion derived from Delany & Scott (2006), Bamford *et al*. (2008) and Li *et al.* (2009).

Sandpiper, Ruddy Turnstone, and Red-necked Stint. In addition, a number of other species appeared to be scarce visitors or vagrants, including Oriental Pratincole, Kentish Plover, Nordmann's Greenshank, Caspian Tern, Common Tern and Black-headed Gull.

Bagan Serdang

We surveyed Bagan Serdang on 23 April 1997 and located a roosting flock of 1,600+ waders of 14 species at a beach on the eastern river mouth (Table 3). Unfortunately, accurate counts were only obtained for eight species as the flock was chased away by a group of children. Less than 50 individuals of each of the uncounted species were present. The small number of terns present were not counted as they were also disturbed by the children. The large roosting flock of 1,410 Asian Dowitcher observed at Bagan Serdang came from feeding grounds along the adjacent shoreline and we are certain that they are different birds to those recorded at Bagan Percut and Sungai Ular over the same period. This concentration exceeds the 1% Ramsar criterion for international importance (Table 2).

Pantai Labu Baru

We observed 1,170 shorebirds at Pantai Labu Baru on 2 October 2005 and 919+ birds on 7 September 2006 (Table 4). Notable counts were made of Asian Dowitcher (198) and Red Knot (58), the latter an uncommon species in Sumatra during southward migration (Crossland & Sinambela 2009). The 600+ unidentified medium-large waders recorded on 7 September 2006 were too distant to allow counts of individual species but the group appeared to comprise mainly Asian Dowitcher and Common Redshank with smaller numbers of Bar-tailed Godwit and Whimbrel.

Sungai Ular River Mouth

Shorebirds roosting on the east side of the river mouth and

Table 3. Waders counted at Bagan Serdang. Terns were present but not counted at this site because of disturbance. n.c. = not counted.

Species	23/4/1997
Pacific Golden Plover	n.c.
Greater Sandplover	n.c.
Asian Dowitcher	1410
Black-tailed Godwit	8
Bar-tailed Godwit	n.c.
Eurasian Curlew	5
Eastern Curlew	1
Common Redshank	n.c.
Common Greenshank	4
Terek Sandpiper	60+
Common Sandpiper	4
Great Knot	n.c.
Red Knot	120
Curlew Sandpiper	n.c.
Total waders	**1612+**

Table 4. Shorebirds counted at Pantai Labu Baru.

Species	2/10/2005	7/9/2006
Pacific Golden Plover	0	15
Lesser Sand Plover	220	3
Greater Sand Plover	0	109
Asian Dowitcher	198	1
Bar-tailed Godwit	31	0
Whimbrel	12	20
Common Redshank	283	29
Marsh Sandpiper	11	0
Common Greenshank	1	0
Terek Sandpiper	138	24
Common Sandpiper	11	1
Ruddy Turnstone	30	0
Great Knot	22	0
Red Knot	58	0
Red-necked Stint	0	2
Curlew Sandpiper	72	5
unidentified medium-large	0	600+
Total waders	**1087**	**809+**
Gull-billed Tern	3	10
Common Tern	0	40
Little Tern	20	60
White-winged Black Tern	60	0
Total terns	**83**	**110**
Total shorebirds	**1170**	**919+**

roosting on the adjacent sand spit were counted on 16 April 1997 (Table 5). A much larger group of waders and terns were observed distantly on the western side of the river mouth but numbers could not be ascertained. We returned the following day (17 April 1997) and navigated our way to a closer observation point but were still unable to cross the river. The roost was located on the beach about 500m west of the river mouth but was just beyond range for an accurate species count. We estimated over 5,000 waders at the roost, including several hundred Asian Dowitcher. A large congregation of terns roosted nearer our position including 900+ White-winged Black Terns and 100+ combined other tern species.

Pantai Cermin - Sungai Perbaungan River Mouth

A mix of waders and terns roosted along the beach at Pantai Cermin, particularly at the eastern tip of the sand spit. Counts were made on 3 April 1997 and 2 October 2005. Twelve wader and six tern species were recorded (Table 6).

DISCUSSION

International significance

With maximum counts of at least 13,644 migratory waders and 1,143 terns observed at Bagan Percut, and maximum counts of at least 500 to more than 6,000 waders and terns at the other four sites, the Deli-Serdang coastline is clearly of importance to migratory shorebirds. The five sites surveyed are a sample of all potential high-tide roosts along a 35 km length of coastline. We are likely to have missed other roosts within this study area, and inter-tidal mudflats continue for tens of kilometres along adjacent coastlines to the north and south. Therefore, the total shorebird numbers along the entire Deli-Serdang coastline are probably comparable to the many tens of thousands found in the nearby Asahan District (Crossland *et al*. 2009, Iqbal *et al*. 2010).

Our count data indicate that eight migratory waders, Lesser Sand Plover, Greater Sand Plover, Asian Dowitcher, Bar-tailed Godwit, Eurasian Curlew, Common Redshank, Terek Sandpiper and Curlew Sandpiper, occur at Bagan Percut in numbers that exceed the 1% criterion for international significance under the Ramsar Convention. This assessment is based on the most recent estimates of East Asian-Australasian Flyway populations (Delany & Scott 2006, Bamford *et al.* 2008, Li *et al*. 2009). Subsequent to our study, Iqbal *et al.* (2010) provided data confirming our findings for Eurasian Curlew and Asian Dowitcher, and added Eastern Curlew to the list for which Bagan Percut is internationally significant. As further survey work takes place and more sites on the Deli-Serdang coastline are investigated it is likely that the 1% threshold will be reached or exceeded for additional species. Likely candidates include Grey Plover, Whimbrel and Nordmann's Greenshank, which are all currently slightly below Ramsar and Wetlands International 1% thresholds.

Asian Dowitcher was the only species we found in internationally significant numbers at more than one site. The max count of 2,370 at Bagan Percut on 8 October 2005 represents 10.3% of the estimated Flyway population and a count of 1,410 at Bagan Serdang on 23 April 2007 represents 6.1% (Delany & Scott 2006). In addition, 198 Asian Dowitcher at Pantai Labu Baru on 2 October 2005 is just under the 1% threshold (0.86%) and a distant view of a flock of over 5,000 waders at Sungai Ular River Mouth on 17

Table 5. Shorebirds counted at Sungai Ular River Mouth

Species	16/4/1997 east side
Pacific Golden Plover	27
Lesser Sand Plover	20
Greater Sand Plover	16
Asian Dowitcher	42
Bar-tailed Godwit	8
Whimbrel	4
Common Redshank	41
Common Greenshank	4
Terek Sandpiper	96
Common Sandpiper	10
Ruddy Turnstone	30
Red-necked Stint	75
Broad-billed Sandpiper	5
Curlew Sandpiper	60
unidentified waders	0
Total waders	**438**
Gull-billed Tern	2
Common Tern	1
Little Tern	2
Whiskered Tern	1
White-winged Black Tern	267
unidentified terns	-
Total terns	**273**
Total shorebirds	**711**

Table 6. Shorebirds counted at Pantai Cermin - Sungai Perbaungan River Mouth.

Species	3-April 1997	2-Oct 2005
Pacific Golden Plover	37	12
Lesser Sand Plover	2	32
Greater Sand Plover	6	0
Asian Dowitcher	0	12
Whimbrel	50	18
Eurasian Curlew	0	1
Common Redshank	1	10
Marsh Sandpiper	1	0
Common Greenshank	1	0
Terek Sandpiper	47	86
Common Sandpiper	31	11
Ruddy Turnstone	9	0
Unidentified waders	0	260
Total waders	**185**	**442**
Crested Tern	0	30
Gull-billed Tern	3	0
Common Tern	3	10
Little Tern	22	10
Whiskered Tern	1	0
White-winged Black Tern	68	30
Total terns	**97**	**80**
Total shorebirds	**282**	**522**

April 1997 included at least several hundred dowitchers. The presence of Asian Dowitcher at all five sites and sizeable maximum counts at Bagan Percut and Bagan Serdang agree with observations in the Asahan Regency (Crossland *et al.* 2009) that the Asian Dowitcher is a prominent component of the wader community on the east coast of North Sumatra.

The importance of the Deli-Serdang coastline to shorebirds

Prior to 1995 the Bagan Percut area was already known by ornithologists (Silvius 1987, Marle & Voous 1988), but our initial survey in December 1995 was the first to document the presence of large shorebird populations there (D. Holmes *pers. comm.*). Following our 1995 and 1997 visits we reported findings to Wetlands International, Birdlife International-Indonesia Programme and the Indonesian Ornithological Society (Crossland 1997). Some of these data were subsequently reproduced in Lopez & Mundkur (1997), Crossland *et al.* (2006), Bamford *et al.* (2008), Li *et al.* (2009) and Crossland & Sinambela (2009). However, this current paper is the first time our shorebird counts have been fully published in one place and are done so in order to emphasise the relative importance of this area to shorebirds.

The number of shorebirds counted at Bagan Percut in late December 1995 (10,154) indicates that large numbers are present during the Northern Hemisphere winter and that Bagan Percut is not simply a transit site for birds passing through North Sumatra on migration. This was confirmed by a count of 7,852 waders made by Iqbal *et al.* (2010) on 4 January 2009, subsequent to our study. Similarly, both visits to Pantai Labu Baru occurred during the southward migration period and the site may well support higher numbers at other times of year. Further survey is necessary to confirm the importance of Pantai Labu Baru during the Northern Hemisphere winter.

Bamford *et al.* (2008) have listed the Bagan Percut to Sungai Ular area as internationally important for Bar-tailed Godwit, Eurasian Curlew, Common Redshank, Terek Sandpiper and Asian Dowitcher. This is based on 1990s data originally sourced from Crossland (1997). The maximum counts for species such as Asian Dowitcher and Eurasian Curlew have been subsequently exceeded by our 2005 counts. In addition, Bagan Percut is recognised as an internationally important site for the threatened Milky Stork (*Mycteria cincerea*) (Li *et al.* 2009, Shepherd & Giyanto 2009) and has more recently been shown to support internationally significant numbers of Eastern Curlew (Iqbal *et al.* 2010). The international importance of the area has recently been highlighted in the Indonesian national press with articles about migratory shorebirds and calls for environment protection on the Deli-Serdang coastline (Ada Burung Migran di Pesisir Timur Sumatera, http://nasional.kompas.com/read/2008/09/15/14454744/ada. burung.migran.di.pesi sir.timur.sumatera accessed 15 September 2008). Subsequent to our 1995-2006 study period other ornithologists had visited Bagan Percut and the Deli-Serdang coastline and confirmed the high wildlife values of the area (Shepherd & Giyanto 2009, Iqbal *et al*. 2010).

Wildlife conservation considerations

Over the period 1995 to 2006 the Deli-Serdang coastal zone underwent a substantial transformation with massive loss of mangrove and nipah swampland habitats and a substantial increase in human recreational use and construction of aquaculture ponds. Although shorebird populations remained high in 2006 a number of emerging threats were noted, including habitat destruction, marine/river pollution, increased levels of disturbance at high tide roosts and foraging grounds by people, and an increase in shorebird hunting.

It is hoped that identification of key sites like Bagan Percut, Bagan Serdang and Sungai Ular will assist Indonesian authorities in the difficult task of balancing land development with wildlife conservation initiatives. An awareness of the outstanding natural values of the Deli-Serdang coastline amongst local communities and within various tiers of governance has recently emerged (Dongoran 2007). Initial moves to reverse negative impacts and implement community-willed environmental outcomes seem encouragingly robust. A joint programme launched by Keidanren Nature Conservation Fund (KNCF), Yayasan Akasia Indonesia (YAI) and the Sumatra Rainforest Institute in May 2006 has created a number of initiatives including a public education and mobilisation programme, a local community shorebird volunteer programme, and a community-based mangrove reforestation programme (Dongoran 2007). Indonesian ornithologists are now actively monitoring shorebirds on this coastline and advocating for recognition and protection (Iqbal *et al.* 2010).

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NOTES ON THE EARLY NORTHWARD MIGRATION OF SUMATRAN WADERS ON THE EAST COAST OF JAMBI PROVINCE, INDONESIA, IN 2011

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A wader population survey of Cemara and Air Hitam Laut beaches on the east coast of Jambi, central Sumatra, Indonesia was carried out during early northward migration (1st March 2011). A total of 4,144 waders was counted, comprising 15 species. Black-tailed Godwit was the most abundant species (48.43% of total count), followed by Bar-tailed Godwit (19.3%), Terek Sandpiper (6.86%) and Lesser Sand Plover (6.75%). The number of Black-tailed Godwit in this survey reached more than 1% of the population estimate of waders for the East Asian-Australasian Flyway. It is confirmed that the east coast of Jambi province provides important habitat for Black-tailed Godwit and is also an important non-breeding area of waders in East Asian-Australasian Flyway.

INTRODUCTION

A high diversity and large numbers of waders have been recorded on the mudflats of the east coast of Jambi Province, Sumatra, Indonesia (Silvius & Verheught 1986, Silvius 1987, Silvius 1988, Danielsen & Skov 1989, Noni & Londo 2008, Noni & Londo 2010). Cemara beach is one of the important sites for migratory waders on the east coast of Jambi Province. The area has been known to host the endangered Nordmann's Greenshank *Tringa guttifer* (Noni & Philippa 2009) and is also a selected site for sampling for the avian influenza virus (HPAI) H5N1 in Indonesia (Noni & Londo 2008; Noni & Londo 2010). Together with the Banyuasin Peninsular, Cemara beach is a hotspot for waders during the non-breeding period in the East Asian-Australasian Flyway (Bamford *et al.* 2008). Although there have been many observations of waders on the east coast of Jambi Province, records during the northerly migration period, when waders start return to their breeding areas, are still lacking.

A survey of waders was conducted at two sites on the east coast of Jambi Province on 1 March 2011. Species numbers and abundance relative to earlier studies are discussed.

METHODS

Study area

Two locations on the east coast of Jambi Province were visited on 1 March 2011 (Figure 1). They were Cemara (01°25'59.0"S; 104°27'16.9"E) and Air Hitam Laut (01°19'53.8"S; 104°27'17.4"E). Cemara beach is a wide sandy coastal beach lined with casuarina trees *Casuarina equisetifolia*, river and mangrove habitat. It is administratively located within Cemara Village. Air Hitam Laut is a village with a sandy beach with mangrove vegetation along the coast. Both of the villages are within Tanjung Jabung Timur District, Jambi Province, Sumatra (Figure 1).

Wader surveys

Waders were counted during low tide when they were present on the mudflats. The time point count technique was used to collect data (Bibby *et al.* 2000). Sites (locations) were determined as one plot, and each plot was divided into five subplots. In every subplot, 30 minutes were taken to identify and count the birds seen along the shore. Binoculars (8x42) were used for identification and counting.

Standard Asian Waterbird Census site description and waterbirds count forms (Li & Ounsted 2007) were used for the surveys. Sites description forms enabled data to be collected on types of wetlands, vegetation, uses of and threats to wetlands. Wader count forms provided a standard list of all waders, against which numbers could be tallied (the standard list included other waterbirds, e.g. Storks, Egrets, etc.).

RESULTS & DISCUSSION

A total of 4,144 waders was counted from 15 species (Table 1). Black-tailed Godwit was most abundant species (48.43% of the total count), followed by Bar-tailed Godwit (19.30%), Terek Sandpiper (6.86%), Lesser Sand Plover (6.75%), Eurasian Curlew (3.81%), Pacific Golden Plover (3.18%), Whimbrel (2.22%), Kentish Plover (1.15%), Greater Sand Plover (1.06%), Asian Dowitcher (0.96%), Common Redshank (0.24%), Common Sandpiper (0.19%), Far Eastern Curlew (0.14%), Common Greenshank (0.12%) and Marsh Sandpiper (0.04%). Only a few birds were in breeding plumage. Comparison of wader numbers on 1 March 2011 with the 1% population estimate for the East Asian-Australasian Flyway (EAAF) is given in Table 2.

The following annotated list provides details of waders recorded and comparisons to earlier records. The sequence and nomenclature of each species follow Sukmantoro *et al.* 2007 as a reference for Indonesian birdlist.

Pacific Golden Plover *Pluvialis fulva*
A total of 132 birds was recorded during this survey. This is a largest number of Pacific Golden Plover ever recorded in Jambi province. Records from previous surveys in Jambi were six during October-November 1984 and three during

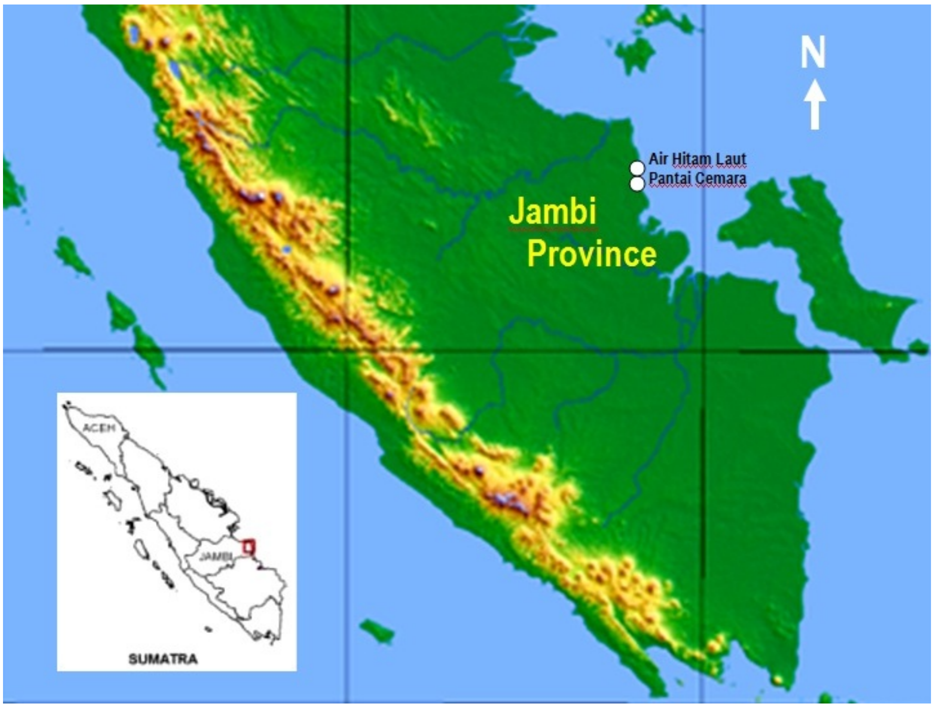

Figure 1. Circles indicate sites visited during the wader surveys on the east coast of Jambi province, Indonesia on 1 March 2011.

Table 1. Waders counted on the east coast of Jambi province on 1 March 2011. Number flagged refers to the count of birds with leg flags.

Species	**Sites**		**Total**	**Number flagged**		**Total**
	Cemara	Air Hitam Laut		Cemara	Air Hitam Laut	
Pacific Golden Plover	120	12	132	0	0	0
Kentish Plover	31	17	48	1	0	1
Lesser Sand Plover	250	30	280	10	1	11
Greater Sand Plover	4	40	44	0	3	3
Asian Dowitcher	40	0	40	0	0	0
Black-tailed Godwit	2,000	7	2,007	2	0	2
Bar-tailed Godwit	800	0	800	2	0	2
Whimbrel	80	12	92	0	0	0
Eurasian Curlew	150	8	158	0	0	0
Far Eastern Curlew	6	0	6	0	0	0
Common Redshank	10	0	10	0	0	0
Common Greenshank	0	5	5	0	0	0
Common Sandpiper	5	3	8	0	0	0
Marsh Sandpiper	2	0	2	0	0	0
Terek Sandpiper	200	82	282	5	3	8
Unidentified	200	30	230	0	0	0
TOTAL	**3,898**	**246**	**4,144**	**10**	**7**	**27**

March-April 1986 (Silvius 1988), one on 21 October 2007 and three on 9 December 2007 (Noni & Londo 2008).

Kentish Plover *Charadrius alexandrinus*
A total of 47 birds was recorded during this survey. This may be the largest number of Kentish Plover ever recorded in Jambi. Previous records in Jambi were one on 24 November in Berbak National Park 1984 (Silvius & Verheught 1986), one during October-November 1984 and 14 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), three on 21 October 2007 and four on 9 December 2007 (Noni & Londo 2008). One bird was observed with a Sumatran flag (Table 1) and is one of three birds flagged during 2007-2010 (Noni & Londo 2010). A bird of race of (White-faced) Kentish Plover *Charadrius alexandrinus dealbatus* was recorded (Figure 2). This is a second record for Cemara beach and possibly the third record for Sumatra (Bakewell & Kennerley 2008, Kennerley *et al.* 2008, Iqbal *et al.* 2010, Noni & Londo 2010).

Lesser Sand Plover *Charadrius mongolus*
A total of 280 birds was recorded during this survey. Previous records in Jambi were “thousands” on 24 November in Berbak National Park (Silvius & Verheught 1986). In addition, 2,199 birds were recorded during October-November 1984, 10 birds during July-August 1985,

Table 2. Composition on waders numbers on the east coast of Jambi province on 1 March 2011 and comparison with 1% population estimate for the EAAF (following Bamford *et al.* 2008).

Species	Total	Percentage (of total count)	1% population in EAAF	Proportion of 1% population in EAAF
Pacific Golden Plover	132	3.18	1,000	0.132
Kentish Plover	48	1.15	1,000	0.048
Lesser Sand Plover	280	6.75	1,300	0.280
Greater Sand Plover	44	1.06	1,100	0.004
Asian Dowitcher	40	0.96	230	0.180
Black-tailed Godwit	2,007	48.43	1,600	1.250
Bar-tailed Godwit	800	19.30	3,250	0.240
Whimbrel	92	2.22	1,000	0.092
Eurasian Curlew	158	3.81	400	0.395
Far Eastern Curlew	6	0.14	380	0.015
Common Redshank	10	0.24	750	0.013
Common Greenshank	5	0.12	600	0.008
Common Sandpiper	8	0.19	250	0.032
Marsh Sandpiper	2	0.04	1,000	0.002
Terek Sandpiper	282	6.86	500	0.560
Unidentified	230	5.55	-	-
TOTAL	**4,144**	**100%**		

Figure 2. A male (White-faced) Kentish Plover *Charadrius alexandrinus dealbatus* at Cemara beach on 1 March 2011.

and 2,786 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), and 2,000 birds were recorded on 21 October 2007 and 560 on 9 December 2007 (Noni & Londo 2008). In the present study, 11 birds with Sumatran flags were observed, the highest number for any species during the survey. These 11 birds are part of 384 birds flagged during 2007-2010 (Noni & Londo 2010).

Greater Sand Plover *Charadrius leschenaultii*
A total of 44 birds were recorded in the east coast of Jambi province during this survey. Previous records in Jambi province were 35 birds during October-November 1984, seven birds during July-August 1985 and 215 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), 500 on 21 October 2007 and 200 on 9 December 2007 (Noni & Londo 2008). Three of 21 birds flagged in Sumatra during 2007-2010 (Noni & Londo 2010) were observed during the present study.

Asian Dowitcher *Limnodromus semipalmatus*
A total of 40 birds was recorded during this survey. Previous records in Jambi province were 97 birds in Berbak area on 24 November 1984 (Silvius & Verheught 1986), 1,460 birds during October-November 1984, 16 birds during July-August 1985 and 2,042 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), and 200 on 21 October 2007 and 100 on 9 December 2007 (Noni & Londo 2008).

Black-tailed Godwit *Limosa limosa*
A total of 2,007 birds was recorded during this survey (Figure 3). Previous records in Jambi were 8-16 birds on October 1983, up to 1,000 on 13 October and 1,500 on 16 October 1984 in Berbak National Park (Marle & Voous 1988), 7,477 birds during October-November 1984, 12,800 birds during July-August 1985 and 2,949 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), 2,000 on 21 October 2007 and 1,400 on 9 December 2007 (Noni & Londo 2008). The east coast of Jambi province is a significant stopover and wintering area for this declining species. Two birds were observed with Sumatran flags during this survey, which are part of six birds flagged during 2007-2010 (Noni & Londo 2010).

Figure 3. A mixed flock of Asian Dowitcher, Black-tailed Godwit, and other waders in flight at Cemara beach on 1 March 2011.

Bar-tailed Godwit *Limosa lapponica*
A total of 800 birds was recorded during this survey. Previous records in Jambi province included 1,209 birds during October-November 1984, 20 birds during July-August 1985 and 88 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), 1,500 on 21 October 2007 and 1,000 on 9 December 2007 (Noni & Londo 2008). A single bird was observed with Sumatra flags (Figure 4).

Eurasian Curlew *Numenius arquata*
A total of 158 birds was recorded during this survey. Previous records include a flock of 800 birds observed in Berbak National Park, Jambi province on 24 November 1984 (Silvius & Verheught 1986), and 1,393 birds during October-November 1984, 2,253 birds during July-August 1985 and 114 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989). The relatively small number recorded in the survey (which is comparable to numbers observed in the same period in 1986) suggests that numbers are fewer during northward migration than during the northern hemisphere autumn and wintering period.

Far Eastern Curlew *Numenius madagascariensis*
A total of six birds was recorded during this survey. Previous records in Jambi province were 23 birds during October-November 1984 and 181 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), 100 birds on 21 October 2007 and 20 on 9 December 2007 (Noni & Londo 2008).

Whimbrel *Numenius phaeopus*
A total of 92 birds was recorded during this survey. Previous records in Jambi province were 700 birds during October-November 1984, 366 birds during July-August 1985 and 545 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), one on 23 October 2007 and 13 on 9 December

Figure 4. Four Bar-tailed Godwits *Limosa lapponica* resting at Cemara beach. The bird on the left has Sumatran flags, and the two birds in the centre are in fresh breeding plumage.

2007 (Noni & Londo 2008).

Common Redshank *Tringa totanus*
A total of 10 birds was recorded during this survey. Previous records in Jambi province were 6,222 birds during October-November 1984, 1,024 birds during July-August 1985 and 4,557 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), 58 on 21 October 2007 and three on 9 December 2007 (Noni & Londo 2008).

Common Greenshank *Tringa nebularia*
A total of five birds was recorded during this survey. Previous records in Jambi province were 38 birds during October-November 1984, one bird during July-August 1985 and 269 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), two on 21 October 2007 and four on 9 December 2007 (Noni & Londo 2008).

Common Sandpiper *Actitis hypoleucos*
A total of five birds was recorded during this survey. Previous records in Jambi province were 128 birds during October-November 1984, three birds during July-August 1985 and 12 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), six on 21 October 2007 and 17 on 9 December 2007 (Noni & Londo 2008).

Marsh Sandpiper *Tringa stagnatilis*
A total of two birds was recorded during this survey. Previous records in Jambi province were up to 15 during 9-16 October 1983 in Berbak National Park (Marle & Voous 1988), 301 birds during October-November 1984, 80 birds during July-August 1985 and 375 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), five on 21 October 2007 and 15 on 9 December 2007 (Noni & Londo 2008).

Terek Sandpiper *Xenus cinereus*
A total of 282 birds was recorded during this survey. Previous records in Jambi province were flocks of up to 100 birds on 14 October 1983 in Berbak National Park (Marle & Voous 1988), 2,331 birds during October-November 1984, 783 birds during July-August 1985 and 571 birds during March-April 1986 (Silvius 1988, Danielsen & Skov 1989), 125 on 21 October 2007 and 300 on 9 December 2007 (Noni & Londo 2008). Eight birds were observed with Sumatran flags during this survey (one is pictured here: Figure 5), which are part of 108 birds flagged during 2007-2010 (Noni & Londo 2010).

DISCUSSION

A total of 4,144 waders was counted, comprising 15 species. Black-tailed Godwit was the most abundant species (48.43% of total count), followed by Bar-tailed Godwit (19.3%), Terek Sandpiper (6.86%) and Lesser Sand Plover (6.75%).

Black-tailed Godwit was the only species counted to reach more than 1% of the population estimate of waders in the EAAF. From previous records on the east coast of Jambi province, Black-tailed Godwit was the commonest wader. The largest number recorded was 12,800 birds during July-August 1985 (Silvius 1988, Danielsen & Skov 1989). There are three subspecies of the Black-tailed Godwit with *L. l. melanuroides* confined to the EAAF. This subspecies accounts for approximately 20% of the global population of the species. *L. l. melanuroides* breeds in eastern Siberia, and during the non-breeding period occurs in south-eastern Asia and Australia. Bamford *et al*. (2008) has been listed Air Hitam Laut (cited as Tanjung Jabung) as one important non-breeding area of Black-tailed Godwit in the EAAF. This recent finding confirms the importance of east coast of Jambi province as a non-breeding area for Black-tailed Godwit in EAAF.

A comparison of wader numbers made by Silvius (1988) on the east coast of Jambi province during the over-summering period (May-July), southward migration (August-October) and northward migration (March-April) showed that numbers occurring during northward migration are moderate compared to those recorded during southward migration and in the over-summering period. This is perhaps due to many birds taking a more direct route, passing east of Sumatra, from their wintering grounds to the breeding areas during the more urgent northward migration. During this survey, we found a number of birds of some species had already commenced or completed moult into breeding plumage (Figure 4).

Twenty-seven Sumatran-flagged waders was observed

Figure 5. A Terek Sandpiper *Xenus cinereus* with Sumatra leg flags (yellow above and black below).

during the survey, out of a total of 774 birds flagged overall between 2007 and 2010 (Noni & Londo 2010), which represents a re-sighting rate of 3.48%. Lesser Sand Plover (11 birds) and Terek Sandpiper (8 birds) were the most commonly sighted species with leg-flags. These are also two species most frequently flagged in Sumatra.

The number of waders counted at Cemara beach was far larger than at Air Hitam Laut. It is suspected that conditions at Cemara beach provide more food and suitable habitat for waders than Air Hitam Laut. Bordering with Berbak National Park, Cemara beach is a rich source of food for waders. This is possibly affected by peatswamp and mangrove forest in the adjacent area. Further surveys are needed to study wader numbers along the east coast of Jambi province, especially to better assess the populations of several threatened species such as Black-tailed Godwit, Asian Dowitcher and Nordmann's Greenshank.

Both Air Hitam Laut and Cemara beach are facing various threats. Main threats facing the areas, as identified by the IUCN and detailed in the Classification Scheme List of Threats (www.iucnredlist.org) are agriculture and aquaculture (by wood or pulp plantations and marine aquaculture) and biological resource use (logging or wood harvesting, and fishing or harvesting aquatic resources). The Cemara beach has been protected as buffer zone of Berbak National Park. Unfortunately, the Air Hitam Laut is still an unprotected area, and its small mangrove area should be protected by Indonesian law as Green Belt Zone. A Green Belt Zone is a border area containing natural vegetation, between the river and land ecosystems (riparian zone), that buffers the river from the landward impacts of human activities (Anon 2011). In the future, some conservation action such as further study and wader monitoring, providing wader identification training to local government staff and local people, and increasing awareness through education of local students should be supported in these areas.

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THE SHOREBIRDS OF BANGKA ISLAND, SUMATRA, INDONESIA

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Bangka Island is the second largest island in Sumatra, Indonesia. The island has a lengthy coastline and may provide important habitat for shorebirds during the migration period. There were 18 shorebirds species previously known from Bangka, and a most recent survey added three new species. This paper reviews all shorebird records from Bangka, including the recent discovery of endemic Javan Plover in the island on March-April 2011.

INTRODUCTION

The island of Bangka, situated roughly between 1°10' - 3°10 S and 105°10' - 106°50'E, is located off the coast of Sumatra, Indonesia. The total area of the island is 11,340 km^2, and is 245 km at its longest and approximately 70 km at its widest (in the south). The north coast is deeply indented by the shallow Klabat Bay, which penetrates almost 40 km inland. Bangka is separated from Sumatra by the shallow Strait Bangka, which at its narrowest point is no more than 14 wide and less than 20 m deep (Mees 1986). Previously, the island was administratively part of South Sumatra province but now together with Belitung Island, they form Bangka-Belitung province.

Bangka has a long coastline which has potential as shorebird habitat during migration period. The island is close to two sites on the mainland of Sumatra, which are listed by Bamford *et al.* (2008) as internationally important for migratory shorebirds. The first is Banyuasin Peninsular (South Sumatra province) approximately 35 km from Bangka Island and has a maximum total population up to 500,000 waders in the autumn (Verheugt *et al.* 1990), and the second is Cemara beach (Jambi province) approximately 130 km from Bangka Island and contains up to 20,000 waders in peak migration period (Tirtaningtyas & Philippa 2009).

Information on shorebirds of Bangka Island has been reported by Mees (1986) and Marle & Voous (1988). Unfortunately, this information only consists of species lists with very little actually known about distribution of key sites, population sizes, seasonal use, non-breeding versus breeding usage. A survey of waders was conducted on the east coast of Bangka Island during 26 March to 3 April 2011 and June 2011. During this survey, seven species of shorebirds were recorded. The occurrence of all species and population counts of shorebirds that have been recorded in Bangka Island is discussed here. It is hoped that this survey can encourage further study on shorebird populations along the entire coast of Bangka Island.

METHODS

Study Area

Some sites on Bangka Island were visited from south to north during March to April and again in June 2011, but because the visits did not coincide with main migration times, shorebirds were recorded from only four sites (Figure 1). The sites are Sadai beach, Pukan beach, Mentok beach and Rambat beach. Sadai beach is administratively located in Bangka Selatan district at 03^{0}00'19.6'' S, 106^{0}44'20.6'' E; Pukan beach is administratively part of Bangka district at 02^{0}02'39.9'' S, 106^{0}09'33.0'' E; Rambat beach is administratively part of located in Bangka Barat district at 01^{0}53'48.2'' S, 105^{0}16'08.3'' E and Mentok beach is administratively part of Bangka Barat district and geographically located at 02^{0}01'10.0'' S, 105^{0}13'10.2'' E. All sites are typically sandy beaches (Figure 2).

Shorebird surveys

The coast along Bangka Island was visited during 26 March to 3 April 2011 and 26 May to 2 June 2011. The birds were counted along the shore using binoculars and telescopes. Standard site description and waterbird count forms (Asian Waterbird Census form) designed and tested by Wetlands International were used for the surveys. Waterbird count forms provided a standard list of all waterbirds, against which numbers could be tallied (the standard list included other waterbirds; e.g. sandpipers, plovers, redshank, etc.)

RESULTS

There were 42 of birds from seven species recorded during this survey (Table 1). Pacific Golden Plover *Pluvialis fulva* and Malaysian Plover *Charadrius peronii* were two most frequently observed shorebirds recorded during this survey, with a total of 10 birds of each species (equivalent to 23.80% of the total count). The second most abundant shorebird was Whimbrel *Numenius phaeopus* (19.04%), followed by Kentish Plover *Charadrius alexandrinus* (14.28%), Common Sandpiper *Tringa hypoleucos* (14.28%), Javan Plover *Charadrius javanicus* (2.40%) and Bar-tailed Godwit *Limosa lapponica* (2.40%). Common Sandpiper (*Actitis hypoleucos*) is the most widespread shorebird and was recorded from three of four sites although in low numbers. Pacific Golden Plover was the second most widespread, recorded at two sites. The other species were only recorded at one site.

Over all sites, the highest number of shorebirds was found in Sadai beach with a total of 17 birds, following Pukan beach with a total of 12 birds, Rambat beach with a total of 10 birds and Mentok beach with only three birds. The Pukan and Sadai beach have the greatest diversity of shorebird habitat, and each had four species present during counts. Rambat and Mentok beach only had one species present each.

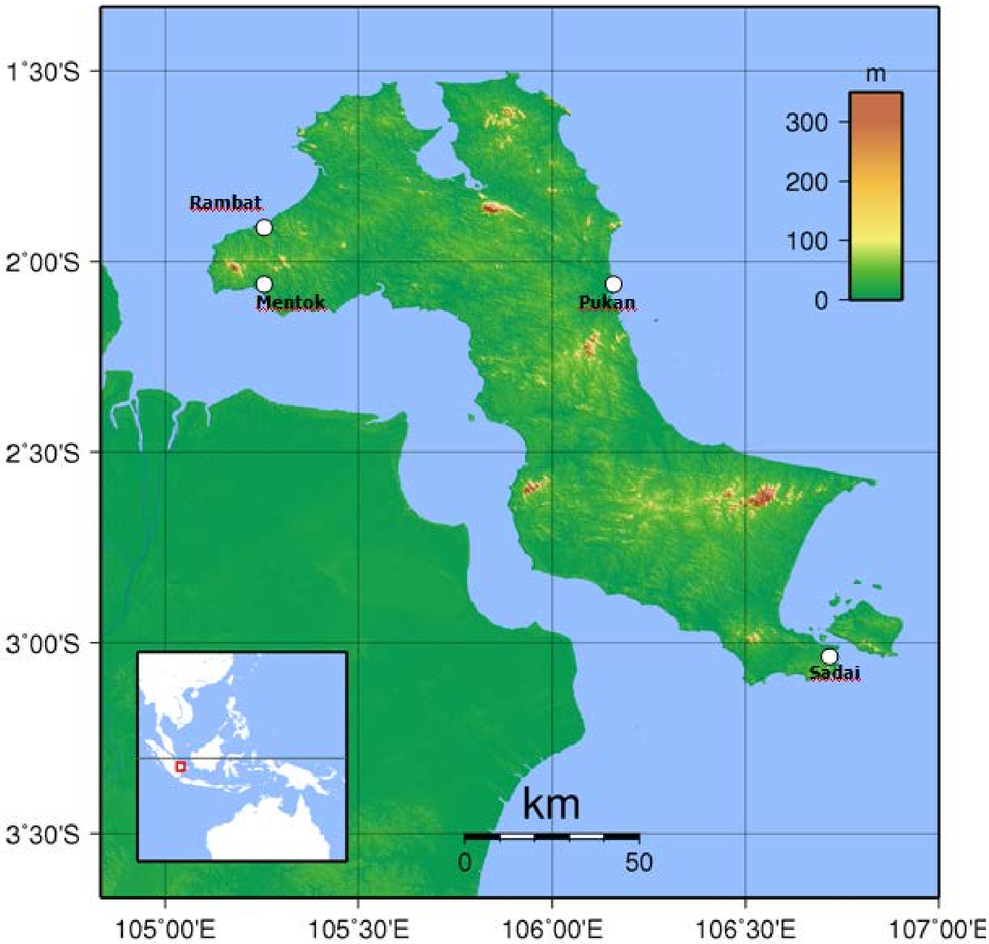

Figure 1. Circled are sites surveyed during shorebird survey in the coast Bangka island, Sumatra, Indonesia.

Figure 2. Condition of Pukan beach at low tide on 31 March 2011. This is typical of most of the coast of Bangka island.

DISCUSSION

Mees (1986) listed 18 species of shorebirds that occur on Bangka Island. Recent surveys recorded seven species of shorebird, three of which were new records for the Island. The three new species for Bangka Island are Javan Plover (Figure 3), Kentish Plover and Bar-tailed Godwit (Figure 4). Pacific Golden-plover, Malaysian Plover, Whimbrel and Common Sandpiper are common shorebirds on Bangka Island and have been recorded previously.

There have been 14 species previously recorded on Bangka Island that were not observed during this survey. These were Grey Plover *Pluvialis squatarola* (two

Table 1. Shorebirds recorded between 26 March to 3 April 2011, and 26 May to 2 June 2011 on Bangka Island, Sumatra.

Species	Sites				Total	Percentage
	Rambat	Mentok	Pukan	Sadai		
Pacific Golden Plover			8	2	10	23.80
Kentish Plover				6	6	14.28
Malaysian Plover	10				10	23.80
Javan Plover			1		1	2.40
Bar-tailed Godwit			1		1	2.40
Whimbrel				8	8	19.04
Common Sandpiper		3	2	1	6	14.28
TOTAL	**10**	**3**	**12**	**17**	**42**	**100**

specimens collected in 1872), Greater Sand-plover *Charadrius leschenaultii* (two specimens collected, one in 1872 and one in 1873), Eurasian Curlew *Numenius arquata* (three specimens collected, one in 1872, one in 1873 and one undated), Wood Sandpiper *Tringa glareola* (one specimen collected in 1872), Common Redshank *Tringa totanus* (three specimens collected in 1872), Terek Sandpiper *Xenus cinereus* (two specimens collected, one in 1872 and one in 1873), Pintail Snipe *Gallinago stenura* (three specimens collected, one around 1860 and two in 1872), Red Knot *Calidris canutus* (one specimen collected in 1905), Red-necked Stint *Calidris ruficollis* (one specimen collected in 1872), Long-toed Stint *Calidris subminuta* (one specimen collected around 1860), Curlew Sandpiper *Calidris ferruginea* (three specimens collected in 1872), Ruddy Turnstone *Arenaria interpres* (three specimens collected, one around 1860 and two in 1872), Beach Stone-curlew *Esacus magnirostris* (one specimen collected around 1860) and Oriental Pratincole *Glareola maldivarum* (nine specimens collected, eight around 1860 and one in 1965) (Mees 1986). Additional (one-off) records have been obtained since then of Pacific Golden Plover, Greater Sand Plover, Common Sandpiper, Pin-tailed Snipe, Red Knot, Long-toed Stint, Ruddy Turnstone and Oriental Pratincole (Chasen 1935). The lack of these species records during the present study is probably a result of not visiting Bangka Island during the main migration period for shorebirds.

The observation of Javan plover on 31 March 2011 at Pukan beach was unexpected. This is a first record for Bangka and second record for Sumatra (Kennerley *et al.* 2008, Iqbal *et al* 2011). This is previously known as a Javan endemic (Piersma & Wiersma 1996, Mackinnon *et al.* 1998, Birdlife International 2011), but it is likely overlooked that records of the bird have spread widely to Wallacea (White & Bruce 1986, Coates & Bishop 2000, Tebb *et al.* 2008).

The occurrence of Kentish plover on Bangka Island was not unexpected, as this species has been recorded in various numbers at nearby Banyuasin Peninsular, which is an important shorebird site in Sumatra (Verheugt *et al.* 1990). In Sumatra, Crossland *et al.* (2006) stated that Kentish plover as an uncommon visitor in all coast and that Sumatra is outside the principal wintering range for this species.

The Whimbrel was recorded with a total of eight birds in Sadai on 31 March 2011. The Whimbrel has been recorded in Bangka Island, but without specific locations. The records of Whimbrel in Bangka Island are two male specimens collected on 2 July 1872 and 8 September 1872 (Mees 1986).

An adult female Malaysian plover was observed at Rambat beach on 29 May 2011 (Figure 5). This adult female

Figure 3. A Javan Plover *Charadrius javanicus* in Pukan beach, Sungai Liat, Bangka.

Figure 4. A first record of Bar-tailed Godwit *Limosa lapponica* for Bangka Island on Pukan beach on 31 March 2011.

Figure 5. An adult female Malaysian plover on Rambat beach on 29 May 2011.

plover occurred in the area when most of shorebirds were absent from the coast of Bangka Island. It suggests that the bird possibly breeds there. In Sumatra, the Malaysian Plover was reported to breed at Singkep, Riau Archipelago where eggs and birds were collected on 21 April 1950 (Marle & Voous 1988). Another breeding report is an observation of downy young juvenile along the beach between Belimbing and Danau Minjukut, south-west Lampung coast, 17-24 May 1992 (Holmes 1996). There have been no reports of breeding Malaysian plover from Sumatra since.

Information on populations and distribution of shorebirds in Bangka Island is still lacking and numbers of each species recorded on Bangka Island during this study were small (no more than 10 birds). Bangka Island has a long coastline and is geographically located close to two internationally important sites for migrating shorebirds in Sumatra, Banyuasin Peninsula in South Sumatra province and Cemara beach in Jambi province. Bangka Island has potential as an important buffer zone habitat linking to three main islands in western Indonesia (Sumatra, Java and Borneo. Further study during the wintering period (October-February) is needed to study the composition, numbers and distribution of shorebirds along the coast of Bangka Island.

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RECORDS OF LITTLE STINT *CALIDRIS MINUTA* AND RED-NECKED STINT *C. RUFICOLLIS* AT SONADIA ISLAND, BANGLADESH

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During an expedition focused on waders, at Sonadia Island, Bangladesh, 20–29 November 2010, a total of ten small *Calidris* were caught and ringed. These were identified as six Little Stints *Calidris minuta* and four Red-necked Stints *C. ruficollis*. Although Little Stint is a regular winter visitor in the Indian subcontinent, there appear to be no undoubted specimens for Bangladesh (Rasmussen & Anderton 2005) and its occurrence was hitherto unproven. Nonetheless, Siddiqui *et al.* (2008) assumed that non-breeding plumage *minuta/ruficollis* stints found inland in small numbers along the main rivers were Little Stints, based merely on the presumption that Little Stint would show a preference for freshwater areas, while Red-necked would be mainly confined to coastal and marine sites. Red-necked Stint is apparently regular, believed to outnumber Little Stint in Bangladesh, and its presence already substantiated by photographs of breeding plumage individuals (Chowdhury 2011, S. U. Chowdhury*, in litt.*)

This paper provides the first undisputed evidence of the co-occurrence during winter of both species in the same habitat in Bangladesh.

Mist-nets were set on an area of disused salt pans at Baradia, near Sonadia Island, Cox's Bazar District, south-east Bangladesh (approximately N 21° 33'; E 91° 53') on three nights, 23, 24 and 26 November. A total of ten stints, six Little Stints and four Red-necked Stints were among 34 waders netted and ringed.

All birds were ringed with metal rings (bands) supplied by the British Trust for Ornithology, measured, weighed, and examined for state of wear and moult before release. Moult score was recorded following Ginn & Melville (1983). All the stints were in non-breeding plumage and, moreover, all Little Stints and all but one Red-necked Stint were still growing their primaries in the course of the complete post-nuptial (or post-juvenile) moult. Little Stint is unusual among *Calidris* waders in that most first-winter birds also undergo a complete moult of primaries (Pearson 1984, Prater *et al*. 1977). This somewhat complicates determination of age, and all were recorded merely as "full-grown" (fg). First-winter Red-necked Stints may also renew one to five outer primaries, though usually later in the winter than during our visit (Paton & Wykes 1978, Prater *et al*. 1977), so that moulting birds were thought to be adults.

The fact that p9 and p10 (the two outermost primaries—descendant numbering) were not full-grown in most birds made separation of Little and Red-necked Stints by accepted methods, which rely on wing:tarso-metatarsus ratio, problematical. The ratio of wing:tarsus is usually < 5.0 in Little Stints, and > 5.1 in most Red-necked (Prater *et al.* 1977). The first Little Stint trapped (Figure 1), unusually, was in the early stages of moult, and the outermost five primaries were full-length. This enabled reliable determination of its wing-length and hence identity, and prepared the observers for subsequent individuals.

Little Stints were, on average longer legged and shorter-winged than Red-necked Stints. They also tended to be longer-billed, although there was proportionately more overlap in bill measurements than tarsus measurements between the two taxa. However, the sample-size was very small (Tables 1 and 2).

Notwithstanding their great similarity, the two species could be readily distinguished in the hand by the longer legs, and greater length of tibio-tarsus exposed below the upper leg feathering, in Little Stint. This was not routinely measured in all birds handled as, with experience, it could be easily detected by eye. The length of exposed tibio-tarsus between the bottom margin of the leg-feathering and the tarso-metatarsal joint was roughly 10-12 mm in Little Stint, compared with usually about 6 mm in Red-necked Stint (measured with a dial caliper). Since this is not necessarily a reliable, internationally accepted, measurement, the value of which may change slightly with positioning of the tarsal feathering during handling, it should be used with care. Nonetheless, for an experienced observer, the longer tibio-tarsus of Little compared with Red-necked Stint is an easier way to separate the two species in non-breeding plumage,

Figure 1. The first Little Stint (ring no. 2660001) caught at Sonadia Island, 24 November 1010

Table 1. Biometrics and moult status of Little and Red-necked Stints ringed at Sonadia Island. November 2010. Measurements are in mm and weights are g.

Date	Ring no.	Species	Age[1]	Wing[2]†	TH[3]	Bill[4]	Tarsus	TT[5]	Weight	Time	Moult[6]	Outer primaries status
24-Nov-10	2660001	*Calidris minuta*	fg	94.5	38.0	16.6	20.7		22.0	00:50	13	pp 6-10 old
26-Nov-10	2660004	*Calidris minuta*	fg	(95)	38.9	19.1	20.8		22.2	22:40	43	p8 full-grown
26-Nov-10	2660005	*Calidris minuta*	fg	94	38.3	17.6	22.3	10.5	21.8	23:24	40	p10 old;
26-Nov-10	2660006	*Calidris minuta*	fg	(92)	40.7	20	23.0	11-12	23.6	23:35	45	p8 full-grown
27-Nov-10	2660007	*Calidris minuta*	fg	(97)	38.7	19.3	21.4		21.8	01:00	49	P9 full-grown
27-Nov-10	2660008	*Calidris minuta*	fg	(102)	40.2	19.1	24.5		25.7	01:01	42	p8 full-grown
25-Nov-10	2660002	*Calidris ruficollis*	ad	(98)	38.4	18.1	20.7		24.3	01:15	47	p8 full-grown
26-Nov-10	2660003	*Calidris ruficollis*	ad		37.6	16.9	19.5		24.8	18:45	47	p8 full-grown
27-Nov-10	2660009	*Calidris ruficollis*	ad	103	38.1	17.3	20.5	6.0	23.8	01:30	50	All new
27-Nov-10	2660100	*Calidris ruficollis*	fg	94	39.2	17.5	20.9		25.2	01:45	?	not recorded

[1] Fg full-grown, age not reliably known; ad adult. [2] Wing-length, maximum chord; [3]TH combined length of bill and head; [4]Bill length measured to feathering.; [5]TT length of exposed tibio-tarsus from upper margin of tibio-tarsal joint to the lower margin of feathering. [6]Primary moult score following Ginn & Melville (1983).

† Wing length in parentheses indicates five individuals in which the outermost primaries were not fully grown. The longest fully grown primaries (pp) that were measured were p8 (four birds), and p9 (one bird).

Table 2. Summary of bill and tarsus measurements (mean ± SD) for Little and Red-necked Stints caught at Sonadia Island

	n	Bill length (mm)	Tarsus length (mm)
Little Stint	6	18.6 ± 1.26 (16.6–20.0)	22.1 ± 1.47 (20.7–24.5)
Red-necked Stint	4	17.5 ± 0.5 (16.9-18.1)	20.4 ± 0.62 (19.5–20.9)

both in the hand and in the field (where it is usually detectable in photographs of the two species together).

Sonadia Island and adjacent parts of the south-east Bangladesh mainland (including Baradia) lie inside the Sonadia Island Ecologically Critical Area, declared by the Bangladeshi government in 1999 (Chowdhury *et al*. 2011). This conveys a measure of habitat protection although implementation of zoning and restrictions on changes in land use remain to be fully developed and enforced (P. Thompson, *in litt*.) Most species of waders are already nominally protected in law (Siddiqui *et al*. 2008), though enforcement of legislation is weak, and there is still some netting of waders for food (Chowdhury 2010).

With its long coastline and extensive wetland habitats, Bangladesh is clearly an important country for wintering waders, probably receiving populations from both the Central Asian Flyway and the East Asian-Australasian Flyway. There is much to be learned and ringing (and ideally leg-flagging or otherwise tracking) migratory waders in the country should be undertaken as a high priority.

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RECORDS OF AUSTRALIAN PRATINCOLE *STILTIA ISABELLA* AT PANTAI TRISIK, YOGYAKARTA, INDONESIA

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Within the East Asian-Australasian Flyway, the Australian Pratincole *Stiltia isabella* breeds in the Australia and after breeding has finished, part of the population migrates north to Papua New Guinea, Timor and Indonesia. The breeding and non-breeding ranges of the species overlaps in northern Australia (Higgins and Davies 1996).

Known as the Roadrunner, Australian Courser or Swallow-plover, Australian Pratincole breed in September to December with 1-2 eggs in the nest (Pizzey and Knight 1997). Movements may be unpredictable from year to year at specific localities in Australia and vary in response to rainfall, but northward and southward movements are well defined, with the species present in the south of its range only during the breeding period. Movements through Papua New Guinea and south-eastern Asia are poorly understood and there is a lack of data on important sites in this region (Higgins and Davies 1996).

Recent population estimates are of 60,000 with the largest single records in Indonesia coming from Kupang bay on 11 June 2010 of 5,000 birds (Bamford *et.al* 2008). MacKinnon & Phillipps (1993) report that Australian Pratincole is an erratic visitor to the Greater Sundas. There is one record from Sumatra, on Belitung Island in June 1888, where it was noted to be numerous on coastal sand bars emerging at low tide (Marle & Voous 1988). In Borneo, there are a few records from Sabah, west Sarawak and South Kalimantan (Myers 2009).

There is one record from Bali on 6 July 1987 of two adult birds in the grasslands around the runway of Denpasar Airport (Bishop 1988). Mason and Jarvis (1989) recorded it as a 'straggler or irregular visitor' to Bali where the best site to see it was the southern tip of the island from Nusa Dua to Ulu Watu.

There are only three records for Java, with all coming from East Java. The first record was made by Kooiman on 17 September 1939, at the edge of a meadow pond on the south coast of East Java (Kooiman 1940), but no information is provided about the specific location and number of birds. A second record was reported by Noni and Londo (2006) from Lumajang. A single bird recorded at Pacinan, near Situbondo on 5 June 2009 by Balen (2011), became the third record for Java.

Observations

During 2008-2010, two encounters were made on Pantai Trisik, Yogyakarta (7º58'41" S, 110º11'06" E), a beach that extends from west to east for about 2.4 km. The first was of three birds on the delta of Kali Progo on 7 July 2008 (Figure 1). The delta contains an island in the middle of the river that formed due to sedimentation of river-borne material. Several species of shorebird observed at that time including Javan Plover *Charadrius javanicus*, Great Knot *Calidris tenuirostris,* Sanderling *Calidris alba,* Rufous-necked Stint *Calidris ruficollis* and Grey-tailed Tattler *Heteroscelus brevipes.* The pratincoles were actively pursuing their prey at the soil surface and when in flight, looked very elegant with the pointed wings. Whistling softly "weeteet" or a shrill whistle 'quirriepeet' became one of the indicators of its presence (Pizzey and Knight 1997).

The next encounter occurred in coastal wetland on 1 October 2010 (Figure 2). This habitat extends from the northern entrance gate of Pantai Trisik to south about 500 m from the beach and the delta of Kali Progo where the bird first recorded in 2008. The area is classified as rainfed rice, meaning it is only stagnant water in the rainy season. At that time, a single bird was observed foraging together with Oriental Plover *Charadrius veredus*. I was unable to

Figure 1. One of three Australian Pratincole observed on the delta of Kali Progo, Pantai Trisik, on 7 July 2008.

Figure 2. Australian Pratincole on the rainfed rice of Pantai Trisik. Photographed on 1 October 2010 by AMT.

determine whether the bird was one of the three birds first encountered in 2008 or not. Although rain is considered to be important for its movement, conditions were not rainy during this encounter and the weather was clear.

These two encounters added to the very few records of the bird in Java (Kooiman 1940, Noni & Londo 2006, Balen 2009). As far as I am aware, these Pantai Trisik records appear to be the fourth and the fifth for Java, and as the first three records were made in East Java, the records from Pantai Trisik were possibly only the first for the central part of Java and are the western-most on the island. We recommend that further shorebird monitoring be undertaken in the area to ascertain the site's true importance and to determine the potential impacts of tourism to the shorebird. Shorebird monitoring at Pantai Trisik and other beaches should prove interesting in terms of gaining an understanding of how the south coast of Java fits into the migration strategy of Australian Pratincole on passage to Australia, and to potentially discover other important sites for this species.

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NORTH-WEST AUSTRALIA WADER AND TERN EXPEDITION REPORT 18TH FEBRUARY TO 11TH MARCH 2012

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INTRODUCTION

Each year it is with some trepidation that we set the dates for the next expedition, decide on the prime objectives, set about putting together a team, and hope that the weather will not adversely affect our fieldwork activities (especially since we moved to a "wet season" timing with expeditions in February / early March). Each year we seem to be able to largely achieve our objectives with a hard-working and diverse team of participants, and with most of the key fieldwork activities fortunately avoiding the worst of the weather.

The NWA 2012 visit was no exception – in fact it was very similar to the previous year's expedition in many ways. The team of 30 turned out to be of the usual high standard and was better than ever in terms of compatibility and of everyone enjoying themselves immensely. We were particularly helped by having a large young contingent (age 40 and under!). The 11 people from Asia were particularly notable for their effervescent personalities and enthusiasm. Whilst we had some rain on most days in February on only one occasion did it coincide with catching activities and therefore limit success.

All the usual key objectives were met including obtaining adequate samples of all the main species to estimate 2011 breeding success (by the proportion of juveniles in catches). We caught sufficient birds at Roebuck Bay to maintain the annual proportion of the population carrying engraved flags and colour bands at similar levels, had several hundred recaptures, which will facilitate survival rate analyses, and deployed more new geolocators.

Detailed below are some of the key results of the expedition.

MAIN ACHIEVEMENTS

Catching

The three weeks of catching followed a similar pattern to NWA 2011, but for somewhat different reasons. This time we again caught very few birds during the initial three field days in Broome, but this year it was mainly because the tides were too low at the beginning of the "spring tide" cycle. The period at 80 Mile Beach again proved to be really successful with a cannon-net catch being made on every day we were based there (two catches even on one day). Back at Broome, at the end of the expedition, large cannon-net catches were again normal.

As in 2011 the small-mesh three-cannon nets were used throughout. Again, these were sometimes set below the high tide mark, this being practical because the birds could be emptied from these nets so quickly (and transported in boxes to the nearby keeping cages). At Broome keeping cages, and associated shade cloth canopies, were nearly always set out on the beach beforehand so that the keeping cages were kept cool and were also immediately available for emptying the boxes of birds extracted from the net. We found it more efficient to go to the trouble of carrying these boxes up to 200 metres, if a closer hidden location for the keeping cages/shade could not be found, than to put up the keeping cages and shade cloth adjacent to the nets immediately after they had been fired. However, this traditional process still had to be used on 80 Mile Beach because, with its very open situation, keeping cages / shade erections were too obvious and deterred birds from landing near the nets.

The usual process of targeting particular species, in order to obtain satisfactory samples of all the main species, was again employed. However, during the last few days at Broome the principal objective was to catch Red Knot, the target species for application of geolocators (and satellite transmitters by Theunis Piersma and his team). Such success was achieved in the latter that the team was given a "day off" catching on the last Friday and instead everybody went scanning for engraved flags and colour-band combinations.

Some of the specific highlights of the catching program are given below:

a) The total number of birds caught (3384), mostly in 13 cannon-net catches, gave the highest average cannon-net catch size for many years (260 birds per catch) (Table 1.) The largest catch was 846 at Boiler Point, Roebuck Bay, on 6 March. Chris Hassell had predicted that we would need to catch about 500 Great Knot in order to catch around 50 Red Knot and he was proved right when we had 42 Red Knot with 485 Great Knot (and a further by-catch of 294 Bar-tailed Godwits).

b) Yet again Great Knot (1369) topped the list of birds caught, with Greater Sand Plover (544) again second (Table 2). The number of Grey-tailed Tattlers (285) and Terek Sandpiper (225) caught were well above the previous year's total whereas Red-necked Stint (90 versus 232) were well down. It is not clear why there was such a dearth of Red-necked Stints this year at both Roebuck Bay and at 80 Mile Beach. It may be that there was still attractive inland locations to which they had adjourned. We also struggled to catch Red Knot (77 versus 210 the previous year). In contrast we did better than usual on Ruddy Turnstone (58 versus 4 the

Table 1. NWA 2012 Expedition catch totals.

Catch date	Location	New	Recapture	Total	
21/02/2012	Broome	48	27	75	
Sub-total		***48***	***27***	***75***	
23/02/2012	80 Mile Beach	209	8	217	including 6 terns
24/02/2012	80 Mile Beach	202	19	221	
25/02/2012	80 Mile Beach	368	15	393	including 22 terns
26/02/2012	80 Mile Beach	85	8	93	including 1 tern
26/02/2012	80 Mile Beach	245	8	253	
27/02/2012	80 Mile Beach	32	1	33	
28/02/2012	80 Mile Beach	250	3	253	
29/02/2012	80 Mile Beach	211	16	227	
1/03/2012	80 Mile Beach	129	6	135	including 7 terns
1/03/2012	80 Mile Beach	1	0	1	Painted Snipe
2/03/2012	80 Mile Beach	16	0	16	
2/03/2012	80 Mile Beach	1	0	1	Bush Stone-curlew
Sub-total		***1749***	***84***	***1833***	
4/03/2012	Broome	4	0	4	Roebuck Plains
6/03/2012	Broome	658	188	846	
7/03/2012	Broome	134	76	210	
8/03/2012	Broome	297	119	416	
Sub-total		***1093***	***383***	***1476***	
TOTAL		**2890**	**494**	**3384**	

previous year) and we again did well for Broad-billed Sandpipers (46 versus 29 the previous year).

c) Time did not allow us to focus on catching efforts on some of the less frequently caught species such as Black-tailed Godwit, Whimbrel, Grey Plover and Eastern Curlew. We did twice try for Greenshank on 80 Mile Beach but they mostly eluded us, partly because they always stand at the edge of the sea. The birds along the inner edge of the flock approach the nets and make it necessary to fire before any birds move into the danger area (the 2 m immediately in front of the net) but whilst the greenshank are still out of range.

The long vegetation on the paddocks at Anna Plains – the result of another good wet season - meant that few Oriental Plover and Little Curlew were present. The absence of hoards of grasshoppers / locusts that were present the previous year, and some other years, also meant that Oriental Pratincole numbers were relatively low and White-winged Black Terns (40,000 the previous year) were almost completely absent.

d) Overall 1833 birds were caught at 80 Mile beach (Table 3), almost equaling the record total of 1925 the previous year. Thunder had been so prevalent in the background during our visit that on one occasion the waders nearby failed to detect the cannon-nets being fired! They remained sitting on the beach adjacent to the nets until the arriving vehicles disturbed them.

e) A bonus at Anna Plains was night-time spotlighting led by Reece Pedler. They managed to catch a Painted Snipe and a Bush Stone Curlew. An added bonus was a large variety of mammals and reptiles seen and handled.

Apart from Gull-billed Terns, which were present in good numbers along 80 Mile Beach, overall tern numbers were relatively low. No sizeable flock of Common or Roseate Terns could be located in the Broome area, even up as far as Coconut Wells. However a large concentration of Whiskered Terns gathered on Roebuck Plains in early March attracted by cumulative rains creating shallow lagoons and a small hatch of "hoppers". An attempt to mist-net the terns as they came to roost was however not successful – we were probably a bit late in setting the nets and the birds instead went to roost at an alternative, distant, location.

f) An oddity was a possible hybrid Great Knot / Red Knot caught at Broome on 6 March. It was in partial breeding plumage and similar in size to a Great Knot but the breast had dark brown streaks (rather than black spots) and a strong chestnut / orange background.

Recaptures and Controls

It is pleasing that recapture rates have increased slightly in recent years (Table 3), suggesting that our efforts are at least maintaining a significant level of the population with bands (and, where appropriate, with engraved leg flags and colour-band combinations). Average recapture rates at Broome (26.5%) during 2012 were, as usual, markedly higher than at 80 Mile Beach (4.6%). This is primarily related to the relative size of the wader populations (80 Mile Beach much higher) and catching effort (Roebuck Bay much higher).

A record number of overseas-banded birds was caught during the expedition (14 Great Knot and 1 Bar-tailed Godwit – all from China) (Table 4). In addition a Curlew Sandpiper banded in Victoria was recaptured. Amazingly three of the Great Knot caught at 80 Mile Beach had been banded on the same day in March 2008 at Chongming Dao, near Shanghai. Two even had adjacent band numbers. Nine of the Great Knot, and the Bar-tailed Godwit, were caught in the same catch on 6 March at Broome. Most birds had been

Table 2. NWA 2012 Expedition - wader and tern catch details.

Species	New	Recapture	Total	Juveniles	% Juv.
Great Knot	1137	232	1369	89	7
Greater Sand Plover	462	82	544	102	19
Bar-tailed Godwit	429	62	491	38	8
Grey-tailed Tattler	265	20	285	57	20
Terek Sandpiper	212	13	225	12	5
Red-necked Stint	61	29	90	22	24
Curlew Sandpiper	66	13	79	1	1
Red Knot	60	17	77	6	8
Ruddy Turnstone	46	12	58	8	14
Broad-billed Sandpiper	35	11	46	13	28
Common Greenshank	26	1	27	4	15
Black-tailed Godwit	22	0	22	1	5
Lesser Sand Plover	8	1	9	0	-
Asian Dowitcher	7	0	7	1	-
Sanderling	3	0	3	0	-
Marsh Sandpiper	3	0	3	0	-
Grey Plover	3	0	3	0	-
Whimbrel	2	0	2	0	-
Masked Lapwing	2	0	2	0	-
Black-winged Stilt	2	0	2	1	-
Red-capped Plover	1	0	1	0	-
Painted Snipe	1	0	1	0	-
Oriental Plover	1	0	1	0	-
Great Knot (hybrid)	1	0	1	0	-
Bush Stone-curlew	1	0	1	0	-
Sub-total	**2856**	**493**	**3349**		
Crested Tern	3	0	3	0	-
Gull-billed Tern	20	1	21	0	-
Lesser Crested Tern	1	0	1	0	-
Little Tern	6	0	6	0	-
Whiskered Tern	4	0	4	0	-
Sub-total	**34**	**1**	**35**		
TOTAL	**2890**	**494**	**3384**		

Table 3. Comparison of catches made during this expedition (in bold) and previous expeditions (2006-2011).

Catch location	Year	New	Recapture	Total
BROOME (1st period)	2006	857	174	1031
	2007	985	223	1208
	2008	807	184	991
	2009	1374	208	1582
	2011	6	3	9
	2012	***48***	***27***	**75**
80 MILE BEACH	2006	1619	55	1674
	2007	1690	95	1785
	2008	1215	62	1277
	2009	604	28	632
	2011	1878	47	1925
	2012	***1749***	***84***	***1833***
BROOME (2nd period)	2006	1120	176	1296
	2007	861	192	1053
	2008	567	88	655
	2009	1172	296	1468
	2011	1072	484	1556
	2012	***1093***	***383***	***1476***
TOTAL	2006	3596	405	4001
	2007	3536	510	4046
	2008	2589	334	2923
	2009	3150	532	3682
	2011	2956	534	3490
	2012	**2890**	**494**	**3384**

marked as adults on northward migration through China but one of the Great Knots had been banded as a juvenile on southward migration (Table 4).

Although China is now using some stainless steel bands on waders there are still many birds in circulation which are carrying the old easily corroded / worn bands. On all of these a more durable Australian band (Incoloy) was added and in some cases the worn Chinese band was removed so that it could be read or to prevent it injuring a bird.

Of the large number of banded birds recaptured during NWA 2012 there were, as usual, a number of old birds (Table 5). It is pleasing that several of these were at 80 Mile Beach, even though the banding intensity and recapture rates there are much lower than in Roebuck Bay. The two oldest birds were Bar-tailed Godwits, which were at least 21 and 24 years old. One recaptured Greater Sand Plover was also at least 18 years old.

Proportion of Juveniles

The results of the percentage juvenile monitoring are given in Table 6. It is immediately apparent that almost all species bred less successfully in the 2011 Northern Hemisphere breeding season than in the preceding year. Only Red-necked Stint showed a significant increase in the proportion of juveniles compared with the previous year. When measured against the long-term average of percentage juveniles the assessment of the 2011 breeding success was average for two species, below average for two species, poor for one species and very poor for three species. We had predicted that 2011 was likely to be a poor breeding year as the two preceding breeding seasons had both been good, or even very good – only one year in three is normally above average.

It is clear that the worst breeding conditions in 2011 must have occurred in the Arctic regions of Siberia with all but one of the species (Red-necked Stint) that breed at high latitudes having poor breeding success. Those species nesting at lower latitudes, such as Grey-tailed Tattler, Greater Sand Plover and Broad-billed Sandpiper, had a relatively better breeding performance.

Geolocators

Forty two geolocators were put onto Red Knot and seven onto Great Knot at Roebuck Bay during the last week of the Expedition. These were obtained from Biotrack in the UK who have now taken over the manufacture of the British Antarctic Survey geolocators which we have used previously. It was intended that all would be put on Red

Table 4. Recaptures (controls) during NWA 2012 of waders banded elsewhere.

Species	Band no.	Banding location	Age at banding	Date of banding	Recapture date	Recapture location	Australian band added
Great Knot	F04-1877	*China CMDT	2+	13/04/2007	21/02/2012	Broome	063-14248
Great Knot	F13-0212	China CMDT	2+	29/03/2010	23/02/2012	80 Mile Beach	none
Great Knot	**F04-7335	China CMDT	2+	25/03/2008	28/02/2012	80 Mile Beach	063-14867
Great Knot	**F04-7336	China CMDT	2+	25/03/2008	24/02/2012	80 Mile Beach	063-14564
Great Knot	**F04-7328	China CMDT	2+	25/03/2008	29/02/2012	80 Mile Beach	063-16002
Great Knot	F07-0624	China CMDT	?	?	6/03/2012	Broome	063-16097
Great Knot	F04-7155	China CMDT	2+	6/04/2008	6/03/2012	Broome	063-16096
Great Knot	F05-8907	China CMDT	2+	3/04/2007	6/03/2012	Broome	063-16299
Great Knot	F12-6174	China CMDT	2+	2/04/2011	6/03/2012	Broome	none
Great Knot	#F05?687	China CMDT	?	*27/03/2006 or 04/04/2007*	6/03/2012	Broome	063-16323
Great Knot	F13-0555	China CMDT	2+	3/04/2010	6/03/2012	Broome	none
Great Knot	F13-0703	China CMDT	2+	7/04/2010	6/03/2012	Broome	063-16200
Great Knot	F12-6166	China CMDT	2+	1/04/2011	6/03/2012	Broome	063-16116
Great Knot	F04-1272	China CMDT	Juv	27/08/2007	6/03/2012	Broome	063-15235
Bar-tailed Godwit	F07-6661	China CMDT	?	?	6/03/2012	Broome	073-64783
Curlew Sandpiper	042-53411	Queenscliff, Victoria	Juv	3/11/2007	6/03/2012	Broome	none

* CMDT=Chongming Dongtan Nature Reserve
*Note two adjacent band numbers recaptured at 80 Mile Beach and total of three birds from same banding date.
#Either F052687 or F055687 (band corroded)

Table 5. Oldest recaptures during NWA 2012

Species	Band number	Date banded	Banding location	Age at banding	Recapture date	Recapture location	Min. age at recapture
Bar-tailed Godwit	072-56578	1/04/1996	80 Mile Beach	2+	1/03/2012	80 Mile Beach	18+
Bar-tailed Godwit	071-86894	18/07/1991	Roebuck Bay	1+	6/03/2012	Roebuck Bay	21+
Bar-tailed Godwit	071-85994	31/03/1990	Roebuck Bay	2+	6/03/2012	Roebuck Bay	24+
Bar-tailed Godwit	*072-61207	28/09/1998	Roebuck Bay	3+	6/03/2012	Roebuck Bay	16+
Bar-tailed Godwit	*072-61203	28/09/1998	Roebuck Bay	3+	6/03/2012	Roebuck Bay	16+
Curlew Sandpiper	042-13900	15/12/2002	Roebuck Bay	2	6/03/2012	Roebuck Bay	11
Great Knot	062-43900	29/08/1998	Roebuck Bay	3+	21/02/2012	Roebuck Bay	16+
Great Knot	062-13731	4/03/1998	Roebuck Bay	2+	21/02/2012	Roebuck Bay	16+
Great Knot	062-15912	6/03/1998	Roebuck Bay	2+	21/02/2012	Roebuck Bay	16+
Great Knot	062-15258	19/04/1996	80 Mile Beach	1	26/02/2012	80 Mile Beach	17
Great Knot	062-15441	25/04/1996	Roebuck Bay	1+	6/03/2012	Roebuck Bay	17+
Greater Sand Plover	051-92345	4/04/1996	80 Mile Beach	2+	24/02/2012	80 Mile Beach	18+
Greater Sand Plover	051-96618	11/09/1998	80 Mile Beach	2+	24/02/2012	80 Mile Beach	16+
Gull-billed Tern	072-78831	8/01/2001	80 Mile Beach	2	25/02/2012	80 Mile Beach	13
Ruddy Turnstone	052-01740	2/01/2001	Roebuck Bay	?	8/03/2012	Roebuck Bay	13+

*Note that two Bar-tailed Godwits banded and recaptured together 14 years later.

Knot but we were unable to catch quite enough birds and so the remainder were deployed on Great Knot. Twenty seven of the Red Knot and five of the Great Knot have been re-sighted so far (up to 28 April). One of the Great Knot has already been seen at Yalu Jiang at the north end of the Yellow Sea, in mid-April.

During the expedition a geolocator, which was deployed in March 2011, was retrieved from a Greater Sand Plover. This now brings to seven the number of geolocators retrieved from Greater Sand Plover this season. Most units retrieved this year have given good tracks to and from breeding grounds in the Gobi Desert, spanning the China / Mongolia border.

A team of eight to 10 people will visit Broome from **26 October to 5 November 2012** to work with the local Broome team in trying to retrieve geolocators from Red Knot, Great Knot and Greater Sand Plover. There are quite a number of Greater Sand Plover still carrying geolocators from 2010 and 2011. **If you would like to participate in this activity please let Clive Minton know immediately.**

Satellite Tracking

For the second consecutive year satellite transmitters were attached to Red Knot by the Global Flyway Network team, this year under the guidance of Dr Theunis Piersma from NIOZ (Netherlands Institute for Sea Research) / University of Groningen. This year 15 units, each weighing five grams, were deployed.

Unfortunately, as in 2011 when 30 units were put on, the glue attachment to the back / rump has not held up to the rigours of a flying bird in Broome conditions. In both years all units were shed by birds, mostly before they had even set off on northward migration. This is disappointing as extensive tests of the attachment method on Red Knot on

Table 6. Percentage juveniles in NWA 2012 cannon-net catches.

Species	Total Catch	% juvenile		Average % juvenile	Assessment of 2011 breeding success
		NWA 2012	NWA 2011	1998/99 to 2010/11	
Great Knot	1369	7	24	13.1	Poor
Bar-tailed Godwit	491	8	21	10.8	Below average
Red Knot	77	8	16	19.8	Very poor
Curlew Sandpiper	79	1	24	19.4	Very poor
Red-necked Stint	90	24	19	21.1	Average
Grey-tailed Tattler	285	20	32	21.4	Average
Terek Sandpiper	225	5	25	14.3	Very poor
Greater Sand Plover	544	19	17	23.6	Below average
Ruddy Turnstone	58	14	-	-	-
Broad-billed Sandpiper	46	28	59	-	-

their wintering grounds in Holland earlier in 2012 had shown good retention rates.

Flag sightings

As usual, many sightings of overseas-flagged birds were made during the expedition as well as many resightings of birds carrying engraved leg flags or colour-band combinations put on locally. Sightings were most frequently made at 80 Mile Beach where the *modus operandi* allowed plenty of time for telescope viewing of roosting waders from the firing hide and of good observation of large roosting wader flocks from the "twinkling" vehicles.

It is planned to give greater attention on future expeditions to the searching for individually-marked birds, especially at 80 Mile Beach where the frequency of flag searches by Chris Hassell and the local Broome team is much less than at Roebuck Bay. Evidence in recent years has indicated that movements of some species (especially Red Knot) between Roebuck Bay and 80 Mile Beach are rather more frequent than previously thought and this requires better quantification.

Passerine banding

The ready availability of water meant that birds were less attracted to the Anna Plains Bore Pool and the BBO birth baths than during the dry season. The unsettled weather also reduced mist-netting opportunities. Nevertheless two enjoyable sessions were held at Anna Plains (Table 7).

OTHER MATTERS

Participants

The 2012 team contained 30 participants, 14 from Australia and 16 from overseas, as detailed below. Yet again, it was extremely pleasing to see how extraordinarily well this mixed nationality group blended together and learned from each other and from the overall expedition experience.

14 Australia (4 VIC, 5 WA, 4 SA, 1 NT)
1 Germany
1 New Zealand
3 China (Hong Kong)
2 China (mainland)
4 Taiwan
2 Japan
3 United Kingdom

Itinerary

We spent nine days catching at 80 Mile Beach and six days at Broome. No catching was possible on the low tide of the 4th March as terns and Sanderling were not roosting at their usual spot at Coconut Well and the tide was too low to catch at Roebuck Bay. The last day of the expedition was used to train participants in searching for and recording engraved leg flags and colour bands.

Finances

The Expedition has not yet received all its projected income

Table 7. Results of mist-netting at Anna Plains Passerine Bore, 27th and 29 February, 2012.

Species	New	Recapture	Total	Juv.
Singing Honeyeater	9	2	11	8
Brown Honeyeater	6	0	6	0
Rufous Whistler	4	0	4	0
Collared Sparrow-hawk	1	0	1	0
Diamond Dove	1	0	1	0
Peaceful Dove	1	1	1	0
Bar-shouldered Dove	1	0	1	0
Horsfield's Bronze Cuckoo	1	0	1	0
TOTAL	**24**	**3**	**26**	

or made all the expected expenditures but at present it appears likely that the overall result will again be close to “break even”. The final result for the NWA 2011 Expedition was a small surplus ($2900). This was carried forward as a contingency for future expeditions. A final financial outcome statement will be prepared later in the year when all income and expenditure matters have been finalized for NWA 2012.

Talks

A wide range of evening presentations was given by members of the Expedition. These included: "Moult/age in waders" by Chris Hassell, "Conservation in the arid zone" by Reece Pedler, "The Okinawa Rail" by Tohru Manu, "Chongming Dao" by Wu Wei, "Taiwan birds and conservation" (2 talks) by Chuck, "Mai Po marshes" by Katherine Leung, "Eyes" by Mike Dawkins, "Bohai Bay and Red Knot studies" by Theunis Piersma, "A life of bird banding" Clive Minton, and "Anna Plains Station" by Helen Stoate.

NEXT EXPEDITION

It has been decided to continue holding the annual NWA Expedition in the February / March period in 2013. The next Expedition will take place between **Saturday 23 February and Saturday 16 March 2013**. We are interested in building a team as soon as possible and therefore please put your hand up if you are interested by contacting one of the Expedition Leaders. Previous participants are strongly encouraged to return. Whilst new participants are always extremely welcome the most efficient teams occur when there is a strong body of experienced personnel in them. It is also hoped that the tradition of having a strong younger contingent in recent years will be continued in 2013.

ACKNOWLEDGEMENTS

As always an Expedition depends on the help and assistance and generosity of a wide range of people. Key amongst these are Broome Bird Observatory and its wardens/assistant wardens and the owners of Anna Plains Station (John, David and Helen Stoate) who provided the essential bases and accommodation for the Expedition over its three week duration. At Anna Plains we again used a range of accommodation in and around John Stoate’s own house. This proved extremely suitable, facilitating even greater team harmony – and much more frequent than usual dips in the adjacent swimming pool! We thank them also for the freedom to roam at will over the 450,000 ha station which abuts a 100km length of 80 Mile Beach.

Thanks are also due to Nyamba Buru Yawuru Ltd for permission to catch on the shores of Roebuck Bay. The area between Wirkinmirre (Willie Creek) and Warrawan (Barn Hill) are the traditional lands of the Yawuru people. We respectfully acknowledge the past and present traditional owners of the land on which we conduct research, the Yawuru people. Thanks also to the Yawuru ranger staff who assisted us with some cannon net catches at Broome. Their help carrying equipment to the beach, “twinkling” and processing birds was greatly appreciated.

As usual the financial viability of the Expedition was greatly assisted by many people providing their personal vehicles for use during the Expedition (Maureen Christie, Prue Wright, Chris Hassell, Maurice O’Connor, Sharon Woodend, Jutta Leyrer) and also Broome Bird Observatory, which made one of its vehicles available. The W.A. Department of Environment and Conservation also very generously loaned a vehicle and trailer and provided $6000 to cover the Australian costs of the participants from mainland China and to help with other Expedition costs. Chris Hassell, George Swann, AQIS and BBO kindly loaned trailers too.

Finally huge thanks are due to the whole team for its incredibly hard work throughout the full three-week period. Everyone contributed enormously but we have to single out for particular mention Chris Hassell for leading all the fieldwork activities, Maureen Christie and Helen Macarthur for organizing and supervising the menus, food purchases and catering and the assistance of everyone and everything during the banding and processing operations.

Research was carried out under permits issued by the WA Department of Environment and Conservation. Banding permits and bands were issued by the Australian Bird and Bat Banding Schemes, Australian Federal Government, Canberra, ACT.

LIST OF PARTICIPANTS

Australia

VIC:	Clive Minton, Roz Jessop, Mike Dawkins, Prue Wright
WA:	Chris Hassell, Kim Onton, Frank O’Connor, Maurice O’Connor, Jill Rowbottom
SA:	Maureen Christie, Greg Kerr, Nicole Kerr, Reece Pedler
NT:	Sharon Woodend (Woody)
New Zealand:	Sioux Plowman
China (Hong Kong):	Katherine Leung, John Allcock, Roger Lee
China (mainland):	Wu Wei, Qianyan Zhou
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