Stilt

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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 *The Tattler*. Please direct all membership enquiries to the Membership Manager at Birds Australia (RAOU) National Office, Suite 2-05, 60 Leicester St, Carlton Vic 3053, AUSTRALIA.
Ph: 1300 730 075, fax: (03) 9347 9323.
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www.tasweb.com.au/awsg/index.htm

Cover Illustration: Annie Rogers.

EDITORIAL

This fiftieth issue of *Stilt* celebrates the twenty-fifth year of the Australasian Wader Studies Group. The aim of this issue is to showcase the status of waders throughout the flyway, the problems they face, the ways in which they are addressed, and what has been learned from the studies. While not being comprehensive, the eclectic collection of papers in this *Stilt* goes a long way to meeting this aim. It starts with an inspirational piece from Theunis Piersma on the exciting challenges of wader research, challenges to which all wader lovers, of whatever inclination, can relate. It ends with a bibliography, prepared by Hugo Phillipps, of *Stilt* contents and selected papers from bulletins issued before *Stilt* started by the two state wader groups: the Victorian Wader Study Group's *VWSG Bulletin*, and the Tasmanian Wader Study Group's *An Occasional Stint*.

In between these bookends, there is much to enjoy. The flyway to the north of Australia is covered with contributions from Russia, China, South Korea, Sumatra, Thailand, and New Guinea. It is of course the migrant waders which link the countries in the flyway, and a section of general interest to all in the wader community starts with an account by Clive Minton and his co-authors of what has been learned of migration routes from banding and flagging in Australia. Four papers on different aspects of population monitoring follow; this is surely the outstanding priority with so much change in the world affecting wader populations. Keith Woodley writes on a site partnership between China and New Zealand, a model perhaps for other similar arrangements and, after all this emphasis on migrant waders, there is a timely reminder from Mike Weston that resident waders should not be forgotten. Finally, there is a group of papers on different aspects of wader studies in Australia and New Zealand at the southern end of the flyway.

It is worth taking a moment to reflect on the size of the task facing Australian wader buffs. Australia is an island continent with an enormous coastline and a small population. Nearly all the monitoring of Australian wader populations, by banding and population monitoring, is done by amateurs working on projects organised by amateurs. This extends from the fieldwork to the analysis and reporting of results. It is true that some wader research is undertaken in universities but there is no single organisation like the BTO in the UK which has the resources to support a full time professional staff. The AWSG is national but wholly voluntary and has to compete for funds needed for specific studies. This patchwork situation that exists throughout Australia is well illustrated in Maureen Christie's snapshot, with contributions from over a dozen colleagues, of wader studies in South Australia.

I have to express my gratitude to the many people who contributed to this special edition of *Stilt*. It has been a pleasure to work with them. I would also like to thank the several authors who were unable in the event to deliver the pieces they wanted to write. It's a busy, busy world and we cannot always be master of our time. I hope to see the missing contributions in later issues of *Stilt*. Particular thanks are due to Hugo Phillipps who helped out in the editing process in a substantial way when I was overloaded and also to David Milton who offered similarly to help. Andrew Dunn, the Production Editor, has been remarkably patient with my rather chaotic presentation of material. He has been doing this job for years now and it is due to him that *Stilt* looks so good. Annie Rogers, David Andrew and Jason Ferris are thanked for substantial help with proof-reading and Danny Rogers for his ability to answer instantly any question on any aspect of waders.

This will be the last issue of *Stilt* which I shall edit. I still enjoy doing it but too many things that I want and need to do have piled up on the back burner in the four years I have been editor. Roz Jessop takes over as editor with the next *Stilt*; I hope she gets as much pleasure out of it as I have. My final word is to thank all the contributors to *Stilt* with whom I have worked over the years. *Stilt* would be nothing without you.

Ken Rogers

A NOTE FROM THE CHAIRMAN

I took over as Chairman of the Australasian Wader Studies Group (AWSG) when the new committee took office in July 2006. I would like to acknowledge the work of Roz Jessop in this role over the previous five years and would also like to thank two retiring members of the committee, Sandra Harding, a vigilant Conservation Officer, and Mike Bamford. It was pleasing to welcome several new faces in Brian Speechley (Treasurer), Penny Johns (Secretary), and Ann Lindsey (Conservation Officer). Adrian Riegen from New Zealand also joins the committee.

The AWSG, like wader groups worldwide, faces enormous challenges. A common theme expressed by shorebird experts is that the majority of shorebird populations are in decline globally; these declines are more common in Arctic breeding species. Over the last three years, international groups have increasingly expressed the need for countries to urgently review the conservation of both migrant and resident shorebirds and the ecosystems that support them. These are also affected by changes in global weather systems. The Asia – Pacific region is of special concern as it has the largest number of shorebird populations under threat or least understood, and the highest population density of any flyway. For migratory species to survive they must have secure breeding, staging and non-breeding areas with sufficient food resources and minimal disturbance. One of the urgent actions identified by the Global Flyways Conference in Edinburgh was '… *to underpin future conservation decisions with high quality scientific advice drawn from co-ordinated, and adequately funded, research and monitoring programs* …'. The AWSG has demonstrated that it can play a major part in facilitating these actions both in Australasia and the East Asian–Australasian Flyway.

This fiftieth edition of our journal *Stilt* is a wonderful recognition of the role and achievements of the AWSG over the 25 years it has been in existence. For a small group in a country with such an extensive coastline and a small concentrated population, we, together with our colleagues from throughout the flyway, have made a major contribution to the knowledge of waders, their movements and utilisation of the flyway from the non-breeding grounds of Australia and New Zealand to the breeding grounds of Russia and Alaska. Many of the papers in this volume review some of our achievements and highlight many of the challenges that lie ahead. *Stilt* has been important in disseminating information on shorebirds and their habitats to a wide audience and is recognised for its quality and the diverse range of topics covered.

It has been recognised for some years that the Yellow Sea is a critical region for the eight million migratory shorebirds in the East Asian–Australasian Flyway; it is the last major stopover and refuelling site between non-breeding areas and the northern breeding grounds. The number and quality of staging sites in the Yellow Sea are vital for birds' survival and breeding success. Sadly these important tidal flats are threatened by a number of human activities that reduce food supply, the most critical of which are extensive reclamations such as the Saemangeum project on the west coast of South Korea. Over the last 10 years people such as Mark Barter and other members of AWSG have gathered an enormous amount of knowledge of this region in terms of habitat, shorebird use and populations as well as documenting threats. One of the challenges facing the AWSG is to extend this knowledge in cooperation with governments and local groups. At the same time there is a need to help train local communities and people with an interest in shorebirds. There are recent examples of the Group participating in programs in China and South Korea, some of which are described in this volume. It is only through gathering robust scientific knowledge of these important areas that we can suggest effective conservation strategies. In addition the AWSG has recently signed the new Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian–Australasian Flyway; this partnership will provide additional opportunities to contribute resources and expertise to other countries and organisations within the Flyway.

One of the challenges in Australia is to provide reliable, scientifically defensible data on shorebird populations around the country. The issues described above led the AWSG to initiate a project to monitor Yellow Sea migrants in Australia (referred to as the MYSMA program). This project, funded by the Australian Government's Natural Heritage Trust via the Department of the Environment and Water Resources, is aimed firstly at the early detection of trends for key species which utilise the Yellow Sea region as a major staging area. Monitoring programs have been established over the last two years in north-west Australia and northern Queensland for this purpose. In the long run we hope that this project will serve to revitalise the Population Monitoring Project (PMP) of the AWSG to provide reliable indices of population change for individual species. In order to understand some of the influences causing population changes, there is a need to continue and expand the knowledge of breeding success which is currently assessed in Australia mostly by captures for banding by the regular expeditions to north-west Australia and state wader groups. The PMP is a very valuable data set, being the only comprehensive data on shorebirds available to planners and government agencies. While it is essential that this program continue, the AWSG, in conjunction with Birds Australia, has developed a strategy to address future directions. The revitalised program will require funding support from government and other organisations; the implementation of this program is the challenge for 2007.

Over the last 25 years an enormous amount of information on waders has been obtained by AWSG and other state wader groups, including data on important sites, movements, biometrics, population characteristics and demographics. While a lot of this information has been analysed and published in quality journals such as *Stilt*, there still remain significant gaps. I would encourage any member to consider taking on a project, no matter how small, with the objective of using data already collected and undertaking analysis and publication. Data collection is of no benefit on its own: it demands analysis and publication if we are to achieve the best outcome for the birds and their habitat that we are committed to conserve.

What of the next 25 years? I hope that the AWSG will have guided the accumulation of information to enable research on shorebirds throughout the Flyway; research that will help ensure that the birds that make their incredible journeys will be on our beaches and wetlands for future generations to enjoy.

I invite members to express their views and aspirations in regard to the future directions of the AWSG. I am sure the papers in this special issue of *Stilt* will inspire you in this regard. I would like to acknowledge the huge effort and personal commitment by Ken Rogers as the Editor of *Stilt* 50. His tenacity and high standards have produced a landmark volume which, I am sure, will be appreciated by shorebird workers throughout the world. Thanks also to Annie Rogers for the wonderful drawing on the cover of this special edition of *Stilt*. I also acknowledge the Australian Government's Natural Heritage Trust via the Department of the Environment and Water Resources for its contribution towards some of the additional costs of producing and posting this special edition to make it more widely available within the Flyway.

Ken Gosbell

UNDERSTANDING THE NUMBERS AND DISTRIBUTION OF WADERS AND OTHER ANIMALS IN A CHANGING WORLD: *HABITAT CHOICE* AS THE LOCK AND THE KEY*

THEUNIS PIERSMA

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On 19 October 2004 Koos van Zomeren finished his series of public lectures[1] as writer in residence at the University of Groningen with the following sentence: *"- in the animal all characteristics of the landscape come together, in the landscape all characteristics of the animal are spread out*." Here I like to start with this beautiful line, or rather, with the first part of the sentence: "*in the animal all characteristics of the landscape come together*."

With these words Van Zomeren gives a powerful summary of that which makes most animal ecologists tick. He also suggests why animal ecology, in addition to the beauty and elegance of the science itself, could be relevant in a societal context.

Animal ecologists try to understand the habitat choice of animals, they investigate the place and role of animals within a landscape, within sets of interconnected landscapes, within certain habitats in certain climate zones, in the world. Animal ecologists try to discover the mechanisms underlying the distribution and abundance of animals.[2] The *urgency* of our science comes from the increasingly human driven changes in this world and the increasing speed of these changes: the rapidity with which landscapes are altered.

Let me begin by identifying some of mechanisms that help us explain habitat choice and the distribution and abundance of animals in changing worlds. What does an animal ecologist think of when confronted with a distributional problem or a change in numbers? What are the keys to explain an animal's distribution, and why is it locked in this state? What would she or he try to measure?

An animal that doesn't eat will starve and die: food is a first condition for survival. With information on the distribution of food, lots can be said about the behaviour of animals that eat that food, and sometimes about their numbers. Thus, we must know what an animal eats, and how prey are distributed over the range of that animal. Building on a 50 year long tradition of Dutch mudflat studies,[3] we have since 1988 investigated the distribution and abundance of Red Knots *Calidris canutus* in the Wadden Sea. We chose knots as a model migrant shorebird in view of their uniform diet of molluscs, a diet that can quite easily be quantified by visual observation and faecal analyses.[4] We also chose Knots because of their strict habitat choice. Non-breeding knots only occur on extensive intertidal flats.[5] With the ships and moveable observation platforms of the Royal Netherlands Institute for Sea Research on Texel such intertidal flats are accessible to us. We have managed to determine the distribution of molluscs over hundreds of square kilometres of intertidal flats for many years.[6]

We have also managed to follow individual Red Knots throughout day and night by applying one and a half gram radio transmitters to their backs and registering their absence or presence within a certain radius with automated radio tracking stations (ARTS). In this way we came to grips with the tidal and daily movements of individual Red Knots. The birds that roosted at Richel during high tide periods, in the course of several days, appeared to use the whole complex of intertidal flats between the island of Vlieland and the Friesian foreshore.[7]

By mapping benthic food availability over much of this area of intertidal flats, we also built a detailed picture of the distribution of their food. In this map (Figure 1), the size of the black dots scales with the predicted average food intake rate at each of these sampling stations: the blacker the area, the more food there is for Red Knots to find.

Most Red Knots use that great sandbank, Richel, to roost. With the outgoing tide they have to decide whether to fly to forage on the intertidal flats of Westwad, or Richelwad, or Grienderwaard or Ballastplaat. *They* have to ask themselves whether it is worth travelling all the way to the Ballastplaat, twenty kilometres from Richel, or whether the poorer intertidal flats closer to Richel are good enough. *We* have to ask ourselves whether Red Knots have all the relevant information to take such strategic decisions.

Figure 2 shows the way that Red Knots with radio tags that roost at Richel distribute themselves at low tide.[8] Many birds remained close to the high tide roost, many birds moved to the Grienderwaard, but the rich mudflats of the Ballastplaat appeared not particularly popular. Apparently many Red Knots decided against the long commute to Ballastplaat: perhaps flight costs prevent this being worth their while.

To evaluate the decisions made by Red Knots we can compare the empirical distribution pattern with predicted distribution patterns, predictions made on the basis of models that either do or do not incorporate their omniscience and travel costs.[8] Red Knots that do not know the distribution of their food, and do not care about the travel costs of reaching the various places, should distribute

* *Editor's note. This essay is based on the text of the author's Inaugural Lecture as Professor in Animal Ecology presented at the University of Groningen on 21 February 2005. The full text of the address is available from the author.*

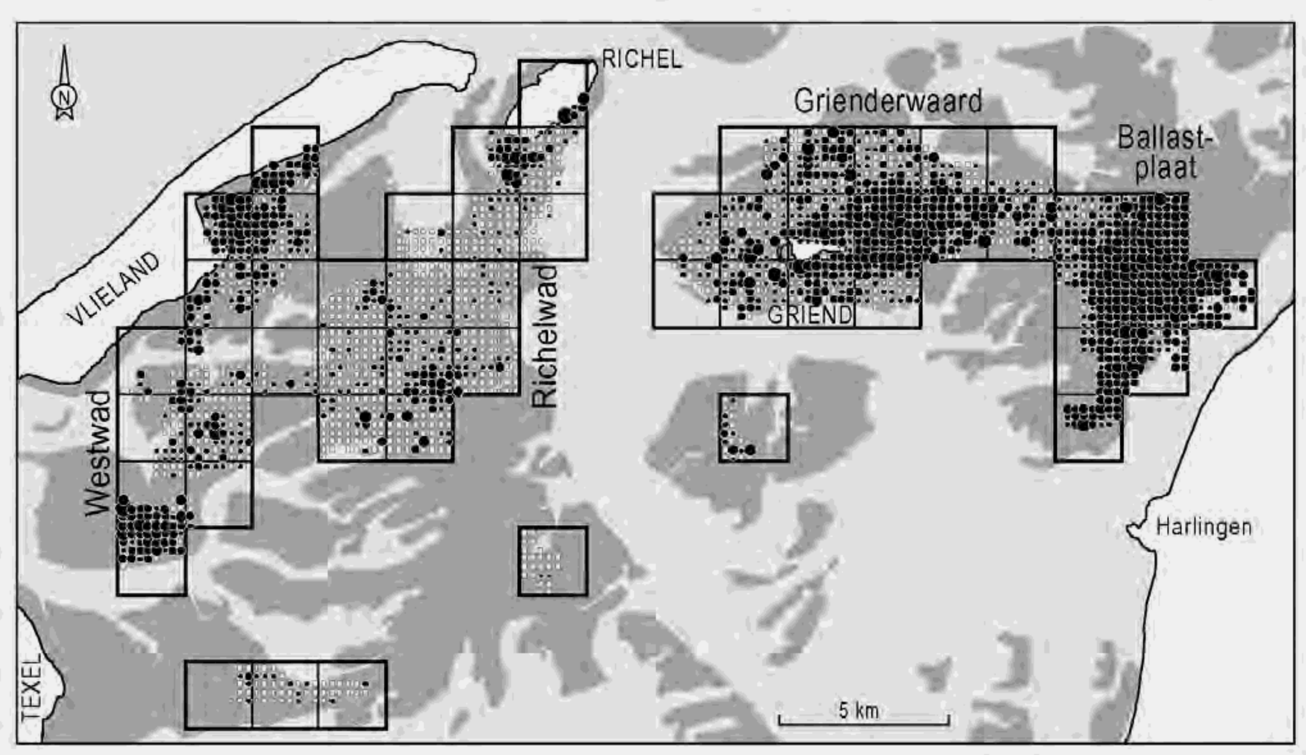

Figure 1. Map of the mudflats in the western Dutch Wadden Sea, with an outline of the annual benthic sampling grid with 250 meter intersections. White dots indicate sites where Red Knots would not have found anything to eat in August-September 1996-2000. The size of the black dots is scaled to the predicted intake rate averaged across the five years of study (August-September 1996-2000). This map is based on van Gils *et al*. (2006).[8]

themselves across the different areas relative to the extents of these areas (Figure 1). Under these assumptions many Red Knots should go to the large flats of Westwad, for example. Red Knots that lack the information on food distribution but do take travel costs into account should remain close to Richel even at low tide. Red Knots that know as much about the distribution of their food as we do, but that don't account for travel costs, should travel to Ballastplaat in much larger numbers than we saw. Finally, omniscient Red Knots that take travel costs into account should distribute themselves approximately according to the real, wild knots. In the words of the scientist their behaviour is consistent with the assumption that they know the distribution of their food really well and that they incorporate flight costs into their strategic decisions. In the words of the writer (van Zomeren), in [*the behaviour of*] the animal all [*relevant*] characteristics of the landscape come together.

Red Knots, and animals in general, have to balance their energy income and energy expenditure, that is, animals have to do ENERGY MANAGEMENT. In areas where daytime air temperatures exceed body temperatures, about forty-one degrees Celsius in the case of birds, animals can only prevent overheating by finding cool shaded locations or by using body water for evaporative cooling.[9] Especially under such conditions the maintenance of energy balance is closely coupled with the maintenance of a water balance (WATER MANAGEMENT).[10]

Over the last thirty years, the animal ecologists from the University of Groningen, under the keen leadership of Rudi Drent, have built up a certain reputation with their detailed mechanistic analyses of the distribution and numbers of especially waterbirds.[11] The distribution models are built on thorough measurements of food availability and detailed empirical knowledge on energy expenditure and water balance. Yet, the maintenance of an energy and a water balance are only two of the considerations that animals should routinely take into account. Birds that fall victim to predators such as a Peregrine Falcon *Falco peregrinus*, for example, won't have as many descendants as birds who avoid the attentions of this dangerous beast. The inescapability of evolutionary mechanisms then ensures that animals do also take danger into account. That is, animals have to find the right balance between fear and external danger; they have to do DANGER MANAGEMENT'.[12]

This leads me to the second part of Van Zomeren's deep statement: that *in the landscape all characteristics of the animal are spread out*. This line troubled me, as most landscapes harbour many different animals. How on earth can their characteristics be spread out in that landscape? Nevertheless, the logic began to make some sense when I started thinking about my own considerations about birds that breed in the extreme High Arctic in summer and all move to marine and saline habitats in winter. If there are reasons to think that in harsh and extreme polar climates parasites and pathogens are rare, there are also reasons to think that the chicks of tundra-breeding birds may not get a chance to build up proper immune systems. They would then have to restrict themselves to relatively 'clean' (i.e. parasite and pathogen poor) habitats during the rest of their lives.

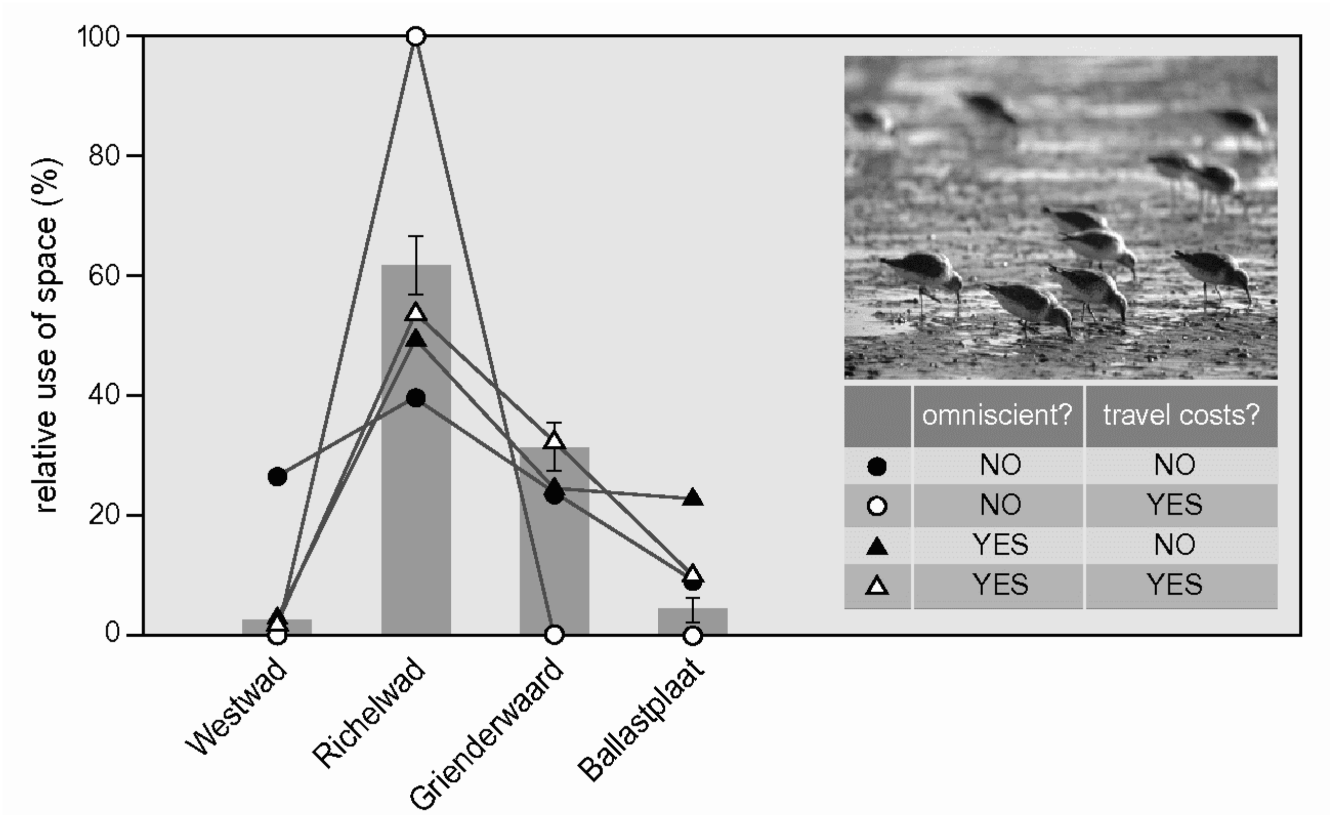

Figure 2. Relative distribution over the four intertidal feeding areas (see Fig. 1) of 121 Red Knots in the late summers of 1996-2000. These Red Knots were marked with small transmitters that were followed day and night with autmatic receiving station and manual radiotelemetry. For the present analysis, tidal cycles were selected during which birds spend the high water period at Richel. Based on van Gils *et al*. (2006).[8]

Marine, seaside and otherwise saline habitats may provide such clean areas.[13]

At the University of Groningen we have meanwhile started to examine disease prevalence and immune competence in tundra breeders and other bird species in earnest. One way of doing this is by the measurement of the capacity of small volumes of blood to kill certain bacteria and fungi *in vitro*.[14] This area of investigation recently received considerable support by the special fellowship from this university for Irene Tieleman. She will lead the development of a comprehensive research program on immune competence and disease in a variety of avian systems. We have high hopes that comparisons between species in different climate zones, and between seasons in the same birds, can yield greater insight into the roles of disease resistance and prevalence in decisions about habitat choice and in the regulation of numbers of animals.[15]

At this point it seems a good idea to say something about the *urgency* of our science. Right now the world is deeply concerned about avian influenza. All of a sudden our information on the distribution, the migration routes and the workings of the immune systems of waterbirds have become important.[16] Worldwide, animal ecologists try to help out with their data as much as possible. The large numbers of blood samples and cloacal swabs that have been accumulated from many different species and sites over the last few years now begin to have more than academic relevance. The results of our own involvement demonstrate that avian flu viruses are very rare in migrant shorebirds. The screening of many Great Knots *Calidris tenuirostris*, for example, a species that connects northern Asia via the Chinese coastal wetlands with Australia, has typically failed to find any viral infections.

The urgency of our work also stems from the concerns about the proper management of the world's last natural areas, about national and international policies with respect to complete protection of such areas or the admission of activities for short-term economic gains.[17] Our research on food, feeding and distribution of Red Knots in the western Dutch Wadden Sea has demonstrated that since 1988 the local stocks of the Baltic Tellin *Macoma balthica* has decreased by ninety-nine percent.[18] That is a drastic ecological change, as Baltic Tellins were one of they key species connecting the planktonic and epibenthic algal production with the wealth of migrant waterbirds for which the government of The Netherlands has claimed responsibility at international forums.

Baltic Tellins are not the only animals that have shown drastic population changes over the last thirty years. The sustained investigations by a whole army of un-, under-, or well-paid but always dedicated and knowledgeable ornithologists have led to incredible information on the changes in the avifauna of The Netherlands.[19] Since 1975 a few species have done very well. The Egyptian Goose

Alopochen aegyptiacus that took our country by storm provides a good example. It is unfortunate that a much greater number of species have disappeared from considerable parts of The Netherlands since 1975. The analyses made by SOVON have shown that species like Garganey *Anas querquedula*, Crested Lark *Galerida cristata* and Nightingale *Luscinia megarhynchos* have disappeared as breeding birds from much of the country. Even though the details of their disappearance have usually not been investigated, lack of food, an overabundance of predators, loss of breeding sites and the loss of connections with wintering areas are among the usual suspects of these declines. In most cases the hand of humankind is clear, although those in power usually prefer to attribute such losses and gains to things like climate change, i.e. causes that are outside governmental control!

A nice example of such a discussion is the variable interpretation of the causes of the extinctions of spectacular megafaunas that over the past 50,000 years have occurred in most parts of the world.[20] In the case of Eurasia, we lost animals such as the giant elk and the mammoth, as well as cave bears and cave lions. In the case of Australia, we lost a large array of large marsupials. Increasingly, the assembled evidence indicates that the rather comfortable explanation that these waves of extinction are due to climate change is no longer tenable. Temporal correlations between extinctions and bad ecological conditions are usually missing, whereas the correlations between extinctions and the arrival of modern man always occur.[20]

This is not to say that I believe that climate change plays no role as a causal agent of the distributional changes of animals. Rather to the contrary, it seems that considerable upheaval is underway.[21] Reflecting a rather continuous trend of loss of Artic ice, between 1979 and 2003 about one seventh of the ice cover of the North Pole region has disappeared, a loss of one million square kilometres of polar ice.[22] Climatologists have now also attempted to also make a *prediction* of the size of this icecap. The ice still covers much of the Arctic Ocean even in late summer, but by 2050, only 45 years from now, that surface may have been halved (Figure 3). This loss of ice cover will be something that today's young biologists will experience during their working lives. The loss of permanent ice cover will undoubtedly greatly influence the habitats in the Arctic and the animals that depend on those habitats.

Societal anxiety decides in a big way which areas of

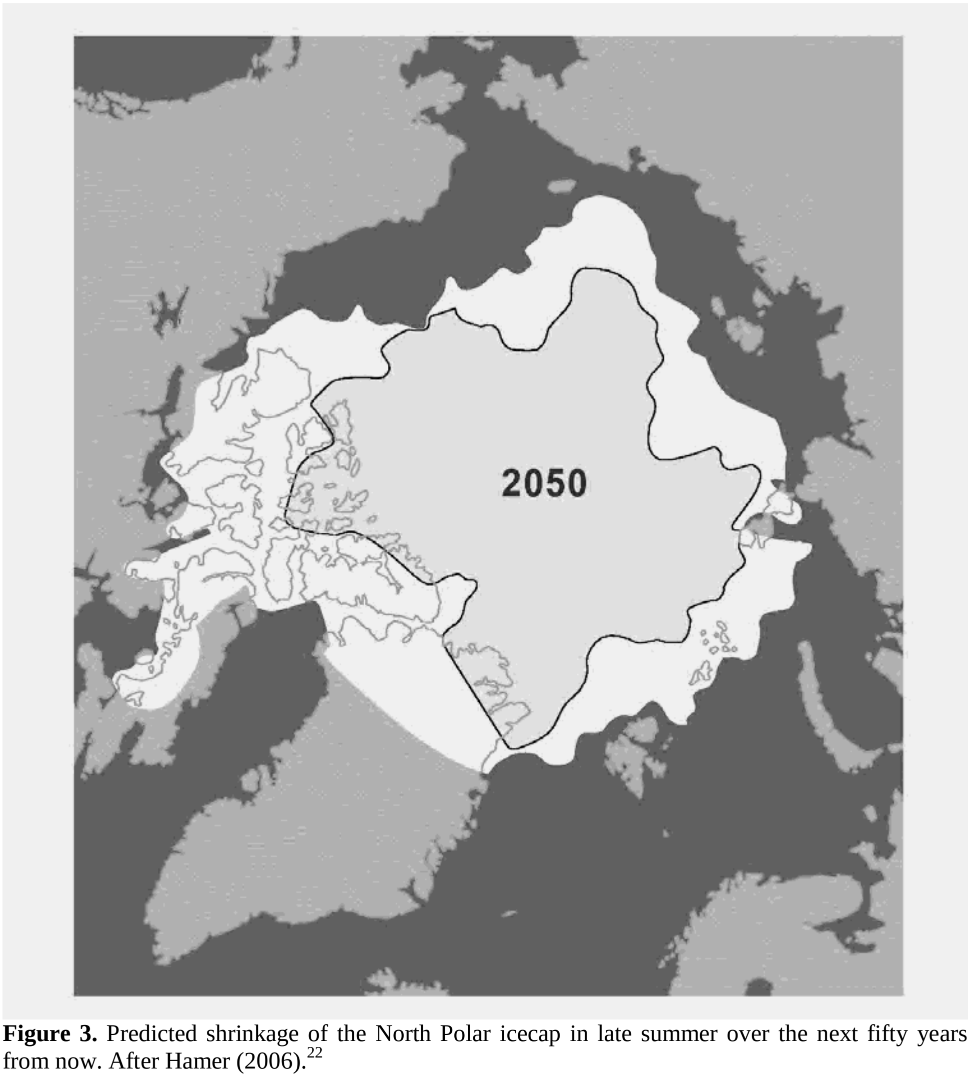

Figure 3. Predicted shrinkage of the North Polar icecap in late summer over the next fifty years from now. After Hamer (2006).[22]

science will get additional financial support (the science of fear). It is thus very likely that climate change will increasingly determine the research agenda. Already, with a rise in global temperatures, an increasing number of studies report ecological change as a function of climatic change.[21] A nice example of such work is the Europe-wide analysis of the timing of breeding in Pied Flycatchers *Ficedula hypoleuca*. (At this point it is interesting to note that although the flycatcher work is 'hot' in the current climate of interest, it is built on many decades of purely scientifically motivated studies on flycatcher populations throughout Europe.) Based on a strong collaborative initiative together with the Netherlands Institute for Ecology (NIOO-KNAW) we are able to look back in time to see whether this species has adjusted to local climate change.[23] Bringing together long-term datasets from much of Europe, Christiaan Both and co-workers were able to demonstrate that Pied Flycatchers had started laying earlier only in localities where spring temperatures had increased. At places where spring temperatures had decreased, Pied Flycatchers had started breeding later in the season. In this quasi-experimental way it was demonstratede that changes in the timing of breeding are actually *caused by* climate change.

In the analyses of the timing of reproduction of Pied Flycatchers we look back in time. Often, however, we are asked to also make 'predictions'. In the case of the spring distribution and migration of Barnacle Geese *Branta leucopsis*, knowledge of causal mechanisms related to seasonal changes in food quality has become so advanced that geese researchers have now ventured to make such predictions.[24] In this particular example the predictions relate to changes in the seasonal phenology of food quality at different stopover sites along the flyway with a five degree increase in temperatures.

Urgency may be an important driving force behind patterns of funding, enjoyment and intellectual perspectives are crucial ingredients to get the best possible science! What gives our current animal ecologists their pleasure and perspective? Why is it a good (or at least an interesting) era to be an animal ecologist? In the first place I would like to mention the blossoming of ecological and evolutionary theory.[25] This is the process in which the consistency of verbal ideas are tested, and by which new and challenging questions are laid on the plate of the empirically minded.

The process can be illustrated by our recent work on distribution models of shorebirds. When animals are forced to forage in close proximity, they will be in each other's way and their intake rate will then go down. Figure 4 shows that at the best foraging patch, 'A' in this example, single animals achieve a high intake rate; as soon as more animals crowd together in A, their intake rate will decrease. When there are five animals in A, the sixth is better off in B. The twelfth animal better goes to the worst patch C. With increasing numbers the intake rate will go down for each of

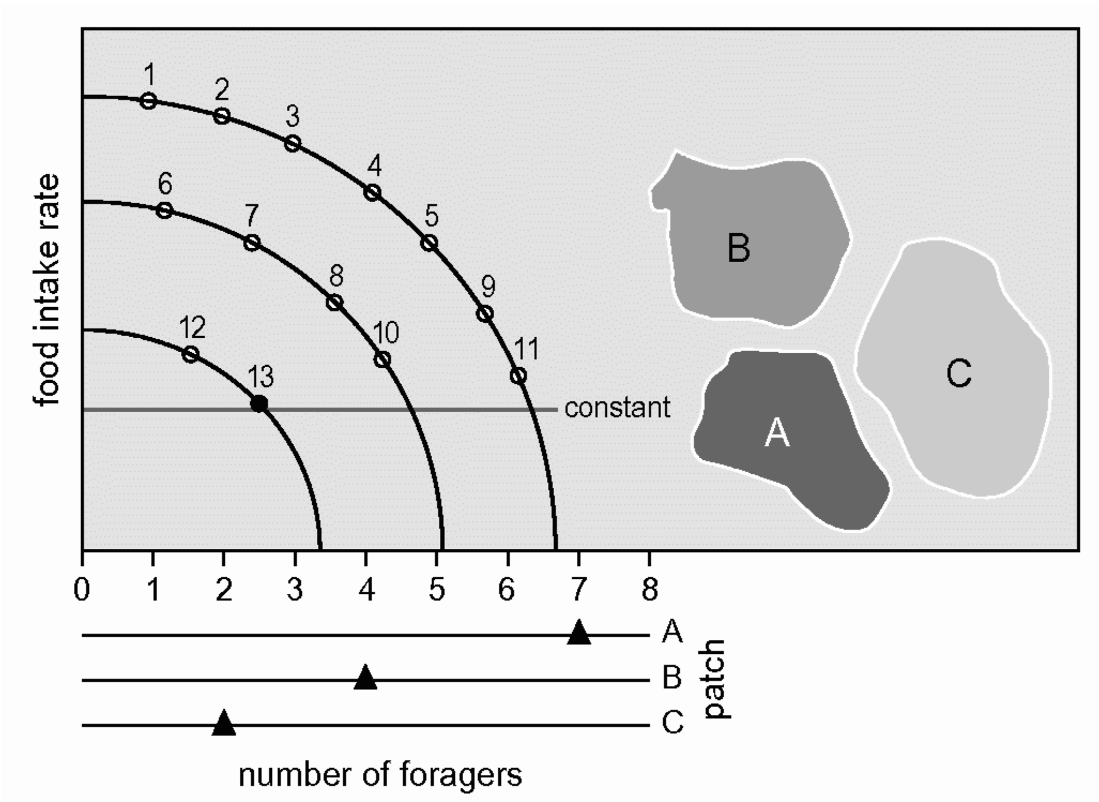

Figure 4. (Ideal free) model of the decrease in food intake rates with an increase in the density of foragers in three different patches (downcurved lines), A, B. and C, of decreasing quality. The numbered dots indicate how successive individuals choose the patch with the highest contemporary intake rate. The axes below the box give the final numbers of animals ending up in the different patches when a total of 13 animals has arrived.

the animals. This so-called ideal free distribution model predicts that animals will achieve the same intake rates in all patches.[26] By making shorebirds feed in different densities on small artificial mudflats in the Experimental Shorebird Facility at NIOZ, we try to test elements of such theories and also to evaluate what the consequences of increasing densities would be in field situations.[27] At this point we encounter a consideration of animals which I have failed to mention so far, their search for a balance between uncomplicated loneliness and living in pairs or groups, their SOCIAL MANAGEMENT.

Within our group ecological and evolutionary theories are tested at the scale of landscapes by Joost Tinbergen, Jan Komdeur and their co-workers. In this particular example they study the life history decisions of Great Tits *Parus major* in the Lauwersmeer area. They are interested in the extent to which the social environment affects fitness components (alternative behaviours such as clutch size or brood sex ratio) of individual animals. In this study the availability of multiple woodlots is used to advantage. In some lots the birds are manipulated to have small clutch sizes. This should reduce competition between offspring. To enhance competition in other woodlots clutch sizes are increased; in some the researchers increase the proportion of male fledglings, in others the proportion of female fledglings is increased. In this way the effects of sex ratio biases on survival and dispersion are experimentally evaluated.[28]

This is a great time to be an animal ecologist because genetic techniques to study subtle structures of relatedness within and between populations are now within reach.[29] We can go back even deeper in time to examine the effective population sizes and deeper layers of relatedness and past distributions. Co-operative ventures with relevant specialists also enable us to use the fast increasing spectrum of biomedical tools to examine body condition and health status of individual animals, and sometimes even to manipulate these variables in naturalistic contexts.[30]

Most of these methodological revolutions are made possible by intense international co-operation with animal ecologists and other specialists worldwide. The ease which we can communicate over the internet is very helpful in this context, and of course relatively cheap international air travel helps as well.

As an example of the new power of insightful comparisons on a worldwide scale is the comparative demographic work on migrant shorebirds in which we take the lead. This map (Figure 5) shows the global flyway network spun by the migratory routes of Red Knots, Red Knots that fan out to all coastal corners of the world from their circumpolar tundra breeding grounds. To achieve an understanding of the evolution and maintenance of the migration systems, with a sense of urgency because of the worldwide threats to the coastal ecosystems on which they depend, long-term demographic studies are now underway for five of the six subspecies. By marking individuals with unique combinations of colour bands and leg flags that are

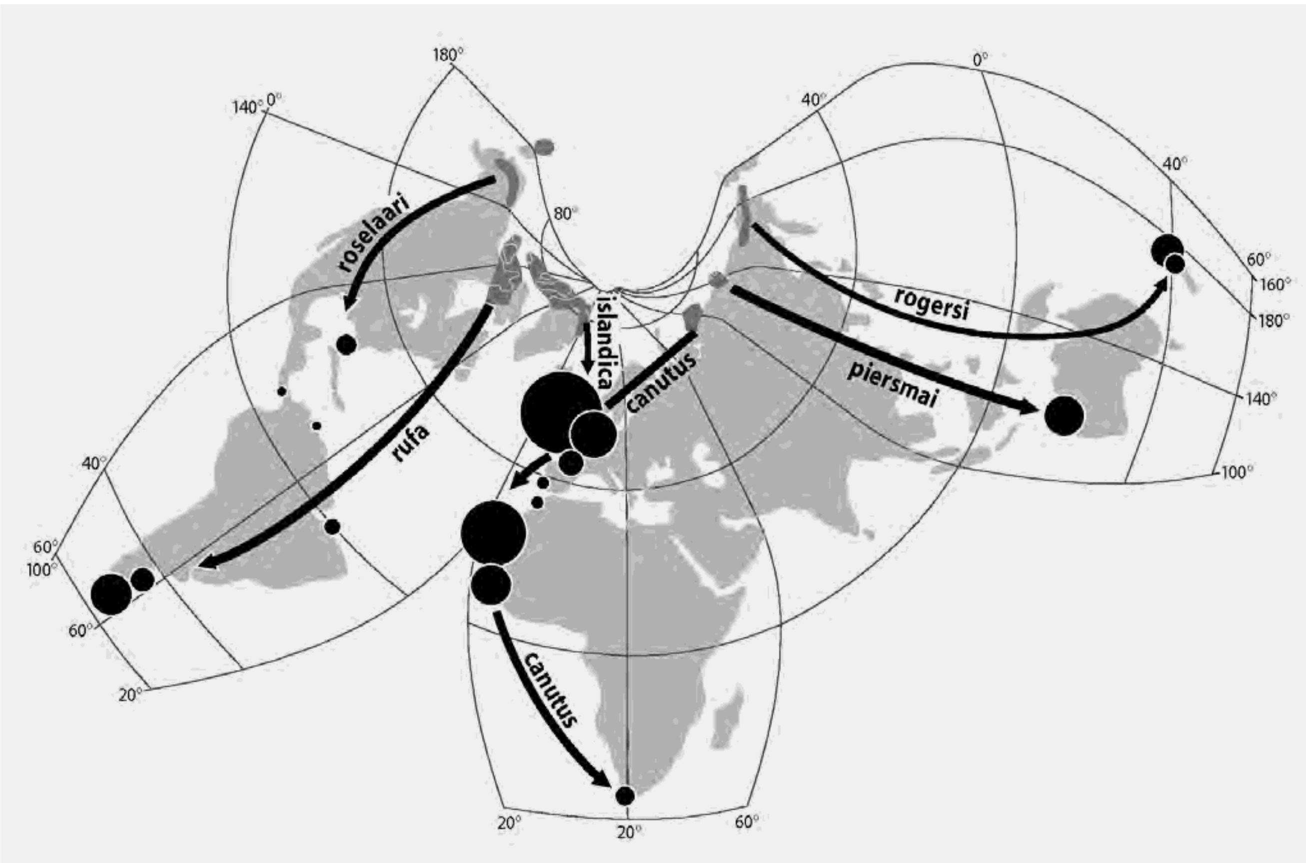

Figure 5. The worldwide network of flyways of the six subspecies of Red Knot. The dots scale to the approximate size (in 2004) of the respective wintering populations. In all subspecies except *roselaari* intense and focused demographic studies are underway.

easy to read in the field, and by making sure that sufficient efforts are made to continue reading these colour combinations, we are now in the position to examine many individual itineraries and to get robust year-by-year estimates of annual survival. Comparisons between subspecies will be very instructive, as will be comparisons between closely related shorebird species.[31] In the meantime demographic research projects are also in hand for four of the five subspecies of Bar-tailed Godwits *Limosa lapponica*.

In this context I am very pleased to announce the moral and financial support that we are starting to receive for this worldwide flyway research[32] by Vogelbescherming-Nederland, the Dutch branch of the BirdLife International partnership. Vogelbescherming has reached the conclusion that the protection of birds needs to be based on solid scientific evidence, and have demonstrated this by supporting new work on the annual cycles of Montagu's Harriers *Circus pygargus* and Skylarks *Alauda arvensis*.

The power of intensive colour-marking projects and other kinds of co-operation can further be illustrated by our new studies on the stopover ecology and migrations of the Ruff *Philomachus pugnax*. It is fantastic to be able to collaborate in this project with the passionate specialist amateur bird catchers and ringers known as 'wilsternetters'.[33] Wilsternetting is an old craft by which the netters try to attract flocks of Eurasian Golden Plovers *Pluvialis apricaria* or Ruffs to a netting site with strong audiovisual stimuli. Upon arrival the birds are caught in midair by the huge net that is pulled up in front of them. Thanks to the wilsternetters we were able to individually colour-mark as many as 2400 ruffs during the past two spring seasons. Observers over much of Europe and in West Africa ensured that within a short period of time we have already built up quite a comprehensive picture of the flyway of Ruffs staging in the west of the province of Fryslân (Figure 6). That this has been achieved within two years of study, also means that we should be able to document changes in flyways in real time; these changes may be a consequence of habitat loss, habitat modification, or climate change.

It is a good time to be an animal ecologist because of fast technological developments, especially with respect to the miniaturization and user-friendliness of all kinds of gadgets. Satellite transmitters are now so small that they can be implanted within the belly cavity of the large female Bar-tailed Godwits breeding in Alaska. The implantations are a veterinary masterpiece, and animals mounted with these new devices survived the applications and explored the shores of the Bering Sea in preparation of the 11,000 km long flight across the whole Pacific toward the wintering grounds in New Zealand. In 2006 Bob Gill and his team were successful in obtaining tracks of birds overflying the Pacific.[34] Although the technology still needs improvement, the dream of following individual small birds across much of the globe is within reach. In Groningen we have meanwhile also been involved in some successful satellite tracking studies on bigger birds such as Brent Geese *Branta bernicla* and Barnacle Geese.[35] On the down side, we all know about the tragic fate of one of the two female Montagu's Harriers that were fitted with satellite tags on their breeding ground in the east of the province of Groningen. As could be read in the newspapers, the harrier called Marion travelled all the way from Groningen to northern Nigeria where she was killed by the hand of man.[36]

Most bird species are much smaller than Bar-tailed Godwits and Montagu's Harriers, and new developments in migration ecology have certainly been hampered by the unavailability of truly small transmitters. We are now engaged in a co-operative venture with Cornell University to develop really small gadgets that combine sensors and a capacity for data storage with the ability to transmit these data at certain - predetermined - points in time. The only thing we have to do is to apply the transmitters and then be there to listen for them a year later.

We hope to begin employ these transmitters in new research on the details of the migration of Red Knots that spend the winter on the intertidal mudflats of Banc d'Arguin, that incredibly important and famous wetland in coastal Mauritania. Here we have already found strong local differences in the annual survival of birds that are faithful to roosts and feeding areas west and east of the village of Iwik.[37] Birds that have their home range west of Iwik have an annual survival of approximately 76% whereas birds that only occur east of Iwik have an annual survival of only 56%. We suspect that the 20% difference in annual survival reflects differences in the quality of the respective mudflat feeding areas (but are puzzled by the factors leading to the maintenance of such striking differences). Whatever the reasons for the survival difference, it provides us with a great contrast in wintering conditions that may enable us to investigate how quality differences between wintering habitats have downstream effects later in the year. Using the archival tags we hope to detect the seasons and sites where the differences in annual survival originate and to learn whether they are related to events during migration on the French or German spring stopover sites.

I must conclude that our enterprise is in full swing. I hope that I have made clear that animal ecologists like us begin to come to grips with all factors that influence habitat choice and animal numbers. We have an increasing spectrum of technical means at our fingertips to study all these factors in an integrative way in several major ecosystems. The strength of our animal ecology, the combination of theoretically inspired large-scale fieldwork with the experimental testing of the theories themselves, forms the basis of a worldwide web of inspiring collaborations.

At this point I am close to the end of this lecture. It is time for another citation, a citation with which Koos van Zomeren began his series of public lectures at this university: "*Well aware of his impermanence, man searches for a relationship with that which is permanent, the eternal, that which will certainly survive. This can be a God. This can be children. This can be art. This can also be the landscape… but not if this landscape is more impermanent than us*."

I would suggest that it could also be *science*, but only science of the inspiring, elegant and 'timeless' kind. When I started off as a university professor two and a half years ago, I hoped to find that within the walls of this 400 year old university the fight for fragile scientific enterprise would be

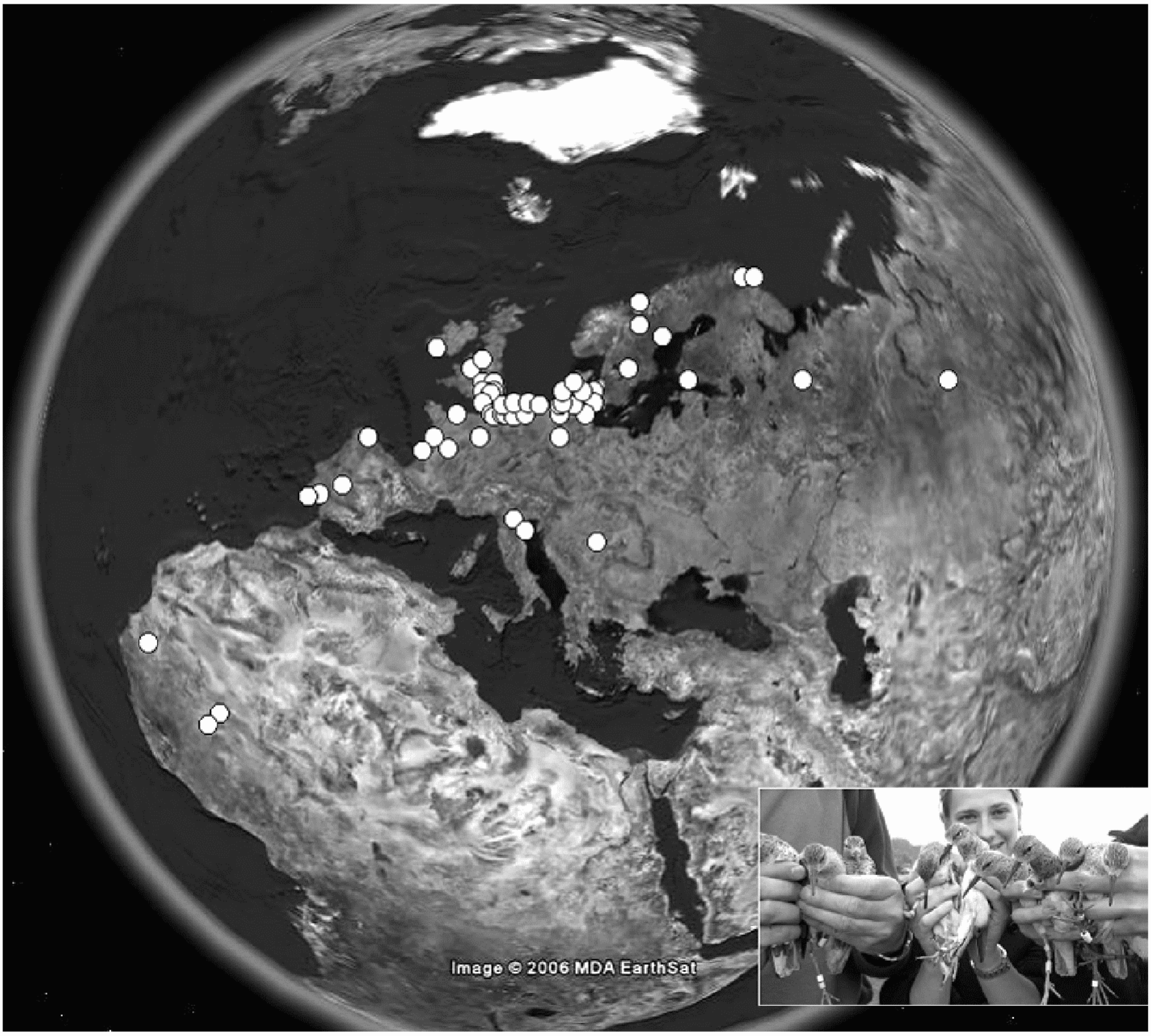

Figure 6. Locations of recovery or resighting (complete till December 2005) yielded by the 2400 Ruffs that were captured by the Friesian wilsternetters in the springs of 2004 and 2005 in southwest Fryslân and provided by the RUG-team with individual colour-ring combinations.

self-evident. I was somewhat dismayed to discover that such an attitude can *not* be taken for granted. Nevertheless, I remain hopeful that at this university, and at our fundamental research institutions as well, we will find ways to try and avoid the treacherous temptation of the 'market'. I believe that succumbing to market forces inescapably leads to the loss much of what is good about our scientific legacy. Only recently, Piet Borst in his column for a national Dutch newspaper (NRC Handelsblad)[38] stated the following: "*All this thematically funded research pushes scientists to run from one money-tap to another to fill their buckets. This selects for handymen, not for brilliant innovators. The fixation on trendy subjects and sexy research priorities also narrows down the basis [of our work]*…". In the case of contract-research, the customer will eventually be king. This is not necessarily a problem if both parties share the need for new hard knowledge. In ecology, however, this is rarely the case. In such instances the soundness and freedom of science is at stake. As much as we need autonomous courts of justice, just as much civil society needs autonomous science.[39] Thus, we need to stand in defence of the Ivory Tower; an ivory tower, of course, with wide open windows through which beautiful and important new knowledge will radiate.

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I thank Ken Rogers for suggesting this essay might be a fitting contribution to the celebratory issue of *Stilt*, and for help in producing it. In my lecture I thank many close friends and colleagues from The Netherlands, but the scope of the enterprise is obviously international. In fact, I cannot really find the proper words to describe what it means to me to be part of that worldwide network of dear friends and colleagues. For starters, I can't get enough of the committee and the membership of the International Wader Study Group! In addition, and in particular, I extend my warmest thanks for being there to Allan Baker, Patricia Gonzalez, Grant Pearson, Hugh Boyd, Phil Battley, Danny and Ken Rogers, Bob Gill and Colleen Handel, Åke Lindström, David Winkler, Pavel Tomkovich, Yaa Ntiamoa-Baidu, Chris Hassell and others. Our intense communications are so exciting and our occasional get togethers and joint adventures so incredibly cool. I thank Dick Visser for his usual patience and eye for detail in making and editing the illustrations.

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SHOREBIRDS OF THE SEA OF OKHOTSK: STATUS AND OVERVIEW

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INTRODUCTION

The Sea of Okhotsk is a large semi-enclosed sea of about 1,600,000 km^2 in area located on the Pacific coast of the Russian Far East. Almost all the coastline and islands belong to the Russian Federation; the southern border is marked by the Japanese island of Hokkaido. Four Russian administrative regions are located around the Sea of Okhotsk: Sakhalin, Khabarovsk, Magadan and Kamchatka.

The Sea of Okhotsk supports some millions of shorebirds in total during the migration periods as the birds travel to and from the breeding grounds in the Russian Far East (Bamford & Watkins 2005).

SHORT RESEARCH HISTORY

The history of modern ornithological research in the Sea of Okhotsk region started in the 18th century with investigations by G.W. Steller (1774) and S.P. Krasheninnikov (1786). Many scientific papers have been published on the region. For example, there are over 1,000 ornithological papers with data on Kamchatka and hundreds of them contain information about shorebirds (Huettmann 2003a). Most of this research is general in nature; however two large monographs were published in the 19th century (Stejneger 1885; Nikolskiy 1889).

Contributions to the study of shorebirds of the Sea of Okhotsk region have also been made by Japanese ornithologists, especially before the Second World War when southern Sakhalin and all the Kurile Islands were Japanese territories (e.g. Moniyama 1928 and others).

A lot of information on birds was collected during the period of the Soviet Union. Many publications, including general monographs on birds of different regions (shorebirds formed an important part of them), appeared from the middle to end of the 20th century (Gizenko 1955; Kistchinski 1968, 1988; Nechaev 1969, 1991; Lobkov 1986). The publication of *Birds of Soviet Union* (Dementyev & Gladkov 1951–1954), more than 4500 pages in total in six volumes, has great importance for ornithological studies to this very day.

The main focus of bird investigations was directed at studying distribution and breeding biology. Migration research was mostly descriptive and mainly involved the study of migration timing. Shorebirds were a part of this research and often a rather significant one. The All Soviet Union shorebird conferences started in 1973 and research contributions about shorebirds of the Sea of Okhotsk region were presented at each of its meetings (Gerasimov & Vyatkin 1973; Rakhilin 1973; Voronov & Voronov, 1980; Gerasimov 1980, 1988; Lobkov 1980; Ostapenko 1980; Pronkevich 2002 and others).

The Odessa Conference in 1992 was an important step in the development of shorebird research in the Soviet Union period. The research papers of that conference were published in English in 1998. Among the 30 papers dealing with Russian work, six of them dealt with the Sea of Okhotsk region (Blokhin 1998; Gerasimov & Gerasimov 1998; Lobkov 1998; Nechaev 1998; Pronkevich 1998; Zykov & Revyakina 1998).

During the 1990s fewer ornithological studies were undertaken in the Sea of Okhotsk area, as well as elsewhere in Russia. Nevertheless, some new information about shorebirds was published (Gerasimov 1991, 1998; Gerasimov & Kalyagina 1995; Kondratyev 1995; Babenko & Masterov 1997; Kondratyev & Andreev 1997 and others) as well as monographs and papers with general ornithological information (Kondratyev *et al.* 1992; Dorogoi 1997; Krechmar & Kondratyev 1996; Tomkovich 1997, 1998; Babenko 2000 and others).

Research by foreign scientists in the Sea of Okhotsk started again in the 1990s, after a break of over 80 years. These investigations have greatly increased our knowledge of shorebirds in the region and introduced new methods and research approaches (Degen *et al*. 1998, 2001; Huettmann 1999, 2001, 2003a, 2003b, 2004; Kruckenberg *et al.* 2001; Huettmann & Gerasimov 2002; Ueta *et al.* 2002; Antonov & Huettmann 2004a, 2004b; Gosbell *et al.* 2004).

From the year 2000 onwards shorebird migration research in the Sea of Okhotsk area started to increase again due to the involvement of new Russian researchers and of the availability of new funding avenues (Andreev & Kondratiev 2001; Blokhin & Tiunov 2004 and others). For example, in 2002 and 2003 research projects were supported by the Australian Department of Environment and Heritage (Gerasimov 2003, 2004, 2005; Antonov & Huettmann, 2004a, 2004b). During that time some papers on specific shorebird species of Kamchatka were published (Gerasimov & Gerasimov 2000b, 2001, 2002, 2006). Shorebirds received attention in the PhD thesis by I.V. Tiunov (2005). Also, work proceeded on mapping the breeding range of tundra shorebirds, which included the northern part of the region (Lappo 1998; Lappo & Tomkovich 1998).

SHOREBIRD STATUS

For many years, breeding season studies were more common than migration research. We believe that the overall status of shorebirds in the Sea of Okhotsk region is quite well known in the administrative regions and can be summarized with confidence. In total, 60 species of shorebird have been recorded in the Sea of Okhotsk area (Table 1); 38 of them are breeding species. Data in this table is mainly based on

Table 1. Status of shorebirds in Sea of Okhotsk area (over all seasons). **Key**: A – abundant; C – common; U – uncommon or fairly common; R – rare; B – breeding; T – transient; S – stragglers, accidentals. Names follow del Hoyo *et al*. (1996).

Species	Sakhalin	Khabarovsk Region	Kamchatka	Magadan Region
Grey Plover *Pluvialis squatarola*	CT	UT	UT	UT
Pacific Golden Plover *Pluvialis fulva*	CT	CT RB	CT UB	CT UB
American Golden Plover *Pluvialis dominica*	–	–	S	–
Common Ringed Plover *Charadrius hiaticula*	RT	RT	UB	UB
Little Ringed Plover *Charadrius dubius*	UB	CB	–	RB
Long-billed Plover *Charadrius placidus*	–	RB?	–	–
Lesser Sandplover *Charadrius mongolus*	AT	CT RB	CB	CB
Kentish Plover *Charadrius alexandrinus*	RB	–	S	–
Eurasian Dotterel *Charadrius morinellus*	S	RT	S	UB
Northern Lapwing *Vanellus vanellus*	RT RB?	CB	–	S
Grey-headed Lapwing *Vanellus cinereus*	S	S	–	–
Ruddy Turnstone *Arenaria interpres*	UT	CT	CT	CT
Black-winged Stilt *Himantopus himantopus*	S	–	S	S
American Black Oystercatcher *Haematopus bachmani*	–	–	S	–
Eurasian Oystercatcher *Haematopus ostralegus*	RT	RT	RB	RB
Green Sandpiper *Tringa ochropus*	RT	CB	S	RB
Wood Sandpiper *Tringa glareola*	CT RB	CT RB	CB	CB
Common Greenshank *Tringa nebularia*	RB	CB	CB	CB
Nordmann's Greenshank *Tringa guttifer*	RB	RB	RB?	RB
Redshank *Tringa totanus*	UB	CB	S	S
Spotted Redshank *Tringa erythropus*	UT	CT	UB	UT RB?
Marsh Sandpiper *Tringa stagnatilis*	T B?	RT	S	–
Grey-tailed Tattler *Heteroscelus (Tringa) brevipes*	CT	UT RB?	CT UB	CB
Wandering Tattler *Heteroscelus (Tringa) incanus*	S	–	RB	–
Common Sandpiper *Actitis hypoleucos*	CB	CB	CB	CB
Terek Sandpiper *Xenus cinereus*	UT	CT RB	CT UB	UB
Gray (Red) Phalarope *Phalaropus fulicaria*	RT	RT	RT	RT
Red-necked Phalarope *Phalaropus lobatus*	CT RB	AT	CB	CB
Ruff *Philomachus pugnax*	RB	RT	UB	UB
Spoon-billed Sandpiper *Eurynorhynchus pygmeus*	RT	UT	UT RB	RT
Little Stint *Calidris minuta*	RT	RT	RT	RT
Red-necked Stint *Calidris ruficollis*	AT	AT	AT RB	AT RB
Long-toed Stint *Calidris subminuta*	CT RB	UT RB	CB	UB
Temminck's Stint *Calidris temminckii*	RT	UT	UB	UB
Baird's Sandpiper *Calidris bairdii*	–	RT?	S	S
Curlew Sandpiper *Calidris ferruginea*	UT	UT	RT	UT
Dunlin *Calidris alpina*	AT RB	AT	AT CB	AT CB
Rock Sandpiper *Calidris ptilocnemis*	S?	–	UB	–
Sharp-tailed Sandpiper *Calidris acuminata*	RT	RT	UT	UT
Pectoral Sandpiper *Calidris melanotos*	S	RT	RT	UT
Great Knot *Calidris tenuirostris*	CT	CT	CT UB	CT RB?
Red Knot *Calidris canutus*	UT	RT	CT	CT
Western Sandpiper *Calidris mauri*	–	RT	RT	–
Sanderling *Calidris alba*	CT	RT	RT	S
Buff-breasted Sandpiper *Tryngites subruficollis*	–	S?	S	–
Broad-Billed Sandpiper *Limicola falcinellus*	RT	RT	RT	S
Jack Snipe *Lymnocryptes minimus*	S	S?	–	RT
Common Snipe *Gallinago gallinago*	CT UB	CB	CB	CB
Latham's Snipe *Gallinago hardwickii*	UB	S?	–	–
Swinhoe's Snipe *Gallinago megala*	S	UB	–	–
Pintail Snipe *Gallinago stenura*	RT	CT RB?	RB	UB
Solitary Snipe *Gallinago solitaria*	UT	RB	RB	RB
Eurasian Woodcock *Scolopax rusticola*	CT	UB	RB?	S
Little Curlew *Numenius minutus*	RT	RT	–	RB
(Far) Eastern Curlew *Numenius madagascariensis*	UT RB?	RB	UB	RB
Whimbrel *Numenius phaeopus*	AT	CT	AT UB	CB
Back-tailed Godwit *Limosa limosa*	AT RB	CB	CB	UB
Bar-tailed Godwit *Limosa lapponica*	CT	UT	CT	CT
Asian Dowitcher *Limnodromus semipalmatus*		S		
Long-billed Dowitcher *Limnodromus scolopaceus*	S	S	UB	RT
Oriental Pratincole *Glareola maldivarum*	–	–	S	–

monographs and papers (Nechaev 1991, Dorogoi 1997, Gerasimov *et al*. 1999, Babenko 2000). However, some rather extensive areas in the Sea of Okhotsk region are still poorly investigated during the breeding season, for example Penzhina Bay and the entire western coast of the Sea of Okhotsk. The southern boundaries of the breeding ranges are still not completely known for some arctic nesting species. Ongoing research shows that these borders are further south than previously believed. Obviously, this is not a function of changes in breeding range, but rather due to the lack of sound baseline information. In 1989 for instance, nesting Pacific Golden Plovers were found 600 km to the south of their otherwise well-described breeding ranges (Gerasimov *et al*. 1992), and in 1990 they were found to nest a further 200 km to the south (unpubl. data). Another example is that the exact breeding range of the Spotted Greenshank, one of the most endangered shorebird species, is still not clearly known.

SHOREBIRD MIGRATION

The total shorebird migration period in the Sea of Okhotsk region exceeds half a year (April – November). The timing of the northward migration in the Sea of Okhotsk area seems to depend on weather conditions. It is especially affected by snow and ice-melt conditions. Earliest snow melting in the Russian Far East usually occurs in the interior, southern part of the Khabarovsk region. It is for this reason that some forest and inland marsh breeding species (Pacific Golden Plover, Little Ringed Plover, Northern Lapwing, European Woodcock, Whimbrel and some others – see Table 2) nest earlier than those species that usually use the sea coasts for feeding (Dunlin, knots, some stilts and sandpipers).

The northern and north-eastern coasts of the Sea of Okhotsk are still covered by ice until late May and early June. The northward migration period is very short in north Sakhalin, Kamchatka and in the Magadan region. For

Table 2. Known timing of northward migration of shorebirds in the Sea of Okhotsk region. N.B. First birds can appear earlier then shown in the table. The number 1 following the oblique stroke indicates days 1 to 10 of the month, 2 indicates days 11 to 20, 3 indicates the remainder of the month.

Species	Sakhalin	Khabarovsk Region	Kamchatka	Magadan Region
Grey Plover	May/2 - Jun/1	May/2 – Jun/1	May/2 – May/3	May/3 – Jun/1
Pacific Golden Plover	May/2 – May/3	Apr/1 – May/3	May/2 – May/3	May/2 – Jun/1
Common Ringed Plover	May/1 – May/3	Little info.	May/2 – May/3	Little info.
Little Ringed Plover	Apr/4 – May/2	Apr/2 – May/2	–	Little info.
Lesser Sandplover	May/2 - Jun/1	Little info.	May/1 – May/3	Little info.
Northern Lapwing	Apr2 – May/3	Apr/1 – May/2	–	Little info.
Ruddy Turnstone	May/2 – Jun/1	May/2 – May/3	May/1 – May/3	May/3 – Jun/1
Eurasian Oystercatcher	May/1 – Jun/1	May/2 – May/3	May/1 – Jun/1	Little info.
Green Sandpiper	May/2 – May/3	Apr/3 – May/3	–	May/3
Wood Sandpiper	May/1 – Jun/1	May/2 – Jun/1	May/2 – May/3	May/2 – Jun/1
Common Greenshank	May/1 – Jun/1	Apr/3 – May/3	May/2 – May/3	May/2 – Jun/1
Nordmann’s Greenshank	May/2 – May/3	May/3	Little info.	Little info.
Common Redshank	May/2 – May/3	Apr/1 – May/3	–	Little info.
Spotted Redshank	May/2 – May/3	May/1 – May/3	May/2 – May/3	May/3 – Jun/1
Grey-tailed Tattler	May/2 – Jun/1	Apr/3 – May/3	May/2 – Jun/1	Little info.
Common Sandpiper	May/1 – May/3	Apr/3 – May/3	May/2 – May/3	May/3 – Jun/1
Terek Sandpiper	May/2 – Jun/1	May/2 – May/3	May/2 – May/3	May/3 – Jun/1
Grey Phalarope	Little info.	Little info.	May/3 – Jun/1	Little info.
Red-necked Phalarope	May/2 – Jun/1	Little info.	May/2 – Jun/1	May/3 – Jun/1
Ruff	May/2 – May/3	May/2 – May/3	May/2 – May/3	May/2 – May/3
Spoon-billed Sandpiper	May/3	Little info.	May/2 – Jun/1	Little info.
Little Stint	May/2 – Jun/1	Little info.	–	Little info.
Red-necked Stint	May/2 – Jun/1	May/2 – Jun/1	May/2 – Jun/1	May/3 – Jun/1
Long-toed Stint	May/2 – Jun/1	May/2 – May/3	May/2 – Jun/1	Little info.
Temminck’s Stint	May/2 – May/3	May/2 – Jun/1	May/2 – May/3	May/3 – Jun/1
Curlew Sandpiper	May/2 – Jun/1	Few	Little info.	Little info.
Dunlin	May/1 – May/3	May/2 – Jun/1	May/2 – May/3	May/3 – Jun/1
Sharp-tailed Sandpiper	May/2 – May/3	Little info.	May/2 – May/3	Little info.
Great Knot	May/2 – May/3	Little info.	May/2 – May/3	May/3 – Jun/1
Red Knot	May/3	Little info.	May/2 – May/3	Little info.
Sanderling	May/2 – Jun/1	Little info.	Little info.	Little info.
Broad-Billed Sandpiper	May/2 – May/3	Little info.	Little info.	Little info.
Common Snipe	May/1 – May/3	Apr/3 – May/3	May/1 – May/3	May/3
Eurasian Woodcock	Apr/3 – May/2	Apr/2 – May/2	Little info.	Little info.
Little Curlew	Little info.	May/3 – Jun/1	May/1 – May/3	Little info.
Eastern Curlew	Apr/2 – May/3	Apr/1 – May/3	May/2 – May/3	May/3
Whimbrel	May/2 – Jun/1	Apr/2 – May/3	May/2 – May/3	May/3 – Jun/1
Back-tailed Godwit	May/2 – Jun/1	Apr/3 – Jun/1	May/2 – May/3	May/3 – Jun/1
Bar-tailed Godwit	May/2 – Jun/1	Little info.	May/2 – May/3	May/3 – Jun/1

instance, in 1994 about 94% of the total shorebird numbers passed the observation area in south-western Kamchatka during just one day! On 21 May, we counted more than 41,000 shorebirds flying by (including 32,330 Dunlins, 5,270 Whimbrels, and 2,720 Bar-tailed Godwits). That day, more than 16,200 Dunlins flew past during the one hour period before dark. After that, we stopped observations, but migration still continued (Gerasimov & Kalyagina 1995).

The directions of the major northward migration routes of coastal feeding shorebirds are shown, to the best of our knowledge, in Figure 1. A true evaluation of these patterns, e.g. based on individually marked birds, is still to be determined. A major part of these species migrate through Sakhalin and then northwards through the Magadan region and north-east Kamchatka. Part of the population migrates over Sakhalin, probably without touch-down. The amount of migration through the Kurile Islands is very small; migration along the eastern coast of Kamchatka is rather small too when compared with the west coast. Shorebirds reach the Bering Sea coast mainly by crossing the northern Kamchatka Peninsula.

There are even several common species for which we still have no clear and confirmed northward migration routes – Wood Sandpiper, Common Sandpiper, Common Greenshank, Long-toed Stint, Common Snipe and others. On Kamchatka, all these species are very common but few migrate along the south-western and western coasts of the peninsula.

One might assume that these species make long nonstop flights at high altitudes starting from the region of the Yellow Sea. However, it is currently not clear why the "northward" migration in Central Kamchatka and on the isthmus of the peninsula takes place from the north and north-west to the south and southeast (Gerasimov 2001, Gerasimov & Gerasimov 2006).

Unfortunately, not all information from shorebird migration counts is published or available (e.g. on Sakhalin Island) and total estimates are only available and published for Kamchatka (Gerasimov in press). The first estimates of the total number of Great and Red Knots migrating through the central part of the western coast of Kamchatka were made in 1975–1976 (Gerasimov 1980). Later, studies of visible shorebird migration were made in different parts of Kamchatka. Detailed counts covering the entire period of northward migration have allowed estimates to be made of the minimum numbers for some species (Table 3). However, the real number is probably significantly higher.

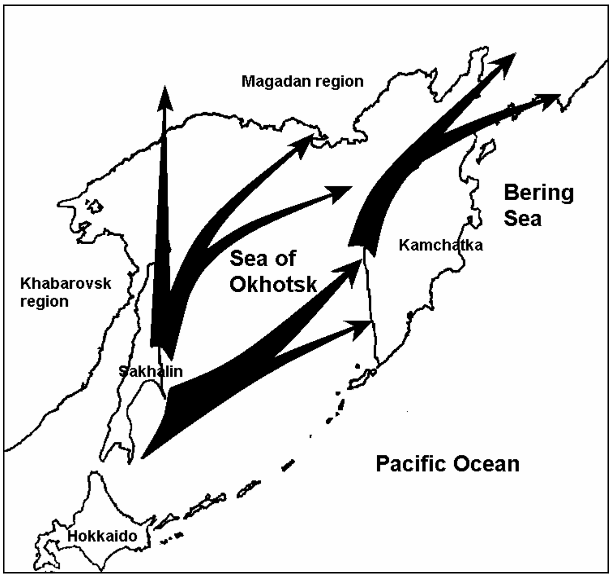

Figure 1. Northward migration

The southward migration period is much longer than the northward one. The concentrations of shorebirds on the sea coast start to increase again in late June and early July. The first migration wave consists of non-breeding individuals. In some species, females leave the breeding grounds after the chicks hatch (Great Knot, Terek Sandpiper, Red-necked Stint, Long-toed Stint and some others) and a strong southward migration begins in July (Table 4).

Many shorebirds arrive from inland on the coasts of Penzhina Bay. The total number of shorebirds migrating through Penzhina Bay and staging on the coast (total shoreline length is over 800 km) probably exceeds 1,000,000 individuals. A significant proportion moves directly to the south, rather than slowly and gradually along the west Kamchatka coast, likely with many stops, and then crosses the Sea of Okhotsk to Sakhalin (Figure 2). Few migrate through the southern tip of Kamchatka (Lobkov 2003) and along the Kurile Islands (Huettmann 2004, pers. comm.). Shorebird concentrations are low on the Magadan coast. High concentrations of shorebirds occur during the southward migration in the bays located on the western side of the Sea of Okhotsk – Udskaya, Konstantina, Ulbanskiy, Tugusrkiy, Schastia Bays and some others. The major proportion of shorebirds arriving in this region come from inland (Pronkevich, 1998). However, some come from elsewhere, probably from the Penzhina Bay area. Obviously, northern Sakhalin is the third of the most important areas during southward migration.

Table 3. Approximate minimum numbers of some shorebird species arriving on Kamchatka and passing through the peninsula during northward migration

Species	Number
Grey Plover	2,000
Pacific Golden Plover	2,000
Lesser Sand Plover	5,000
Ruddy Turnstone	3,000
Eurasian Oystercatcher	500
Wood Sandpiper	25,000
Common Greenshank	12,000
Red-necked Stint	120,000
Dunlin	250,000
Great Knot	40,000
Red Knot	3,000
Eastern Curlew	1,500
Whimbrel	15,000
Black-Tailed Godwit	6,000
Bar-tailed Godwit	11,000
Total	496,000

Table 4. Timing of southward migration of shorebirds in the Sea of Okhotsk region. N.B. A few birds can be recorded later then stated in the table. The number 1 following the oblique stroke indicates days 1 to 10 of the month, 2 indicates days 11 to 20, 3 indicates the remainder of the month.

Species	Sakhalin	Khabarovsk Region	Kamchatka	Magadan Region
Grey Plover	Jul/3 - Oct/2	Jul/3 - Oct/1	Jul/3 - Oct/2	Jul/3 - Aug/2
Pacific Golden Plover	Jul/3 - Oct/1	Jul/3 - Sep/3	Jul/3 - Nov/2	Aug/1 - Aug/3
Common Ringed Plover	Little info.	Little info.	Jul/2 - Sep/2	Little info.
Little Ringed Plover	Jul/3 - Oct/1	Aug/1 - Sep/3	–	Little info.
Lesser Sandplover	Jun/3 - Sep/3	Jul/2 - Sep/3	Jul/3 - Oct/1	Jul/1 - Sep/1
Northern Lapwing	Jul/2 - Sep/2	Jul/2 - Oct/2	–	Little info.
Ruddy Turnstone	Jul/2 - Sep/3	Jul/3 - Sep/2	Jul/2 - Oct/2	Jul/2 - Aug/3
Eurasian Oystercatcher	Jul/3 - Oct/1	Little info.	Aug/3 - Sep/3	Little info.
Green Sandpiper	Aug/1 - Sep/3	Jul/3 - Sep/3	–	Aug/1 - Aug/3
Wood Sandpiper	Jul/2 - Oct/1	Jul/2 - Sep/2	Jul/3 - Sep/3	Jul/2 - Sep/2
Common Greenshank	Jul/1 - Oct/2	Jul/2 - Sep/3	Jul/2 - Sep/2	Aug/1 - Aug/3
Nordmann's Greenshank	Jul/3 - Sep/1	Aug/1 - Aug/3	–	Little info.
Common Redshank	Jul/2 - Aug/3	Jul/2 - Oct/1	–	Little info.
Spotted Redshank	Jul/2 - Oct/2	Jun/3 - Oct/2	Aug/2 - Sep/3	Jul/1 - Aug/3
Grey-tailed Tattler	Jul/3 - Sep/1	Jul/2 - Sep/3	Jul/2 - Oct/2	Jul/2 - Sep/3
Common Sandpiper	Jul/3 - Sep/3	Jul/2 - Sep/2	Jul/3 - Sep/2	Jul/1 - Sep/1
Terek Sandpiper	Jul/3 - Sep/1	Jul/2 - Sep/1	Jul/2 - Aug/3	Jul/1 - Aug/2
Grey Phalarope	Jul/3 - Sep/3	Aug/2 - Sep/2	Little info.	Little info.
Red-necked Phalarope	Jul/2 - Sep/3	Jul/2 - Sep/3	Jul/3 - Sep/2	Jul/3 - Sep/3
Ruff	Jul/3 - Sep/2	Jul/3 - Sep/2	Aug/2 - Sep/1	Little info.
Spoon-billed Sandpiper	Jul/3 - Oct/1	Aug/1 - Sep/1	Aug/2 - Aug/3	Little info.
Little Stint	Little info.	Little info.	–	Jul/2 - Aug/3
Red-necked Stint	Jul/2 - Oct/3	Jul/2 - Sep/1	Jul/1 - Sep/3	Jul/2 - Sep/1
Long-toed Stint	Aug/1 - Sep/1	Jul/2 - Sep/3	Jul/2 - Aug/3	Aug/1 - Aug/2
Temminck's Stint	Aug/1 - Sep/1	Jul/2 - Oct/1	Jul/2 - Aug/3	Jul/2 - Aug/3
Curlew Sandpiper	Aug/1 - Oct/1	Aug/1 - Sep/1	Aug/3	Aug/1 - Aug/3
Dunlin	Jul/1 - Nov/1	Jul/2 - Oct/3	Jul/2 - Sep/3	Jul/2 - Sep/2
Sharp-tailed Sandpiper	Jul/1 - Oct/3	Aug/2 - Oct/3	Aug/3 - Nov/1	Aug/2 - Aug/3
Great Knot	Jul/2 - Oct/3	Jun/3 - Sep/2	Jul/2 - Aug/3	Jul/3 - Aug/3
Red Knot	Jul/3 - Sep/1	Aug/1 - Sep/1	Jul/3 - Aug/3	Jul/1 - Aug/2
Sanderling	Jul/2 - Sep/3	Jul/3 - Sep/2	Jul/2 - Oct/1	Jul/2 - Aug/1
Broad-Billed Sandpiper	Aug/2 - Sep/2	Aug/2 - Sep/2	Sep/2 - Oct/1	Little info.
Common Snipe	Aug/1 - Oct/3	Aug/1 - Oct/2	Jul/3 - Oct/2	Aug/1 - Sep/3
Eurasian Woodcock	Sep/1 - Oct/2	Aug/3 - Oct/3	–	Little info.
Little Curlew	Little info.	Jul/3 - Aug/3	–	Jul/3 - Aug/2
Eastern Curlew	Jul/2 - Oct/1	Jun/3 - Sep/3	Jul/2 - Sep/2	Jul/3 - Aug/2
Whimbrel	Jul/2 - Sep/3	Jul/3 - Sep/2	Jul/2 - Sep/2	Jul/3 - Sep/1
Back-tailed Godwit	Jul/2 - Oct/1	Jul/1 - Sep/2	Jul/2 - Sep/2	Jun/3 - Aug/3
Bar-tailed Godwit	Jul/2 - Oct/3	Jul/2 - Sep/3	Jul/2 - Sep/2	Jul/2 - Aug/3

For many shorebird species southward migration can be observed in the southern parts of Sakhalin and Khabarovsk areas until October; for some species (Pacific Golden Plover, Grey Plover), migration continues until late October – November, even on Kamchatka.

It is not difficult to define the start of the northward migration because shorebirds are absent from the area during winter. However, it is practically impossible to determine the exact ending of northward migration. To determine the start of the southward migration is also quite difficult, even for species which have breeding ranges located to the north of the Sea of Okhotsk. Parts of the shorebird population remain in the area as non-breeders; this topic requires much more attention. Immature birds can migrate to the north considerably later than the main part of the population, as they do not need to reach breeding areas and they can afford to remain all summer in regions otherwise used for migration. Further, it is difficult to determine the exact boundary between local post-breeding movements and real southward migration. The information given in Tables 2 and 4 presents the best information we have available.

STAGING AREAS

The total number of shorebird staging sites reaching international importance in the Sea of Okhotsk region should reach at least several tens. The present knowledge of such sites depends mainly on the locations where survey work has been carried out (Figure 3; Table 5). So for Kamchatka, we believe that many lagoons and river estuaries can satisfy the requirements for sites of international importance during southward migration. We think the same situation will apply to the western parts of the Sea of Okhotsk and Sakhalin. The list of sites in Table 5 is prepared based on the reports of total shorebird numbers (5,000 single count or 20,000 for the complete migration period; Watkins 1997).

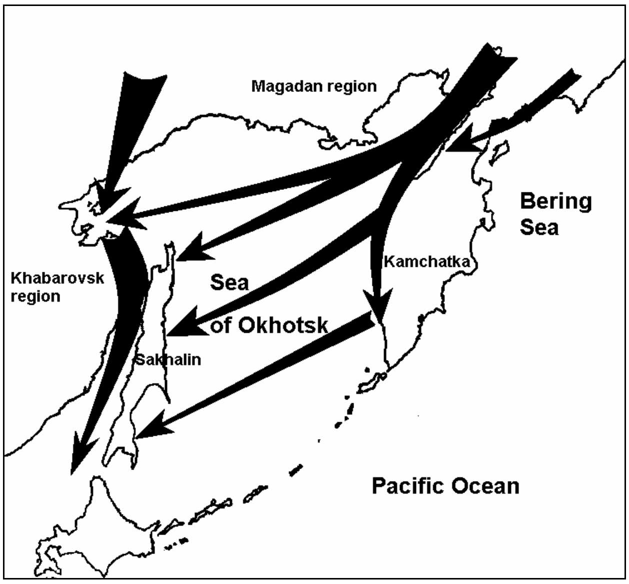

Figure 2. Southward migration

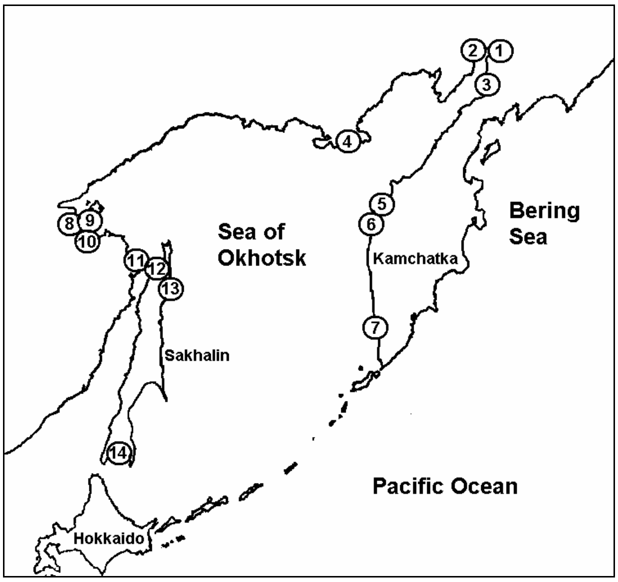

Figure 3. Known main staging sites

We do not include information on the 1% criterion for different shorebird species because of lack of information in many cases. However, some of the data for Penzhina mouth, Moroshechnaya estuary and other sites (Pronkevich, 1998, Gerasimov & Gerasimov 2000b, Gerasimov 2005, and Schuckhard *et al*. unpub.) can be used. For example, in Konstantina Bay on 3 August 1989 about 3,800 Terek Sandpipers were counted along a five kilometre shoreline (the total shoreline is tens of kilometres). In Tugursky Bay on 28 August 1990 more than 10,000 Great Knots and 5,000 Terek Sandpipers were counted for a 20 km shoreline section (the total shoreline is more than 200 km) (Pronkevich, 1998).

Unfortunately, shorebird migration studies are often not site-based (Zykov 1997; Blokhin & Kokorin 2002) or counts are not made (Dorogoi 2002). Hence, it is difficult to determine the quantitative significance of some well-known places (e.g. Lunsky Bay, Ola Lagoon) from published information (Zikov & Revyakina 1998).

There are many opportunities available for future investigations of shorebirds around the Sea of Okhotsk. Collecting more high quality data during the migration periods, including the "shoulder" seasons, when numbers are changing rapidly, is especially important. Habitat data, prey and benthos data, are urgently needed, too.

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Table 5. Known main staging sites for shorebirds on the coasts of Sea of Okhotsk. See Figure 5 for locations.

Name	Season	Maximum single count	Total number	Main species	Main references
1. Mouth of Penzhina River	southward	40,200	Up to 500,000	Dunlin, Red-necked Stint, Red-necked Phalarope	Gerasimov 2003, 2004, 2005
2. NW Penzhina Bay	southward	60,000	>100,000	Dunlin, Red-necked Stint	Gerasimov 2004
3. Rekkiniky Bay	southward	15,000	?	Great Knot, Black-tailed and Bar-tailed Godwits, Dunlin, Red-necked Stint	Lobkov 1986, 1998
4. Babushkina Bay	southward	5,000	?	Red-necked Phalarope, Red-necked Stint	Degen *et al.* 1998, 2001
5. Khayruzova Bay	southward	10,000	?	Black-tailed and Bar-tailed Godwits, Red-necked Stint	Lobkov 1986, 1998
6. Moroshechnaya Estuary	northward	33,000	>150,000	Dunlin, Red-necked Stint, Great Knot	Gerasimov 1991; Gerasimov & Gerasimov 2000a
	southward	11,500	>200,000	Dunlin, Red-necked Stint, Great Knot, Bar-tailed Godwit	Gerasimov & Gerasimov 1997, 1998; Schuchard vl *et al.* in press
7. Bolshoe Lake	northward	5,000	20,000	Dunlin	Gerasimov 1998.
8. Tugurskiy Bay	southward	17,000	?	Dunlin, Great Knot, Terek Sandpiper	Pronkevich 1998.
9. Konstantina Bay	southward	5,500	?	Terek Sandpiper, Great Knot	Pronkevich 1998.
10.Ulbanskiy Bay	southward	5,000	?	Terek Sandpiper, Great Knot, Wood Sandpiper	Pronkevich 1998.
11. Schastya Bay	southward	>5000	?	Dunlin, Red-necked Stint, Great Knot, Black-tailed Godwit.	Babenko, 2000
12. Baykal Bay	southward	6,300	?	Bar-tailed Godwit, Great Knot, Red Knot	Nechaev 1991
13. Chayvo Bay	southward	5,500	?	Dunlin, Sundering	Blokhin A.Yu. & Kokorin A.I. 2002.
14. Aniva Bay	northward	8,000	?	Dunlin, Red-necked Stint	Nechaev 1991, 1998

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CONSERVATION OF MIGRATORY SHOREBIRDS AND THEIR HABITATS IN THE SEA OF OKHOTSK, RUSSIAN FAR EAST, IN THE YEAR 2006: STATE-OF-THE-ART AND AN OUTLOOK

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The Sea of the Okhotsk is a large water body, located in the Russian Far East (PICES 2004). It has a vast shoreline and hinterland. The region lies to the east of Siberia and has always been difficult (both physically and politically) for westerners to access. Its huge coastline and water mass has captured peoples' imaginations for hundreds of years, and famous explorers like J. von Krusenstern, G. Steller and J. Cooke sailed there, made detailed site descriptions, and collected various specimens (for an overview see Wannhoff and Toermer 1997, Glavin 2000).

Migratory shorebirds of the vast East Asian–Australasian (EAA) Flyway (Wetlands International 2005) have used this large region for more than 15,000 years (e.g. Parish *et al.* 1987, Engelmoer & Roselaar 1998). The Sea of Okhotsk presents a major part of their habitat and flyways (Flint *et al.* 1984) and, with few exceptions, affects most aspects of the life of migratory shorebirds in the eastern Russian Arctic and indeed Asia.

Most shorebirds, specifically Arctic ones, are declining globally (del Hoyo *et al.* 1996, CAFF 2001; see also Huettmann & Czech (in press) for human-caused reasons). The exact trends for birds and their habitats in the Sea of Okhotsk remain widely unknown to the western world. Over the last 100 years major political and economical changes have occurred in this region, affecting all of its biodiversity in various ways (Glavin 2000). A comprehensive review and summary of this region does not exist for shorebirds and habitats (see Dementyev & Gladkov 1951–1954, Il´iČev & Zubakin 1990, Krechmar & Kondratyev 1996, Newell 2004 for general reviews, and Konyukhov *et al.* 1998, Kondratyev *et al.* 2000, Shuntov 2000a,b for seabirds). Here we present and review the current environmental and conservation situation of the Sea of Okhotsk as it relates to migratory shorebirds and their habitats. We focus on species that occur along the EAA flyway. For Kamchatka, this review will only cover the western side because, as shown in Figure 1, it has no shoreline on the Sea of Okhotsk. For completeness, the coastline as south as Vladivostok is also included in this review. We draw this review and assessment from our own work in Russia and in the study area for over 10 years, as well as on literature reviews and various communications with international experts and Russian colleagues.

THE COASTAL OCEANOGRAPHY AND ADMINISTRATIVE SET-UP

The Sea of Okhotsk is partly internationally managed (PICES 2004), but generally it is dominated by Russian policy, and to a lesser extent, by Japanese political history and international politics. The management of this water body does not really follow an adaptive management approach (Walters 1986) and does not involve democratic participatory principles as known in the western world.

The Sea of Okhotsk connects with the northern Pacific Ocean and consists of several components and ocean regimes (Wadachi 1987. See also Huettmann *et al.* 2005 for a general overview and references). Marine hotspots are found at distinct mixing zones (Shuntov 2000b), providing for much of the productivity (Sorokin & Sorokin 1999, Agatova *et al.* 2000). Penzhina Bay (Gerasimov 2005) in the north-east has the second highest tides in the world. The Sea of Okhotsk is bordered to the eastern side by the Kamchatka peninsula and its volcanoes (Gerasimov & Gerasimov 1998). The cool northern section, administered mainly by the Magadan region, can be considered as sub-arctic, whereas the southern part just north of Hokkaido-Japan has some subtropical characteristics. The biological components of the western section are not that well known; this area includes the Shantar Islands and the Amur River estuary. Sakhalin Island, an administrative centre and a major island over 600 km north to south, is located further south and is rich in natural resources such as forests, coal, oil, and gas (Newell 2004). The eastern section of the Sea of Okhotsk receives relatively cool Pacific waters and is characterized by over 50 islands, the Kurile Islands chain. The Sea of Okhotsk shows much seismic and volcanic activity, and large oil and gas findings, mostly offshore, are associated with the geological structure (Ludmann & Wong 2003). There is an international section in the centre of the Sea of Okhotsk (referred to as an 'international doughnut hole'); its access and fishery management is controlled by Russia and Japan. It is, however, difficult for the western world to obtain sustainability information for that region. It is certain that shorebirds cross these waters during migration (Gerasimov & Huettmann 2006), and that other birds of major international conservation concern regularly occur, for example, Short-tailed Albatross *Phoebastria albatrus* and Pink-footed Shearwater *Puffinus creatopus* (Arthukin & Burkanov 1999).

Many rivers flow into the Sea of Okhotsk such as the Amur, Penzhina, Tigil, Moroshechnaya, and Bolshaya rivers (just to name a few relevant to shorebirds; see Huettmann 2003 for a commented review and more details). Consequently, numerous estuaries, wetlands and tidal mudflats exist along the shore. Many of these estuaries are not well described, mapped, or inventoried and can extend

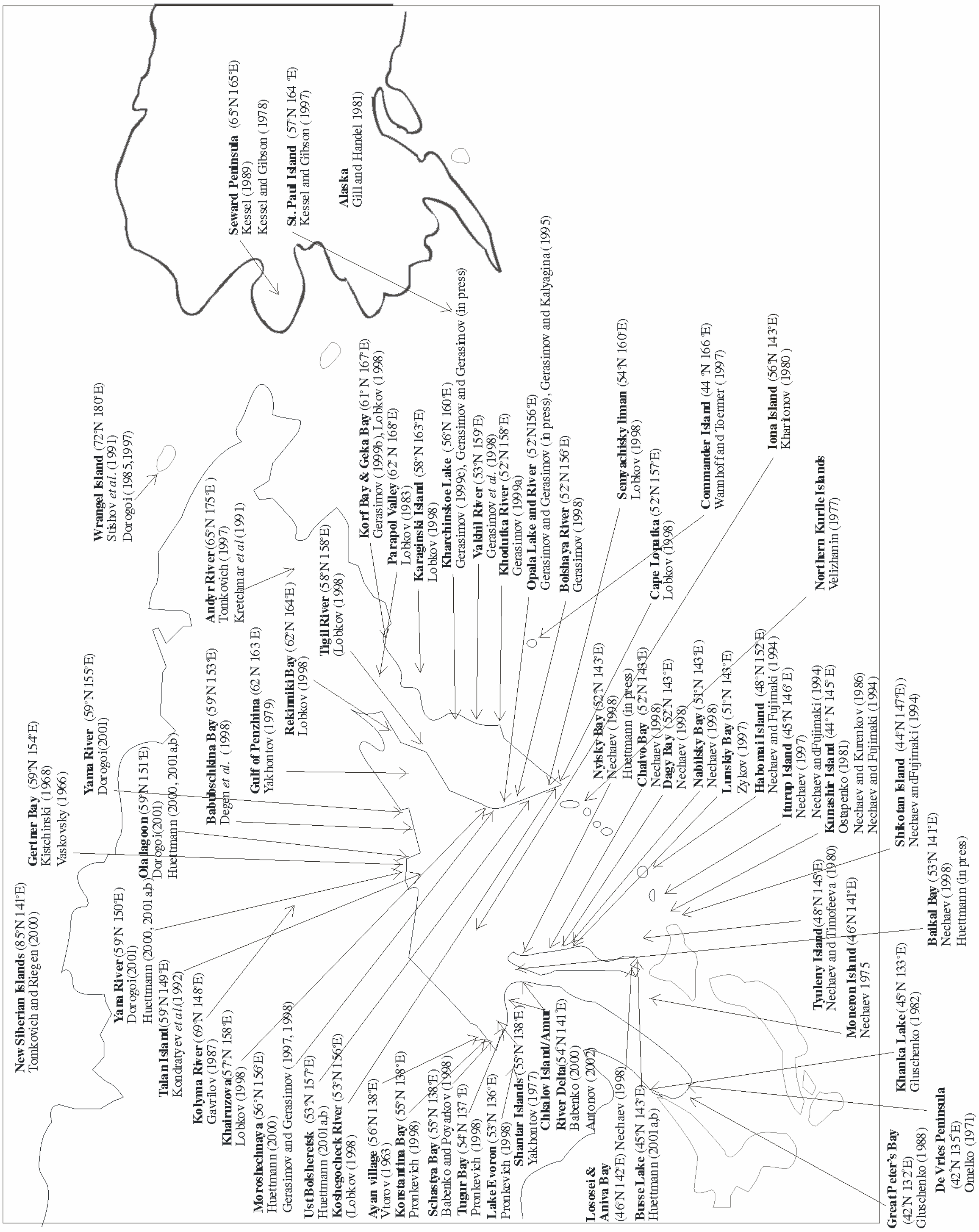

Figure 1. Results from a Literature Review on published and relevant shorebird sightings in the wider Sea of Okhotsk region.

well over 20 kilometres of coastline (see also Graeber 2006). These estuaries have a large and often still unspoiled hinterland. They are backed by watersheds where rivers are formed; these flow through the hinterlands bringing rich sediments into the estuaries and coastal mudflats. The coastline of the Sea of Okhotsk has some sandy beaches (e.g. on Sakhalin Island and Kamchatka) but usually it is made up of gravel shore with several tidal mudflats widely spaced along the coast. During winter, over one third of the Sea of Okhotsk is covered by ice, which thaws end of May (Kimura & Wakatsuchi 2004; see also Shuntov 1998, Haas & Eicken 2001, Huettmann *et al.* 2005). In the northern hemisphere summer and autumn, the weather is often overcast and 'gloomy' (see Schuckard *et al.* 2006 for a site description). A strong ocean current flows southward along the western Kamchatka peninsula and then westwards into the Sea of Okhotsk accounting for much of the coastal weather patterns there. Such currents often distribute plastic and other pollution from fisheries and other offshore activities along the shores of the Sea of Okhotsk (Robards *et al*. 1997). It is believed that the Pacific Ocean receives a strong water inflow from this region, contributing to larger ocean events.

THE NATURAL WEALTH OF THE SEA OF OKHOTSK

The Sea of Okhotsk provides resources not only to the adjacent cities (Vladivostok, Khabarovsk, Magadan, and Yushnow-Sakhalinsk), but also to remote locations such as Moscow, St. Petersburg, and Kaliningrad. Increasingly, it also supplies Asian markets such as Japan, Korea and China (Newell 2004); their resource demands are huge and still increasing. The resource extraction affects shorebirds and their habitats in many ways. Many of these resources are fishery and forestry products, as well as recent oil and gas findings. The region is well known for its abundant salmon, but also for its offshore fisheries; many seabird and marine mammal species occur as well (Arthukin & Burkhanov 1999, Shuntov 2000a,b). The Kamchatka and Magadan regions are considering further expansion of their gold extraction industry, which will likely affect the qualities of rivers and estuaries. Sakhalin Island has already received much offshore oil and gas exploration, and more is scheduled over the years. This policy is promoted by the Russian government as well as by the international community (namely companies from Holland, England, U.S.A., Japan, India, and China). Most watersheds in the east and north of the Sea of Okhotsk have no relevant timber products because this area is beyond the tree line and consists of taiga and tundra. However, the western section consists of coastal old-growth forests, some of which have already received intense logging activities (e.g. Primorye and on Sakhalin I. through Russian and Japanese management regimes). It is worth emphasizing that although China has no coastline on the Sea of Okhotsk, it still affects its watersheds, e.g. through the Amur river. Except for the northern Primorye region near China, hydropower is not a big issue in the region, yet, but several projects have been outlined which await further decisions. Large wind farm projects do not exist but first steps in this direction have been taken in Kamchatka and more are expected in other locations.

SHOREBIRD ABUNDANCE AND DISTRIBUTION

Arctic and sub-arctic shorebirds have used the Sea of Okhotsk during their migrations for thousands of years (Hayman *et al.* 1986, Engelmoer & Roselaar 1998). In addition to 58 relatively common species (see Gerasimov & Huettmann 2006 for an overview), three taxa of major international conservation concern occur (see del Hoyo *et al*. 1996 for overview): Spoon-billed Sandpiper *Eurynorhynchus pygmeus* which breeds on Chukotka and northern Kamchatka (CAFF 2001); Nordmann's Greenshank *Tringa guttifer* which breeds primarily on Sakhalin Island with smaller breeding sites to be assumed in adjacent regions (Hayman *et al*. 1986), and the Sakhalin subspecies of the Dunlin *Calidris alpina* (Hayman *et al*. 1986).

The impacts of climate change, or potential climate cycles, on shorebird populations and migration patterns have yet to be studied, unlike in some other flyways (Agler *et al*. 1999; see Forchhammer *et al*. 2002 for North Atlantic Oscillation).

For most species, the southward migration starts by mid-July, peaks in early August, and seems to last until end of August, with some birds using the area as late as November (Huettmann 1999, 2000, 2003b, and 2004a). There is the suggestion that species like Great Knot *Calidris tenuirostris* and Bar-tailed Godwit *Limosa lapponica* might overfly the Sea of Okhotsk in favour of a long-distance migration not yet described in detail (Tomkovich 1997, Huettmann 2003a).

Northward migration is quicker than the southward migration, and usually starts around 15 May, peaks around 20 May and is completed by end of May (e.g. Huettmann 2001a,b). The timing and occurrence of shorebird migrations are fairly well described (see Gerasimov & Huettmann 2006 for details). However, we have only very limited information regarding the demographics, abundance, distribution, turnover and detailed migration strategies of shorebirds in the Sea of Okhotsk region. For instance, a very relevant migration region along the southern part of the flyway and comparable in size, the Yellow Sea, has received much survey and study effort, and thus is much better known and described (Barter 2002). Only a few hotspots are known for the Sea of Okhotsk (see Gerasimov & Huettmann 2006).

It is believed that many migration sites are still undetected and unknown and remain unsurveyed. Their conservation status must be considered as unknown. This is likely a true assumption because bird numbers encountered so far total much fewer than the overall flyway estimate. If this is the case, the importance of the Sea of Okhotsk for migratory shorebirds will be even greater than is currently thought. Other than work presented by the following scholars, in alphabetical order; Antonov & Huettmann (2004), Degen *et al.* (1998), Gerasimov & Gerasimov (1998), Gerasimov & Huettmann (2006), Huettmann (2003a,b), Nechaev (1992, 1969), Pronkevich (1998), Schuckard *et al.* (2006), Tomkovich (1997), and Zykov (1997), not much western peer reviewed literature exists on the migratory shorebirds for this region; publications focusing on shorebird habitat are virtually lacking. Nevertheless, the authors believe that the Sea of Okhotsk has already received a longer history of local surveys and assessments and that this history should enter the pool of information available to the international audience. Although some major sites are well known, they are not well described with studies with a hypothesis-testing framework and accurate confidence intervals and statistics (*sensu* Anderson *et al*. 2003), nor are the data readily available to the global citizen for the international review and assessment (e.g. SakhNIRO 2005 for Aniva Bay ecosystem). Much of this information still needs to be extracted from the Russian literature, from the grey literature (Russian and western), from historical and local knowledge, and from coarse global sources (Lotze *et al*. 2006, Global Millennium Ecosystem Assessment http://www.millenniumassessment.org/en/products.global.overview.asp).

CONSERVATION-RELATED RESEARCH HISTORY

Sustainable conservation management of a natural resource has a science-based foundation (Walters 1986, Braun 2005). So far, the Sea of Okhotsk has mostly been investigated by Russian scientists but deserves to be put and investigated in a much wider context. This is particularly important in the times of globalization, global climate change, habitat loss (del Hoyo *et al*. 1996), and due to the many international companies acting in the Sea of Okhotsk. Highest scientific standards need to established for safeguarding natural resources. This principle is well accepted and in line with best professional practices and principles (e.g. Truet & Johnson 2000, Braun 2005, Truet *et al*. 2005).

Descriptive research efforts started as early as the 18th century (Krasheninnikov 1786), and some were also international (Steller 1774). Much of motivation for these expeditions was driven by interests in natural resources, rather than interests in birds alone (but see for instance Moniyama 1928, Yamashina 1931, Belopolski 1933). None of the findings of these studies were used in conservation management as known today (Caughley & Sinclair 1994, Primack 1998, Braun 2005). Other than the work by Tomkovich (1997), Gerasimov & Gerasimov (1998), and Gerasimov *et al*. (1999), it is difficult even today to find research in the international peer reviewed literature that truly studies and addresses conservation issues for the study area. The word ‘conservation’ is hard to locate in ornithological research for the Russian Far East; it appears that such issues are actually discouraged by the Russian government. Although Shtilmark (2003) reports the establishment of protected zones, Zapovedniks, in the study area as early as the end of the 19th century, these efforts were done primarily to assure the survival of fur animal resources for harvesting.

Figure 1 shows locations in the wider study area that have received shorebird-related ornithological studies during the last 100 years. This is an incomplete survey because not all Russian museums and libraries have yet been scanned and investigated, a large task waiting to be undertaken. Further, interviews with local inhabitants seeking knowledge of shorebirds in their region have yet to be undertaken. It is clear from Figure 1 and Huettmann (2000) that many of the accessible sites along the coastline, specifically islands, have been surveyed at some stage during southward migration, but less so for the fast northward migration. This is due to weather and ice conditions in the Sea of Okhotsk which usually do not allow much travel until May, unless helicopters and motorboats are used. Due to the availability of such vehicles (Shtilmark 2003), these sites became accessible from the 1960s onwards. Since then this type of basic information has become available for the less easily accessible sites. Also since then, Russian shorebird research was often directed from Moscow and traditionally focused on descriptive breeding and general migration biology but without any clear hypothesis testing or application of modern statistics and analytical methods (Anderson *et al*. 2003), nor was it geared towards modern conservation management principles (Caughley & Sinclair 1994, Primack 1998, Braun 2005). Such data were not collected for monitoring, or management purposes, nor were centralized digital databases built. Fieldwork in these remote regions often lasted many months, allowing for a thorough picture to be built up of animals present. One should emphasize that the research structure in Russia differs from the western one, and sites like Sakhalin Island and Kamchatka for instance lack large universities as found in Moscow and St. Petersburg. Independent, international, peer reviewed, modern, quantitative ornithological research beyond the confirmation of species presence or absence is often missing. This results in many problems when it comes to sound environmental decision making with a view to the future of the region. The notion of forecasting and modelling, a requirement for many western impact activities (see Truet & Johnson 2000, Schneider *et al*. 2003, Braun 2005), is virtually not applied in the study area (but see Huettmann & Kusch 2006).

Some studies have been made by western or foreign scientists but their data and findings are usually not easily available, if at all. They might exist in field notes, as short published birding lists in local magazines, or as unpublished trip summary reports (e.g. Suter 1992). Many sites in the Sea of Okhotsk also have legal access restrictions, e.g. imposed by boarder guards for military and immigration reasons, further adding to the lack of surveys and information.

The lack of latest statistics and standardized survey protocols for shorebirds (for comparisons see, Seber 2002, Buckland *et al.* 2004, Braun 2005) harm inventories, site assessments and delineations, and our profession as a whole because we cannot produce reliable and robust findings for court decisions nor for safeguarding shorebirds and habitats along the flyway. Although this is also a larger problem in other parts of the EAA flyway and its management, and difficult technically with migratory birds in general (see Berthold 2001), there is no reason not to address this issue in the study area. Other than various visual assessments and the work by Schuckard *et al.* (2006), defendable turnover rates of migratory shorebirds are not known for the study area.

Shorebird banding, demographics, and physiology were not a Russian research priority, nor was creating consistent long-term data sets, any Remote Sensing & GIS-related research (see Gottschalk *et al.* 2005 for an overview), or using birds as bioindicators. Some bird banding work has, however, been done by Russian, Japanese, Australian and American groups in the study area but data from these studies are difficult to trace. Other relevant banding and sighting work dealing with birds from Russian Far East is carried out in many countries where these birds spend the non-breeding season. However, a thorough data exchange and a synoptic review of the current findings has not been made (see Canadian Bird Migration Atlas for an example Brewer *et al*. 2000), nor have protocols been harmonized. The authors know of no study that compared original migratory shorebird and habitat inventories with latest field investigations to assess trends over time (but see Tomkovich 1992 for breeding range), nor are Russian shorebird studies known to the authors dealing with stable isotopes and DNA (*sensu* Wenink 1994) in order to link Russian shorebirds with non-breeding grounds or food items. Monitoring, stable isotope, DNA, physiology and landscape studies (Huettmann 2004b) have just started.

Some mudflat inventories and benthos surveys exist (e.g. SakhNIRO 2005), but they usually carry a purely taxonomic and descriptive focus and do not link well with shorebirds, or habitat protection. Only a few single species studies have been carried out (see Tomkovich 1997, Gerasimov & Gerasimov 2000 for Great Knot; Gerasimov & Gerasimov 2001 for Dunlin *Calidris alpina*; Gerasimov and Gerasimov 2002 for Whimbrels *Numenius phaeopus*; and Gerasimov & Gerasimov 2006 for Wood Sandpiper *Tringa glareola*). Further, the occurrence of subspecies, their migration and habitat needs are not yet well established. Some references exist that summarize shorebird resources for the Sea of Okhotsk (Gerasimov *et al.* 1999, Gerasimov & Huettmann 2006). We have not learned of any large-scale landscape studies for the study area that consider the roles of the surrounding watersheds and landscapes (*sensu* Forman 1995; but see Huettmann & Kusch 2006 and Graeber 2006).

Most of the shorebird findings for the Sea of Okhotsk are traditionally published in summaries and national journals, but these are usually unknown to the western world and not externally peer reviewed. Such information can consist of abstract-length articles, describing field work done without hypothesis testing or addressing detectability issues. A centralized database on shorebird findings does not exist yet (but Pavel Tomkovich and his colleagues are currently developing a Russian Arctic shorebird atlas). One will not find relevant shorebird studies published with GBIF (Global Biodiversity Information Facility www.gbif.org), or ones that offer easily accessible digital data online and with Metadata (data that describe databases; see FGDC NBII website (http://metadata.nbii.gov/).

The Russian Red Data book covers species for all of Russia (Iliashenko & Iliashenko 2000). Species listed automatically become protected and a non-hunting species Russia-wide. The individual administrative regions of the Sea of Okhotsk have specific Red Data books, usually published by the respective governmental agencies (see also Russian Academy of Science 2000 for list of vertebrates). The local Red Data books usually include the entire Russian list, but they can make specific rules, e.g. when it comes to accidental species. According to Russian law, any listed Red Data book species and their habitat must not be affected by human action. However, these progressive laws are rarely enforced. Kamchatka currently includes six shorebird species of the Red Data Book (excluding accidental species such as Wandering Tattler), Sakhalin has 21 shorebird species listed, and the Kharabovsk region lists seven species (see Table 1).

Russia also has a Faunistic Commission on Waders. This Commission welcomes the discussion and confirmation of any new or interesting findings on shorebirds. They also check all new (and sometimes old) publications which contain information about shorebirds. This Commission publishes the results in “Information materials of the Working Group on Waders” once a year.

During the last decade, much investigation effort was carried out by local and international contractors and consultants, e.g. for basic environmental impact studies. These later data collections can be large and detailed but, unfortunately, they are not freely available, still in Russian, and not peer reviewed (see Truet & Johnson 2000 for comparison with a similar situation in Alaska). Examples where such efforts have been made are found on Sakhalin and in most of the official development projects throughout the study area. However, such investigations had unfortunately to be excluded from this review because they were not publicly available. The very recent construction of the largest liquefied natural gas (LNG) plant in the world on Sakhalin, supported in concert with the Russian government and industry and by many of the major and international oil companies (http://www.sakhalinenergy.com/ en/default.asp), has not resulted into the largest environmental impact studies and research projects of the world. One should state once more that Russia is a global player; that it was in 2004 the largest oil and gas producer in the world; and that it fully acts in collaboration with the western world. It is hard to understand why the western, or even higher environmental business standards, are not applied to provide a balanced and sustainable approach, to set a new global standard to be proud of, and to provide a great vision for the global community to follow.

Environmental lobby groups also act in the area (e.g. Sakhalin Environmental Watch www.sakhenvwatch.org, Salmon Lobby Groups like Pacific Environment http://pacificenvironment.org/ and Wild Salmon Center http://www.wildsalmoncenter.org/, and traditional environmental NGOs such as Greenpeace www.greenpeace.ru.org, WWF www.wwf.org) but usually they do not do very much scientific research and peer reviewed publication, or compile organized biodiversity databases of free access to the Russian and global public. So far, their role has mostly been to raise awareness, and run relevant lobbying and funding campaigns.

THE HABITAT AND ENVIRONMENTAL SITUATION

The Sea of Okhotsk is surrounded by the Russian landmass, and receives water from Japan and the northern Pacific. Some water inflow comes from as far as China. The area and related watersheds are relatively little populated, and except for Sakhalin Island’s economic development, many people have left the area over the last 15 years due to overall economic declines and growth elsewhere. This has resulted in a relatively good conservation situation, since the coastal region is consequently not that much threatened by real estate, pollution and boat traffic, as compared to many

Table 1. Russian Red Data Book (RDB) species in the Sea of Okhotsk. Names follow del Hoyo *et al.* (1996).

Species / Subspecies	**RDB of Russia**	**RDB of NE Asia**	**RDB of Khaba-rovsk region**	**RDB of Sakh-alin**	**RDB of Kam-chatka**
Long-billed Plover *Charadrius placidus*	*	.	*	.	.
Kentish Plover *Charadrius alexandrinus*	.	.	.	*	.
Eurasian Dotterel *Eudromias morinellus*	.	*	.	.	.
Black-winged Stilt *Himantopus himantopus*	*	.	.	*	.
Eurasian Oystercatcher (spp.) *Haematopus ostralegus osculans*	*	*	*	*	*
Green Sandpiper *Tringa ochropus*	.	.	.	*	.
Nordmann's Greenshank *Tringa guttifer*	*	*	*	*	*
Marsh Sandpiper *Tringa stagnatilis*	.	.	.	*	.
Wandering Tattler *Heteroscelus (Tringa) incanus*	.	*	.	.	.
Red-necked Phalarope *Phalaropus lobatus*	.	.	.	*	.
Ruff *Philomachus pugnax*	.	.	.	*	.
Spoon-billed Sandpiper *Eurynorhynchus pygmeus*	*	*	*	*	*
Long-toed Stint *Calidris subminuta*	.	.	.	*	.
Baird's Sandpiper *Calidris bairdii*	.	*	.	.	.
Curlew Sandpiper *Calidris ferruginea*	.	.	.	*	.
Dunlin (spp.) *Calidris alpine actites*	*	.	.	*	.
Rock Sandpiper *Calidris ptilocnemis*	*	*	.	*	*
Sharp-tailed Sandpiper *Calidris acuminata*	.	*	*	*	.
Western Sandpiper *Calidris mauri*	.	*	.	.	.
Buff-breasted Sandpiper *Tryngites subruficollis*	*	*	.	*	.
Broad-Billed Sandpiper (spp.) *Limicola falcinellus sibirica*	.	*	.	*	.
Jack Snipe *Lymnocryptes minimus*	.	*	.	.	.
Latham's Snipe *Gallinago hardwickii*	.	*	.	*	.
Solitary Snipe *Gallinago solitaria*	.	*	*	*	*
Little Curlew *Numenius minutus*	*	*	*	*	.
(Far) Eastern Curlew *Numenius madagascariensis*	*	*	*	*	*
Back-tailed Godwit (spp.) *Limosa limosa melanuroides*	.	*	.	.	.
Bar-tailed Godwit *Limosa lapponica*	.	*	.	.	.
Asian Dowitcher *Limnodromus semipalmatus*	*	.	.	.	.

regions elsewhere in the world (del Hoyo *et al*. 1996, Lotze *et al.* 2006 gives a global assessment). This coastal strip is also an important area for other species, e.g. breeding habitat for Locustella Warblers (Huettmann & Gerasimov 2002, Flint *et al.* 1984), gulls (Huettmann *et al.* 2005), and even ravens and bears (Graeber 2006).

For a period, gold mining in Kamchatka has been on hold in order to protect the salmon fisheries. However, the mining industry in Kamchatka has developed rapidly, not only for gold but for other big projects such as platinum and nickel extraction. Further, an oil exploring industry might develop on the shelf of the northeast Kamchatka coast very soon (see also Sintchenko 1998 for general economic development in Kamchatka). Periodically, the Magadan gold development was not that profitable and stalled, but in the last few years it has expanded. Some gold mining is also carried out on Sakhalin Island. Most watersheds in the Sea of Okhotsk are still not industrially developed and can be seen as relatively pristine (The Verengy river watershed provides a globally leading example, Martin & Augerot unpublished; http://www.wildsalmoncenter.org/). With few exceptions, forests in Primorye, and on the Kuriles are either protected or have not received much logging. Except for some disturbances caused by caterpillar tracks, trucks and snowmobiles bringing hunting, mushroom and berry gathering into the wilderness, most of the surrounding tundra is usually untouched. This tundra is already well known to be an important habitat for Whimbrels and other birds for instance (Huettmann & Gerasimov 2002, Schuckard *et al*. 2006).

Several villages and settlements on the Sea of Okhotsk shore have been deserted and many of their facilities are disintegrating leaving behind large amounts of metal and concrete (such coastal sites get used by shorebirds such as Grey-tailed Tattlers *Heteroscelus (Tringa) brevipes*). Some northern regions of the study area still include native reindeer herders who do not usually create a large human footprint on shorebird habitats. Much non-timber use of the land occurs as well e.g. mushroom and berry gathering. This can bring a larger amount of people in the wilderness regions (Newell 2004).

Other than suggestions by Wetlands International (2005), the Ramsar Convention (www.ramsar.org), CMS/GROMS (Convention of Migratory Species/Global Registry of Migratory Species www.groms.org) conventions, the Bird Migration Act (e.g. signed with the U.S.A. and Japan) and the Asia-Pacific Migratory Waterbird Conservation Strategy: 2001–2005 (http://www.deh.gov.au/biodiversity/migratory/waterbirds/2001-2005/section-d.html), a truly binding and local approach with an international and future vision for managing migratory shorebirds and coastal wetlands in the Sea of Okhotsk is missing (e.g. compare with Chabreck & Nyman 2005). Instead, however, there is a very strong motivation by local and federal governments as well as by the international community to develop many regions of the Sea of Okhotsk and to provide economic opportunities and incentives to the local communities (Newell 2004). This development is rapid and continues almost uncontrolled. Fishing is an intense activity in the study area, and many sea mammals - e.g. Grey, Killer and Beluga Whales, Walrus, Seals, Sea Lions and Sea Otters (Arthukin & Burkhanov 1999) - have been historically over harvested or otherwise affected. A similar situation can be found for land mammals (Shtilmark 2003); for seabirds this issue is not well studied (Shuntov 2000 a,b). Eco-tourism is widely promoted in the Sea of Okhotsk region, and it includes hiking, mountaineering, hunting, and catch and release fishing, often involving helicopter use (Zwirn *et al*. 2005). It seems, so far, not to have left a major human footprint, but is of general concern.

Oil and gas development off Sakhalin Island is one topic of serious environmental concern. Others are the constant pressures and initiatives to further intensify mining in Magadan, Kamchatka and in parts of Sakhalin Island. The hydropower project in the Khabarovsk region (supposed to provide electricity to China and the surrounding region), and underwater pipelines and new port facilities on Sakhalin Island (for extracting and shipping oil and gas) are other relevant projects affecting ecosystems. The largest liquefied natural gas plant of the world can be found at a wetland (locally known as Meira) at Aniva Bay, Sakhalin Island, which is a known site where many shorebirds of the EAA flyway rest and Red Book species such as Latham's Snipe *Gallinago hardwickii* occur (Nechaev 1992, Huettmann 2004b, FH pers. obs.).

Pollution caused by military is not that well reported but it is assumed to be substantial. For instance, Aniva Bay and Vostoshnii experienced military helicopter crashes; there was no major clean-up, and fuel and debris were deposited on the shores. Aniva Bay is also located near a major sea port (Khorsakov) and international airport (Yushnow); both are used for military, domestic, international and cargo purposes, adding further to the constant disturbance of shorebirds (Huettmann unpubl.). The remains of large military bases are also found in the Sea of Okhotsk region, for instance Nakhodka, Eleisovo/Petropavlovsk and on the Kuriles. Pollution levels there, e.g. due to sunk nuclear submarines and other waste, are not well known. In this regard, the biggest environmental topic in the Sea of Okhotsk is probably the uncertainty of toxic pollution levels (see Crane and Galasso 1999 for an overview). Chronic oil spills are not well documented; Keisuke and Huettmann (unpubl.) give observations of oiled seabirds; Wiese 2002 reviews intense chronic oil spill experiences in other parts of the world. Sakhalin Island for instance had lighthouses that were fuelled in Soviet times with radioactive nuclear batteries. It is reported in newspapers that these batteries would provide pollution and run-off in coastal waters of unknown effects (e.g. documented for Terpenia Bay and Schmidt Peninsula). Some plastic pollution, usually caused by fishing activities or inappropriate sewage treatments, was found on all shores of the Sea of Okhotsk we visited (Huettmann unpubl., Robards *et al.* 1997). The trends for this type of pollution are believed to be on the increase. Some river run-offs seem to carry toxic loads, such as for instance phenol in the Amur River, apparently coming from China.

An active and coordinated environmental monitoring scheme informing Russians and the international community about the state of the Sea of Okhotsk does not currently exist (for such an example in the Northern Pacific see Coastal Observation and Seabird Survey Team COASST http://coasst.org/index.cfm for citizen science on the opposite side of the Sea of Okhotsk). Despite these concerns, when compared to other sites in Russia, e.g. some arctic regions (CAFF 2001), the Sea of Okhotsk and its watersheds must still be considered to be relatively pristine and unspoiled. This relates specifically to physical habitat destruction and disturbances, e.g. extensive settlements, road networks, cars and related air pollution levels are usually lacking in coastal regions. One should consider though the widespread use of fishing boats and trucks on beaches (when accessible and for many fishing sites and cities such as Poronyask/Sakhalin, Vladivostok, Petropavlovsk, Yushnow/Iturp), the increasing international cruise ship eco-tourism (e.g. for Kamchatka, Kurile and Shantar Islands), and the abundant temporary fishing villages during summer (hovercrafts and All Terrain Vehicles were observed at several sites for instance). They all leave a significant footprint in the region affecting shorebirds and their habitats. For instance, many rivers are intensely fished, sometimes legally, sometimes illegally, for salmon and 'ikra' (salmon eggs) (Martin & Augerot unpublished, http://www.wildsalmoncenter.org/) using large fishing cranes operated by 'small' commercial enterprises; the authors have seen rivers with over 100 commercial cranes (Huettmann 2001a,b). The effects of predators such as inflated bear or gull numbers (Huettmann *et al*. 2005 for an inventory) on shorebirds and on local biodiversity are unknown but are assumed to be big (del Hoyo *et al*. 1996).

Any human settlement and most activities come with the introduction of rats (e.g. Primack 1998, Nettleship *et al*. 1994). Also, it was Russian policy for a long time to control predators nation-wide, e.g. bears and wolves (Russell and Enns 2003), and to introduce fur bearing animals such as sable, mink and fox (Shtilmark 2003; see also Wannhoff & Toermer 1997). Shorebirds are easily predated by such species. Hunting and poaching play a role in some communities and protected areas, but we believe that, except for perhaps Whimbrel (Huettmann & Gerasimov 2002), this is less of an issue for shorebirds because of their relatively low protein content not justifying the cost of an expensive bullet. It is worth mentioning that many hunters are not that skilled in the identification of shorebird species, and that confusion can occur, e.g. Nordmann's Greenshank v. Common Greenshank *Tringa nebularia* or Little Curlew *Numenius minutus* v. Whimbrel *N. phaeopus*.

Finally, we know of no settlement at the Sea of Okhotsk that has an environmentally safe sewage treatment plant (see Huettmann 2001a,b for concentrated Wood Sandpiper and Long-toed Stint *Calidris subminuta* sightings in sewage ponds). This situation is slowly changing but adds further to the cumulative effects that degrade the Sea of Okhotsk and its migratory shorebird habitat. Biodiversity Zones aside, habitat protection measures, e.g. in the form of strictly enforced National Parks or Marine Protected Areas, are not known to the authors and for the study area.

OUTLOOK AND RESEARCH MANAGEMENT SUGGESTIONS

The Sea of Okhotsk has links through its migratory species with many parts of the world; namely with Asia, North America, Europe, and Australia and New Zealand even. Most of the Sea of Okhotsk is currently not under immediate threat of human sprawl, but is instead greatly affected by the increasing human consumption of goods and resource extraction. Relevant, strategic and truly enforced habitat protection measures for shorebirds such as National Parks are crucial to have but none are envisioned. The research demands from Asia on the Sea of Okhotsk have to be judged as 'huge'. For the region overall, the human population is slowly decreasing, creating an unusual pattern along the EAA flyway where coastal real estate is always under heavy threat. However, regions like Sakhalin Island are experiencing a steep increase in oil and gas development without making use of the latest biological science and best professional environmental practices (see Anderson *et al*. 2003, Truett *et al.* 2005, Huettmann 2005 for commonly accepted approaches). This is only possible due to the absence of research and democratic review mechanisms and lacking international awareness. These serious deficiencies have already left a large and lasting footprint on shorebird habitat and beyond, and will further add to ongoing species declines, extinctions and habitat loss. Despite the involvement of western companies usually abiding by democratic and environmental standards, environmentally appropriate oil spill plans and other protective measures and impact studies are not satisfactory and mutually accepted when it comes to shorebirds and many other biodiversity components. Based on the public record for instance, environmental impact assessments by various oil companies acting on Sakhalin do not mention shorebirds sufficiently, if at all, and do not use appropriate and latest statistical methods and interpretation (van Horne 1988; see also Anderson et al. 2003, Braun 2005). (The current bird focus is mostly on Steller's Sea Eagle *Haliaeetus pelagicus*; bears are for instance virtually ignored.) Some of the largest oil and gas facilities of the world exist in the heart of the study area and are located along flyways of international shorebirds (Gerasimov & Huettmann 2006). This situation has not resulted in a correspondingly large body of sustainable knowledge and data about the region, nor have mechanisms been put in place to ensure that an efficient use of this information can be made for a sound decision-making. Several of the large Russian resource extraction companies are also active in the study area, and usually they apply even lower environmental standards. A classic example is found with the Komi oil spill (http://www.american.edu/projects/mandala/TED/KOMI.HTM; see also Burger 1997 and CAFF 2001 for a global overview).

The fact that global warming is of global concern and that it will affect coastlines, habitats and shorebirds (Arctic Council 2004, CAFF 2001) has yet not stimulated the administrative bodies and international companies in the Sea of Okhotsk region to act and to be pro-active.

Science-based management of resources is not achieved; this results in unbalanced unsustainable exploitation and treatment of natural resources (Taber & Payne 2003, Braun 2005). Reaching these goals is time-critical because resources get destroyed in the meantime making efficient conservation impossible (Primack 1998, Braun 2005).

Research Management Suggestions

It needs to be discussed with the global and local community if and why the Sea of Okhotsk would not qualify for a World Heritage listing, why it has no Marine Protected Areas, and similar protection measures. Science-based management is the globally accepted standard for safeguarding natural resources (Walters 1986, Anderson *et al*. 2003, Braun 2005). When sound data are missing, the cautionary principle applies (see Caughley & Sinclair 1994, Primack 1998). These basic concepts need to be communicated and implemented with all players in the study area and along the flyway. Foremost, we suggest an effective, independent, transparent, international and interdisciplinary science and management board be set up to oversee and guide the development of the Sea of Okhotsk. For a science-based management regime to be successful, it is crucial to know more about the Sea of Okhotsk, its shorebirds and habitats along the flyway. An international monitoring scheme needs to be set up that links with the North Pacific, the Arctic, and globally; this should include Citizen Science projects. Interdisciplinary studies linking shorebirds with benthos and mudflats are required. Research findings need to exist in a convenient form so that they always represent the 'best available science', and then can be freely and efficiently used for policy and management by the local community, by the Russian government, by the national and international media, as well as by the international oil and gas companies, flyway conservation managers and the global community as a whole. All relevant data need to be independently peer reviewed and then made available online, digital, and be readily accessible (e.g. via GBIF; see also Huettmann 2005). Data policies set forth by the International Polar Year (IPY; http://www.ipy.org/ with Russia being a signatory country) already provide great examples and a template to follow (http://www.ipy.org/Subcommittees/final_ipy_data_policy.pdf). Relevant shorebird habitats need to be known. Demographics, physiology, populations, migration strategies, migration sites, turn-over rates, and migration windows need to be fully documented and understood.

It is likely that many of the required data can be achieved through coordinated and quantitative international shorebird banding, flagging and classic monitoring projects. Existing museum collections should be included as well (Graham *et al*. 2004). Shorebird work should directly complement global biodiversity research and conservation management, e.g. NAGISA (http://www.coml.org/descrip/nagisa.htm), ORNIS (http://olla.berkeley.edu/ornis/) and GBIF. Approaches commonly applied at flyways elsewhere need also to be applied (e.g. monitoring, stable isotope, genetics and using birds as bioindicators). Distribution maps for the Sea of Okhotsk region need to be created that show distributions, absolute abundances and uncertainties. Due to the urgency and the vast area being impossible to survey quickly, predictive modelling presents the only practicable short term solution (Elith *et al*. 2006, Huettmann & Kusch 2005, Yen *et al*. 2004) and it needs to be applied; the derived models then need to be constantly improved and implemented in an Adaptive Management framework (Walters 1986; Braun 2005). A shorebird and habitat field guide publication needs to be made available for the western as well as for the local communities. Accepted standards for environmental impact studies of migratory shorebirds and habitats need to be created and followed. Errors of the past need to be corrected. As already requested by the U.S. NEPA (National Environmental Policy Act) for instance (Braun 2005), a cumulative impact model must be developed (*sensu* Schneider *et al*. 2003) to show and assess all impacts, as well as future scenarios, e.g. global change and a habitat-based Population Viability Analysis (PVA; e.g. Morris & Doak 2002). A vision and policy needs to be outlined by the international community on how the future of migratory shorebirds and their habitats can be maintained world-wide and in a pristine state.

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SHOREBIRD AND GULL CENSUS AT MOROSHECHNAYA ESTUARY, KAMCHATKA, FAR EAST RUSSIA, DURING AUGUST 2004.

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An international team of ornithologists visited the mouth of the Moroshechnaya River, Kamchatka (56°50'N, 156°10'E), the most northern Shorebird Network Site in the East Asian–Australasian Flyway from 9 to 16 August 2004. The expedition was organised to gather information on shorebirds using this site during southward migration. Earlier studies by Gerasimov and Huettmann pointed to the importance of this estuary during northward and southward migration. The expedition carried out the following program:

(i) Quantitative monitoring of populations during southward migration in seven surveys of the estuary and ocean beach. The most common shorebird species detected were Dunlin (*Calidris alpina*), Red-necked Stint (*C. ruficollis*), Whimbrel (*Numenius phaeopus*), Bar-tailed Godwit (*Limosa lapponica*), and Great Knot (*C. tenuirostris*). Maximum number of shorebirds on one day was about 15,000. Moroshechnaya is of international importance for Whimbrels and Bar-tailed Godwits. Total shorebird numbers and the daily totals for Lesser Sand Plover, Great Knot, Dunlin and Red-necked Stint also reach the threshold of international importance at the staging criterion of 0.25%.

(ii) A total of 227 shorebirds were captured and banded. For the first time, yellow over black leg flags were used. Three Red-necked Stints have been resighted in Japan and one was reported from north-west Australia. Three Dunlins have been resighted, one in Japan and two in China. One Great Knot has been resighted in Saemangeum, South Korea.

(iii) Blood samples were taken from Dunlin to allow determination of subspecies using the area by DNA analysis (leader: Liv Wennerberg).

(iv) Feather samples were taken for stable isotope analysis to investigate the origin of birds (leader: Falk Huettmann).

(v) Faecal samples were taken from 84 individual shorebirds of 4 species, mostly juvenile Dunlin and Red-necked Stint, to examine for avian influenza viruses (leader: Paul Selleck, Australian Animal Health Laboratory).

INTRODUCTION

Many species of shorebird are well known for their long-distance migration. This group includes some of the longest non-stop migrants of any bird species. During migration shorebirds use a network of stopover sites which connect the breeding areas in the northern high Arctic with the non-breeding areas located in the southern hemisphere. The disappearance of a single site in this crucial chain could impact entire populations of shorebirds. Long-distance migratory shorebirds are a common asset shared by all countries visited by them. They are part of our global heritage. Goals of protection, maintenance and expansion of the network of important wader stopover sites are declared in a number of international agreements signed by many countries. There are at least five international conventions dealing with the protection of shorebirds and their habitat. One of the best known declarations is the Ramsar Convention. Based on criteria listed in this convention, the Asia-Pacific Migratory Waterbird Conservation Strategy was developed to identify and conserve the main framework of the important shorebird sites in the flyway. One of the actions highlighted in this Plan is the *"Ongoing survey, monitoring and research work on shorebirds and their habitats are needed to ensure that the Network actually is achieving the conservation of migratory shorebirds in the East Asian–Australasian Flyway"*. The establishment of wetland inventories, obtained using the best scientific methods available, is needed to promote the designation, and help protect, sites of international importance. Recommendation 4.6 (Montreux 1990) urges contracting parties to establish inventories showing in particular those sites which are of international importance according to the Ramsar Site criteria:

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Staging sites in the flyway are notoriously difficult to assess for bird numbers during migration because continuous arrival and departure obscures the total number of shorebirds using a staging site. It has been proposed that during migration a staging site of international importance needs to support a total of 5,000 shorebirds or 0.25% of the population of a staging shorebird species (Watkins 1997). Within the East Asian–Australasian Flyway (EAAF), most shorebirds breed in the Russian Far East, northern China and Alaska and migrate to Southeast Asia, Australia and New Zealand. Until now, most effort has been given to the monitoring of shorebird populations in countries such as Australia, New Zealand and Japan. However, for successful conservation of shorebird populations, other countries along the flyway must be included.

It is estimated that about eight million migratory shorebirds are in the EAAF (Bamford & Watkins 2005). Although much is unknown about migration patterns of many of the species (e.g. breeding, non-breeding, and stopover sites or migration routes), 455 key sites have been identified in the flyway. In the Russian Far East on the Kamchatka Peninsula, the Moroshechnaya estuary (56°50'N, 156°10'E) (Figure 1) has been identified as one of these key sites (Gerasimov & Gerasimov 1999b). An estimated 800,000–1,000,000 shorebirds have been reported to use this site during southward migration and 300,000 birds during northward migration (Gerasimov & Gerasimov 1997, 1999a).

In 1994 the Russian government established a Ramsar site encompassing 1500 km^2 of the 5450 km^2 Moroshechnaya catchment. This area comprises some of the most valuable coastal and wetland areas of the coast of the Sea of Okhotsk

Figure 1. The East Asian-Australasian Flyway shorebird site network. Moroshechnaya is the northernmost site.

(Newell 2004). From the 1970s to the early 1990s, the Moroshechnaya zakaznik (wildlife refuge) was properly protected, but after the late 1990s poaching became a significant threat for migrating, breeding and moulting geese. Also people working seasonally at the fishing settlement near the mouth of Moroshechnaya River were a source of disturbance for shorebirds, geese and ducks.

At the Ramsar conference in Brisbane, Australia in 1996, the Moroshechnaya River estuary was included in the "East Asian–Australian Shorebird Reserve Network" (Figure 1). In 1997, the Kamchatka Institute of Ecology sought support to conduct additional wildlife research at the site. A strategic part of the Shorebird Action Plan 2001–2005 is the development of a database of shorebird counts at internationally important sites. As part of the implementation of this plan, Wetlands International – Oceania endorsed the International Shorebird Research Expedition to the Moroshechnaya estuary. In August 2004, naturalists from the Russian Federation, U.S.A., Canada, Australia and New Zealand participated in this expedition to inventory shorebirds passing through the estuary on southward migration.

In this paper we report the results of shorebird and gull censuses at the Moroshechnaya estuary, and the adjacent areas along the Sea of Okhotsk (Figure 2). We also report on capture and banding/flagging efforts and turnover rates of some species based on recapture. In addition blood and feather samples were collected for DNA and stable isotope analysis to investigate the origin of some of the shorebird species using the site. Faecal samples were collected to screen for avian influenza in the birds passing through the estuary.

METHODS

Study Area

The Moroshechnaya estuary is located on the western side of the Kamchatka Peninsula in the Russian Far East. The Moroshechnaya River, one of the largest rivers in the region, flows westward across the Kamchatka plain from the Sredinny Mountains to the Sea of Okhotsk. The river is 270 km long and its watershed covers 5,450 km^2. Tidal flows at the river mouth created a 20 km long by 2 km wide estuary (Figure 2). The estuary is separated from the Sea of Okhotsk by a 1.5 to 2 km wide shingle spit with an area of 30 km^2. Tides range up to 5.7 m and influence the estuary for tens of kilometres inland. At low tide, large sandy beaches and mudflats are exposed, creating important feeding areas for substantial numbers of the shorebirds during migration. Approximately 3,700 ha of tidal flats were included in our census area. The biggest tidal flat area is situated to north-east of this spit.

The large volume of fresh water flowing down the Moroshechnaya River, in conjunction with strong sea currents and large tidal range, result in a complex estuary of marine and riverine sediments. The western shores of the spit are a predominantly coarse, sandy substrate exposed to the Sea of Okhotsk. The beach is dynamic with changing coastlines and habitats. The tidal zone in front of the beach appears to be very productive. Many exposed tube-worms and bivalves were observed (species not identified) after a big storm. The substrate along the river is small pea-gravel with mudflats of fine silt where the water flow decreases.

Gerasimov & Gerasimov (1997, 1999a, and 2000) found from surveys between 1975 and 1990 that about 23 shorebird species regularly pass through the Moroshechnaya Estuary during migration. Northward migration takes place from the middle of May to early June and the southward migration from July to September. They estimate that 300,000 shorebirds and about 92,000 gulls and terns staged at the estuary on northward migration and 800,000–1,000,000 shorebirds on southward migration. Table 1 gives their estimates for the most common species. A list of all bird species seen by date is given in the Appendix.

All numbers presented by these authors are based on the assumption of one day turnover rate and totals for the study periods were the sums of all daily counts. Total numbers for spring and autumn migration were further extrapolated for the overall migration period.

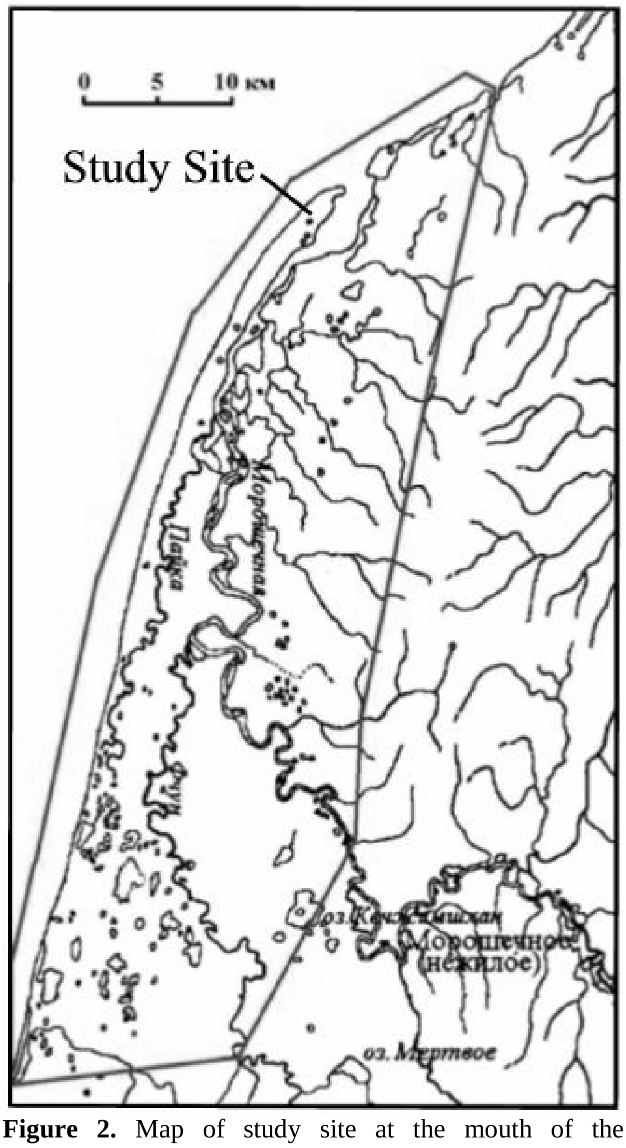

Figure 2. Map of study site at the mouth of the Moroshechnaya River. Area enclosed by line is Ramsar site.

Table 1. Estimates of shorebird numbers of main species passing through Moroshechnaya estuary on migration. Source: Gerasimov & Gerasimov (1997, 1999a, 2000)

Species	**Northward**		**Southward**
	Total Estimated	**Maximum Daily Count**	**Total Estimated**
Dunlin	150,000	18,500	350,000
Great Knot	40,000	17,000	100,000
Red-necked Stint	100,000	12,000	300,000
Red Knot	3,000	-	-
Bar-tailed Godwit	5,000	390	50,000
Whimbrel	1,000	420	100,000
Black-tailed Godwit	1,000	-	10,000
Lesser Sand Plover	1,000	-	-
Eastern Curlew	-	-	1,000
Eurasian Oystercatcher	-	-	1,000

Survey Methods

Surveys to determine bird abundance and species composition were conducted on foraging areas during low tide every 2 days (except for the first 2 surveys which were done on consecutive days). The surveys were carried out by three or four teams, each comprising three or four people. The composition of teams changed on each survey. Binoculars and spotting scopes were used to observe birds. Flocks were also scanned to look for birds that had been colour flagged in various locations of the flyway.

Surveys began at the base camp near the ranger's hut (Figure 3). The first survey area extended north along the river bank and ended at the fishing village (sections 1, 2 and 3). In this area, the far edge of the tidal flat in some areas was more than a kilometre away, making it difficult to identify and count distant birds; unidentified birds were recorded as unknown species. The second survey (section 5) area extended along the coastline from a point due west of the ranger's hut north towards the tip of the spit and back to the fishing village (section 4) on the inside of the spit. The third survey area extended south 6 km along the estuary (section 6a). On some surveys, the team covering this area crossed the spit from the southern end of the area to the coast and then surveyed northward to the second survey area (section 6b). Standard low water counts lasted between 3–5 hours per team.

When crossing the spit from the rangers hut to survey section 5 and on returning to the camp from the fishing village, distance sampling methods (Buckland *et al*. 2001) were used to survey birds using tundra areas. Using this technique, all species observed were counted; the most common species were Whimbrel, Willow Ptarmigan (*Lagopus lagopus*) and Middendorf's Grasshopper Warblers (*Locustella ochotensis*). Distance and angle from the transect line was recorded for each observation. Results from these surveys will be reported separately.

Capture Program

Mist nets were erected at five locations around the base camp to catch birds for banding and flagging. Most capture sessions occurred from dusk to midnight and dawn to mid-morning. Captured birds were assessed for moult, biometrics and mass, banded, and colour-flagged with a yellow and a

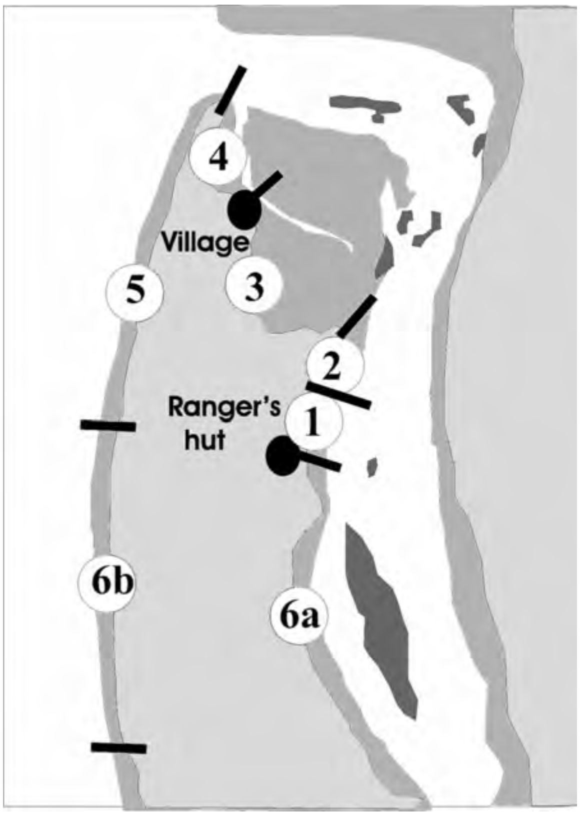

Figure 3. Study area at the mouth of the Moroshechnaya River. Light grey areas are tundra. Medium grey areas are mudflats exposed at low tide. Dark grey areas are elevated silt/ shingle islands exposed at low tide. Both mudflats and islands are covered at high tide.

black flag according to the EAAF flagging protocol.

The migration of subspecies of Dunlins passing through Kamchatka during southward migration has rarely been studied. Most Dunlin breeding in Kamchatka are subspecies *kitchinski*, but other subspecies (*articola* and *sakhalina*) may pass through during migration (Gerasimov *et al.* 1999). Blood samples were taken from Dunlins for genetic analysis to identify the subspecies caught. Secondary feathers were collected from juvenile Dunlins and Red-necked Stints for stable isotope analyses. These samples will complement blood samples to identify the breeding location of both species. Results from this program will be presented elsewhere.

RESULTS

Seven surveys were conducted between 8 and 22 August 2004. Weather conditions were generally favourable for surveying. On the 8, 12 and 16 August, the wind was coming from a southerly direction. On all other days the wind was coming from a more northerly direction.

Some of the surveys did not cover the complete study area. On 12 August, a sudden fog prevented the completion of the northern 50% of section 5 and section 4, and on 9 August the areas south of the ranger's hut (6a and 6b) were not included. Omitting counts from section 5 would likely result in undercounting of the species commonly observed along this part of the coastline: Great Knot, Eastern Curlew, Bar-tailed Godwit and gulls. Omitting the southern area on 9 August would result in undercounting Dunlin, Whimbrel and to a lesser extend Lesser Sand Plover and Red-necked Stint. Additionally, only three surveys covered the southern area (Section 6b) on the coastline, but this likely had little effect on shorebird counts as this area typically had few shorebirds and gulls. Details of the counts follow.

Shorebird Numbers

Twenty-three species of shorebird were observed during surveys (Table 2) and twenty six species were recorded over the whole expedition period. Western Sandpiper *(Calidris mauri)* was recorded as a new species for Kamchatka (Matsyna & Gerasimov 2005). A maximum count of approximately 15,000 shorebirds was recorded on 18 August, which is about 4 birds/ha of tidal flat. Most of the birds observed were foraging on the mudflats.

The most abundant shorebird species (Table 2) were Dunlin (22.4%-62.7% of daily counts), Bar-tailed Godwit (8.9%-29.6%), Red-necked Stint (1.3%-15.3%), Great Knot (0.7%-26.2%) and Lesser Sand Plover (0%-7.8%). Eurasian Oystercatcher, Red Knot, Far Eastern Curlew, and Black-tailed Godwit were observed in small numbers, never more than 2% of the daily counts. The endangered Spoon-billed Sandpiper was observed three times, one bird on both the 10 and 16 August and two on 18 August. Maximum counts of Great Knot and Eastern Curlew occurred on 9 August, the first day of the expedition. Red-necked Stint and Bar-tailed Godwit had their highest numbers during the first week of the expedition and Dunlin, Whimbrel and Lesser Sand Plover reached their peak numbers during the last few days of the expedition.

Shorebird Distribution

Table 3 gives the relative frequency with which each of the seven main species was recorded on each of the survey sections. It is very evident that there are very real differences in the species preferences.

Bar-tailed Godwit foraged mostly at the northern end of the study area, both along the Sea of Okhotsk and in the channel near the fishing village. Almost 70% of all Bar-tailed Godwits were recorded from these sections 3 and 5.

Dunlin occurred at very specific sites on the estuary. Almost 70% of all recorded Dunlins were along the banks of the river south of the Ranger's Hut (section 6a). Particularly after high spring tides, juveniles were observed foraging on what appeared to be amphipods in the tidal pools and small lagoons along the river

Red-necked Stint were widespread through the survey area, with no specific preference. Some of juvenile Red-necked Stints were also observed with juvenile Dunlins in the shallow tidal pools near the coast after the spring high tides.

Lesser Sand Plover were predominantly observed near the fishing village. Almost 65% of all Lesser Sand Plovers were recorded from section 3.

Great Knot were mostly recorded (44%) along the northern sandy coastline of the Sea of Okhotsk (section 5).

Whimbrel were mostly (91%) recorded along the river banks to the south of the Ranger's Hut (section 6a) while even higher numbers were observed foraging on berries and insects on tundra areas. These areas were sampled using different techniques (distance sampling) and will be reported in a separate paper.

Eastern Curlew were predominantly (87%) recorded along the northern coastline of the Sea of Okhotsk near the mouth of the river (section 5).

The most common shorebird species of Moroshechnaya have distinctive differences in their distribution through the study area. Bar-tailed Godwit, Lesser Sandplover, Great Knot and Eastern Curlew were mostly recorded in section 3 and or 5, In contrast, Whimbrel and Dunlin were most common where marine and freshwater environment overlapped, along the river south of the Ranger's hut, section 6a. The highest concentrations of Whimbrels were encountered in the tundra, presumably feeding on berries and insects. Great Knot and Dunlin were also recorded feeding on berries in the tundra.

Gull Numbers

Six species of gull were observed during the surveys, with a maximum count of almost 3,000 birds (Table 4). The most commonly observed gull species were Slaty-backed Gull (21%-39% of daily counts), Black-headed Gull (16%-30%), Mew Gull (14%-52%), and Glaucous Gull (1%-7%). Herring Gull and Black-legged Kittiwake were observed in small numbers. We did not differentiate the *vegae* subspecies of the Herring Gull, which is considered by some to be a separate species (East Siberian Gull *Larus argentatus vegae*). Maximum counts of Slaty-backed Gull, Black-headed Gull and Mew Gull occurred on 16 August, while

Table 2. Shorebirds at Moroshechnaya Estuary, August 2004

Species	**Date**						
	9	**10**	**12**	**14**	**16**	**18**	**20**
Grey Plover *Pluvialis squatarola*	1	12	-	-	-	-	-
Pacific Golden Plover *Pluvialis fulva*	-	1	1	-	3	1	-
Lesser Sand Plover *Charadrius mongolus*	2	274	107	327	150	7	751
Ruddy Turnstone *Arenaria interpres*	-	-	1	4	8	2	-
Eurasian Oystercatcher *Haematopus ostralegus*	39	51	17	25	25	21	18
Sandpiper unid.	-	-	15	1	-	-	80
Wood Sandpiper *Tringa glareola*	4	1	-	1	-	-	-
Common Greenshank *Tringa nebularia*	3	2	3	39	4	13	2
Spotted Redshank *Tringa erythropus*	-	2	-	-	-	-	-
Marsh Sandpiper *Tringa stagnatilis*	3	4	-	-	-	-	-
Grey-tailed Tattler *Heteroscelus brevipes*	-	1	-	-	-	1	1
Common Sandpiper *Actitis hypoleucos*	-	-	1	2	1	-	-
Terek Sandpiper *Xenus cinereus*	1	1	-	-		-	-
Red-necked Phalarope *Phalaropus lobatus*	4	19	1	11	-	-	-
Spoon-billed Sandpiper *Eurynorhynchus pygmaeus*	-	1	-	-	1	2	-
Red-necked Stint *Calidris ruficollis*	700	736	778	1205	506	404	127
Long-toed Stint *Calidris subminuta*	-	-	1	-	-	-	-
Dunlin *Calidris alpina*	1024	2719	2881	7103	6994	9161	4847
Great Knot *Calidris tenuirostris*	1198	806	119	160	226	100	84
Red Knot *Calidris canutus*	5	6	104	4	40	83	9
Eastern Curlew *Numenius madagascariensis*	34	14	1	14	6	6	4
Whimbrel *Numenius phaeopus*	116	1190	1506	2221	2091	3490	2554
Black-tailed Godwit *Limosa limosa*	80	21	25	8	22	19	60
Bar-tailed Godwit *Limosa lapponica*	1351	1867	774	1598	1458	1302	1067
Totals	4565	7728	6335	12723	11535	14612	9604

Table 3. Percentages of main shorebird species counted in each section

Section	**Bar-tailed Godwit**	**Dunlin**	**Red-necked Stint**	**Lesser Sand Plover**	**Great Knot**	**Whimbrel**	**Eastern Curlew**
1 and 2	0.3%	5.6%	11.6%	0.2%	21.1%	2.4%	-
3a, 3b, 3c	33.1%	20.9%	17.8%	63.4%	22.1%	3.7%	6.3%
4	20.0%	4.3%	15.4%	1.7%	4.5%	0.2%	2.5%
5	35.0%	1.2%	18.0%	-	44.2%	2.1%	87.3%
6a	11.6%	67.6%	27.4%	34.6%	7.2%	91.4%	2.5%
6b	-	0.3%	9.8%	0.1%	0.9%	0.2%	1.3%

Table 4. Main gull species at Moroshechnaya Estuary, August 2004

Species	**Date**						
	9	**10**	**12**	**14**	**16**	**18**	**20**
Black-headed Gull *Larus ridibundus*	181	72	169	253	572	312	234
Slaty-backed Gull *Larus schistisagus*	228	158	202	389	621	454	284
Glaucous Gull *Larus hyperboreus*	26	21	25	40	29	59	68
Mew Gull *Larus canus*	493	138	81	675	714	214	272
Totals	928	389	477	1357	1936	1039	858

Glaucous Gulls reached their maximum at the end of the expedition, on 20 August.

Gull Distribution

Over half of gull observations were near the north end the spit in section 5 (Table 5). This is likely due to favourable foraging opportunities caused by human activities at the fishing village. Gulls world-wide respond to human presence, e.g. through the additional provisioning of food (Blokpoel and Spaans 1991, Furness and Monaghan 1987), a situation that occurs in the Sea of Okhotsk region (Huettmann unpubl., Huettmann *et al*. 2005)

Shorebird Banding

Mist nets were used near the base camp to catch feeding and roosting shorebirds. During 13 trapping sessions, 227 individuals of 6 shorebird species were caught (Table 6). Only Dunlin (123) and Red-necked Stint (85) were caught in appreciable numbers. All but 3 of the Dunlin were juveniles. Nineteen (15.4%) juvenile Dunlin were recaptured on subsequent days. These re-trapped birds had been staging at

Table 5. Percentages of main gull species counted in each section

Section	Black-headed Gull	Slaty-backed Gull	Glaucous Gull	Mew Gull
1 and 2	5.7%	2.6%	3.4%	3.6%
3a, 3b, 3c	15.7%	6.3%	13.8%	5.4%
4	8.0%	8.2%	8.2%	3.3%
5	45.0%	59.7%	61.9%	65.3%
6a	5.5%	13.9%	8.6%	18.1%
6b	20.1%	9.4%	4.1%	4.3%

Table 6. Daily numbers of shorebird captures at the Moroschechnaya Estuary in August 2004.

Date	Dunlin	Red-necked Stint	Lesser Sand Plover	Great Knot	Whimbrel	Red-necked Phalarope
9	1	-	-	-	-	-
10	1	-	-	-	-	-
11	7	-	-	-	-	-
12	1	4	-	-	-	-
13	7	7	-	-	-	-
14	10	13	-	-	-	1
15	22	18	1	-	2	-
16	13	-	2	-	-	-
17	10	1	5	-	-	-
18	9	4	1	-	-	-
19	23	24	2	1	-	-
20	12	8	-	-	-	-
21	7	6	-	4	-	-
Totals	123	85	11	5	2	1

the estuary between 2 and 10 days (average: 6 ± 3 days) after their first capture. All of the captured Red-necked Stints were juveniles. Eight (9.4%) of the total were re-trapped between 1 and 7 days (average 3 ± 2days) after their first capture.

Biometrics and Additional Samples from Captured Shorebirds

Captured birds were fully processed; moult, bill length, wing length and weight were recorded for all birds. Blood samples for genetic analysis were collected from 57 Dunlins. Secondary feather samples for stable isotope analysis were collected from 115 Dunlin and 84 Red-necked Stint. All biometric data will be assessed in combination with blood samples for DNA and feather samples for stable isotopes. The results will be published separately. Faecal samples to screen for the presence of Avian Influenza were collected from 47 Dunlins, 31 Red-necked Stints, 4 Lesser Sand Plovers and 2 Great Knots. Paul Selleck, of the Australian Animal Health Laboratory, has confirmed the absence of avian influenza viruses.

Flag Sightings at Moroshechnaya

During the expedition, there were sightings of 13 flagged Bar-tailed Godwits and 2 flagged Red Knots (Table 7). Seven of the flagged godwits had a white flag on the right tibia, indicating they were captured in New Zealand. Six godwits had a yellow flag on the right tibia, indicating that they were captured in north-west Australia. Careful observation of plumage characteristics indicated that these observations represent minima of two white flagged and four yellow flagged godwits.

Both Red Knots had an orange flag on the right tibia, the colour combination used in south-east Australia. Both were in full breeding plumage, making it impossible to judge if one or two individuals were involved.

Observations elsewhere in the Flyway of Birds Banded at Moroshechnaya

Between 14 and 32 days after banding, three Red-necked Stints banded in Moroshechnaya were observed in Japan. One Red-necked Stint was sighted in north-west Australia between 222 and 231 days after banding. Two flagged Dunlins were observed: one from Japan 28–40 days after banding and one from China 141–153 days after banding. A colour-banded Great Knot was re-sighted on northward migration at Saemangeum, South Korea on 14 April 2006.

Relative Species Abundance

It would be of interest to compare species abundance in 2004 with that of previous years. This is done for the counts conducted on 18 August in the two years 1999 and 2004 (Huettmann 1999). Relative abundance can be examined using rank correlation methods. Figure 4 plots the 2004 rank against that of 1999 for the ten species caught in both surveys. This shows that the four species (Dunlin, Bar-tailed Godwit, Great Knot, and Red-necked Stint) were the most common in both years and three species (Far Eastern Curlew, Common Greenshank, and Ruddy Turnstone) were the least common in both years. The relationship is statistically significant at the 1% Level (Spearman's rank correlation coefficient = 0.770).

Table 7. Observation of colour flagged birds at the Moroshechnaya Estuary. Russia, August 2004. Yellow flags are applied in north-west Australia, orange flags are applied in Victoria in south-east Australia and white flags are applied in New Zealand.

Date	Location	Observers	Combination	Comment
Bar-tailed Godwit				
10-Aug-04	Village	RS / JG	Yellow R Tibia	
12-Aug-04	Ocean (SOFO)	RS / JG / SK	White R Tibia	
14-Aug-04	Ocean (SOFO)	RS / SK	White R Tibia	
14-Aug-04	Ocean (SOFO)	RS / SK	Yellow R Tibia`	
15-Aug-04	Ocean (SOFO)	JG / KG	White R Tibia	
16-Aug-04	Ocean (SOFO)	FH / KM	White R Tibia	
16-Aug-04	Village	RS / JG / KG	Yellow L Tibia	Breeding plumage
16-Aug-04	Village	RS / JG / KG	Yellow R Tibia	Non-breeding plumage
16-Aug-04	Village	RS / JG / KG	Yellow R Tibia	Breeding plumage (female?)
16-Aug-04	Village	RS / JG / KG	White R Tibia	Breeding plumage (moulting)
18-Aug-04	Village	RS / SK /KM	Yellow R Tibia	Non-breeding plumage (female?)
18-Aug-04	Village	RS / SK /KM	White R Tibia	Breeding plumage (moulting)
18-Aug-04	Ocean (SOFO)	KG / JG	White R Tibia	
Red Knot				
14-Aug-04	Rangers Hut	JG / KG	Orange R Tibia	Breeding plumage
16-Aug-04	River (South)	YG / SK	Orange R Tibia	Summer plumage

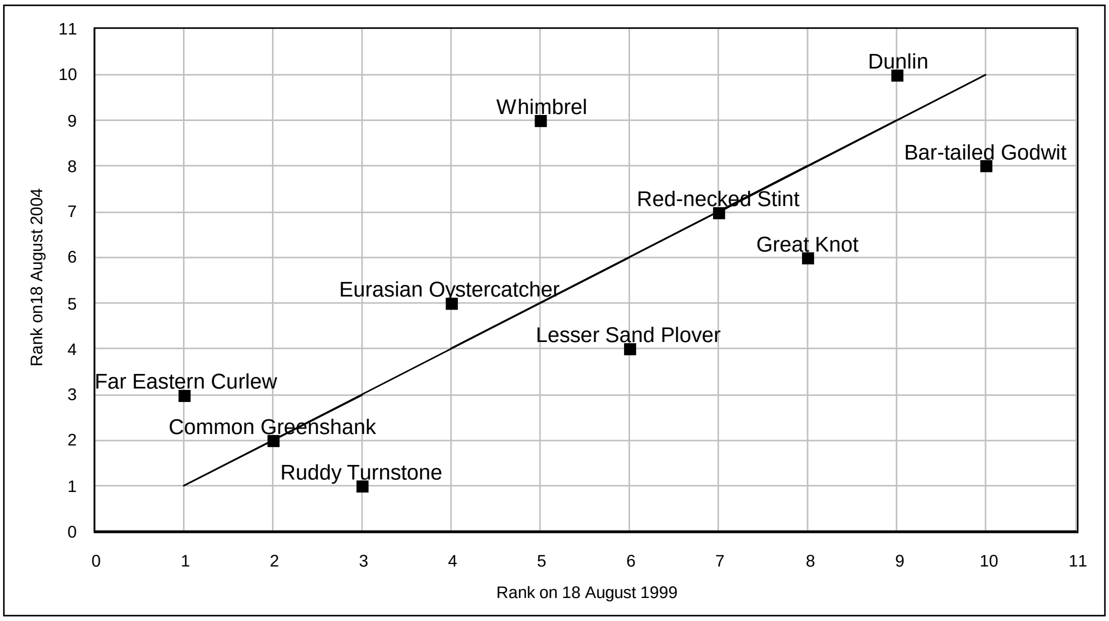

Figure 4. Species ranks on 18 August in 1999 and 2004 for species caught in both years.

DISCUSSION

Assessment of International Importance

Our estimates of shorebirds using the area support earlier studies highlighting the importance of the estuary during southward migration. The numbers from our expedition are, however, lower than numbers reported by Gerasimov & Gerasimov (1997, 1999a and 2000). This could be partly an artefact due to different survey and population estimation methods. As previously mentioned, our estimates are maximum daily counts rather than the sum of daily counted birds that passed through the area.

During the expedition in 2004 southward migration had already started. The staging criterion (0.25%) was therefore appropriately applied. The total number of shorebirds, as well as numbers of Lesser Sand Plover, Great Knot, Red-necked Stints and Dunlin, were recorded in numbers of International Importance (Table 8). The maximum number of shorebirds at Moroshechnaya during the 2004 expedition was approximately 15,000. By the staging criterion of 0.25%, Moroshechnaya is a site of international importance if 5,000 shorebirds occur at one moment (Table 8). While 15,000 is the maximum number of birds observed at one time, it is likely that were a census conducted in all habitats of Moroshechnaya estuary, in particular the tundra, the threshold of 20,000 shorebirds (Ramsar criterion 5) would likely be exceeded. Huettmann & Gerasimov (2002) concluded that the total number of shorebirds from coast and

Table 8. Maximum numbers of the common shorebird species of the Moroshechnaya Estuary. In bold, numbers according to the 1% and 0.25% criteria to assess if sites are of international importance.

	Maximum between 8 and 20 August 2004	1% Ramsar Criterion for Sites of International Importance	0.25% Criterion for staging sites of International Importance
All Shorebirds	14,612	20,000	**5,000**
Lesser Sand Plover	751	1,300	**325**
Great Knot	1,198	3,300	**950**
Red-necked Stint	1,205	3,150	**788**
Dunlin	9,161	9,500	**2,375**
Whimbrel	3,490	**550**	138
Bar-tailed Godwit	1,867	**1,700**	425

tundra in Moroshechnaya estuary easily reached the threshold of 20,000 shorebirds during southward migration.

Whimbrel

Whimbrel (*N. p. variegatus)* breed in eastern Russia and occur in southern and south-eastern Asia and Australia in the non-breeding season. Whimbrel that occur in southern Asia during the non-breeding season use the Central Asian Indian Flyway (CAIF), while those that occur in south-eastern Asia and Australasia in the non-breeding season utilize the EAAF (Bamford *et al.* in prep.). The total population of Whimbrel in the EAAF is estimated at 55,000 (Bamford *et al.* in prep.). During the expedition more than 6% of this population were observed in a single day on the tidal flats at Moroshechnaya. This estimate does not include the large number of birds foraging in tundra areas. Our peak count of 3,490 on 18 August in 2004 seems to support earlier reports of peak numbers from mid-August to early September (Lobkov 1980 in Huettmann *et al.* 2002). Further study is required to determine if additional later waves of Whimbrel do occur and continue to use Moroshechnaya during southward migration. Gerasimov & Gerasimov (1997, 1999a, 2000) estimated 15,000–20,000 Whimbrel at Moroshechnaya at one time and assumed as many as 100,000 individuals could pass through the estuary on southward migration. Huettmann and Gerasimov (2002) incorporated both the tundra and the shoreline in their survey of Moroshechnaya estuary in August 1999. Apart from the tundra, their study area was about the same as this study. They estimated about 28,000 Whimbrels use the spit as a daily average. They conclude that most Whimbrel use the tundra and move upriver during low tide. Southward migration counts in this region far exceed the suggested Minimum Population Estimate for the EAAF; this is possibly related to an admixture of birds from the EAAF and adjacent CAIF (Bamford *et al.* in prep.). Our data support the conclusion that Moroshechnaya is a very important area for Whimbrel during southward migration.

Bar-tailed Godwit

Two subspecies of Bar-tailed Godwit occur in the central Pacific basin. The subspecies *L. l. menzbieri* breeds coastally in north-eastern Siberia, from the Yana River delta east to Chaun Gulf (McCaffery & Gill 2001, Gill *et al.* 2005) and spends the non-breeding season in north-west Australia (e.g. Higgins & Davies 1996, Gill *et al.* 2005). The population of *L. l. menzbieri* is estimated at 170,000 (Gill *et al.* 2005). The *L. l. baueri* population breeds in western and northern Alaska and spends the non-breeding season in New Zealand and eastern Australia (McCaffery & Gill 2001, Gill *et al.* 2005). This population is estimated at 155,000 (Bamford *et al.* in prep.).

There have only been two records on southward migration of marked *baueri* on the Asian mainland compared to regular sightings of marked *menzbieri* at intermediate East-Asian stopover sites. Both subspecies use intermediate stopover sites along the Asian coast on northward migration (e.g. Minton *et al*. 2001, 2004, Gill *et al*. 2005). One of the marked *baueri* birds was banded in North Island of New Zealand as an adult and shot on 2 October 1992 near Lake Bolshoe, Kamchatka, Russia (A. Riegen pers. comm.). It is thought that during southward migration *baueri* follow a direct route across the Pacific from Alaska to New Zealand and south-east Australia (e.g. Minton *et al*. 2001, 2004; Gill *et al*. 2005). Sightings of two to seven white-flagged individuals during the expedition would at least double the number of records of birds that spend the non-breeding season in New Zealand after taking an Asian route during southward migration. One explanation is that a few *baueri* follow the southward migration route of *L. l. menzbieri*. Alternatively a small portion of *menzbieri* visit New Zealand in the non-breeding season. Repeated observation of white-flagged godwits in Moroshechnaya during the expedition in 2004 with similar plumages, provided a strong indication that the same birds staged for several days. The majority of godwits recorded during the expedition are *L. l. menzbieri*. A peak of 1,867 birds exceeds the threshold of 1% to make this site of international importance to this sub-species.

Lesser Sand Plover

Lesser Sand Plover has four recognized races in the EAAF (Bamford *et al.* in prep.). The race *Charadrius mongolus stegmanni* is a common breeder in dry mountain tundra of the whole of Kamchatka (Gerasimov *et al.* 1999b) and it is presumed that all 11 birds that were trapped were of the race *stegmanni*. While the total number of Large Sand Plover is estimated at about 130,000, the subspecies *stegmanni* is estimated at 20,000. With a maximum of 751 birds passing through Moreshechnaya, it is debatable if we reached the 1% criterion for this subspecies. Moroshechnaya is of international importance for Lesser Sand Plover if the numbers are assessed with the staging criterion (Table 8).

Great Knot
Great Knot has been reported from the Moroshechnaya Estuary in high numbers on southward migration (Gerasimov & Gerasimov 1997, 1999a, 2000). Also, Huettmann reported sighting 5,000 Great Knots from the same estuary between 1 and 8 August (Huettmann 2003). Our numbers are similar to earlier studies with peak numbers of about 1,100 birds (Huettmann 1999). There are still big gaps in our knowledge of the distribution of this species in the Sea of Okhotsk during southward and northward migration (Huettmann 2003). It is speculated that the speed of migration and shorter stop-over periods on southward migration result in lower counts for the Yellow Sea compared to northward migration (Bamford *et al.* in prep.). Only five juvenile Great Knots were banded during the expedition. It was noticed that some of these birds had been feeding on berries in the tundra. It is unknown how many birds were uncounted during surveys because they were feeding on the tundra. Moroshechnaya is of international importance for Great Knot if the numbers are assessed with the staging criterion (Table 8).

Dunlin
Of the nine recognized races of Dunlin, four are currently believed to migrate through the EAAF. They are *C. a. arcticola,* breeding in Alaska, and *C. a. kistchinski*, *C. a. sakhalina*, and *C. a. actite*s, breeding in Siberia and eastern Russia. The population estimates of Dunlin in the EAAF vary between 1 and 3 million (Bamford *et al.* in prep.). Dunlin was by far the most common species during the expedition, accounting for 22% – 63% of daily counts with a maximum of 9,161 on 18 August. The occurrence of Dunlin was very site specific with a strong preference for the river habitat. All but 3 of the 123 trapped birds were juveniles. Most of the Dunlins feeding in the shallow ponds of the tundra appeared to be juveniles. A difference in preference of feeding juvenile and adult Dunlins has been reported for other races too. Younger birds from *C. a. pacifica* had a significantly higher terrestrial contribution to diet (43%) than did adults (35%) (Ogden *et al.* 2005). Nineteen juveniles (15.4% of the total catch of 123 individuals) were recaptured on subsequent days. These re-trapped birds had been staging at the estuary between 2 and 10 days (average: 6 ± 3days) after their first capture. This is the first indication that at least a portion of the most commonly encountered species stages for longer than one day. The average weight change of the retrapped birds was +0.5% (± 1.9% points) of the original bodyweight per day (n=19). Weight loss as a result of the catching procedure has been reported (Wilson *et al.* 1999). Birds may have to extend their staging to compensate for this loss. This seems however an unlikely scenario in Moroshechnaya where birds were mostly processed within the hour after catching. Also, natural higher weight loss in the first hour after capture is probably mainly due to defecation, natural metabolism and evaporative cooling (Wilson *et al.* 1999). Due to the cool conditions of Moroshechnaya, even the loss of water for evaporative cooling also seems unlikely. Further analyses of DNA, biometrics and stable isotopes will provide more information on where the migrating Dunlin originate.

Red-necked Stint
Red-necked Stint breed in the high Arctic of far eastern Russian and north-west Alaska (Bamford *et al.* in prep.). Red-necked Stint accounted for 1% -15% of total shorebird numbers in daily counts with a maximum of 1,205 on 14 August. All of the captured Red-necked Stint were juveniles. Eight (9.4% of the total catch of 85 individuals) were re-trapped between 1 and 7 days (average 3 ± 2days) after their first capture, indicating that at least a portion of this species also stages longer than 1 day. Weight change of the retrapped birds was +1.7% (± 5.4% points) of the original bodyweight per day (n=6). See Dunlin above for further comment. A further analysis of biometrics and stable isotopes will provide more information on where the migrating Red-necked Stint of Moroshechnaya originate.

Overview

Fifty-three species and subspecies of shorebirds have been recorded in Kamchatka, as either local breeders or migrants (Gerasimov *et al.* 1999). During this expedition 26 shorebird species were recorded, including Western Sandpiper which is a new species for Kamchatka. Of the species observed, Black-tailed Godwit, Dunlin *(C. a. kitchinski*), Eurasian Oystercatcher, Whimbrel, Lesser Sand Plover and Far Eastern Curlew have been reported as common breeders in Kamchatka (Gerasimov *et al.* 1999). The other species, including different subspecies of Dunlin (*C. a. articola* and *C. a. sakhalina*), are migrants (Gerasimov *et al.* 1999), using Moroshechnaya as a stopover site between breeding and non-breeding areas. Most of the species known to occur on Kamchatka that were not recorded at Moroshechnaya during the 2004 expedition are considered to be rare (Gerasimov *et al.* 1999).

This study re-emphasises the importance of the Moroshechnaya estuary to the East Asian–Australasian Flyway. Densities of 4 birds/ha during low tide at the flats are comparable to other important staging areas, for example: the 5.0 birds/ha in Waddensea in north-western Europe (Smith and Wolf 1981) and 5.0 birds/ha in Morecombe Bay in the United Kingdom (Davidson *et al.* 1991).

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APPENDIX. BIRDS SIGHTED AT MOROSHECHNAYA ESTUARY IN AUGUST 2004

N.B. Dates in boldface indicate days on which both the river and coast were surveyed.

Species	**Date**															
	7	**8**	**9**	**10**	11	**12**	13	**14**	15	**16**	17	**18**	19	**20**	21	22
Bean Goose *Anser fabalis*			*	*	*	*	*	*	*	*	*	*	*	*	*	*
Eurasian Wigeon *Anas penelope*				*				*		*	*		*	*	*	
Northern Shoveller *Anas clypeata*			*												*	
Northern Pintail *Anas acuta*			*	*	*	*	*	*	*	*	*	*	*	*	*	*
Green-winged Teal *Anas crecca*		*				*	*	*	*	*	*	*	*	*	*	
Greater Scaup *Aythya marila*			*	*	*	*	*	*	*	*	*	*	*	*	*	
Harlequin Duck *Histrionicus histrionicus*		*	*	*	*	*	*	*	*	*	*	*	*	*		
White-winged Scoter *Melanitta fusca*			*	*	*	*	*	*	*	*	*	*				
Black Scoter *Melanitta nigra*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Common Goldeneye *Bucephala clangula*			*													
Common Merganser *Mergus merganser*		*	*	*	*	*	*	*	*	*	*	*				
Red-breasted Merganser *Mergus serrator*					*					*		*		*		
Willow Ptarmigan *Lagopus lagopus*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Red-throated Loon *Gavia stellata*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cormorant sp. *Phalacrocorax* sp.														*		
Steller's Sea-Eagle *Haliaeetus pelagicus*	*															
Black-bellied Plover *Pluvialis squatarola*			*													
Pacific Golden Plover *Pluvialis fulva*				*		*		*		*		*				
Lesser Sand Plover *Charadrius mongolus*		*		*		*		*		*	*	*	*	*	*	
Eurasian Oystercatcher *Haematopus ostralegus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Common Greenshank *Tringa nebularia*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Marsh Sandpiper *Tringa stagnatilis*		*		*												
Spotted Redshank *Tringa erythropus*				*												
Wood Sandpiper *Tringa glareola*		*	*	*	*	*	*	*	*	*	*	*	*			
Gray-tailed Tattler *Tringa brevipes*				*								*		*		
Common Sandpiper *Tringa hypoleucos*					*		*		*			*		*		
Terek Sandpiper *Tringa cinerea*		*		*	*	*	*									
Whimbrel *Numenius phaeopus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Far Eastern Curlew *Numenius madagascariensis*		*	*	*	*	*	*	*	*	*	*	*	*	*		
Black-tailed Godwit *Limosa limosa*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bar-tailed Godwit *Limosa lapponica*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Ruddy Turnstone *Arenaria interpres*			*			*		*		*		*			*	
Great Knot *Calidris tenuirostris*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Red Knot *Calidris canutus*			*	*	*	*	*	*	*	*	*	*	*	*	*	
Red-necked Stint *Calidris ruficollis*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Temminck's Stint *Calidris temminckii*									*							
Long-toed Stint *Calidris subminuta*					*	*										
Dunlin *Calidris alpina*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Western Sandpiper *Calidris mauri*																
Spoonbill Sandpiper *Eurynorhynchus pygmeus*	*			*						*	*	*				
Snipe sp. *Gallinago* sp.	*														*	
Common Snipe *Gallinago gallinago*			*													
Red-necked Phalarope *Phalaropus lobatus*		*	*	*		*		*			*				*	
Parasitic Jaeger *Stercorarius parasiticus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Long-tailed Jaeger *Stercorarius longicaudus*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
[Common] Black-headed Gull *Larus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Species	**Date**															
	7	**8**	**9**	**10**	11	**12**	13	**14**	15	**16**	17	**18**	19	**20**	21	22
ridibundus																
Mew Gull *Larus canus*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Herring Gull *Larus argentatus*		*	*	*				*	*	*		*		*		
Slaty-backed Gull *Larus schistisagus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Glaucous Gull *Larus hyperboreus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Black-legged Kittiwake *Rissa tridactyla*		*	*	*		*			*			*		*		
Common Tern *Sterna hirundo*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Arctic Tern *Sterna paradisaea*		*	*						*	*						
Aleutian Tern *Sterna aleutica*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
White-winged Tern *Chlidonias leucopterus*				*?												
Murre sp. *Uria* sp.									*							
Cuckoo sp. *Cuculus* sp.			*													
Common Raven *Corvus corax*			*		*	*		*	*			*		*	*	*
[Eurasian] Skylark *Alauda arvensis*		*	*	*	*	*	*	*	*	*	*	*	*	*		
Middendorff's Grasshopper-Warbler *Locustella ochotensis*		*	*	*	*	*	*	*	*	*	*	*	*	*		
White Wagtail *Motacilla alba*									*						*	*
Yellow Wagtail *Motacilla flava*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Olive Tree-Pipit [Olive-backed Pipit] *Anthus hodgsoni*			*													
Pechora Pipit *Anthus gustavi*									*	*	*	*	*	*	*	*
Red-throated Pipit *Anthus cervinus*														*		
Lapland Longspur *Calcarius lapponicus*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Yellow-breasted Bunting *Emberiza aureola*					*											
Pallas's Reed-Bunting *Emberiza pallasi*										*						
Common Rosefinch *Carpodacus erythrinus*				*												
Redpoll sp. *Carduelis* sp.								*								
Common Redpoll *Carduelis flammea*														*		

THE FOURTH FULL SHOREBIRD SURVEY OF YALU JIANG NATIONAL NATURE RESERVE. 13 – 23 APRIL 2006

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INTRODUCTION

Yalu Jiang National Nature Reserve is situated on the northeast coast of the Yellow Sea in China, adjacent to North Korea (Fig. 1). Little ornithological data for the reserve was available before 1999 when the first full survey of the reserve was undertaken (Barter *et al.* 1999). In all, four comprehensive shorebird counts have now been conducted at the Yalu Jiang National Nature Reserve, located on the northeast coast of the Yellow Sea in Liaoning Province, China (Barter *et al*. 2000a, Barter *et al*. 2000b, Barter & Riegen 2004). In addition a partial count was conducted in May 2005. These have taken place in mid- and late April and early and late May. In late April 2004, 166,000 shorebirds were counted, slightly fewer at 153,000 in early May 1999, 129,000 in mid-April 2006, and a low of 93,000 in late May 2000 when many birds had already left for the breeding grounds. The most numerous species present (based on an average of all four counts) were Bar-tailed Godwit, Great Knot, Dunlin, Grey Plover, Eurasian Curlew and Eastern Curlew. These six species account for 95% of the shorebirds counted and all six species occur in internationally important numbers. A further five of the 36 species recorded in the Reserve – Broad-billed Sandpiper, Lesser Sand Plover, Kentish Plover, Eurasian Oystercatcher and Nordmann's Greenshank – have also occurred in internationally important numbers. Yalu Jiang has been considered the second most important site for shorebirds yet found in the Yellow Sea behind Saemangeum in South Korea. However, with the completion of the sea wall in the 40,000 ha Saemangeum reclamation area in April 2006, Yalu Jiang will probably become the most important site in the Yellow Sea. Yalu Jiang is by far the most important single site yet discovered for Bar-tailed Godwit on northward migration in Asia and it is quite possible that most of the *baueri* subspecies passes through there. The *menzbieri* subspecies also occurs in the reserve although generally slightly later than *baueri*, probably because the breeding grounds of *baueri* in western Alaska become ice-free sooner than those of eastern Siberia, the range of *menzbieri*.

SURVEY METHODS

As in previous years the shorebird survey was conducted along the intertidal zone and coastal aquaculture ponds along the entire 60 km coastline of the reserve (Fig. 2). The reserve has been split into five sections and 15 individual sites (Fig. 2). These sites are all situated along the seawall at the last mudflat points to be covered by the incoming tide. All 15 sites can be covered well in 6 days with two teams of counters. No birds were recorded in the reed beds near the Gushan Management Station which were dry in 2006; in 2004 they held Little Curlew and Wood Sandpiper.

Counts were carried out from 13–23 April 2006, 20–25 April 2004, 2–9 May 1999, and 16–23 May 2000. In 2006 the weather, although often cold and breezy, was generally fine allowing a good counts by four experienced counters from New Zealand and several Yalu Jiang National Nature Reserve staff along with staff from various nature reserves around China who where there for a training course. The count was interrupted on several occasions. April 16 was lost to heavy rain and the period April 17–20 to other events. Erdaogou (site 2) was visited on 18 and 19 April and although no formal counting was undertaken numbers were thought to be similar to those formally counted on 23 April.

During a spring sequence of tides most tides reach the

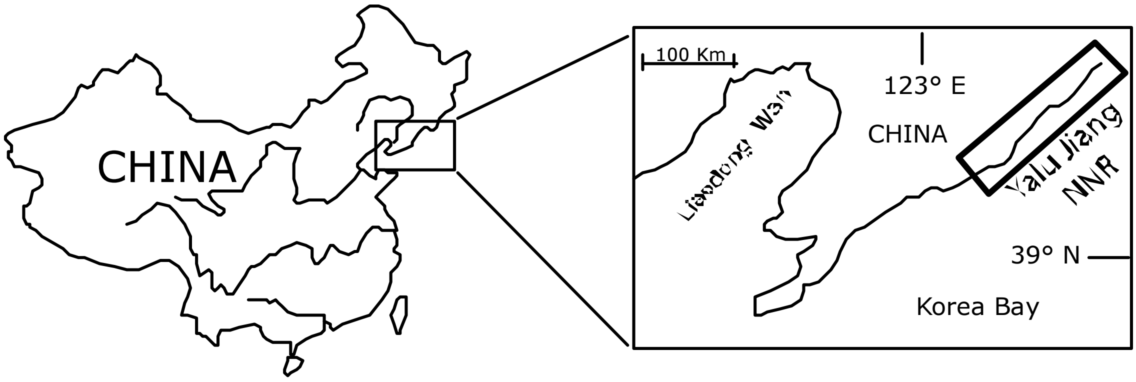

Figure 1. China & Yalu Jiang Location Map.

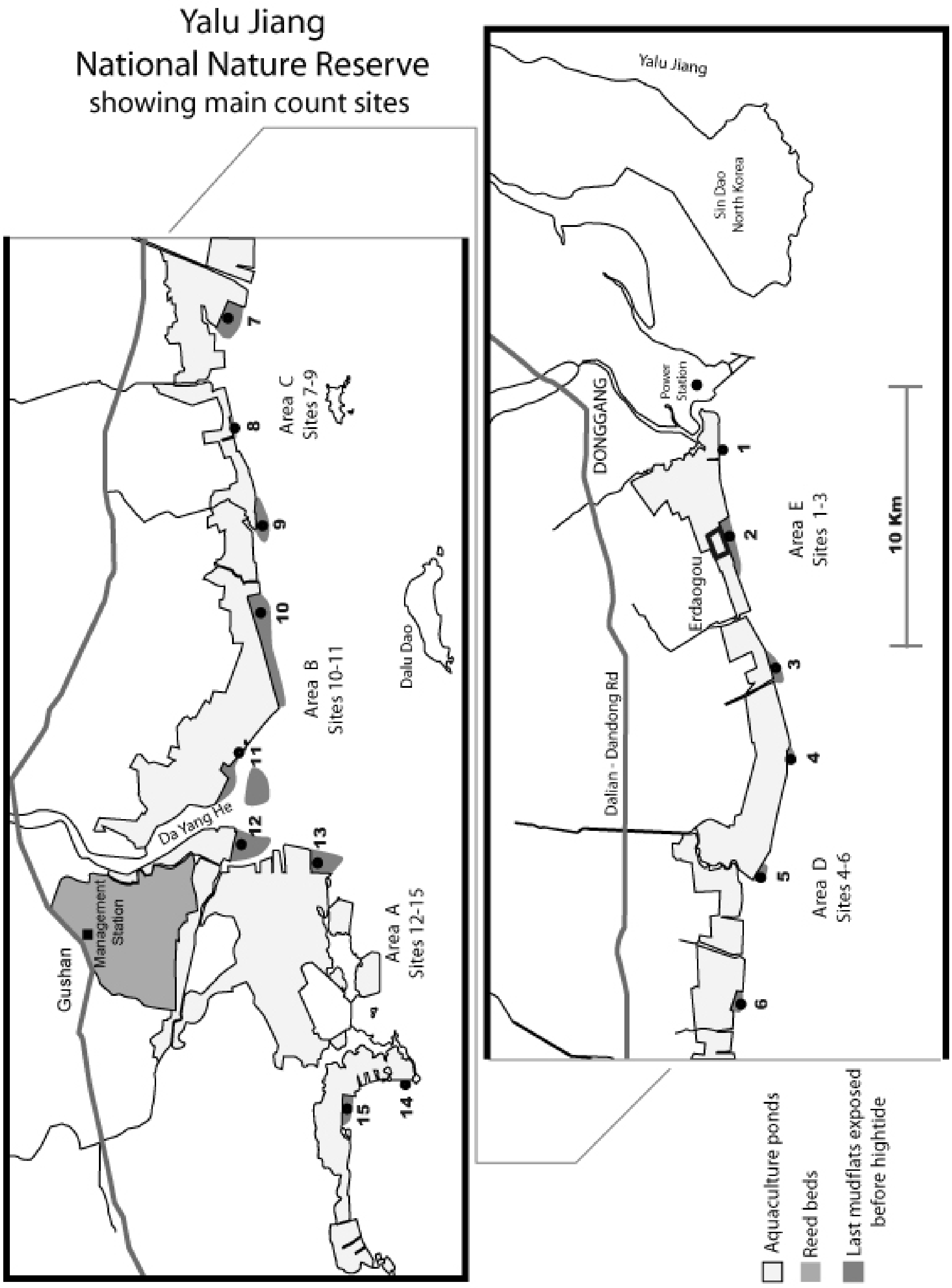

Figure 2. Location map of Yalu Jiang National Nature Reserve showing count sites.

seawall at Yalu Jiang forcing the birds to leave the mudflat and roost within the aquaculture ponds over the high tide period. During neap tides birds remain along the water's edge often some distance from the seawall making counting difficult. Counts are therefore planned to coincide with spring tides. Shorebirds gather on the last remaining mudflats to be covered by the high tides and it is at this time that the birds are counted. As they leave the mud they are observed to check for movement to other count sites. Often they scatter to numerous ponds, some of which are quite difficult to reach. They are also quite wary, particularly if they need to roost on pond banks. At these times it is very difficult to count birds accurately. Some birds return to the mudflats as soon as the first mud is exposed on the dropping tide. Others only return once the tide has receded some distance when they are too far away to count. Counting just before the tide reaches the seawall is considered the optimum time.

The 15 recognised sites have proved over the four counts to be the best places to count birds. Counters aim to reach these sites at least two hours before high tide – and monitor movement of birds as they approach the sea wall. Birds are constantly recounted during this time to ensure the best possible accuracy. On particularly high tides the sea reaches the seawall very quickly making accurate counting difficult. As our understanding of the Yalu Jiang tides improves we can select the most suitable tides for counting.

Generally we believe the counts are reasonably complete and accurate. Some problems arise with the largest flocks sometimes containing 15–30,000 birds and methods of improving these counts are being considered, including the use of digital photos. Counts are adjusted when birds move between sites although we believe birds are reasonably site faithful in the short term. This is illustrated by the fact that certain species seem to favour particular sites from one year to the next.

We use the 'Pangolin' tide table for Dalu Dao, a small island just south of the reserve. This table, first used by Mark Barter in 1999, differs from the official Chinese tide table only in predicted tide heights. Tide times in both tables are very similar but the Chinese tables show tides higher by about one metre. This is of little consequence as long as we can interpret the predicted heights. We have ascertained that 5.1 m tides on the Pangolin tables reach the seawall at all count sites and determine count periods accordingly.

RESULTS

Table 1 summarizes the species and totals for April 2006. A total of 24 shorebirds species were counted totalling 129,359 birds. Nine species occurred in internationally important numbers (i.e. more than 1% of the world population): Bar-tailed Godwit, Great Knot, Dunlin, Eurasian Curlew, Eastern Curlew, Grey Plover, Eurasian Oystercatcher, Nordmann's Greenshank, and Kentish Plover, the last being added to this list for the first time. Together they account for 98% of the birds counted. Total counts from all years including the 2005 partial count are shown in Table 2. Table 3 summarizes numbers of shorebirds at each site on the four full counts and it is clear from this that Site 2, Erdaogu, where the hides are set up, consistently holds the largest number of birds.

Species Reaching the 1% Criterion at Yalu Jiang

Bar-tailed Godwit

On three main counts Bar-tailed Godwit have been the most numerous shorebird (average over four counts is 47,000 birds). Only in early May 1999 were they slightly outnumbered by Great Knot. Observations and flag sightings have shown that two subspecies, *baueri* and *menzbieri*, use Yalu Jiang on northward migration. Both subspecies were present in mid-April 2006 although *baueri* were more numerous as was expected. The spring thaw occurs earlier in western Alaska allowing *baueri* to reach their Alaskan breeding grounds in the first week of May, whereas the spring thaw is later in Siberia constraining *menzbieri* to move through slightly later (McCaffery & Gill 2001). Determining how many Bar-tailed Godwit actually use the site is problematic but it is likely to be significantly more

Table 1. Total count for April 2006 by area. Internationally important species in 2006 in bold face. Count sites are shown in Fig. 2.

Species	Total	Count Sites					1% Criterion
		12-15	10-11	7-9	4-6	1-3	
Black-tailed Godwit	3	2	-	-	-	1	1600
Bar-tailed Godwit	**45,691**	**2,737**	**1,026**	**2,053**	**7,870**	**32,005**	**3,250**
Whimbrel	89	31	28	-	15	15	550
Eurasian Curlew	**6,100**	**623**	**4,308**	**183**	**951**	**35**	**350**
Eastern Curlew	**2,126**	**289**	**1,050**	**162**	**494**	**131**	**380**
Curlew sp.	4,100	130	-	1,840	920	1,210	
Spotted Redshank	113	7	71	-	11	24	250
Common Redshank	54	16	11	2	12	13	650
Marsh Sandpiper	2	-	-	-	2	-	1,000
Common Greenshank	33	2	7	2	10	12	550
Nordmann's Greenshank	**24**	**-**	**-**	**-**	**-**	**24**	**10**
Wood Sandpiper	3	3	-	-	-	-	1,000
Terek Sandpiper	27	-	-	-	4	23	500
Common Sandpiper	6	1	1	-	-	4	300
Ruddy Turnstone	4	-	-	-	-	4	310
Great Knot	**16,268**	**468**	**2,210**	**50**	**3,140**	**10,400**	**3,800**
Red Knot	1	-	-	-	-	1	2,200
Red-necked Stint	62	1	60	-	-	1	3,150
Dunlin	**43,875**	**23,435**	**5,875**	**600**	**6,395**	**7,570**	**9,500**
Curlew Sandpiper	7	-	6	-	-	1	1,800
Eurasian Oystercatcher	**296**	**2**	**2**	**273**	**13**	**6**	**100**
Black-winged Stilt	13	-	-	-	13	-	250
Grey Plover	**5,573**	**230**	**699**	**483**	**1,754**	**2,407**	**1,250**
Kentish Plover	**1,485**	**228**	**730**	**181**	**297**	**49**	**1,000**
Lesser Sand Plover	4	2	-	1	-	1	600
Unidentified	1,000	-	1,000	-	-	-	
Unidentified large	1,200	1,200	-	-	-	-	
Unidentified small	1,200	-	-	1,200	-	-	
Site Totals	**129,359**	**29,407**	**17,084**	**7,030**	**21,901**	**53,937**	**34,348**

Table 2. Summary of all full counts and 2005 partial count. Internationally important species in bold face.

Species	Survey period					1% Criterion
	13–23 April 2006	**20–25 April 2004**	**2–9 May 1999**	**8–12 May 2005**	**16–23 May 2000**	
Common Snipe *Gallinago gallinago*	-	2	-	-	-	1,000
Snipe sp.	-	-	5	-	-	
Black-tailed Godwit *Limosa limosa*	3	2	-	-	17	1,600
Bar-tailed Godwit *Limosa lapponica*	**45,691**	**66,134**	**51,918**	**49,100**	**26,169**	**3,250**
Little Curlew *Numenius minutus*	-	1,183	-	20	-	
Whimbrel *Numenius phaeopus*	89	414	286	166	232	550
Eurasian Curlew *Numenius arquata*	**6,100**	**13,136**	**234**	**645**	**563**	**350**
Eastern Curlew *Numenius madagascariensis*	**2,126**	**3,874**	**3,744**	**955**	**731**	**380**
Curlew sp.	4,100	1,407	20	-	130	
Spotted Redshank *Tringa erythropus*	113	171	162	31	10	250
Common Redshank *Tringa totanus*	54	18	49	35	44	650
Marsh Sandpiper *Tringa stagnatilis*	2	1	-	16	-	1,000
Common Greenshank *Tringa nebularia*	33	165	351	72	258	550
Nordmann's Greenshank *Tringa guttifer*	**24**	**-**	**-**	**12**	**3**	**10**
Green Sandpiper *Tringa ochropus*	-	5	-	-	-	
Wood Sandpiper *Tringa glareola*	3	465	490	49	123	1,000
Terek Sandpiper *Xenus cinereus*	27	56	153	99	326	500
Common Sandpiper *Actitis hypoleucos*	6	3	5	3	23	300
Grey-tailed Tattler *Heteroscelus brevipes*	-	-	6	2	19	
Ruddy Turnstone *Arenaria interpres*	4	9	44	39	194	310
Great Knot *Calidris tenuirostris*	**16,268**	**32,880**	**55,178**	**20,270**	**26,093**	**3,800**
Red Knot *Calidris canutus*	1	33	1,499	-	61	2,200
Sanderling *Calidris alba*	-	7	-	-	13	220
Red-necked Stint *Calidris ruficollis*	62	20	299	36	541	3,150
Temminck's Stint *Calidris temminckii*	-	-	-	1	-	
Long-toed Stint *Calidris subminuta*	-	3	24	7	-	250
Sharp-tailed Sandpiper *Calidris acuminata*	-	35	61	47	97	1,600
Dunlin *Calidris alpina*	**43,875**	**34,841**	**25,181**	**22,913**	**22,482**	**9,500**
Curlew Sandpiper *Calidris ferruginea*	7	1	-	6	2	1,800
Spoon-billed Sandpiper *Eurynorhynchus pygmaeus*	-	-	-	-	1	30
Broad-billed Sandpiper *Limicola falcinellus*	**-**	**12**	**729**	**98**	**723**	**250**
Eurasian Oystercatcher *Haematopus ostralegus*	**296**	**224**	**70**	**109**	**189**	**100**
Black-winged Stilt *Himantopus himantopus*	13	14	38	15	-	250
Pacific Golden Plover *Pluvialis fulva*	-	9	147	2	-	
Grey Plover *Pluvialis squatarola*	**5,573**	**4,628**	**4,005**	**6,010**	**7,232**	**1,250**
Kentish Plover *Charadrius alexandrinus*	**1,485**	**436**	**12**	**15**	**17**	**1,000**
Lesser Sand Plover *Charadrius mongolus*	**4**	**171**	**306**	**305**	**647**	**600**
Oriental Pratincole *Glareola maldivarum*	-	1	-	-	-	30,000
Unidentified	1,000	2,111	7,702	17,930	6,050	
Unidentified large	1,200	4,000	-	-	-	
Unidentified small	1,200	-	-	-	-	
Totals	**129,359**	**166,471**	**152,718**	**119,008**	**92,990**	

than the highest count.

Dunlin

Very large numbers of this species have been counted on each survey with the highest number in mid-April 2006 when almost 44,000 were counted. This number represents some 5% of the flyway population and was over a third of the total number of shorebirds counted. On the first day of the survey (April 13), Dunlin were showing quite low levels of breeding plumage but by the April 23 their breeding plumage was much more advanced.

Great Knot

The 16,000 counted in mid-April 2006 is the lowest figure to date of the second most numerous shorebird (average of 32,000). The count is only half that of late-April 2004. The peak number (55,100) was in early-May. Great Knot was one species that visibly increased in the course of the 2006 survey. Observations in South Korea in late-April 2006 showed large numbers of Great Knot at Saemangeum with many looking very lean. There were also colour-flagged birds from Chongming Dongtan flagged just two weeks earlier. This evidence further confirms that this species works its way up the Yellow Sea during northward migration.

Eurasian Curlew

Yalu Jiang is a very important site for this species on migration with a peak number of 13,000 recorded in late-April 2004. By early-May 1999 numbers had dropped to less

Table 3. Site totals for comprehensive surveys. Count sites are shown in Fig. 2.

Count Site	1999	2000	2004	2006	Average
1	22,714	4,220	7,837	1,399	9,043
Erdaogu **2**	**30,869**	**18,222**	**38,032**	**33,616**	**30,185**
3	18,890	9,429	10,229	18,922	14,368
4	5,002	3,613	1,160	3,470	3,311
5	9,459	6,428	17,679	15,097	12,166
6	5,137	6,514	5,785	3,334	5,193
7	9,781	14,249	23,236	4,748	13,004
8	-	1,029	3,700	275	1,251
9	12,077	1,080	7,272	2,007	5,609
10	10,830	17,392	9,150	10,546	11,980
11	4,269	7,166	9,447	6,538	6,855
12	20,919	2,391	14,333	6,328	10,993
13	With 12	1,006	1,711	921	910
14	1,381	-	-	7	347
15	-	-	14,910	22,133	9,261

than 250. In 2006, 4,100 curlews were not identified to species level for several reasons, including being too distant, in mainly back-lit situations, or too tightly packed. It was difficult to estimate the proportion of Eurasian Curlew to Eastern Curlew as both species were often unevenly distributed in the roosting flocks.

Grey Plover
Numbers on three counts fairly steady in the range 4,000 – 5,500 but with over 7,000 in late-May 1999. Yalu Jiang is clearly a significant site for this species with an average of over 5,300 birds.

Eastern Curlew
Another species still on the increase in mid-April with 2,100 counted, rather less than the 3,800 in late-April 2004 and the 3,700 in early-May 1999. Yalu Jiang is an important staging site for this species and total numbers passing through are likely to be much higher.

Eurasian Oystercatcher
Site 7 is the only site that holds a flock of this species; 256 were counted here in 2006 out of a total of 296. Other counts are usually of nesting pairs scattered through the reserve. Several pairs were apparently sitting on eggs in 2006. This year's count is almost 3% of the flyway population.

Broad-billed Sandpiper
None were seen in 2006 but with over 700 seen in early and late-May and only 12 in late-April, this species clearly comes through the reserve later in the season.

Nordmann's Greenshank
This globally endangered species has been recorded at Site 2 three times in five surveys, with 3 in late-May 2000, 12 in early-May, and 24 in mid-April 2006. The 24 represents about 3% of the world population. At the same time, 43 were recorded at Saemangeum in South Korea (Tattler April 2006). On 13 May 2006, 39 were recorded at Site 2 (Bai Qingquan pers. comm.). The birds seen on 23 April 2006 showed little sign of breeding plumage, but photos taken on 13 May showed at least 50% breeding plumage. Based on observations in 2006 Yalu Jiang is an important site for this species.

Kentish Plover
Fewer than 500 had been counted at Yalu Jiang before 2006 when almost 1,500 were present.

Lesser Sand Plover
Only 4 birds were seen in 2006 but, with 306 in early May 1999 and 647 in late May, this is clearly a late migrating species.

Other species

Red Knot
The only large count of this species was 1,499 in May 1999. The estimated flyway population is 220,000 but the only significant concentration yet found has been in the Tianjin - Tangshan region of the Bohai Wan, China. The major staging sites in Asia for this species have still to be discovered.

Ruddy Turnstone
This is another species poorly represented at Yalu Jiang.

Whimbrel
With just 89 birds counted in 2006, numbers were very low compared to the other years when between 232 and 414 were counted.

Common Greenshank
Only 33 were counted in 2006, well down on the 351 counted in early May. In 2000 it was estimated that almost every shrimp pond (numbering *c*. 1,500) had at least one Greenshank. Even though many ponds were checked in 2006 the species was mostly absent. This species probably occurs in internationally important numbers and future counts of more ponds may confirm this.

Red-necked Stint
This is another species which appears to build up numbers towards the end of May with 541 counted in late-May 2000 but only 62 in mid-April 2006.

Wood Sandpiper
Just three recorded this year close to site 12 near the reed beds.

Little Curlew, Sharp-tailed Sandpiper, and Long-toed Stint prefer freshwater or brackish wetland. They were not recorded in 2006 probably because the reed beds at Gushan and the paddy fields were still very dry. All other species either occurred in similarly low numbers to previous years or were absent in 2006.

Flag and Colour Band Sightings

A good number of birds with leg flags and/or colour bands were observed. All colour bands were from New Zealand. A total of 63 partial or full band combinations were recorded but of these only 25 can be fully confirmed. Tables 4 and 5 summarise these sightings. Colour bands and flags were recorded by the following individuals: Bai Qingquan, Goa Zhidong, Niu Dongliang, Bruce Postill, Adrian Riegen, Sun Dong Yu, Gillian Vaughan, Wang Tao, Wang Xiaofei, Keith Woodley, Yan Meifang, Yuan Xiao, Zhang Guangming, Zhang Hong, and Zhang Zhi Yong

DISCUSSION

There is a need to carry out additional surveys particularly during the periods not yet covered; these will take several more years due to unhelpful tide cycles. Ongoing long-term monitoring will be valuable to determine the status of several migratory shorebird species in the flyway.

With so many keen eyes, 2006 proved to be a bumper year for flag and band sighting even though Yalu Jiang is not an ideal place for band sightings. Prior to roosting, most birds are on the mudflats to the south of the observers who are looking into the light. When birds are close to the seawall or in the ponds they are often packed in very tightly making observations difficult.

Initial attempts were made to band birds at Yalu Jiang during the period covered by the survey. While these were unsuccessful, valuable experience was gained by reserve staff. This will doubtless be useful for further attempts next year and beyond.

The reserve is without doubt the most important staging site on the East Asian–Australasian Flyway for both sub-species of Bar-tailed Godwit. Yalu Jiang is also the final staging site in the northern Yellow Sea and for many birds the last feeding place before their Arctic breeding grounds. As mentioned before, Yalu Jiang National Nature Reserve has, with the closing of the seawall at Saemangeum, become the single most important site for northbound migratory shorebirds on EAAF. This puts more pressure on the authorities in Liaoning Province to see that this newly acquired status is not lost. It will be interesting to monitor numbers over the coming years in an effort to determine the effects of the loss of Saemangeum.

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Table 4. Summary of leg flag sightings at Yalu Jiang

Species & Colours	Flagging Country	Flagging Region	Site Number							
			2	4	6	7	10	11a	15	Total
Bar-tailed Godwit										
yellow	Australia	North-west	3	-	3	2	1	-	1	10
yellow alphanumeric	Australia	North-west	1	-	-	-	-	-	1	2
green	Australia	SE Queensland	1	-	1	-	-	-	1	3
white	New Zealand	North Island	4	-	2	-	-	-	3	9
orange	Australia	Victoria	7	-	1	3	1	-	2	14
orange/green	China	Yalu Jiang	2	-	-	-	-	-	-	2
white/black	China	Chongming Dao	1	-	-	-	-	-	-	1
black/white	China	Chongming Dao (2006)	1	-	-	-	-	-	1	2
white/green	New Zealand	South Island	1	-	-	-	-	-	-	1
Great Knot										
yellow	Australia	North-west	-	1	-	-	-	-	1	2
orange	Australia	Victoria	-	-	-	-	-	-	1	1
Grey Plover										
orange/green	China	Yalu Jiang	-	1	-	-	-	-	-	1
yellow	Australia	North-west	-	-	-	-	-	1	-	1
		Total	**21**	**2**	**7**	**5**	**2**	**1**	**11**	**49**

Table 5. Confirmed Sightings of New Zealand colour banded Bar-tailed Godwits

#	Date	Site	Colour bands	Site/Region	Island	Details
1	16/04/06	7	2RWWR	Firth of Thames	North	Adult male, 22/10/05
2	18/04/06	2	4YYYW	Manawatu	North	Adult female, 31/1/06
3	18/04/06	2	1YWWW	Golden Bay	South	1st year female, 13/12/04. Now age 2.
4	18/04/06	2	1WBRR	Tasman Bay	South	Either Adult male 15/12/04 or Adult female 9/3/05
5	18/04/06	2	2YWYY	Firth of Thames	North	Immature female (age 2 or 3), 11/3/04.
6	18/04/06	2	1RRYY	Avon-Heathcote	South	Adult female, 22/10/04.
7	18/04/06	2	1RWRB	Avon-Heathcote	South	Adult, probable female, 22/10/04.
9	18/04/06	2	3YYYR	Farewell Spit	South	Adult male, 2/2/06
10	18/04/06	2	5YWWW	Farewell Spit	South	Adult male, 2/2/06
11	18/04/06	2	5YYWW	Farewell Spit	South	Adult male, 2/2/06
12	22/04/06	3	1WYYB	Tasman Bay	South	Either Adult female 15-12-04 or Adult male 9/3/05
13	22/04/06	3	3WYWW	Tasman Bay	South	Adult male, 16/11/05
14	23/04/06	2	2WRRR	Firth of Thames	North	2nd year male, 31/10/04; now age 3
15	23/04/06	2	3YWRR	Farewell Spit	South	Adult female, 2/2/06
16	23/04/06	2	1RWRB	Avon-Heathcote	South	Adult female, 22/10/04
17	23/04/06	2	3WBBB	Tasman Bay	South	Adult male, 16/11/05
18	23/04/06	2	1YYYB	Golden Bay	South	Adult female, 13/12/04.
19	23/04/06	2	3WWRB	Tasman Bay	South	Adult male, 16/11/05
20	23/04/06	2	3YBWW	Golden Bay	South	Adult? male, 4/12/05
21	23/04/06	2	2YYBY	Firth of Thames	North	Adult female, 10/3/04
22	23/04/06	2	5WWBR	Tasman Bay	South	Adult female, 16/1/06
23	23/04/06	2	4YYYY	Manawatu	North	Adult female, 31/1/06
24	23/04/06	2	2WYWW	Firth of Thames	North	Adult male, 18/11/04
25	23/04/06	2	2WBRR	Firth of Thames	North	2nd year female, 31/10/04

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THE IMPORTANCE OF JIUDUANSHA WETLANDS FOR SHOREBIRDS DURING NORTHWARD MIGRATION: ENERGY-REPLENISHING SITES OR TEMPORARY STAGES?

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Three shorebird surveys were conducted at Jiuduansha wetlands in the Yangtze River estuary during the northward migration period in 2006. An old report estimated that 160,000 shorebirds staged at Jiuduansha wetlands but only 6,287 shorebirds from 23 species were recorded during these surveys. It's likely that Jiuduansha wetlands are not stable energy-replenishing sites but temporary stages for shorebirds during northward migration. With the continuing sedimentation of silt and sand in the Yangtze River estuary, the intertidal flats continue to grow and provide potentially valuable stopover sites for shorebirds. However, the loss of suitable habitat caused by the rapid spread of the invasive plant smooth cordgrass is a serious threat to shorebirds through habitat destruction.

INTRODUCTION

Over two million shorebirds migrate in the East Asian–Australasian Flyway every year (Barter 2002). In order to fly over thousands of kilometres between the breeding and non-breeding grounds, shorebirds need a series of stopover sites to replenish energy reserves, to rest, or to stay briefly during bad weather conditions. Located in the southern part of the Yellow Sea region, the Yangtze River estuary is an important stopover site for shorebirds during migration. This region is the first stopover site for some long-distance migrating shorebirds (e.g. Great Knot, Bar-tailed Godwit) after they have left their north-west Australian non-breeding grounds, and some from eastern Australia, and flown over the western Pacific Ocean during their northward migration (Barter *et al.* 1997). It is also the last stopover site available to them on the Asian mainland on southward migration to their non-breeding grounds (Ma and Ma 2006).

The Jiuduansha wetlands are newly-formed shoals in the Yangtze River estuary. They were largely ignored until the middle of 1990s when the Pudong International Airport on the east coastal region of Shanghai City was designed. Since this region is located at the middle of the East Asian–Australasian Flyway, bird strikes seriously threatened the safety of aircraft. In 1996, a project named "planting vegetation and attracting birds" was put forward by some experts, who considered that birds could be attracted to Jiuduansha wetlands about 20 km away from the airport by means of vegetation planting there, and consequently, effectively reducing the risk of bird strikes around the airport and surrounding area. This project was approved by the Shanghai government. In 1997, a total of 430,000 reeds (*Phragmites australis*) and 540,000 smooth cordgrasses (*Spartina alterniflora*) were intentionally planted at Jiuduansha wetlands (Xie 2004). The reed did not grow well due to the low elevation of Jiuduansha wetlands at that time but smooth cordgrass settled there successfully and has spread rapidly in the past years. Presently, smooth cordgrass is one of the major plants at Jiuduansha wetlands, and covers more than 20% of the vegetated area (2003 data, Li *et al.* 2006).

Shorebird surveys have been conducted at Jiuduansha wetlands since the 1990s. A 1996 survey estimated that 160,000 shorebirds were present there during northward migration (Lu in litt. cited in Barter 2002), possibly using the area as an emergency stopover site in the poor weather conditions that prevailed. Data at the species level were not published until Mark Barter conducted a shorebird survey at Jiuduansha wetlands in April 1997 but he counted only 690 birds of 15 species (Barter *et al.* 1999). In order to add to our understanding of the shorebirds status there, we conducted shorebirds surveys at Jiuduansha wetlands during northward migration in 2006.

METHODS

The Jiuduansha wetlands are located in the outermost region of the Yangtze River estuary, and consist of three shoals Shangsha, Zhongsha and Xiasha. Silt sedimentation from the Yangtze River keeps intertidal areas growing continuously. The area of the wetlands above sea level was about 11,500 ha in 2002. The highest point, with an altitude of about 4.3 m, is located on Shangsha. Tidal fluctuation is regular and semidiurnal there. Two distinct periods of ebb and flood tides occur each day. During high spring tides, most of Shangsha and the whole of Zhongsha and Xiasha are submerged by tidewater (Chen *et al.* 2003).

The vegetational composition is simple at the Jiuduansha wetlands. The total vegetated area was 3,567 ha in 2003, with reed (*Phragmites australis* 1,358 ha) and sea bulrush (*Scirpus mariqueter* 1,441 ha) as the dominant native plants in the intertidal areas (Huang *et al.* 2005). Smooth cordgrass, an invasive species native to North America, was intentionally introduced and spread rapidly by natural dispersal. It occupied an area of 769 ha at Jiuduansha in 2003 (Li *et al.* 2006).

Migratory shorebirds pass through the Yangtze River estuary from the end of March to the middle of May during northward migration (Huang *et al.* 1993). Shorebird counts were conducted three times on 6–7 April, 29–30 April, and 16–18 May in 2006. Due to strong winds and heavy rain, we did not conduct a planned survey in late March. We walked on the intertidal flats and recorded shorebirds on neap or low spring tides when the intertidal flats were uncovered by the tidewater. Since shorebirds preferred the open intertidal flats and the sea bulrush communities (Jing 2005), transects 3 km long were set along the interface of sea bulrush communities and open intertidal flats at Shangsha, Zhongsha and Xiasha. Bird surveys were conducted along the transects. Further details of the wetlands and survey sites are in Zheng *et al.* (2006).

RESULTS

A total of 6,287 shorebirds from 23 species were recorded during the three surveys at Jiuduansha wetlands; these comprised 876 shorebirds of 14 species in early April, 3,104 birds of 19 species in late April, and 2,307 birds of 18 species in mid-May. The largest numbers of species and birds were recorded in late April (Table 1). The distribution of shorebirds differs at the three shoals. Table 2 shows that Xiasha held the most species (19) and the largest number of birds (4,558, 72.5% of the total), while Zhongsha held the fewest species (14) and the smallest number of birds (446, only 7.1% of the total). This suggests that Xiasha is the most important area for shorebirds.

Dunlin was the most abundant species comprising 56% of the total birds recorded. Six species, Terek Sandpiper, Red-necked Stint, Whimbrel, Kentish Plover, Common Greenshank and Great Knot provided another 37% of the total birds recorded. The remaining 7% of birds were from 16 species (Table 1).

The species and numbers of shorebirds changed greatly between the three surveys. The largest numbers of Great Knot, Kentish Plover, and Grey Plover were recorded in the early April, while the largest numbers of Red-necked Stint, Terek Sandpiper, Sharp-tailed Sandpiper, Grey-tailed Plover and Lesser and Greater Sand Plovers were recorded in late April or mid-May. This suggests a high turnover rate for shorebirds during northward migration.

During our surveys, one Great Knot with an orange leg flag was recorded at Xiasha on 4 April, and one Red-necked Stint with an orange leg flag was recorded at Shangsha on 16 May. Orange leg flags show that these birds came from Victoria, Australia.

DISCUSSION

Some reports have shown that hundreds of thousand of shorebirds stayed at Jiuduansha wetlands during northward migration (Lu in litt. cited in Barter 2002) but we did not record large numbers of shorebirds during our three surveys in 2006. Similar numbers of species and shorebirds were recorded in two surveys of northward migration in 2005 (Ma ZJ, unpublished data). During the northward migration of 2006, shorebirds surveys were also conducted at Chongming Dongtan, an internationally important wetland in the Yangtze River estuary which is located about 40 km north of Jiuduansha wetlands. Many more shorebirds were recorded there (10,466 birds were recorded during three surveys, Ma Qiang, pers. comm.). These results suggest that Jiuduansha wetlands are not stable energy-replenishing sites for shorebirds during northward migration but they may act as temporary staging sites for shorebirds during bad weather conditions. Possibly the frequent inundation of the intertidal flats inhibits long stopovers.

Due to the recent formation of the Jiuduansha wetlands,

Table 1. Shorebird counts number at Jiuduansha wetlands during northward migration in 2006

Species	April 6-7	April 29-30	May 16-18	Total	%
Dunlin *Calidris alpina*	290	1641	1592	3523	56.1
Terek Sandpiper *Xenus cinereus*	2	387	193	582	9.3
Red-necked Stint *Calidris ruficollis*	17	334	219	570	9.1
Whimbrel *Numenius phaeopus*		281	117	398	6.3
Kentish Plover *Charadrius alexandrinus*	295	2	2	299	4.8
Common Greenshank *Tringa nebularia*	4	230	59	293	4.7
Great Knot *Calidris tenuirostris*	195	4	2	201	3.2
Lesser Sand Plover *Charadrius mongolus*	1	73	19	93	1.5
Greater Sand Plover *Charadrius leschenaultii*	23	52	7	82	1.3
Curlew Sandpiper *Calidris ferruginea*	-	45	-	45	0.7
Grey-tailed Tattler *Heteroscelus brevipes*	-	6	30	36	0.6
Sanderling *Calidris alba*	-	-	34	34	0.5
Grey Plover *Pluvialis squatarola*	29	-	1	30	0.5
Sharp-tailed Sandpiper *Calidris acuminata*	-	13	15	28	0.4
Bar-tailed Godwit *Limosa lapponica*	6	4	2	12	0.2
Black-tailed Godwit *Limosa limosa*	-	-	10	10	0.2
Red Knot *Calidris canutus*	6	3	-	9	0.1
Spotted Redshank *Tringa erythropus*	5	1	2	8	0.1
Ruddy Turnstone *Arenaria interpres*	-	3	1	4	0.1
Broad-billed Sandpiper *Limicola falcinellus*	-	2	2	4	0.1
Eurasian Curlew *Numenius arquata*	2		-	2	0.0
Common Redshank *Tringa totanus*	1	1	-	2	0.0
Common Sandpiper *Actitis hypoleucos*	-	2	-	2	0.0
Unidentified species	-	20	-	20	0.3
Total number	876	3104	2307	6287	100.0
Total species	14	19	18	23	

Table 2. Distribution of shorebirds at the three shoals of Jiuduansha wetlands during northward migration in 2006

Species	Shangsha	Zhongsha	Xiasha	Total
Dunlin	180	28	3315	3523
Terek Sandpiper	336	38	208	582
Red-necked Stint	35	28	507	570
Whimbrel	90	239	69	398
Kentish Plover	262	2	35	299
Common Greenshank	205	44	44	293
Great Knot	30	4	167	201
Lesser Sand Plover	40	18	35	93
Greater Sand Plover	38	9	35	82
Curlew Sandpiper	-	-	45	45
Grey-tailed Tattler	12	1	23	36
Sanderling	-	-	34	34
Grey Plover	9	11	10	30
Sharp-tailed Sandpiper	20	8	-	28
Bar-tailed Godwit	5	4	3	12
Black-tailed Godwit	-	-	10	10
Red Knot	1	2	6	9
Spotted Redshank	1	-	7	8
Ruddy Turnstone	3	-	1	4
Broad-billed Sandpiper	-	-	4	4
Eurasian Curlew	-	2	-	2
Common Redshank	1	1	-	2
Common Sandpiper	2	-	-	2
Unidentified species	13	7	-	20
Total species	18	16	19	23
Total number	1283	446	4558	6287

the elevation of the shoals is still low and, during high spring tides, most of intertidal areas are submerged. When this happens there are few foraging and roosting opportunities for shorebirds. With the continuing sedimentation of sand and silt in the Yangtze River estuary, the area of intertidal flats should increase and the altitude of the shoals should rise in the future and provide more permanent shorebird habitat. This could make the Jiuduansha wetlands increasingly important for the stopover of shorebirds and especially valuable given the large intertidal areas lost by the over-reclamation of intertidal flats in the Yangtze River estuary.

In recent years, smooth cordgrass has expanded rapidly in the Yangtze River estuary. In 2003, the total area of smooth cordgrass reached 4,553 ha, which takes about one third of the total vegetated intertidal flats in the Yangtze River estuary (Huang *et al.* 2005). At Jiuduansha wetlands, the area of smooth cordgrass increased 15.4 times from 1997 when it was introduced to 2003 (47 ha in 1997, 769 ha in 2003). Ma and his colleagues (Ma *et al.* 2006) showed that shorebirds preferred open intertidal flats and sea-bulrush communities and avoided the smooth cordgrass communities. Consequently, the rapid expansion of smooth cordgrass has disadvantageous effects on the shorebirds and their preferred habitats. The effective control of the smooth cordgrass is important to the provision of suitable stopover sites for migrating shorebirds in the East Asian–Australasian Flyway.

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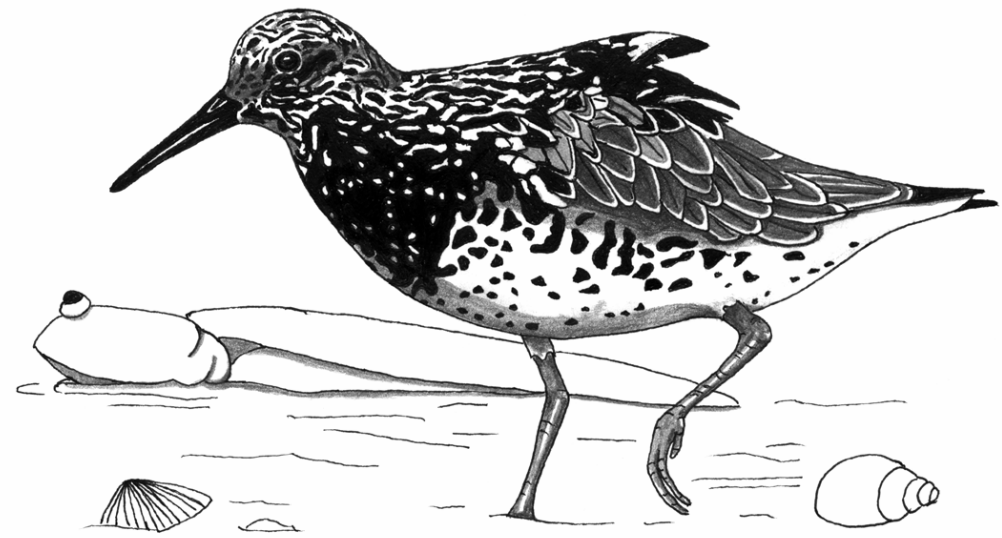

SHOREBIRD NUMBERS AT THE JIUDUANSHA WETLANDS DURING THE 2005 SOUTHWARD MIGRATION

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The Yangtze River estuary is an important stopover site for shorebirds in the East Asian–Australasian Flyway. We conducted shorebird surveys at newly-formed shoals, known as the Jiuduansha wetlands, in the estuary during southward migration in 2005. A total of 1,583 shorebirds of 24 species were recorded in three surveys from August to October. Kentish Plover, Whimbrel, Dunlin, Terek Sandpiper and Common Greenshank were the dominant species and accounted for nearly 90% of shorebirds. Fewer shorebirds were recorded than in the northward migration. This suggests that shorebirds may use different stopover sites during southward and northward migrations. Since the reclamation and development of intertidal flats have caused significant loss and degradation of wetlands in the Yangtze River estuary, the Jiuduansha wetlands, which are still increasing in area, have great potential for providing stopover sites for shorebirds in the Flyway.

INTRODUCTION

The Yangtze River estuary is an important stopover site for shorebirds in the East Asian–Australasian Flyway (Barter 2002). Estuarine wetlands provided good foraging and resting habitats for shorebirds during migration. Unfortunately, reclamation and development of intertidal flats have been conducted on a large scale in the Yangtze River estuary over the past two decades. Large areas of estuarine wetlands have been lost or degraded, causing significant loss of habitats for shorebirds in this stopover site. Located in the Yangtze River estuary, the Jiuduansha wetlands are new shoals formed by the sedimentation of silt and sand brought down by the Yangtze River. The wetlands continue to increase in area and the newly-formed intertidal flats provide habitats for shorebirds during migration.

Shorebird surveys have been conducted at the Jiuduansha wetlands during northward migration in the past (Barter *et al.* 1999, Barter 2002) but there are no detailed reports of shorebirds at the wetlands on southward migration. To fill this gap, three shorebird surveys were conducted at the wetlands from August to October in 2005. The aim of this work was to improve our understanding of the importance of the Jiuduansha wetlands for shorebirds on migration and to inform strategies for the conservation of shorebirds and their habitats.

METHODS

The three outermost shoals in the Yangtze River estuary, Shangsha, Zhongsha and Xiasha, comprise the Jiuduansha wetlands. Their geographical position is between 31°06' 20"-31°14' 00"N and 121°53' 06"-122°04' 33"E (Fig. 1). They stretch 18 km from east to west and 13 km from south to north, with an area of 115 km^2 above sea level. The altitudes of the three shoals increase from Xiasha (2.8 m) to Zhongsha (3.2 m) and Shangsha (4.3 m). Only Shangsha has a high tide zone; during high spring tides, most of Shangsha and the whole area of Zhongsha and Xiasha are submerged by tidewater (Chen *et al.* 2003). Due to the unfavourable conditions, no people are presently settled on Jiuduansha. The Jiuduansha Wetlands Nature Reserve was established in 2000 and was promoted to a national nature reserve in 2005.

The dominant plant species at Jiuduansha wetlands are reed *Phragmites australis*, sea bulrush *Scirpus mariqueter* and smooth cordgrass *Spartina alterniflora*. Smooth cordgrass originated in North America and was introduced intentionally at Zhongsha in 1997 to accelerate the accretion of intertidal flats (Chen *et al.* 2003). In recent years, smooth cordgrass has spread rapidly and covers about one third area of the vegetated region on Jiuduansha.

Three shorebird surveys were conducted (25–26 August, 15–16 September, and 19–20 October) during the southward migration in 2005. We counted shorebirds using telescopes (20–60×) during neap or spring low tides while walking on the intertidal flats. We recorded the species, numbers, and their habitats during surveys. Due to the effects of unpredicted wind, most of intertidal flats at Shangsha were submerged by tidewater on 26 August and very few shorebirds were recorded there.

According to our surveys at other regions in the Yangtze River estuary, most shorebirds are distributed in sea bulrush communities and on open intertidal flats (Jing *et al.* 2005). We set 3 km long transects along the interface of sea bulrush communities and open intertidal flats at Shangsha, Zhongsha and Xiasha respectively. Shorebird surveys were conducted along the transects. We also recorded shorebirds when we moved between the three shoals. The survey regions are shown in Fig. 1.

RESULTS

A total of 1,583 shorebirds of 24 species were recorded during the three surveys (Table 1). Kentish Plover was the most abundant species, comprising 36% of the birds recorded. Four species, Whimbrel, Dunlin, Terek Sandpiper and Common Greenshank, provided another 42%. The remaining 22% was shared among 19 species. A total of 171 shorebirds of 12 species were recorded at Shangsha, 667 birds of 21 species at Zhongsha, and 745 birds of 10 species at Xiasha. Zhongsha recorded the most species and Xiasha the largest number of birds.

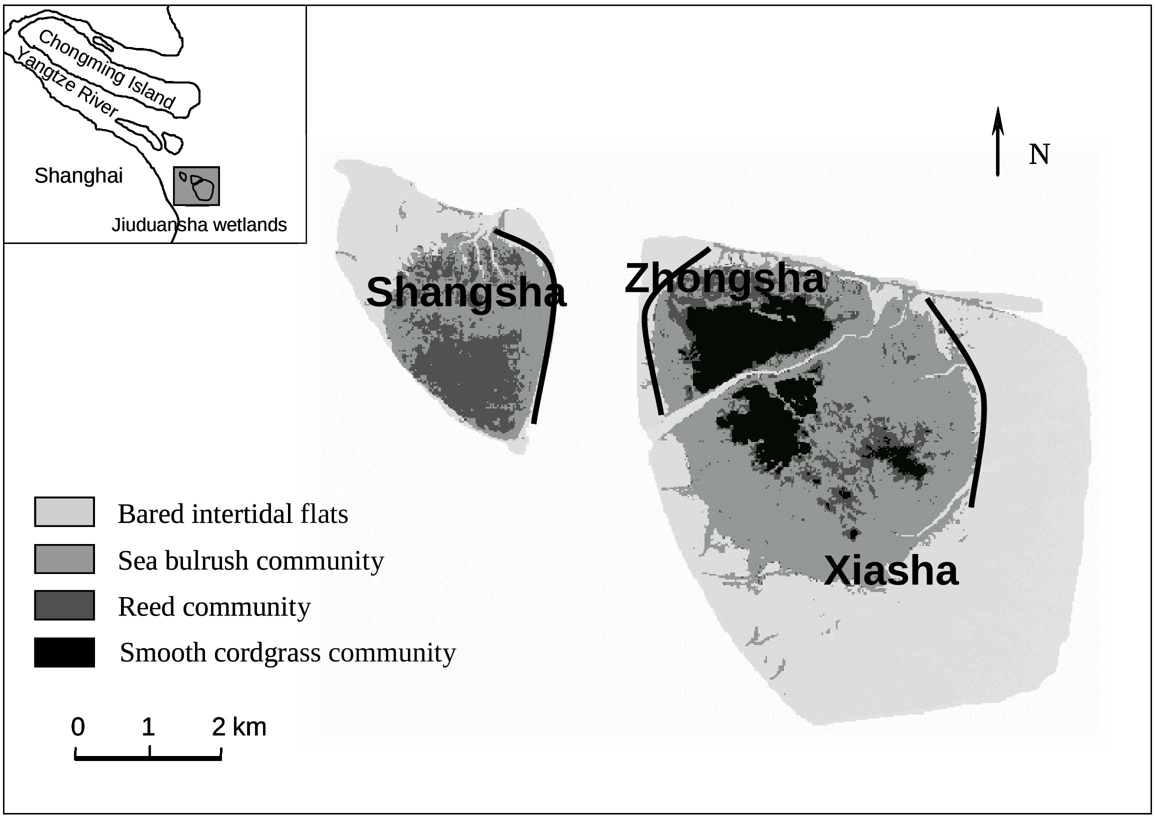

Figure 1. Jiuduansha wetlands and their location in the Yangtze River estuary. The curves on the three shoals showed the survey transects.

The numbers of shorebirds recorded in August, September, and October were 586, 417, and 580 respectively. Although, there is little difference in bird numbers between the surveys, the number of species counted decreased from 21 in August to 17 in September and to 8 in October. Except for the Terek Sandpiper (6 birds), Bar-tailed Godwit (3 birds) and Whimbrel (1 bird), the other five species recorded in October (Kentish Plover, Dunlin, Eurasian Curlew, Common Greenshank, and Spotted Redshank) can also be recorded in winter (Ma *et al.* 2006). This suggests that most of the migratory shorebirds that spend the non-breeding season further south may have left Jiuduansha by middle October. Peak numbers of migrant species not present in winter were recorded in August. Numbers of species of which some birds were present in winter, such as Eurasian Curlew, Spotted Redshank and Kentish Plover reached their peak in October.

Nearly all shorebirds (94.3%) were recorded on the open intertidal flats; only 5.7% of the total was recorded in the vegetated area. Sharp-tailed Sandpiper and Wood Sandpiper were distributed mainly in sea bulrush communities.

DISCUSSION

More species and most birds were recorded in August than in other months, despite the intertidal flats of Shangsha being submerged by tidewater during our survey leading to fewer birds being recorded there than would normally be expected. It seems likely that, if surveys were conducted during low tide periods, more species and shorebirds would be recorded than this study achieved. In October, fewer species of shorebirds were recorded; some members of the species counted are also present in winter in the Yangtze River estuary. This suggests that most passage migrants have left the Yangtze River estuary by the middle of October. Though Wang and Qian (1988) considered that shorebirds migrated southward from late August to early November in the Yangtze River estuary, Yuren Gao (pers. comm.) considered that some shorebirds arrived at their non-breeding grounds in Australia in the mid-August. Bird banding data at Chongming Dongtan has shown that some shorebirds (e.g. Great Sand Plover, Terek Sandpiper, Wood Sandpiper) started arriving in the Yangtze River estuary in late July. This supports Gao’s point of view. Further work is needed to determine the stopover period of shorebirds in the Yangtze River estuary during southward migration.

Most shorebirds preferred open intertidal flats to other habitat types. This is consistent with the habitat use of shorebirds at Chongming Dongtan (Jing 2005). In the Yangtze River estuary, bivalves and crustaceans, the major foods for shorebirds (Jing 2005), are abundant in open intertidal flats where shorebirds feed. More shorebirds are recorded at Xiasha which has the largest area of open intertidal flats. The sea bulrush communities are also habitats for some shorebirds, such as Wood Sandpiper and Sharp-tailed Sandpiper. According to our observations, gastropods, which can provide foods for these species, are the dominant zoobenthos in the sea-bulrush communities.

Table 1. Numbers of shorebirds at Jiuduansha wetlands during southward migration in 2005.

Species	**25-26 Aug.**	**15-16 Sep.**	**19-20 Oct.**	**Total**	**Percentage**
Kentish Plover *Charadrius alexandrinus*	85	89	393	567	35.8%
Whimbrel *Numenius phaeopus*	139	31	1	171	10.8%
Dunlin *Calidris alpina*	40	49	80	169	10.7%
Terek Sandpiper *Xenus cinereus*	101	61	6	168	10.6%
Common Greenshank *Tringa nebularia*	28	87	44	159	10.0%
Red-necked Stint *Calidris ruficollis*	42	43	0	85	5.4%
Red Knot *Calidris canutus*	51	0	0	51	3.2%
Great Sand Plover *Charadrius leschenaultii*	28	20	0	48	3.0%
Wood Sandpiper *Tringa glareola*	37	0	0	37	2.3%
Eurasian Curlew *Numenius arquata*	0	1	29	30	1.9%
Bar-tailed Godwit *Limosa lapponica*	4	5	12	21	1.3%
Spotted Redshank *Tringa erythropus*	1	3	15	19	1.2%
Sharp-tailed Sandpiper *Calidris acuminata*	13	0	0	13	0.8%
Mongolian Sand Plover *Charadrius mongolus*	5	7	0	12	0.8%
Common Sandpiper *Actitis hypoleucos*	3	6	0	9	0.6%
Black-tailed Godwit *Limosa limosa*	0	7	0	7	0.4%
Ruddy Turnstone *Arenaria interpres*	1	3	0	4	0.3%
Gray-tailed Tattler *Heteroscelus brevipes*	3	0	0	3	0.2%
Broad-billed Sandpiper *Limicola falcinellus*	1	2	0	3	0.2%
Green Sandpiper *Tringa ochropus*	0	2	0	2	0.1%
Common Redshank *Tringa totanus*	1	1	0	2	0.1%
Great Knot *Calidris tenuirostris*	1	0	0	1	0.1%
Eastern Curlew *Numenius madagascariensis*	1	0	0	1	0.1%
Curlew Sandpiper *Calidris ferruginea*	1	0	0	1	0.1%
Total number	586	417	580	1583	100%
Total species	21	17	8	24	

Mark Barter recorded 690 shorebirds of 15 species in a survey of the Jiuduansha wetlands in April 1997 (Barter *et al.* 1999). The dominant species were Great Knot, Dunlin and Kentish Plover, which comprised 70% of the total number. During our three surveys during southward migration, only one Great Knot was recorded. This result was similar to that of surveys at Chongming Dongtan, where many more Great Knots were recorded during northward than southward migration (Ma *et al.* 2002 a,b). This suggests that the Yangtze River estuary is an important stopover site for Great Knot during northward migration, while Great Knot maybe over fly the Yangtze River estuary during southward migration (Barter 2002). Also, there is some evidence that Great Knot can make a non-stop flight from the Sea of Okhotsk to northern Australia during southward migration (Tomkovich 1997).

Historical surveys show that the Jiuduansha wetlands are important stopover sites for shorebirds during northward migration (Lu JJ in litt., cited in Barter 2002); our results show that fewer birds are recorded during southward migration. This suggests that Jiuduansha may play different roles for shorebirds during the different migration periods. Jiuduansha may be an important stopover sites during northward migration, being the first stopover site for some long-distance migratory shorebirds from their non-breeding grounds in Australia (e.g. Great Knot, Red Knot, Bar-Tailed Godwit). Birds can feed and replenish energy stores depleted on their non-stop flight over the western Pacific Ocean. Most of the shorebirds observed during southward migration were juveniles. This is consistent with shorebird banding records at Chongming Dongtan, where fewer adults are banded during southward migration (Ma *et al.*, in prep.). We consider it possible that adults and juveniles may select different migration routes or use different stopover sites during southward migration. We have no estimates of the numbers of shorebirds staging at Jiuduansha Wetlands during southward migration as stopover durations are unknown. From resightings of shorebirds with leg flags at Chongming Dongtan, the stopover duration of most shorebirds is believed to be short compared with the period between surveys. Very few birds will have been recorded in more than one of the three surveys. More study is needed to understand fully the migration strategies and stopover durations of shorebirds passing through the Yellow Sea in the East Asian–Australasian Flyway.

Smooth cordgrass was introduced intentionally at Zhongsha of Jiuduansha in 1997. It has spread rapidly into the sea bulrush communities and open tidal flats. According to the vegetation map of 2004, smooth cordgrass now covers more than one third of vegetation area at Jiuduansha wetlands. Since the sea bulrush communities and open tidal flats are important habitats for shorebirds, it seems urgent to control the spread of smooth cordgrass at Jiuduansha wetlands in order to protect the shorebird habitat.

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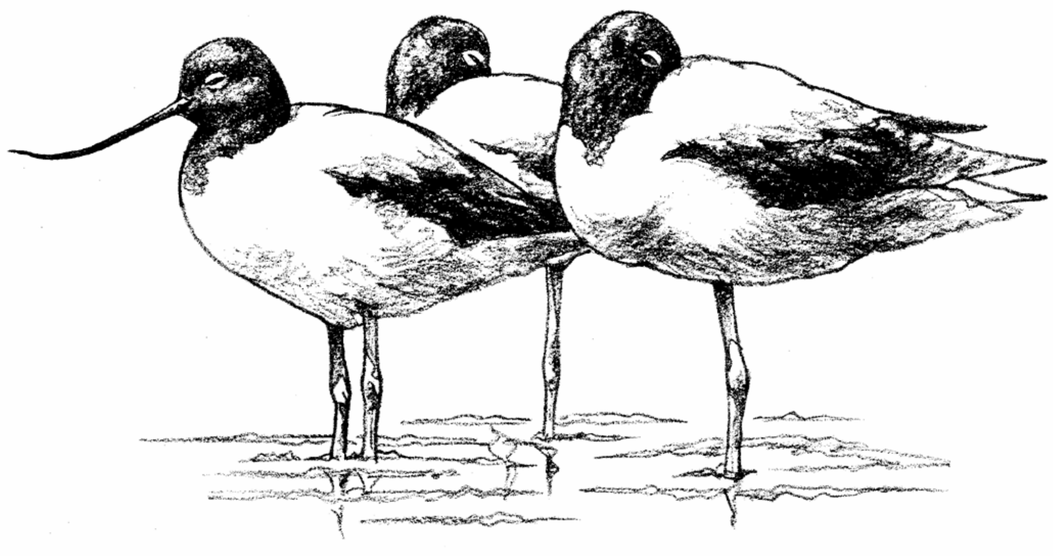

SOUTH KOREA'S SHOREBIRDS: A REVIEW OF ABUNDANCE, DISTRIBUTION, THREATS AND CONSERVATION STATUS.

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INTRODUCTION

South Korea is increasingly recognized for its importance to long-range migrant shorebirds of the East Asian–Australasian Flyway, supporting an official estimate of 12.7% of the Flyway's shorebirds on northward migration and 8.7% on southward migration. This understanding has developed gradually over the past three decades, with most shorebird research conducted to the background of (or even as part of) tidal flat reclamation projects and the construction in the mid-1980s of estuarine barrages across three of the nation's largest rivers: The Geum, the Yeongsan and the Nakdong. While the historical tidal flat area in South Korea exceeded 450,000 ha, one recent estimate suggests that this area will be reduced to a little over 110,000 ha within a decade. Lacking an extensive historical record of shorebird numbers, either nationally or at the Flyway level, it is difficult to suggest with any confidence what the impacts of such massive habitat loss and habitat degradation (not only in South Korea but in many other parts of the Yellow Sea) have been up to now, and what they will be in the future. Already, there has been a near-collapse of inshore fisheries in South Korea, an obvious and precipitous decline of the Endangered Spoon-billed Sandpiper, and several other tidal flat dependent species closely associated with the Yellow Sea have a very poor conservation status, including Nordmann's Greenshank (Endangered), Black-faced Spoonbill *Platelea minor* (Endangered), Chinese Egret *Egretta eulophotes* (Vulnerable) and Saunders's Gull *Larus saundersi* (Vulnerable). Concern over the anticipated impacts of the largest of the reclamation projects to date, the ongoing 40,100 ha reclamation of the Mangyeung and Dongjin estuaries (collectively known as "Saemangeum"), has generated sufficient national and international concern to lead to the development of the three-year Saemangeum Shorebird Monitoring Program (2006–2008). This Program will monitor impacts of the reclamation on shorebirds at both the local and the population level, and over time help to improve conservation possibilities in Korea. What is clear already is that the present conservation initiatives in South Korea, while often good on paper, still lack the political will or authority to stem the present tidal-wave of habitat loss.

This paper aims to provide sufficient information to enable a fuller understanding of the status of shorebirds in South Korea, and to help facilitate discussions and actions leading to their better conservation. It is divided into five sections:

- a review of shorebird research;
- shorebird habitats, and threats to them;
- a list of internationally important shorebird sites;
- estimates of contemporary shorebird populations in South Korea;
- background to shorebird conservation.

A REVIEW OF SHOREBIRD RESEARCH

Before 1950

In attempting to describe the abundance, trends, and conservation status of shorebirds at the national level, it is usually necessary to have a historical base for comparison. There is, however, very little useful information on most shorebird species and their habitats in South Korea before 1980, with the first national review of Korea's avifauna (Austin 1948) assessing the status of species like the Great Knot as a "rare transient", based on a Korean-peninsula record of only five specimens (compared to 14 specimens of Spoon-billed Sandpiper already collected by that time). The apparent rarity of species like the Great Knot and other tidal flat dependent shorebirds was most likely due to their "habit of staying on the outer beaches and offshore islands instead of coming into the paddies, where (they) could have been observed and collected more frequently" (Austin 1948). Of the 48 shorebird species accepted by Austin's review, only 22 were assessed as "common" or at least "not uncommon" in Korea, with the majority either distinctive or freshwater associated species: Eastern Oystercatcher, Grey Plover, Pacific Golden Plover, Little Ringed Plover, Kentish Plover, Long-billed Plover, Lesser Sand Plover, Whimbrel, Eurasian Curlew, Far Eastern Curlew ("commonest of the curlews, a fairly common spring and autumn transient"), Bar-tailed Godwit, Spotted Redshank (in the rice fields "flocks of several hundred individuals were not uncommon"), Common Greenshank, Green Sandpiper, Wood Sandpiper, Common Sandpiper, Ruddy Turnstone, Pintail Snipe, Common Snipe, Long-toed Stint, Sharp-tailed Sandpiper and Dunlin. Austin accepted only two of these, the Eastern Oystercatcher and Little Ringed Plover, as breeding species, although the Common Sandpiper had also been found breeding in the previous century (Taczanowski 1888).

The 1960s and 1970s

With a limited amount of ornithological activity in South Korea, and access to much of the coastal zone restricted by the military from at least the 1940s through almost to the present (Long *et al.* 1988; pers. obs.), only limited research was conducted in estuarine habitats in the 1960s and 1970s. Fennel & King (1964) revealed new national high counts of Broad-billed Sandpiper (including a single flock of 500 on 2 September 1962 in Gyeonggi province), a total of 39 Nordmann's Greenshank over two autumns near Incheon, and added Great Ringed Plover *Charadrius hiaticula* and Curlew Sandpiper to the national list. In the late 1960s and early 1970s, more intensive surveys, especially by South Korea's pre-eminent ornithologist Won Pyong-Oh at the Nakdong Estuary in the south-east, provided improved data for the revised species assessments given by Gore & Won (1971), the last published comprehensive review of South Korea's avifauna in English. Their review included 51 species of shorebird, and significantly a count of "several hundred Spoon-billed Sandpiper on the mudflats in the Naktong delta on 18–20 September, 1970" (with this count then re-presented as a more modest 200 by Long *et al*. 1988). Gore & Won (1971) largely agreed with Austin's shorebird species' assessments from two decades before, but considered Eastern Oystercatcher, Ruddy Turnstone, Pintail Snipe and Long-toed Stint (as well as Spoon-billed Sandpiper) to be only "uncommon passage migrant(s)", and added four more coastal species to the list of species considered to be relatively common: Black-tailed Godwit, Terek Sandpiper, Sanderling, and Red-necked Stint (the last, "Abundant"). Considering the species' distinctiveness (and its present rather local status), the description of Spotted Redshank at that time as "the most common wader in the flooded rice fields in spring from March-early May" (Gore & Won 1970) seems suggestive of significant declines at the national level of that species in recent decades, with only one unverified report (in Moores & Moores 2004) of up to 2,500 in spring 2004, somewhere in the north-west, at all comparable in recent years.

The 1980s

According to the account in Long *et al.* (1988), survey work at the Nakdong Estuary by Piersma in 1984 and by Won in 1987, at the Geum River by Ham and Lee (1985), and in the north-west in the late 1980s by Won (unpubl.) produced several significant improvements in knowledge. These were often achieved through research conducted in connection with major development plans, including the barraging of both the Nakdong and the Geum rivers at their estuaries in the mid-1980s. New national high counts from this period included 850 Eastern Oystercatcher at the Geum Estuary on the west coast in December 1984, and of Kentish Plover (2,561 in September 1984), Great Knot (1,240 in September 1984), Red-necked Stint (2,320 in May 1987, 10,880 in September 1984), Dunlin (9,012 in October 1983), Far Eastern Curlew (635 in September 1984), Grey-tailed Tattler (309 in September 1987), and Terek Sandpiper (790 in September 1987) at the Nakdong Estuary. It also returned Eastern Oystercatcher and added Kentish Plover to the list of South Korean breeding shorebird species.

Spring 1988 saw the first attempt at coverage of shorebird habitats along all of the west and parts of the south coast, where most of South Korea's tidal flats are concentrated. A joint initiative of East Anglia (UK) and Kyung-Hee Universities (South Korea), this pioneering survey "completely changed the state of knowledge of distribution and numbers of shorebirds in the country" (Long *et al.* 1988). Surveying 23 coastal sites over two months (early April to early June), coverage was very limited for much of the coastline away from the north-west close to Seoul, and (only) five sites that were considered "internationally important to migratory shorebirds" were identified: the Nakdong Estuary (based on previous surveys), and the four main north-western sites, i.e. Ganghwa, Yeongjong, Namyang Bay and Asan Bay, for which "No previous counts exist" (Long *et al.* 1988). Eight further sites were identified as of national importance, including the Dongjin River Estuary, in present-day Saemangeum (Long *et al.* 1988). The survey recorded between 136,157 and 167,823 shorebirds of 35 species in total, including 98–135 Nordmann's Greenshank. The most numerous shorebirds recorded were Dunlin (64,500–74, 785), Great Knot (20,000–35,000), Black-tailed Godwit (16,345–17,370) and Bar-tailed Godwit (13,220–15,720), accounting for 84 percent of the total numbers of shorebirds seen (Long *et al.* 1988). It is critical to note when comparing these results with other counts or national estimates that the survey did not include the Nakdong Estuary (as it had already been covered by previous survey effort) and did not cover most of the south-western sand- and sand-mudflats at all well. The survey also covered the Geum Estuary very poorly (counting Yubu Island only once, on either 26 or 27 May, when "there were few birds present and saltpan workers said the birds had left in early May", and did not even visit mainland tidal flats to the north of the river-mouth). The survey team also visited the Mangyeung Estuary only once (on 27 May, when "poor coverage" and when "no birds were seen"), and the Dongjin Estuary twice: once on 28 April during a neap tide, and again on 26 May (by which time most shorebirds would have migrated [Moores *et al.* 2006]). The very small numbers of shorebirds seen in this vast area in spring 1988 should not and cannot be used to infer in any way that later counts at Saemangeum were due (largely) to shorebirds displaced from elsewhere. Counts attempted post-1998 also found almost no birds at neap tides and/or at the end of May (pers. obs.).

In addition to establishing South Korea's importance to species such as the Great Knot and Nordmann's Greenshank, Long *et al.* (1988) also provided perhaps the first detailed account in English of numerous coastal reclamation plans being considered by the South Korean military government as part of The National Masterplan, 1984–2001. This masterplan simplistically identified almost precisely two-thirds (66.5%) of remaining coastal wetlands along the west and south coasts as fit for reclamation by 2001, listing 150 potential projects, involving 155 estuaries and bays and covering 480,000 ha (Long *et al.* 1988). As noted at the time: "There is no doubt that future land reclamation of coastal wetlands is going to take a significant percentage of the present total … If the large-scale reclamation projects in the four key sites (Ganghwa, Yeongjong, Namyang and Asan Bays) were executed, this would severely jeopardize the staging areas for a very important percentage of shorebirds in the East Asian-Western Pacific Flyway … Theoretical studies on the possible effect of reclamation of mudflat areas on populations of migratory shorebirds have been carried out on data from the Wash (UK) … But nothing is known about the real effects that intertidal reclamation, on the scale that is proposed in South Korea, could have on such populations." (Long *et al.* 1988).

The 1990s to the present

The year 1991 saw the start of construction of the Saemangeum sea-wall and the 1990s saw the completion of a series of coastal reclamations, significantly reducing shorebird habitat at Yeongjong, along the Incheon coastline and, Shihwa, in Asan Bay, as well as many bays and estuaries on the south coast. The next significant paper on shorebirds (Kim *et al.* 1997) contained the results of shorebird survey work conducted on a total of 75 days during the northward and southward migrations between September 1993 and October 1996. Survey work again concentrated on the north-western sites, three of which (Yeongjong south, Namyang and Asan) were already undergoing partial or near-complete reclamation. It improved on earlier coverage of the 40, 000 ha Saemangeum estuarine system, with counts on eight dates there during the three-year period (in May, September and October), and also included two counts at the Geum Estuary (11 May and 24 September, 1996). Even with such limited coverage, the survey team found internationally important concentrations at Saemangeum of Great Knot (12,700) and Nordmann's Greenshank (52 on 19 October 1994). They also recorded high counts of at least two other species at the north-west sites: Kentish Plover (3,048 at Yeongjong Island on 17 October 1993) and Eurasian Curlew (1,516 at Namyang Bay on 16 September 1993), clearly indicating the importance of these sites on southward as well as northward migration.

An intensive survey of shorebirds and their coastal habitats between April 1998 and February 1999 (Moores 1999a, 1999b) then covered 56 coastal wetlands, identifying (dependent on delineation) at least 20 internationally shorebird sites, and suggesting that probably 20 species of shorebird were supported in internationally important concentrations in South Korea (based on waterbird population estimates found in Rose and Scott [1997], and unpublished estimates by Watkins [1999]). The main survey was conducted in (more or less) one-day per site circuits along the whole length of the south and west coasts, followed by repeat surveying in other months. During spring (13 April-27 May), a largely similar period to that covered by Long *et al.* (1988) a decade before, three circuits were made, finding a minimum total of 225,847 shorebirds (based on a simple totalling of maximum counts for each of the species during the spring period). Much of the increase in total numbers counted, when compared to the survey a decade before, can be considered likely due to improved site access and improved coverage of sites away from the north-west. This assumption is based largely on the similarity of total counts made at the same four main north-western sites (Ganghwa, Yeongjong South, Namyang and Asan Bays), with a minimum of 111,316 shorebirds there in 1988 (Long *et al.* 1988) and a minimum at the same sites of 108,044 in 1998 (Moores 1998a). Most numerous species over the three spring circuits along the entire west and south coastline in 1998 included Great Knot (80,404 between 29 April and 11 May), Dunlin (73,659 between 13 April and 25 April), Black-tailed Godwit (24,715 between 29 April and 11 May) and Bar-tailed Godwit (17,138 between 13 April and 25 April). While the counts by Moores (1999a, 1999b) included the Geum Estuary and Saemangeum, coverage was very restricted in time and scope, with only 3 full days at Saemangeum during northward migration, and no coverage of Yubu Island in the Geum Estuary. Subsequent counting at Saemangeum and the Geum Estuary by the same surveyor, that year and later, indicate that all counts during northward and southward migration in 1998 were likely to have been significant underestimates (Moores 1999b).

While the data in Moores (1999a, 1999b) should be considered as only partial counts for many of the larger sites, they identified an increased number of sites as internationally important for shorebirds, and helped confirm the importance of several of these sites on southward migration too. They also provide a limited opportunity to compare abundance in shorebird numbers at a few specific sites. A preliminary analysis of peak waterbird counts, comparing published shorebird numbers at the Nakdong Estuary pre-barrage closure, and again during counts on six dates in 1998, suggested declines in at least 13 shorebird species, little change in two species, and an increase in two species (Whimbrel and Grey-tailed Tattler). Species suggesting the most significant declines at the Nakdong included Red-necked Stint (10,900 to 1,425), Far Eastern Curlew (635 to 40), Spotted Redshank (150 to 1) and Ruddy Turnstone (637 to 13) (Moores 1999b); subsequent survey work (pers. obs.) further confirmed the trend. In addition, the surveys in 1998 at the Nakdong Estuary failed to find any Spoon-billed Sandpiper, a species previously present there "in the hundreds" (Gore & Won 1971), and found only in very small numbers in recent years (Zöckler *et al.* in prep. [2006]). At a larger scale, significantly lower nationwide counts in 1998 than in 1988 of Nordmann's Greenshank (9) and Red-necked Stint (3,797 compared to between 5, 225 and 5,578 recorded by Long *et al.* 1988, at far fewer sites), and lower counts of Dunlin at specific sites suggested that those species were less numerous in spring 1998 than in 1988, while one species, Terek Sandpiper, "appeared to be genuinely more numerous" (Moores 1999b).

The 1998–1999 survey (Moores 1999a) coincided with government-led shorebird surveying that continues, more or less, to the present. These counts, for a period supported by banding and flagging (mostly at one major shorebird roost in the Mangyeung Estuary), have been conducted largely by the National Institute for Environmental Research (the NIER, formerly known as the Forestry Research Institute, and now under the auspices of the Ministry of Environment). The NIER is responsible for official shorebird estimates and counts (e.g. Ministry of Environment [MoE] 1998; and unpublished data used by Barter 2002), and forms the focal point for a very broad range of national and international shorebird (and other species) conservation initiatives, including coordinating flag-sightings data, identifying sites for inclusion in Site Networks, and bilateral bird conservation agreements. Regrettably, rather few NIER shorebird data appear to have been formally published or made widely available in more recent years. However, once-a-month shorebird counts have also been conducted in the Saemangeum area by a research unit (KARICO) of the Ministry of Agriculture and Forestry, with this data published in annual environmental assessment reports. The MoE and KARICO (2003, 2004, 2005) surveys improved greatly upon the counts within the Saemangeum area especially, finding between 180 and 280 Spoon-billed Sandpiper there in 1999 (Barter 2002), and a peak of 123,000 Great Knot on southward migration in 2004 (KARICO 2004). The combination of NIER data provided by Yi & Kim (in prep.) and Moores (1999) led Barter (2002) to identify 16 South Korean sites as internationally important for shorebirds (Barter 2002), with the two sites of the Mangyeung and Dongjin Estuaries combined (as Saemangeum) considered the most important known shorebird in the Yellow Sea at that time.

More recently, Lee (2004) provided useful data from Yubu Island in the Geum Estuary (especially on Eastern Oystercatcher), while Moores *et al.* (2006) and Rogers *et al.* (2006), provided the most recent assessment of shorebird numbers within the massively important Saemangeum estuarine system, which supported a minimum 192,872 shorebirds on northward migration in 2006, with 15 species in internationally important concentrations, and the adjacent Geum Estuary, 80,000 shorebirds with 13 species in internationally important concentrations. These counts, conducted as part of the Birds Korea-Australasian Wader Studies Group Saemangeum Shorebird Monitoring Program, were made by a large team of experienced counters over two months, during which time the 33 km Saemangeum seawall was completed, and the tidal regime there significantly altered. While the spring survey reinforced the findings of previous (1998–2005) surveys, basic counting and habitat assessment within the Saemangeum area in September and October 2006 suggested that numbers of shorebirds there were much reduced when compared to previous autumns, with Great Knot almost entirely absent (pers. obs.).

Contemporary Perspective

Following several decades of massive degradation and loss of shorebird habitats, improving coverage of coastal habitats has gradually increased understanding of the extreme importance of South Korea for migratory shorebirds, with the nation's wetlands now recognised as supporting both high shorebird diversity and internationally important concentrations of a number of species, including some of the highest counts known anywhere of both the Endangered Nordmann's Greenshank and the Endangered Spoon-billed Sandpiper. The NIER concluded that eight major staging sites supported 84% of shorebirds on northward migration, and 87% on southward migration nationwide, with South Korean tidal flats holding 12.7% and 8.7% respectively of the East Asian–Australasian Flyway's migratory shorebirds. They recognized 11 sites as holding more than 10,000 shorebirds in a season, and 19 sites holding internationally important concentrations (Yi 2004).

The checklist of the conservation organization Birds Korea, as of November 2006, listed 59 species of shorebird as documented with photographs or specimens in South Korea, with a further four species considered inadequately documented. A further two species, Wandering Tattler *Tringa incanus* and Western Sandpiper *Calidris maura* are listed for North Korea by Tomek (1999) on the basis of specimens. Of the total, only eight species have been proven to breed in South Korea: Common Sandpiper, Greater Painted Snipe, Pheasant-tailed Jacana (first in 2006: documented with photographs on the internet), Eastern Oystercatcher, Black-winged Stilt (first in 1998: Park, 2002), Long-billed Plover, Little Ringed Plover, and Kentish Plover. In addition, the Oriental Pratincole is strongly suspected of having bred once, in 2004 (Moores & Moores 2004).

At least 28 species of shorebird have also been reliably recorded in the northern mid-winter period in Korea (mid-December to mid-February), with 13 or 14 species over-wintering regularly (see below), and the remainder doing so only rarely or irregularly. Claims of over-wintering flocks of Far Eastern Curlew, Little Ringed Plover and Red-necked Stint, for example, which have on occasion been reported in national winter waterbird surveys (e.g. Ministry of Environment 2004), usually by inexperienced observers, are best considered to be in error, unless full supporting details can be provided.

SHOREBIRD HABITATS IN SOUTH KOREA AND THREATS TO THEM

Moores *et al.* (2006) concluded that out of the 56 or so species of shorebirds now recorded more or less annually in South Korea, 35 of these are dependent on tidal flats (23 of these being found in internationally important concentrations), with the majority of the remainder occupying a narrow range of freshwater habitats, most especially rice fields and small rivers. While tidal flats are used by the majority of shorebirds (individuals and species) during migration, they also support the largest number between October and March. Over 31,000 shorebirds were counted along the west and south coasts in January and February 1999, with Dunlin (20,442), Grey Plover (4,493), Eurasian Curlew (2,671), Eastern Oystercatcher (2,987) and Kentish Plover (458) the most numerous species (Moores 1999a).

Two regular wintering tidal flat species, the Eastern Oystercatcher and the Kentish Plover, also breed in Korea, with the former typically egg-laying in rock crevices on small rocky islets, and the latter preferring sandy islands and spits, often nesting in loose colonies. Some species such as Northern Lapwing, a winter visitor to Korea, are found equally in rice fields and on tidal flats, with a further dozen species very largely dependent on freshwater habitats (including three species of snipe and Long-toed Stint) during migration, and in a few cases during the breeding season too. Both Greater Painted Snipe and Black-winged Stilt, for example, have been found breeding very locally in wet rice fields, while the much more widespread Little Ringed Plover nests on drier ground next to rice fields, and also in river beds, in many areas sharing shingle-bed habitat with breeding Long-billed Plover. One other species, the Solitary Snipe, a very uncommon and localized winter visitor, is also almost entirely confined to small rivers. Other habitats used by shorebirds in Korea include woodland (Eurasian Woodcock) and open sea areas (Red-necked Phalarope and Grey Phalarope *Phalaropus fulicarius*). None of the shorebird species dependent on freshwater habitat in South Korea are considered to be either globally threatened or found in internationally important concentrations, although Black-tailed Godwit uses both estuaries and rice fields in internationally significant numbers during migration. The Red-necked Phalarope likely occurs in internationally important concentrations on occasion in sea areas, although it is perhaps less numerous now than in the recent past. There is convincing anecdotal evidence of very significant decline in recent decades in the region (Rubega *et al.* 2000).

Tidal flats: Reclamation, Over-exploitation and Degradation

Estuaries and tidal flats are the most important shorebird habitats in South Korea. Due to rapid changes in wetland type and land use (primarily due to reclamation, urbanization, and changes in agricultural practice), in combination with the complex and different methods used by different ministries and administrative authorities to calculate such changes, there are perhaps no fully reliable figures either for area of tidal flat (lost or remaining) or for remaining areas of other significant shorebird habitat at the national level. There is also very limited information available on changes in the quality of feeding and roosting at those sites that do remain. The most urgent conservation concern, however, is undoubtedly loss of habitat due to coastal reclamation, though a range of other threats exist for all wetlands and for most species of waterbirds, not only shorebirds (e.g. Moores 2002).

The Yellow Sea is one of the most extensive tidal flat and shallow sea areas in the world (e.g. Hong and Miller in prep.), with the tidal range reaching 9.3 m in Gyeongii Bay (north-western South Korea), a major landform containing the internationally important shorebird sites of Ganghwa Island, Yeongjong Island, Song Do (and Sorae) tidal flats, Namyang Bay and Asan Bay. Tidal-range is progressively less extreme southward along the west and south coasts, falling to 7 m at the Geum Estuary, 5 m in the south-west of the peninsula, and only 2.4 m at maximum at the Nakdong Estuary in the far south-east (Koh 1999).

Based on the present area remaining and the area of tidal flat believed reclaimed, it can be assumed that South Korea had at least 460,000 ha of tidal flat historically. Recognising that tidal flat reclamation “has a long history” in Korea, Long *et al.* (1988) stated that the first reclamation projects dated from the thirteenth century and that about 41,000 ha had been reclaimed in total by 1941. The pace of reclamation remained comparatively slow until the 1960s when, according to the Ministry of Agriculture and Forestry (1996) in Moores *et al.* (2001), 17,215 ha were reclaimed; increasing to 18,072 ha reclaimed in the 1970s; and a further 34,000 ha reclaimed between 1980 and the mid-1990s. These figures vary somewhat from the 97,000 ha reclaimed in total by 1983 suggested by Long *et al.* (1988), presumably based on different data from the Ministry of Construction and Transport provided to NEDECO (1985).

According to Koh (1999) there were an estimated 390,500 ha of tidal flats in South Korea in 1964, which had been reduced to an estimated 285,000 ha by the beginning of the 1990s (a loss averaging 1% per annum over the same period), with 83% of remaining tidal flats along the west coast and 17% along the south coast. By 1998, the year after South Korea acceded to the Ramsar Convention and the year before the passing of the national Wetlands Conservation Act (1999) which divided responsibility for wetland and wetland species conservation between the MoE and Ministry of Maritime Affairs and Fisheries (MOMAF), significant efforts were made to calculate the remaining area of tidal flat, and consequently area of authority for each ministry. Koh (1999) stated that 62,000 ha had already been dyked between 1985 and 1994, with a further 76,000 ha undergoing reclamation, including the 40,100 ha Saemangeum reclamation project. This might well be an underestimate, however, as it likely excludes from the total those tidal areas lost in rivers due to dams and barrages (with tidal influence formerly extending 70 km up the Geum River, and 42.4 km up the Nakdong: Moores *et al.* 2001); tidal-areas illegally reclaimed by private users (for salt pans, fish farms or other uses); and areas of lower tidal flat lost due to changes in tidal-regimes (including local sea-level rise due to embankments). In some areas by contrast, new tidal flats will likely have formed, and existing tidal flats changed in type and quality, due to barrage or dyke construction (e.g. Kim *et al.* 2006).

A very recent study by MOMAF, reported in the national Hankyoreh Newspaper (6 November, 2006), confirmed that tidal flat area had declined almost 20% in the past 20 years, to only 225,000 ha. In addition, with 267 reclamation projects now ongoing, and with ongoing and future plans targeting a further 113,600 ha, the Ministry anticipated a further loss of 44.5% of remaining tidal flat within the next 5 years: i.e. leading to an approximate 75% decline in tidal flat area from a historic total of *c.* 460,000 ha to less than 112,000 ha, with most of this loss occurring in only 50 years.

Due to this massive reclamation, in combination with pollution of inshore waters and over-fishing, South Korea’s fishing industry has had to increase fishing effort enormously in recent decades to maintain catches in national waters, inevitably leading to increased pressure on remaining shallow sea and tidal flat natural resources. Many extant tidal flat areas are also very heavily exploited by people, with bird scarers employed on the tidal flats in some areas (e.g. at the Suncheon Bay Ramsar site) to reduce competition between people and foraging shorebirds, and many tidal flats are lined with crab traps and fish nets. Almost all are significantly disturbed.

In addition, following the construction of the Geum, Yeongsan and Nakdong Estuary barrages, and the loss of the Saemangeum system, there are now only two major estuaries that are open to the sea: the Han-Imjin complex in the north-west, and the Seomjin River on the south coast. The former maintains very large shorebird populations, while the latter flows into Gwangyang Bay, now very extensively developed for heavy industry, with almost all tidal flat areas already reclaimed or targeted for reclamation. The loss of this brackish zone throughout much of coastal South Korea seems likely to have impacted fish populations, benthic communities and shorebird populations – and might be partly responsible for the massive decline at the Nakdong Estuary of some species following barrage closure.

While feeding areas for many shorebirds have been degraded by pollution or lost through reclamation and barrages, roost opportunities in many areas have also been reduced. The majority of salt-marsh and upper tidal flat areas (used for roosting by a broad range of species) have been lost to reclamation, while alternative artificial roost sites such as salt-pans have also become increasingly lost to recent changes in land use, with the pans either becoming overgrown or converted to other uses. Much of the hinterland of tidal flat areas (largely composed of agricultural land) has also become increasingly intensively developed following road construction programs initiated at the end of the 1990s, with a now well developed infrastructure along most of the coastline including higher dikes, roads, bridges, electric wires and in many areas restaurants or motels – elements potentially reducing attractiveness of such areas to roosting tidal flat shorebirds or even feeding freshwater dependent shorebirds. Changes over recent decades in agricultural practice also mean that most rice fields are either dry in April or May (during northward migration) or densely vegetated with rice crop from July until harvesting in October (the period of southward migration).

Housing, industrial estates, commercial properties, and especially rice fields (a suboptimal wetland type for a broad range of floodplain-associated species) now occupy almost all the remaining floodplain area, as well as reclaimed coastal flat-lands, with rice covering almost 1,000,000 ha nationwide in 1998. Despite the legal conditions of the Public Water Reclamation Act (requiring agriculture to be the primary purpose of any reclamation of public waters), the area of rice field is decreasing annually due to urban sprawl and other changes in land use, related largely to the growth in the national economy. Although there has been no national survey of shorebirds in rice fields, this habitat appears to be used by a rather small number of birds (both species and individuals), probably due to a combination of crop cycle outlined above, intensive use, well-developed infrastructure, disturbance, very high levels of pesticide and fertiliser use, and low levels of winter precipitation, when most fields often appear barren and frozen. As a result, perhaps only the Black-tailed Godwit is found in internationally important concentrations regularly in rice fields (as well as in adjacent coastal areas) with several thousand staging at Seosan and near Namyang Bay on northward migration. In addition, probably only *c.* 100 Northern Lapwing winter nationwide in rice fields. Grey-headed Lapwing, a fairly representative bird of rice fields in parts of central Japan, occurs only as a rare migrant. Breeding shorebirds like Black-winged Stilt has been found nesting in only two small discrete areas of rice field nationwide (both in very extensive areas reclaimed in the 1980s and 1990s, still lacking a well-developed infrastructure). The Greater Painted Snipe also seems to be of very local occurrence, breeding in rice fields interlaced with fallow fields or near-permanent shallow wetland.

There are even fewer data on area, length and quality of river used regularly by shorebirds. The Solitary Snipe is known regularly from only one stretch of river nationwide (less than 1 km in length) with records from probably the same area dating back over almost a century (e.g. Austin 1948, Fennell & King 1964, Moores & Moores 2004); yet this area is unprotected and suffering from increasing alteration of the river bank and catchment. The Long-billed Plover, a largely resident river-specialist, appears to be a reasonably widespread breeding species, tolerant to some degree, but apparently unable to use areas that suffer repeated dike-building and dredging.

Research priorities

While most coastal areas have now been surveyed, the following areas need attention.

- Gathering and analysing existing data on shorebirds, to detect statistically significant changes in species' number and abundance.
- In addition to counts conducted as part of the Saemangeum Shorebird Monitoring Program, regular counts are needed at other control sites, especially those not experiencing significant development pressures (if any exist), to help better understand the dynamics of shorebird migration in Korea, and the ecological requirements of staging shorebirds in the Yellow Sea.
- Coordination of counts targeting species of highest conservation value, such as Nordmann's Greenshank and Spoon-billed Sandpiper, is needed to establish an accurate national estimate and to identify more clearly these species' ecological needs.
- Shorebird research needs to be conducted in rice field areas to determine abundance, trends, and limiting factors for shorebirds. Ideally, such research should extend to investigate ways to modify farming practice, to enhance such areas for shorebirds.
- Counts need to be coordinated within river systems, to develop a more reasonable estimate of the numbers of shorebirds using such areas, especially for breeding. As with rice field research, this should extend to investigate ways to modify river-management methods, to maintain populations, or enable them to increase

INTERNATIONALLY IMPORTANT SHOREBIRD SITES

Based on the research described above and on other information received or reviewed, and dependent upon delineation, probably 17 discrete intertidal areas in South Korea used to support or still do support internationally important concentrations of shorebirds, though none are comprehensively protected or managed (Table 1). It is worth noting that while there is much overlap, these sites do not correspond exactly with those identified by Moores (1999a), Barter (2002), or Yi (2004) due to changes in shorebird population estimates, different datasets, and different delineation (the NIER for example, followed by Barter (2002), recognised the Mangyeung and Dongjin Estuaries as separate sites, despite shorebirds moving between both estuaries during tide-cycles, as well as listing Yubu Island as separate from the Geum Estuary [Yi 2004]). Several potentially internationally important sites have probably already been lost (e.g. Gwangyang Bay), while several others so-identified have been significantly degraded, even since 2000; eleven have been partially reclaimed; and three

Table 1. Internationally important wetlands for shorebirds in South Korea. In Threat column: 1 = Urbanization; 2 = Degradation; 3 = Over-exploitation/disturbance; 4 = Part-reclamation; 5 = Major Reclamation or development ongoing; 6 = Complete Reclamation ongoing; 7 = Threatened with further major reclamation. Table based on Moores *et al.* (2006).

Name	Coordinates	Threats
Han-Imjin Estuary	37º 45'N, 126º 48'E	1
Ganghwa Island	37º 35'N, 126º 27'E	1,2,3,4
Yeongjong Island (south)	37º 35'N, 126º 32'E	1,2,3,5
Song Do	37º 25'N, 126º 39'E	1,3,6
Daebu Island	37º 20'N, 126º 35'E	2,3,4
Namyang Bay	37º 10'N, 126º 44'E	5/6
Asan Bay	36º 55'N, 126º 53'E	1,2,4,7
Cheonsu Bay	36º 37'N, 126º 25'E	2
Geum Estuary	36º 01'N, 126º 35'E	1, 2, 3, 4, 7
Saemangeum Area	35º 50'N, 126º 45'E	6
Paeksu Tidal flat	35º 20'N, 126º 21'E	3,4
Hampyeong Bay	35º 07'N, 126º 25'E	2,4
Muan-Gun tidal flats	35º 04'N, 126º 16'E	2,4
Aphae Island	34º 50'N, 126º 20'E	2,4,5
Haenam Tidal flats	34º 25'N, 126º 30'E	2, 4
Suncheon Bay	34º 50'N, 127º 30'E	1,2,3,4
Nakdong Estuary	35º 05'N, 128º 50'E	1,2,3,4,5

or four have been or are being completely reclaimed. These include Saemangeum.

ESTIMATES OF CONTEMPORARY SHOREBIRD POPULATIONS IN SOUTH KOREA

The combination of the relative paucity of historical (and even contemporary) data on shorebird numbers outlined above, the very extensive and rapid degradation and loss of shorebird habitats, the anticipated annual fluctuations in population, and the lack of research on measuring or estimating population turnover rates within the region require that any national estimate of contemporary shorebird numbers in South Korea cannot be exact and needs to have a very significant margin of error built in. This is expressed in Table 2 through inclusion of a coarse measurement of level of confidence in the estimate, with greatest confidence (1) in estimates based on shorebirds that occur at only a few well known intertidal sites, and lowest confidence (3) for estimates of species usually found in very poorly researched habitats.

Table 2 is based on the following major sources of information:

- shorebird data gathered through nationwide survey effort, especially in 1998–1999 (Moores 1999a, 1999b) but also in subsequent years (pers. obs.);
- unpublished NIER data given in presentation (Yi in litt. 2003) and also national estimates provided for key sites (Yi 2004);
- Saemangeum and Geum Estuary data published in a number of sources, including that presented in Moores *et al.* (2006);
- Published and unpublished information, most especially in Gore and Won (1971), Long *et al.* (1988), Park (2002), and Barter (2002);
- Records in the Birds Korea archives, either submitted or gathered through internet and other searches.

While the estimates in Table 2 are similar in many cases to those presented by Yi (in litt. 2003), for others, e.g. Great Knot, they are very significantly lower (150,000 compared to 250,000 on northward migration), helping in turn to produce a rather more modest estimate of total numbers of shorebird present during migration (*c.* 470,000 of all species at all sites during northward migration, compared to 535,000 of a more limited range of species at the 8 major sites alone [Yi 2004]). These differences probably derive largely from the different method of calculation. The present estimates aim to be contemporary and aim to allow for the apparent decline of some species in recent years (e.g. Dunlin). More significantly, the NIER data is apparently based on adding maximum counts of a given species made over a period of years at different sites (with for example the Mangyeung and Dongjin, Geum Estuary and Yubu Island described as four sites), perhaps inadvertently increasing the possibility of double-counting. For Great Knot, although data remain insufficient to confirm the hypothesis, this paper instead recognizes two different main areas used in South Korea on northward migration especially – one centred on Saemangeum and the Geum (central west coast) and the other centred on Gyeonggi Bay (north-west coast), with Great Knot assumed to move frequently between contiguous key sites within these two discrete areas. Long *et al.* (1988) for example noted some movement of Great Knot between Namyang Bay and neighbouring Asan Bay, while survey effort in 1998 also recorded flocks of birds moving overland between the two sites. A count of 34,000 Great Knot at Asan Bay on 23 and 24 April 1998, with only 1,033 counted at

Table 2. National population estimates for the fifty-three most numerous shorebird species in South Korea. In all columns: r = recorded; CL = Confidence level (1: +/- 30%; 2: +/- 50% 3: +/- 75% or more); NM = Northward Migration (late March-late May); SM = Southward Migration (late July-late October); Br = Breeding species, with estimate expressed in pairs (late March-June); Non-Br = Non-breeding species, present in the northern mid-winter period (mid-December to mid-February); Trend: Inc. = Increasing; Dec. = Declining.

Species	**CL**	**NM**	**SM**	**Br Prs**	**Non-Br**	**Trend**
Eastern Oystercatcher *Haematopus (ostralegus) osculans*	1	r	r	300	5,000	
Black-winged Stilt *Himantopus himantopus*	2	100	<100	5-10	r	Inc.
Pied Avocet *Recurvirostra avosetta*	1	<5	<10	-	<5	-
Northern Lapwing *Vanellus vanellus*	2	r	r	-	250	-
Grey-headed Lapwing *Vanellus cinereus*	1	<10	<10	-	-	-
Pacific Golden Plover *Pluvialis fulva*	2	300	300	-	-	-
Grey Plover *Pluvialis squatarola*	1	15,000	20,000	-	6,000	-
Long-billed Plover *Charadrius placidus*	3	r	r	300	<1,000	-
Little Ringed Plover *Charadrius dubius*	3	2,000	3,000	500	-	-
Kentish Plover *Charadrius alexandrinus*	2	3,000	30,000	300	<1,000	-
Lesser Sand Plover *Charadrius mongolus*	2	12,000	10,000	-	<10	-
Greater Sand Plover *Charadrius leschenaultii*	2	<10	50	-	-	-
Greater Painted Snipe *Rostratula benghalensis*	3	r	r	10	<20	-
Pheasant-tailed Jacana *Hydrophasanius chirurgus*	1	<10	<5	(1)	-	Inc.
Eurasian Woodcock *Scolopax rusticola*	3	1,000?	1,000?	-	?	-
Solitary Snipe *Gallinago solitaria*	3		<20	-	10	-
Latham's Snipe *Gallinago hardwickii*	3	100	100	-	-	-
Pintail Snipe *Gallinago stenura*	3	100	500	-	r	-
Swinhoe's Snipe *Gallinago megala*	3	<100	<100	-	-	-
Common Snipe *Gallinago gallinago*	3	1,000?	10,000	-	<500	-
Long-billed Dowitcher *Limnodromus scolopaceus*	2	<10	<10	-	r	-
Asian Dowitcher *Limnodromus semipalmatus*	2	<5	5-10	-	-	-
Black-tailed Godwit *Limosa (limosa) melanuroides*	2	30,000	15,000	-	r	-
Bar-tailed Godwit *Limosa lapponica*	2	35,000	10,000	-	r	-
Little Curlew *Numenius minutus*	2	<50	r	-	-	-
Whimbrel *Numenius phaeopus*	2	6,000	3,000	-	r	-
Eurasian Curlew *Numenius arquata*	2	3,000	10,000	-	3,000	-
Far Eastern Curlew *Numenius madagascariensis*	2	10,000	7,500	-	r	-
Spotted Redshank *Tringa erythropus*	2	1,000?	200	-	<100	Dec.
Common Redshank *Tringa totanus*	2	100	250	-	10	-
Marsh Sandpiper *Tringa stagnatilis*	2	300	750	-	-	Inc.
Common Greenshank *Tringa nebularia*	2	4,000	10,000	-	25	-
Nordmann's Greenshank *Tringa guttifer*	2	100	150	-	-	-
Grey-tailed Tattler *Tringa brevipes*	2	8,000	2,000	-	-	-
Green Sandpiper *Tringa ochropus*	2	500	1,000	-	>250	-
Wood Sandpiper *Tringa glareola*	3	5,000	5,000	-	-	-
Terek Sandpiper *Xenus cinereus*	2	10,000	15,000	-	-	Inc.
Common Sandpiper *Actitis hypoleucos*	3	1,000	2,000	50	100	-
Ruddy Turnstone *Arenaria interpres*	2	1,200	2,000	-	r	Dec.
Great Knot *Calidris tenuirostris*	2	150,000	160,000	-	-	-
Red Knot *Calidris canutus*	3	5,000	1,000	-	-	-
Sanderling *Calidris alba*	2	500	1,000	-	300	-
Red-necked Stint *Calidris ruficollis*	2	10,000	7,500	-	<5	Dec.
Temminck's Stint *Calidris temminckii*	2	100	50	-	-	-
Long-toed Stint *Calidris subminuta*	3	500	500	-	-	-
Sharp-tailed Sandpiper *Calidris acuminata*	2	3,000	250	-	-	-
Curlew Sandpiper *Calidris ferruginea*	2	<100	<50	-	-	-
Dunlin *Calidris alpina*	2	150,000	70,000	-	30,000	Dec.
Spoon-billed Sandpiper *Eurynorhynchus pygmeus*	2	<50	<250	-	-	Dec.
Broad-billed Sandpiper *Limicola falcinellus*	2	<1,000	1,000	-	-	Dec.
Ruff *Philomachus pugnax*	2	<25	<25	-	-	
Red-necked Phalarope *Phalaropus lobatus*	3	1,000-10,000	1,000-10,000	-	-	Dec?
Oriental Pratincole *Glareola maldivarum*	1	<50	<25	(1)	-	Inc.

Namyang Bay over the same two days, was followed two weeks later by a count of 18,000 at Asan and 12,500 at Namyang Bay on 8 and 9 May 1998 (Moores 1999a), also strongly suggesting birds were moving between the two sites. In addition, within the Saemangeum area, Great Knot and other shorebirds (including Spoon-billed Sandpiper) have been observed regularly moving from the Dongjin Estuary to the Mangyeung, especially on incoming spring tides, with movement between the contiguous sites inevitable even at low tide, as many birds used the tidal flat lying between the two main river channels for feeding. In 1998 at least, large numbers of Great Knot were also watched moving between the northern part of Saemangeum (an area identified as part of the Geum estuary by Long *et al.* [1988], before reclamation of part of the site) and the Geum Estuary proper, while in 2006, some shorebirds feeding on the outer tidal flats of the Geum Estuary were also watched moving towards the Saemangeum reclamation area during the highest tides, returning soon on falling tides (pers. obs.). Apparently no simultaneous counts have recorded 150,000 Great Knot in Korea, and there was no obvious evidence of a high turnover of Great Knot through Saemangeum, the most important site for the species in Korea, at least in 2006. Instead, numbers built gradually through April and May, until most individuals departed towards the end of the month (with nearly all shorebirds gone by 20 May). Based on repeat counts and on the pattern of flag-sightings, it was deduced that Great Knot from eastern Australia arrived at Saemangeum in early April, and remained there for a long period, with their numbers augmented by birds, presumably from north-western Australia, which had first staged in eastern China (Moores *et al.* 2006). Moreover, counts of Great Knot on southward migration at Saemangeum showed extreme variation in the years 2003–2005, with maximum counts of 26,680, 123,745 and 66,380 respectively (KARICO 2003, 2004, 2005). As no mass mortality has been suggested by counts on northward migration during the same period, and unless there was double-counting at that time, it can be assumed that some of these birds were simply staging in different sites in different years, with almost all Great Knot in Korea staging at Saemangeum in 2004. In conclusion, it is considered that totalling maxima from adjacent sites greatly increases the potential for exaggerating the numbers at the national level of the species concerned.

BACKGROUND TO SHOREBIRD CONSERVATION

"Shorebird conservation status is best measured by the actual extent to which shorebirds and their habitats are being effectively protected by legislation, policies and plans, and the Protected Area system" (Barter 2002).

Fortunately, there is very little, if any, impact on shorebirds by hunting in South Korea, with the major threat to populations being the degradation and loss of habitat. This has been widely recognised. For example:

- there have been repeated calls for the conservation of key intertidal areas since at least 1988 (Long *et al.* 1988);
- South Korea has acceded to the Convention on Biodiversity Conservation and the Ramsar Convention, and intends to host the 10th Convention of the Parties in 2008;
- South Korea has enacted eight laws that charge four ministries with making policies for coastal and marine protected areas, designating 422 different Marine Protected Areas, including five Ecosystem Conservation Areas, 7 Wetlands Conservation Areas, 86 Wild Birds and Mammals Protected Areas, four Environmental Conservation Areas and 153 National Natural Monuments (Hong and Miller in prep.);
- it has also established a bilateral agreement with Russia for the protection of migratory birds, and has recently finalised a similar agreement with Australia;
- South Korea has also initiated a UNDP-GEF Wetlands Biodiversity project and a Yellow Sea project with China.

Despite these initiatives, there is still not a single comprehensively protected area of tidal flat in South Korea, and still almost 50% of remaining tidal flats are threatened by reclamation (Hangyoreh Newspaper, 6 November 2006). The Nakdong Estuary, on paper, is probably the most protected level of wetland nationwide, but is presently being part-reclaimed, with, in addition, a major expressway also being constructed through a recently restored wetland area there; and, even the Dongjin Estuary, the only South Korean coastal Protected Area identified by Barter (2002), has, as of April 2006, already been reclaimed.

The present failure of wetland conservation in South Korea has many underlying causes. An analysis in 2004, undertaken under the auspices of the MoE as part of the UNDP-GEF Wetlands Biodiversity project, identified approximately 23 major root causes of wetland loss and degradation in South Korea, which were then grouped under the following 5 overlapping headings.

- Lack of economic incentives to conserve, and provision of perverse incentives by local and national governments, to reclaim and degrade wetlands.
- Administrative and structural weaknesses.
- Legal framework loopholes and legal complexity.
- Lack of adequate information (and accessible models).
- Lack of capacity and support, especially for local key players and stakeholders, to develop local community-based initiatives.

Plans for reclamation, damming and conversion of rivers suffer from a combination of these elements, themselves deriving largely from the socio-economic conditions created by several decades of extremely rapid economic and industrial growth. Although certain sections of government (e.g. MoE and MoMAF) are required under the provisions of the Wetland Conservation Act (1999) to oversee wetland conservation, they apparently lack adequate funding and capacity to do so. Between the ministries there are few effective mechanisms to allow for exchange of information and even some of the ministries with responsibility for wetland conservation lack detailed information on wetland conservation and how best to achieve it. The Wetland Conservation Act itself appears to be deeply flawed in structure, with the MoE now responsible for species, for freshwater and for international conventions (such as Ramsar), while MoMAF is responsible for intertidal areas. Estuaries and brackish waters therefore fall under either both or neither ministry's authority. At the same time, other sections of government (most especially the Ministry of Construction and Transport and the Ministry of Agriculture and Forestry) have created an extremely strong political and financial power base, appropriating massive national funds, many of which are then used in converting, degrading or even destroying wetlands. The problems of achieving wetland and shorebird conservation are further confounded by the near-absence of a specialist non-government organisation (NGO) community (and a largely uninterested urban population). The environmental NGO community originated only in the 1970s and 1980s in response to the policies of a military government; it has less than 1% popular membership at the national level and it largely lacks adequate capacity to cooperate fully with existing specialist international NGOs, like Birdlife International and Wetlands International, neither of which has established national offices or formal partnerships with organizations in Korea.

Beyond the need within South Korea to improve existing structures to enable more communication and coordination between ministries and to increase awareness of the need and benefits of good conservation practice, there is also an urgent need for established NGOs and specialist institutions outside of Korea to find ways to involve further in and support wetland conservation initiatives in Korea and the Yellow Sea as a whole. While South Korea is one of the most economically powerful nations in the world, it has one of the poorest conservation records and still very limited capacity (and time) to modify existing policies on intertidal areas. Ramsar Resolution 7: 21, endorsed in 1999, calls for Contracting Parties, "to review and modify existing policies that adversely affect intertidal wetlands, to seek to introduce measures for the long-term conservation of these areas, and to provide advice on the success, or otherwise, of these actions in their National Reports" and "to identify and designate as Wetlands of International Importance a greater number and area of intertidal wetlands, especially tidal flats, giving priority to those sites which are important to indigenous people and local communities, and those holding globally threatened wetland species" (http://www.ramsar.org /res/key_res_vii.21e.htm). With only one tidal flat area to date designated a Ramsar site, and with almost all remaining internationally important areas threatened, it now appears especially ironic that this key Resolution was first proposed to the Ramsar Convention conference by South Korea's own government delegation.

SUMMARY

While information and datasets are hard to compare, the following can be suggested:

- Before1970, there was very limited shorebird research in South Korea. Between 1970 and 1988, this research was more or less confined to the north-west sites of Ganghwa Island, Yeongjong Island, Namyang Bay, Asan Bay and the Nakdong Estuary in the south-east. Between 1993 and 1998, survey effort began to include other sites along the west and south coasts. Between 1998 and the present, the Saemangeum area became recognized as the most important site for shorebirds in South Korea and the Yellow Sea.
- Estuaries and tidal flats are the most important habitat for shorebirds in South Korea, supporting several hundred thousand shorebirds on both northward and southward migration.
- While South Korea historically had an estimated 460,000 ha of tidal flat, over 50% of this area has already been lost, and a recent estimate suggested that only 110,000 ha will remain within the coming decade. In addition, remaining areas are typically heavily exploited, and most rivers are now dammed at their estuary.
- In addition to the decline of fisheries, some shorebird species appear to have shown significant declines in recent decades; these include Spotted Redshank, Red-necked Stint, Dunlin, Spoon-billed Sandpiper and perhaps Broad-billed Sandpiper. Other species have at least shown declines at known sites, due to either local changes or also to a decline in population, notably Nordmann's Greenshank. Some species have appeared to increase, likely due almost entirely to improved observer coverage; these include Grey Plover, Black-tailed Godwit and Great Knot; others, such as Terek Sandpiper, have apparently become genuinely more numerous in recent decades.
- More research is required to fill remaining information gaps.
- Much greater national effort and international cooperation and support is required if the present period is to result in genuinely improved conservation possibilities for Korea's and the Flyway's shorebirds.

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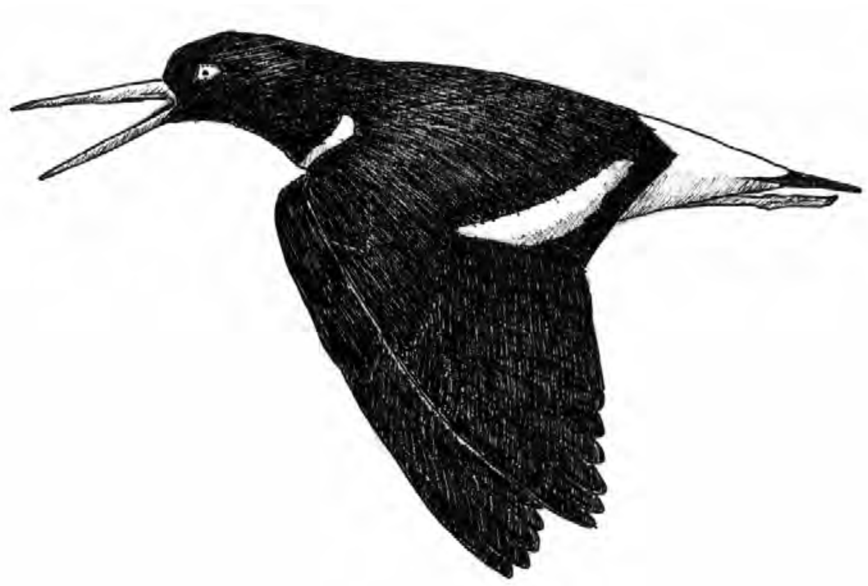

NORTHWARDS MIGRATION OF SHOREBIRDS THROUGH SAEMANGEUM, THE GEUM ESTUARY AND GOMSO BAY, SOUTH KOREA IN 2006

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Saemangeum, on the west coast of South Korea, was until recently recognised as the single most important staging site for migratory shorebirds in the East Asian–Australasian Flyway. However, construction of the Saemangeum sea-wall was completed in late April 2006. The 33 km dam across the Mangyeung and Dongjin Estuaries is part of the largest "reclamation" in the world, and will convert *c.* 400 km^2 of tidal flats to land and a freshwater reservoir. Here we report on systematic counts and scans for colour-banded and flagged shorebirds in Saemangeum, the adjacent Geum Estuary and Gomso Bay in April and May 2006. This was the first of a planned series of surveys to assess the effects of the reclamation on shorebirds.

We counted a minimum of 198,031 shorebirds in Saemangeum, 15 of which (including the endangered Spoon-billed Sandpiper) occurred in internationally important numbers. Local distribution of the shorebirds changed after closure of the sea-wall caused a decline in tidal range (with dried out inner estuarine sites being abandoned by shorebirds) and a dramatic die-off of benthic molluscs. Many shorebirds fed on the dying molluscs and this temporary food source may have enabled them to stage successfully. We had no clear evidence that birds abandoned Saemangeum on northwards migration in 2006, but the area and quality of suitable habitat for shorebirds in Saemangeum is likely to be greatly diminished by the time of the next northwards migration.

On the Geum Estuary we counted a minimum of 82,990 shorebirds, including internationally significant numbers of at least 13 species; these include among the largest counts made at any single site of the globally endangered Nordmann's Greenshank.

In at least two species, Bar-tailed Godwit and Great Knot, resightings of colour-banded birds indicated that the earliest migrants were dominated by birds from non-breeding grounds in eastern Australia or New Zealand, with a later influx of birds from north-western Australia which had probably staged on the coast of China. For Great Knots, and probably for several other species, the region appeared to be the final staging point before a direct flight to the breeding grounds. There was considerable interspecific variation in the timing of shorebird migration through the region, so peak numbers of particular species in the region can easily be overlooked in short-term surveys. The prolonged duration of our survey, in addition to the intensity of coverage achieved, may explain why the shorebird numbers we observed in the Geum Estuary were considerably higher than those reported in previous surveys. With the probable loss of Saemangeum to shorebirds, the Geum Estuary is now likely to be South Korea's premier shorebird site. Unfortunately, it too is threatened by a major land reclamation project.

INTRODUCTION

In recent years it has become clear that the Yellow Sea is the most important staging area for migratory shorebirds in the East Asian–Australasian Flyway (Barter 2002). The discovery of the importance of the area for shorebirds has coincided with the realisation that intertidal habitats in the Yellow Sea are threatened, and diminishing rapidly in both area and quality, as a result of the huge and fast-growing human populations and economies of China and South Korea. The main cause of habitat loss in the Yellow Sea is reclamation of tidal flats for a variety of purposes, including agriculture, industrial development, mariculture, saltworks and freshwater reservoirs (Barter 2002).

The largest single reclamation project undertaken in the Yellow Sea has been the development of Saemangeum, on the west coast of South Korea. This site has been recognised as the single most important staging site for shorebirds in the Yellow Sea (Barter 2002) and ecologists expect its loss will cause substantial population declines of shorebirds in the East Asian–Australasian flyway (Moores in press; Moores *et al*. 2006). This view is not shared by proponents of the sea-wall, who have claimed that the reclamation will be "environmentally friendly" and that displaced shorebirds can simply move elsewhere. In 2003 the Korean Ministry of Agriculture and Forestry identified the Geum Estuary and Gomso Bay as areas to which shorebirds displaced by the Saemangeum reclamation will move. These claims are strongly undermined by the facts that over 50% of Korea's tidal flat areas have been reclaimed since 1964, limiting the options for displaced shorebirds; that a major reclamation is also planned in the Geum Estuary; and that shorebirds displaced by reclamation elsewhere have been shown to suffer significantly increased mortality (Burton *et al*. 2006). Nevertheless, the existence of strongly conflicting viewpoints on the conservation impacts of reclamations such as Saemangeum make it difficult to ensure that key shorebird habitats in the Yellow Sea are protected. It is therefore extremely important that the effects of reclamation projects on shorebirds are measured and adequately documented.

With this consideration in mind, the Australasian Wader Studies Group (AWSG) and Birds Korea have formed a partnership to conduct the Saemangeum Shorebird

Monitoring Project (SSMP). The objective of the three-year program is to document the effect of the Saemangeum reclamation on shorebirds in Saemangeum itself and in adjacent estuarine systems (the Geum Estuary and Gomso Bay) which may receive displaced birds. The AWSG is also stepping up population monitoring counts of shorebirds in Australia (Gosbell & Clemens 2006), in part to assess whether the Saemangeum reclamation has detectable effects on non-breeding shorebird populations elsewhere in the flyway. Results of these studies will be disseminated widely to inform future conservation work in the East Asia–Australasian flyway.

In this paper we report on the first Korean field season of the SSMP. The work was undertaken in April and May 2006, coinciding with completion of construction of the Saemangeum sea-wall on 21 April 2006. Objectives of this report are:

1. To document numbers of shorebirds occurring in Saemangeum, the Geum and Gomso Bay on northwards migration, as a baseline against which subsequent surveys in these areas can be compared.
2. To document the timing of shorebird migration through the region, a necessary step if the overall number of birds using it as a staging area is to be estimated;
3. To make preliminary assessments of migratory origins of Saemangeum birds, so predictions can be made about where population declines caused by the Saemangeum reclamation will be observed;
4. To document roost locations, local shorebird movements and short-term effects of construction of the Saemangeum sea-wall.

METHODS

We carried out regular counts at seven high tide roosts in the Geum Estuary, at twenty roosts in the Saemangeum complex and at five sites in Gomso Bay (Figure 1). We refer to these sites combined as "the survey area" in the remainder of this paper. Fieldwork was carried out throughout April and May 2006, but particular effort was made to obtain comprehensive counts on the spring tide series that occurred in the study area over 15–17 April, 27–29 April, and 13–17 May. The actual period of surveying was much longer. Each of the main counts was preceded and followed by several days of additional surveying, so that we could ensure that we had located all the main shorebird roosts present, and so we could check that local shorebird movements did not cause us to "double-count" any birds.

Our team was not large enough to carry out counts at all sites in the region in a single day, but it was possible to carry out simultaneous counts at all major roosts in the Geum Estuary on a single high tide, in the Mangyeung Estuary on a single high tide, and in the Dongjin Estuary to Gomso Bay in a single day. In the same spring tide series we carried out additional observations in targetted sites (Yubu Island and Gunsan Air Base) to see if there were any tide-related movements of birds between the Geum and Mangyeung estuaries, and at Simpo in case there were movements between the inner parts of the Mangyeung and Dongjin estuaries. Movements between the Mangyeung and Dongjin Rivers were recorded at Simpo, but they appeared to involve local birds from the local open mudflats rather than individuals from the inner parts of the Mangyeung and Dongjin. No major movements between Saemangeum and the Geum Estuary were seen within any particular high tide during our survey (though we did see such movements from Yubu Island in September 2006), and sites that were counted twice in the same tide series had similar bird numbers on each occasion, suggesting that we did not have any double-counting problems.

We treated the peak count of each species obtained from a spring tide survey as a minimum estimate of the number of shorebirds staging on northwards migration in each of the Geum, Saemangeum and Gomso Bay. These totals may however be an underestimate of the number of shorebirds staging in the region, as we did not make any corrections for potential migratory turnover. In addition, the numbers of relatively rare species at Saemangeum and the Geum Estuary could easily be underestimated; for example Spoon-billed Sandpipers can be difficult to find when mingling with a large flock of Dunlins.

The core activity of the expedition was counting shorebirds, but we also counted the globally endangered Black-faced Spoonbill *Platalea minor*, vulnerable Chinese Egret *Egretta eulophotes* and vulnerable Saunders's Gull *Larus saundersi* if they were encountered during our surveys. We recorded all observations of colour-banded and leg-flagged shorebirds; scans for these were made opportunistically during counts, and more systematically during neap tides. Search effort for colour-marked birds was not recorded systematically, but was reasonably consistent throughout the expedition period. However, colour-marked birds were more difficult to detect in early and mid-April, when it was cold and windy, and shorebirds often fluffed up their plumage or sat down at roosts, concealing their legs. Migratory departure behaviour, which is readily recognised in shorebirds (Piersma *et al*. 1990) was recorded if seen. Finally, abdominal profiles of Great Knot were scored following the methodology of Wiersma & Piersma (1995) on several days during the expedition.

DR, NM and Ju-Yung Gi made a brief visit to Saemangeum and the Geum Estuary in late September 2006, and a few observations from this visit (including a count at Yubu Island) are also presented in this paper.

RESULTS

Notes on shorebird habitats and distribution within the study area

Geum Estuary

The distribution of shorebird habitat within the Geum Estuary has been extensively modified by human development. No shorebird roosts were found on the heavily urbanised southern shores of the lower Geum River, which are occupied by the industrial city and adjacent port of Gunsan. The upper reaches of the estuary have been unsuitable for most species of shorebird since the Geum River Barrage was built in the late 1980's, forming a large freshwater lake that flooded the former tidal flats and saltmarsh. The great majority of shorebird habitat remaining in the Geum occurs on the reasonably large tidal flat

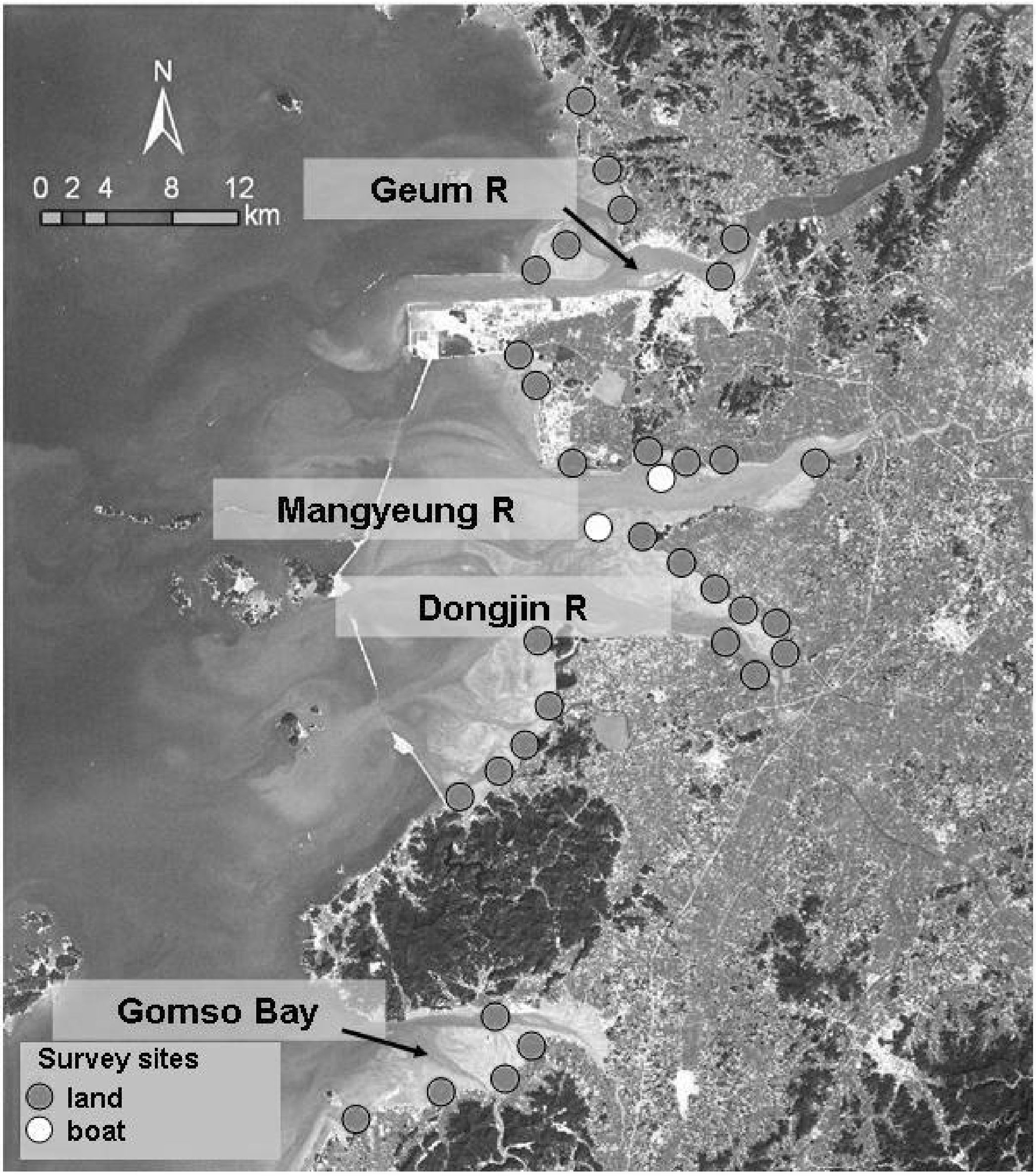

Figure 1. Map of the study region, showing main roost sites where counts were conducted (counts from some of these sites were pooled for analysis – see Figure 3).

remnants to the north of the river mouth (*c.* 10.5 km^2 exposed at low tide), and shorebirds also feed on tidal flats in those parts of the river channel below the Geum River Barrage.

Observations of birds flying into or out of high tide roosts suggested that the majority of shorebirds in the Geum Estuary fed on the Daejuk Tidal Flat, especially along the shores of the Gaeya Channel (Figure 2). At high tide these birds moved to roosts on Yubu Island and Daejuk Island (or, if the tide was not very high, on the sandflats between them), or to roosts on the mainland coast at Songsok Ri, Namjeon Ri or Daemoe, Janghang-Eup. These mainland roosts were partially to completely submerged by tides over 6.5 m high, and in such conditions shorebirds were forced to Yubu or Daejuk islands. The potential roosting areas on these islands were small on very high tides, and on 6.8 m tides in September 2006, some shorebirds (especially Grey Plovers) were seen leaving Yubu Island and flying to roosts in the Saemangeum system, probably near the US Air Force base at Gunsan. Such movements have been seen in the region before (NM unpubl.), but we had no evidence that they occurred during our northwards migration study period in 2006.

The lower parts of the Geum River channel are tidal; at low water extensive soft mudflats are exposed on Haemangdong Tidal Flat and Gupo Tidal Flat (Figure 2), and they are used as feeding areas by reasonably large numbers of shorebirds. These can be counted most efficiently on rising tides, which push the shorebirds into pre-roosts on mudflats on the northern shore of the Geum River. These pre-roosts are submerged at the peak of high tide. Some of the displaced shorebirds flew to high tide roosts at Daemoe Harbour, but we were unable to relocate all the Gupo Tidal Flat birds at high tide roosts. We suspect some of these,

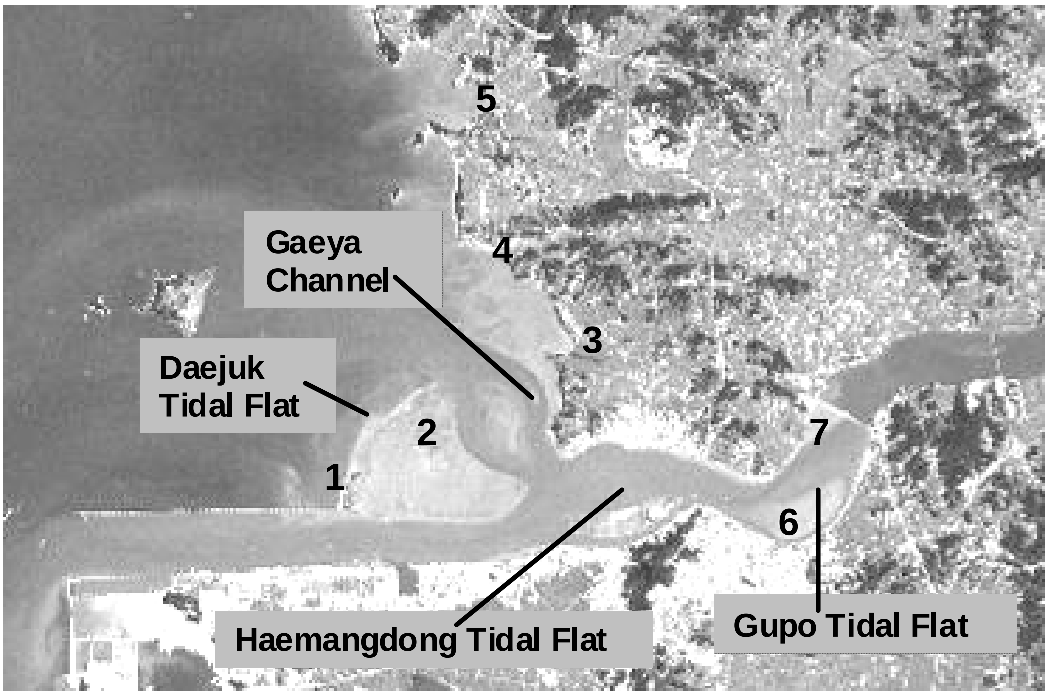

Figure 2. Satellite photograph of the Geum Estuary. Numbers indicate the roost sites and pre-roosts counted regularly in April-May 2006 (names given in quotation marks are nicknames for sites that do not appear to have a Korean name); maximum shorebird counts recorded in a single high tide at each site are given below, along with maxima recorded in previous surveys by N. Moores (unpubl. data) or Lee *et al.* (2002).

#	Roost name	Peak count in April-May 2006	* Peak historic count
1	Yubu Island	40,582	31,268
2	Daejuk Island	15,215	NA
3	Daemoe, Oknam Ri	22,443	22,532
4	Namjeon Ri	4,094	3,396
5	Songsok Ri (Janggu Bay)	1,122	645
6	“Geum Barrage S”	8,994	NA
7	“Geum Barrage N”	1,527	5,618

*These data should not be considered comprehensive as few other data sources have been checked.

particularly Black-tailed Godwits, Broad-billed and Sharp-tailed Sandpipers, must have had undiscovered roosts on rice fields inland of the Geum Barrage.

Saemangeum

The largest shorebird roosts found within the Saemangeum complex were at Okgu and Simpo (Figure 3); observations of birds flying into and out of these roosts suggested that both sites were used largely by birds feeding on the extensive outer tidal flats at the confluence of the Mangyeung and Dongjin rivers. At both of these sites, counts were dominated by Great Knot. Smaller shorebird roosts were found adjacent to the tidal flats north of the Mangyeung River channel (near Gunsan Airport; dominated by Dunlin), and adjacent to the tidal flats south-west of the Dongjin River channel (sandy flats, dominated by Eastern Curlew and Dunlin). Shorebird roosts on the inner reaches of the Mangyeung and Dongjin Rivers had relatively lower numbers of shorebirds (Figure 3). In contrast, in previous years tens of thousands of shorebirds had been counted coming into roosts in salt-marsh near Wolyeon, at Hapo/Mangyeung-Eup (Mangyeung) and along much of the entire northern shore of the Dongjin (N. Moores, unpubl.). Historically these roosts were used most by shorebirds on medium-high tides; on the very highest tides, when the salt-marsh was inundated, many of the shorebirds tended to roost at other easier-to-count roost sites, such as at Okgu or to a lesser extent, Gyewhado, where banding and counting efforts were largely concentrated.

Shorebird habitat and distribution within Saemangeum changed markedly during the study period. The natural tidal range in Saemangeum was over 7 m during the biggest spring tides, but construction of the sea-wall has greatly reduced exchange of estuarine and Yellow Sea waters. The 33 km sea-wall was officially completed on 21 April, with the only remaining gaps being the 540 m of sluice gates opposite the Dongjin River. The sluice gates were open throughout our study period, but tidal range nevertheless dropped markedly: in late April and May it was less than a metre, even on spring tides. As a result, high tides no longer reached tidal flats in the upper reaches of the estuaries. This is probably why shorebird counts at the inner Saemangeum roosts (sites 5, 10 and 11 in Figure 3) were highest in early April, despite the fact that the number of shorebirds in the

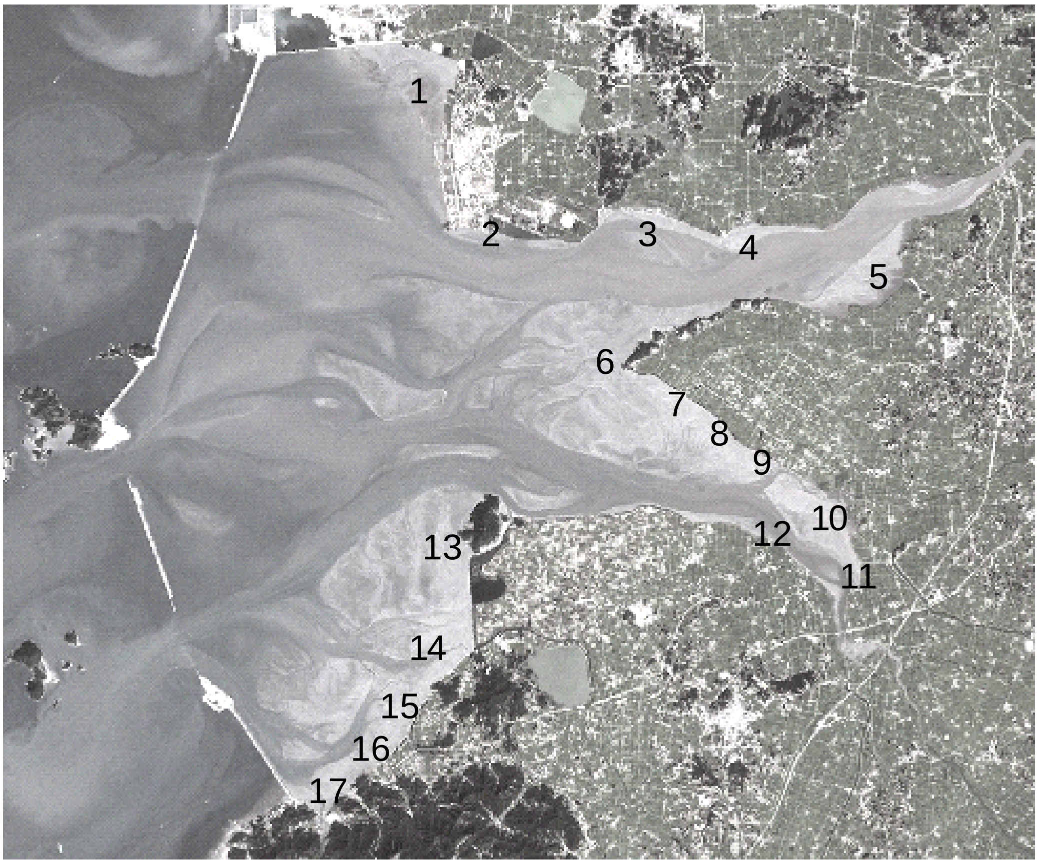

Figure 3. Satellite photograph of Saemangeum. Numbers indicate the roost sites and pre-roosts counted regularly in April-May 2006 (site names given in quotation marks are unofficial nicknames assigned on our expedition); maximum shorebird counts recorded in a single high tide at each count are given below.

#	Roost name	Peak count in April-May 2006	Date of peak count (2006)
1	"Gunsan Airbase"/Okbong Ri	17,151	14 May
2	Haje Harbour	2,447	26 Apr.
3	Okgu Eup	80,000	29 Apr.
4	Wolyeon Ri, "Crane Point"	6,916	25 Apr.
5	Mangyeung Eup, "S1"	4,054	3 Apr.
6	Simpo Ri	52,297	13 May
7	Changjae Ri, "Dongjin N6"	5,201	11 Apr.
8	Gwanghwalmyeon, "Dongjin N5"	10,337	1 Apr.
9	Unpari, "Dongjin N4"	10,047	14 May
10	Nampo Ri, "Dongjin N2"	5,534	15 Apr.
11	Seobo Ri, "Dongjin N1"	2,062	10 Apr.
12	Munpo, Anseong Ri, "Dongjin South"	2,044	16 May
13	Gyehwa Ri	5,000	27 Apr.
14	Buldung, "South-west 3"	3,594	15 Apr.
15	Jangsin Ri, "South-west 2"	4,900	15 Apr.
16	Wolpo, "South-west 1"	10,364	14 May
17	Haseo Myeon, "Education centre"	1,468	14 May

general region increased steadily through April and peaked in mid-May.

The lack of tidal inundation on the upper flats of the Saemangeum system caused a massive die-off of shellfish in late April and May. Large numbers of shellfish came to the surface of the mudflats and died, gaping open and providing a ready food source for shorebirds (Figure 4). In particular, thousands of Great Knots and Dunlin were seen picking the flesh out of dying or freshly dead cockles in the Simpo area. Shellfish species that were observed dying included the brachiopod *Lingula anatina*, solenoid bivalves (probably *Solen strictus*), the cockle *Mactra veneriformis*, several smaller species of bivalve (*Sinonovacula constricta*, *Nuttalia obscurata*), the gastropod *Umbonium thomasi* and the crabs *Macrophthalmus japonicus*, *Philyra pisum* and *Portunus trituberculatus*. Local fisherfolk operating crab traps on

Figure 4. Saemangeum in the last week of April, 2006. Within a week of sea-wall closure, many square kilometres of mudflat were dominated by dying bivalves that came to the surface and lay gaping open (photo: Ju-Yung Gi). In the short term this provided an easily accessible food supply for shorebirds such as the Dunlin *Calidris alpina* (inset photo: Jan van de Kam) but neither this food source, nor any other, will be available to staging shorebirds on the mudflats of Saemangeum in the future.

areas of the lower tidal flats that still received tidal waters reported that 30–40% of crabs found in their traps were dead, suggesting a loss of condition (usually crabs are captured alive in these traps).

We did not have time to make quantitative observations of the scale of the shellfish die-off. In theory doing so would have been straightforward, as the dying shellfish were easily seen on the surface, and the zones in which they occurred were extensive (hundreds of metres wide) and sharply defined. In May it was noted that the "dead shellfish zones" were expanding seawards, and that they occurred not only in areas no longer inundated by high tides, but also in areas that were only occasionally inundated. At the same time, dead shellfish that had been longest exposed had been scavenged or decomposed to the point that they no longer provided a food source, so those areas of the "dead shellfish" zones at the highest tidal levels were abandoned by feeding shorebirds. In September 2006, when DR and NM revisited the same sites at Simpo, these habitats had changed considerably in appearance. The Saemangeum Development Corporation had apparently employed people to collect the remains of dead shellfish from the surface and to scatter seeds of halophytes, transforming large areas of open mudflat to saltmarsh.

Several dead shorebirds were found on a large sandflat island roost off Okgu, in Saemangeum. Two Great Knot corpses were found there on 29 April, and a further 7 (plus one Dunlin) on 15 May. In early September 2006, 14 dead juvenile Red-necked Stints and a dead juvenile Spoon-billed Sandpiper were found at the same site. Interestingly, no dead shorebirds were found on sandflat roosts on the Geum Estuary, despite the fact that a similar amount of time was spent there by observers, and that the presence of two dead passerines in the flats at Yubu Island (a Dusky Thrush and a Siskin) suggests that the tides had not caused bird corpses on the Geum sandflats to be washed away. It is therefore possible that the death of the Saemangeum birds was related to the reclamation, perhaps because food supplies were insufficient or because birds became ill as they were forced to eat carrion. However, the cause of death of these birds is unconfirmed; those found in spring did not appear to be emaciated.

The reduction in tidal range in Saemangeum must also have influenced lower tidal levels, as large mudflat areas are now permanently inundated, and are no longer exposed to low tides (or feeding shorebirds). We have no data on how this might have affected the local benthos.

Gomso Bay

This is a large, mostly sandy bay, approximately 15 km in length and 5 km wide at its mouth, fed however by only two significant streams. Much of the bay's hinterland remains potentially attractive to shorebirds (with salt-pans and wet rice fields for example, especially in the north), and while all such areas were checked during the survey, the most-used roosts were in the bay proper (most especially a stretch of rocky shore in the northwest, and a rather small area of salt-marsh in the innermost part). At lower tides, in good light, scans across the whole inner bay were also conducted from several vantage points. Despite adequate coverage, we found few shorebirds in total. Local fisherfolk complain of the bay's rather low productivity, presumably in part due to the combination of sandy substrate and marine-influence, and this is reflected not only by the low number of shorebirds found during the survey period, but also by the relative scarcity of other waterbird species at other seasons. Despite the small numbers of shorebirds there, Gomso Bay was still found to be internationally important for Whimbrel (most of which were found in the northwest part of the bay), held a single Black-faced Spoonbill during the survey period, and also supported up to 10 endangered Oriental White Stork *Ciconia boyciana* in early January 2007 (Ju Yong-Gi pers. comm. 2007)

Species totals and peaks

Species totals observed in the complete counts on the spring tide series from 14–17 April, 27–29 April and 13–17 May are summarised in Table 1. A minimum of 82,993 shorebirds were found in the Geum Estuary, including 13 species that occurred in internationally significant numbers; given that our counts were likely to be underestimates, we consider it probable that a fourteenth species (Sanderling) was also present in internationally significant numbers. A minimum of 198,031 shorebirds were found in Saemangeum, including 15 species that occurred in internationally significant numbers. Gomso Bay had far fewer shorebirds (a minimum of 1,139) but still had one species, Whimbrel, in internationally significant numbers.

Few observations of migratory departures were made during the expedition, largely because we only had a small team in mid- and late May, when most departures are thought to have occurred. Some departures were seen from the Geum Estuary on 15 May (74 Common Greenshank from Namjeon Ri; 14 Lesser Sand Plovers, 115 Bar-tailed Godwits and 50 Dunlin from Daemoe Harbour), and 63 Terek Sandpipers were seen departing from Simpo on 26 May. Expedition members Kevin and Kelly White made almost daily visits to Simpo (the largest easily accessible roost in Saemangeum in mid-May) from 13 May to 21 May, and although they did not have the time or light conditions to conduct complete counts of the site, they observed a very obvious decline in shorebird numbers and considered that most departures occurred between about 15 and 20 May; by 26 May they found only 233 shorebirds at this site, though it had held 50,000 shorebirds on 13 May.

Different species of shorebird migrated through the region at slightly different times (Figure 5). Specific notes on timing of migration are given in the annotated species list below, along with notes on migratory origins if colour-band and leg-flag resightings were made.

Eastern Oystercatcher *Haematopus ostralegus osculans*

Most of the 1,485 seen in the region occurred in the Geum Estuary, roosting on Yubu and Daejuk ISLANDS. In late September 495 Eastern Oystercatchers were found roosting on Yubu Island; they were followed by observers at low tide and almost all birds fed on sandy tidal flats north of the island. Previous surveys have shown that the numbers roosting at Yubu Island are highest in the non-breeding period (Barter 2002, Lee *et al*. 2002), with a maximum count of 5,700 – i.e. 57% of the estimated world population of 10,000 of this distinctive taxon; they also breed there and on surrounding islets in lower numbers (Lee 2004). Saemangeum had lower numbers of Oystercatchers but they were still in internationally significant levels during our survey. Most were found on tidal mudflats near the Gunsan airport, or on tidal sandflats at Simpo. There were small rocky islets at both of these sites, and oystercatchers are suspected to have nested in both these areas in the past.

Given that Eastern Oystercatchers occur in the region in largest numbers during the non-breeding season (i.e. the boreal winter), it is a little surprising that our count in mid-April was lower than that at the end of April (Figure 1), both in the Geum Estuary and Saemangeum. This may suggest there was some passage migration through the region. We did not find any colour-banded or flagged oystercatchers, but it is unlikely that many have been colour-marked elsewhere in the flyway.

Black-winged Stilt *Himantopus himantopus*

A few were found in the Saemangeum region in mid-April, some in flooded rice fields or fishponds near the coast and some on the tidal flats themselves.

Northern Lapwing *Vanellus vanellus*

A single bird was seen on mudflats in the Geum River (near the barrage) on 6 April.

Pacific Golden Plover *Pluvialis fulva*

Low numbers were seen in Saemangeum and the Geum in April; counts were lower at the end of mid-April, suggesting that numbers might have peaked before we began intensive surveying. No colour-marked birds were seen.

Grey Plover *Pluvialis squatarola*

A minimum total of 5,424 Grey Plover was recorded in the survey area, constituting 4.4% of the estimated flyway population. Highest counts were made in the Geum Estuary on Yubu Island and Daemoe Harbour. In Saemangeum, the highest numbers were seen at Okgu, roosts on the northern shores of the Dongjin Estuary, and (in early April only) on the mudflats near the Gunsan US Air-Force base. About 6,000 Grey Plover occur in South Korea during the non-breeding period, and such birds are likely to have still been present at the start of our survey. Numbers of Grey Plover increased gradually during the survey period, suggesting the

Table 1. Shorebird counts during the spring tide surveys in April-May 2006 at the Geum Estuary, Saemangeum and Gomso Bay. The total shorebird counts given are the sum of the peak counts observed during the surveys, and do not include any corrections for potential turnover; they are therefore minimum estimates of the numbers of shorebirds using these sites on northwards migration. The second column gives the 1% criterion for each species (in the East Asian–Australasian flyway, from Wetland International 2006, except for the Broad-billed Sandpiper estimate from Bamford *et al.* 2006 and the Spoon-billed Sandpiper estimate from Syroechkovsky 2005; Lesser Sand Plover estimate combines subspecies *mongolus* and *stegmanni*, Bar-tailed Godwit estimate combines subspecies *baueri* and *menzbieri*, Common Redshank estimate combines subspecies *terrignotae* and *craggi*, Dunlin estimate combines subspecies *arcticola* and *sakhalina*). Sites where peak numbers exceed this total (i.e. >1% of the minimum flyway population estimate) are considered to be of international significance under the Ramsar convention on wetlands and are highlighted in boldface.

Species	1% Level	Geum Estuary				Saemangeum				Gomso Bay			
		Mid-April	Late April	Mid-May	Peak	Mid-April	Late April	Mid-May	Peak	Mid-April	Late April	Mid-May	Peak
Shorebirds													
Eastern Oystercatcher	100	862	1,255	70	**1,255**	180	227	81	**227**	-	1	3	3
Black-winged Stilt	1000	-	-	-	-	29	1	-	29	-	-	-	-
Northern Lapwing	10,000	1	-	-	1	-	-	-	-	-	-	-	-
Pacific Golden Plover	1,000	15	-	1	15	21	12	2	21	-	-	-	-
Grey Plover	1,300	2,194	2,771	3,004	**3,004**	1,615	1,786	2,179	**2,179**	1	-	71	71
Little Ringed Plover	250	10	1		10	-	-	2	2	-	5	-	5
Kentish Plover	1,000	25	32	11	32	486	102	61	486	-	-	-	-
Lesser Sand Plover	600	1	533	1,691	**1,691**	4	1,445	5,914	**5,914**	-	-	1	1
Greater Sand Plover	1,000	1	-	-	1	-	-	1	1	-	-	-	-
Eurasian Woodcock		-	-	-	1	-	-	-	-	-	-	-	-
Common Snipe	10,000	-	5	-	5	-	-	-	-	-	-	-	-
Asian Dowitcher	230	-	-	-	-	-	1	1	1	-	-	-	-
Black-tailed Godwit	1,600	15	37	930	930	3	261	613	613	-	-	-	-
Bar-tailed Godwit	3,300	11,460	12,479	3,338	**12,479**	4,416	5,826	5,422	**5,826**	-	-	-	-
Little Curlew	1,800	-	-	-	1	1	-	-	3	-	-	-	-
Whimbrel	550	24	150	1,215	**1,215**	45	552	1,028	**1,028**	-	609	439	**609**
Eurasian Curlew	350	324	428	30	**428**	36	83	21	83	-	4	-	4
Eastern Curlew	380	2,582	726	278	**2,582**	2,261	794	610	**2,261**	-	14	-	14
Curlew sp.		-	-	237	237	-	-	20	20		-	-	-
Spotted Redshank	1,000	2	2	56	56	137	55	113	137	-	-	-	-
Common Redshank	650	-	1	-	1	2	5	41	41	-	1	-	1
Marsh Sandpiper	10,000	-	-	-	0	5	7	1	7	-	-	-	-
Common Greenshank	1,000	50	84	1,482	**1,482**	100	110	912	912	-	55	20	55
Nordmann's Greenshank	8	14	43	70	**70**	-	7	14	**14**	-	-	-	-
Green Sandpiper	1,000	-	-	-	-	3	1	-	3	-	-	3	3
Wood Sandpiper	1,000	1	2	-	2	-	-	12	12	-	27	9	27
Terek Sandpiper	500	29	206	1,629	**1,629**	103	744	3,855	**3,855**	-	-	149	149
Common Sandpiper	500	-	1	5	5	1	2	10	10	-	-	2	2
Grey-tailed Tattler	400	-	2	59	59	-	3	233	233	-	-	10	10
Ruddy Turnstone	310	2	187	695	**695**	-	315	744	**744**	-	-	-	-
Great Knot	3,800	10,429	16,135	29,838	**29,838**	27,258	83,404	86,288	**86,288**	-	-	-	13
Red Knot	2,200	2	3	10	10	37	45	64	64	-	-	-	-
Sanderling	220	120	196	78	196	1	222	2	**222**	-	-	-	-
Red-necked Stint	3,200	4	92	719	719	296	782	5,154	**5,154**	-	16	-	16
Temminck's Stint	1,000	2	-	-	2	-	-	-	-	-	-	-	-
Pectoral Sandpiper		-	-	-	-	-	-	-	1	-	-	-	-
Sharp-tailed Sandpiper	1,600	15	9	1,014	1,014	18	99	645	645	-	-	-	-
Curlew Sandpiper	1,800	-	-	5	5	-	1	32	32	-	-	-	-
Dunlin	17,500	17,300	23,310	20,150	**23,310**	34,645	41,593	62,508	**62,508**	-	169	60	169
Spoon-billed Sandpiper	15	-	-	1	1	1	5	34	**34**	-	-	-	-
Broad-billed Sandpiper	250	-	1	11	11	2	2	338	**338**	-	-	-	-
Ruff		-	-	-	-	5	1	-	5	-	-	-	-
Oriental Pratincole	750	-	2	-	2	-	-	-	-	-	-	-	-
Unidentified shorebirds		-	-	-	-	-	18,092	-	18,092	-	-	-	-
										-	-	-	-
Total Shorebirds		45,484	58,693	66,627	82,993	71,711	156,585	176,955	198,031	1	901	767	1,139
Other noteworthy species													
Black-faced Spoonbill	15	1	4	-	4	1	1	5	5	-	-	-	-
Chinese Egret	30	-	-	-	-	-	1	1	1	-	-	-	-
Saunders's Gull	85	25	10	5	25	19	12	3	19	-	-	-	-

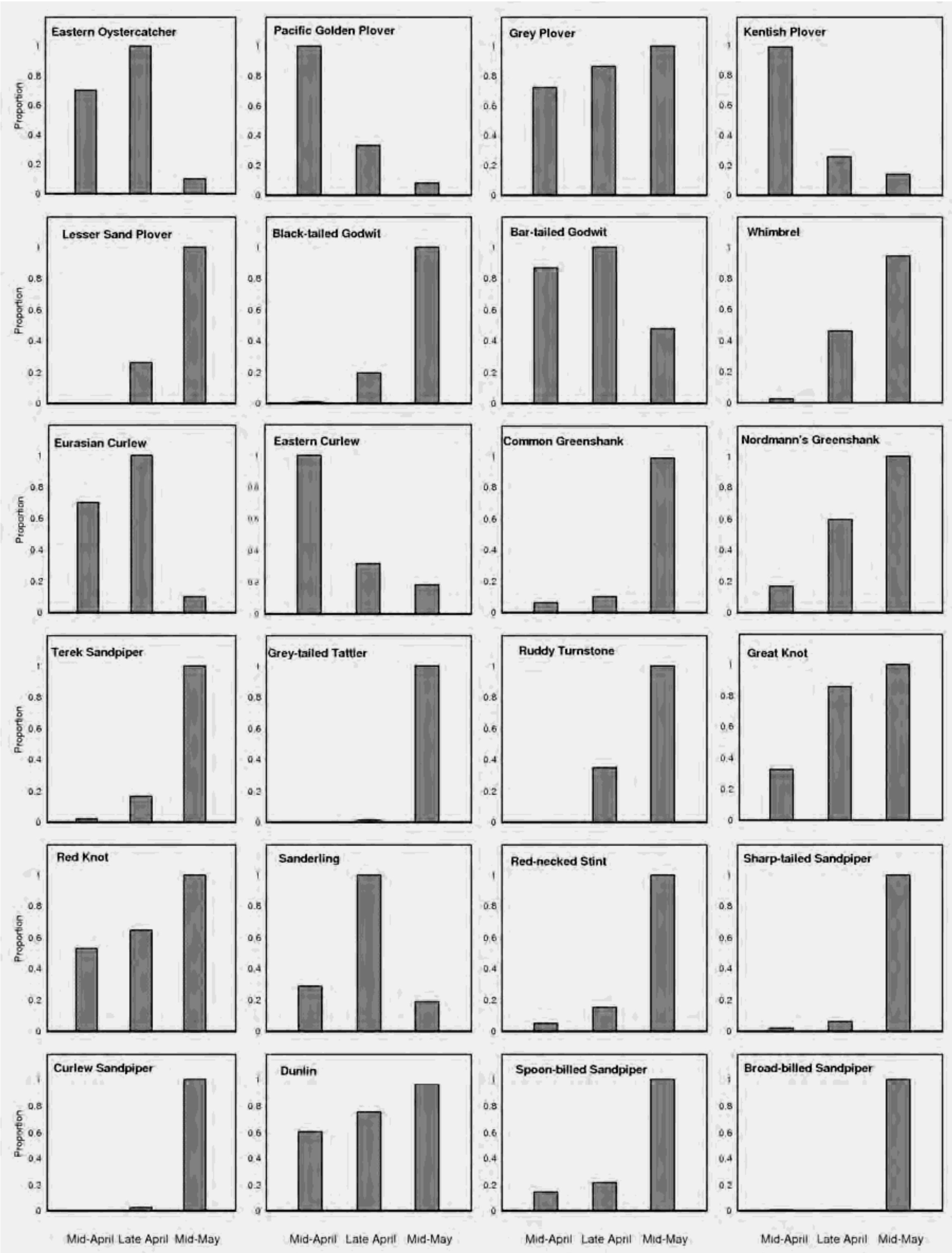

Figure 5. Timing of migration of selected shorebird species through the west coast of South Korea in mid-April (left-hand bar), late April and mid-May (right-hand bar). Data from Saemangeum, the Geum Estuary and Gomso Bay are pooled. On the Y-axis, the number of birds is presented as the proportion of the peak count.

arrival of passage migrants. No flagged or colour-banded birds were found, perhaps reflecting the low numbers of this species banded elsewhere in the flyway (at the time of our study, only 239 had been flagged in north-western Australia, and 86 in Victoria).

Little Ringed Plover *Charadius dubius*

Low numbers were seen in Saemangeum and the Geum in April; mostly beside freshwater wetlands near the coast or on small pools on upper mudflats. No colour-marked birds were seen.

Kentish Plover *Charadrius alexandrinus*

A few were seen at most sites within Saemangeum and the Geum estuary, but high counts were only made on mudflats near the Gunsan US Air-Force base, with 552 there on a neap high tide on 14 April. Numbers declined steadily through April and May, suggesting that departure to the breeding areas occurred earlier than in species that breed at higher latitudes. Given the early passage of this species, it is likely our counts were an underestimate of the number occurring in the area on northwards migration. Numbers in the region are considerably higher on southwards migration, when peak counts of 2,500 have been made in the Geum Estuary, 11,000 in the Mangyeung Estuary and 8,500 in the Dongjin Estuary (Barter 2002). No colour-marked birds were seen.

Lesser Sand Plover *Charadius mongolus*

A minimum total of 7,606 was recorded during our survey, comprising 5.9% of the estimated flyway population. Plumage characters suggested that most or all seen were in the *mongolus* subspecies group, which some workers consider to be a full species "Mongolian Plover" (Hirschfield *et al*. 2000). Five leg-flagged birds were seen. Two of these, with an orange-white flag combination, had been banded in Korea. A bird with a single orange flag, and another with a single white flag, may also have been birds that had been banded in Korea but subsequently lost a leg-flag; alternatively the orange-flagged bird may have come from Victoria, where 55 Lesser Sand Plovers have been flagged. Origins of a bird seen with a single blue leg-flag were unclear as the bird may have lost a leg-flag; this colour is part of the leg-flag codes for both Japan and Taiwan.

Greater Sand Plover *Charadrius leschenaultii*

Single birds were seen at Yubu Island (17 April) and Okgu (15 May).

Eurasian Woodcock *Scolopax rusticola*

A single bird was seen on Yubu Island on 9 April.

Common Snipe *Gallinago gallinago*

Up to five birds were seen on a flooded rice field next to Daemoe Harbour (Geum Estuary) between 24 and 26 April.

Asian Dowitcher *Limnodromus semipalmatus*

Single birds were seen on the northern shores of the Dongjin Estuary on 17 April and 14 May, with one further individual seen near Daemoe Harbour on 30 April.

Black-tailed Godwit *Limosa limosa*

This species occurred in largest numbers on inner tidal flats of estuarine systems. The highest counts were made in the Geum Estuary, with 830 on the Haemangdong and Gupo Tidal Flats on 16 May. In Saemangeum, the highest counts were made on the northern shores of the Dongjin River, and at Okgu. Black-tailed Godwit was a late migrant through the region, with numbers increasing five-fold between the end of April and mid-May. The late arrival of this species suggests that it stages elsewhere before reaching Korea; this suggestion is supported by the single leg-flag resighting, a bird banded at Chongming Dao (near Shanghai, on the Chinese coast). No north-west Australian leg-flags were seen, although 586 Black-tailed Godwits had been flagged in north-western Australia in the years before our expedition began.

Bar-tailed Godwit *Limosa lapponica*

Two subspecies of Bar-tailed Godwit occurred in the study region, *baueri* (which breeds in Alaska and spends the non-breeding season in eastern Australia and New Zealand) and *menzbieri* (which breeds in Yakutia and spends the non-breeding season in north-western Australia). The presence of both subspecies would have been apparent simply from field observations, as the whiter rump of subspecies *menzbieri* was reasonably easy to detect when birds were in flight. However, we had still stronger support for the presence of both subspecies from leg-flag and colour-band resightings. We made 131 observations of colour-marked birds, this high total being caused by a combination of: (1) large numbers colour-marked in the flyway (*c.* 7,900 had been flagged in north-western Australia, *c.* 2,230 flagged in south-eastern Australia, and 1,248 in New Zealand before our survey began); (2) ease of detection, leg-flags or colour-bands often being visible on this long-legged species in cold weather when bands or flags on the tibia of other species were concealed by fluffed-up feathers; and (3) particular attention being paid to Bar-tailed Godwits by expedition participants seeking birds from their own banding projects.

Resightings of colour-marked birds confirmed that *baueri* was by far the most abundant subspecies of Bar-tailed Godwit in the region, with 130 birds being resighted from New Zealand (n = 38), Victoria (85), Queensland (4) and New South Wales (3). Only 22 north-west Australian *menzbieri* were relocated, despite more Bar-tailed Godwits having been leg-flagged in north-western Australia than in south-eastern Australia and New Zealand. At least 23 birds were with individual colour-band combinations from New Zealand, one of which was seen just 11 days after last being seen in New Zealand. Five of these individuals were seen more than once; one of these remained in the study area for at least 11 days, and another for at least 25 days. This indicates that some Bar-tailed Godwits stage in the region for a long period, presumably undertaking substantial pre-migratory fuelling in that time.

Despite this evidence for some *baueri* staging for long periods, it was clear that many other *baueri* did not remain in the region throughout our study period. Numbers of Bar-tailed Godwits decreased sharply after the end of April. However, numbers of north-west Australian *menzbieri* rose in the same period (Figure 6), indicating that they were moving into the area as *baueri* departed. Most Bar-tailed Godwit departures from the north-west Australian non-breeding grounds occur in the first fortnight of April,

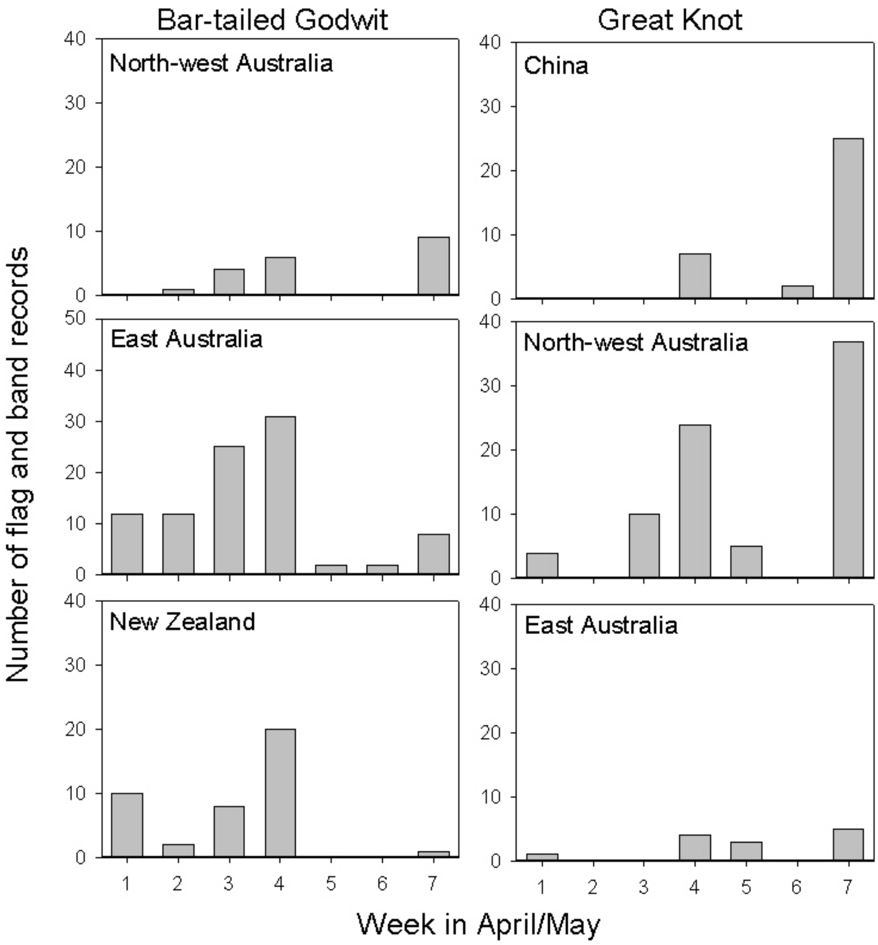

Figure 6. Timing of flag and band resightings of Bar-tailed Godwit and Great Knot from the Saemangeum area in April-May 2006.

suggesting that *menzbieri* arriving on the west coast of Korea in May must stage somewhere *en route*. This idea is supported to some extent by the five Bar-tailed Godwits flagged in Chongming Dao (China) that were found in our study area. Three of these birds were found between 22 and 29 April, and another on 19 May. However, one Chongming Dao bird was found so early in the study period (3 April) that it seems unlikely to have staged in China before reaching Korea.

In view of the population turnover occurring in Bar-tailed Godwits, peak counts observed in late April must have been an underestimate of the total number of birds staging. Nevertheless, internationally significant numbers were found in both Saemangeum and the Geum Estuary. The most important roosts in the Geum Estuary were on Yubu Island (peak count of 9,000) and in Daemoe Harbour (peak count of 6,000). In Saemangeum Bar-tailed Godwits were reasonably widespread on roosts closest to outer estuarine tidal flats, with counts of over a thousand being made at Okgu, Simpo, the Gunsan US Air-Force BASE, a roost on the northern shores of the Dongjin River, and the south-west coast between the Dongjin River and the Saemangeum sea-wall.

Little Curlew *Numenius minutus*

Singles or pairs were seen at three separate sites between 10 and 23 April (only one of these was seen in a spring tide period, but the others are included in the totals in Table 1.)

Whimbrel *Numenius phaeopus*

A late migrant through the region, with numbers peaking in mid-May. Internationally significant numbers were found in Saemangeum, the Geum Estuary and Gomso Bay; they were widespread in the study region, occurring at most roosts. No colour-marked birds were seen, but this may reflect the low number that have been flagged – only *c.* 280 have been leg-flagged in Australia.

Eurasian Curlew *Numenius arquata*

Internationally significant numbers were found in the Geum Estuary, mostly roosting on Yubu Island. Here they tended to roost separately from Eastern Curlews; at other sites where numbers were smaller, they often mingled with Eastern Curlew flocks and were therefore easily overlooked. In both the Geum Estuary and Saemangeum, numbers increased between mid-April and late April, suggesting that the birds present included passage migrants. They may also have included birds that had spent the non-breeding season in the area (non-breeding counts of *c.* 1200 Eurasian Curlew have been made in the Geum Estuary, Lee *et al.* 2002). The highest previous count of Eurasian Curlews in the Geum Estuary (2,800 – 7.3 % of the flyway population) was made during southwards migration at the end of August (Barter 2002, Lee *et al.* 2002); consistent with this pattern, we counted 1,450 at Yubu Island on 24 September.

Eastern Curlew *Numenius madagascariensis*

Internationally significant numbers were counted in both Saemangeum and the Geum Estuary, with concentrations tending to be largest at the roosts closest to outer estuarine habitats. In the Geum Estuary counts were highest at Yubu Island, with good numbers also being found on Daejuk Island and adjacent mainland roosts. In Saemangeum, they were widespread but the largest numbers were seen south of the mouth of the Dongjin River, along the coast to the Saemangeum sea-wall.

Eastern Curlews were early migrants, and their numbers declined considerably between the middle and end of April; it is possible that their numbers peaked before our survey began. Five colour-marked individuals were seen, all from Victoria, south-east Australia (544 had been flagged in Victoria before our surveys, compared with 169 flagged in north-western Australia).

Spotted Redshank *Tringa erythropus*

Low numbers were seen, mostly at roosts on the inner shores of the Dongjin River (Saemangeum) and the Haemangdong and Gupo Tidal Flats of the Geum Estuary. Counts in Saemangeum were lower at the end of April than those in mid-April or mid-May; we do not know if this was caused by population turnover in this typically early migrant or by a failure to find roost sites in the late April counts.

Common Redshank *Tringa totanus*

Uncommon in the region; numbers at Saemangeum peaked in mid-May.

Marsh Sandpiper *Tringa stagnatilis*

Uncommon in the region; most seen were found in the inner Dongjin, or on ponds beside Okgu.

Common Greenshank *Tringa nebularia*

Common Greenshanks occurred in internationally significant numbers in the Geum Estuary and numbers approached this level in Saemangeum. They occurred in small numbers at nearly all roosts, with unusual concentrations of birds being found at a roost at Okgu (418 on 15 May) and on the tidal flats within the Geum River Channel (920 on 16 May). They were late migrants, with numbers increasing by a factor of 12 between late April and mid-May; a migratory departure of 74 birds from Namjeon Ri (Geum Estuary) was observed on 15 May, suggesting that migratory turnover may cause an underestimation of the number of birds staging in the region. A single individual leg-flagged in north-western Australia was found in the Geum Estuary on 16 May; about 150 Common Greenshank had been leg-flagged in north-western Australia and about 450 had been leg-flagged in Victoria at the time our survey began.

Nordmann's Greenshank *Tringa guttifer*

This endangered species was found in internationally significant numbers in both Saemangeum and the Geum Estuary. Counts from the Geum were particularly noteworthy, with the 70 found in mid-May (including a single flock of 69 birds at Yubu Island) constituting about 7% of the world population. At the time of observation the Yubu Island flock appears to have been the largest concentration of this species seen in at least 20 years until a flock of 70 was found in Peninsular Malaysia on 3 February 2007 (David Li, posting to Asia-Pacific Migratory Bird network). Another concentration of Nordmann’s Greenshank was also found at Daejuk Island (25 birds on 26 April); other observations were of single birds or small flocks (less than 10 birds) at roosts relatively close to outer estuarine mudflats. Almost all of the Nordmann’s Greenshank seen at roosts were mingling with flocks of Grey Plover.

Internationally significant numbers of Nordmann’s Greenshank were also found in the Geum Estuary on southwards migration, with a minimum of 31 individuals (possibly as many as 38) being found at Yubu Island on 24–25 September 2006.

Green Sandpiper *Tringa ochropus*

A few birds were seen, mostly on freshwater wetlands or inner estuarine mudflats.

Wood Sandpiper *Tringa glareola*

A few birds were seen, mostly on freshwater wetlands or inner estuarine mudflats.

Common Sandpiper *Actitis hypoleucos*

A few birds were seen, mostly on freshwater wetlands or inner estuarine mudflats.

Terek Sandpiper *Xenus cinereus*

Internationally significant numbers were found in both Saemangeum and the Geum Estuary, with moderate numbers occurring on most roosts adjacent to outer estuarine mudflats; large numbers (579) were also found feeding on the Haemangdong and Gupo Tidal Flats of the Geum Estuary on 16 May. This species was a late migrant, with numbers increasing over five-fold between late April and mid-May. Five colour-marked birds were found: four from north-western Australia (where 3,679 birds had been flagged by 2005) and one from Chongming Dao, China. All these birds were found in mid-May, except for one north-west Australian bird found on 25 April. This may suggest that, as in Bar-tailed Godwit and Great Knot, a late influx of Terek

Sandpipers to the west coast of Korea consists largely of north-west Australian birds that have staged in China.

Grey-tailed Tattler *Heteroscelus brevipes*

Fairly small numbers were seen, with the largest counts being made in Saemangeum (especially on the flats opposite the US Air Force base in Gunsan, and on the coast between the Dongjin River and the Saemangeum sea-wall). In the Geum Estuary, most birds were seen at Namjeon Ri. Grey-tailed Tattlers were late migrants with nearly all seen in mid-May. No colour-marked birds were seen.

Ruddy Turnstone *Arenaria interpres*

Internationally significant numbers were found in both Saemangeum (mostly at Simpo and near the Gunsan airbase) and the Geum Estuary (mostly on Yubu Island and at Namjeon Ri). They were late migrants, with numbers increasing three-fold between late April and mid-May. A single white-flagged bird, presumably from New Zealand, was seen at Simpo on 2 May.

Great Knot *Calidris tenuirostris*

The most abundant shorebird in the study region, with the total minimum count (116,126) comprising 30.6% of the world population of this species. Internationally significant numbers were found in Saemangeum (22.7% of the world population) and the Geum Estuary (7.9% of the world population), with only tiny numbers found at Gomso Bay (none during spring tide periods). Within Saemangeum, much the largest concentrations of Great Knot were found at Okgu, where there was a single flock of about 60,000 Great Knot at the end of April (three independent counts of this flock ranged from 56,000 to 60,840). By mid-May numbers of Great Knot at this locality dropped to 34,950, but there was a roughly corresponding increase in numbers at Simpo, where Great Knot numbers increased from 10,843 in late April to 40,000 in mid-May. This shift in distribution might have been a response to the shellfish die-off, as Great Knots were feeding on very extensive beds of dying shellfish in the Simpo area during May. Elsewhere in Saemangeum, Great Knots were found in moderate numbers (hundreds or low thousands) at several outer estuarine roosts. In May numbers increased considerably on the coast between the southern mouth of the Dongjin River and the Saemangeum sea-wall (225 in mid-April, none in late April, 9,874 in mid-May). In contrast, counts decreased during the survey period at inner estuarine roosts in the Dongjin (1,301 in mid-April, 1,030 in late April, 134 in mid-May) and no Great Knots were found at all at the innermost roosts of the Mangyeung River, at sites that have held up to 30,000 Great Knot on spring tides in previous years. These changes in distribution were probably related to the decreasing tidal range and shellfish die-off within Saemangeum following completion of the sea-wall.

In the Geum Estuary the largest roosts of Great Knot were found on Yubu Island (peaking at 23,190 on 16 May), Daejuk Island (maximum of 6,335 on 26 April) and Daemoe Harbour (maximum of 6,500 on 13 April). We suspect many Great Knots moved between these roosts, being forced to Yubu Island on the highest tides. Great Knot numbers increased in the general region during the study period (Figure 5). Most of this increase occurred in the Geum Estuary, where counts almost doubled between the end of April and mid-May; in contrast Great Knot numbers in Saemangeum were almost equal in the late April and mid-May surveys. It is possible that some birds moved from Saemangeum to the Geum as habitat conditions within Saemangeum deteriorated. Alternatively, the increase in numbers of birds at the Geum might have been caused by incoming migrants selecting this site in preference to Saemangeum.

The latter interpretation is more consistent with resightings of colour-marked birds made during the expedition (Figure 6). Most colour-marked birds recorded were from north-western Australia (80) or mainland China (34), with smaller numbers from Victoria, south-east Australia (11), south-eastern Queensland, eastern Australia (2), Kamchatka, Russia (1) and South Korea (3). The number of colour-marked birds from eastern Australia was lower than that from north-western Australia, but this must to some extent be a reflection of the number of Great Knot flagged in both regions. By 2006, only 313 Great Knot had been flagged in Victoria and there were unlikely to be many flagged Great Knot in the flyway from Queensland, as flagging stopped there about six years ago; in contrast, 12,484 had been flagged in north-western Australia by the time we undertook our Korean fieldwork. Bearing this in mind, the colour-band records suggest that proportionately more Great Knot from eastern Australia migrate through South Korea than do those from north-western Australia.

Numbers of birds from south-eastern Australia seemed reasonably consistent through the study period, but the proportion of resighted birds from north-western Australia and (especially) mainland China increased markedly in May. This suggested that birds from north-western Australia were moving into the region in May after staging in China, and we indeed had confirmation that staging in mainland China occurred. Eight of the resighted Chinese birds, all seen between 13 and 18 May, had been marked at Chongming Dao in March/April 2006 (flag colours at this site were reversed in 2006 so birds from this season could be distinguished from birds flagged in previous seasons). It is very likely that these birds had previously spent the non-breeding season in north-western Australia, as a strong migratory link between the Great Knots of north-western Australia and Chongming Dao has been established in the past (e.g. Battley *et al*. 2000).

Most migratory departures of Great Knot from the region are thought to have occurred between 15 May and 20 May. Few Great Knots could be found in the Simpo area after this period, although there was an abundance of dying shellfish to feed on, and there had been up to 40,000 Great Knot present there on 13 May. Average abdominal profiles of Great Knots in Saemangeum declined sharply after the middle of May (Figure 7), suggesting that the heaviest birds were departing on reaching departure mass. Abdominal profile scores in the Geum Estuary (on Yubu Island) were higher than those in Saemangeum in mid-May, suggesting that birds were experiencing better feeding conditions there,

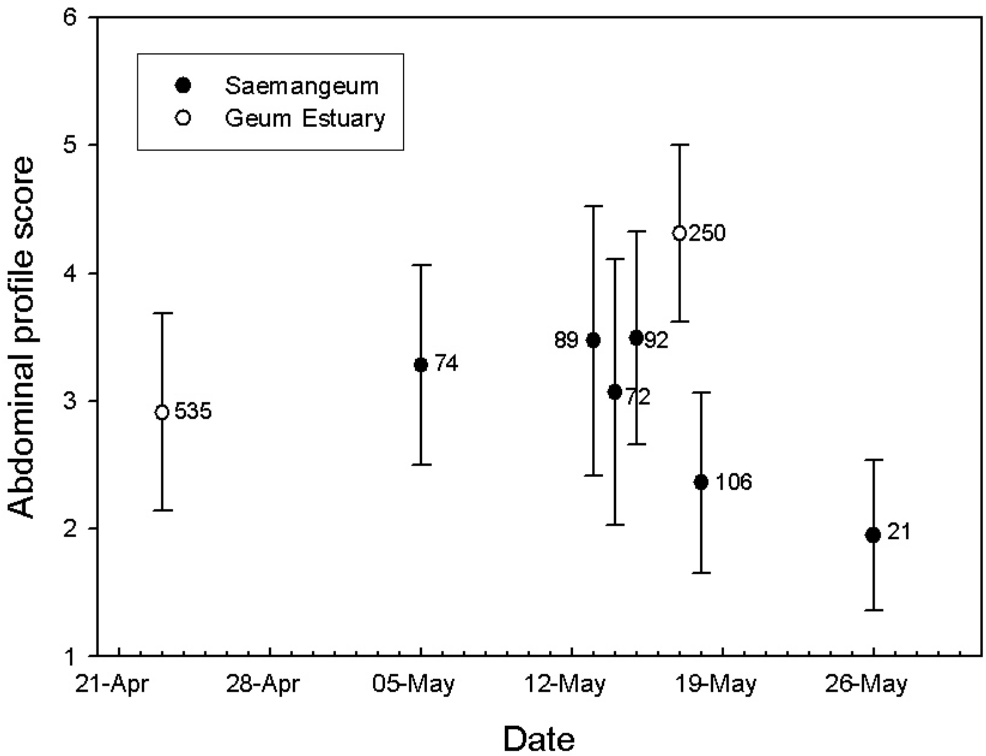

Figure 7. Average abdominal profile score (± s.d.) of Great Knot at Saemangeum and the Geum Estuary during the study period. Numbers next to the symbols are sample sizes.

or perhaps that the heaviest birds had moved into the Geum from Saemangeum.

Red Knot *Calidris canutus*

An uncommon, late migrant through the region, usually found mingling with large flocks of Great Knot. Three leg-flagged birds were seen in Saemangeum on 14–15 May: one each from New Zealand, Victoria (south-eastern Australia) and north-western Australia.

Sanderling *Calidris alba*

Most birds seen were on sandy island roosts at Yubu Island (Geum Estuary) and off Okgu (Saemangeum), usually mingling with flocks of Dunlin and Lesser Sand Plover. Numbers were much higher in late April than in either mid-April or mid-May (Figure 6), suggesting that this species staged rather briefly; it is therefore likely that migratory turnover could have led to an underestimate of the number of Sanderling staging in the region. No colour-marked birds were seen.

Red-necked Stint *Calidris ruficollis*

Widespread within the study region, with the largest numbers being found at Okgu (over 2,000 on 13 and 15 May). This species was a late migrant, and numbers increased more than six-fold between late April and mid-May. Four leg-flagged birds from Victoria were seen; a bird with a white flag was probably a bird from previous banding work in Korea that had lost an orange flag.

Temminck's Stint *Calidris temminckii*

Two birds were seen in a brackish pond on Yubu Island on 13 and 15 April.

Pectoral Sandpiper *Calidris melanotus*

A single bird was seen on the inner Dongjin Estuary on 5 April.

Sharp-tailed Sandpiper *Calidris acuminata*

A late migrant through the area, with numbers increasing by a factor of 15 between late April and mid-May. The largest counts made were on the Haemangdong and Gupo Tidal Flats of the Geum Estuary, where 970 birds were found feeding on 16 May. In Saemangeum most Sharp-tailed Sandpipers were found at Okgu, with a peak of 459 on 15 May. A single colour-marked bird, flagged in Victoria, was found on the Gupo tidal flat (Geum Estuary) on 12 May.

Curlew Sandpiper *Calidris ferruginea*

An uncommon, late migrant through the region. No colour-marked birds were seen.

Dunlin *Calidris alpina*

The second most abundant shorebird species in the region; it was found on almost all roosts, although counts tended to be highest on those near outer estuarine tidal flats. Numbers of Dunlin increased gradually over the study period, peaking in mid-May. We do not know if migratory turnover in this species might have influenced our estimates of the numbers of staging birds. Dunlin have a broad breeding distribution, with many distinct subspecies that may have different migratory schedules, and the subspecies occurring in Saemangeum have not been fully resolved. Resightings of two colour-banded birds banded near Barrow in Alaska indicate that they include subspecies *arcticola*, and the resighting of a bird flagged in Chukotka, Russia suggests that subspecies *sakhalina* is also present. Other leg-flagged Dunlin were seen from mainland China (n = 7), Taiwan (1) and South Korea (4).

Spoon-billed Sandpiper *Eurynorhynchus pygmeus*

An uncommon, late migrant through the region, but the world population of this species is so small (*c.* 1000 birds, Syroechkovsky 2005) that the numbers seen at Saemangeum are of international significance. The only concentrations seen were at Okgu (peak of 21 birds on 15 May) and Simpo (peak of 12 birds on 18 May), with singles also recorded opposite the Gunsan military airbase and the inner Dongjin. Single birds (possibly the same individual) were recorded at Yubu Island on 13 April and 17 May; the former record (on a neap tide and hence not included in Table 1) was unusually early in the season for this species in Korea. Fifteen Spoon-billed Sandpipers, including a colour-banded adult from the breeding grounds, were found during an opportunistic count at Yubu Island on 24 and 25 September 2006, confirming that the species also occurs in the Geum Estuary in internationally significant numbers. It is quite possible that we underestimated numbers of this species in both Saemangeum and the Geum Estuary, as it usually mingled at roosts with large flocks of similarly sized waders.

Spoon-billed Sandpipers at Simpo, Okgu and Yubu were usually active through much of high tide, feeding on the waterline on reasonably firm sandy substrates. They usually fed by pecking firmly at the substrate, with their bills angled at about 45 degrees. We were seldom able to identify the prey taken, but Jan van de Kam photographed an adult capturing a slender polychaete about 4 cm long.

Broad-billed Sandpiper *Limicola falcinellus*

A late migrant through the region; almost all birds seen were found in Saemangeum (at Okgu and the inner Dongjin) in mid-May. A bird leg-flagged in north-western Australia was found at Okgu on 15 May. Larger numbers were seen in the Geum Estuary on southwards migration (600 at Yubu Island on 24–25 September, all juveniles), a trend also noted in Saemangeum by Barter (2002).

Ruff *Philomachus pugnax*

An uncommon early migrant; most seen were found on the inner Dongjin (Saemangeum) in the first half of April.

Oriental Pratincole *Glareola maldivorum*

Single birds (possibly the same individual) were seen at Yubu and Taeching islands on 26 April.

DISCUSSION

Our surveys confirmed the importance of Saemangeum to shorebirds on northwards migration. Counts made in 2006 were broadly consistent with surveys in previous years by Moores (1999) and the Korean Ministry of Environment (Ministry of Environment 1998; KARICO 2003, 2004, 2005; for a summary of totals observed in these surveys, see Moores *et al*. 2006). For some species, the totals we observed were higher than previously recorded in Saemangeum: Eastern Oystercatcher, Common Greenshank, Nordmann's Greenshank, Terek Sandpiper, Sanderling, Dunlin, Spoon-billed Sandpiper and Broad-billed Sandpiper. Internationally important counts of Eastern Oystercatcher, Common Greenshank, Nordmann's Greenshank, Sanderling and Spoon-billed Sandpiper had not previously been published for Saemangeum during northwards migration (Barter 2002). It is unlikely that the higher counts of these species in Saemangeum in 2006 reflect a genuine change in population level. They are much more likely to reflect the intensive survey coverage we were able to achieve in April-May 2006, as our team was sufficiently large to visit all roost sites, and to count simultaneously at several different sites at the peak of high tide. Importantly, our team was also able to carry out counts throughout the migration period. Different species migrated through Saemangeum at different times, and there is no single date during northwards migration at which peak numbers of all species are present.

Counts made in the Geum Estuary turned out to be considerably higher than we had anticipated, with almost all species being found in higher numbers than previously reported. Overall we recorded a minimum of 82,993 shorebirds in the Geum Estuary, a considerable difference from the previously recorded peak of 34,198 shorebirds on northwards migration. These included 13 or 14 species that occurred in internationally significant numbers, and the second-highest count ever made in a single site of the endangered Nordmann's Greenshank. Moreover, winter surveys have shown the Geum Estuary to support 57% of the world population of Eastern Oystercatcher. In short, the Geum Estuary is a site of very high conservation value and (given the deterioration that is likely to have occurred in Saemangeum over the past few months) it is probably the premier shorebird site remaining in South Korea. Unfortunately, it too is threatened with a major reclamation proposal (Lee *et al*. 2002).

In comparison with Saemangeum and the Geum Estuary, Gomso Bay is not an important shorebird site for species other than Whimbrel. The low numbers of shorebirds in Gomso Bay are somewhat surprising, given that the bay has extensive tidal flats, but presumably these do not support the benthic food supplies required by shorebirds.

The completion of the Saemangeum sea-wall had some immediately obvious ecological effects, the most striking of these being the reduction of the tidal range within Saemangeum and the resultant die-off of shellfish on the intertidal flats. This die-off was in itself a considerable loss of biodiversity of the Saemangeum region; about 100 mollusc species are known from the estuarine waters of Saemangeum, including an extraordinary bivalve found only in symbiosis with the brachiopod *Lingula anatina*, which appears to be extremely rare outside Saemangeum, the Geum Estuary and Gomso Bay (Hong *et al*. 2007). In the short term, shorebirds may have managed to survive, and may even have benefited from, the shorebird die-off by eating the dying bivalves as they came to the surface. We suspect that by exploiting this temporary resource, most migratory shorebirds in Saemangeum were able to complete northwards migration in a reasonably normal manner in 2006. We did not have strong evidence for birds abandoning Saemangeum in April and May 2006, though the changes in food supplies might have prompted a possible movement of Great Knots from Saemangeum to the Geum Estuary in mid-May.

We can only speculate on the longer term effects of the sea-wall closure. At present the sea-wall gates have not been closed (for engineering reasons rather than conservation purposes) and there are still small tides within Saemangeum. The tidal range is now only about half a metre, and the intertidal area is perhaps only 10% of its previous size, but in such a large tidal system, this still amounts to a large intertidal area of potential conservation significance to shorebirds. However, the quality of the benthic prey reserves in the remaining intertidal area will be very much dependent on management of the sluice gates. Sato (2006) has demonstrated that in a reclamation in Japan most molluscs were killed by salinity changes or hypoxia shortly after sea-wall closure, but that a few species were reasonably tolerant of these changes and survived (and even increased) for some time, though these too died off eventually in the absence of improvement of environmental conditions. If the Saemangeum reclamation project is completed as planned, complete loss of the intertidal habitats is inevitable, as the plans involve conversion of the entire area to land and a freshwater lake system. Over half of the shorebird species occurring in the Saemangeum area are restricted to intertidal habitats during the non-breeding season and while staging, including most species for which this site is of particular conservation importance (e.g. Great Knot, Eastern Oystercatcher, Nordmann’s Greenshank and Spoon-billed Sandpiper). These species will presumably be lost from the Saemangeum system, as will the local shellfishery industry, which is estimated to provide a livelihood for 25,000 people (Moores *et al*. 2006, Hong *et al*. 2007).

Shorebirds that are unable to feed at Saemangeum will presumably look for alternative staging areas, but it is quite likely that they will have difficulty finding suitable sites, especially when the numbers of displaced birds (potentially *c*. 200,000 on northwards migration) are considered. Furthermore, our data suggested that for most species, Saemangeum was, in the northern spring of 2006, a site where a good deal of pre-migratory mass gain occurs. In more than half the species present, shorebird numbers built up during April and early May, with departure dates in the last half of May occurring shortly before snowmelt is likely to begin on the breeding grounds. In Great Knots, for example, average abdominal profiles increased through April and mid-May, with many individuals reaching the maximum fat stages of 4 or 5; most departures from the Saemangeum region appeared to occur between 15 and 20 May, and peak arrivals of this species on the breeding grounds (*c*. 4,000 km away) occur only a few days later, on 22 to 23 May (Tomkovich 1997). It therefore seems probable that Great Knots use Saemangeum as the final staging point before undertaking a long migratory flight to the breeding grounds.

It is likely that the Saemangeum reclamation will cause population declines in migratory shorebirds, and if this occurs, the effect should in theory be detectable on the non-breeding grounds. Resightings of colour-marked birds suggested that for a number of species (e.g. Great Knot, Bar-tailed Godwit, Eastern Curlew, Red-necked Stint) the majority of migrants through Saemangeum have migrated from eastern Australia or New Zealand. In at least two species, Bar-tailed Godwit and Great Knot, there was evidence of an influx of migrants from north-western Australia late in the migration period, in at least the case of Great Knots occurring after they had staged on the coast of mainland China. Careful monitoring of shorebird populations in eastern and north-western Australia and New Zealand is therefore of considerable importance in documentation of the effects of the Saemangeum reclamation.

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AN OVERVIEW OF THE STATUS AND ABUNDANCE OF MIGRATORY WADERS IN SUMATRA, INDONESIA

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This paper provides a summary of the status and abundance of 37 species of migratory wader recorded in Sumatra, western Indonesia. High numbers, totalling tens of thousands of birds occur along the eastern coastline of Sumatra in the provinces of North Sumatra, Riau, Jambi, South Sumatra and Lampung. Smaller numbers occur in the northern province of Aceh and along the west coast. Wader species occurring in thousands include Lesser Sand Plover, Greater Sand Plover, Asian Dowitcher, Black-tailed Godwit, Bar-tailed Godwit, Eurasian Curlew, Common Redshank, Terek Sandpiper and Curlew Sandpiper. Species found in hundreds include Pacific Golden Plover, Grey Plover, Pintail Snipe, Whimbrel, Eastern Curlew, Marsh Sandpiper, Wood Sandpiper, Great Knot and Red Knot. Sumatra is both a terminus for some migrants, as well as a passage zone for waders migrating towards eastern Indonesia and probably Australia. The eastern coastline of Sumatra and adjacent islands combine with the west coast of Peninsular Malaysia to create one of the most important areas for waders and other shorebirds in South-East Asia.

INTRODUCTION

The Indonesian archipelago comprises 13,600 islands and forms a 5,000 km wide barrier between South-East Asia and Australasia. The coastline of this archipelago, as well as its inland wetlands and extensive areas of human-created rice fields support large populations of native and migratory waterbirds. Although vast numbers of migratory waders are assumed to overfly or transit through Indonesia on migration (Lane 1987), many thousands more spend the northern winter on the archipelago's shores.

The island of Sumatra (476,000 km^2) straddles the equator at the western end of the Indonesian archipelago (Figure 1); it comprises both a passage zone for waders migrating between northern Asia and Australasia, as well as a terminus for species that spend the non-breeding season in the tropics. This overview summarises what is known about the status and abundance of migratory waders in Sumatra. This information is collated from a number of sources but mainly derives from a decade of field observations by the authors in north-east Sumatra, and from the published results of survey work carried out in south-east Sumatra during the 1980s and 90s – principally by Silvius (1988), Verheught *et al.* (1990, 1993) and Parrott & Andrew (1996). Little is known of wader concentrations along the west coast of Sumatra as, to date, minimal survey work has taken place there. However the existence of large concentrations is unlikely because the extent of intertidal mudflats is limited.

Coastal Wader Habitats

The coastline of north-eastern Sumatra (facing the Andaman Sea and the northern part of the Strait of Malacca) is characterised by a semi-diurnal tidal cycle and generally low-energy wave environments (Whitten *et al*. 2000). This, combined with high loads of suspended sediments transported by rivers, has allowed the development of extensive soft mudflats along open shorelines, backed in most areas by mangrove forest, nipah swampland or, following land reclamation, aquaculture ponds. North of Lake Toba, coastal rivers tend to develop extensive deltaic river mouths with associated mangrove forests. East of Lake Toba, rivers tend to carry a larger volume of coarser sediments resulting in the prevalence of sandy beach and sand spit development between the mudflat and mangrove zones. Further south, the first of the major river estuary systems starts with the Asahan, Kuala, Bila and Barumun Rivers, culminating with the Rokan River. The mouths of these rivers are characterised by expansive areas of intertidal mudflat, ranging in width from 500 m to upwards of 10 km.

The coastline of south-eastern Sumatra (facing the southern part of the Strait of Malacca, the South China Sea and the Java Sea) has a complex mix of tidal cycles (including mixed, semi-diurnal and diurnal) and generally low-energy wave environments (Whitten *et al*. 2000). The mainland coastline comprises a sequence of large embayments punctuated by major drainage systems entering the sea either via extensive deltas or through single channel (Amazon-like) river estuaries. The largest rivers such as the Musi, Banyuasin, Bantang Hari, Indragiri and Kampar carry enormous volumes of sediment to the coast, resulting in high rates of accretion, the development of expansive mudflats and creation of mangrove-covered islands. Behind the accreting coastline lies a wide alluvial plain with zones of mangrove, swampland and peat forest, in places extending up to 100 km inland. Large barrier islands line the coastlines of southern Riau and South Sumatra Provinces, while the coastline of Lampung consists mainly of open shorelines.

Compared with the east coast, the western coastline of Sumatra offers limited wader habitat. The west coast is characterised by steep hill country, a narrow coastal plain and a shoreline exposed to the high energy waves of the Indian Ocean. Much of the west coast comprises beaches and cliffs, with mudflat habitat limited to a small number of embayments and river mouths.

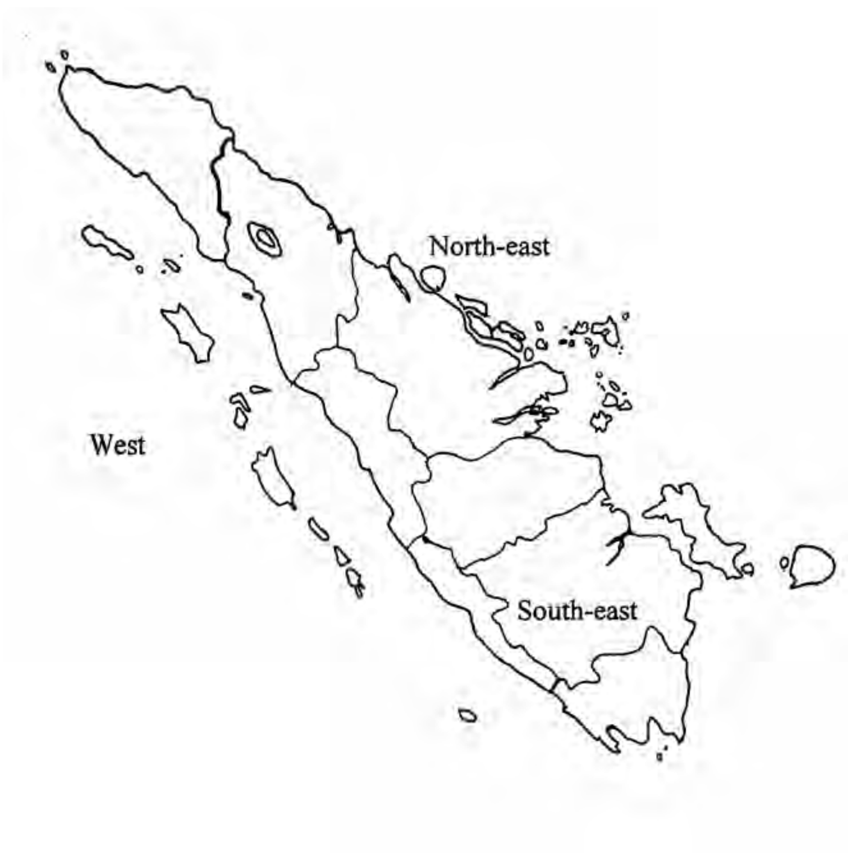

Figure 1. Sumatra, showing geographical regions referred to in text.

Inland Wader Habitats

Inland wader habitats include the banks of large rivers, lake shores, water reservoirs, aquaculture ponds, freshwater swamps and rice fields. The last is the most significant with tens of thousands of hectares under cultivation across Sumatra. Although difficult to survey, rice fields are known to support sizeable wader populations, especially of snipe and some of the sandpipers and stints.

PREVIOUS SURVEYS

South-eastern Sumatra has had the best survey coverage, mainly as a result of fieldwork by M. Silvius and colleagues who completed wader surveys along the eastern coastlines of Riau, Jambi and South Sumatra provinces over the period 1984 to 1986 (Silvius 1988). Subsequently, Verheught *et al.* (1990, 1993) carried out aerial and ground surveys of the South Sumatra Province tidal lowlands and floodplains in 1988 and 1989. Milton (1985) and Parrott & Andrew (1996) reported on wader observations made at Way Kambas National Park in Lampung Province in 1985, and in 1988 and 1989, respectively. Crossland & Sinambela (2005) reported on a survey of waders on Batam Island in the Riau Archipelago in 2001 and 2002.

Wader populations in north-eastern Sumatra have received much less survey coverage. Crossland (2000) reported on wader populations observed at three coastal wetlands in the northern tip of Aceh Province in December 1995. Over the period 1994–2006 the authors have progressively surveyed the eastern coastline of North Sumatra Province from Belawan in the north to the Asahan Rivermouth in the south.

Other information on wader numbers and distribution in Sumatra (including limited survey data from the west coast of Sumatra) comes from the Asian Waterbird Census (Lopez & Mundkur 1997; Li & Mundkur 2004), from the Sumatra Bird Report periodically published in *Kukila* (Holmes 1996), and from accounts in various regional field guides.

SPECIES ACCOUNTS

“Summer” and “winter” in these accounts refer to northern hemisphere seasons. The summer months, June to August, refer to the northern hemisphere breeding season. The other months comprise the non-breeding season; winter refers to that part of the non-breeding season in which there is no migration, usually December to February.

Oriental Pratincole *Glareola maldivarum*

A rare passage wader in the north-east (Crossland in prep.); an uncommon migrant and winter visitor elsewhere, including islands (MacKinnon & Phillipps 1993). Flocks of up to 60 observed in the north-east (Crossland in prep.); up to 87 in the south-east (Silvius 1988) and 24 in the west (Holmes 1996).

Pacific Golden Plover *Pluvialis fulva*

A common migrant with flocks of low hundreds in the north-east, with highest numbers occurring in winter (Crossland in prep.). This species is scarce in the south-east (Silvius 1988) but common in the Riau archipelago with highest numbers recorded during southward migration (Crossland & Sinambela 2005). Pacific Golden Plovers are found mainly on coastal sites, but also occur inland up to 1400 m a.s.l. (Holmes 1996).

Grey Plover *Pluvialis squatarola*

Slightly less common but more widespread than preceding species in the north-east. Low numbers during southern migration; highest numbers during northward migration with flocks of up to 200 (Crossland in prep.). Much more common than *P. fulva* in the south-east. Highest numbers observed during southward migration with a moderate influx during northward migration (Silvius 1988, Verheught *et al.* 1990).

Little Ringed Plover *Charadrius dubius*

Relatively common in the Aceh area of the north-east (Crossland 2000), but generally scarce elsewhere (Strange 2001, Crossland & Sinambela 2005).

Kentish Plover *Charadrius alexandrinus*

An uncommon visitor on all coasts (Parrott & Andrew 1996, Strange 2001). Sumatra is outside the principal wintering range for this species.

Lesser Sand Plover *Charadrius mongolus*

An abundant and widespread migrant to mudflats, aquaculture ponds and marshland on all coasts. Flocks of thousands observed in the north-east (Crossland in prep.) and the south-east (Silvius 1988).

Greater Sand Plover *Charadrius leschenaultii*

An abundant and widespread migrant in the north-east where it is often more numerous than preceding species, with flocks of 2000+ recorded (Crossland in prep.). Much less numerous in the south-east, with highest numbers during northward migration (Silvius 1988).

Oriental Plover *Charadrius veredus*

Sumatra lies west of the usual wintering range of this species and it has been recorded as a rare vagrant only (Silvius 1988, MacKinnon & Phillipps 1993, Parrott & Andrew 1996).

Pintail Snipe *Gallinago stenura*

A common migrant to marshland and rice fields where it can be locally abundant (MacKinnon & Phillipps 1993, Crossland in prep.).

Swinhoe's Snipe *Gallinago megala*

An uncommon visitor to Sumatra, recently recorded in North Sumatra Province (Crossland in prep.) but a need for further records to clarify its status and distribution throughout the island (MacKinnon & Phillipps 1993).

Common Snipe *Gallinago gallinago*

Reported by MacKinnon & Phillipps (1993) as a scarce visitor to the Greater Sundas with doubtful records from Sumatra. As with the preceding species, further records are required to clarify the status and distribution of Common Snipe in Sumatra.

Asian Dowitcher *Limnodromus semipalmatus*

An abundant and widespread migrant with flocks of up to 7000 recorded in the north-east (Crossland in prep.) and up to 12,000 recorded in the south-east (Verheught *et al.* 1990, 1993). Distribution and abundance insufficiently documented for the west. The most abundant wader species at a number of sites, including Pantai Sejara in North Sumatra Province (Crossland in prep.) and Way Kambas in Lampung Province (Parrott & Andrew 1996). The east coast of Sumatra is the principal wintering ground for this species. The current estimated world population of 23,000 (Wetlands International 2006) is likely to need revision upwards once full survey coverage of Sumatran coastal wetlands is achieved.

Black-tailed Godwit *Limosa limosa*

Generally uncommon during southward migration and winter in the north-east but a strong passage occurs during northward migration, especially in March and April, with flocks of up to 3800 recorded (Crossland in prep). A quite different seasonal pattern has been observed in the south-east with Black-tailed Godwit being one of the most abundant species year-round. Single flocks of up to 25,000 recorded during southward migration in South Sumatra Province (Verheught *et al*. 1990). High numbers (thousands) have been recorded in summer (July-August) and these are presumed to be non-breeders and immatures (Silvius 1988). The origins of these summering birds are as yet unknown but may be other parts of Indonesia or possibly Australia.

Bar-tailed Godwit *Limosa lapponica*

Locally abundant in the north-east. Most abundant during southward and northward migrations with substantial numbers also present through winter (Crossland in prep.). Also abundant and widespread in the south-east with highest numbers during southward migration but very few during northward migration (Silvius 1988, Verheught *et al.* 1990).

Whimbrel *Numenius phaeopus*

A widespread and common migrant in the north- and south-east (Crossland in prep., Silvius 1988) with flocks of up to 400 recorded. Highest numbers observed during southward migration with much lower numbers during northward migration, especially in the south-east. Upwards of 3000 counted on the coastlines of Jambi and South Sumatra Provinces during July-August 1985 indicating the importance of the south-east Sumatra as an over-summering area for non-breeders (Silvius 1988).

Eurasian Curlew *Numenius arquata*

Contrary to MacKinnon & Phillipps (1993), who state that this species is a regular visitor to the Greater Sundas but never numerous, recent surveys have found it to be an abundant and widespread migrant in Sumatra with flocks of up to 2600 recorded in the north-east (Crossland in prep.) and 7100 in the south-east (Verheught *et al.* 1990). Clearly, Sumatra is a major migration terminus for this species.

Highest numbers in both the north-east and south-east recorded during southward migration and winter with lower numbers during northward migration (Silvius 1988, Verheught 1990, Crossland in prep.). Upwards of 3000 recorded in summer (July-August) along the coastlines of Jambi and South Sumatra Provinces in the south-east (Silvius 1988), indicating that relatively large numbers may stay through summer.

Eastern Curlew *Numenius madagascariensis*

Generally an uncommon visitor (MacKinnon & Phillipps 1993, Strange 2001), but localised concentrations of 100 or more have been found in the north-east (Crossland in prep.) and up to 2600 in the south-east (Verheught *et al.* 1990). Highest numbers observed in winter in the north-east and during southward migration in the south-east.

Lesser Yellowlegs *Tringa flavipes*

A rare vagrant to Sumatra, first recorded in 1983 (Ollington & Parrish 1989, MacKinnon & Phillipps 1993).

Common Redshank *Tringa totanus*

An abundant and widespread migrant in both the north-east (Crossland in prep.) and the south-east (Silvius 1988, Verheught *et al.* 1990). Sumatra is a major wintering area for this species with flocks of up to 10,000 recorded (MacKinnon & Phillipps 1993). Highest numbers recorded during winter and northern migration.

Spotted Redshank *Tringa erythropus*

A scarce visitor to Sumatra, recorded in September 1988 at Lebak Pampangan in South Sumatra Province and occasionally from other localities in the south-east (Verheught *et al.* 1993). Not yet recorded from the north-east but, given the closer proximity to the southern limit of this species' normal wintering range (the Thai- Malay Peninsula), its occurrence is likely.

Marsh Sandpiper *Tringa stagnatilis*

A locally common migrant to the north- and south-east with flocks of up to 300 recorded. Highest numbers recorded in winter in the north-east (Crossland in prep.) and during southward migration in the south-east (Verheught *et al.* 1990).

Common Greenshank *Tringa nebularia*

A widespread but not numerous migrant on all coasts. Flocks in the north-east and the south-east seldom exceed 50 birds with highest numbers present during winter and during northward migration (Silvius 1988, Crossland in prep.).

Nordmann's Greenshank *Tringa guttifer*

Not identified in Sumatra until 6 birds were found at Cemara Beach (Jambi Province) in April 1986 (Silvius 1987). Subsequently found to be a regular migrant in small numbers to the north-east (MacKinnon & Phillipps 1993; Crossland in prep.) and the south-east (Silvius 1988). Typically groups of 6 or less have been spotted but Verheught *et al.* (1990, 1993) reported a flock of 21 from South Sumatra. This species is probably more numerous than the limited records to date suggest. All congregations of Common Greenshank anywhere in Sumatra should be carefully scrutinised for any Nordmann's Greenshank that might be among them.

Green Sandpiper *Tringa ochropus*

Sumatra lies on the edge of this species' wintering range and it occurs as an uncommon visitor in small numbers (MacKinnon & Phillipps 1993, Verheught *et al.* 1993, Holmes 1996).

Wood Sandpiper *Tringa glareola*

Said by Strange (2001) to be probably the most numerous and widespread shorebird in Indonesia. Both MacKinnon & Phillipps (1993) and Tilford & Compost (2000) state that this species is common and widespread in the Greater Sundas. Holmes & Nash (1990) list this as one of the three most common waders seen inland in Sumatra and Kalimantan, while Parrott & Andrew (1996) report it as common in agricultural land surrounding Way Kambas National Park in Lampung Province. The Wood Sandpiper is not typically a species of intertidal mudflats so it has received poor coverage in wader surveys conducted in north- and south-east Sumatra to date. More surveys of rice field and freshwater wetland habitats are required before the true abundance of this species in Sumatra can be assessed.

Terek Sandpiper *Xenus cinereus*

An abundant and widespread migrant in the north- and south-east with flocks of over 2000 recorded (Crossland in prep., Silvius 1988, Verheught *et al.* 1990, MacKinnon & Phillipps 1993). In the north-east high numbers observed on southward and northward migrations with relatively low numbers over winter. In the south-east highest numbers on southward migration with much lower numbers recorded on northward migration. These patterns suggests heavy passage of Terek Sandpipers through Sumatra, probably involving birds moving through to Java and eastern Indonesia or possibly further still to Australia.

Common Sandpiper *Actitis hypoleucos*

A common and widespread migrant, found in a wide range of estuarine, wetland and riverine habitats from the coast up to 1500 m (Holmes & Nash 1990, MacKinnon & Phillipps 1993). Flocks of up to 40 have been observed in the north-east (Crossland in prep.).

Grey-tailed Tattler *Tringa brevipes*

This species has not been observed in shorebird surveys in the north-east (Crossland 2000, Crossland in prep.) or the south-east (Silvius 1988, Verheught *et al.* 1993, Parrott & Andrew 1996, Crossland & Sinambela 2005). However, it is reported by both MacKinnon & Phillipps (1993) and Strange (2001) as an uncommon to rare visitor to the Sundas, including Sumatra.

Ruddy Turnstone *Arenaria interpres*

Widespread but nowhere numerous in the north-east (Crossland in prep.). More numerous in the south-east where highest numbers recorded on southward migration (Silvius

1988, Verheught *et al.* 1990). Scarce on west coast with first record in May 1992 (Holmes 1996).

Great Knot *Calidris tenuirostris*

A locally common migrant in the north-east with flocks of up to 400 recorded. Much less common in the south-east where mainly seen on southward migration (Silvius 1988).

Red Knot *Calidris canutus*

Described by MacKinnon & Phillipps (1993) as a rare passage migrant, this species is generally very scarce in Sumatra except for a brief passage during northward migration (Silvius 1988, Crossland in prep.). Flocks of up to 400, usually comprising birds in full breeding plumage, have been observed mainly in late March to early April and quickly pass through. With an absence of concentrations of Red Knot wintering in western Indonesia, it is likely that these birds have an Australian origin.

Sanderling *Calidris alba*

A rare visitor to the north-east (Holmes 1996) and the south-east (Silvius 1987, 1988; Verheught *et al.* 1993). Likely to be more common on the sandy coastlines of the west, but shorebird surveys have yet to be undertaken in areas of suitable habitat to confirm this.

Red-necked Stint *Calidris ruficollis*

A widespread but generally uncommon migrant to the north- and the south-east with flocks exceeding 170 birds recorded in Aceh Province (Crossland 2000), but seldom exceeding 50 birds elsewhere (Silvius 1988, Crossland in prep.).

Long-toed Stint *Calidris subminuta*

A widespread but scarce visitor to Indonesia, including Sumatra (Tilford & Compost 2000, Strange 2001). This species does not usually frequent coastal mudflats so has not been picked up on shorebird surveys in the north- and south-east.

Broad-billed Sandpiper *Limicola falcinellus*

A locally common migrant in the north-east with flocks of up to 100 observed (Crossland in prep.). A rare visitor in the south-east, recorded mainly during northward migration (Silvius 1988, Verheught *et al.* 1993).

Curlew Sandpiper *Calidris ferruginea*

An abundant and widespread migrant with flocks of over 1000 recorded in the north-east (Crossland in prep.). Less abundant but still widespread and common in the south-east, particularly during winter and northward migration (Silvius 1988, Verheught *et al.* 1990).

Ruff *Philomachus pugnax*

An uncommon migrant to Sumatra, where it occurs on coastal and inland habitats (MacKinnon & Phillipps 1993). Not recorded on coastal surveys in the north-east (Crossland in prep.) or the south-east (Silvius 1988, Verheught *et al.* 1993).

DISCUSSION

Wintering migrants, passage migrants and vagrants

Wader surveys completed to date in Sumatra have very much been preliminary work with only about half of the east coast and just a fraction of the west coast covered. Much greater survey effort is required before a definitive understanding of abundance and distribution of waders in Sumatra can emerge.

This paper has provided a summary for 37 migratory wader species recorded in Sumatra up until 2006. Approximately a fifth of these use Sumatra (and presumably neighbouring parts of the Indonesian archipelago) as a migration terminus and don't migrate beyond the region in any great numbers. Such species include Pintail Snipe, Swinhoe’s Snipe, Little Ringed Plover, Asian Dowitcher, Eurasian Curlew, Common Redshank and Nordmann's Greenshank.

Another group (comprising over half the recorded species) overwinter in Sumatra as well as in neighbouring Indonesian islands and Australia. For most of these species, influxes evident during one or both migration periods suggest passage through Sumatra – presumably to Java and neighbouring islands, and possibly onwards to Australia. These species include: Pacific Golden Plover, Grey Plover, Greater Sand Plover, Lesser Sand Plover, Black-tailed Godwit, Bar-tailed Godwit, Whimbrel, Eastern Curlew, Marsh Sandpiper, Common Greenshank, Wood Sandpiper, Terek Sandpiper, Common Sandpiper, Ruddy Turnstone, Great Knot, Curlew Sandpiper, Sanderling, Red-necked Stint and Broad-billed Sandpiper.

A third group comprises species which are seldom recorded wintering in Sumatra, but which occur as passage migrants, probably heading to (or from) eastern Indonesia or Australia. This group includes Oriental Pratincole, Oriental Plover, Red Knot and Grey-tailed Tattler.

A fourth group consists of species for which Sumatra lies on the edge of their the south-east Asian range and they consequently occur as stragglers in very low numbers. This group includes: Kentish Plover, Common Snipe, Spotted Redshank, Green Sandpiper, Long-toed Stint and Ruff. Potential additions to this group which should be looked for on Sumatran wetlands include Ringed Plover *Charadrius hiaticula*, Long-billed Plover *Charadrius placidus*, Temminck's Stint *Calidris temminckii*, Spoon-billed Sandpiper *Eurynorhynchus pygmaeus*, Dunlin *Calidris alpina* and Red-necked Phalarope *Phalaropus lobatus*.

An estimate of total migratory wader numbers

The total shoreline length of Sumatra’s east coast and adjacent islands exceeds 3500 km, much of which comprises intertidal mudflats, mangroves and swampland. In addition, there are thousands of hectares of aquaculture ponds and tens of thousands of hectares of rice fields throughout the coastal lowlands. Verheught *et al.* (1990) estimated that 500,000 migratory waders were dependent on the coastal mudflats of South Sumatra Province. Extrapolations from this to cover the entire east coast and adjacent islands, as well as pockets of suitable wader habitat along the west coast, suggest that upwards of one million migratory waders could overwinter in or migrate through Sumatra during the course of a year. However, the results of more recent survey work undertaken by Wetlands International, Wildlife Conservation Society and others require publication before a more satisfactory population estimate can be made.

Eastern Sumatra supports wader populations comparable or greater than those found on the west coast of Peninsular Malaysia (Li *et al.* 2006). Together these coastlines on opposite sides of the Strait of Malacca comprise one of the most important areas for waders and other shorebirds in Asia, comparable to areas like the Yellow Sea, the Gulf of Thailand and the coast of Bangladesh.

Key sites

Numerous sites around the coastlines of Sumatra support upwards of 1000 migratory waders. Surveyed sites known to support 10,000 birds or more include Bagan Percut and Pantai Sejara-Tanjung Tiram in North Sumatra Province; Tanjung Datuk and Tanjung Bakung in Riau Province; Tanjung Jabung in Jambi Province and the Banyuasin Peninsula, Musi Delta and Lumpur Bay in South Sumatra.

Areas that still require survey coverage

In north-east Sumatra, the northern tip of Aceh and much of the coastline of North Sumatra Province from Belawan south to the Asahan Rivermouth have been surveyed at least once. Sites that require initial inventorial surveys in Aceh include the coastline from Sigli to Cape Tamiang, particularly Langsa Bay and the mangrove shorelines around Cape Jambuair, Peureuak Point and Cape Tamiang. In North Sumatra Province, the intricate coastal area from Aru Bay to Karanggaging is likely to support large wader populatons, as is the Barumun-Bila-Kuala area in the southern part of the province. The northern part of Riau Province, particularly the enormous expanse of mudflats around Bagansiapiapi and the Rokan river mouth are rumoured to hold tens of thousands of waders.

In south-east Sumatra, the coastline from Tanjung Datuk in Riau Province down to Way Kambas in Lampung has been surveyed by a number of research teams, principally the Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA) and Wetlands International. A survey of waders on Batam Island in the Riau Archipelago has been carried out but shoreline and estuary surveys on nearby islands, such Bintan and Kundur are yet to take place. Additional areas that require survey effort include the northern and eastern shorelines of Rupat, Bengkalis and Rangsang islands bordering the Strait of Malacca; the Kampar river mouth area; the islands in the Lingga Archipelago, especially Lingga and Singkep; and the southern coastlines of Lampung Province.

Along the west coast, localised wader surveys have taken place as part of the Asian Waterbird Census in West Sumatra Province, but a comprehensive survey is needed covering suitable wader habitats throughout the western coastlines of Aceh, North Sumatra, West Sumatra, Bengkulu and Lampung Provinces.

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SHOREBIRDS IN THE INNER GULF OF THAILAND

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INTRODUCTION

As a predominantly lowland country with a long shoreline, Thailand is of major importance for waterbirds, both passage and wintering species, and residents and local dispersants. A total of 64 species of shorebirds are found both in coastal mudflat and mangrove habitats, and also inland on the paddylands and marshes of alluvial basins; many of these species occur in internationally important concentrations. Scott (1989) listed 42 sites in Thailand that were wetlands of probable international importance, while Tunhikorn & Round (1995) considered that 14 sites, nine coastal and five inland, were of international importance for waders.

In view of the time that has elapsed since the latter review, and the great amount of new information collected, an up-date on Thai wader sites would be timely. I focus here on one of these, the Inner Gulf, probably Thailand's single most important wetland site because of the numbers and species diversity of shorebirds it supports.

Southern Hemisphere readers should note that the winter referred to here is the Northern Hemisphere winter, the non-breeding season for Arctic breeders.

THE STUDY AREA

Extending east and west of the city of Bangkok, the Inner Gulf encompasses a roughly 100 km length of shoreline at the head of a 350,000 km^2 enclosed shallow bay (45–80 m depth), lying on the Sunda Shelf. In addition to the delta of the Chao Phraya River (on which Bangkok is situated), the Inner Gulf also encompasses the mouths of the Bang Pakong River to the east, and three further rivers to the west, the Thachin (a deltaic branch of the Chao Phraya), the Mae Klong (better known as the River Kwai), and the much smaller and shorter Phetchaburi River (Figure 1). Together these areas form the second or third largest river delta in south-east Asia.

Roughly 800–1000 km^2 of mudflats, salt-pans, prawn-

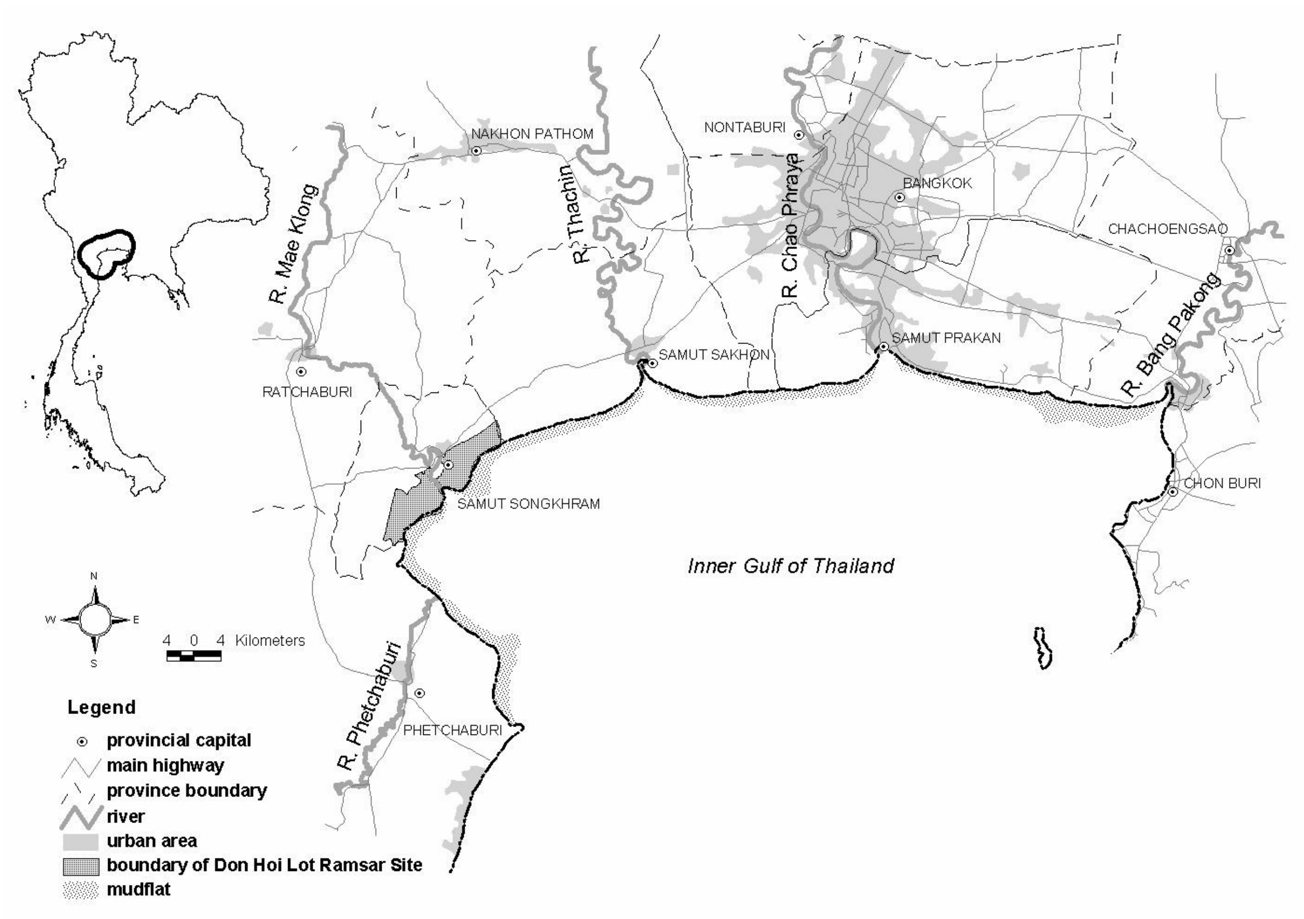

Figure 1. Inner Gulf of Thailand.

capture ponds and unused coastal flats lie adjacent to, and grade into, one of the largest rice-growing areas in the world, Thailand's Central Plains. There is a long history of human use of coastal habitats in the Inner Gulf. Salt-pan usage in the western parts of the area dates back perhaps 800 years (Reid 1988) and salt pans continue to occupy *c*. 106 km^2. Low intensity prawn-capture ponds including some abandoned, unutilised areas occupy around 400 km^2 while approximately 235 km^2 of mudflats lie offshore (Erftemeijer & Jukmongkol 1999). Mangroves (129 km^2) are now limited to a narrow (100–200 m wide) belt along the coast, with largest areas (approximately 80% of the total) in the western gulf, around Phetchaburi. Clearance of mangroves probably took place as long as 100 years ago, and the area remaining is largely secondary regrowth, dominated by *Avicennia* spp., *Rhizophora mucronata* and *R. apiculata*.

The tidal pattern is characterised as mixed semi-diurnal; two high and two low tides occur each lunar day, but one tide is much smaller and often negligible. During much of December and January, for example, the tidal flats of the Inner Gulf are inundated throughout the daylight hours and exposed only during the hours of darkness. Thus mudflat usage cannot be assessed at that season.

Human use of the Inner Gulf is intensive. In addition to onshore activities, the mudflats are exploited for molluscs, and coastal waters support inshore fisheries for fishes, molluscs and crustacea, and plankton.

HISTORY OF WADER STUDIES

The importance of the site for waterbirds, and especially as a wintering and staging area for migratory shorebirds, has long been recognized. W.J.F. Williamson collected Great Knots, Asian Dowitchers and a range of other shorebirds from the gulf early in the twentieth century (Williamson 1918), as did C.J. Aagaard a decade or so later (Jørgensen 1949). Only a handful of shorebirds numbered among the more than 185,000 birds banded in Thailand during the (1963–1971) Migratory Animals Pathological Survey (McClure 1974).

Small-scale banding and surveys of shorebirds have taken place from 1980 onwards (e.g. Melville 1982, Parish & Wells 1985), and more recently, since September 2000, by the author and colleagues. Since September 2005, all shorebirds banded in the Inner Gulf have been marked with leg-flags under the East Asian–Australasian Shorebird Flagging Protocol.

Observer coverage of the gulf has improved markedly since 1999. In particular, better access to, and knowledge of, shorebird habitats in the western sectors of the gulf has greatly improved our understanding of the status of many species, and led to the discovery of a regular wintering population of Nordmann's Greenshanks and two regular wintering locations for Spoon-billed Sandpipers. Extensive midwinter coverage of the Inner Gulf during the Asian Midwinter Waterbird Census (AWC) was achieved in three years since 2000 (2000, 2005 and 2006). Many birdwatchers and photographers who are now active around Bangkok have contributed greatly to recent coverage.

STATUS OF SHOREBIRDS

Fifty-six shorebird species have occurred in the Inner Gulf (Table 1); 49 species are winter visitors or passage migrants. Seven species breed locally: Pheasant-tailed Jacana, Bronze-winged Jacana, Black-winged Stilt, Eurasian Thick-knee, Oriental Pratincole, Red-wattled Lapwing and Malaysian Plover.

Numbers presented are midwinter count maxima. Midwinter concentrations of 20 species are thought to be of international importance. The most numerous wintering shorebirds are Lesser Sand Plover (6,298), Red-necked Stint (3,447), Black-tailed Godwit (3,078), Marsh Sandpiper (2,324), Black-winged Stilt (2,726), and Common Redshank (1,523). Based on allowance for turnover, Erftemeijer and Jukmongkol (1999) estimated the numbers of wintering and staging shorebirds that use the site as 100,000–135,000 per year, and the numbers using the site in midwinter as 30,000–40,000.

Indications are that the western sectors of the gulf receive higher usage than the sectors to the more heavily industrialised east of the Chao Phraya River, where it is thought that mudflat usage may be constrained by a shortage of suitable onshore roosting areas (see below under Status of Habitats).

Globally threatened species

Small numbers of Spoon-billed Sandpipers are now known to winter at two localities in the Inner Gulf, having first been recorded in 1995, and have been found in every winter period since late 1999. The largest single site count is 16 birds. Most sightings have been made on temporarily out-of-use, shallow-flooded salt pans where the birds evidently feed. The first birds arrive in mid-October and remain until mid-April (exceptionally early May).

A regular presence of Nordmann's Greenshank at two localities in the Inner Gulf has only been recognised since November 2003. The largest single count was a single flock of 60 birds on 24 December 2005 while up to 30 birds have been seen at a second site some 60 km distant, so there could potentially be as many as 90 birds wintering in total. There is very little local information on ecology since most birds have been roosting on ponds at high tide during the daylight hours and are presumed to fly out to feed on mudflats as the tide drops, usually during the hours of darkness

Breeding populations

Undoubtedly the most important shorebird breeding population is that of Black-winged Stilt. Nesting of this species on coastal flats near Samut Sakhon was mentioned by Madoc (1950), and breeders are common and widespread, laying their eggs on, for example, pond margins in brackish water areas in the coastal zone but also on floating vegetation in freshwater sites well inland. There have been no counts of the breeding population, though it probably numbers over 1000 pairs. Those recorded in winter (~3000) are assumed to be mainly or entirely local birds, although the occurrence of northern migrants is also to be expected.

Roughly 10–15 pairs of Malaysian Plovers nest at the

Table 1: Shorebirds known from the Inner Gulf of Thailand. Largest midwinter counts are the largest single site concentration or largest coordinated count made within the study area. Maximum counts are provided where these are larger than midwinter numbers. Waterfowl populations exceeding 1% of the estimated flyway population levels (following Wetlands International, 2002) are considered globally significant according to criteria set down by the Ramsar Convention. Numbers and concentration in Inner Gulf of *probable* international importance or *definite* international importance according to currently accepted criteria. Asterisk (*) indicates figure for 1% level no longer applicable due to recent findings; that for Oriental Pratincole is now much larger than listed (Sitters *et al*., 2004) while that for Spoon-billed Sandpiper is now thought to be much lower (Zöckler *et al*., 2006). In the count columns: na = Not available. Source: Round and Gardner in press; unpubl. AWC results from January 2006.

Species	Status	1% level	Largest midwinter count	Maximum count	Global significance
Pheasant-tailed Jacana *Hydrophasianus chirurgus*	R, N	1,000	na	120	
Bronze-winged Jacana *Metopidius indicus*	R	na	-	na	
Greater Painted-snipe *Rostratula benghalensis*	R	na	-	na	
Black-winged Stilt *Himantopus himantopus*	R	1,000	2,726	2,726	definite
Pied Avocet *Recurvirostra avosetta*	N	1,000	13	13	
Eurasian Thick-knee *Burhinus oedicnemus*	R	na	-	1	
Great Thick-knee *Esacus recurvirostris*	N	na	-	1	
Oriental Pratincole *Glareola maldivarum*	N	750*	Na	10,000	
Small Pratincole *Glareola lactea*	N	1,000	2	2	
Grey-headed Lapwing *Vanellus cinereus*	N	1,000	-	na	
Red-wattled Lapwing *Vanellus indicus*	R	na	-	na	
Pacific Golden Plover *Pluvialis fulva*	N	1,000	607	2,000	definite
Grey Plover *Pluvialis squatarola*	N	1,300	118	800	
Common Ringed Plover *Charadrius hiaticula*	N	2,100	1	-	One record
Long-billed Plover *Charadrius placidus*	N	100	-	1	
Little Ringed Plover *Chadrius dubius*	R,N	1,000	186	440	
Kentish Plover *Charadrius alexandrinus*	N	1,000	788	-	probable
Malaysian Plover *Charadrius peronii*	R	250	16	25	
Lesser Sand Plover *Charadrius mongolus*	N	1,000	6,298	4,800	definite
Greater Sand Plover *Charadrius leschenaultii*	N	1,000	1,945	700	probable
Pintail Snipe *Gallinago stenura*	N	na	-	na	
Common Snipe *Gallinago gallinago*	N	10,000	-	na	
Long-billed Dowitcher *Limnodromus scolopaceus*	N	na	1	1	
Asian Dowitcher *Limnodromus semipalmatus*	N	230	150	600	definite
Black-tailed Godwit *Limosa limosa*	N	1,600	3,078	3,078	definite
Bar-tailed Godwit *Limosa lapponica*	N	1,500	275	275	
Little Curlew *Numenius minutus*	N	1,800	0	5	
Whimbrel *Numenius phaeopus*	N	550	65	750	definite
Eurasian Curlew *Numenius arquata*	N	350	345	345	probable
Eastern Curlew *Numenius madagascariensis*	N	380	2	2	
Spotted Redshank *Tringa erythropus*	N	1,000	870	870	probable
Common Redshank *Tringa totanus*	N	1,000	702	1,523	definite
Marsh Sandpiper *Tringa stagnatilis*	N	900	2,324	-	definite
Common Greenshank *Tringa nebularia*	N	550	308	514	probable
Nordmann's Greenshank *Tringa guttifer*	N	6	60	60	definite
Green Sandpiper *Tringa ochropus*	N	1,000	Na	Na	
Wood Sandpiper *Tringa glareola*	N	1,000	541	Na	probable
Terek Sandpiper *Xenus cinereus*	N	500	5	27	
Common Sandpiper *Actitis hypoleucos*	N	3,000	88	Na	
Grey-tailed Tattler *Heteroscelus brevipes*	N	400	0	27	
Ruddy Turnstone *Arenaria interpres*	N	1,000	200	-	
Great Knot *Calidris tenuirostris*	N	3,800	1,450	-	
Red Knot *Calidris canutus*	N	2,200	200	-	
Sanderling *Calidris alba*	N	220	68	-	
Little Stint *Calidris minuta*	N	2,000	2	4	
Red-necked Stint *Calidris ruficollis*	N	3,200	3,447	-	definite
Temminck's Stint *Calidris temminckii*	N	1,000	24	-	
Long-toed Stint *Calidris subminuta*	N	1,000	777	-	probable
Sharp-tailed Sandpiper *Calidris acuminata*	N	1,600	2	-	
Dunlin *Calidris alpina*	N	10,000	7	-	
Curlew Sandpiper *Calidris ferruginea*	N	1,800	1,211	2,800	definite
Spoon-billed Sandpiper *Eurynorhynchus pygmeus*	N	30*	16	-	definite
Broad-billed Sandpiper *Limicola falcinellus*	N	1,000	632	-	probable
Ruff *Philomachus pugnax*	N	1,000	37	-	
Red-necked Phalarope *Phalaropus lobatus*	N	na	4	-	
Red Phalarope *Phalaropus fulicarius*	N	10,000	1	-	One record

south-west margins of the gulf, on the site's only sand-beach habitat, on an accreting 3 km long sandspit. Although this is not the largest single population, it is of national significance, given the threats from disturbance posed by tourism at other, more extensive sand-beach habitats elsewhere in the peninsula.

The Inner Gulf as a staging area for migrants

Counts are too few, and coverage too uneven, to be able to reliably chart seasonal changes in numbers in the many shorebirds in the gulf. Paradoxically, midwinter counts for most species now generally outnumber those during spring and autumn, perhaps because those seasons are less well-sampled, and also due to turnover.

The clearest evidence of the importance of the Inner Gulf as a staging area comes from observations of Asian Dowitcher. The *c*. 400 Asian Dowitchers observed in the Inner Gulf in April 1984 (Round 1985) was then the largest number known anywhere until a major wintering concentration in Sumatra was discovered in the autumn of that same year. Although Asian Dowitchers are now known to winter in the gulf in significant numbers (Table 1), midwinter numbers are greatly exceeded by spring maxima, usually recorded in the first half of April. In autumn, Asian Dowitchers begin to arrive in mid- to late July and passage continues into October, though numbers are generally lower than those in spring, perhaps because the passage is more protracted.

Small numbers of Grey-tailed Tattlers are also recorded on spring and autumn passage; none winter. Most other species are recorded both on passage and in midwinter.

Flag-sightings and recoveries/controls have also begun to inform on movements. Two flag-sightings and one control indicate that some Common Redshanks that move through the Inner Gulf migrate further, to winter in West Malaysia or Singapore. Sightings of a Singaporean leg-flagged Lesser Sand Plover, and of Curlew Sandpipers from north-west and southern Australia, and Red-necked Stints from the east Asian seaboard have also been reported (Table 2).

All Lesser Sand Plovers handled, and those observed in breeding dress in spring, have shown the characteristics of the *atrifrons* group of races that breed in central Asia. So far as known there are no records in Thailand of the north-east Asian breeding *mongolus*, which presumably passes further east.

Changes in status of species

Trends in numbers through time cannot be tracked reliably for most species. Although recorded maxima for most have increased in recent years, this is almost certainly due to better coverage. An increase in the wintering population of Black-tailed Godwits *Limosa limosa* appears, however, to be genuine as the numbers at a single frequently covered site (Bang Pu) increased from 300 in December 1996 to 800 in December 1997, and 1,200 one year later (Round & Gardner, in press). The midwinter count throughout the gulf in January 2006 was 3,078. Increased numbers of Great Knots (previously thought to be only a spring and autumn passage migrant) have also been recorded in midwinter. Roughly 60 were counted in year 2000, but 800 in January 2005, and over 1,450 in January 2006.

The trend detected in Asian Dowitcher runs counter to that for most other shorebirds and is possibly of concern. Single day concentrations of 200–400 birds were regularly found in spring during the 1980s. The largest reliably documented count is 600 birds on 22 April 1989 (Round & Gardner, in press) although there are anecdotal reports of "about one thousand" during peak spring passage. Coverage during April has subsequently been very limited, and relatively few have been recorded in recent years (maximum 93 in April 1999; Erftemeijer and Jukmongkol 1999) and during March–May 2006 (120; S. Nimnuan, *in litt.*) indicating that further study is needed. It is not clear whether this represents a genuine decline in the population using the gulf, or a local shift in areas used so that some birds remained undetected.

OTHER WATERFOWL

Other than shorebirds, there are at least another 11 species of waterbird for which the populations in the Inner Gulf are of known, or probable, international importance (Round & Gardner, in press). These are: Brown-headed Gull *Larus brunnicephalus*, Caspian Tern *Sterna caspia*, Common Tern *S. hirundo*, Whiskered Tern *Chlidonias hybrida*, Little Cormorant *Phalacrocorax niger*, Indian Cormorant *P. fuscicollis*, Little Egret *Egretta garzetta*, Great Egret *Casmerodius albus*, Javan Pond Heron *Ardeola speciosa*, Spot-billed Pelican *Pelecanus philippensis* and Painted Stork *Mycteria leucocephala*. The number of Brown-headed Gulls, roughly 10,000 of which winter, may be one of the largest wintering concentrations known.

STATUS OF HABITATS

The importance of the Inner Gulf is owed largely to the relatively great expanse of low intensity ponds, so-called "supratidal habitats" that occur in proximity to the extensive mudflats. While the importance of traditional aquaculture ponds and salt-pans as shorebird roosting areas has long been recognised, such areas also provide feeding habitat, with shorebirds showing similar rates of energy intake on salt pans as they do on semi-natural wetlands (Yasué and Dearden, in prep.). For some species, such as Long-toed and Red-necked Stints, and Broad-billed Sandpipers, salt-pans possibly support the majority of birds throughout all stages of the tidal cycle.

Industrial and urban expansion

The integrity of the Inner Gulf is threatened by a number of factors. Virtually none of this onshore habitat is protected; no zoning is in place to prevent piecemeal loss from land-speculation, creeping urbanisation, and industrialisation associated with the spread of Bangkok and the provincial capitals of Samut Prakan, Samut Sakhon, Samut Songkhram and Phetchaburi. The area has suffered from a proliferation of inappropriate constructions, and ribbon development along some roads. In addition, several new highways are

Table 2. Trans-national recoveries or resightings of shorebirds from the Inner Gulf of Thailand

Flagging/Banding site	Coordinates	Date flagged/banded	Resighting/recovery site	Coordinates	Date re-sighted	Dist-ance (km)	Azi-muth (°)
Common Redshank							
Laem Phak Bia, Thailand	13° 03'N 100° 05'E	autumn 2006	Tanjung Tokong, Penang, Malaysia	05° 15'N 100° 12'E	07-Oct-06	867	181
Tanjung Kerang, Malaysia	03° 25'N 101° 10'E	21-Apr-89	Laem Phak Bia, Thailand	13° 03'N 100° 05'E	10-Sep-06	1,077	354
Laem Phak Bia, Thailand	13° 03'N 100° 05'E	since August 2006	Sungei Buloh, Singapore	01° 27'N 103° 43'E	12-Oct-06	1,350	163
Curlew Sandpiper							
SE South Australia	38° 00'S 140° 00'E	since April 1999	Khok Kham, Thailand	13° 30'N 100° 21'E	02-Apr-05	7,056	316
NW Australia	19° 00'S 122° 00'E	since August 1992	Khok Kham, Thailand	13° 30'N 100° 22'E	17-Aug-06	4,319	325
Red-necked Stint							
Furen Lake, Nemuro City, Hokkaido, Japan	43° 16'N 145° 27'E	since August 1997	Pak Thale, Thailand	13° 09'N 100° 03'E	08-Nov-04	5,464	246
Chongming Dongtan, Shanghai, China	31° 27'N 121° 55'E	since April 2006	Laem Phak Bia, Thailand	13° 03'N 100° 05'E	04-Sep-06	3,017	232
Taipei-Kaohsiung, Taiwan	24° 05'N 120° 24'E	since 1998	Khok Kham, Thailand	13° 30'N 100° 21'E	16-Oct-04	2,410	244
Mai Po, Hong Kong	22° 29'N 114° 02'E	Since spring 2001	Khok Kham, Thailand	13° 30'N 100° 21'E	14-Nov-06	1,755	238
Spoon-billed Sandpiper							
N. Chuchotka, Russia	67° 04'N 174° 35'E	June or July 2002, 2004 or 2005	Pak Thale, Thailand	13° 09'N 100° 03'E	02-Mar-06	7,989	261
S. Chuchotka, Russia	62° 00'N 177° 00'E	since June 2004	Khok Kham, Thailand	13° 30'N 100° 21'E	03-Nov-05	7,984	264
Lesser Sand Plover							
Sungei Buloh, Singapore	01° 27'N 103° 43'E	since August 2003	Khok Kham, Thailand	13° 30'N 100° 22'E	27-Feb-06	1,389	345

either being constructed, or are planned within the coastal zone. The eastern sectors of the gulf, to the east of the Chao Phraya River, have borne the brunt of the industrialisation up to the present. However, industrialisation of the western sectors is now beginning, with the construction of an oil-refinery on 1 km^2 of land close to one of the two Spoon-billed Sandpiper wintering areas on the Inner Gulf (Manopawitr and Round 2004).

Loss of mudflats

Although mudflat reclamations have occasionally been proposed, no reclamation on any significant scale has taken place. A more significant threat is posed by coastal erosion. Over 80% of the shoreline is suffering erosion rates of 5–25 m/year (study on coastal change by the Department of Mineral Resources; data supplied by N. Chaimanee, *in litt*.). The problem is compounded by the extraction of groundwater for industrial and household use, which causes compaction of sediments and land subsidence, and also by reduced outflow of sediments from the major rivers, most of which are dammed.

Responses to erosion include *ad hoc* mangrove plantings on mudflats (which may exacerbate the loss of shorebird feeding areas), and the construction of concrete sea-walls or boulder embankments on some stretches of shoreline, which may alter tidal flow pattens and worsen erosion on unprotected sections of coast.

Changing land-use

The Inner Gulf was spared the worst of the (post-1980) boom in intensive prawn-farming which has blighted many areas of south-east Asia and which would have destroyed or damaged onshore feeding and roosting areas for shorebirds. Following an initial boom in the mid- to late 1980s, poor water circulation and inappropriate management caused the industry to collapse within about four years (around 1990) due to the proliferation of fungal diseases and the accumulation of pollutants. Most areas then reverted to low intensity prawn-capture ponds including some abandoned, unutilised areas, which continued to support significant numbers of shorebirds.

The cycle may now, however, be being repeated. The current practice in some areas is to remove the accumulated pond sediments for landfills, converting once shallow, traditional ponds into deep, steep-sided ponds for aquaculture of prawns and crabs combined, or in some cases for cultivation of molluscs. If the trend towards conversion to deep water-filled ponds continues, this will greatly reduce onshore feeding and roosting areas for waders, and could conceivably increase the susceptibility of the coastal zone to erosion, or perhaps even catastrophic tidal breach.

Another disturbing trend is the use of polythene pond-liners on salt pans in some areas, rendering them unavailable as feeding areas. So far, however, use of these is limited.

Pollution

A wide array of organic and inorganic pollutants enters the gulf and, because of poor circulation, they tend to accumulate. However, there are no data on the effects of these on waterbirds. Occasional deaths of small numbers of birds have been recorded, possibly associated with dinoflagellate blooms.

Hunting

Direct persecution of shorebirds (netting for supply to local markets as food) still occurs, but probably on too small a scale to have a major impact. Awareness is generally high and most species are fully protected in law under the Wild Animal Reservations and Protection Act (1992).

CONSERVATION STATUS

No traditional protected areas exist in the Inner Gulf. Although archaic legislation, such as the 1913 Thai Waterways Act, and some land ownership laws, restricts development in coastal areas without specific permission, there is no conventional conservation or protected area legislation that can easily be applied to areas that support human populations or otherwise receive human use. Additionally, government agencies are usually exempt from the requirement to obtain Environmental Impact Assessments before undertaking most construction and public works activities.

Approximately 24 km^2 of coastal habitats, and an undetermined area of offshore mudflats and shallow coastal waters at Don Hoi Lot in the western sector of the gulf, were declared as a Wetland of International Importance under the Convention on Wetlands. However, the area receives no special protection in law and, additionally, offshore flats receive heavy human use from shellfish collectors so that shorebird usage is relatively low compared with some other sectors that receive no special recognition.

Although the government has prepared its own national inventory of wetlands (OEPP 1999; 2002), the Inner Gulf, listed as of international importance by IUCN (Scott 1989), was perversely downgraded to only national importance in the national inventory. This suggests that designation was not based on objective scientific criteria, and that the lowered importance level of the Inner Gulf may have been due to political pressure applied to the inventory compilers.

To summarise, the Inner Gulf of Thailand is one of the most important coastal wetlands in Asia, yet also one of the most threatened. It is accorded no special recognition by government agencies, even though Thailand is a party to the Convention on Wetlands.

RECOMMENDATIONS FOR FUTURE WORK

1) Monitoring of numbers and usage. There is a clear need for more frequent and systematic counting of shorebirds throughout the Inner Gulf so as to better track numbers and usage. In particular, more emphasis needs to be placed on:
    - i) identifying key mudflat feeding areas;
    - ii) investigating how differential usage of feeding areas relates to the density and distribution of shorebird prey; and
    - iii) investigating how conditions of onshore habitats influences mudflat usage.

2) Determining origins and movements of birds through increased emphasis on banding and colour-flagging.

3) Increasing awareness of the importance of the Inner Gulf among Thai government agencies. Sufficient information already exists to warrant nomination of at least the western sectors of the Inner Gulf as a shorebird reserve network site, and such a designation would usefully provide focus for those government agencies involved in coastal resource management. Additional information on shorebirds that is collected could be integrated into a comprehensive zoning plan for coastal habitats in the gulf.

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SHOREBIRDS IN NEW GUINEA: THEIR STATUS, CONSERVATION AND DISTRIBUTION

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INTRODUCTION

New Guinea is geographically located near the southern terminus of the East Asian–Australasian shorebird Flyway (Fig. 1). 'Flyways' are a useful concept for the management and conservation of migratory shorebirds because these birds often stop-off, rest, recuperate and feed in many countries within a Flyway in the course of their migrations between their breeding grounds and wintering grounds. For example it is of limited value to use large resources protecting shorebirds in one country, if they are not also protected in the other countries through which they migrate, or where they spend the breeding and non-breeding seasons. The island of New Guinea, the second largest island (*c.* 800,000 sq km) in the world after Greenland, is split politically between Papua (Indonesia) in the west and the independent nation of Papua New Guinea (PNG) in the east. For the purposes of this paper PNG also encompasses the Bismarck Archipelago (New Britain and New Ireland) and the Admiralty Islands. Located at the eastern end of the Indonesian Archipelago and immediately to the north of the continental land-mass of Australia, New Guinea is pivotally placed in the path of migrant palearctic shorebirds moving to and from Australia. Consequently it almost certainly has an important role to play in both the East Asian–Australasian Flyway and in part of the Pacific Flyway. Notwithstanding, there is very little published information about the shorebirds of New Guinea; much of what there is is rather arcane, scattered, in the grey literature, or unpublished data. This is a preliminary attempt to draw all of that information together and create a picture of shorebird migration in New Guinea.

Most of the migrant shorebirds that occur in New Guinea follow the East Asian–Australasian Flyway which is the flyway for large numbers of high Arctic Siberian breeding birds. However, unknown numbers of birds may also either join this flyway from Alaska and/or follow the Pacific Flyway. The Australasian Wader Study Group website says that there is probably a minimum of four million migratory waders in the East Asian–Australasian Flyway and that, within Australia, there are estimated minima of one million resident waders and two million migratory waders. An unknown percentage of these two million migratory shorebirds passes through or spends time in New Guinea *en route* to and from Australia and, in some cases, New Zealand.

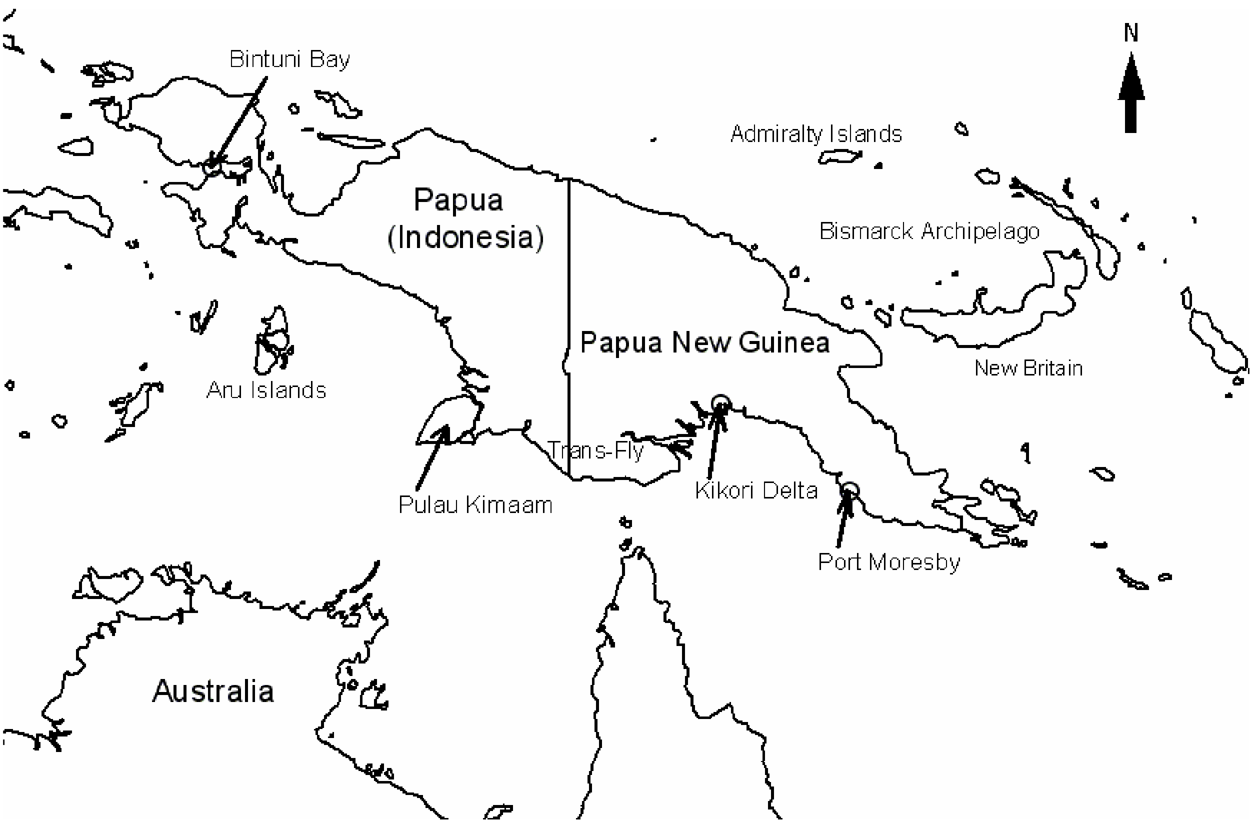

Figure 1. New Guinea.

Taxonomy

The taxonomy and sequence of families, genera and species generally follows Beehler and Finch (1985) although updated wherever more recent revisions of various taxa are appropriate. The following changes to Beehler and Finch (1985) have been adopted:

- White-headed Stilt *Himantopus leucocephalus* is lumped with Black-winged Stilt *H. himantopus*;
- Beach Stone-curlew – *giganteus* has priority over *grallarius* and *magnirostris*;
- Pacific Golden Plover *Pluvilais fulva* is split from Lesser Golden Plover *P. dominica;*
- New Guinea Woodcock *Scolopax rosenbergii* is split from Dusky Woodcock *S. saturata* (Kennedy *et al*. 2001).
- Grey-tailed Tattler and Wandering Tattler are placed in *Heteroscelus*;
- Common Sandpiper is placed in *Actitis;*
- Terek Sandpiper is placed in *Xenus* and as a consequence the specific name becomes *cinereus*.

METHODS AND RATIONALE

All shorebirds reliably recorded from New Guinea are listed in Table 1. This table presents the following data:

1. An indication whether or not the presence of a given species has been confirmed by the collection of a specimen in Papua and PNG.
2. The breeding range of the specific population that has been or likely recorded in New Guinea.
3. A synopsis of species breeding and migrant status in Australia.
4. A synopsis of species breeding and migrant status in New Guinea.

Shorebirds recorded in Australia but not New Guinea are listed in Table 2. The appendix presents counts for those species of shorebirds in New Guinea for which data are available. This appendix also presents population estimates for Australia and the world population of the defined subspecies or breeding population known to occur in New Guinea. Because of the un-stratified, uncoordinated, opportunistic and consequently disparate nature of the data, the counts are not necessarily from the same year or season.

The compilation of Tables 1 and 2, the appendix, and the detailed species accounts are largely derived from a study which included creating a comprehensive database of bird records including all taxa (species and subspecies) that I prepared for the World Wildlife Fund as a contribution to their conservation management planning of the Trans-Fly ecoregion (henceforth referred to as the Trans-Fly) (Bishop 2006). These records are based upon specimen records, literature records, published and unpublished reports, and the unpublished field data of this author and one or two other field workers known to the author to be experienced and reliable observers. Additional data were drawn in a similar way from the rest of New Guinea. Whilst every effort has been made to determine the exact location for each record, sometimes the data are too imprecise for this to be possible and a general locality is registered e.g. Wasur National Park or Kurik area. In order to add confidence to the listing of a given species for these sites every effort has been made to locate a supporting specimen record for both Papuan and PNG parts of New Guinea (see above). Species are not included, with a few specified exceptions, if the sole record is based on a non-peer reviewed trip report or an in-house report from unproven sources.

RESULTS

Overview

A total of 49 species of shorebird have been recorded from New Guinea and its associated islands (including the Bismarck Archipelago and Admiralty Islands) (Table 1). This total includes seven resident species: Comb-crested Jacana (two races), Bush Thick-knee, Beach Thick-knee, Black-winged Stilt, Little Ringed Plover, Masked Lapwing and New Guinea Woodcock (Coates 1985; Bishop 2006). Some of these resident shorebird populations are likely supplemented by migrants from Australia (Bishop 2006). A total of 33 regular or scarce but regular palearctic migrants has been recorded from New Guinea in addition to six palearctic species for which there are very few records and are consequently classified here as vagrants: Little Ringed Plover (migrant race *curonicus*), Bristle-thighed Curlew, Common Redshank, Long-billed Dowitcher, Baird's Sandpiper and Buff-breasted Sandpiper. Note that Little Ringed Plover is also represented in New Guinea by a resident population *C. d. dubius* as well as a rarely recorded migrant population *C. d. curonicus*. Six species are or are possible migrants/vagrants from Australia: Pied Oystercatcher, Black-winged Stilt, Red-necked Avocet, Masked Lapwing, Red-kneed Dotterel and Australian Pratincole. Of these six species only Masked Lapwing and Australian Pratincole are confirmed as regular migrants from Australia (Bishop 2006). It may be of interest to note that seventeen species of palearctic migrants have been recorded in Australia but not New Guinea (Table 2). Virtually all of these latter species, with the exception of Pintail Snipe, are vagrants to Australia. In comparison New Guinea has recorded two breeding species of shorebird, Little Ringed Plover and New Guinea Woodcock and one vagrant nearctic species, Bristle-thighed Curlew, not recorded in Australia.

Six species of shorebird recorded in New Guinea and its associated islands are listed by Birdlife International (2006) as Globally Threatened or Near Threatened: Bush Thick-knee (NT), Beach Thick-knee (NT), Black-tailed Godwit (NT), Bristle-thighed Curlew (VU), Asian Dowitcher (NT), and Buff-breasted Sandpiper (NT). It is the opinion of this author that Little Whimbrel should be added to this list and classified as Near Threatened (see Bishop 2006 and below).

Table 1 presents a brief synopsis of the breeding distribution of the likely population of each species of shorebird to occur in the New Guinea region. From this tabulation it can be quickly seen that a large number of

Table 1. Shorebirds Recorded in New Guinea and associated islands. P in Voucher/ Specimen column indicates voucher or specimen is available; PNG indicates same for Papua New Guinea. (**NT**) in Taxon column indicates Near Threatened status of population.

Taxon	**Voucher/ Specimen**	**Breeding range of New Guinea population**	**Status in Australia**	**Status in New Guinea**
1 Comb-crested Jacana *Irediparra gallinacean novaeguinae*	P - PNG	North & Central NG, Misool, Aru Islands	Resident	Resident
1 Comb-crested Jacana *Irediparra gallinacea novaehollandiae*	PNG	South NG, D'Entrecasteaux Islands;,North & East Australia	Resident	Resident
2 Bush Thick-knee (**NT**) *Burhinus grallarius*	PNG	South NG and Australia (patchily)	Resident	Trans-Fly local resident
3 Beach Thick-knee (**NT**) *Esacus magnirostris*	P - PNG	NG, Bismarcks and Australia	Resident	Resident
4 Pied Oystercatcher *Haematopus longirostris*	P	Australia	Resident	Irregular visitor
5 Black-winged Stilt *Himantopus himantopus leucocephalus*	P - PNG	Java, Wallacea, NG? New Britain, Australia and New Zealand	Resident	Resident (very local); also migrant?
6 Red-necked Avocet *Recurvirostra novaehollandiae*		Australia	Resident	Vagrant
7 Pacific Golden Plover *Pluvialis fulva*	P - PNG	North C & E Siberia W Alaska	Regular migrant	Regular migrant
8 Grey Plover *Pluvialis squatarola*	Don't Know	Arctic Russia	Regular migrant	Regular migrant
9 Little Ringed Plover *Charadrius dubius dubius*	P - PNG	Philippines, NG, Bismarcks	No records	Resident
9 Little Ringed Plover *Charadrius dubius curonicus*	P	Siberia, N, E & S China, Korea, Japan and Taiwan	Regular visitor in small nos	Vagrant
10 Lesser Sand Plover *Charadrius mongolus stegmanni*	P	Kolymskiy, Kamchatka, N Kuril Is N to Chukotskiy Penin	Regular migrant	Regular migrant
11 Greater Sand Plover *Charadrius leschenaultii leschenaultii*	P - PNG	W China, S Mongolia, S Siberia & Altai Mts	Regular migrant	Regular migrant
12 Oriental Plover *Charadrius veredus*	P	S Siberia, W, N & E Mongolia, NE China	Regular visitor in large nos	Regular but scarce migrant
13 Red-kneed Dotterel *Erythrogenys cinctus*	P	NG?, Australia	Resident	Trans-Fly – resident?
14 Masked Lapwing *Vanellus miles miles*	P - PNG	NE & S NG; Aru Is; N Australia	Resident	Resident; also migrant
15 Latham's Snipe *Gallinago hardwickii*	P - PNG	Japan, Kuril Is, S Sakhalin, E Pimorskiy	Regular migrant	Status unclear probably only a passage migrant
[Pintail Snipe *Gallinago stenura*]		CS Siberia, N Mongolia, SE Russia & NE China	Local and uncommon migrant	Status unclear ?rare – uncommon migrant
16 Swinhoe's Snipe *Gallinago megala*	P - PNG	CS Siberia, N Mongolia, SE Russia & NE China	Few definite records	Regular migrant
17 New Guinea Woodcock *Scolopax rosenbergii*	P - PNG	NG mountains	No records	Resident – Endemic
18 Black-tailed Godwit (**NT**) *Limosa limosa melanuroides*	P	Disjunct areas in C & E Siberia: E Mongolia, NE China, Russian far East	Regular migrant	Regular migrant
19 Bar-tailed Godwit *Limosa lapponica baueri*	PNG	N E Siberia east of R Kolyma to W Alaska	Regular migrant	Regular migrant
20 Little Whimbrel *Numenius minutus*	P	N Siberia population	Regular migrant in large nos	Regular migrant
21 Whimbrel *Numensius phaeopus variegatus*	P	NE Siberia	Regular migrant	Regular migrant
22 Bristle-thighed Curlew (**VU**) *Numenius tahitiensis*		West Alaska	No definitive records	Vagrant One definitive record
23 Far Eastern Curlew *Numenius madagascariensis*	P - PNG	NE Mongolia, NE China, E Siberia to Kamchatka	Regular migrant	Regular but uncommon migrant

Taxon	**Voucher/ Specimen**	**Breeding range of New Guinea population**	**Status in Australia**	**Status in New Guinea**
24 Common Redshank *Tringa tetanus ?terrignotae*		?S Manchuria	Regular migrant in very small nos	Vagrant
25 Marsh Sandpiper *Tringa stagnatilis*	P	Siberia to NE China	Regular migrant	Regular migrant
26 Common Greenshank *Tringa nebularia*	P - PNG	Central Asia, Central & E Siberia to Kamchatka	Regular migrant	Regular migrant
[Green Sandpiper *Tringa ochropus***]**		Central & E Siberia, NE China	No records	Vagrant
27 Wood Sandpiper *Tringa glareola*	P	C & E Siberia to Kamchatka, Commander Is, NE China	Regular migrant	Regular migrant
28 Terek Sandpiper *Xenus cinerea*	P - PNG	Boreal Central & E Siberia	Regular migrant	Regular migrant
29 Common Sandpiper *Actitis hypolencos*	P - PNG	Central Asia, Central & E Siberia, NE China to Kamchatka, Sakhalin & Japan, Korea, Taiwan	Regular migrant	Regular migrant
30 Grey-tailed Tattler *Heteroscelus brevipes*	P - PNG	NC & NE Siberia, Kamchatka, N Kuril Is	Regular migrant	Regular migrant
31 Wandering Tattler *Heteroscelus incanus*		Extreme E Siberia, S Alaska E to Yukon, S British Colombia	Regular migrant	Regular but uncommon passage migrant
32 Ruddy Turnstone *Arenaria interpres interpres*	P	High Arctic Siberia, NW Alaska	Regular migrant	Regular migrant
33 Asian Dowitcher (**NT**) *Limnodromus semipalmatus*		W, C & E Siberia, Mongolia, N Manchuria	Regular but local migrant	Rare migrant – regular?
34 Long-billed Dowitcher *Limnodromus scolopaceus*		NE Siberia (E of R Yana), W Alaska, N Inuvik	No records	Vagrant
35 Great Knot *Calidris tenuirostris*	P	NE Siberia E of Verhoyansk Mts	Regular migrant	Regular migrant
36 Red Knot *Calidris canutus rogersi*	P	Chukotskiy Peninsula, far NE Russia	Regular migrant	Regular, locally common but generally uncommon migrant
37 Sanderling *Calidris alba*	P	Severnaya Zemlaya, Tamyr, Lena Delta, New Siberian Is, N Alaska	Regular migrant	Regular but scarce migrant
[Little Stint *Calidris minuta***]**		NW & NC Siberia to New Siberian Is & R Yana	Vagrant	Vagrant?
38 Red-necked Stint *Calidris ruficollis*	P - PNG	N Siberia E of C & E Tamyr S to N Kamchatka, sporadic W & N Alaska	Regular migrant	Regular migrant
39 Long-toed Stint *Calidris subminuta*	PNG	Disjunct pops SW, C & E Siberia, Commander & Kuril Is	Regular but scarce migrant	Regular but scarce migrant
40 Baird's Sandpiper *Calidris bairdii*		Wrangel I, Chukotskiy Penin, N Alaska & Canada to Baffin I, NW Greenland	Vagrant	Vagrant
41 Pectoral Sandpiper *Calidris melanotus*		E Siberia, W & N Alaska	Regular migrant in small nos	Regular but scarce migrant
42 Sharp-tailed Sandpiper *Calidris acuminata*	P - PNG	NC & NE Siberia Lena Delta - Kolyma River	Regular migrant	Regular migrant
43 Curlew Sandpiper *Calidris ferruginea*	P	Arctic Siberia Yamal Penin - N Chukotskiy Penin	Regular migrant	Regular migrant
44 Broad-billed Sandpiper *Limicola falcinellus sibirica*	P	Taymyr Peninsula to R Kolyma	Regular migrant	Regular but uncommon migrant
45 Buff-breasted Sandpiper (**NT**) *Tryngites subruficollis*		Wrangel Is, Chukotskiy Peninsula, N Alaska, N Canada	Vagrant	Vagrant
46 Ruff *Philomachus pugnax*		W C & E Siberia, W C & E Siberia	Regular migrant in small nos	Regular but very uncommon migrant
47 Red-necked Phalarope *Phalaorpus lobatus*		E Siberia	Regular but local migrant in small nos	Regular but localized migrant
48 Oriental Pratincole *Glareola maldivarum*		Extreme S Siberia, NE Mongolia, S Manchuria, Taiwan, Japan, Indochina, Philippines	Regular visitor occasionally in huge nos	Regular migrant in small nos
49 Australian Pratincole *Stiltia Isabella*	P	Australia	Resident	Regular migrant in large nos

Table 2. Palearctic Shorebirds Recorded in Australia but not New Guinea. Global estimates from Wetlands International (2006)

Latin Name	Breeding range of Australian population	Global estimate	Status in Australia
1 Pheasant-tailed Jacana *Hydrophasianus chirurgus*	N India, C, E China, N Myanmar	100,000	Vagrant
2 Caspian Plover *Charadrius veredus*	S Siberia, W N & E Mongolia, NE China	70,000	Vagrant
3 Ringed Plover *Charadrius hiaticula*	NE Europe & Russia (High Arctic)	145 – 280,000	Vagrant
4 Pintail Snipe *Gallinago strenua*	C Siberia - Sea of Okhotsk	25,000 – 1,000,000	Scarce, but regular migrant
5 Hudsonian Godwit *Limosa haemastica*	NW & S Alaska	14,000	Vagrant
6 Upland Sandpiper *Bartramia longicauda*	C Alaska, Yukon, Canada, S & SE USA	350,000	Vagrant
7 Spotted Redshank *Tringa erythropus*	N Siberia	100,000	Vagrant
8 Lesser Yellowlegs *Tringa flavipes*	Alaska to SC Canada E to James Bay	400,000	Vagrant
9 Solitary Sandpiper *Tringa solitaria*	W Canada, Alaska	100,000	Vagrant
10 Western Sandpiper *Calidris mauri*	W & N Alaska, Chukotskiy Penin	3,500,000	Vagrant
11 Least Sandpiper *Calidris minutilla*	Alaska to Nova Scotia	700,000	Vagrant
12 White-rumped Sandpiper *Calidris fuscicollis*	NE Alaska & N Canada E to S Baffin Is	1,120,000	Vagrant
13 Little Stint *Calidris minuta*	NW & NC Siberia to New Siberian Is & R Yana	200,000	Vagrant
14 Dunlin *Calidris alpina*	N Alaska N of Seward Peninsula, NW Canada	100,000	Vagrant
15 Stilt Sandpiper *Micropalma himantopus*	N Alaska E to S Victoria Is, W Hudson Bay	820,000	Vagrant
16 Wilson's Phalarope *Steganopus tricolor*	EC California N to N Alberta E to Great Lakes	1,500,000	Vagrant
17 Grey Phalarope *Phalaropus fulicarius*	High Arctic Canada, Greenland, Iceland	100,000	Vagrant

shorebird species that spend the palearctic winter or migrate through the New Guinea region breed in eastern Siberia, especially the high Arctic. It is these populations of shorebirds that form the majority of the East Asian–Australasian Flyway. Table 1 also provides a brief synopsis of the status of each species of shorebird in New Guinea and, for comparison, Australia.

The counts of shorebirds from seven sites in New Guinea (see Appendix) provide a preliminary, albeit rather crude, window into the populations of shorebird species in New Guinea. Comparison with the global and Australian population estimates (see Appendix) reveals that New Guinea supports significant populations of several species of shorebird. For example, counts of sand plovers at two separate sites both represent *c*. 3.7% of the entire Australian population; one count and another specific comment (see Hoogerwerf 1964) indicates that *c*. 1% of the entire Australian population of Black-tailed Godwits occurs at two sites in New Guinea. Similarly important counts have also been made for Whimbrel, Far Eastern Curlew, Terek Sandpiper, Great Knot, Red-necked Stint, and Sharp-tailed Sandpiper. Generalized and specific counts clearly show that two areas, Wasur National Park and the Bulla Plains of the Tonda Wildlife Manangement Area, support globally important populations of Little Whimbrel (Little Curlew in Australia). Whether or not these latter birds are solely on passage or some spend the palearctic winter in New Guinea requires confirmation. A very large percentage of the entire global population of Australian Pratincole winters in the southern Trans-Fly but this too requires proper documentation. Despite these data being rather crude, they do, in the absence of any other data, provide us with a baseline with which to work and against which to compare other population estimates.

Burrows (1994) states that many of the migratory shorebirds reaching Australian shores use the southern New Guinea wetlands as important staging points to refuel on their long journey south. Whilst this is almost certainly true, this would appear to be a perspective based on the author's Port Moresby experience rather than an overall New Guinea perspective. Currently there is insufficient data to be clear exactly how many shorebirds remain in New Guinea throughout the palearctic winter (December to March) or if, at the onset of the rains, some or the majority move further south to Australia. Nevertheless the data presented in the species accounts and the Appendix does suggest that New

Guinea is likely to be an important palearctic winter site for several species, especially in the southern Trans-Fly. Similarly, preliminary data from sites elsewhere, such as the Kikori Delta and Bintuni Bay, indicate that other parts of New Guinea also support large assemblages of shorebirds on northwards passage.

It is clear even from these few data that several areas support important numbers of shorebirds; the Trans-Fly, and in particular the southern Trans-Fly, is clearly of especially high importance for shorebirds as shown by the Appendix. The following sites in New Guinea are those for which there is confirmation of their importance for shorebirds.

Confirmed sites of importance for shorebirds in New Guinea

Papua, North Coast

Wandammen Peninsula
Location: Wasior, south-west coast of Wandammen peninsula 2° 49'S, 134° 31'E
Description: Mud-flats, beach, and football field. 16 spp. recorded.
Date: 16–17 October 1983.
Reference: (J. M. Diamond pers. comm.).

Papua, South Coast

Aru Islands
Location: Extreme south-western corner of the New Guinea region 6° 12'S, 134º 30'E.
Description: A complex of land-bridge islands with extensive, largely primary and untouched mangrove forests and associated intertidal flats; a freshwater swamp at the southern end with associated marshy margins.
Area: 7,700 km^2.
Date: March-April 1988.
Reference: Diamond and Bishop (1994).

Bintuni Bay
Location: South coast of Papua between the Vogelkop peninsula and main body of western New Guinea. 2° 17'S, 133° 52'E.
Description: A huge, long and relatively narrow bay bordered by extensive brackish and freshwater swamplands, including 450,000 ha of mangrove forests. Regarded as one of the most extensive and least disturbed mangrove areas anywhere in Asia and the south-west Pacific. 9–10 species recorded. Total *c*. 10,000 shorebirds.
Date: March – April 1989.
Reference: Erftemeijer *et al.* (1991).

The Trans-Fly Ecoregion

The Trans-Fly of southern New Guinea encompasses parts of the territories of both Papua (Republic of Indonesia) and Papua New Guinea. This region is here defined by the northern limits of the monsoonal, seasonally much drier, mosaic of floristically less diverse forests and woodlands, swamps, marshes and grasslands that characterize southern New Guinea (Map 2). In view of the importance of this region, possibly the single most important site in the whole of the New Guinea region for shorebirds, a more detailed appraisal is provided below. This is almost entirely based on Bishop (1983b, 2006).

Pulau Kimaam (Frederick-Henderick Island)
Location: Extreme south-western Papua, immediately west of the Princess Marianne Straits. 07° 55'S, 138° 24'E (centre of the island).
Description: A vast and sparsely populated area of very low lying freshwater and brackish swamps and marshes including an extensive mosaic of muddy and open areas.
Reference: Bishop (1983b, 2006, unpubl.); Silvius & Taufik (1989).

Pulau Komolom
Location: South-west corner of the Princess Marianne Straits and the south-east corner of Pulau Kimaam (Frederick-Henderick Island). 8° 23'S, 138° 48'E (southern coast).
Description: Slightly elevated ocean sand-flat, isolated at high-tide from the main island.
Date: September 1983.
Reference: Bishop (1983b, 2006, unpubl.).

Kurik area
Location: Coastal areas between the Bian, Kumbe and Maro rivers and inland *c*. 30 km. 8° 44'E, 140° 16'S.
Description: Ocean beaches, inter-tidal mud-flats and rice-fields.
Reference: Hoogerwerf (1964); Mees (1982).

Lampusatu
Location: Eastern edge of the mouth of the Maro River, near Merauke 8° 30'S, 140° 22'E.
Description: Ocean beach sand-mud flats.
Date: September to December 1983.
Reference: Bishop (1983b, 2006, unpubl.).

Wasur National Park
Location: Extreme south-east Papua.
Description: A mosaic of ocean beaches, mud-flats, short open grasslands, *Imperata cylindrica* grasslands, permanent and ephemeral freshwater swamps and marshes. Includes important sites such as the extensive grasslands of the Yorr Plains (N.B. The nature of these may have changed as a result of burning and consequent invasion by noxious weeds). The latter are essentially contiguous with the adjoining Bulla Plains in PNG 8° 50'S, 140° 48'E; Delere Creek wetlands 8° 39'S, 140° 32'E; and Ongaya inter-tidal mud-flats.
Reference: Bishop (1983b, 2006); Silvius *et al.* (1989); Bishop (2006).

Bian Lakes
Location: Northern periphery of the Trans-Fly. 07° 05'–25'S, 140° 17'–30'E.
Description: A large area of interconnected freshwater lakes with associated areas of freshwater marshes and swamps.
Date: November to December 1983.
Reference: Bishop (1983b, 2006, unpubl.).

Papua New Guinea, North Coast

No sites confirmed.

Papua New Guinea, South Coast - Trans-Fly

Bensbach River area
Location: The most south-westerly river in PNG. 8° 46'S, 141° 171'E to 09° 51'S, 141° 15'E.
Description: A notably beautiful river which bisects an equally attractive mosaic of freshwater swamps and marshes and adjacent grasslands including the Bulla Plains.
Reference: Finch (1980a, 1982c), Finch and Howell (1982), Bishop 2006, Bishop (unpubl.).

Bulla Plains
Location: South-west PNG immediately east of the Bensbach River. 09º 03.26'S, 141º 16.30'E.
Description: The periphery of wetlands within *Pseudoraphis* sp. grasslands.
Reference: Bishop (2006, pers. obs.); Stronach (1980, pers. comm.); Bowe (pers. comm.).

Wemenevre Swamp
Location: North-eastern margins of the Bensbach River. 8° 45'S 141° 25'E.
Description: A large freshwater marsh.
Reference: Bishop (2006, pers. obs.); Stronach (pers. comm.).

Coastal beaches adjacent to the estuary of the Bensbach River
Location: Extreme south-west coast of PNG 09º 09'S 141º 21'E.
Description: Extensive ocean sand and mud-flats.
Reference: Finch (1980a), D. Watkins (pers. comm.).

Daru Island
Location: Off the south-west coast of PNG. 9° 05'S, 143° 12.25'E.
Description: A small, tall mangrove dominated island with modest areas of inter-tidal mud-flats.
Reference: Bishop (2006, pers. obs.).

Aramia Wetlands
Location: Immediately east of the lower Fly River 8° 02'S, 142° 50'E.
Description: A large complex of freshwater swamps and marshes.
Reference: Bell (1967).

Middle Fly Wetlands
Location: Lake Daviumbu. 07º 34'S, 141º 16'E. Lake Pangua. 07º 32'S, 141º 25'E. Lake Ambuve. 07º 43'S, 141º 23'E.
Description: A very large area of highly seasonal freshwater lakes and marshes associated with the Fly River floodplain.
Reference: Halse *et al.* (1996), Gregory & Jaensch (1995), Gregory (1995)

Papua New Guinea, South Coast

Kikori Delta
Location: The coastal lowlands of Gulf Province, south coast of PNG from the mouth of the Turama River to the delta of the Purari River and including the large and complex delta of the Kikori River. 07° 00'-50'S, 143° 10'-30'E.
Description: A vast mosaic of inter-tidal mudflats, tidal creeks, mangroves, freshwater and brackish swamps, floodplain swamps and swamp forests. 1,331,300 ha.
Reference: Diamond & Bishop (unpubl.), Scott (1989), R. Jaensch (pers. comm.).

Bereina area
Location: The mouth of the Angabunga River, the beach between Aviara and Waima as well as lowland swamps and short grassland near Bereina, 8º 38'S, 146º 31'E.
Description: Inter-tidal mudflats, ocean beach and lowland swamps and short grassland. 33 species recorded.
Reference: Heron (1978).

Port Moresby area

Hisui Lagoon, Central Province
Location: *c*. 65 km north-west of Port Moresby 09°02'S, 146°45'E.
Description: Highly seasonal freshwater lagoon.
Reference: Burrows (1994), Bishop (pers. obs.).

Lea Lea Salt Flats, Central Province
Location: *c*. 28 km north-west of Port Moresby 09° 18'S, 146° 59'E.
Description: Highly seasonal brackish pools
Reference: Burrows (1994).

Lake Iaraguma
Location: *c*. 32 km north-west of Port Moresby. 09° 16'S, 147° 02'E.
Description: *c*. 200 ha. Seasonal freshwater lake.
Reference: Burrows (1994).

Kanosia Lagoon
Location: *c*. 55 km north-west of Port Moresby. 09° 01'S, 146° 54'E.
Description: 30 ha. Seasonal pool and muddy margins within cattle pasture.
Reference: Burrows (1994), Bishop (pers. obs.).

Aroa Lagoon
Location: *c*. 65 km north-west of Port Moresby. 09° 01'S, 146° 47'E.
Description: Seasonal freshwater lagoon with muddy margins.
Reference: Burrows (1994).

Islands

New Britain

Lake Dakatua
Location: Northern tip of the Willuamez Peninsula, central-north coast, West New Britain Province 5° 01.41'S, 150° 05.17'E.
Description: A freshwater lake within an extinct imploded volcano. First NG breeding site for Black-winged Stilt and large numbers of wintering Red-necked Phalarope.
Date: October 1979.
Reference: Bishop (1983a).

Potential but unconfirmed shorebird sites in New Guinea:

Papua

The south-west coast from the estuary of the Digul River north and west to Lakahia Bay (at the narrowest point of the entire island of New Guinea). This is a vast and ornithologically completely unexplored area. Many large and not so large rivers debouch into the Arafura Sea and satellite imagery indicates that considerable areas of potentially important shorebird habitat exist in this rather inaccessible area.

The entire south coast of the Vogelkop Peninsula.

Papua New Guinea

The following sites were listed by Burrows (1994) but without a description or supporting detail:

Sepik and Ramu Floodplains
Described by Burrows (1994) as ranging from the border with Papua in the west to the upper Ramu valley south west of Madang in the east. Area 1,200,000 ha.

Mambare Wetland

Musa Wetland

Mullins Harbour, Milne Bay

Toriu
South-west of Rabaul, East New Britain Province, PNG.

Lake Namo
Listed by Burrows (1994) presumably on the basis of my aerial survey of this site (see Bishop & Broome 1980). Although this was (and possibly still is) an important freshwater lake on the north coast of West New Britain Province for water-birds, its importance for shorebirds is completely unknown.

SHOREBIRD SPECIES ACCOUNTS

1. Comb-crested Jacana *Irediparra gallinacea*

Comb-crested Jacana is widespread in freshwater wetlands, especially those with an extensive covering of floating vegetation, sometimes in moderately large numbers, throughout much of lowland New Guinea especially the Trans-Fly. In Papua this species has been recorded from the Aru Islands; Misool in the Western Papuan Islands; Lake Sentani on the north coast near Jayapura; in the southern lowlands, Comb-crested Jacana is found throughout the Trans-Fly from Pulau Kimaam in the west (Bishop 1983b, 2006, Silvius & Taufik 1989) eastwards without intervening records to the Kurik area (Mees 1982). Judging from the large number of specimens collected in this area (Mees 1982), it was common during the early 1960s. Further east this species was collected by Thomas Jackson on the Merauke Swamp in 1923 (Bangs & Peters 1926) and it was observed to be locally common within Wasur National Park during 1982 and 1991 (Bishop 1983b; pers. obs.; Hornbuckle 1991). Further to the north within the Trans-Fly, Bishop (unpubl.) recorded this species commonly on freshwater swamps associated with the Bian Lakes during November 1983.

Within the PNG part of the Trans-Fly, jacanas were found to be locally common along the Bensbach River and its associated swamps sometimes in moderately large numbers, occasionally numbering as many as 50 birds (Bishop pers. obs.; Stronoch 1981). Similarly large numbers have been observed on swamps within the neighboring Bulla Plains and on Wemenevre Swamp. Further east this species has been recorded on the mainland opposite Daru Island and Bell (1967) observed it regularly on the freshwater lagoon at Balimo, on the Aramia River during 28 September to 1 November 1965. Further north on the Middle Fly wetlands, Halse *et al.* (1996) found jacanas breeding or just having bred during April, although probably in low numbers. During aerial surveys of the Middle Fly wetlands Halse *et al.* (1996) estimated a total of 6,404 Comb-crested Jacanas during December 1994 at the end of the dry season but before the onset of rains and a total of 3,394 jacanas during April 1995 at the conclusion of the rains. Further east this species is common throughout the freshwater swamplands of the Port Moresby capital district and adjoining areas of Central Province. This species has also been recorded along the north coast of PNG between Vanimo and Wewak; along the Sepik River and its tributaries; on small swamps near Madang and Lae; on Ferguson and Goodenough islands in the D'Entrecasteaux archipelago and on the north coast of West New Britain Province (Ap-Thomas 1978, Coates 1985, Bishop unpubl.).

There are no global or even Australian population estimates of Comb-crested Jacana (see Marchant & Higgins 1993) but it is clear from the above that New Guinea supports a large breeding population of this species. It is unclear what proportion if any of New Guinea's birds are migrants from Australia.

2. Bush Thick-knee *Esacus grallarius*

Bush Thick-knee is a distinctive, vocal and nocturnal inhabitant of much of northern and parts of southern Australia plus a tiny part of the southern Trans-Fly of New Guinea. Bush Thick-knee is very poorly known in New Guinea and it appears to occupy a very restricted range defined by Wasur National Park (Papua) in the west of the southern Trans-Fly and the contiguous Bensbach River area (PNG) in the east of the southern Tran-Fly including the very important Bulla Plains. This species was first recorded for New Guinea on 16 October 1969 when a specimen of a juvenile taken in the Wando village area located along the Bensbach River was shown to the ornithologist Eric Lindgren. Subsequently, during October 1969, and May, July and September 1970 several more birds were seen and heard and subsequently banded *c.* 5 km south of Wando in a remnant patch of *Melaleuca* sp. woodland (Lindgren 1971). This species has been recorded during several subsequent visits to the Bensbach River area during July and August (Bishop pers. obs., Finch 1980a). However, this species' retiring and largely crepuscular and nocturnal behaviour ensures it is almost certainly overlooked and as a consequence only low numbers have been recorded. The sole record for the Papua part of the Trans-Fly is a single bird heard calling on the night of 2 August 1991 near Tomerau within Wasur National Park (Hornbuckle 1991).

Within the Trans-Fly Bush Thick-knees inhabit open savanna woodland and grassland with scattered trees. Very little is known about this species' true status in the Trans-Fly. Some damage to this population may be caused by predation from feral domestic dogs and pigs. Nevertheless the size of the New Guinea population of Bush Thick-knee is unknown. This species should be searched for in suitable habitat throughout the entire Trans-Fly. This species is currently classified as Near Threatened (Birdlife International 2006a).

3. Beach Thick-knee *Esacus neglectus*

Beach Thick-knee appears to be very sparsely distributed on the coast of mainland New Guinea (Coates 1985) and there are surprisingly few published observations or specimen records. However, this species is widely distributed on New Guinea's islands and throughout Melanesia (Mayr 1941, Coates 1985, Mayr and Diamond 2001). Within the Trans-Fly this species appears to have been recorded from just four localities: (i) observed on Pulau Kimaam (Papua) (Silvius and Taufik 1989); (ii) one collected by A. J. M. Monsanto in the Merauke area (Papua) (Mees 1964); (iii) two observed on the Fourth Beach near the mouth of the Bensbach River (PNG) during 9–16 October 1980 (Finch 1980a); and (iv) four observed on the mudflats at the southern most point between Bulla and Bensbach River mouth, 19–23 November 1998 (D. Watkins pers. comm.)

The paucity of records of Beach Thick-knee from mainland New Guinea almost certainly reflects the lack of collectors and observers working coastal areas. Nevertheless Beach Thick-knee is a large and vocal coastal inhabitant and has the potential to function as a good indicator species of habitat quality and hunting intensity. There appear to be no data that suggest there is any movement of this species between Australia and New Guinea (Draffan *et al.* 1983, Marchant & Higgins 1993).

Birdlife International (2006b) notes that Beach Thick-knee's population in Australia may number *c.* 5,000 birds and is probably stable and Wetlands International (2006) estimates the world population as *c.* 6,000. Birdlife International, however, also note that this species is very rare on and around Sumatra, Vanuatu and New Caledonia, where it has not been seen for six years. Similarly it has not been recorded recently in Peninsular Malaysia for many years (Robson 2000). Elsewhere within its range Beach Thick-knee is a scarce but widespread resident in the Andaman Islands (Rasmussen & Anderton 2005), a rare to scarce resident in south Myanmar (Cocos Islands), southern Tenasserim, S (west) Thailand (offshore islands only) and Singapore (Robson 2000), a scarce, probable resident on small offshore islands of Sumatra (van Marle & Voous 1988), a scarce and localized resident with apparently seasonal dispersive movements in Borneo (Smythies & Davison 1999), a very local resident on Java (Bishop pers. obs.), a rare resident in the Philippines (Dickinson *et al*. 1991) and an uncommon, sparsely distributed resident in Wallacea (Coates & Bishop 1997). It appears to be threatened by extensive human disturbance of beach habitats in many areas and is consequently categorized as Near Threatened. In view of this assessment New Guinea and especially its islands, big and small, with extensive areas of relatively undisturbed coastal habitat, likely support a significant population of this declining species.

4. Pied Oystercatcher *Haematopus longirostris*

Pied Oystercatcher is known from just a handful of records from the south coast of New Guinea: Aru Islands (Mayr 1941, Diamond & Bishop unpubl.); the south coast of the Vogelkop Peninsula between Konda and Inanwatan; the Utanata River and within the Trans-Fly from Pulau Kimaam and P. Komolom, including eight on 30 September 1983 (Bishop unpubl.) at the latter site, eastwards without intervening records to the mouth of the Bian River where a single individual was collected by Hoogerwerf (in Mees 1982) on 13 May 1962. This species was observed on several occasions during October to November 1983 at Lampusatu beach near Merauke, including three on 30 November (Bishop unpubl.). Continuing east just across the international border to PNG within the Tonda Wildlife Management Area (WMA) a total of ten were observed on the mud-flats at the Fourth Beach on 17 November 1979 (Stronach 1981). Subsequently, Finch (1980a) observed six at the same site during 9–16 October 1980 and D. Watkins (pers. comm.) observed two on the mudflats at the southern most point between the Bulla and Bensbach River mouths. There is also an old record from Orangerie Bay and from the island of Misima in the Louisiade Archipelago (Mayr 1941). There is no evidence that Pied Oystercatcher breeds in New Guinea and it thus appears likely that all records refer to migrants from Australia. This species has however been recorded breeding on Ree Island and has been recorded on several other islands in south-east Wallacea (Coates & Bishop 1997); consequently breeding in New Guinea is not impossible.

5. Black-winged Stilt *Himantopus himantopus leucocephalus*

Black-winged Stilt is widespread throughout the lowlands of New Guinea (Coates 1985) and it has been recorded breeding occasionally but at notably few sites. Within the Papuan part of the Trans-Fly, this species ranges from Pulau Kimaam and P. Komolom in the west (Bishop 2006), eastwards without intervening records, to the Kurik area where two specimens were collected by Hoogerwerf during November 1960 (Mees 1982). Black-winged Stilts were regularly observed at Lampusatu near Merauke including 18 on 24 November 1983; 35 on 25 November 1983; 27 on 26 November 1983 and 17 on 22 December 1983 (Bishop unpubl.). At nearby at Ndalir Hornbuckle (1991) observed a roost of 500+ on the beach on 31 July and 3 August 1991. Surprisingly this species appears to be rather uncommon within Wasur National Park with only scattered records of low numbers (Bishop unpubl.; Hornbuckle 1991).

In the adjoining PNG part of the Trans-Fly to the east, Black-winged Stilt was locally common in the Bensbach River and Tonda WMA area during July and August 1989–1997 (Bishop 2006) and Finch (1980a) found it very common in the same area during 9–16 October 1980. Further to the east Black-winged Stilts have been recorded at Balimo Lagoon on the Aramia River where Bell (1967) observed a flock of more than 30 on mudflats north of the station. At the northern margins of the Trans-Fly this species has been recorded in the Middle Fly wetlands (PNG) (Halse *et al.* 1996) but it has not been recorded on the Bian Lakes (Papua). Heron (1978) lists just two records of this species for the Bereina area (PNG): four on 3 July 1976 and thirty over 12–13 November 1977. In the Port Moresby area Black-winged Stilt is locally and seasonally common.

During aerial surveys of Pulau Kimaam, a total of 120 Black-winged Stilts were recorded at Rawa Dembuwan on 18 July 1988 and 300 at Rawa Cuwoon on 30 July 1988 (Silvius & Taufik 1989). During aerial surveys of the Middle Fly wetlands, Halse *et al.* (1996) recorded an estimated total of 656 Black-winged Stilts during December 1994 at the end of the dry season but before the onset of rains. During April 1995, at the end of the wet season, this species was not recorded.

Black-winged Stilts were first found breeding in the New Guinea region during early October 1979 when Bishop (1983a) observed several pairs nesting and with young at the margins of Lake Dakatua, West New Britain Province, PNG. Subsequently, on 14 June 1982, Finch (1982a) observed one pair nesting and another pair with young at Kanosia Lagoon near Port Moresby (PNG). These appear to be the only records of this species breeding in New Guinea, thus Black-winged Stilt remains unknown as a breeding species in Papua and much of New Guinea, notably the Trans-Fly. The large number of Black-winged Stilts regularly recorded in New Guinea suggests that this species is either widely overlooked as a breeding species or that the New Guinea breeding population is supplemented by migrants (possibly in large numbers) from Australia despite the statement in Marchant & Higgins (1993) that there is "no regular northerly movement (of birds) from Australia to PNG." Draffan *et al.* (1983) noted that this species was an uncommon winter visitor to the islands of the Torres Straits.

6. Red-necked Avocet *Recurvirostra novaehollandiae*

This handsome species is only known from New Guinea from a single record of a bird in adult-looking plumage. This bird was feeding with a group of palearctic shorebird migrants on the coast of Wasur National Park (Papua) within the Trans-Fly (Bostock 2000). This is an exceptional record of this Australian endemic. However, during the dry season in northern Australia birds move northwards to the Northern Territory (e.g. Kakadu and Darwin areas) (Marchant & Higgins 1993). Consequently it may be that this individual overshot its dry season haunts and landed in southern New Guinea. Elsewhere this species has been found on offshore islands and as far away as New Zealand suggesting that it is capable of long distance movement (Marchant & Higgins 1993).

7. Pacific Golden Plover *Pluvialis fulva*

Pacific Golden Plover is arguably the most widespread and most commonly seen palearctic shorebird over the northern winter and/or on passage in New Guinea and its islands (Coates 1985; Hicks 1990; Bishop unpubl.). As is the case in Australia (Marchant & Higgins 1993) this species is widespread throughout the coastline of New Guinea and its islands. In New Guinea it inhabits sandy beaches, mudflats and exposed coral reefs and inland at the margins of swamps, on grassy plains, ploughed fields and recently burnt grassland savanna. This species is also regularly observed on airfields, especially mid-sized airfields with extensive areas of short-cut grass and playing fields. It also occasionally occurs in highland valleys up to *c.* 1700 m (Coates 1985). Pacific Golden Plover occurs in monotypic flocks which are typically observed on airstrips or playing fields or in mixed flocks on both sandy and muddy beaches. Birds depart New Guinea during May – the latest date for Port Moresby is 13 May 1979 (Hicks 1990) and return mid-July – the earliest date for Port Moresby is 19 July 1980 (Hicks 1990). However, our perception of departure and arrival dates may be skewed by the presence of non-breeders during the austral winter.

In Australia Pacific Golden Plover is a widespread palearctic winter visitor along the entire coastline but scarce inland and has an estimated population of 9,000 (Watkins in Marchant & Higgins 1993). In south-east Asia and the Greater Sundas, this species is an uncommon to fairly common northern winter visitor and passage migrant (Robson 2000, MacKinnon & Phillipps 1993, van Marle & Voous 1988, Smythies & Davison 1999). In the Philippines and Wallacea it is a common northern winter visitor and passage migrant (Dickinson *et al*. 1991, Coates & Bishop 1997).

8. Grey Plover *Pluvialis squatarola*

Grey Plover is a widely but rather sparsely distributed winter visitor/passage migrant to New Guinea and its islands. In New Guinea this species inhabits broad open ocean beaches on both sand and mud flats. It is rarely encountered in inland habitats such as coastal airstrips and even less frequently in the islands. An exceptional record is of a group of 15 at the mouth of the Dhagi River on the north coast West New Britain Province (PNG), 8 December 1979 (Bishop unpubl.). There appear to be few other records from the Bismarck Archipelago, further evidence of the point argued by Mayr (1945) that this species characteristically migrates to the west of Northern Melanesia. In the Port Moresby area Hicks (1990) regarded this species as a "Common passage migrant and uncommon winter visitor to coastal sites, with a few records from inland." The earliest date for the Port Moresby area is 16 August 1987 and the latest date for Port Moresby area is 19 May 1984 (Hicks 1990).

In Australia Pacific Grey Plover is a widespread but sparsely distributed palearctic winter visitor especially in coastal areas of the west and south and has an estimated population of 12,000 (Watkins in Marchant & Higgins 1993). In south-east Asia and the Greater Sundas this species is an uncommon to fairly common northern winter visitor and passage migrant (Robson 2000, MacKinnon & Phillipps 1993, van Marle & Voous 1988, Smythies & Davison 1999). In the Philippines it is a rare northern winter visitor and uncommon passage migrant (Dickinson et al 1991) and in

Wallacea it is a regular passage migrant and northern winter visitor (Coates & Bishop 1997).

9. Little Ringed Plover *Charadrius dubius*

Little Ringed Plover is represented in New Guinea and its islands by a resident subspecies *C. d. dubius* and the palearctic migrant subspecies *curonicus*. Resident *dubius* is widespread throughout the region and typically inhabits gravel bars along and within rivers, also nearby open areas of bare ground including the concrete bases of disused buildings, gravel tracks, paved roads and occasionally gravel airstrips near water. This resident subspecies ranges from near the coast up to highland valleys. Although the nest in New Guinea has not been described a half-grown, still quite downy chick was observed along the Kumil River, Madang Province (PNG) during mid-August (Berggy 1978). Migrant *curonicus* is known from New Guinea on the basis of a specimen collected on Japen Island (Papua) and a second specimen collected at Kurik in the southern Trans-Fly on 29 December 1960 (Mees 1962). There are two sight records from the Port Moresby region (PNG) (Finch 1983a). There is only one record of Little Ringed Plover from the Bensbach River area (PNG) on 16 November 1985 but the observers were unable to assign it to subspecies (Hicks 1985).

In Australia migrant *dubius* is regarded as probably a regular visitor to the north in small numbers with sporadic records in the south (Marchant & Higgins 1993). Subspecies *curonicus* is a widespread migrant in south-east Asia, the Greater Sundas, the Philippines and Wallacea (Robson 2000, MacKinnon & Phillipps 1993, Dickinson *et al*. 1991, Coates & Bishop 1997).

10. Lesser Sand Plover *Charadrius mongolus stegmanni*

Lesser Sand Plover is a widespread and common palearctic winter visitor and passage migrant throughout coastal areas of New Guinea and its islands. However, because of their similarities there is almost certainly some confusion between the identification of this species and Large Sand Plover *Charadrius leschenaultii*. In the Port Moresby area Hicks (1990) regarded Lesser Sand Plover as a common (palearctic) winter visitor and passage migrant with a few individuals remaining in the area during the austral Summer. The earliest date for the Port Moresby area is 16 August 1987 including some birds in breeding plumage. The latest date for the Port Moresby area is 19 May 1984 (Hicks 1990). At the mouth of the Angabunga River near Bereina, Heron (1978) found this species common on tidal flats and sheltered beaches during all months particularly mid-August to mid-May although some do not migrate north.

The estimated Australian population is *c.* 20,000 (Watkins in Marchant & Higgins 1993). High counts of Sand Plovers (Lesser and Greater combined) in New Guinea include:

Papua (Bishop unpubl.)

30 September	1983	3,700	Pulau Komolom, Princess Marianne Straits, southern Trans-Fly. (N.B. This count is likely an underestimate.)
15 September	1983	3,450	Lampusatu, Merauke.
26 October	1983	1,010	10 km south of Ongaya, Wasur National Park, southern Trans-Fly.
4 November	1983	2,255	Lampusatu, Merauke.
26 November	1983	3,130	Lampusatu, Merauke.
19 October	1983	441	Dalere River Mouth, Wasur National Park, southern Trans-Fly.
22 December	1983	1,713	Lampusatu, Merauke.

Papua New Guinea (R. Jaensch pers. comm.)

20 March	2000	1,700+	Kikori Delta.

Combining the Australian population estimates for both Lesser and Greater Sand Plovers produces a total of *c.* 94,000. The highest single count at one site of combined Lesser and Greater Sand Plovers recorded for New Guinea is *c.* 3,700 on 30 September 1983 at Pulau Komolom in the southern Trans-Fly (Papua). Thus we know that New Guinea supports, at the very minimum, 3.7% of the total estimated Australian population for these two species at just one site. Whether or not these birds are on passage or staying for the non-breeding period, the large numbers of birds from elsewhere in New Guinea strongly suggest that New Guinea is at the very least an important staging site for these two species.

In Australia Lesser Sand Plover is a widespread and common palearctic winter visitor especially in coastal areas and, as noted above, has an estimated population of 20,000. In south-east Asia, the Greater Sundas and the Philippines this species is a common to fairly coastal northern winter visitor and passage migrant (Robson 2000, MacKinnon & Phillipps 1993, van Marle & Voous 1988, Smythies & Davison 1999, Dickinson *et al*. 1991) and in Wallacea it is a locally moderately common to common passage migrant and a less common northern winter visitor (Coates & Bishop 1997).

11. Greater Sand Plover *Charadrius leschenaultii leschenaultii*

Greater Sand Plover is a widespread and common palearctic winter visitor and passage migrant throughout coastal areas of New Guinea and its islands. However, because of their similarities there is almost certainly some confusion between the identification of this species and Lesser Sand Plover *Charadrius mongolus*. In the Port Moresby area Hicks (1990) regarded Greater Sand Plover as a common winter visitor and passage migrant with a few individuals remaining in the area during the austral summer. The earliest date for the Port Moresby area is 16 August 1987 including some birds in breeding plumage. The latest date for the Port Moresby area is 19 May 1984 (Hicks 1990). At the mouth of the Angabunga River near Bereina, Heron (1978) recorded Greater Sand Plover as fairly common in all months especially late August to late April.

In Australia Greater Sand Plover is a widespread and locally abundant palearctic winter visitor especially in coastal areas and has an estimated population of 74,000 (Watkins in Marchant & Higgins 1993). In south-east Asia and the Greater Sundas this species is an uncommon to fairly common coastal northern winter visitor and passage migrant

(Robson 2000, MacKinnon & Phillipps 1993, van Marle & Voous 1988, Smythies & Davison 1999). In the Philippines it is a common northern winter visitor and passage migrant (Dickinson et al 1991) and in Wallacea it is a locally moderately common to common northern winter visitor (Coates & Bishop 1997). For a discussion of the size of the New Guinea population see Lesser Sand Plover above.

12. Oriental Plover *Charadrius veredus*

Mayr (1941) listed just two records of this species for New Guinea: Aru Islands (Papua) and Astrolabe Bay (PNG). Rand and Gilliard (1967) regarded Oriental Plover as rare despite Hoogerwerf (1964) having observed several in dry rice-fields in the Kurik area and on the nearby beach between the Kumbe and Bian rivers (Papua). Hoogerwerf thought this species was less rare than perhaps his records indicated. Subsequently, Coates (1985) regarded Oriental Plover as a regular annual visitor to New Guinea. In the Port Moresby area Hicks (1990) listed this species as "Irregular and rare passage migrant. Most often recorded in November…" Coates's (1985) assessment notwithstanding, there are surprisingly few records of this species from New Guinea given that it is such a widespread and common winter visitor to Australia (Marchant & Higgins 1993). Most records are widely scattered and of small numbers; for example on 26 September 2001, Oriental Plover was recorded for the first time on the north coast of Papua (Tindige 2003).

Lane (1987) suggested that the lack of records between breeding and non-breeding areas in locations such as New Guinea was because this species typically flies between China and Australia without stopping. All the evidence appears to confirm Lane's (1987) conclusion. For further discussion of the implications of this behaviour see Branson & Minton (2006). Nevertheless it is perhaps surprising that this species has not been found more commonly in the seemingly ideal habitat of the open, short-grass plains of the Trans-Fly of southern New Guinea, in particular the relatively well watched Bulla Plains and Bensbach area (Bishop 2006). This point is perhaps underscored by Branson & Minton (2006) who point out that "In the case of Oriental Plover, however, their relatively late arrival in Australia, probably related to the availability of food, requires them to carry out much of their primary moult either on the breeding grounds or at unknown stop-over locations somewhere in Asia." One possibility is that there have been very few observers in the Trans-Fly during October to March and that this species has been overlooked. For example D. Watkins (pers. comm.) found a group of 39 during 19 – 23 November 1998 at the junction of Tambari Creek and the Bensbach River (PNG) and a further 20 in the nearby eastern swamps.

Contrary to the statement in Hayman *et al.* (1986) (and unfortunately reiterated in Marchant & Higgins [1993]), there appears to be no basis for the assertion that this species spends the non-breeding season chiefly in Indonesia (and northern Australia). In the Greater Sundas, Oriental Plover is a rarely recorded species; for example, there are just two records from Sumatra (van Marle and Voous 1988) and one record from Kalimantan, Borneo (Van Balen & Hedges 2000). It is a rare autumn passage migrant in the Philippines (Dickinson *et al.* 1991) and in Wallacea, and whilst it has been recorded from several islands there are no records of any substantial numbers or evidence of numbers over-wintering (Coates & Bishop 1997; Bishop pers. obs.).

Birdlife International (2006c) summarizes the status and conservation of this species as follows: Oriental Plover has a large range, with an estimated global Extent of Occurrence of 100,000–1,000,000 km^2. It has a large global population estimated to be 70,000 individuals (Wetlands International 2006). Global population trends have not been quantified, but the species is not believed to approach the thresholds for the population decline criterion of the IUCN Red List (i.e. declining more than 30% in ten years or three generations). For these reasons, the species is evaluated as Least Concern. The population wintering in Australia was initially estimated at *c.* 40,000 (D. Watkins in Marchant & Higgins 1993), however, a count of 60,000+ made near Eighty Mile Beach on 17 October 1988 (Minton *et al.* 2003) substantially changes this estimate. Based on this count the world population is estimated as *c.* 70,000 (D. Watkins pers. comm.). In view of the lack of large numbers spending the non-breeding season anywhere in south-east Asia, Indonesia, the Philippines or New Guinea, it would appear that the entire world population of Oriental Plover resides during the palearctic winter in Australia. Such a revision of the known non-breeding range of this species clearly underscores the importance of Australia for this species together with the responsibilities it confers for this species' conservation management.

13. Red-kneed Dotterel *Erythrogenys cinctus*

Red-kneed Dotterel appears to be an infrequent and scarce visitor from Australia to New Guinea (Coates 1985; Bishop pers. obs.) (but see below). This species was first recorded in New Guinea when a single specimen was collected in the Kurik area just west of the Kumbe River, southern Trans-Fly (Papua) during April 1961 (Hoogerwerf 1964). There are no other published records of this species from Papua. Conversely, there are several records of this attractive species, invariably during July to December and usually in low numbers, in the Bensbach area of the PNG part of the Trans-Fly (Bishop unpubl; Finch 1980a; Stronach 1981). Hicks (1985) observed a group of ten near the Bensbach River on 16 November 1985 and possibly six additional birds at another nearby site. The only other locality in PNG at which this species has been recorded is Kanosia Lagoon near Port Moresby where Finch (1982b) recorded two birds on 10 July 1982. This species appears to be a regular dry season visitor in small numbers, but Finch (1980a) observed two adults with one immature at Bale (Bensbach area) during October 1980 and speculated that this species may breed within the Trans-Fly. There appear to be no data indicating that this species migrates between Australia and New Guinea (Marchant & Higgins 1993), despite the fact of it only having been recorded during the dry season perhaps lending some credence to Finch's (1980a) speculation this species is indeed locally resident in New Guinea.

14. Masked Lapwing ***Vanellus miles***

Masked Lapwing is widespread and locally common throughout the lowlands of New Guinea and the Aru Islands within suitable open country. Within the Papua part of the Trans-Fly, this species ranges from Pulau Kimaam and Pulau Komolom in the west (Bishop 2006) then eastwards to Lampusatu near Merauke (Bishop pers. obs.) and Wasur National Park where it is widespread and common (Bishop pers. obs.). Further to the north in the Trans-Fly, this species has also been recorded at the Bian Lakes (Papua) (Bishop pers. obs.). Within the PNG part of the Trans-Fly, Masked Lapwing is widespread and common throughout the Bensbach River area and Tonda WMA. On occasions large numbers of this species have been observed in these areas including a total of *c.* 2,000 in flocks of 10–20 during August 1992 (Bishop 2006). Halse *et al*. (1996) recorded totals of *c.* 3,259 in aerial surveys of the Middle Fly wetlands in December 1994 and *c.* 588 in April 1995.

Breeding of Masked Lapwing takes place throughout much of its range in New Guinea (Coates 1985). Within the Trans-Fly it has been found breeding in May 1960 at Pulau Kimaam (Mees 1962); November 1983 at Wasur National Park (Bishop pers. obs.); August 1988 at Bensbach River area (Field Guides Inc. in. litt.) and September 1936 near Lake Daviumbu (Rand 1942). In addition to a large breeding population in New Guinea, there appears to be strong circumstantial evidence to indicate that this species is a regular migrant from Australia, possibly in large numbers. Marchant & Higgins (1993) summarizes the movements of this species in Australia by stating that it is essentially resident and does not undergo large scale movements. Notwithstanding, this species clearly does have the capacity to move long distances including over water as evidenced by it recent colonization of such islands as Lord Howe Island and the Chatham Islands. Mayr (1941) stated "Most New Guinea birds, except in the south, were collected during the Australian winter and are obviously winter visitors." Furthermore, Coates (1985) thought that the occasional presence in New Guinea of the subspecies *novaehollandiae* which does not breed there and intermediates of *V. m. miles* and *V. m. novaehollandiae* is evidence that this species migrates from Australia to New Guinea. In addition the presence of this species on many islands in the Torres Strait but not breeding (Draffan *et al.* 1983) is also cited as evidence that this species migrates from Australia to New Guinea.

15. Latham's Snipe ***Gallinago hardwickii***

Latham's Snipe has been recorded for certainty (specimens) from New Guinea on only a handful of occasions. This species was first recorded from New Guinea on Mt Wilhelmina (Papua) at 3,550 m (Rand 1942b). Subsequently Latham's Snipe was collected by Gyldenstolpe at Nondugl in the Wahgi Valley (PNG) during September 1951 (Gyldenstolpe 1955) and Hoogerwerf (1964) collected two specimens from near Kurik on the south coast of Papua within the Trans-Fly in May 1961 and April 1962. There have been many sight records claiming to be of this species, especially from the Port Moresby area (Hicks 1990), but in view of the extreme difficulty of separating this species from Swinhoe's Snipe, these records are regarded as unacceptable.

In Australia Latham's Snipe is a widespread and locally abundant palearctic winter visitor throughout the eastern states and Tasmania.The global breeding population is estimated as *c.* 37,000 of which almost the entire population spends the northern winter in Australia (Higgins & Davies 1996). There are very few records of Latham's Snipe between the breeding grounds in Japan and its non-breeding grounds suggesting that this species flies directly from Japan to Australia. The complete lack of records in south-east Asia, the Greater Sundas, the Philippines and Wallacea (Robson 2000, MacKinnon & Phillipps 1993, van Marle & Voous 1988, Smythies & Davison 1999, Dickinson *et al*. 1991, Coates & Bishop 1997) emphatically underscores this point. However, the great difficulty of separating this species in the field from Swinhoe's Snipe may have resulted in Latham's Snipe being overlooked.

[Pintail Snipe ***Gallinago strenua*****]**

Coates (1985) noted that a third species of snipe, probably Pin-tailed Snipe, is occasionally observed in the Port Moresby area. There are however insufficient details to permit acceptance of this species to the New Guinea list. Nevertheless it is not unreasonable to expect this species to occur in New Guinea although a specimen or a live bird in the hand are the only realistically acceptable records. In Australia this species, despite the paucity of acceptable records alluded to in Higgins & Davies (1996), is increasingly reliably recorded (live capture for banding) in the north-west of the continent (Chris Hassell pers. comm.).

16. Swinhoe's Snipe ***Gallinago megala***

The relatively large number of specimens of Swinhoe's Snipe collected in New Guinea and its islands and the associated larger numbers of snipe observed with those collected indicates that this species is a regular and at times common winter visitor and passage migrant to New Guinea and its islands. This species typically occurs in small, loosely associated groups in areas of short moist grassland from near sea level to *c.* 3,720 m. Occasionally Swinhoe's Snipe occurs in large concentrations (assuming the identification is correct), see for example Rand (1942a,b) and Gyldenstolpe (1955). A remarkable concentration of 217 was reported from Lae airstrip (L. Silva in Coates 1985)

In Australia Swinhoe's Snipe is only known from a few definitive records (specimens or birds in the hand) with the great majority being from the Top End and eastern Kimberly areas (Higgins & Davies 1996). There is no estimate for the population in Australia. In south-east Asia this species is a rare to scarce northern winter visitor (Robson 2000); it has not been recorded in Sumatra but is presumed to have been overlooked (van Marle & Voous 1988); in Borneo Swinhoe's Snipe is an irregular migrant and non-breeding visitor in small numbers (Smythies & Davison 1999); in Java and Bali it is a regular northern winter visitor (MacKinnon & Phillipps 1993); in the Philippines it is a common passage migrant and northern winter visitor (Dickinson *et al*. 1991); and in Wallacea it is a locally common northern winter visitor (Coates & Bishop 1997). The relatively high numbers recorded in New Guinea together with neighbouring Philippines and Wallacea compared to those in Australia suggests that this species tends to winter largely just to the north and west of Australia and only occurs marginally in that continent. New Guinea may be an important winter quarters for this species.

17. New Guinea Woodcock *Scolopax rosenbergii*

It has recently been demonstrated that New Guinea Woodcock is a separate species from Javan Woodcock (previously Dusky Woodcock) *Scolopax saturata* (Kennedy *et al.* 2001). Consequently New Guinea Woodcock becomes a taxon endemic to the mountains of New Guinea. As with most members of the genus this species is poorly known. In part this is a consequence of its cryptic and nocturnal behaviour but also to the fact that it inhabits dense montane vegetation at high altitudes either difficult of access or rarely if ever visited by ornithologists.

New Guinea Woodcock ranges throughout the New Guinea mainland as follows (localities presented on an west to east axis). **Papua**: Tamrau Mountains; Arfak Mountains; Oranje Mountains; Mamberano; Ilaga Valley, Nassau Range – 2,440 to 2,740 m (Ripley 1964); Mt Wilhelmina, Lake Habbema, Snow Mountains; Bele River Camp, Bernard Camp 1,500 – 3,800 m (Rand 1942). **Papua New Guinea**: Central Mountains including Mt Wilhelm – 2,960 m (Mayr & Gilliard 1954), Mt Gilewe, Lamende Range, Wahgi Divide Mountains, and the Schrader Range east to the Owen Stanley Mountains: Mt Talfa – 2,400 m and Mt Albert-Edward – 3,680 m (Mayr & Rand 1937) of the south-east. This species inhabits dense montane forest and the margins of alpine grassland from 1,500 up to 3,800 m, mostly above 2,400 m. The nesting habits of this species are undescribed.

Birdlife International (2006d) summarizes the status of this species as follows: "This species has a large range, with an estimated global Extent of Occurrence of 100,000–1,000,000 km^2. The global population size has not been quantified, but the species is not believed to approach the thresholds for the population size criterion of the IUCN Red List (i.e. less than 10,000 mature individuals in conjunction with appropriate decline rates and subpopulation qualifiers). Global population trends have not been quantified, but the species is not believed to approach the thresholds for the population decline criterion of the IUCN Red List (i.e. declining more than 30% in ten years or three generations). For these reasons, the species is evaluated as Least Concern". On the basis of his field experience in New Guinea this author concurs with this evaluation.

18. Black-tailed Godwit *Limosa limosa melanuroides*

Coates (1985) summarises the status and distribution of Black-tailed Godwit as "A regular visitor to New Guinea." The majority of records of this species are from the south coast. In Papua this species has been recorded from Bintuni Bay (Erftemeijer *et al.* 1991) eastwards without intervening records to the Trans-Fly. Within the Trans-Fly, Black-tailed Godwit has been recorded from Pulau Kimaam with a maximum count of 1,000 at Rawa Cuwoon on 30 July 1988 (Sivius & Taufik 1989) and Pulau Komolom with maximum count of 60 on 30 September 1983 in the west (Bishop 2006); then eastwards without intervening records to the Kurik area. Hoogerwerf (1964) found this species very common on the beach between the Maro and Bian rivers from September to May. In April 1961 and April 1962, Hoogerwerf observed flocks comprising several thousands and recorded this species commonly during late May and as many as several hundreds on 17 June. A little further east, 122 Black-tailed Godwits were recorded at Lampusatu near Merauke on 12 December 1983 (Bishop 2006); small numbers have been recorded in nearby Wasur National Park with 75 recorded at Ongaya on 26 October 1983 (Bishop 2006).

In the PNG part of the Trans-Fly, Black-tailed Godwit has been recorded relatively frequently. D. Watkins (pers. comm.) recorded 200 on the mudflats at the southernmost point between Bulla and the Bensbach River mouth on 23 October 2001 and 40 near Bulla village on 24 October 2001. Further east, on 20 March 2000, 250 Black-tailed Godwits were counted in just one section of the huge Kikori Delta (R. Jaensch pers. comm.). Further east still on the south coast of PNG, Heron (1978) observed this species irregularly including ten records between 28 August and 21 November on mudflats and sandbanks at the mouth of the Angabunga River near Bereina. In the Port Moresby area Black-tailed Godwit is a common passage migrant with small numbers spending the northern winter at freshwater sites (Hicks 1990). Peak counts of 60 to 100 birds have been recorded during October and November (Coates 1995). The earliest date for Port Moresby is 11 July 1982 and the latest date for near to Port Moresby is 23 May 1986 (Hicks 1990). Elsewhere in PNG this species has been recorded near Madang on the north coast; Lae and New Britain (Coates 1985). On 25 August 1979 Bishop (unpubl.) recorded a group of *c.* 50 at the mouth of the Dhagi River on the north coast West New Britain Province.

The population of the subspecies *melanuroides* has recently been estimated at 160,000 individuals (Wetlands International 2006). Birdlife International (2006e) point out that population trends vary in different parts of its range. There have been large and well-documented declines in mainland Europe and in the species' Australian wetlands which hold *c.* 50% of the population of *L. l. melanuroides* in the non-breeding season. A recent analysis based on published literature, survey data and expert opinions from throughout the species' range suggests that, overall the global population may have declined at a rate approaching 30% over the last 15 years. As a consequence of these concerns and perceived declines, this species has now been classified as globally Near Threatened. Among Birdlife International's (2006e) conservation measures they encourage ensuring that migratory staging posts and northern winter feeding habitats and roosts are conserved and monitored. The large numbers of Black-tailed Godwits stopping over in New Guinea suggest that this is an important area for the conservation management of this species.

19. Bar-tailed Godwit *Limosa lapponica baueri*

Mayr (1941) stated that Bar-tailed Godwit was recorded from "all parts" of New Guinea. Conversely Coates (1985) summarizes the status and distribution of this species as "A regular but generally rather scarce visitor to the New Guinea area." The majority of records of this species are from the south coast. In Papua this species has been recorded from the Aru Islands (Mayr 1941) eastwards without intervening records to the Trans-Fly. Within the Trans-Fly Bar-tailed Godwit has been recorded from Pulau Kimaam (Hoogerwerf 1964) and Pulau Komolom (maximum count 70 on 30 September 1983) (Bishop 2006) in the west, then eastwards without intervening records to the Kurik area. Hoogerwerf (1964) found this species rather rare on the beach between the Kumbe and Bian rivers during September to May. A little further east 39 Bar-tailed Godwits were recorded at Lampusatu near Merauke on 24 November 1983 (Bishop 2006) and small numbers were recorded in nearby Wasur National Park with 160 recorded at Ongaya on 26 October 1983 (Bishop 2006).

In the PNG part of the Trans-Fly, this species has been recorded infrequently, D. Watkins (pers. comm.) recorded 50 on the mudflats at the southernmost point between Bulla and the Bensbach River mouth on 23 October 2001 and 20 near Bulla village on 24 October 2001. Further east, on 20 March 2000, 230 Bar-tailed Godwits were counted in just one section of the huge Kikori Delta (R. Jaensch pers. comm.). Still further east on the south coast of PNG, Heron (1978) observed this species frequently in (1–15) annually between 4 September and 5 June at the mouth of the Angabunga River near Bereina. In the Port Moresby area Bar-tailed Godwit is an uncommon passage migrant and winter visitor and occasionally recorded at freshwater sites. The earliest date for Port Moresby is 7 July 1988 and the latest date for near to Port Moresby is 19 May 1984 (Hicks 1990). Elsewhere in PNG this species has been recorded near Madang on the north coast, at Lae in the Huon Gulf, the Louisiade Archipelago, New Britain, and New Ireland (Coates 1985).

Australia supports an estimated palearctic winter population of 165,000 (Watkins 1993). Thus it would appear that the entire population of the subspecies *baueri* spends the palearctic winter in Australia. The relatively small numbers recorded in New Guinea suggest that Bar-tailed Godwit either over-flies New Guinea or is overlooked.

20. Little Whimbrel (a.k.a. Little Curlew) *Numenius minutus*

Mayr (1941) and Rand and Gilliard (1967) found very few records of Little Whimbrel for New Guinea. However, we now know that New Guinea, especially the southern Trans-Fly, supports a very large and likely globally important population of this species.

In Papua Little Whimbrel has been recorded from the Aru Islands (Mayr 1941); the Kebar Valley, Vogelkop and near Sorong (Hoogerwerf 1964); the Meren Glacier, Carstenz Mountains – a carcass was recovered at 4,450 m on 7 January 1972 (Schodde *et al.* 1975); and the southern Trans-Fly (Bishop 2006). Within the Trans-Fly this species ranges from Pulau Kimaam in the west (Silvius & Taufik 1989), eastwards to the Kurik area (Hoogerwerf 1964). At the latter site Hoogerwerf recorded this species during October 1959, October to December 1960, and April, May and June 1961. During 19 to 22 April 1961 Hoogerwerf (1964) recorded a maximum of 150–200 in one day. From September to December 1983 Bishop (2006; unpubl.) found this species widespread and common with hundreds, likely many thousands, of birds inhabiting the grasslands of Wasur National Park and surrounding areas. The following are sample counts made by this author during this period:

7 October	1983	120+ just east of Merauke
21 October	1983	600+ in the Yorr Plains area, Wasur Nat. Pk.
23 November	1983	Thousands in the damper areas of Memungal swamp complex.
18 November	1983	549 counted in the Yorr Plains, Wasur Nat. Pk. and many more in the surrounding area, possibly numbering in the thousands.
19 November	1983	Over 1900 counted in the Oukra area of Wasur Nat. Pk. and many more in the surrounding area, possibly numbering in the thousands.

Within the adjoining PNG part of the Trans-Fly, Finch (1980a) found Little Whimbrel "Exceedingly abundant throughout the area, probably tens of thousands of birds over the plains." "… But the plains of the south of the island of New Guinea must be a stopping-off place for virtually the world population of this species." During mid-October 1990 Bishop (unpubl.) also observed thousands of birds on the Bulla Plains and D. Watkins (pers. comm.), during the course of the International Wetlands Survey, recorded at least 2,500 in the grasslands and at small pools adjacent to the Bensbach River. Further, on 16 November 1985 Hicks (1985) observed *c.* 10,000 near the Bensbach River. This species appears to be uncommon or virtually absent in the southern Trans-Fly during July and August (Bishop pers. obs.). Further east Little Whimbrel has been recorded along the Fly River, within the Aramia wetlands, and northwards in the Middle Fly wetlands where small numbers were recorded (Halse *et al.* 1996). Heron (1978) found this species "fairly regular each year on airstrips, playing fields and cultivation paddocks in flocks (5–11) between 13 September and 10 November". In the Port Moresby area this species is an uncommon but regular passage migrant with most records in October and November with a few birds possibly staying over the palearctic winter. There is only one spring record. The earliest date in the Port Morsby area is 24 September 1978 and the latest date is 6 March 1967 (Hicks 1990). Elsewhere in PNG there are a handful of records from near Madang on the north coast and in the Baiyer Valley, Western Highlands Province. In West New Britain Province, Little Whimbrel occurs regularly in small numbers with a maximum count of seven in October 1978 on the Mosa Oil Palm Golf Course (Bishop unpubl.).

The above data demonstrate clearly that the grasslands of the southern Trans-Fly support a large, possibly very large, but as yet unknown proportion of the world's wintering Little Whimbrel. Discussions with various authorities, including D. Watkins (pers. comm.), suggest that the global population of this species may be in decline. There is therefore an urgent need to monitor this species' numbers in the Trans-Fly (and elsewhere) and to determine its distribution within the Trans-Fly and any other important sites in New Guinea. Birdlife International (2006f) summarizes the status and conservation of this species as follows: Little Whimbrel has a large range, with an estimated global Extent of Occurrence of 100,000–1,000,000 km². It has a large global population estimated to be 180,000 individuals (Wetlands International 2006). Global population trends have not been quantified, but the species is not believed to approach the thresholds for the population decline criterion of the IUCN Red List (i.e. declining more than 30% in ten years or three generations). For these reasons, the species is evaluated as Least Concern. In this author's opinion, and based on the above data, Little Whimbrel does approach those thresholds and should be classified as Near Threatened.

21. Whimbrel *Numenius phaeopus variegatus*

Whimbrel is common and widespread throughout New Guinea and its associated islands (Coates 1985, Bishop pers. obs.). This is arguably the most widespread shorebird occurring in New Guinea and this is evidenced by the fact that it has been recorded widely on the north coast and throughout the islands as well the south coast. Whimbrel is regularly recorded inland in the lowlands but rarely in upland areas but Bell (1970) recorded one at 1,500 m at Kosipi, near Woitape, Central Province. In the Port Moresby area, Hicks (1990) regarded it as a common, annual passage migrant and visitor in the northern winter. Small numbers regularly occur over the northern summer; a high proportion of Papua New Guinea Bird Society records (23%) refer to these birds, which makes it difficult to determine earliest and latest dates for this species. Flocks of as many as 150 birds have been observed in April near Port Moresby (Coates 1985) and 200 on the mudflats at the southernmost point between Bulla and Bensbach River mouths in the southern Trans-Fly (D. Watkins pers. comm.). However, a count of 1,050 (Bishop unpubl.) together with other shorebirds on Pulau Komolom (Papua) on 30 September 1983 eclipses this count. Birds almost certainly belonging to this species were observed on the valley floor of the Carstenz Mountains (Papua) at 3,600 m to 3,950 m (Schodde *et al.* 1975).

In Australia Whimbrel has an estimated population of *c.* 10,000 (Watkins 1983) and it is regarded as a regular visitor, more common in the north. In south-east Asia, the Greater Sundas, the Philippines and Wallacea this species is a common winter visitor and passage migrant (Robson 2000, MacKinnon & Phillipps 1993, van Marle & Voous 1988, Smythies & Davison 1999, Dickinson *et al.* 1991, and Coates & Bishop 1997).

From these data it would appear that a substantial proportion of the palearctic winter population of the subspecies *variegatus* resides in New Guinea and Australia with smaller populations in south-east Asia, Wallacea and northern Melanesia.

22. Bristle-thighed Curlew *Numenius tahitensis*

Bristle-thighed Curlew breeds only on the tundra of western Alaska (A.O.U. 1998). It migrates to winter on islands in the Pacific from north-west Hawaii south-east to Ducie Island. The main wintering range extends from Midway Island in the north-west Hawaiian Islands south-east to the atolls in the Marquesas, Tuamotu and Society groups in Polynesia. Further west, it becomes scarcer but still occurs regularly in eastern Micronesia, including Samoa, Tonga, Fiji, the Marshall Islands and New Caledonia. Its occurrence is casual in western Micronesia including Mariana and Caroline Islands and Yap (Higgins & Davies 1996). There are a handful of records of Bristle-thighed Curlew from the Solomon Islands (Kennerley & Bishop 2001).

The main wintering range therefore lies well to the east of New Guinea with the nearest regular wintering birds occurring about 2,000 km away. This species becomes increasingly uncommon further west in its winter range and the only accepted records, to date, for this species in the Australasian region are of three single birds in the Kermadec Islands (Higgins & Davies 1996). The sole record of this species for the New Guinea region is that of a single immature bird observed on the airstrip of Manus Island in the Admiralty Islands, PNG on 13 August 2000 (Kennerley and Bishop 2001). The occurrence of Bristle-thighed Curlew on Manus in the Admiralty Islands, Papua New Guinea, while surprising, is not entirely unexpected (Coates 1985). It remains to be seen whether regular observations on Papua New Guinea's outlying islands show that the species occurs regularly in the region (Kennerley and Bishop 2001).

23. Far Eastern Curlew *Numenius madagascariensis*

Coates (1985) summarizes the status and distribution of Far Eastern Curlew as "An uncommon but regular visitor to New Guinea." with the vast majority of records from the south coast. In Papua this species has been recorded from the Aru Islands (Diamond & Bishop 1994) in the west, eastwards along the south coast to the mouth of the Mimika River (Mayr 1941). In the Trans-Fly, Far Eastern Curlew has been recorded from Pulau Kimaam and Pulau Komolom (maximum count 122 on 30 September 1983) in the west (Bishop 2006), then eastwards without intervening records to the Kurik area where Hoogerwerf (1964) found it "quite common" on the beach between the Kumbe and Bian rivers. A little further east this species has been recorded regularly at Lampusatu (maximum count 61 on 26 November 1983), near Merauke (Bishop 2006), and in Wasur National Park (Bishop 2006).

In the PNG part of the Trans-Fly this species has been recorded infrequently although 350 (D. Watkins pers. comm.) on the mudflats at the southernmost point between Bulla and the Bensbach River mouth on 23 October 2001 is one of the largest flocks recorded in New Guinea. Finch (1980a) recorded 20 on the "tidal flats at the Fourth Beach" in October 1980. On 24 October 2001, D. Watkins (pers. comm.) observed a roost of 39 curlews near Bulla village. Small numbers of Far Eastern Curlew have been recorded on inter-tidal mudflats at Daru Island (Bishop pers. obs.). Further to the east, on 20 March 2000 a total of 343 were counted in just one section of the huge Kikori Delta (R. Jaensch pers. comm.). Further east still on the south coast of PNG, Heron (1978) observed this species fairly regularly in ones, twos and small groups (3–11) on mudflats and sandbanks at the mouth of the Angabunga River near Bereina in most years between 26 August and 21 December. In the Port Moresby area Far Eastern Curlew is an uncommon but regular passage migrant (most records from October to March) with small numbers staying over the northern winter (Hicks 1990). There is one record of a bird remaining during the austral summer. On 12 March 1967, Coates (1985) made an exceptional observation of a flock of *c.* 500 on mud-flats at Bootless Bay near Port Moresby. The earliest date for Port Moresby is 19 August 1969 and the latest date for near to Port Moresby (Angabunga River) is 18 April 1976 (Hicks 1990). One bird banded on 29 January 1977 in Newcastle, New South Wales, Australia was recovered on 16 April 1977 at Marshall Lagoon, Central Province (Coates 1985). Elsewhere in PNG this species has been recorded on Long Island (Diamond 1976) and in the Huon Gulf (Coates 1985). In the islands this species has been recorded from Manus Island in the Admiralty Archipelago and New Ireland (Coates 1985). A group of seven at the mouth of the Dhagi River, on the north coast of West New Britain Province during August 1979 (Bishop unpubl.) appears to be the first record of this species for West New Britain.

Birdlife International (2006g) summarizes the status and conservation of Far Eastern Curlew as having an estimated Extent of Occurrence of 1,000,000–10,000,000 km^2. Potential future threats are habitat loss, hunting and a decrease in the availability of food because of pollution, and additionally females appear to migrate further south, to the more threatened southern Australian wetlands. It has a large global population estimated to be 38,000 individuals. There appears to be no population decline on mainland Australia, but regular counts of the marginal wintering population of Tasmania suggest a decline of over 65% since the 1950s (Reid and Park 2003). However, the species is not believed to approach the thresholds for the population decline criterion of the IUCN Red List (i.e. declining more than 30% in ten years or three generations). For these reasons, the species is evaluated as Least Concern.

The data presented here and in the appendix suggest that New Guinea supports important numbers of Far Eastern Curlew on passage to Australia. In view of this species' decline in southern Australia, it is perhaps more important than ever to determine just how important New Guinea is for this species and to identify the most important sites for this species. Already it is clear that the south coast of the Trans-Fly, the Kikori Delta and possibly Bootless Bay, are key sites and there is a need to establish a mechanism to protect these sites.

24. Common Redshank *Tringa tetanus*

Common Redshank appears to be only a vagrant to New Guinea with just one acceptable record of a single bird at the Waigani Sewerage Ponds (PNG) on 7 October 1972 (Coates 1972b). In Australia, this species is a regular palearctic winter visitor and is probably more common than records suggest (Higgins & Davies 1996). In south-east Asia, Common Redshank is a common winter visitor and passage migrant (Robson); in the Greater Sundas it is a locally common to abundant winter visitor (van Marle & Voous 1988, Smythies & Davison 1999, MacKinnon & Phillipps 1993); in the Philippines this species is an uncommon winter visitor (Dickinson *et al*. 1991); and in Wallacea it is a regular winter visitor in small numbers (Coates & Bishop 1997). In view of the number of records in neighbouring regions, Common Redshank would appear to be overlooked and consequently under-recorded in New Guinea.

25. Marsh Sandpiper *Tringa stagnatilis*

Coates (1985) summarizes Marsh Sandpiper as "Regular and locally fairly common in New Guinea where it is recorded from widely scattered localities in the south and east. This species was first recorded for New Guinea on 13 April 1962 (Hoogerwerf 1964) when a solitary bird was seen in an inundated rice-field in the Kurik area. Subsequently Hoogerwerf (1964) regularly observed small numbers of this species throughout the remainder of April and until 8 May. Hoogerwerf supported his observations with specimens. Elsewhere in Papua, Marsh Sandpiper has been recorded in the Aru Islands at Woda Woda on 29 March 1988 (Diamond & Bishop 1994). In the Trans-Fly, Marsh Sandpiper has been recorded from Pulau Kimaam - 20 at Rawa Dambuwan on 18 July 1988 (Silvius & Taufik 1989), Pulau Komolom - 28 on 30 September 1983 (Bishop unpubl.) in the west, and then eastwards without intervening records to the Kurik area (see above). A little further east this species has been recorded at Lampusatu near Merauke (Bishop unpubl.) and nearby Wasur National Park.

In the PNG part of the Trans-Fly, Marsh Sandpiper has been recorded widely in the Bensbach River and Bulla Plains area, usually in small scattered groups (Finch 1980a, Bishop unpubl., R. Jaensch pers. comm.). By far the highest count was of 173 at Waku Swamp in the Bensbach area in August 1999 (R. Jaensch pers. comm.). In PNG this species has also been observed in the Middle Fly wetlands (Halse *et al.* 1996); the Kikori Delta (10 on 20 March 2000); and the Bereina area where Heron (1978) found it rather rare with just four records of single birds and small groups (2–13) between 11 September and 12 November. In the Port Moresby area this species is regarded as a common passage migrant with small numbers staying over the palearctic winter (Hicks 1990). The earliest date for the Port Moresby area is 26 June 1982 and the latest date is 23 May 1986 (Hicks 1990). The records during June and July in the Port Moresby and the southern Trans-Fly (see above) suggest that a relatively large number of individuals remains in New Guinea during the austral winter. Finch *et al.* (1982) provide further evidence of this with an observation of *c.* 230 in the Bensbach area on 17 July 1982. Elsewhere in PNG this species is recorded from a handful of other localities (Coates 1985). Small numbers (1–3) were occasionally observed along the north coast of West New Britain Province during 1979 -1980 (Bishop in prep.); these appear to be the first records of this species for the Bismarck Archipelago.

The estimated Australian population of Marsh Sandpiper is *c.* 9,000 (Watkins 1983) and it is regarded as a widespread and regular visitor in the palearctic winter, more common on the north coast and eastern half of the continent. In south-east Asia and Sumatra and Borneo in the Greater Sundas, it is a common winter visitor and passage migrant (Robson 2000, van Marle & Voous 1988, Smythies & Davison 1999). In Java, Bali and the Philippines it is an uncommon winter visitor and passage migrant (MacKinnon & Phillipps 1993, Dickinson *et al.* 1991), and in Wallacea this species is a regular winter visitor and locally common in Sulawesi (Coates & Bishop 1997).

It is unclear from the above data exactly what the status of this species is in New Guinea. Nevertheless it is clear that at the very least New Guinea is an important staging site for this species and it may support an unusually large number of birds during the austral winter

26. Common Greenshank *Tringa nebularia*

Common Greenshank is a widespread and moderately common palearctic winter visitor and passage migrant with most records being from the south coast. In Papua this species has been recorded from the Aru Islands (Mayr 1941, Diamond & Bishop unpubl.); Bintuni Bay (Erftemeijer *et al*. 1991); Pulau Adi (Gyldenstolpe 1955); and Wissel Lakes region (Junge 1953). In the Trans-Fly, Common Greenshank has been recorded from Pulau Kimaam – many during late May 1959 (Hoogerwerf 1964), 130 at Rawa Dembuwan on 18 July 1988 (Silvius & Taufik 1989) in the west then eastwards to the Kurik area where Hoogerwerf (1964) found it common in small groups along the coast between the Kumbe and Bian rivers and inland in fallow rice-fields. Hoogerwerf (1964) found this species unusually common during the austral winter. Further east, low numbers (maxima 35 on 4 November 1983) were regularly recorded at Lampusatu (Bishop unpubl.) and in nearby Wasur National Park where 120 were recorded at Ongaya on 26 September 1983.

In the PNG part of the Trans-Fly Common Greenshank is widespread and moderately common in the Bensbach River and Tonda WMA areas with a maximum count of 90 on the mudflats at the southernmost point between Bulla and the Bensbach River mouth on 23 October 2001 (D. Watkins pers. comm.); further east this species has been recorded at Daru Island (Bishop pers. obs.) and in the Aramia wetlands (Bell 1967). In the northern Trans-Fly this species has been recorded in the Middle Fly wetlands (Halse *et al*. 1996) but not in the nearby Bian Lakes of Papua. On 20 March 2000, 130 Common Greenshank were observed in just a small section of the huge Kikori Delta (R. Jaensch pers. comm.). Heron (1978) found this species regular in small numbers (1–5) annually between 22 August and 30 December. In the Port Moresby area it is an uncommon passage migrant, only rarely staying over the northern winter. Very few have been recorded on northward passage and there is only one record of an individual remaining during the austral winter. The earliest date for the Port Moresby area is 18 July 1986 and the latest date is 7 May 1986 (Hicks 1990). Common Greenshank has been recorded at handful of other localities in PNG including Amazon Bay (Bell 1970), Higaturu near Popondetta (Mordue 1981), and the north coast of West New Britain Province (Bishop in prep.).

The estimated Australian population of Common Greenshank is *c.* 20,000 (Watkins 1983) and it is regarded as the most widespread scolopacid palearctic winter visitor. In south-east Asia it is a fairly common to common winter visitor and passage migrant (Robson 2000); in the Greater Sundas and the Philippines it is an uncommon winter visitor and passage migrant (van Marle & Voous 1988, MacKinnon & Phillipps 1993, Dickinson *et al*. 1991). On Borneo however it is a locally common winter visitor (Smythies & Davison 1999) and is a regular but sparsely distributed winter visitor in Wallacea (Coates & Bishop 1997).

From the above data it would appear that New Guinea is an important staging post for Common Greenshank on both southward and northward migration. Numbers on northward migration appear to be most abundant on the south coast of the Trans-Fly.

[Green Sandpiper *Tringa ochropus*]

Green Sandpiper is known from New Guinea on the basis of a single observation by one observer near the town of Manokwari on the north coast of the Vogelkop, Papua. On 11 January 1963, Hoogerwerf (1964) observed a single bird together with a handful of other shorebirds at a small freshwater pool quite close to Rendani airstrip. Hoogerwerf's description is notably brief, "The call of the bird and the dark coloured inner wing, together with its clear white rump, were characters which were superfluous affirmations of its identification." Despite this record being perpetually cited in the literature (see Coates 1990, Higgins & Davies 1996), the lack of supporting evidence of this observation make this record unacceptable.

27. Wood Sandpiper *Tringa glareola*

Wood Sandpiper is a regular and locally moderately common palearctic winter visitor and passage migrant to New Guinea. In Papua this species has been recorded from Waigeu Island (Mayr 1941), near Sorong and Manokwari (Hoogerwerf 1964), the Mimika River (Mayr 1941), at 1,735 m in the Wissel Lakes area during March (Melville 1980), and within the Trans-Fly from Pulau Kimmam and Pulau Komolom in the west, then eastwards without intervening records to the Kurik area. Here Hoogerwerf (1964) found it to be a regular visitor to the rice-fields with flocks of 10–20 during March and April and he obtained several specimens. Surprisingly there are no records from the Merauke area or nearby Wasur National Park. In the PNG part of the Trans-Fly Wood Sandpiper is recorded from notably few records including six in the Bensbach River area on 26 December 1991 (Finch 1982c), two at Goose Swamp on 20 October 1998, and three at the mouth of the Morehead River also on 20 October 1998 (R. Jaensch pers. comm.). This species has been recorded in the Middle Fly wetlands (Halse *et al*. 1996). There were no records to the eastwards until Heron (1978) observed one on a freshwater marsh behind the dunes at Aviara near Bereina on 5 November 1977.

In the Port Moresby area Wood Sandpiper is a common passage migrant, with few staying over the northern winter. It is common on southwards migration with the first birds usually seen from mid-August to early September. It is rare on northwards migration. The earliest date for the Port Moresby area is 16 August 1978 and the latest date is 10 April 1983 (Hicks 1990). This species has also been recorded in the Madang area and at Higaturu near Popondetta in Northern Province (Mordue 1981b). Interestingly there is just one record from the Bismarck Archipelago, two birds on Lake Dakatua on the north coast of West New Britain an 17 December 1997 (Dutson 2001).

In Australia Wood Sandpiper is a widespread palearctic winter visitor throughout the continent but most common in the north-west; with an estimated population of 6,000 (Watkins 1983, Higgins & Davies 1996). In south-east Asia this species is an uncommon to common winter visitor and passage migrant (Robson 2000); in the Greater Sundas it is a common and widespread winter visitor and passage migrant (MacKinnon & Phillipps 1993, van Marle & Voous 1988). In the Philippines Wood Sandpiper is a common palearctic winter visitor and passage migrant (Dickinson *et al*. 1991) and in Wallacea it is common to abundant palearctic winter visitor (Coates & Bishop 1997). The steady accumulation of records throughout New Guinea suggests this species has been, and continues to be, overlooked and is in fact locally common in suitable habitat as suggested by Hoogerwerf's observations on the southern Trans-Fly.

28. Terek Sandpiper *Xenus cinerea*

Terek Sandpiper is widely distributed and moderately common to locally very common throughout much of New Guinea, especially the south coast and its islands. This species typically inhabits inter-tidal mudflats and ocean beaches and less frequently freshwater swamps and areas of short grassy areas near the coast (Coates 1985, Bishop pers. obs.). In Papua this species has been recorded from the Aru Islands – mouth of the river near Salerem on 9 April 1988 (Diamond & Bishop 1994); Bintuni Bay (Erftemeijer *et al.* 1991); Wanggar and the Mimika River (Mayr 1941; and in the Trans-Fly from Pulau Kimaam and Pulau Komolom (maximum count 90 on 30 September 1983) (Bishop 2006) in the west; and then eastwards without intervening records to the Merauke area with counts at Lampusatu of 228 on 4 November 1983 and 190 on 22 December 1983 (Bishop 2006). A short distance to the east at Ongaya at the periphery of Wasur National Park a total of 360 were recorded on 26 October 1983 (Bishop unpubl.).

In the PNG part of the Trans-Fly, 100 were recorded on the mudflats at the southernmost point between Bulla and Bensbach river mouths on 23 October 2001 (D. Watkins pers. comm.) and 200 near Bulla Village on 24 October 2001 (D. Watkins pers. comm.). Finch (1980a) recorded 100 on the tidal flats at the fourth beach during October 1980; small numbers have been recorded on Daru Island (Bishop pers. obs.); and then no other records east to the Kikori Delta where R. Jaensch (pers. comm.) recorded an impressive 1,015 Terek Sandpipers on 20 March 2000 in just one section of this important site. Heron (1978) observed this species regularly in pairs and small groups (3–12) annually from 23 July to 30 April in the Bereina area. In the Port Moresby area Hicks (1990) summarised this species as an uncommon passage migrant with single birds staying over the austral winter. This species has occasionally been recorded during the austral summer. The earliest date for Port Moresby is 7 September 1980 and the latest date 13 May 1987 (Hicks 1990). Terek Sandpiper has been widely and regularly recorded in PNG's islands including Ferguson Island, New Britain and New Ireland (Coates 1985, Bishop unpubl.).

In Australia Terek Sandpiper is widespread and generally common along the northern and eastern coasts (Higgins & Davies 1996) and has an estimated population of 18,000 (Watkins 1993). In south-east Asia this species is an uncommon to fairly common coastal northern winter visitor and passage migrant (Robson 2000); in the Greater Sundas it is a common coastal northern winter visitor with large numbers recorded locally in Sumatra (MacKinnon & Phillipps 1993); in the Philippines it is an uncommon passage migrant and northern winter visitor (Dickinson *et al*. 1991); and in Wallacea it is a generally scarce northern winter visitor and passage migrant (Coates & Bishop 1997). The numbers counted at just a few sites in New Guinea strongly suggests that a large proportion of the Australian population stops over in New Guinea before on both southward and northward migrations.

29. Common Sandpiper *Actitis hypoleucos*

Common Sandpiper is a widespread and common palearctic winter visitor throughout the entire island of New Guinea and its associated islands. It ranges from sea level to *c.* 3,500 m (Bishop pers. obs.) and inhabits the widest variety of habitats of any New Guinea shorebird. It occurs mostly in ones and twos but occasionally in groups of as many as 30. A roost of 50–100 Common Sandpipers was located near the mouth of the Dhagi River on the north coast of West New Britain between September and December 1979 (Bishop unpubl.). Small numbers of this species regularly remain in New Guinea during the austral winter. In the Port Moresby area, Common Sandpiper is an abundant winter visitor and passage migrant. It has been recorded in all months except June. The earliest date for the Port Moresby area is 7 July 1981 and the latest date is 9 May 1986 (Hicks 1990).

In Australia Common Sandpiper is a common and widespread species in both coastal and inland areas; with an estimated population of 3,000 (Watkins 1983). In south-east Asia, the Greater Sundas, the Philippine and Wallacea this species is a common winter visitor and passage migrant (Robson 2000, van Marle & Voous 1988, Smythies & Davison 1999, MacKinnon & Phillipps 1993, Dickinson *et al*. 1991, Coates & Bishop 1997).

30. Grey-tailed Tattler *Heteroscelus brevipes*

Grey-tailed Tattler is a common and widespread palearctic winter visitor and passage migrant throughout coastal areas of New Guinea and its islands. Very occasionally this species is recorded inland and it has been recorded to elevations as high as 1,100 m (Watson *et al*. 1962). Unlike most species Grey-tailed Tattler is notably uncommon and infrequently recorded in the southern Trans-Fly with a group of 20 on the mudflats at the southern most point between Bulla and Bensbach River mouth on 23 October 2001 (D. Watkins pers. comm.) being a rare congregation. In the Port

Moresby area this species is an uncommon to common passage migrant and visitor in the northern winter, but is probably under-recorded. The earliest date for the Port Moresby area is 7 August 1988 and the latest date is 20 May 1988 (Hicks 1990).

In Australia Grey-tailed Tattler is a widespread and common palearctic winter migrant to almost the entire coastline and has an estimated population of 36,000 Watkins 1993). In south-east Asia and the Greater Sundas this species is a rare to uncommon passage migrant and local winter migrant (Robson 2000, MacKinnon & Phillipps 1993). There are no records from Sumatra (van Marle & Voous 1988), however, this species is a moderately common visitor in Borneo during the palearctic winter and as a passage migrant (Smythies & Davison 1999). In the Philippines and Wallacea Grey-tailed Tattler is a common passage migrant and winter visitor (Dickinson *et al*. 1991, Coates & Bishop 1997).

31. Wandering Tattler *Heteroscelus incanus*

Wandering Tattler is a regular palearctic-winter visitor to New Guinea although there are very few records from Papua and possibly none from the Papua mainland. This species migrates across the Pacific and as a consequence is found predominantly on the eastern side of New Guinea where it is characteristically found on PNG's islands and islets especially in the Bismarck Archipelago. However, the similarity in identification of this species with Grey-tailed Tattler, except for their distinctive calls, often results in confusion and as a consequence this species may be overlooked. In the Port Moresby area, one of the few sites on the south side of New Guinea for which this species has been reliably recorded (Bishop pers. obs., Hicks 1990), Wandering Tattler is a rare but probably regular passage migrant. Most records are in spring, probably because this species is then often seen in its diagnostic breeding dress (Hicks 1990).

In Australia Wandering Tattler is generally uncommon but difficult to distinguish from Grey-tailed Tattler and consequently is overlooked and it is therefore difficult to estimate its population (Higgins & Davies 1996). Not surprisingly there are no records of this species anywhere in south-east Asia, the Greater Sundas, the Philippine and Wallacea (Robson 2000, van Marle & Voous 1988, Smythies & Davison 1999, MacKinnon & Phillipps 1993, Dickinson *et al*. 1991, Coates & Bishop 1997). Eastern New Guinea, in particular the Bismarck Archipelago, and the east coast of Australia form the western margins of this species palearctic winter range. Confirmation of the importance to this species of the islands of the Bismarck Archipelago is desirable.

32. Ruddy Turnstone *Arenaria interpres interpres*

Ruddy Turnstone is a widespread and common palearctic winter visitor and passage migrant throughout the coastal areas of New Guinea and its islands. Whilst this species characteristically prefers rocky and stony beaches, in New Guinea it is often found with other shorebirds on ocean beaches and inter-tidal mudflats and sand-flats. In the Port Moresby area it is an uncommon passage migrant and rare winter visitor to coastal sites. It has occasionally been found during the austral winter despite there being no March to May records for this area. The earliest date for the Port Moresby area is 16 August 1987 and the latest date is February 1979 (Hicks 1990).

In Australia Ruddy Turnstone is widespread round most of coastal mainland including offshore islands with an estimated population of 14,000 (Watkins 1993). In south-east Asia, the Greater Sundas and the Philippines this species is a scarce to fairly common passage migrant and winter visitor (Robson 2000, van Marle & Voous 1988, Smythies & Davison 1999, MacKinnon & Phillipps 1993, Dickinson *et al*. 1991). In Wallacea Ruddy Turnstone is a locally common passage migrant but winter records are lacking (Coates & Bishop 1997).

33. Asian Dowitcher *Limnodromus semipalmatus*

Asian Dowitcher was first recorded for New Guinea on 20 September 1976 and again on 25 and 26 September and 2 and 3 October close to the mouth of the Angabunga River near Bereina, Central Province (PNG) (Heron 1977). The second record was of a single bird on 8th November 1981 at Moitaka Settling Ponds near Port Moresby (PNG) (Finch 1981). The latter bird remained at Moitaka until at least 21 November. Both records are supported by acceptable descriptions. A third record for 8–12 November 1989 is listed without any supporting details (Eastwood 1989). The sole record for Papua appears to be of a single bird observed together with other shorebirds on the beach of Wasur National Park within the Trans-Fly on 16 September 1992 (Bostock 2000). There are no supporting details for this record. On 20 March 2000, R. Jaensch (pers. comm.) found a total of four birds together with large numbers of other shorebirds on sandy spits and islets within the Kikori Delta on the south coast of PNG. In Australia Asian Dowitcher is a regular visitor in small numbers largely to the north-west of the continent (Higgins & Davies 1996). The main wintering grounds for this species appear to be in east Sumatra and north-east Java with just small numbers moving eastwards and south through Wallacea (Coates & Bishop 1987). The small numbers recorded in both New Guinea and Australia indicate that Asian Dowitcher occurs only marginally in the region. Notwithstanding, it is the opinion of the author that this species is likely overlooked in the hundreds of kilometres of suitable and largely unsurveyed coastal habitat that characterize the shores of New Guinea especially in the south.

Birdlife International (2006h) summarizes the status and conservation of Asian Dowitcher as being particularly vulnerable to habitat loss, hunting, pollution and other pressures on both the breeding and non-breeding grounds. Birdlife International estimates this species global population at 23,000 individuals. In view of the small population size and general conservation concerns it is classified as Near Threatened.

34. Long-billed Dowitcher *Limnodromus scolopaceus*

Long-billed Dowitcher is recorded from New Guinea on the basis of one well documented record (Anon 1984). On 2 December 1984 a single bird was observed at Aroa Lagoon, Central Province. This would appear to be the only acceptably documented record of this species in Australasia. There is one well documented record in India (Holt 1999) and it is regarded as a vagrant in south-east Asia, Borneo and Bali (Robson 2000, MacKinnon & Phillipps 1993).

35. Great Knot *Calidris tenuirostris*

Great Knot is a widespread and locally common palearctic winter visitor to New Guinea. In Papua this species has been recorded from the Boemi River on the north coast where Melville (1980) observed *c.* 15 on 8 April 1976. In the southern Trans-Fly, 70 were observed on 30 September 1983 (Bishop unpubl.) at Pulau Komolom in the west, then eastwards to the coast between the Kumbe and Bian rivers (Hoogerwerf 1964). The latter author observed Great Knot in "enormous flocks" of many thousands during November, February, March and April from 1959 to 1962. Hoogerwerf's observations are supported by at least 13 specimens. A little further east this species has been regularly observed in good numbers at Lampusatu near Merauke with a peak count of 154 on 4 November 1983 (Bishop unpubl.). In the PNG part of the southern Trans-Fly, Great Knot has been recorded in large numbers in the Bensbach River area with counts of *c.* 1000 on the mudflats at the southern most point between Bulla and Bensbach River mouths on 23 October 2001 (D. Watkins pers. comm.) and 800 on the Bulla Plains on 24 October 2001 (D. Watkins pers. comm.). Further east in just one section of the huge Kikori Delta 552 were counted on 20 March 2000 (R. Jaensch pers. comm.). In the Port Moresby area Great Knot is a rare passage migrant, only recorded on southward passage. The earliest date for Port Moresby is 9 September 1978 and the latest date 18 January 1986 (Hicks 1990) .

Great Knot is "One of the most abundant shorebirds in Australia though considered rare, endangered or uncommon till 1979" (Higgins & Davies 1996). Currently Australia supports an estimated population of 270,000 (Watkins 1993) which represents 70% of the entire world population. In south-east Asia this species is a rare to uncommon passage migrant (Robson 2000) and in the Greater Sundas, the Philippine and Wallacea it is a scarce to uncommon winter visitor and passage migrant (van Marle & Voous 1988, Smythies & Davison 1999, MacKinnon & Phillipps 1993, Dickinson *et al*. 1991, Coates & Bishop 1997).

The above data indicate that the majority of Great Knot flies directly from eastern China and Japan direct to New Guinea or Australia. The large numbers recorded in New Guinea almost certainly reflect the very large numbers that spend the northern winter in Australia but it is not clear what percentage of these birds remains in New Guinea throughout the palearctic winter. Clearly New Guinea is an important site for this species.

36. Red Knot *Calidris canutus rogersi*

Red Knot is something of an enigma in New Guinea. This species was not listed by Mayr (1941) or Rand and Gilliard (1967). Conversely this species is characteristically widespread in Australia throughout coastal regions. Red Knot was first recorded in New Guinea between October 1961 and May 1962 during which time Hoogerwerf (1964) found it to be a regular visitor to the beaches between the Kumbe and Bian Rivers on the south coast of the Trans-Fly (Papua). On 5 April 1962 Hoogerwerf (1964) observed large flocks containing 3,000–5,000 Great Knot, Red Knot and Black-tailed Godwit. Confirmation of the identification of all three species in this flock is provided by a collection of 22 specimens obtained by the author. Large flocks were also observed at the same site on 10 April and 15 April 1962. Numbers declined towards the end of April although a flock of 150 were observed on 28 April. Hoogerwerf (1964) noted that the species was most numerous during October and November and March and April. During December to February Red Knot were less common and sometimes absent although possibly overlooked. On 8 April 1976, three birds in partial breeding plumage were seen on the Boemi River on the north coast (Melvile 1980). On 23 November 1983 Bishop (unpubl.) observed two Red Knot together with other shorebirds on mudflats near Ongaya, adjacent to the western end of Wasur National Park (Papua). The only other record of this species from Papua appears to be that of Bostock (2000) who on 16 September 1992 observed a single bird together with other shorebirds on mudflats also adjacent to Wasur National Park. It is likely that Bishop, in the course of his surveys in the southern Trans-Fly of Papua, overlooked this species. For example during a brief survey along the beaches west of Meruake and the Maro River, large numbers of Great Knot and godwits were observed but owing to circumstances careful scrutiny was not possible. In PNG this species is known from just three records: two on mudflats near the mouth of the Angabanga River on 17 September 1976 (Heron 1976); two at the same site on 23 Octopber 1977 (Heron 1978); and one on a sub-coastal lagoon at Hisui, Central Province, near Port Moresby, November (1982).

In Australia Red Knot is widespread throughout coastal areas and locally inland (Higgins & Davies 1996) and it has an estimated population of 153,000 (Watkins 1993). In south-east Asia this species is a scarce to uncommon coastal passage migrant (Robson 2000); in the Greater Sundas there are very few records for Sumatra and it is a rare passage migrant in Java (van Marle & Voous 1988, MacKinnon & Phillipps 1993); in Borneo it is a passage migrant and northern winter visitor to all the coastline but is particularly scarce in Kalimantan (Smythies & Davison 1999); in the Philippines it is a rare passage migrant and northern winter visitor (Dickinson *et al*. 1991); and in Wallacea it is a rare to uncommon passage migrant and possible northern winter visitor (Coates & Bishop 1997).

In view of the impressive numbers of this species recorded by Hoogerwerf (1964) in New Guinea and the large numbers regularly observed in Australia it is remarkable that there are so few other records of Red Knot from anywhere else in New Guinea. There are, however, extensive areas of suitable habitat that have never been surveyed, especially along the south coast of Papua, and consequently it is almost certain that this species is under-recorded in New Guinea. It is also interesting to note that relatively large numbers of this species have been observed in spring on northward passage when numbers of most other shorebird species in New Guinea are generally sparse.

37. Sanderling *Calidris alba*

Sanderling is a rather infrequently and sparsely recorded palearctic-winter visitor and/or passage migrant to New Guinea (Coates 1985, Bishop pers. obs.). It was not listed by Mayr (1941) and Rand and Gilliard (1997). This species was first recorded from New Guinea by van den Assem (1960) on 16 February 1959 near Merauke (Papua). Hoogerwerf (1964) subsequently observed this species only on "rare occasions" on the beach between the Kumbe and Bian rivers. Hoogerwerf (1964) remarked though that he may have overlooked this species. Hoogerwerf's (1964) record is supported by a specimen he collected on 27 November 1960. During Bishop's survey on 30 September 1983 in the Pulau Kimaam area, just a single bird was observed at the periphery of a large flock of shorebirds congregating on Pulau Komolom. Subsequently, on 4 November 1983 a total of ten Sanderling was counted at Lampusatu near Merauke (Bishop unpubl.). This species was also recorded by Bishop (unpubl.) on several occasions in Wasur National Park. There appear to be no other reports of this species from elsewhere in Papua. Consequently this species is currently only known from the Trans-Fly within Papua. Interestingly Sanderling has not yet been recorded in the PNG part of the southern Trans-Fly. In fact there are very few records from anywhere in PNG. Nevertheless, Heron (1978) found this species fairly regular but scarce near Bereina. In most years, Heron (1978) noted small parties (3–4) ten times between 7 October and 21 November and from 5 March to 9 April. Finch (1979) observed one bird at Hisiu Beach on 4 November in the same locality where up to three birds were present at the beginning of the year. Hick (1990) regarded this species as a rare and irregular winter visitor to the beaches in the Port Moresby area. The earliest record for the Port Moresby area is 19 September 1987 and the latest date for this area is 20 March 1982. There are no records of this species from the islands.

In Australia Sanderling is widespread but sparsely distributed throughout coastal areas (Higgins & Davies 1996) and it has an estimated population of 8,000 (Watkins 1993). In south-east Asia this species is a scarce to uncommon coastal northern winter visitor and passage migrant (Robson 2000); in the Greater Sundas there are very few records for Sumatra and it is an uncommon northern winter visitor in Java (van Marle & Voous 1988, MacKinnon & Phillipps 1993); in Borneo it is a regular northern winter visitor in moderate numbers (Smythies & Davison 1999); in the Philippine it is a rare passage migrant and northern winter visitor (Dickinson *et al*. 1991); and in Wallacea it is a regular passage migrant and northern winter visitor (Coates & Bishop 1997).

[Little Stint *Calidris minuta*]

Little Stint is a monotypic species which breeds in northern Scandinavia through southern Novaya Zemlaya and north-west and north-central Siberia to the New Siberian Islands and the Yana River. It winters from southern England and the Mediterranean, throughout much of Africa, the Arabian Peninsula and the Persian Gulf east to the Indian sub-continent and Myanmar. Elsewhere in south-east Asia, Little Stint is a coastal vagrant to western Thailand, the Malay Peninsula, eastern Tonkin in northern Vietnam (Robson 2000) and the Philippines (Dickinson *et al.* 1991). Interestingly there appear to be no records for Indonesia (Andrew 1991; Coates & Bishop 1997). On the basis of at least one specimen; several live captures and detailed published records in peer-reviewed journals this species is regarded as probably a regular visitor to Australia in small numbers (Higgins & Davies 1996). Conversely, the two New Guinea records, both from the Port Moresby area of PNG are unacceptable. The supporting details provided are insufficient to be sure of the birds' correct identification. Furthermore, the records were published in a non-peer reviewed newsletter of which one of the primary authors was the editor. On the first record, Finch (1980b) described what was regarded as an unusual stint resembling Little Stint but the author states quite clearly "* PLEASE NOTE: The observers accept that this is a sight-record only, and not sufficient evidence to include the species on the Papua New Guinea list." Nevertheless, Finch persists in later publications to refer to this record as if the identity of this bird was confirmed. On the second record, Anon also provides insufficient evidence to include the species on the PNG/New Guinea list despite the author's comment that "this species is now indelibly on the PNG list". Photographs taken of the individual bird in question and claimed to be diagnostic were never published and the record is therefore unverifiable. Thus the statement in Higgins & Davies (1996) that Little Stint is a "rare vagrant to New Guinea" is incorrect.

38. Red-necked Stint *Calidris ruficollis*

Red-necked Stint is a widespread and common to very common palearctic winter visitor and passage migrant. This species has been recorded widely throughout both Papua and PNG, on both the north and south coasts and in the islands. This species is most common during southwards migration and is recorded from mid-August to sometimes as late as late May. A few individuals have been recorded during the austral winter. Red-necked Stints often form large flocks together with other shorebirds on inter-tidal mudflats, sand flats on ocean beaches, saltpans, brackish coastal lagoons and less commonly the margins of freshwater swamps, lakes and sewerage treatment ponds; very occasionally it is found on short, grassy areas such as coastal airstrips especially at very high tides (Coates 1985, Bishop pers. obs.). Notable congregations of this species in New Guinea include:

30 September	1983	1,400+	Pulau Komolom, Papua. (Bishop unpubl.)
4 November	1983	262	Lampusatu, Merauke, Papua. (Bishop unpubl.)
26 October	1983	600+	Ongaya, Wasur National Park, Papua. (Bishop unpubl.)
20 March	2000	473	Kikori Delta, PNG. (R. Jaensch pers. comm..)

In the Port Moresby area Red-necked Stint is a common passage migrant with smaller number spending the northern winter on beaches. There are records of birds remaining over the austral winter; these include a flock of 40 from June to August 1982. The earliest date for the Port Moresby area is 31 July 1977 and the latest date is 2 May 1977 (Hicks 1990).

Red-necked Stint is the most common palearctic shorebird in Australia and it is widespread throughout the continent with an estimated population of 353,000 (Watkins 1993). In south-east Asia this species is an uncommon to common northern winter visitor and passage migrant (Robson 2000) and in the Greater Sundas, the Philippines and Wallacea, it is a moderately common to locally very common winter visitor and passage migrant (van Marle & Voous 1988, Smythies & Davison 1999, MacKinnon & Phillipps 1993 Dickinson *et al*. 1991, Coates & Bishop 1997). Almost the entire world population spends the palearctic winter in Australia. It is unclear from the above data what proportion of the world population remains in New Guinea during this period or whether most birds are only passage migrants. What is clear is that New Guinea supports large numbers of this species especially on the south coast of the Trans-Fly.

39. Long-toed Stint *Calidris subminuta*

Long-toed Stint was not listed for New Guinea by either Mayr (1941) or Rand and Gilliard (1967). The first New Guinea record was of a single bird at Dokuna, Bootless Bay, Central District, near Port Moresby (PNG) 5 November 1967 (Bell 1967) but there are no supporting details. The species was subsequently observed at Moitaka Sewerage Ponds, Port Moresby (PNG) on 30 September 1973 (Coates 1973). The latter observation was supported by a brief but convincing description. On 28 October 1979 one bird was observed at Hisui Lagoon, one was observed on 3 November at Lake Iaraguma, three were there on 11 November, and one was at Moitaka Sewerage Ponds on 3 November 1979 (Finch 1979). All localities are near Port Moresby (PNG). During October 1980 Finch (1980a) observed a total of six in the Bensbach River area but only one in the same area on 26 December 1981 (Finch 1982c). In October 1998, D. Watkins (pers. comm.) observed two birds at Goose Swamp in the Bensbach/Tonda WMA of the southern Trans-Fly, PNG. The only records for Papua are those listed by Silvius and Taufik (1989) for Pulau Kimmam and Silvius *et al.* (1989) for Wasur National Park in the southern Trans-Fly. The latter two references provide no details of their records.

Despite the paucity of records of this species from New Guinea, Coates (1985) regards Long-toed Stint as a regular but rare to very uncommon visitor to New Guinea where it is mostly recorded during the period early or mid-September to early or late January; it is occasionally seen during late February to late March and was once seen on 21 May (New Britain). Hicks (1990) regards this species as an uncommon and irregular passage migrant in the Port Moresby area, occasionally staying over the northern winter; Hicks (1990) recorded this species annually between 1978 and 1984, but then none until 1989, however, there are only two spring records. In the Port Moresby area the earliest date is 9 September 1979 at Hisui and the latest date is 25 Mar 1981.

In Australia this species is a regular and widespread palearctic winter migrant with counts of as many as 96 in the west (Higgins & Davies 1996). In south-east Asia Long-toed Stint is an uncommon to common winter visitor (Robson 2000); on Sumatra in the Greater Sundas it is a rare or accidental visitor (van Marle & Voous 1988). Conversely in Borneo it is a locally common winter visitor and passage migrant (Smythies & Davison 1999). There are relatively few records for Wallacea although it is locally common in Sulawesi (Coates & Bishop 1997).

Undoubtedly this small and relatively easily overlooked species is under-recorded in New Guinea. For example on the evening of 12 December 1979, the author and three students, whilst netting and banding shorebirds at night on the north coast of West New Britain, nearly released a bird incorrectly identified as Red-necked Stint. Extensive areas of suitable-looking habitat permeate the southern Trans-Fly and it is anticipated that thorough surveys of this area by experienced observers will produce many more records of this species for New Guinea.

40. Baird’s Sandpiper *Calidris bairdii*

Baird’s Sandpiper is recorded from New Guinea on the basis of a single bird observed together with other shorebirds at Kanosia Lagoon, near Port Moresby (PNG) on 24 November 1985 (Finch 1990). As with the records of Little Stint (see above) the details, albeit somewhat more convincing, were presented in a non-peer reviewed publication without supporting photographs or sketches. This species is a vagrant to Australia where it is known from five acceptable records (Higgins & Davies 1996). Baird’s Sandpiper typically winters in South America and there appear to be no records from south or south-east Asia (Rasmussen & Anderton 2005, Robson 2000, Andrew 1991, Coates & Bishop 1997, Dickinson *et al.* 1991).

41. Pectoral Sandpiper *Calidris melanotus*

Pectoral Sandpiper is a regular but very uncommon visitor to the New Guinea area mainly during October and November (Coates 1985). This species was first recorded for New Guinea on 6 October 1973 when two birds were observed with other shorebirds at Moitaka Sewerage Ponds (Coates 1973). Supporting notes were provided. Either this bird or another was seen at the same site on 13 October and again on 11 November (Coates 1973). Subsequently Pectoral Sandpiper has been recorded annually in the Port Moresby area in small numbers on southward passage, usually associated with Sharp-tailed Sandpipers. There are only two spring records. The earliest date for the Port Moresby area is 21 August 1982 and the latest date is 19 May 1985 (Hicks 1990). Heron (1978) observed a single Pectoral Sandpiper on a freshwater marsh behind Aviara beach from 30 October to 6 November 1977. The only record from the Trans-Fly is of a single bird observed by D. Watkins (pers. comm.) at Goose Swamp near the Bensbach River on 20 October 1998. In Australia Pectoral Sandpiper is a regular visitor in small numbers but with as many as 123 being recorded throughout the continent (Higgins & Davies 1996). This species is a vagrant in south-east Asia (Robson 2000) but with no records in the Philippines (Dickinson *et al.* 1991) or Indonesia (Andrew 1992). The lack of records from south-east Asia but relatively large number from New Guinea and Australia suggests that this species migrates across the Pacific rather through the chain of south-east Asian islands.

42. Sharp-tailed Sandpiper *Calidris acuminata*

Sharp-tailed Sandpiper is a common and widespread passage migrant and less common palearctic-winter visitor to New Guinea and its islands. It occurs from mid-August to early May (extreme dates 4 August to 25 May, once in July) but more typically from October to early November with most birds (certainly in the Port Moresby area) departing at the onset of the rains. Sharp-tailed Sandpiper ranges from sea-level to as high as 3,720m on Mt Scratchley (PNG). This species sometimes occurs in flocks of hundreds, possibly sometimes thousands, congregating characteristically with other species of shorebird. In Papua on 30 July 1988, *c.* 500 Sharp-tailed Sandpipers were observed on Rawa Cuwoon on Pulau Kimaam in the southern Trans-Fly of Papua (Silvius & Taufik 1989); in the Kurik area this species was found commonly between the Kumbe and Bian rivers (Hoogerwerf 1964); and Bishop (unpubl.) counted 370 at Lampusatu near Merauke on 9 November 1983 and 655 on 22 December 1983. In the PNG part of the Trans-Fly this species is common and widespread with the largest count of 813 reported from the Bensbach area during August and November 1995 (Milton 1998). In the Port Moresby area Sharp-tailed Sandpiper is an abundant passage migrant, with very few staying over the northern winter (Hicks 1990, Coates 1985).

In Australia, Sharp-tailed Sandpiper is a widespread and locally very common palearctic-winter visitor with an estimated population of 166,000 (Watkins 1983), almost the entire global population of this species. In south-east Asia this species is a vagrant (Robson 2000) and in Borneo, Java and Bali it is very rare (Smythies & Davison 1999, MacKinnon & Phillipps 1993). There are no records from Sumatra (van Marle & Voous 1988) and in the Philippines it is an uncommon passage migrant, commoner in spring (Dickinson *et al.* 1991). In Wallacea this species is also an uncommon passage migrant (Coates & Bishop 1997).

The above data indicate that the Sharp-tailed Sandpiper migrates in a relatively narrow funnel from its breeding grounds to New Guinea and Australia and only marginally to south-east Asia, Indonesia, and the Philippines. The large but as yet undetermined numbers of this species that occur annually in New Guinea strongly suggest that at the very least this is a very important staging point for this species.

43. Curlew Sandpiper *Calidris ferruginea*

Curlew Sandpiper is an uncommon but regular passage migrant to New Guinea (Coates 1985). This species was first recorded from New Guinea on 19 April 1959 (Hoogerwerf 1964) on a beach between the Kumbe and Bian rivers. On 25 May 1960, 'some' were observed with other shorebirds on the south coast of Pulau Kimaam. Thereafter Curlew Sandpiper was recorded regularly, "possibly even a permanent visitor to the wet fallow rice-fields of the north polder." The largest group observed in this area was five. On 13 April two specimens were obtained showing advanced "spring dress" despite many others still being in non-breeding plumage. The latest date this species was recorded was 25 May 1960 when 'some' were seen together with other shorebirds (Hoogerwerf 1964). Elsewhere in Papua this species is recorded from Pulau Kimaam (maximum count – 500 at Rawa Cuwoon Silvius & Taufik 1989), Pulau Komolom in the west, then eastwards without intervening records to the Kurik area (see above). A little further east small numbers were regularly counted from September to December 1983 (Bishop unpubl.) at Lampusatu, near Merauke; and *c.* 100 were observed on the mud-flats at Ongaya at the periphery of Wasur National Park (Bishop unpubl.). In the PNG part of the Trans-Fly there are very few records of this species with a high count of 20 on 23 October 2001 on the mudflats at the southernmost point between the Bulla and Bensbach river mouths (D. Watkins pers. comm.). Heron (1978) found this species irregular being first seen on mudflats on 18 October 1975. Subsequently Heron observed Curlew Sandpipers singly or in groups (2–8) many times between 2 April and 31 December. Elsewhere in PNG this species has been recorded at Amazon Bay (Bell 1970) and Higaturu near Popondetta, Northern Province (Mordue 1981b). A group of six at the mouth of the Dhagi River on the north coast of West New Britain Province on 25 August 1979 (Bishop unpubl.) appears to be the first record of this species for the Bismarck Archipelago. In the Port Moresby area Hicks (1990) regarded this species as an uncommon but regular passage migrant, mainly between October and November. There is just one spring record. The earliest date for the Port Moresby area (Angabunga River) is 22 August 1975 and the latest date is 13 April 1980.

In Australia Curlew Sandpiper is a widespread and common palearctic winter visitor with an estimated population of 188,000 (Watkins 1983). There has been a widespread reduction in Curlew Sandpiper numbers in Australia in recent years. In Victoria, numbers have declined from 30,000 in early 1980s to *c.* 5,000 over the last few years (Rogers & Gosbell 2006). Populations declines are rather less severe in the rest of country (Gosbell & Clemens 2006). In south-east Asia, Sumatra and Borneo this species is a fairly common to common winter visitor and passage migrant (Robson 2000, van Marle & Voous 1988, Smythies & Davison 1999); in Java and Bali it is a rare visitor in the northern winter, known from just a few records but it is likely overlooked (MacKinnon & Phillipps 1993, Bishop pers. obs.). In the Philippines Curlew Sandpiper is an uncommon passage migrant (Dickinson *et al.* 1991). In Wallacea this species is a regular passage migrant, sometimes numerous; and a scarce winter visitor (Coates & Bishop 1997).

44. Broad-billed Sandpiper *Limicola falcinellus sibirica*

Broad-billed Sandpiper was not listed by Mayr (1941) and Rand and Gilliard (1967) were able to find just one record. Coates (1985) regarded this species as a rare but regular migrant in New Guinea. In Papua, Junge (1953) collected two specimens in Etna Bay in November 1939. Subsequently, a single specimen was collected on 15 April

1959 on the beach between the Kumbe and Maro rivers, southern Trans-Fly (Hoogerwerf 1964). The latter author also feels he overlooked this species and may have seen it on Pulau Kimaam. Single birds were observed together with large numbers of other shorebirds on Pulau Komolom on 30 September 1983 and at Lampusatu near Merauke on 4 November 1983 (Bishop unpubl.). In the PNG part of the Trans-Fly this species is only known from two records: Finch (1980a) observed one on tidal flats at the Fourth Beach and D. Watkins (pers. comm.) recorded an impressive total of 25 near Bulla village on 24 October 2001. Heron (1978a) found Broad-billed Sandpiper a regular visitor around Bereina in small numbers (1–3) and flocks (8–23) from 11 September to 31 December and occasionally in the northern winter, on 10 July 1976 and 18 June 1977. Interestingly Broad-billed Sandpiper has only been recorded from the Port Moresby area on three occasions in October (Hicks 1990).

In Australia Broad-billed Sandpiper is most common on the north and north-west coasts and regular at scattered localities in the south with an estimated population of 8,000 (Watkins 1983, Higgins & Davies 1996). In south-east Asia this species is an uncommon to common winter visitor and passage migrant (Robson 2000). In the Greater Sundas it is a winter visitor known from just a few records but is likely overlooked (MacKinnon & Phillipps 1993, Bishop pers. obs.). In the Philippines Broad-billed Sandpiper is an uncommon winter visitor and passage migrant (Dickinson *et al.* 1991). In Wallacea the species is locally common on Sulawesi but scarce elsewhere (Coates & Bishop 1997). The steady accumulation of records throughout New Guinea suggests this species has been and continues to be overlooked and is in fact locally common in suitable habitat.

45. Buff-breasted Sandpiper *Tryngites subruficollis*

Buff-breasted Sandpiper is recorded from New Guinea on the basis of a single bird observed together with other shorebirds at Higaturu oil palm processing mill, Sangara, Oro Province (PNG) on 26 September 1981 (Mordue 1981a). As with other records of vagrant shorebirds to PNG the details, albeit supported by a sketch, leave a lot to be desired. Nevertheless, the description and sketch provided together with the distinctiveness of the species involved make this record acceptable. This species is also a vagrant to Australia where it is recorded from many acceptable reports (Higgins & Davies 1996). Buff-breasted Sandpiper breeds in extreme eastern Siberia, Alaska and eastwards across northern Canada to just west of Hudson's Bay. The entire population migrates south to southern South America although it is regularly recorded in a variety of countries as a vagrant. (Higgins & Davies 1996)

46. Ruff *Philomachus pugnax*

Ruff is a regular but very uncommon passage migrant in New Guinea with all known records being confined to PNG with the majority from the Port Moresby area. This species was first recorded in Papua New Guinea at the Waigani Sewerage Ponds on 14 November 1970 (Coates 1970) but without any supporting notes. However, on 5 November 1974 Lindgren (1974) observed a single male at the Waigani Sewage Ponds. Fortunately this observer provided a detailed and acceptable description. This individual was subsequently seen by several other observers on subsequent days. Other records of this species all from the Port Moresby area include: 26 March 1971 two birds; between 9 and 14 April 1971, three birds including a large male; and in October 1971, three birds including a male. Hicks (1990) regards Ruff as an uncommon and irregular passage migrant in the Port Moresby area (although annual from 1974–1981) with a total of 38 individuals during the recording period. The earliest date for Port Moresby is 11 September 1979 and the latest date for Port Moresby is 12 April 1971. Hicks (1990) lists a record for Manus in the Admiralty Islands, however, the observer provided no details whatsoever. Hicks (1990) lists a second record away from Port Moresby for "30 December 1989 Bensbach, Wes." but again with no further details. On 11 October 1979 a single male was observed at Kandrian airstrip, south coast West New Britain Province (Bishop in prep.) This appears to be the first record for the island of New Britain.

In Australia Ruff is a rare but regular visitor with a maximum of eight in any one year (Higgins & Davies 1996). In south-east Asia, the Greater Sundas and Philippines this species is a rare to scarce to visitor in the northern winter (Robson 2000, MacKinnon & Phillipps 1993, Dickinson *et al.* 1991). Conversely in Wallacea Ruff is possibly a regular but uncommon visitor at this time (Coates & Bishop 1997). The number of records of this passage migrant for New Guinea suggests this species may be overlooked in Australia.

47. Red-necked Phalarope *Phalaropus lobatus*

Red-necked Phalarope winters at three known general locations of which the seas north and west of New Guinea together with the neighbouring seas of the southern Philippines (Kennedy *et al.* 2000), Borneo (and inland) (Smythies & Davison 1999) and Wallacea (Coates & Bishop 1997) appear to host a large proportion of this species' world population. Red-necked Phalarope is numerous to abundant in certain favoured areas, such as Lake Dakatua, West New Britain Province, PNG (Bishop 1983a) from October to late April. There are just two records off the south coast of New Guinea: one on an inundated rice-field at Kurik (Papua) in the southern Trans-Fly (Hoogerwerf 1964) and a dense flock of *c.* 50 birds on the sea off Round Hill, Central Province (PNG) during mid March 1968 (Cleland 1968). As in other parts of this species' range such as Borneo, Red-necked Phalarope clearly flies over land, sometimes crossing very high mountains. Schodde *et al.* (1975) found two specimens on the Meren Glacier at 4,420 m on 30 December 1971 and another, freshly killed, on the rocks near the edge of a glacial tarn at 4,500 m on the North Wall on 16 January 1972 of the Carstenz Mountains of central Papua. Flocks of small white 'ducks', almost certainly this species, were seen swimming in the centre of lakes in the Carstenz meadow and lower Meren Valley. In Australia Red-necked Phalarope is a regular palearctic-winter visitor (Higgins & Davies 1996).

48. Oriental Pratincole ***Glareola maldivarum***

Coates (1985) regards Oriental Pratincole as a rare but annual visitor to New Guinea. In south-east Asia this species is a local breeding resident and scarce to fairly common passage migrant (Robson 2000). In the Greater Sundas Oriental Pratincole is an uncommon winter visitor on Sumatra with occasional large flocks (van Marle & Voous 1988). On Java this species is locally abundant passage migrant along the north coast of Java, especially during September (MacKinnon & Phillipps 1993). In Borneo Oriental Pratincole is increasingly common, but it is difficult to determine whether this is due to an increase in the number of migrants and/or an increase in the number of breeding birds (Smythies & Davison 1999, Bishop pers. obs.). In Wallacea this species is widely recorded but with the largest flock being just *c.* 85 on Flores (Coates & Coates 1997). Until 7 February 2004 the population of Oriental Pratincole wintering in Australia was estimated at *c.* 60,000 (Watkins 1993, Higgins & Davies 1996). This all changed dramatically with the discovery of 2.88 million Oriental Pratincoles at Eighty Mile Beach in north-west Australia (Sitters *et al.* 2004). In contrast there are surprisingly few records from New Guinea with just scattered individuals and small groups being recorded from a handful of localities including inland airstrips as high as 1,500 m. Given the extensive area in New Guinea of seemingly suitable habitat especially in the southern Trans-Fly this species has either been overlooked in New Guinea or genuinely rarely occurs there.

49. Australian Pratincole ***Stiltia isabella***

Australian Pratincole, despite there being no records of banded birds recovered from New Guinea, is clearly a regular migrant from Australia. This species arrives in New Guinea during late March and stays until as late as early December (Coates 1985), although typically most birds arrive in May and depart by the end of September (Hoogerwerf 1964; Bishop pers. obs.). Within the Trans-Fly this species has been recorded from Pulau Kimaam (Nash typescript; Bishop pers. obs.; Silvius and Taufik 1989) in the west then eastwards, without intervening records, to Kurik where Hoogerwerf (1964) observed it commonly in some years and uncommonly even rarely in other years in the area between the Maro and Bian rivers. Mees (1982) provides details of the two specimens collected from Kurik. Mees (1982) also discusses the assertion by Mayr (1941) and Rand and Gilliard (1967) that this species may breed on New Guinea and points out that the characters these authors were citing as evidence of the presence of a juvenile in New Guinea was actually a bird with fully grown wings and was not really a young bird at all (*contra* Higgins & Davies 1996). Further east this species has been recorded by van Oort (1909) near Merauke and in Wasur National Park (Papua) (Bishop pers. obs.; Hornbuckle 1991). Elsewhere in Papua this species is known from just a handful of records including from the Western Papuan and Aru Islands.

Within the PNG part of the Trans-Fly this species has been recorded commonly, sometimes abundantly throughout the Tonda WMA and Bensbach area. For example, during 10–14 July 1995 Bishop (1995) noted approximately 5,000 birds on the Bulla Plains, stating “Hundreds of birds scattered for as far as the eye could see”. Similar numbers were observed by Bishop in most years from 1987 to 1995. In August 1989, however, only a single bird was observed (Bishop 1989). In July 1982 Finch *et al.* (1982) recorded more than 20,000 in the Bensbach area and from 9–16 October 1980, Finch (1980a) observed that this species was “Extremely common in the dry country and around inlets and ox-bows. Many thousands of birds in the area; the total population wintering in the area could be the greater part of the Australian breeding population.” During Finch’s subsequent visit to the Bensbach area on 26 December 1981 this species was conspicuously absent (Finch 1982c). The only other records of this species from the Trans-Fly are irregular observations (Bishop pers. obs.) in most years of low numbers on the airstrip at Daru. Elsewhere in PNG this species is locally common but largely confined to areas south of the central ranges and at elevations as high as 1800 m. As many as 100 Australian Pratincoles have been observed at Port Moresby airport and it is known from just a handful of records from north of the central ranges and islands.

Watkins (1993) estimates the Australian population as *c.* 60,000 but qualifies this estimate by pointing out that Australian Pratincole was not well surveyed by the Shorebird Project. Presumably this implies that this species was possibly under-recorded and that the population estimate is too low. Notwithstanding, it is clear that whilst New Guinea, and in particular the Trans-Fly, supports a large proportion of the entire non-breeding population of this species, it is perhaps overstating the point to say that it supports the greater part of the Australian breeding population. For example lower, albeit important, numbers have been observed elsewhere in neighbouring Wallacea (Indonesia) (Bishop pers. obs.; Coates & Bishop 1987).

DISCUSSION

The documentation of the occurrence of individual species of shorebirds in New Guinea has generally been poor. This not only applies to novelties such as rarities and vagrants but also to more regularly occurring species. For example, several species that have been seemingly uncritically accepted on the New Guinea list are surely unacceptable by standards applied elsewhere including Australia. For an example of how to document a new species to New Guinea (or anywhere else), see Kennerely and Bishop 2001. It is suggested that all future records of significance in New Guinea be submitted to a peer reviewed journal. As a consequence of this evaluation, the following species have been eliminated from the New Guinea list subject to the submission of appropriate documentation: Pintail Snipe, Green Sandpiper, and Little Stint. Descriptions of Baird’s Sandpiper and Buff-breasted Sandpiper are also marginal. Similarly the much more commonly occurring Pectoral Sandpiper, Long-toed Stint and Ruff have never been properly documented in New Guinea. As a consequence of this poor documentation I have indicated in Table 1 those species whose presence in New Guinea is supported by a specimen. For example there appear to be no specimens of

Pectoral Sandpiper, Ruff and Oriental Pratincole and only one specimen of Long-toed Stint. Not only do specimens provide unambiguous documentation of the presence of a species at a given site they also provide information on which subspecies occurs, moult, body-fat and feather wear.

It is clear from the above species accounts and the data presented in Table I and the Appendix that New Guinea supports a rich and diverse shorebird fauna. Furthermore, some of New Guinea's known shorebird sites such as the southern Trans-Fly and the Kikori Delta support regionally and possibly globally important congregations of shorebirds. Nevertheless, our knowledge of these sites is rudimentary at best and there is clearly a great deal more basic research to be done on the shorebirds of these sites. For example whilst opportunistic observations indicate that sites such as Pulau Komolom support large numbers of shorebirds, it is not unreasonable to suppose that carefully timed, systematic surveys over an entire season may reveal much larger numbers of shorebirds. Kikori Delta has only been 'surveyed' twice, once briefly during September 1999 (Diamond & Bishop unpubl.) and then more thoroughly by R. Jaensch in March 2000. Nevertheless, these surveys immediately revealed that this to be an important shorebird site. It is interesting to note that the latter observations were made during northward passage when shorebird numbers in New Guinea are characteristically much lower than during southward passage.

The recent discovery of nearly three million Oriental Pratincole spending the northern winter in north-west Australia, an area in which shorebirds have been intensively studied for over 20 years, suggests that similarly large and exciting finds may still be a possible in an area as relatively poorly explored and surveyed as New Guinea. Species targeted surveys such as those urgently needed for Little Whimbrel could provide important data towards understanding better what are, for example, the most important areas of grasslands in New Guinea for this likely threatened species. Several areas of potential Little Whimbrel habitat remain completely unexplored ornithologically; these include the extensive area in Papua between the Princess Marianne Straits and the Kurik area and in PNG the area east of the Kikori Delta to the Angabunga River. Similar, carefully timed surveys may also reveal more information on the distribution of Oriental Plover and Oriental Pratincole in New Guinea.

New Guinea is a huge land-mass (sometimes referred to as a continental island) and as such is topographically complex and diverse and offers visiting shorebirds a great variety of habitats and choice of potential feeding sites. As the data in the Appendix show, some species such as Great Knot are genuinely very rare in the south-east wetlands whereas they are very common to abundant in certain coastal sites of the southern Trans-Fly. Other species such as Black-tailed Godwit and Red Knot were found by Hoogerwerf (1964) during 1959 to 1962 to be seasonally very common, sometimes in large flocks, in contrast to our knowledge of these species subsequently in New Guinea.

Undoubtedly the south coast of New Guinea supports much more suitable shorebird habitat than the north coast. The only site on the north coast that has revealed any numbers of shorebirds is the interesting observation of Jared Diamond (pers. comm.) who observed hundreds possibly thousands of shorebirds on the south-west coast of the Wandammen Peninsula in October 1983. However, there appear to have been very few surveys conducted along the north coast of New Guinea especially in such areas as the Sepik and Ramu river deltas which may also support good numbers of shorebirds. Nevertheless it is clear that the south coast does have more suitable shorebird habitat and the southern Trans-Fly in particular supports important numbers of shorebirds (see Appendix).

The single most urgent requirement to advance our knowledge of shorebirds in New Guinea is a great deal of more carefully targeted and timed surveys. Much of the potential shorebird habitat in New Guinea, especially in Papua, is virtually unknown and certainly never surveyed. For example the entire Digul River estuary has never been surveyed and neither has the entire coastline that extends from the Digul north and westwards to Lakahia Bay. Even the most opportunistic and preliminary survey can produce important results. For example, the entirely fortuitous observation of large numbers of shorebirds congregating and feeding on the shores of Pulau Komolom (Bishop 1983b) led to that island being included in the Papua (Indonesia) reserve system. Similarly, a brief helicopter reconnaissance and one morning's bird watching in the Kikori Delta (Diamond & Bishop unpubl.) led to a survey and subsequent recognition by Wetlands International of the importance of this area. And even areas which have received a preliminary survey are likely to produce interesting and possibly exciting results. For example Bintuni Bay was surveyed for the first and only time during the palearctic-spring migration. Even in March and April Erftemeijer *et al*. (1991) recorded *c.* 10,000 shorebirds providing evidence that that this site must surely support considerably greater numbers of shorebirds over the August to November southward migration period.

Within the East Asian–Australasian Flyway a total of 15 of the 22 countries in the Flyway have signed the Ramsar Convention including Indonesia (for Papua) and Papua New Guinea. However, only one area within the island of New Guinea has been declared a Ramsar site and that is the Tonda Wildlife Management Area. In view of the large numbers of water-birds and shorebirds now known to inhabit several other parts of New Guinea there is an urgent need to have these areas declared as Ramsar sites. Strong candidates include: Bintuni Bay, Pulau Kimaam (including Pulau Komolom); the ocean beaches and inter-tidal mud flats between the Kumbe, Bian and Maro rivers and Kikori Delta.

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APPENDIX. SHOREBIRD COUNTS IN NEW GUINEA

Key to column headings

A = Pulau Kimaam (Silvius & Taufik 1989)
B = Pulau Komolom (Bishop Unpubl.)
C = Lampusatu, Merauke (Bishop Unpubl.)
D = Ongaya, Trans-Fly, Papua (Bishop Unpubl.)
E = Miscellaneous
F = Bensbach
G = Kikori Delta
H = Maximum counts at six sites around Port Moresby (Burrows 1994)
J = Estimated Australian population (Watkins 1983, Watkins in Marchant & Higgins 1993, Higgins & Davies 1996)
K = Estimated global population for that subspecies or particular breeding population (Wetlands International 2006)

Taxon	Status in New Guinea	A	B	C	D	E	F	G	H	J	K
1. Beach Thick-knee	Resident.						4	3		1,000	6,000
2. Pied Oystercatcher	Irregular visitor		8	3			10[4]			10,000	11,000
3. Black-winged Stilt	Resident and migrant?	300		35		500[1] 656[2]	140		60	266,000	300,000
4. Pacific Golden Plover	Regular migrant.		10	56			60[5]	4	70	9,000	100,000
5. Grey Plover	Regular migrant.		80		10+		50	49	4	12,000	125,000
6. Lesser Sand Plover	Regular migrant.							5	50	20,000	No data
7. Greater Sand Plover	Regular migrant.						2000	1700	150	74,000	100,000
Plover sp			3,700	3,450	1,560					(94,000)	

Taxon	Status in New Guinea	A	B	C	D	E	F	G	H	J	K
8. Oriental Plover	Regular but infrequently recorded migrant.						39		2	60,000	
9. Red-kneed Dotterel	Resident?						16[6]			26,000	26,000
10. Masked Lapwing	Resident	100+					2,000[7]			258,000	170,000
11. Black-tailed Godwit	Regular migrant.	1,000	60	122	75		260	250	100	81,000	160,000
12. Bar-tailed Godwit	Regular migrant.		70	3	160		50	230	4	165,000[11]	155,000
13. Little Whimbrel	Regular migrant. In the Trans-Fly sometimes in lge. nos.					1,900[3]	20,000[8]		60	180,000	180,000
14. Whimbrel	Regular migrant.		1,050	90	100		200	63	12	10,000	55,000
15. Far Eastern Curlew	Regular migrant.		122	61	2		350	343	4	19,000	38,000
16. Marsh Sandpiper	Regular migrant.	20	28	12			230[9]	10	200	9,000	90,000
17. Common Greenshank	Regular migrant.	130	14	35	120		90	130	80	20,000	55,000
18. Wood Sandpiper	Regular migrant.						6[10]		40	6,000	100,000
19. Terek Sandpiper	Regular migrant.		90	228	360		200	1015	5	18,000	50,000
20. Common Sandpiper	Regular migrant.		7	33			84	35	20	3,000	30,000
21. Grey-tailed Tattler	Regular migrant.		6				20	40	102	36,000	40,000
22. Ruddy Turnstone	Regular migrant.		35	3				23	6	14,000	100,000
23. Asian Dowitcher	Rare migrant – regular?							4	1	No data	23,000
25. Great Knot	Regular migrant.		70	154			1,000	552	12	270,000	380,000
26. Red Knot	Regular, migrant, but generally uncommon.				2			2		153,000	220,00
27. Sanderling	Regular but scarce migrant.		3	2	1			3		8,000	22,000
28. Red-necked Stint	Regular migrant.		1,400	262	600		52	473	2,500	353,000[11]	315,00
29. Long-toed Stint	Regular but scarce migrant.						2		3	No data	100,000
30. Sharp-tailed Sandpiper	Regular migrant.	500		370	10		270	10	3,000	166,000[11]	160,000
31. Curlew Sandpiper	Regular migrant.		10	12	100		20	7	70	188,000[11]	180,000
32. Broad-billed Sandpiper	Regular but uncommon migrant.			1			25		8	8,000	10,000 – 100,000
33. Oriental Pratincole	Regular migrant in small nos.								10	2.88 million[12]	2.8 million
34. Australian Pratincole	Regular migrant in large nos.	4					>20,000[10]		10	60,000	60,000

Notes:
1. Hornbuckle (1991)
2. Halse *et al.* (1996)
3. Wasur N.P. Minimum count. Maximum several thousands (Bishop unpubl.)
4. Stronach (1981)
5. Finch (1982c)
6. Hicks (1985)
7. (Bishop unpubl.)
8. Minimum count. Finch 1980a
9. Finch *et al.* (1982)
10. Finch (1980a)
11. Watkins and WI estimates similar but precision unknown. They imply that most of the population visits Australia.
12. Wakins pre-1996 estimate superseded.

MIGRATION ROUTES OF WADERS WHICH SPEND THE NON-BREEDING SEASON IN AUSTRALIA

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Recoveries and flag sightings of 26 species of migratory wader which visit Australia were analysed to determine migration routes, destinations and stopover locations. Each species had a different migration pattern. There was a strong preference for migratory stopovers to be made along the Chinese coast, particularly on northward migration. Routes through Asia ranged from south-east India and Sri Lanka in the west to Japan in the east. There was a tendency in many species for birds from non-breeding areas in eastern Australia to use a more easterly route through Asia than birds from Western Australia. Most species appear to overfly the islands between the northern coast of Australia and the Asian mainland, and also Taiwan and Japan, on both northward and southward migration. The breeding grounds of waders which spend the non-breeding season in Australia range from 98ºE (Curlew Sandpiper in north-west Taimyr, Siberia) to 149ºW (Bar-tailed Godwit in north-east Alaska). These extremes are over 13,000 km from the banding locations.

INTRODUCTION

One of the traditional reasons for banding migratory birds is to obtain information on their migration routes, stopover locations and ultimate destinations. This is of especial interest for waders, which collectively make some of the longest migrations of any animals in the world. All except one of the migratory wader species which spend the non-breeding season in Australia have their breeding grounds in the Northern Hemisphere, many in the Arctic regions. These birds make round trip migrations of up to 26,000 km. each year.

Migratory movement studies were the initial main objective of wader banding research in Australia. Wader banding started in 1958/59, began to expand in the late 1960s/1970s and then intensified from 1979 onwards (Minton 2005). Information on movements accrued only slowly because of the low recovery rates. However following the introduction of colour leg flagging in 1990, initially in Australia but subsequently in 20 different locations in the East Asian–Australasian Flyway, the rate of generation of migration knowledge increased rapidly.

Migratory movements are not just of scientific interest. Identifying key migratory stopover locations is fundamental to developing conservation measures to protect them. All the evidence in this flyway suggests that the greatest current threats to waders come from loss or degradation of habitats in Asia rather than from changes in habitats in the Northern Hemisphere breeding areas or in the Australian non-breeding areas. Also, it is possible that, in the longer term, the effects of climate change may alter migration patterns.

Analyses of recoveries and flag sightings have already been published on a number of species for which information has reached a level where this has become worthwhile (Barter 1989, Barter 1992, Minton 1996, Minton 1998, Minton 2005, Minton *et al*. 2000, Minton *et al*. 2006a, Minton *et al*. 2006b). A number of further analyses on individual species are currently in progress. However up to the present the results have been published in papers where only a single, or a limited number of, species is covered. It would be helpful to have a publication which brought together all the information obtained from banding and flagging on the migratory movements of all wader species for which there are data. This paper is intended to meet that end.

The need for such a paper has become particularly relevant with the outbreaks of avian influenza in Siberia and in Asia during the last two years. Many people have become concerned about the possibility of migratory waders carrying the disease into Australia. A knowledge of which species pass through which countries will assist in judging the risk levels and in selecting priority species for avian influenza monitoring.

This paper brings together all current Australian banding and flagging information into a single map for each species. This mapping concept was first introduced in 2001 when JW was working as a volunteer with Wetlands International in Canberra. They required illustration of the different migratory corridors of species within the East Asian–Australasian Flyway. The resulting maps give a visual impression of the migration routes and destinations of the different wader species in an easily comprehended format. They are not a substitute for a more detailed analysis for each species which needs, for example, to take into account the specific dates of banding and of recoveries and flag sightings in order to provide a more insightful analysis.

METHODS

Each species account starts with a brief description of the distribution within Australia (Lane 1987, Marchant & Higgins 1993, Watkins 1993, Higgins & Davies 1996). The breeding ranges shown in the maps are from Hayman *et al*. 1986 with some minor updates. All recoveries of Australian-banded waders which had moved more than 200 km from their original banding location and which were on the Australian Bird and Bat Banding Schemes recoveries database as of 27 July 2006 are incorporated into the maps. Inward movements, those of waders banded overseas but subsequently found in Australia, are also included. Similarly both inward and outward movements of leg-flagged birds are used, although in the case of flag sightings the cut-off date is 5 September 2006 (except for the Long-toed Stint q.v.) and the source is the Australasian Wader Studies Group leg flag database.

No differentiation is made between recoveries and flag sightings in the maps. Also reports from all months in the year are combined and therefore no indication of the timing of migrations is given. It is not therefore possible to differentiate in the maps between the routes used on northward and southward migrations. The maps also show the known main breeding areas of each species. An approximate boundary for the parts of the flyway in which the main Australian population of each species may occur is marked.

The number of recoveries and flag sightings for each species depends on the numbers which have been caught, banded and flagged. Details of these for the different species/regions in Australia up to the end of 2003 were given by Minton (2005). Figures updated to the end of 2005 for the two main wader catching locations in Australia – Victoria/south-east of South Australia, and north-west Australia – are given in Minton (2006a), Minton (2006b).

In the maps a line has been drawn between the original marking location and the final reporting place for each bird. The line does not however mean that this was the route actually flown by the bird. Care also needs to be taken in interpreting recovery and flag sighting information as this will be dependent on a number of different factors which can, and almost certainly do, lead to biases. Wader recoveries mainly arise through other wader banders recapturing a bird or through a bird being killed by hunters. Banding locations are irregularly scattered throughout the flyway and over the main period of this study hunting has been confined to only a few areas (mainly Siberia, parts of China, and Indonesia). Most flag sightings are from birdwatchers or those making studies of waders e.g. population monitoring counts. Again, the distribution of such people throughout the flyway is non-uniform. The most intensive watching of waders has taken place in New Zealand, Hong Kong, Japan, and Taiwan. In recent years, searches for flags have been expanded in the Yellow Sea area of mainland China and South Korea and in parts of the Russian and Alaskan Arctic. Within Australia the most watched locations have been north-west Australia and Moreton Bay in south-east Queensland. It should also be noted that whereas only one recovery normally arises for any individual bird many flag sightings may occur for a bird which remains in well-watched locations. Flag sightings therefore may produce an inflated indication of the frequency of migratory movements.

The 26 maps show the places between which we know movements have taken place. What we do not know is what other patterns of movements were not recorded, or were under-recorded, because of the factors mentioned above.

RESULTS

Recoveries and flag sightings have been reported for 26 species of waders which spend the non-breeding season in Australia. These are detailed below for each species.

Grey Plover

Grey Plover occur around the coasts of Australia. Overseas recoveries and flag sightings have all been in the Yellow Sea (both China and Korea) and Japan (Fig. 1). Birds from the two principal marking areas in Australia, north-west Australia and Victoria, have been reported from both regions in Asia, though there is a tendency for a greater proportion of Victorian birds to be recorded in Japan. The migration path appears to be relatively narrow through Asia, but this may partly be a reflection of the relatively small numbers banded and flagged. There are no reports of marked birds anywhere to the north of these Asian stopover locations and therefore the specific part of the breeding range to which Australian Grey Plover migrate is unknown.

There is one movement of a Victorian-flagged Grey Plover to north-west Australia, but no indication that such trans-Australia movements are a regular feature of the migration pattern.

Pacific Golden Plover

Pacific Golden Plover occur on coasts around Australia and occasionally inland. Few have been banded or flagged in Australia. The most interesting movement concerns a bird banded on the Pribilof Islands, off the south-west of Alaska which was subsequently found on the northern New South Wales coast, and a bird banded at this latter location which was subsequently found on Vanuatu (Fig. 2). These records suggest that at least part of the eastern Australian population breeds in south-west Alaska. Most of the Pacific Golden Plover from Alaska move to islands in the Pacific during the non-breeding season (Johnson *et al*. 1989, Johnson *et al*. 2006).

The only overseas recovery of an Australian-banded bird was at the southern end of the Yellow Sea in China. There are also a couple of movements within Australia between Victoria and the east coast.

Greater Sand Plover

Most of the Greater Sand Plover which spend the non-breeding season in Australia occur in the northern half of the continent, particularly in north-west Australia. Migratory movements seem to be in a more north-westerly direction than in any other species, with a concentration of recoveries and flag sightings in a fairly narrow band in Vietnam, in the southern half of the Chinese mainland, and in Taiwan (Fig. 3). There are no reports north of these staging areas. It would appear that all birds from Australia migrate towards the breeding grounds at the eastern end of the Greater Sand Plover breeding range. It could well be that the southerly location of the breeding grounds and the northerly non-breeding areas enable many Greater Sand Plover to make their relatively short migration (7,500 km) with only one major stopover.

Lesser Sand Plover

Lesser Sand Plover have a rather more widespread distribution within Australia than Greater Sand Plover and there is a tendency for the largest numbers to be in north-eastern areas, particularly Queensland. They have a much wider migration spread through Asia with Australian-marked birds being reported from locations ranging from Vietnam right across to the north island of Japan (Fig. 4.).

The Lesser Sand Plover has several subspecies, each with a separate breeding area. Because none of the recoveries or flag sightings reported were further north than their Asian coastal staging sites, it is not possible to deduce from the recovery and flag sighting information which of them come to Australia. Subspecies *mongolus*, which breeds in eastern Siberia, is thought to form the bulk of the population (Lane 1987, Marchant & Higgins 1993). The movements of some birds from Australia to Vietnam and Hong Kong could, however, indicate that one of the more westerly breeding subspecies, such as *atrifons*, may also come to Australia (Barter 1991).

Double-banded Plover

The Double-banded Plover is the only New Zealand land bird which regularly migrates to spend the non-breeding season in Australia. About a third of the total population makes this trans-Tasman movement, with birds being in Australia from around February/April until August. Banding and flagging have shown that it is only the birds which breed in the centre of the South Island of New Zealand which are involved in this movement (Fig. 5). Those which breed on the lower ground around the perimeter of the South Island and those which nest in the North Island remain in New Zealand for the winter (Barter & Minton 1987, Pierce 1999).

The main areas in Australia visited by Double-banded Plover are Tasmania and Victoria although birds reach up into southern Queensland and as far west as the eastern parts of South Australia. The heavy concentration of movements recorded between Victoria and New Zealand is the result of a special study carried out by the Victorian Wader Study Group between 1979 and 1988 and studies taking place on the breeding areas in New Zealand at the same time. Nearly 400 movements between Victoria and New Zealand have now been recorded. These special studies have biased the data away from Tasmania, which holds the highest numbers of Double-banded Plover in the non-breeding season (Pierce 1987).

Ruddy Turnstone

Ruddy Turnstone are present on the coasts around Australia. They appear to migrate through Asia on a relatively broad front, between Hong Kong and Japan (Fig. 6). Recoveries and flag sightings have particularly come from Taiwan, central Japan and Hong Kong, with a smaller proportion being reported in the Yellow Sea than for many other species. The pattern of reports in Asia shows a considerable overlap in staging areas used by birds from south-east Australia and north-west Australia, although there is a slight tendency for proportionately more of the former to have been reported from Japan.

Only two reports have been received of birds close to their breeding grounds and these both indicate a destination in the coastal areas of Yakutia in northern Siberia. There is no current evidence that Ruddy Turnstone from the Alaskan breeding grounds come to Australia. Their main wintering areas are on Pacific Islands (Condon 1975).

There have now been a good number of reports of Australian-marked Ruddy Turnstone in New Zealand, in both North and South Islands. Most of these have occurred in recent years as this species became increasingly studied in New Zealand and as the intensity of flag sighting efforts there escalated. It appears that these movements are of both adults and juveniles marked whilst on migration through south-east Australia. There is no evidence to suggest that immature Ruddy Turnstone preferentially spend their first year in Australia, before moving on to New Zealand, in the way that many Red Knot and some Bar-tailed Godwit do.

There are now quite a number of trans-Australia movements recorded between north-west and northern Australia and south-eastern Australia. It appears that these northern regions of Australia are regular staging areas for some Ruddy Turnstone on both northward and southward migrations.

Eastern Curlew

Eastern Curlew occur all round the coasts of Australia, with the largest numbers in the eastern and northern parts of the continent. The birds from Australia seem to migrate on a relatively narrow front through Asia on their way to their breeding grounds in south-east Siberia (Driscoll and Ueta 2002) (Fig. 7). Most recoveries and flag sightings have been in the southern third of Japan and on the west coast of Korea. However reports of marked birds have been received from as far west as Taiwan. As in many species, there is a tendency for birds from north-west Australia to be found towards the western side of the migratory path through Asia. It is probable that the Yellow Sea area of China is under-represented because of the fewer observers there and because of the difficulties of getting close enough there to make observations of leg flags on this rather shy species.

Within Australia it appears that many birds make stopovers on the east coast of Queensland and New South Wales on their southward migration back to Victoria.

Whimbrel

Most Whimbrel which visit Australia spend the non-breeding season along the mangrove-lined shores of the northern half of Australia. Relatively few have been banded or flagged. The recoveries and flag sightings show a strong easterly bias with all but one being in Japan and the Kamchatka region of eastern Siberia (Fig. 8). There is only one report from the Yellow Sea in China but, as with Eastern Curlew, it is likely that this under-reflects the true importance of the Yellow Sea as a migratory stopover for this species. The three reports in Kamchatka suggest that at least part of the breeding population which visits Australia is from the north-eastern region of Siberia.

Grey-tailed Tattler

Grey-tailed Tattler mainly spend the non-breeding season in the northern half of Australia. The species is particularly widespread in Queensland as shown by the large number of movements, in both directions, recorded between Japan and Queensland (Fig. 9). Grey-tailed Tattler from north-west Australia also visit Japan but their main stopover locations in Asia are further west in Korea, Taiwan, and the southern Chinese coast. The two recoveries in the breeding areas are compatible with the migratory stopover pattern. They indicate that Queensland birds may breed at the eastern end of the breeding range and the north-western Australia birds further west.

Common Greenshank

Greenshank occur all round the coasts of Australia and, to a lesser extent, inland also. They have shown one of the lowest returns for the banding and flagging effort of any wader species marked in Australia. This may be because many use freshwater habitats on migration and these are less well watched than coastal areas. The sparse movement information indicates that birds on northward migration through Asia may use stopovers along the whole of the Chinese coast and into the Korean part of the Yellow Sea (Fig. 10).

Marsh Sandpiper

Marsh Sandpiper are widespread throughout Australia at both coastal and inland locations. Most of the relatively few Marsh Sandpiper marked in Australia have been caught in north-west Australia and on the Hunter Estuary near Newcastle in New South Wales. One bird from the latter location was recovered in Siberia, but was rather further east than the main breeding areas even though it was at the same latitude (Fig. 11). There have been a number of flag sightings indicating movements of up to 400 km between different locations on the coast in north-west Australia.

Common Sandpiper

Australia is at the southern end of the main wintering range for Common Sandpiper. There is only one recorded movement from the few Common Sandpipers marked. This was a bird flagged in north-west Australia and subsequently seen in Singapore during the migration season (Fig. 12).

Terek Sandpiper

Most Terek Sandpiper occur mainly in the northern half of Australia, particularly in north-west Australia. The migration path in Asia seems to be quite wide with recoveries and flag sightings ranging between Hong Kong and the north island of Japan (Fig. 13). The Korean part of the Yellow Sea seems to be particularly favoured but many reports have also come from well-studied areas such as Hong Kong and the Shanghai area of China. As in most species, there is a proportionately greater number of reports in Japan from the Terek Sandpiper populations which spend the non-breeding season in the eastern part of Australia. There are three reports from the breeding grounds, spread across a longitude of 30º, suggesting that birds from a broad section of the eastern part of the breeding range migrate to Australia.

Swinhoe's Snipe

Australia is at the southern fringe of the non-breeding area of Swinhoe's Snipe. Only very small numbers of these birds reach Australia. Amazingly, two birds banded at the sewage farm near Darwin on 22 December 1984 were recovered the following year in The Philippines, only two weeks apart, on 28 August and 11 September 1985 (Fig. 14).

Latham's Snipe

The majority of Latham's Snipe, which breed in the northern parts of Japan and the adjacent region of south-east Siberia, come to eastern Australia, especially south-east Australia, for the non-breeding season (Fig. 15). There are quite a number of recoveries linking these two locations. There are no recoveries of Australian-marked birds at intermediate locations (e.g. The Philippines and New Guinea), possibly because the recovery rates in those areas may be very low. There is both direct and indirect evidence that Latham's Snipe, which spend most of the non-breeding season in south-east Australia, move northward in February to stage in New South Wales and Queensland before continuing their migration to the breeding areas in March and early April (Garnett & Shephard 1997). Whether they fly directly from Australia (or New Guinea) to Japan or via a stopover in Asia is not known.

Asian Dowitcher

North-west Australia is the only region in Australia where Asian Dowitchers regularly occur and then only in small, but internationally significant, numbers. The small number of flag sightings which has accrued suggests that the migration route is northward through Taiwan and the Chinese part of the Yellow Sea (Fig. 16). There has been one report from the breeding grounds. In May 2006, an Asian Dowitcher flagged in north-west Australia was seen at a nest in northern Mongolia.

Black-tailed Godwit

Black-tailed Godwit mostly occur on the northern coast of Australia between the Gulf of Carpentaria and Roebuck Bay, Broome. No recoveries have yet been reported. Flag sightings indicate a strong orientation towards the Yellow Sea as the major stopover location in Asia, with the west coast of Korea being particularly favoured (Fig. 17). Some birds, particularly from north-west Australia, seem also to visit Taiwan, possibly when their energy supplies run out in unfavourable migration conditions before they reach the Chinese mainland. There have been no recoveries on or near the breeding grounds but the movement pattern indicates that the birds which visit Australia are likely to be from the populations breeding in various parts of eastern Siberia.

Bar-tailed Godwit

Bar-tailed Godwit occur in substantial numbers all round the coasts of Australia (and widely in New Zealand). There appears to be a marked difference in migratory behaviour between the Bar-tailed Godwit marked in north-west Australia and those marked in eastern Australia (Fig. 18). Birds from both regions migrate northwards through the Yellow Sea and, to a lesser extent, the southern half of Japan (Wilson & Minton 2000). The timing of the migration through this region is different for birds from the two non-breeding areas, with the birds from eastern Australia (and New Zealand) being some two to three weeks earlier than those from north-west Australia. Birds from north-west Australia then continue to breeding grounds in northern Yakutia, the breeding location of the *menzbieri* subspecies. The majority of the birds marked in eastern Australia go to western and northern Alaska, the breeding area of the *baueri* subspecies. One Victorian-flagged Bar-tailed Godwit was seen on its breeding territory near Deadhorse, Prudhoe Bay, Alaska (149ºW) over 13,000 km away and close to the north-eastern limit of the range. We do not know the migratory strategy of Bar-tailed Godwit occurring in northern Queensland and the Northern Territory because no birds have been banded there.

The return migration of the birds breeding in Yakutia is also through Asia, although there are few recoveries or flag sightings, other than in Korea, to indicate routes and stopover locations. In contrast Bar-tailed Godwit marked in eastern Australia congregate on the shores of south-west Alaska from late July onwards and do not set off for Australia and New Zealand until September. All the evidence (lack of reports in Asia, two reports on Pacific Islands, radar observations and timing) suggests that these birds make a 10 – 11,000 km. non-stop flight across the western Pacific Ocean direct from Alaska to northern Australia and New Zealand. This is the longest non-stop flight of any migratory species (Minton *et al*. 2001, Gill *et al*. 2005).

There have been a large number of flag sightings and some recoveries indicating that many Bar-tailed Godwit marked in eastern Australia subsequently move to New Zealand (Riegen 2000). Some of these movements, particularly of juveniles, were birds which were staging on southward migration when banded in east and south-east Australia. Others were of birds which spent at least their first non-breeding season in Australia before later establishing their main non-breeding area as New Zealand. The explanation for a number of Bar-tailed Godwit marked in north-west Australia subsequently being seen in North Island, New Zealand, is still not clear. In contrast there have been very few movements of Bar-tailed Godwit between north-west Australia and east and south-east Australia.

Great Knot

The majority of Great Knot in Australia occur along the northern coasts between Moreton Bay, south-east Queensland, and Carnarvon in north-west Australia. A major stopover location of Great Knot on northward migration is the Chinese coast, particularly around Shanghai but not all birds stop here. Some birds, perhaps encountering ideal weather conditions, fly non-stop to the northern and eastern parts of the Yellow Sea (Fig. 19). The west coast of Korea is particularly favoured. Marked Great Knot have also been seen quite regularly in southern parts of Japan. The reports from Hong Kong and Taiwan may mainly be of birds which encountered unfavourable weather conditions en route and were forced to land before reaching their preferred destination in the area of the Yellow Sea (Barter 2000). There is a strong tendency for birds from east and south-east Australia to be found in the more eastern parts of the Asian migratory stopover region, particularly in Japan.

There have been several recoveries and flag sightings in or near the breeding areas in north-east Siberia.

On southward migration, in the second half of July and early August, there is a strong concentration of reports of birds on the southern shores of the Sea of Okhotsk. Apart from a few sightings in Korea there are very few reports of birds on southward migration elsewhere in Asia. It appears likely that many birds make a direct flight of up to 8000 km from the Sea of Okhotsk to their non-breeding areas in Australia. This is supported by radar observations of flocks of what appear to be waders migrating on a course towards northern Australia over the island of Guam (Williams & Williams 1998).

There is no evidence that Great Knot that spend the non-breeding season in east or south-east Australia use north-west Australia as a staging area on either southward or northward migration.

Red Knot

Red Knot occur widely all round the coast of Australia and in New Zealand. A difference in migration patterns occurs, although not quite so marked as in the Bar-tailed Godwit, between the birds marked in north-west Australia and those from east and south-east Australia. (Lindstrom *et al*. 1999). Birds from all regions show a heavy concentration around the shores of the Yellow Sea during the period of northward migration in April and May (Fig. 20). The centre of the migratory movement appears to be slightly further west than that for Great Knot with few reports from southern Japan and proportionately fewer from Korea. The many reports from Hong Kong and Taiwan may again be birds which did not achieve their intended goal of the Yellow Sea in a single flight from Australia.

Most of the birds from north-west Australia seem to over-fly Siberia on their way to the breeding grounds of the *piersmai* subspecies in the New Siberian Islands (Tomkovich 2001). One bird marked there as a breeding adult was subsequently seen five times in north-west Australia (Lindstrom *et al*. 1999). There have also been some recent sightings of Red Knot flagged in north-west Australia in the Chukotsk region of north-east Siberia, the breeding area of the *rogersi* subspecies. There have, however, been more flag sightings linking the *rogersi* subspecies with eastern and south-eastern Australia and New Zealand. There has also been one recapture in Victoria of a Red Knot banded as a chick in Chukotsk.

There have been few reports of marked Red Knot on southward migration in Asia but several reports from around the Sea of Okhotsk suggest that many Red Knot may be making a non-stop migration from there to the coasts of northern Australia in a similar way to the Great Knot.

A large number of Red Knot banded and flagged in east and south-east Australia have subsequently been recaptured or seen in New Zealand (Tomkovich & Riegen 2000, Riegen *et al*. 2005). Some of these are adult birds which were passing through eastern parts of Australia on their way to or from their non-breeding areas in New Zealand, but most were birds which spent their first year (sometimes two years) in Australia and then transferred, permanently, to a non-breeding area in New Zealand. The quite large number of movements to New Zealand of birds marked in north-west Australia is not yet fully understood. They suggest that there is not a clear-cut separation- of *piersmai* to north-west Australia and of *rogersi* to eastern Australia and New Zealand (Tomkovich and Riegen 2000).

There have been a few movements, in both directions, of Red Knot between north-west Australia and east and south-east Australia but these are not indicative of north-west Australia being a regularly used gateway by Red Knot which spend the non-breeding season in eastern and south-eastern Australia. These movements are of immature birds within Australia and a few apparent changes of preferred non-breeding area.

Sharp-tailed Sandpiper

Sharp-tailed Sandpiper are spread throughout the whole of Australia, inhabiting both intertidal habitats and inland wetlands. The migratory path through Asia seems to be in a rather narrow band along the Chinese coast from Hong Kong up into the Yellow Sea, on the west coast of Korea, and in Taiwan (Fig. 21). Some birds also stopover, particularly on southward migration, on the Asian islands (e.g. Java and Borneo) between China and Australia. There is no apparent difference in migration routes between birds marked in east and south-east Australia and those from north-west Australia. There are also some trans-Australia movements with north-west Australia particularly being favoured as a stopover location on southward migration. The recoveries and flag sightings at inland locations reflect the Sharp-tailed Sandpiper's widespread use of freshwater habitats.

There are three recoveries from close to the breeding grounds on the Yakutia coast of northern Siberia. Each of these birds had been marked in a different part of Australia. There are no recoveries or flag sightings yet linking Australia with the juvenile Sharp-tailed Sandpipers which gather on the shores of south-west Alaska in August and September.

Curlew Sandpiper

Curlew Sandpiper occur all round the coasts of Australia and also, in modest numbers, at inland freshwater and saltwater locations. Overall, the spread of places in the flyway where birds have been recovered, or flagged birds have been sighted, is wider than for any other species (Fig. 22). Whilst this is partly a function of the large numbers marked it is also the result of the different, more westerly, route used by many Curlew Sandpipers on southward migration. On northward migration the front is quite narrow with almost all birds passing through Hong Kong, Taiwan and the mainland coast of China up as far as the north-west corner of the Yellow Sea. There is an almost complete absence of reports of birds from further east, with none from Korea and just two from the very southern tip of Japan. There is no indication of any difference in migration route of birds from the eastern half of Australia and those from Western Australia (Minton 1998, Minton *et al*. 2006a).

There are a number of reports of Curlew Sandpiper at inland locations in Siberia. These mostly relate to birds on southward migration, including all the recoveries and flag sightings west of 110ºE. Three of the locations in central Siberia were further west than any of the recoveries in the breeding areas. The recovery in south-east India (80ºE) and the flag sighting in Sri Lanka were even further west. It therefore appears that Curlew Sandpiper make a loop migration with the southward migration path being generally well to the west of the northward migration route. There is also quite a number of reports of Australian-marked Curlew Sandpiper in Indonesia, indicating that at least some birds make a stopover there before they reach northern Australia. Within Australia there is a large number of recorded movements of Curlew Sandpiper between the north-west and the south-east (Minton *et al*. 2006b). North-west Australia is used as a major stopover location on northward and, especially, southward migration.

Recoveries and flag sightings on the northern Siberian breeding grounds of Curlew Sandpiper have all been of birds marked in east and south-east Australia (Minton *et al*. 2006a). Surprisingly, none have yet been reported for birds marked in north-west Australia. Most Curlew Sandpiper which come to Australia breed in northern Yakutia but some come from as far west as the Taimyr Peninsula, the furthest being at 98ºE. This breeding bird was recovered more than 13,000 km from where it was banded in Victoria.

Red-necked Stint

Red-necked Stint is the most widespread and numerous wader species in Australia inhabiting all coastal areas and, to a lesser extent, inland wetland habitats. Consequently there are more recoveries and flag sightings for this species than for any other (Fig. 23). They seem to migrate northwards through Asia on a much broader front than Curlew Sandpiper. Stopover locations range from Vietnam right along the Chinese coast and Korea to, extensively, Japan. There is no apparent difference between the migration routes used by birds from different parts of Australia.

There are quite a number of reports from inland locations in Siberia indicating that on both northward and southward migration many birds will make a stopover between the Asian coastline and the north Siberian breeding areas. The Daurian steppes, near the junction of Mongolia, China, and Siberia, are particularly favoured on northward migration (Goroshko 1999). There is a tendency for the more westerly reports to relate to southward migration but the Red-necked Stint certainly does not show the large westward loop migration of the Curlew Sandpiper.

There have been quite a number of reports of Australian-marked Red-necked Stint in the island countries between the

Asian mainland and northern Australia. Indonesia is particularly favoured as a stopover location, particularly during southward migration. It is probable that the smaller size, and consequently shorter flight range, of the Red-necked Stint is the main reason for it being much more frequently reported at these intermediate locations.

There have been numerous recorded movements of marked Red-necked Stint within Australia. These have particularly occurred between north-west and south-east Australia, with north-west Australia being used as an important stopover location, particularly during southward migration.

There have been a small number of movements of Red-necked Stint from Victoria to New Zealand but the population there is only very small.

Recoveries on or near the breeding grounds have been across the full range of the breeding areas in northern Siberia, from the Taimyr Peninsula in the west to the very eastern end of the Chukotsk Peninsula. The original hypothesis that this species exhibited a crossover migration, with birds from the west of the breeding area spending the non-breeding season further east, and vice versa, has not been supported by later recoveries and flag sighting reports (Minton 1996). Nevertheless it is interesting that a bird banded as an adult at its nest at Uelen at the very eastern end of its range was subsequently recaptured in Perth in Western Australia, about as far west as it could go.

Long-toed Stint

Long-toed Stint occur in only small numbers in Australia, mostly in freshwater habitats in the northern parts of Western Australia and occasionally as far south as the Perth region. Only a few have been caught in Australia. The first overseas flag sighting has just been reported (September 2006) from Malaysia (Fig. 24).

Broad-billed Sandpiper

Broad-billed Sandpiper occur in only moderate numbers in Australia, mostly on the northern coast and particularly in north-west Australia. The few recoveries and flag sightings which have so far been reported indicate a migration route through Asia ranging from Hong Kong to northern Japan (Fig. 25). There has been one report in Russia, from northern Sakhalin Island, but none yet from the area of the breeding grounds in northern Siberia.

Sanderling

Sanderling occur all round the coasts of Australia but their distribution is rather uneven. Marking has been confined to the south-east of South Australia, Victoria and north-west Australia. Sanderling show a strong easterly bias in their migration corridor through Asia (Fig. 26). Japan is strongly favoured as a stopover location on both northward and southward migration. Many reports have also come from Korea and from the Chinese coast down to Hong Kong and from Taiwan. The more westerly locations seem to be used mainly on northward migration, with a strong bias towards Japan on southward migration. There does not appear to be any marked difference in the migration route used by Sanderling from different parts of Australia.

There have also been many movements by Sanderling recorded between north-west Australia and south-east Australia, indicating that north-west Australia is used as a migratory stopover on northward and, especially, southward migration.

The only record linking the northern Siberian breeding grounds with the non-breeding areas in Australia is a leg flagged bird from south-east Australia which was seen on its breeding territory on the New Siberian Islands in July 1994. In addition, there is quite a number of reports of marked Sanderling from the northern end of Sakhalin Island indicating that this is an important stopover location in eastern Siberia for birds on their way to and from their breeding area.

DISCUSSION

Each of the 26 species for which movement data are available has its own migration pattern. These patterns depend on a number of factors including:

- the location of the breeding areas;
- the habitat preferences and availability for migratory stopovers;
- the size, and therefore the flight range, of each species;
- the areas of Australia used as non-breeding areas.
- the population structure i.e. when different sub-species/sub-populations are involved.

The most common feature of the migration routes is the extensive use of the coastline of China as a major stopover location, especially during the northward migration between late March and mid-May. Twenty of the 26 species have recoveries and flag sightings from China. Most reports are from Shanghai northwards around the western and northern shores of the Yellow Sea. However, the extensive reports from Hong Kong and Taiwan suggest that the southern half of the mainland Chinese coast may also be extensively used and that the relative lack of reports from there may be more related to a lack of observers or hunters than to habitat. The Yellow Sea shores of Korea and Japan are also extensively used.

The islands and countries between the north coast of Australia and the Asian mainland seem to be over-flown by most species, especially on northward migration. Pre-migratory weight data collected in Australia indicates that most species take on sufficient fuel in the form of fat reserves to make the journey from northern Australia to the Asian mainland non-stop (Barter & Wang Tian-Rou 1990). Only the smaller waders such as Red-necked Stint and Curlew Sandpiper, and to a lesser extent Sharp-tailed Sandpiper, seem regularly to use Indonesia and other countries in the region for stopovers.

The migration routes of some species cover a broad spread of longitude, whilst others seem to have a narrower more focussed migration route through Asia. In part this may reflect the breadth of the breeding area to which birds are migrating but this is not always the case. The species with the widest range of stopover locations are Red-necked Stint, Curlew Sandpiper, Bar-tailed Godwit, Grey-tailed Tattler, Terek Sandpiper, Ruddy Turnstone and Lesser Sand Plover. Most of these have a wide breeding range. In contrast only relatively narrow migratory paths are shown by species such as Eastern Curlew, Grey Plover, Greater Sand Plover, Black-tailed Godwit, Red Knot and Sharp-tailed Sandpiper. Some of these have relatively restricted breeding ranges.

The migration route of almost all species extends across the central part of the East Asian–Australasian flyway but some species have a distinct bias towards one half of the flyway. Those with the most easterly routes are Sanderling, Grey Plover, Eastern Curlew and Whimbrel. In contrast there is a strong westerly bias in the Greater Sand Plover movement pattern and that of the Curlew Sandpiper on its southward migration.

In some species there is a strong tendency for birds from non-breeding areas in the eastern half of Australia to have a more easterly migration route through Asia than birds marked in north-west Australia. However in other species there does not appear to be any difference in migration routes through Asia for birds from different non-breeding areas in Australia. In some cases these migration route differences may be associated with the different breeding areas used by the populations. The most extreme example is shown by Bar-tailed Godwit on southward migration where the Alaskan breeding birds migrate directly across the Pacific to their non-breeding areas in eastern Australia (and New Zealand) whilst the Yakutia breeding population migrates back through eastern Siberia and the Yellow Sea to north-west Australia.

The breeding areas of waders which visit Australia extend across a 110º range of longitude in the Arctic. The spread of non-breeding areas in Australia is only 40º. However because Australia is closer to the equator the actual difference between the two ranges is not very great. The most north-westerly breeding location recorded was a Curlew Sandpiper in the Taimyr Peninsula at 98ºE, but Red-necked Stint and Sharp-tailed Sandpiper (presumably from Australia) also breed in this part of north-west Siberia. The Bar-tailed Godwit sighting at 149ºW, on the northern coast of Alaska, was the easternmost report from the breeding grounds. It was not all that far from reaching Canada.

Bar-tailed Godwit and Pacific Golden Plover are the only Alaskan-breeding waders so far known to visit Australia. The non-breeding range of Ruddy Turnstones from Alaska extends to the Pacific Islands; it is possible that the fringe of this range may just reach north-east Australia, but there is no evidence of this so far. Some juvenile Sharp-tailed Sandpipers, which have been bred in Siberia, use the south-west shores of Alaska for fattening before southward migration. Reports of these birds in Australia are likely to occur in the near future now that banding and flagging of these is now taking place there (R. Gill pers. comm.).

Migratory links between Australia and New Zealand are confined to only a few wader species. Foremost is the New Zealand-breeding Double-banded Plover; part of this population comes to south-eastern parts of Australia for the austral autumn and winter. Many Red Knot and Bar-tailed Godwit visit Australia during migration to and from New Zealand. Also, some spend the first year or two of their lives in Australia before moving to New Zealand non-breeding areas. Quite a few New Zealand Ruddy Turnstone also use south-east Australia as a migratory staging area. All of the very small New Zealand population of Red-necked Stint probably uses eastern Australia as a migratory stopover location.

A more in-depth analysis of the migration routes, stopover locations, breeding destinations and non-breeding areas of each species is necessary for a full understanding of the migratory strategy and habits of each population. It does, however, appear that most species have at least one, and in some species several, long-hop stages during both their northward and southward migrations (Barter 1996). These long flights are interspersed with periods when birds are laying down fat reserves for the next stage of their migration. Intermediate short distance movements may take place to adjust for any shortfall arising because intended destinations, whether they be breeding locations, stopover sites or non-breeding areas, may not always be reached in the planned flight. In Asia, for example, the preferred fattening area for many species on northward migration appears to be the Yellow Sea. Those making a landfall south of this area may thus make intermediate relatively short journeys up the Chinese coast, or from southern Japan, to reach this preferred staging area (Barter *et al*. 1997). Another example is given by the many recoveries and flag sightings in Siberia just to the south of the breeding ranges. These suggest that some birds may either deliberately stop before reaching their final destination or that weather conditions (e.g. late snow melt) may cause them temporarily to halt the last stage of their migration before they reach the breeding areas. Within Australia also, especially on southward migration, some species appear to make quite short movements, especially down the east coast on their way to non-breeding areas in Victoria. Overall, all species (except the Double-banded Plover) make at least one stopover on their migration between their breeding areas and non-breeding areas, and most species probably make two to four stops. Whilst they may have a preferred migratory strategy, they also need a flexible approach to cater for shortfalls in achievement, mainly likely to be caused by encountering adverse weather conditions during a migratory flight.

Knowing migration routes and stopover locations is important for conservation purposes if the population of any species is found, through regular population monitoring in the non-breeding areas, to be decreasing. It is the areas in Asia used by waders on migration which seem to be under the greatest threat at the present time. There have been few major changes in the availability or quality of inter-tidal habitats in the Australian non-breeding areas. There has been some loss of inland fresh water habitat in the past, but this is compensated to some extent by man-made habitats such as rice fields, saltworks etc. In the breeding regions in Siberia there have been few changes. This may alter in the longer term as a result of global warming; this could lead to a reduction in the area of breeding habitat available in the Arctic.

Changes in habitat in the Asian migratory stopover areas have, in contrast, been extensive and are still ongoing. Large areas of inter-tidal mudflats and sand flats have been reclaimed for agriculture, industrial development, housing, and the creation of fish and shrimp farms and other aquaculture. If waders are not able to put on sufficient fat at migratory stopovers to make the next stage of their migratory flight their breeding success and survival may be impaired. This is particularly so on northward migration where they have a tight time scale. If this is not met then chicks will hatch later than the optimum time and they may miss the peak period of food availability in the short Arctic summer. The northward migrating adults also need to be able to put on enough of a fat reserve to cover for - possible scarce food resources - in the Arctic – soon after they arrive if late snowfalls occur. This is a time of peak energy need for the adults, with the female laying the equivalent of almost her own body weight in eggs within days of arrival.

Because of the critical role of migratory stopovers in a wader's annual cycle, and because of the real threats resulting from habitat loss in the flyway, a Network of Shorebird Reserves has been set up in the East Asian–Australasian Flyway over the last seven years in a collaborative approach between Wetlands International and the governments of most countries in the flyway. The banding and flagging data was an important foundation for this. These reserves are helping to preserve key stopover sites. However it is almost certain that the population declines which have been recorded now in a number of species are the result of habitat losses which have occurred since shorebird monitoring in the flyway began in the 1970s and 1980s. It is to be hoped that future developments can be successfully encouraged to avoid damaging the now increasingly well-identified important stopover locations.

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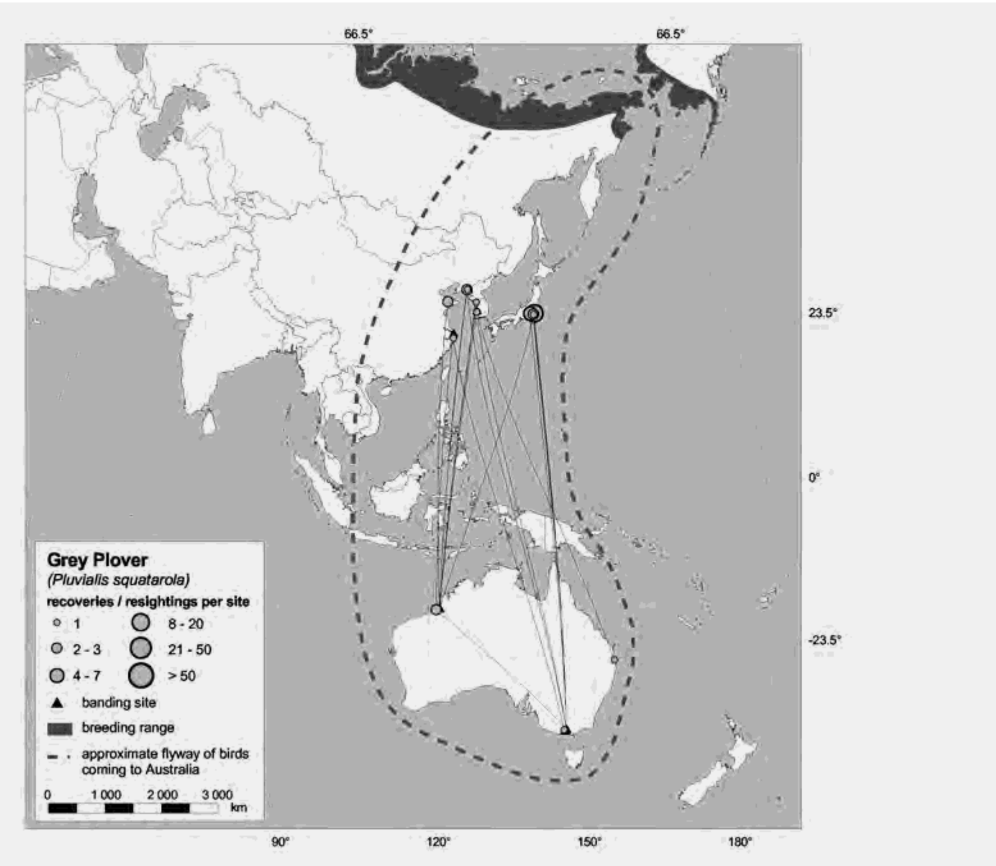

Figure 1. Grey Plover

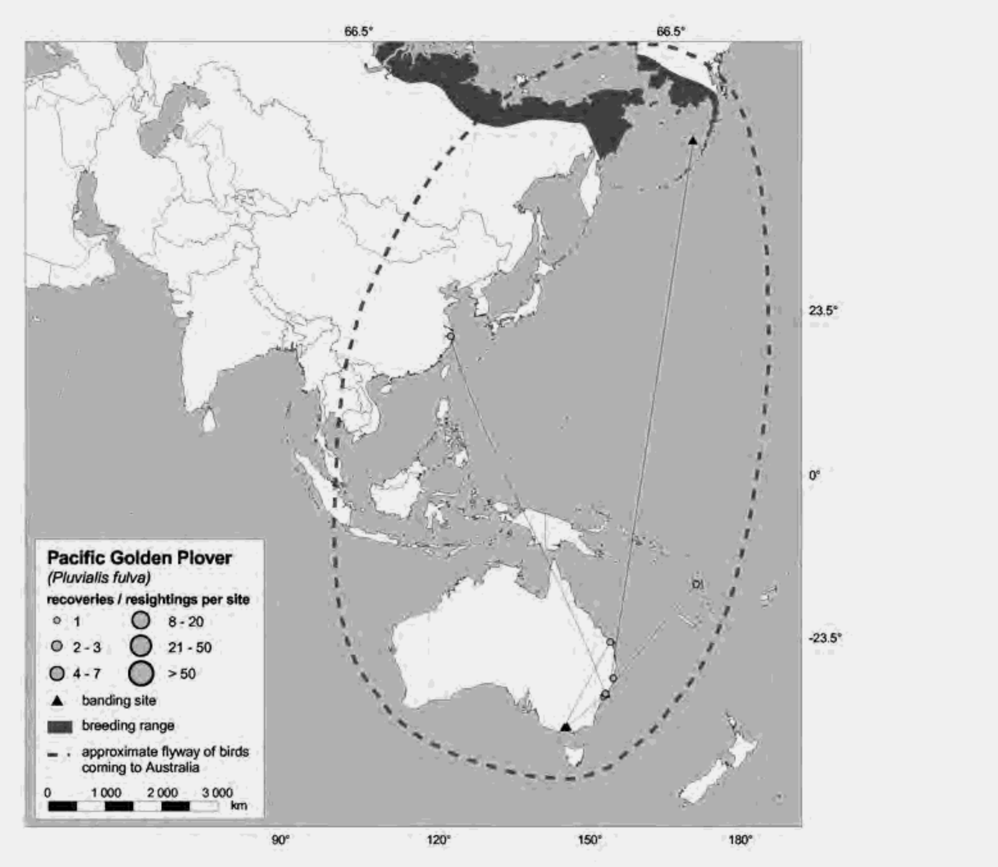

Figure 2. Pacific Golden Plover

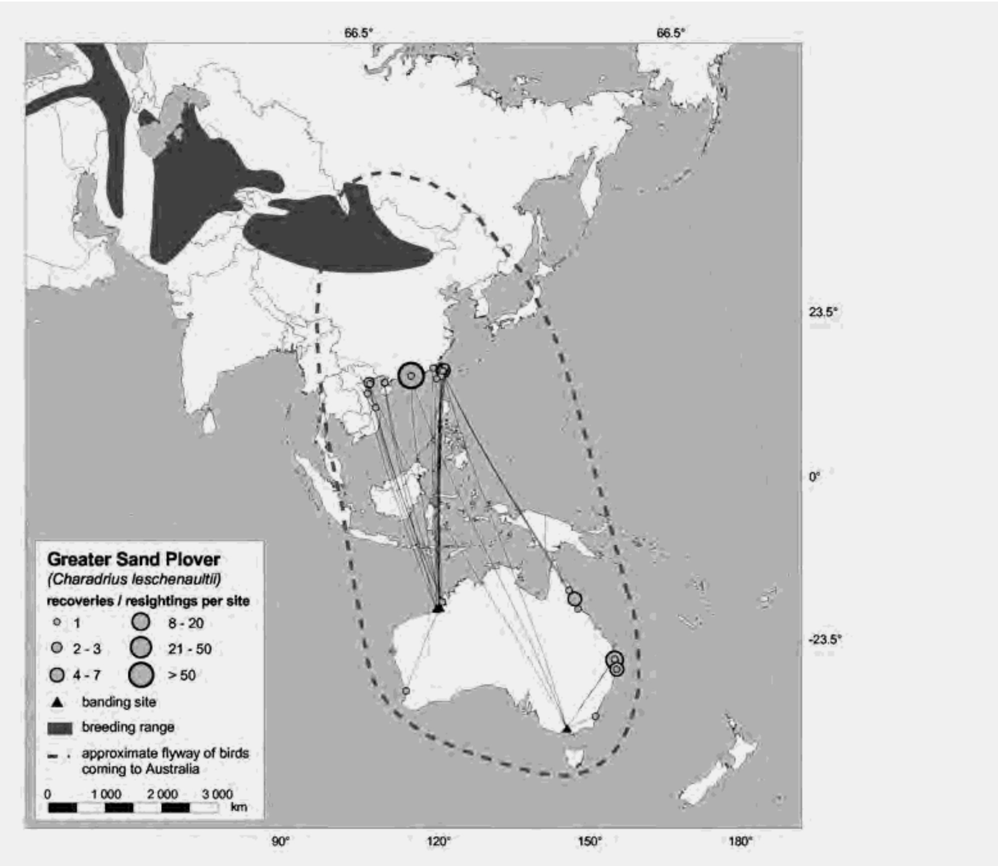

Figure 3. Greater Sand Plover

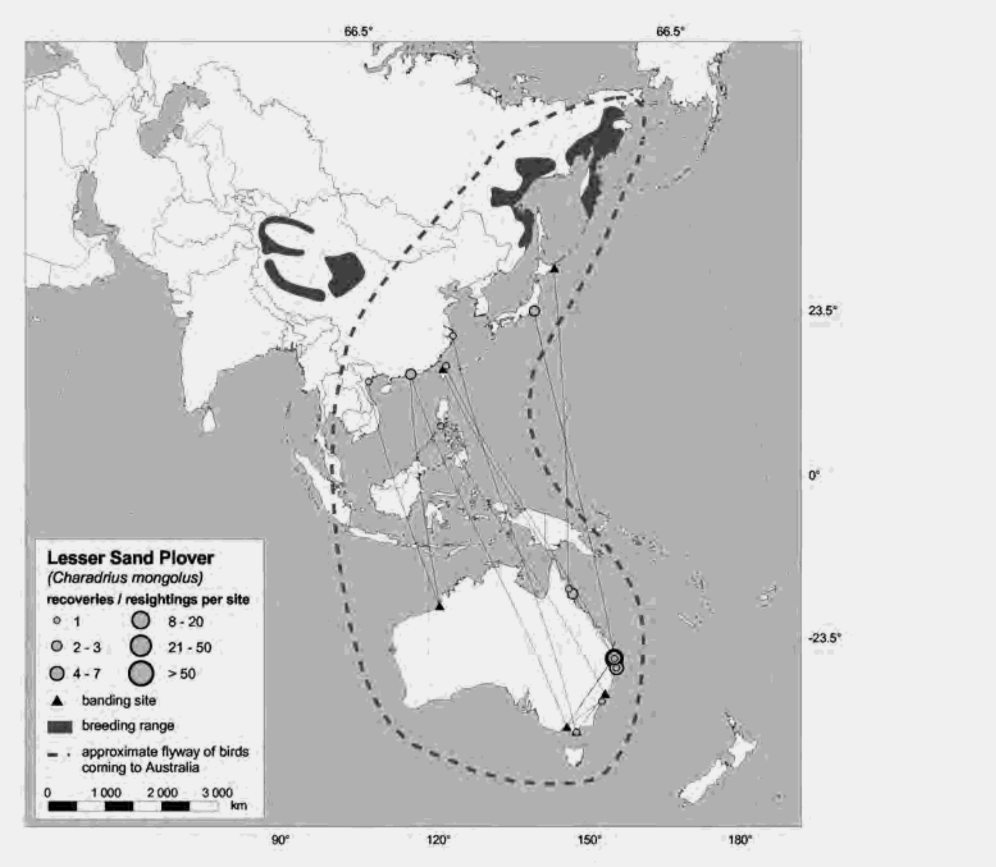

Figure 4. Lesser Sand Plover

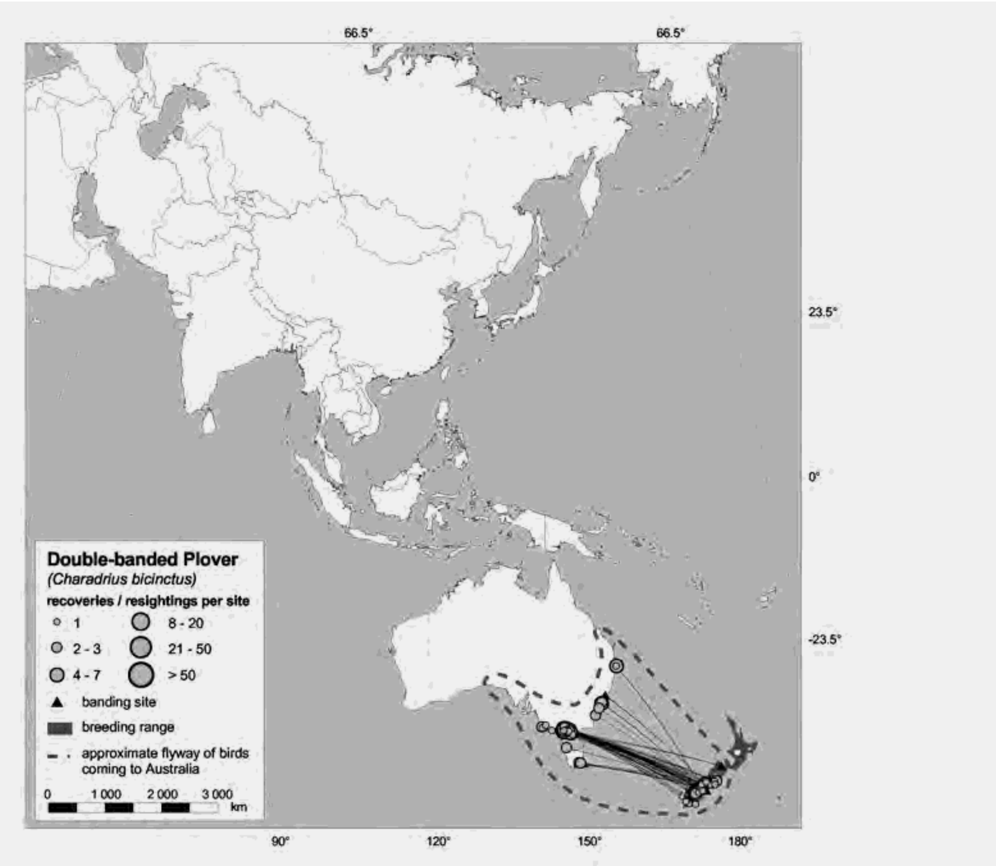

Figure 5. Double-banded Plover

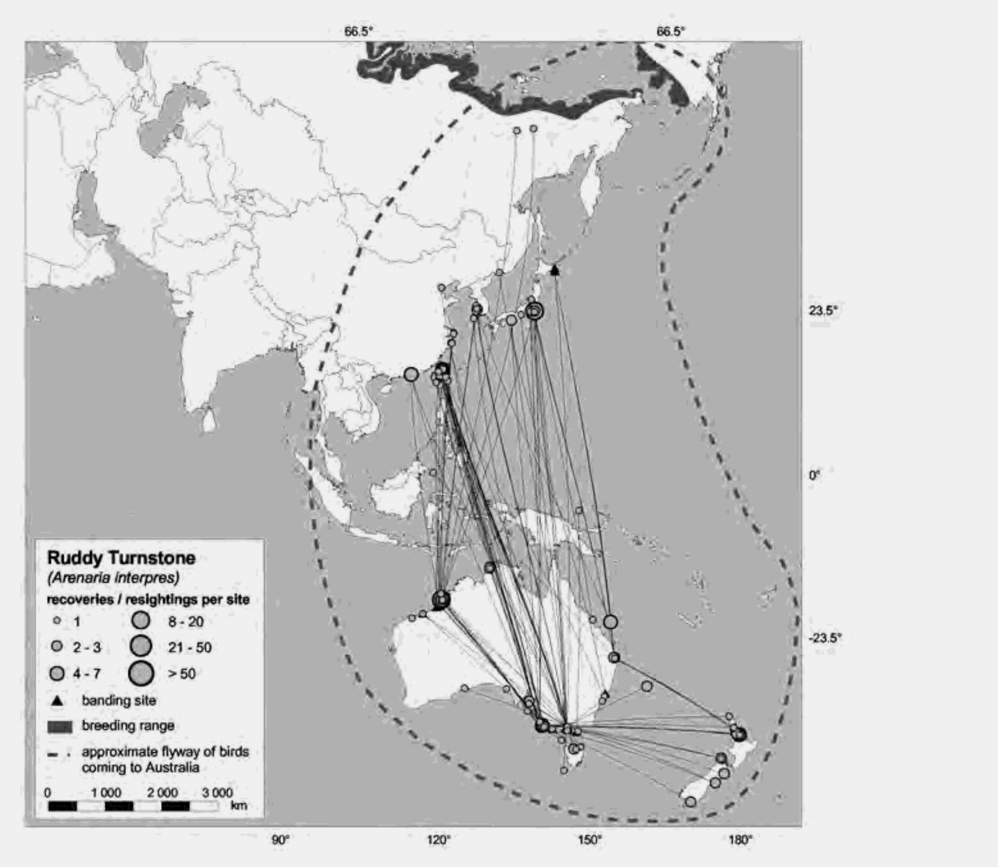

Figure 6. Ruddy Turnstone

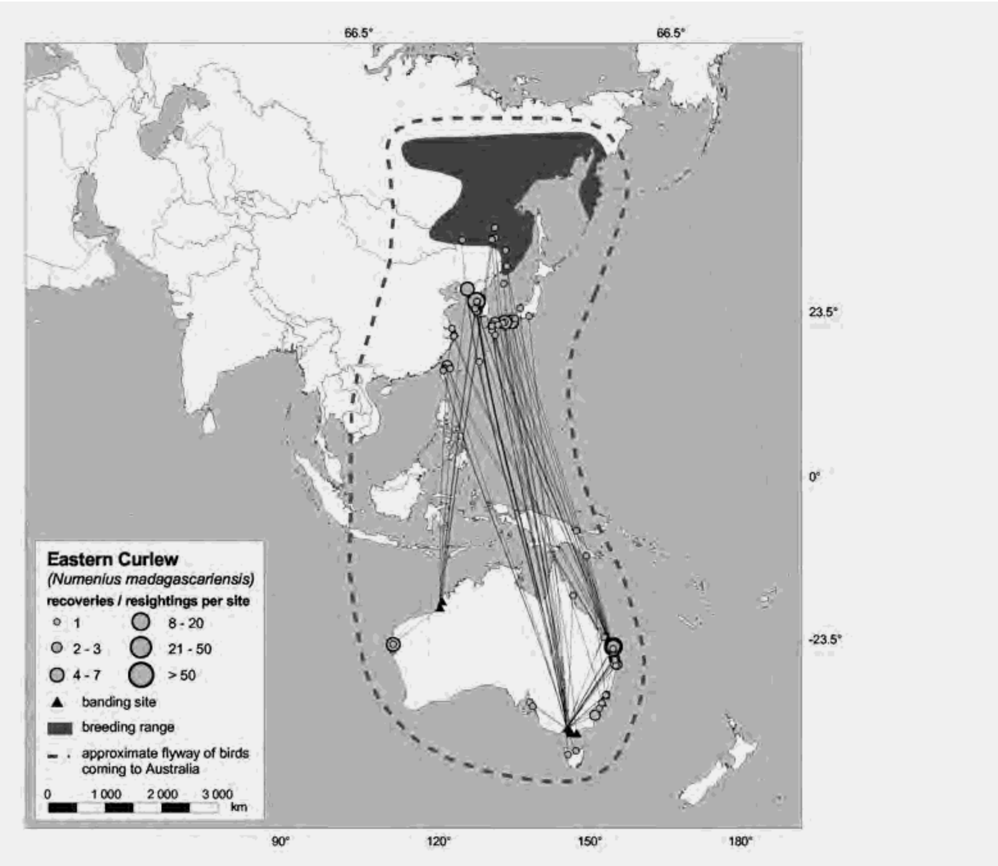

Figure 7. Eastern Curlew

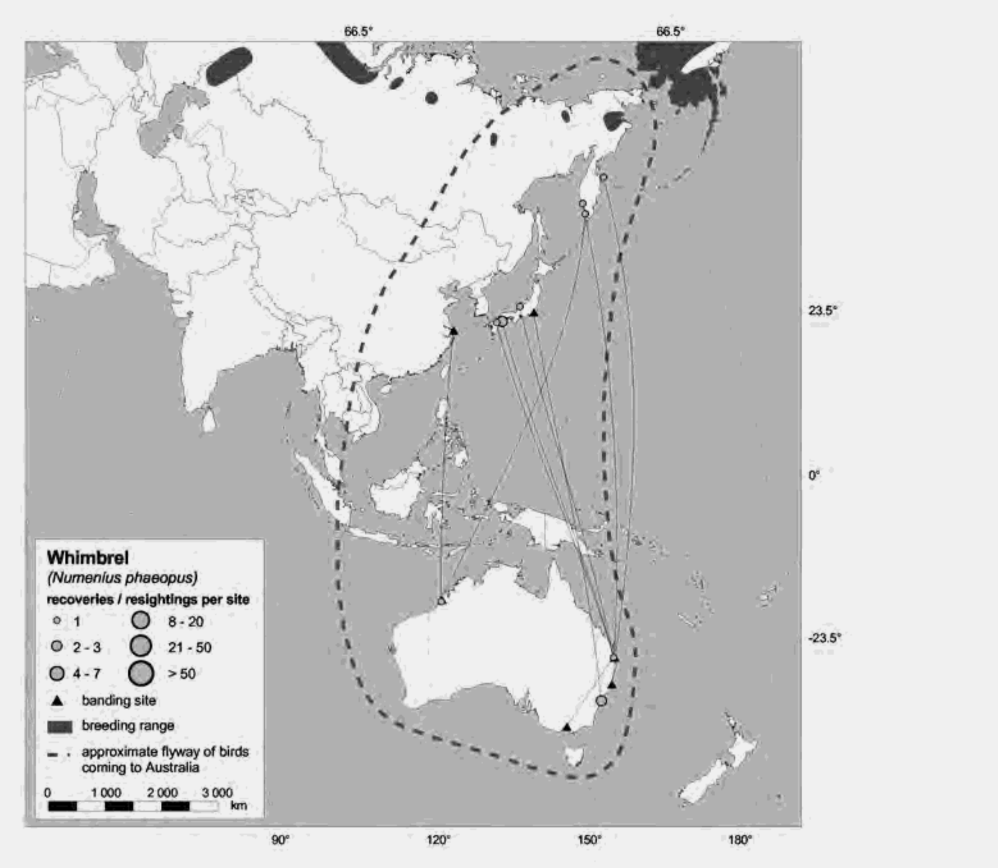

Figure 8. Whimbrel

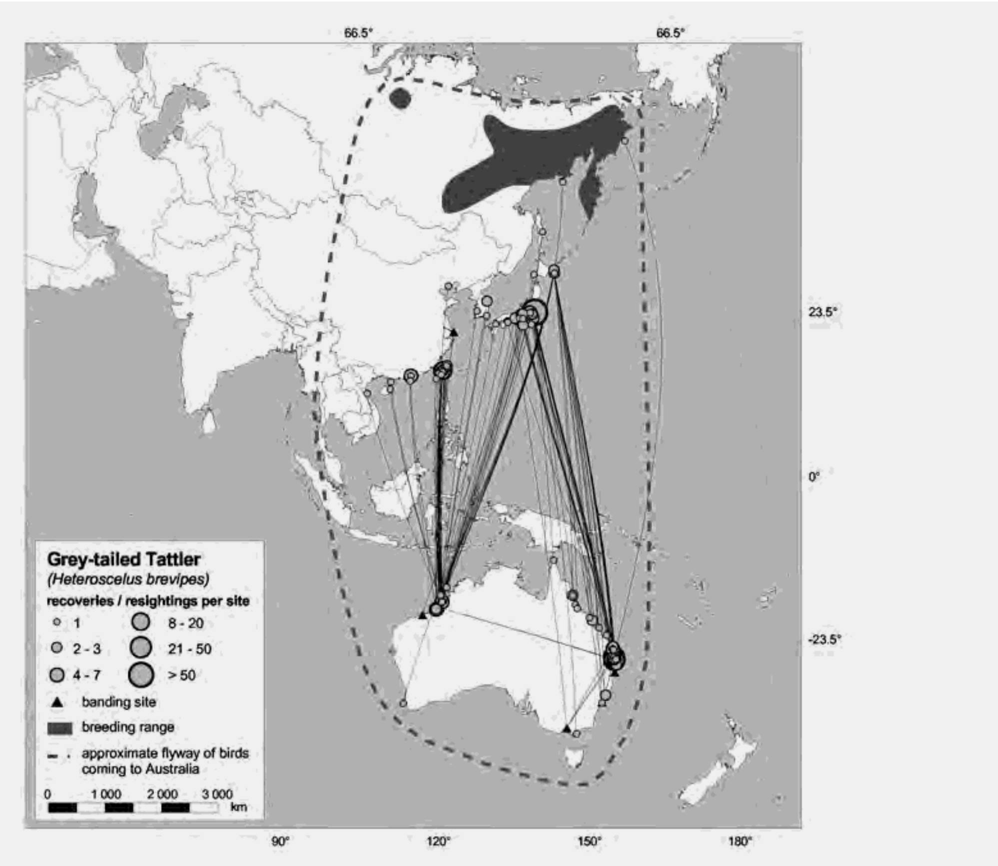

Figure 9. Grey-tailed Tattler

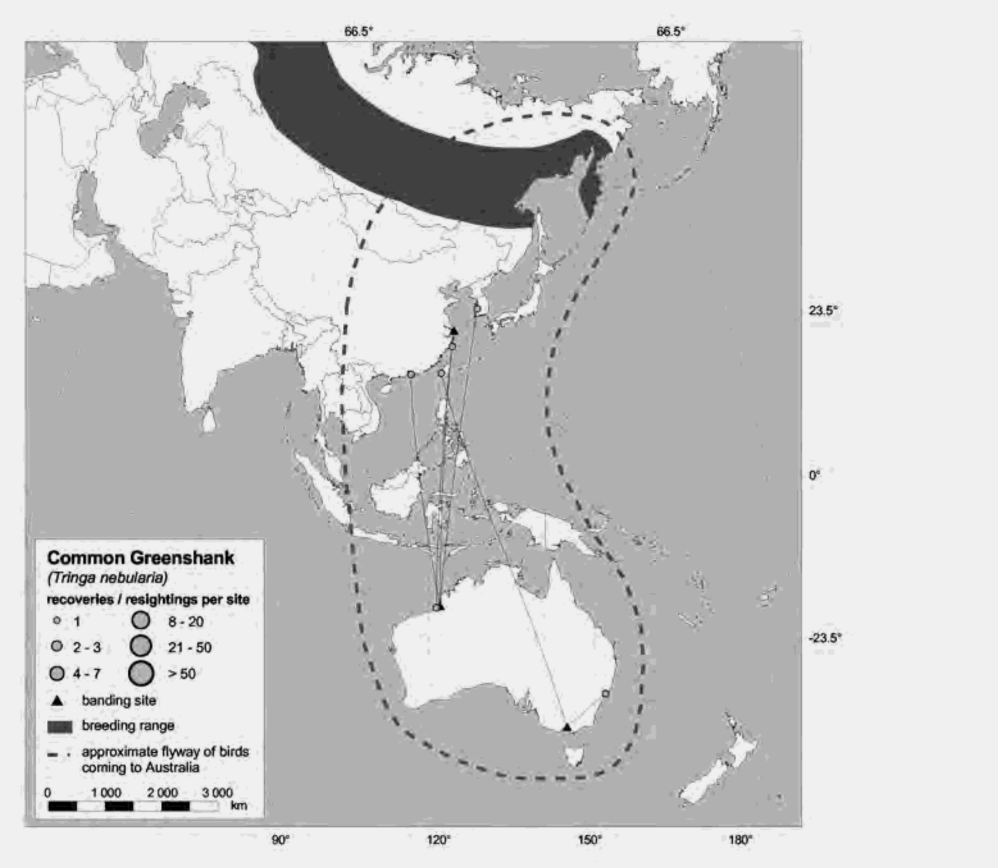

Figure 10. Common Greenshank

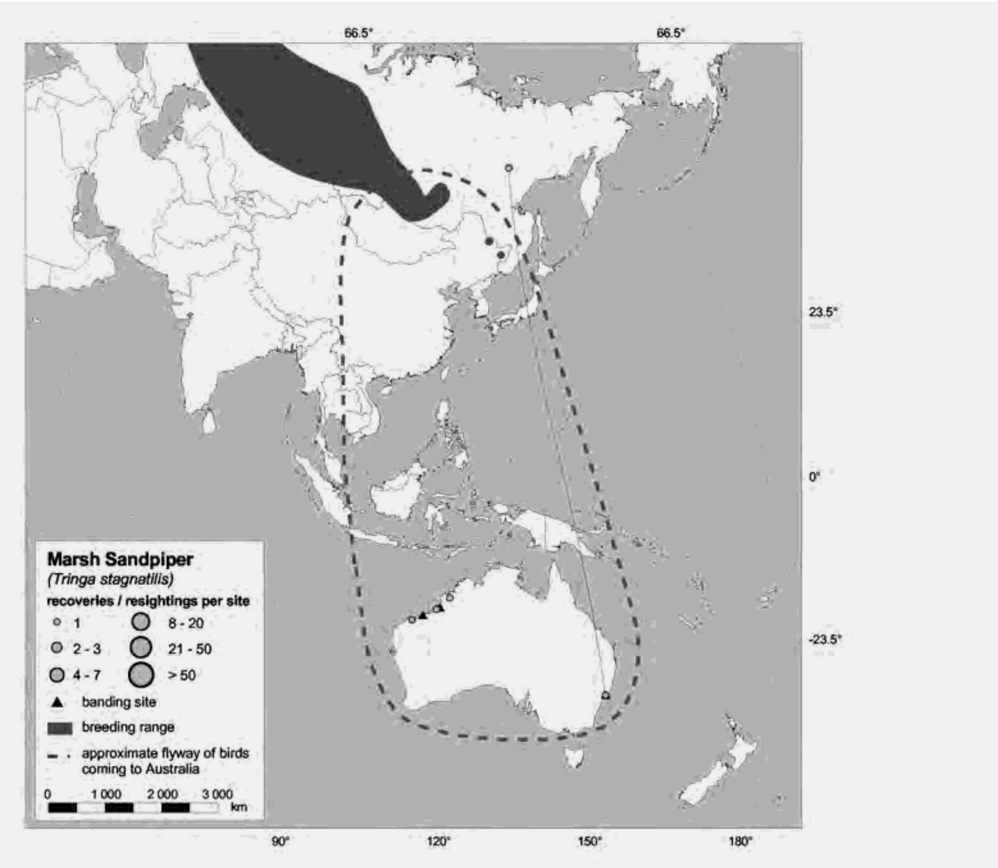

Figure 11. Marsh Sandpiper

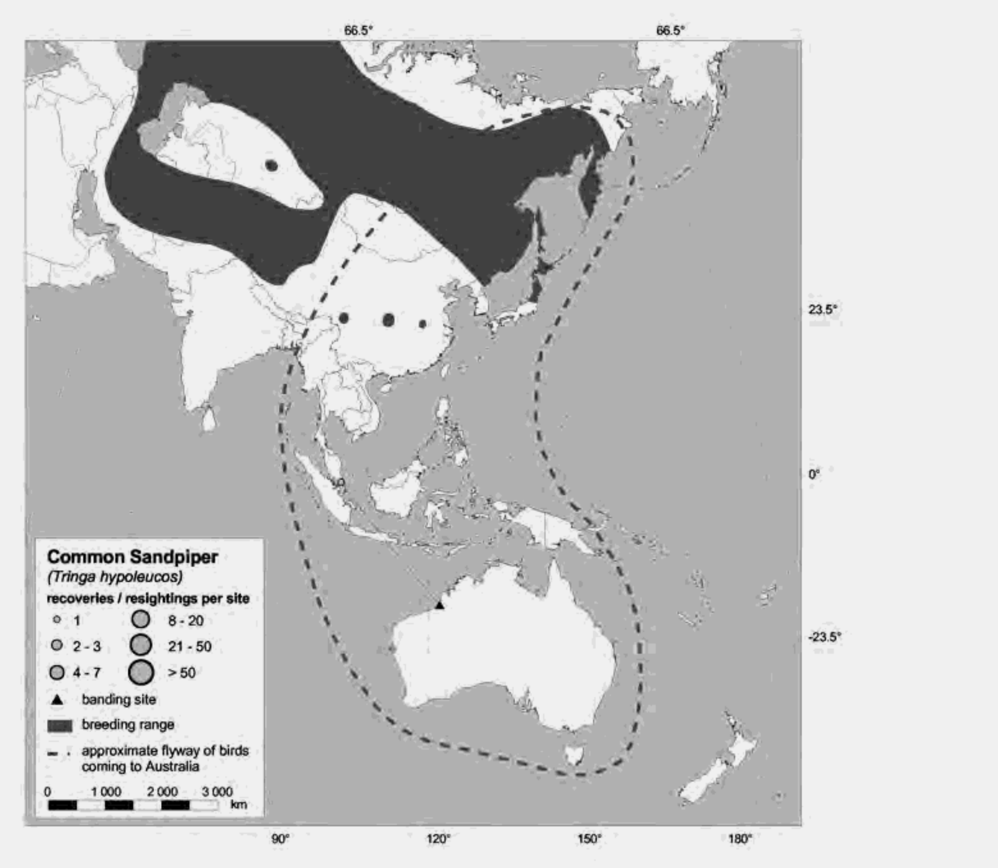

Figure 12. Common Sandpiper

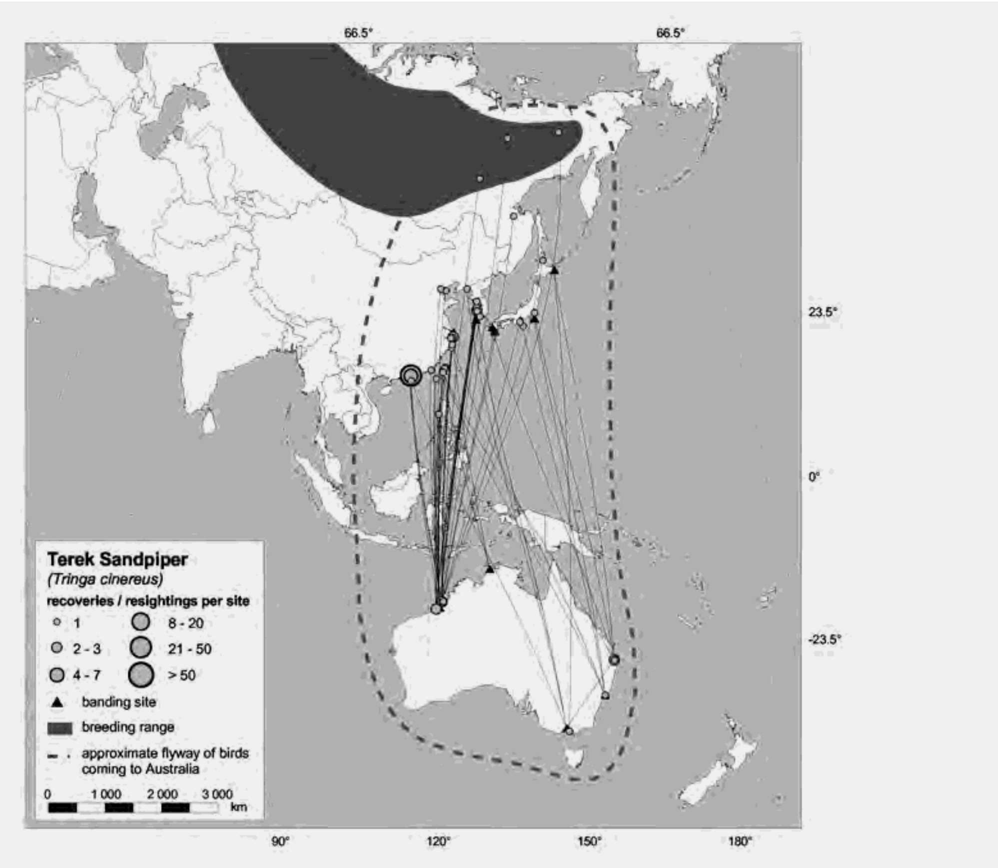

Figure 13. Terek Sandpiper

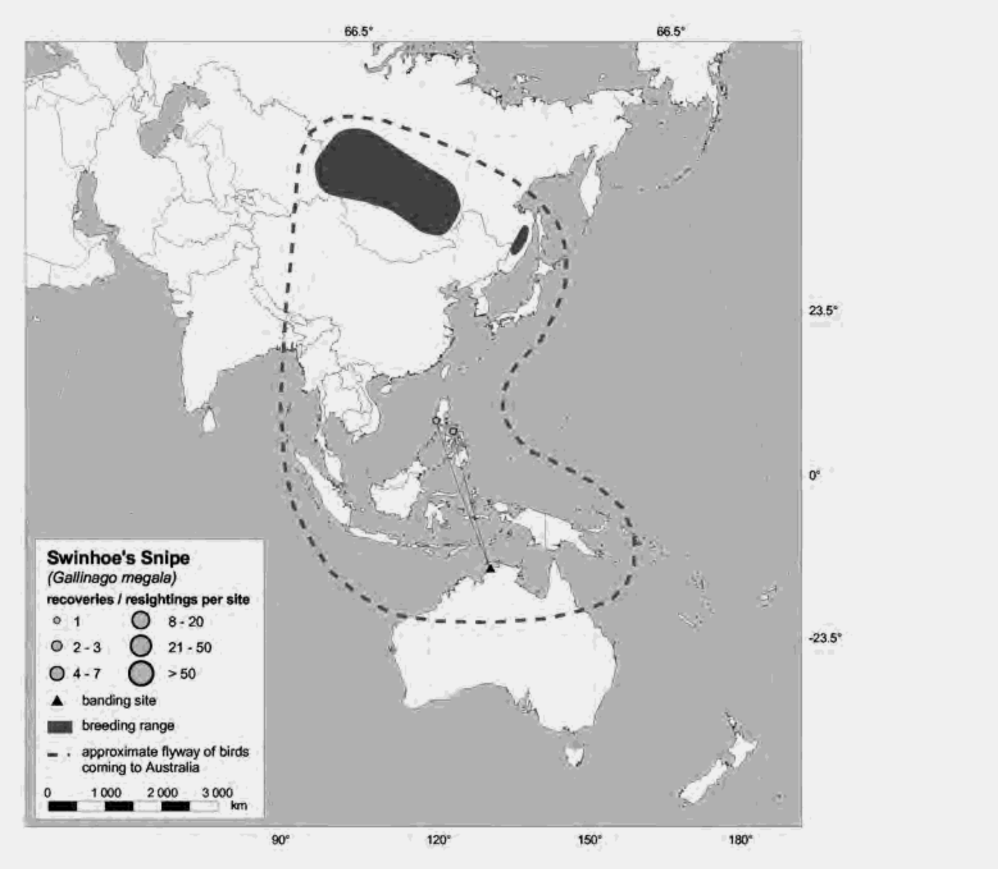

Figure 14. Swinhoe's Snipe

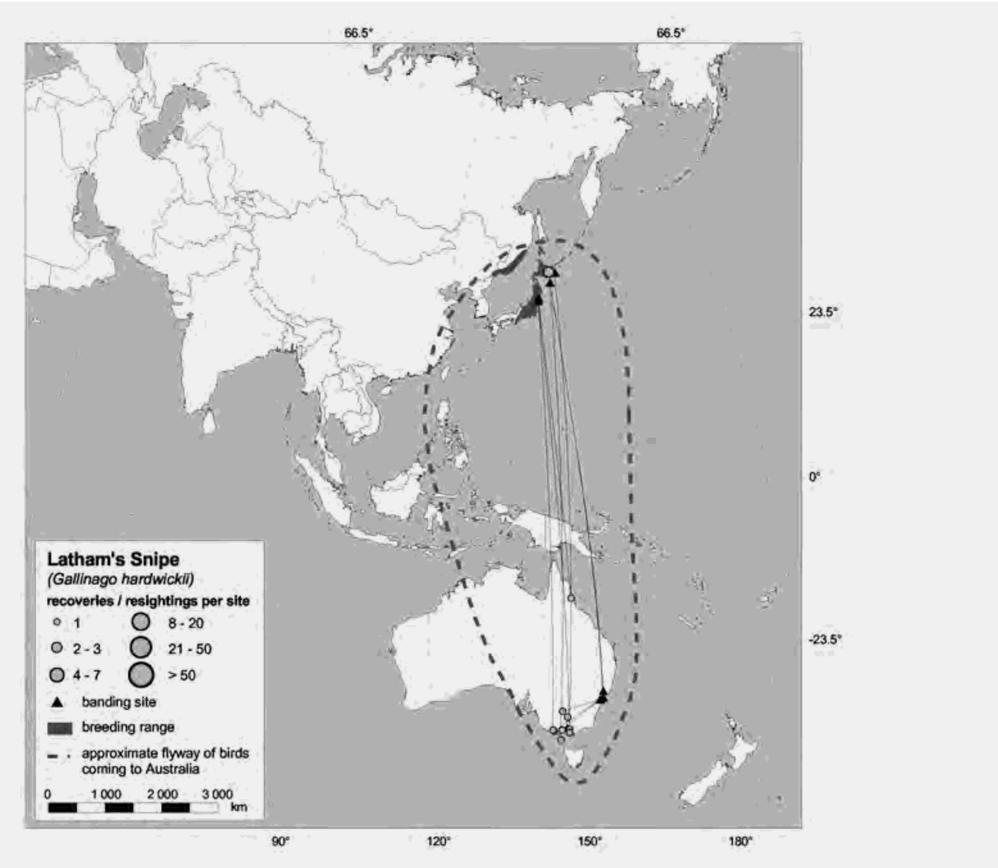

Figure 15. Latham's Snipe

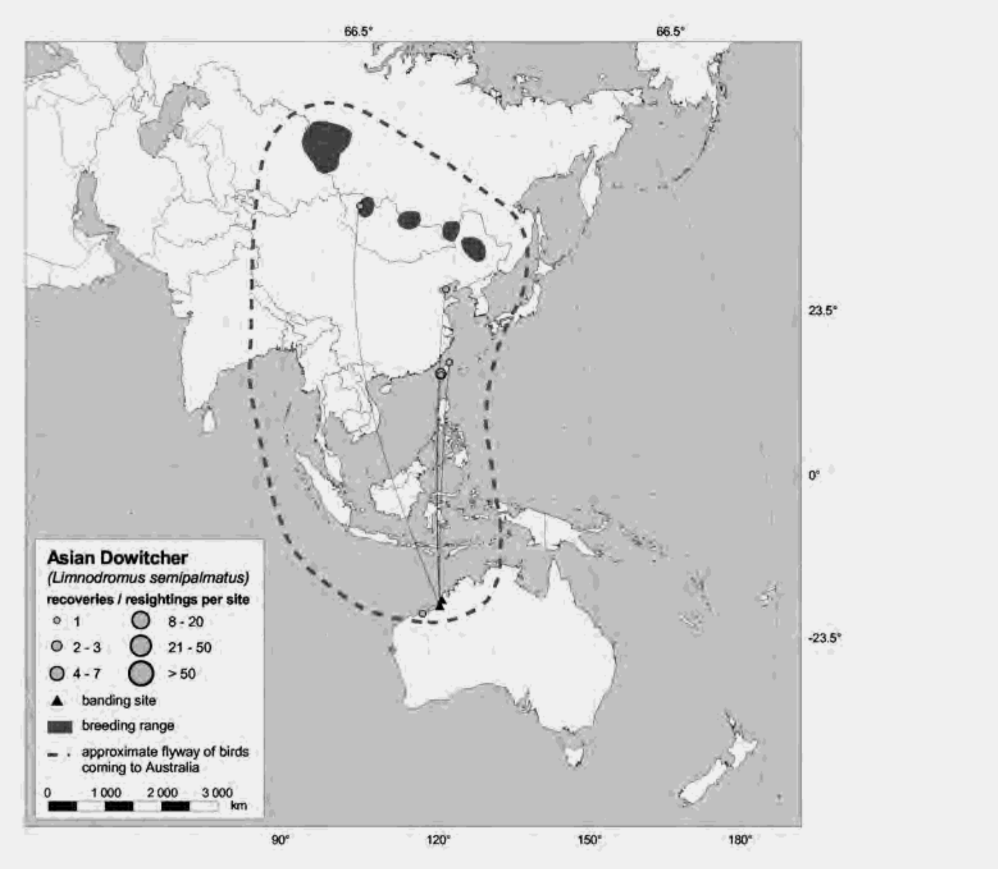

Figure 16. Asian Dowitcher

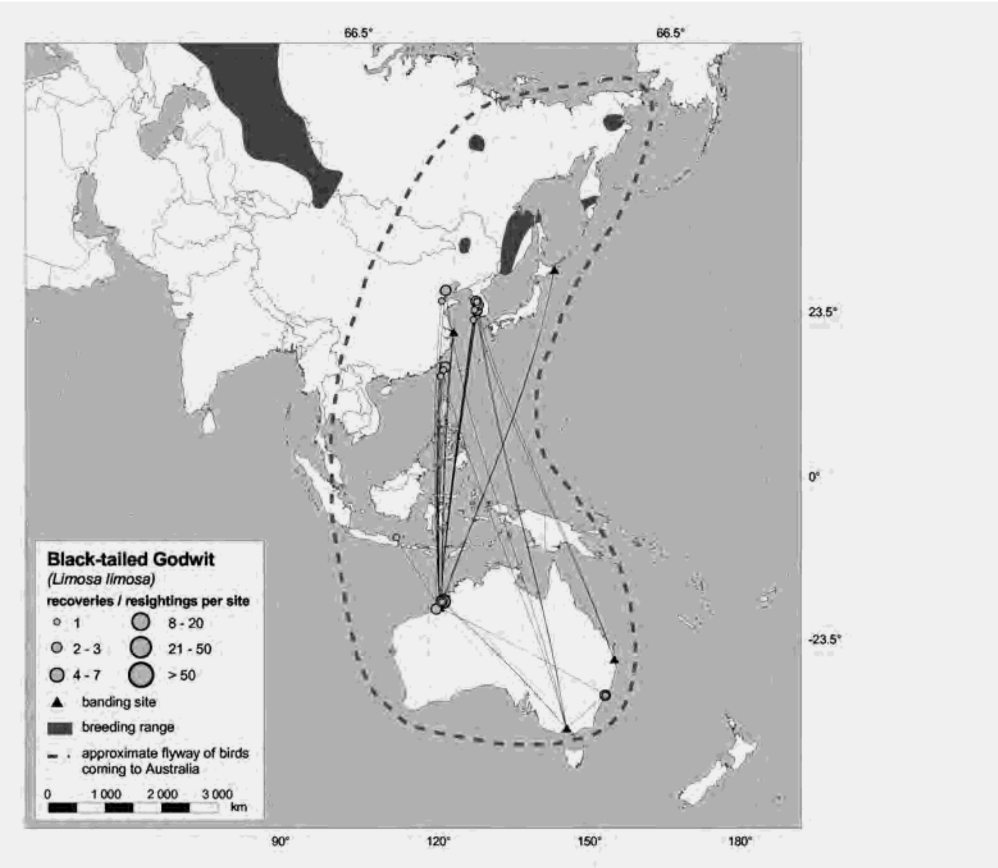

Figure 17. Black-tailed Godwit

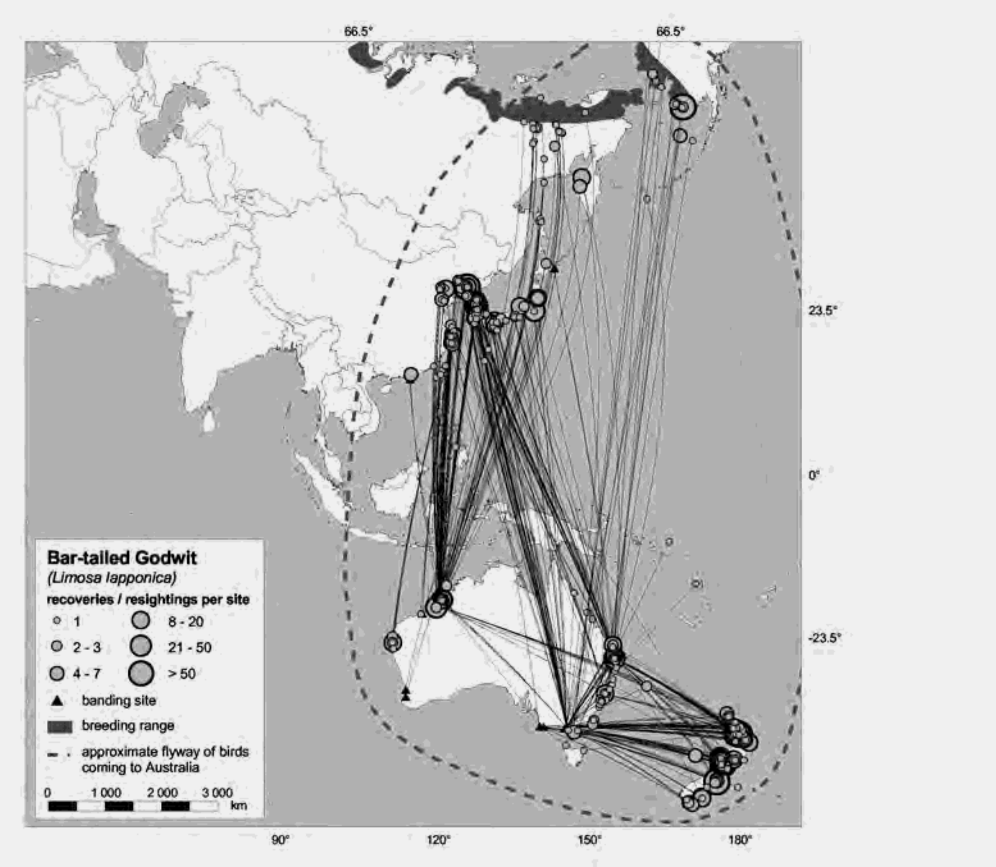

Figure 18. Bar-tailed Godwit

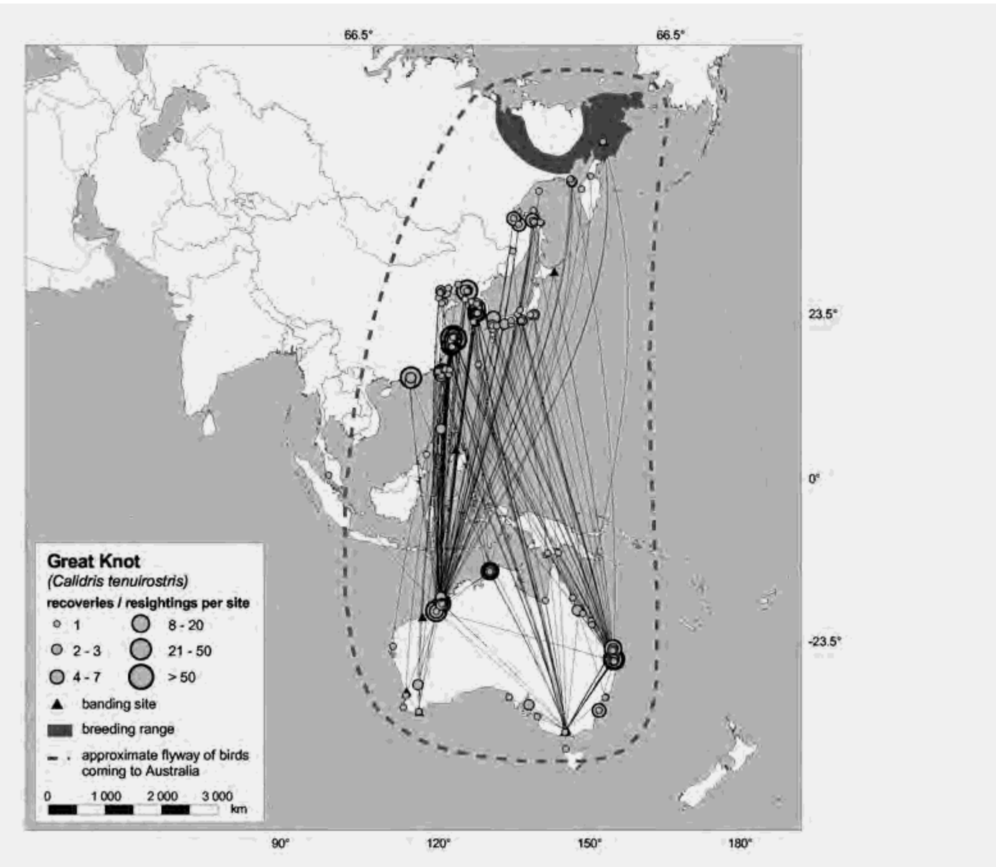

Figure 19. Great Knot

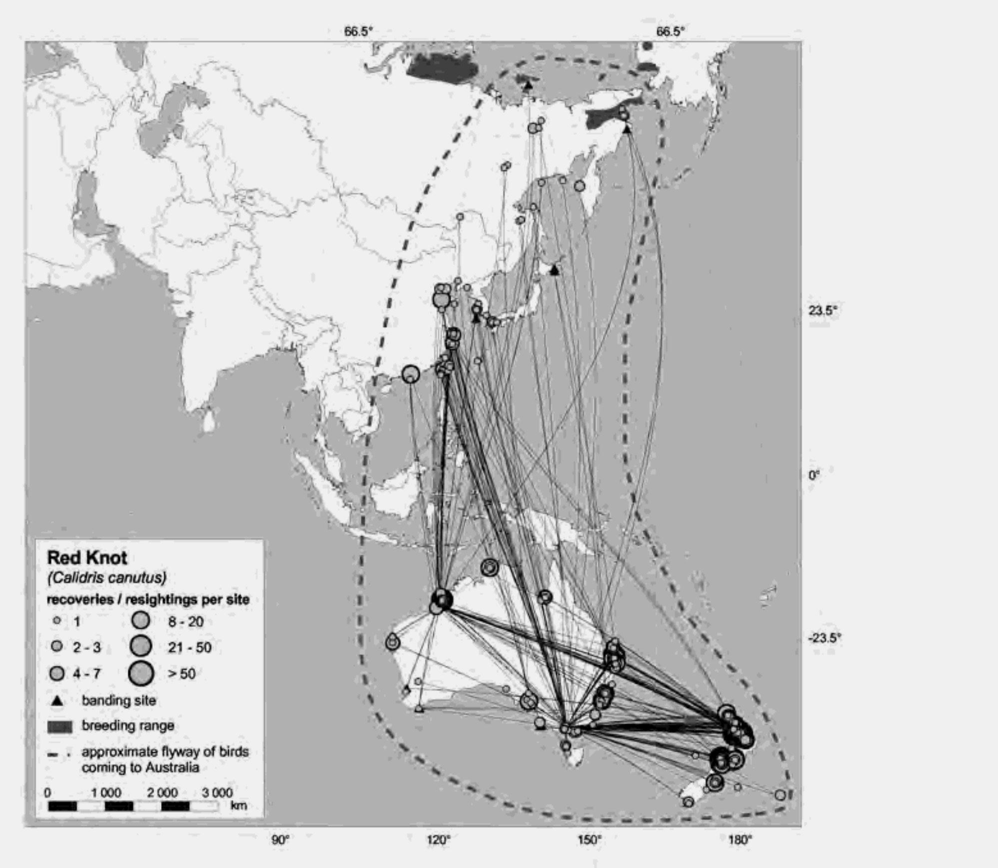

Figure 20. Red Knot

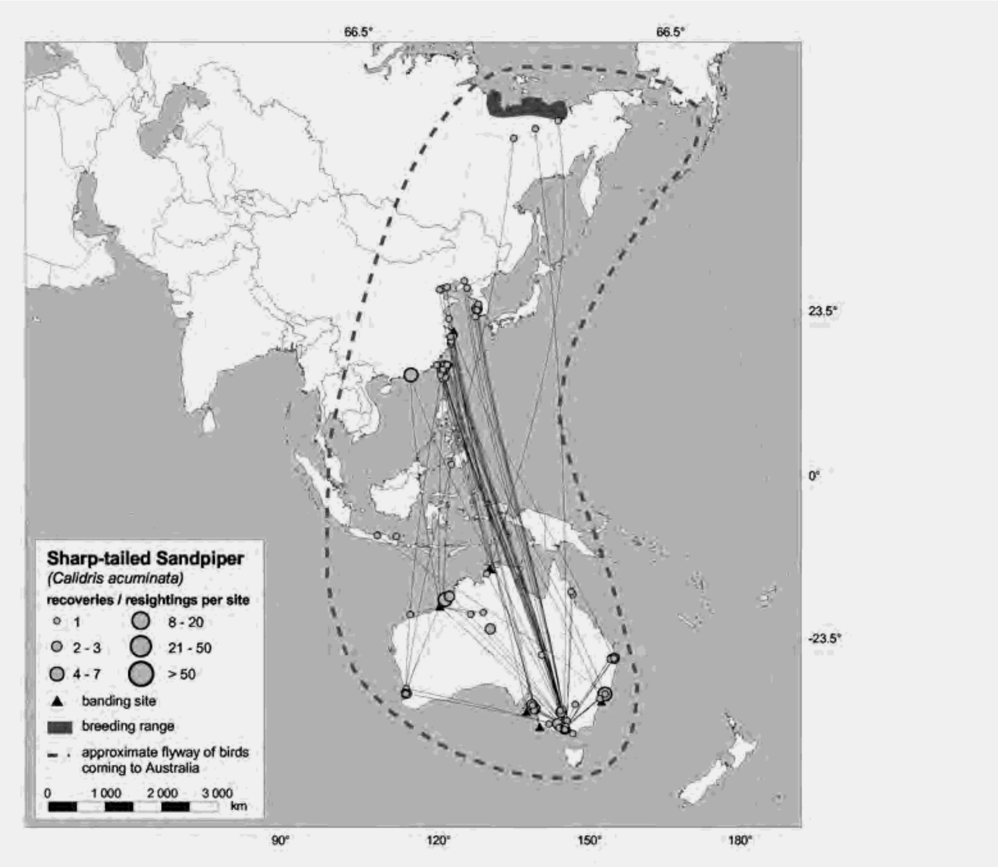

Figure 21. Sharp-tailed Sandpiper

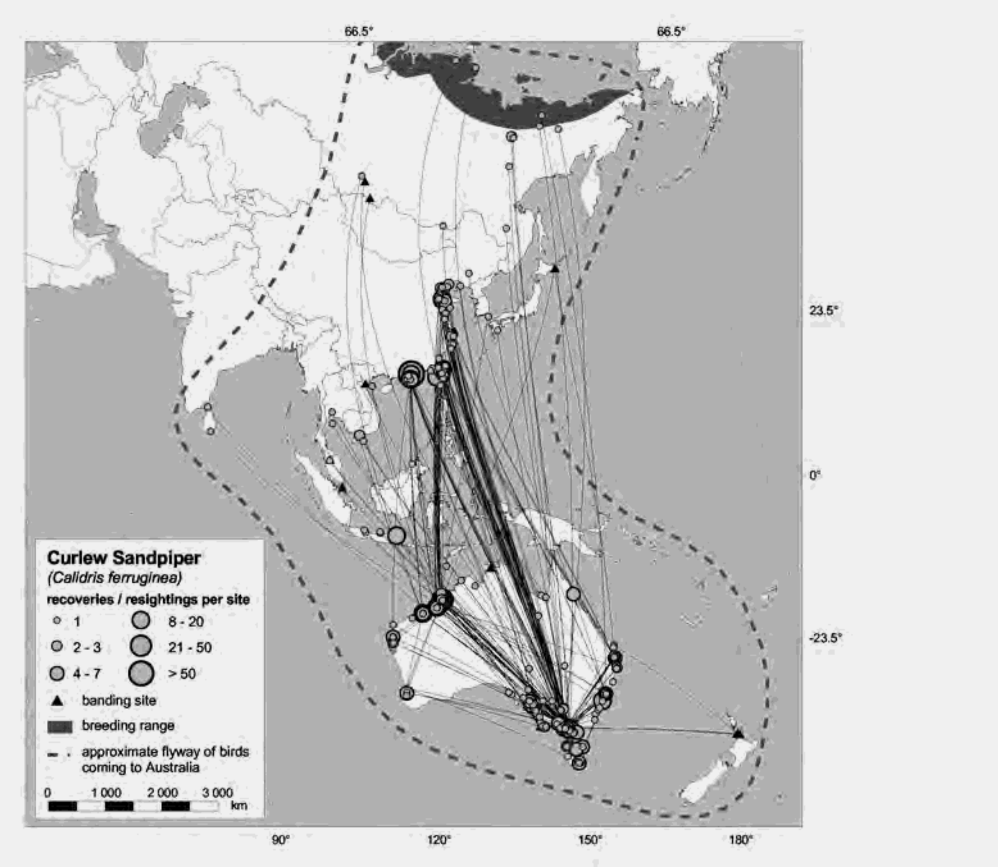

Figure 22. Curlew Sandpiper

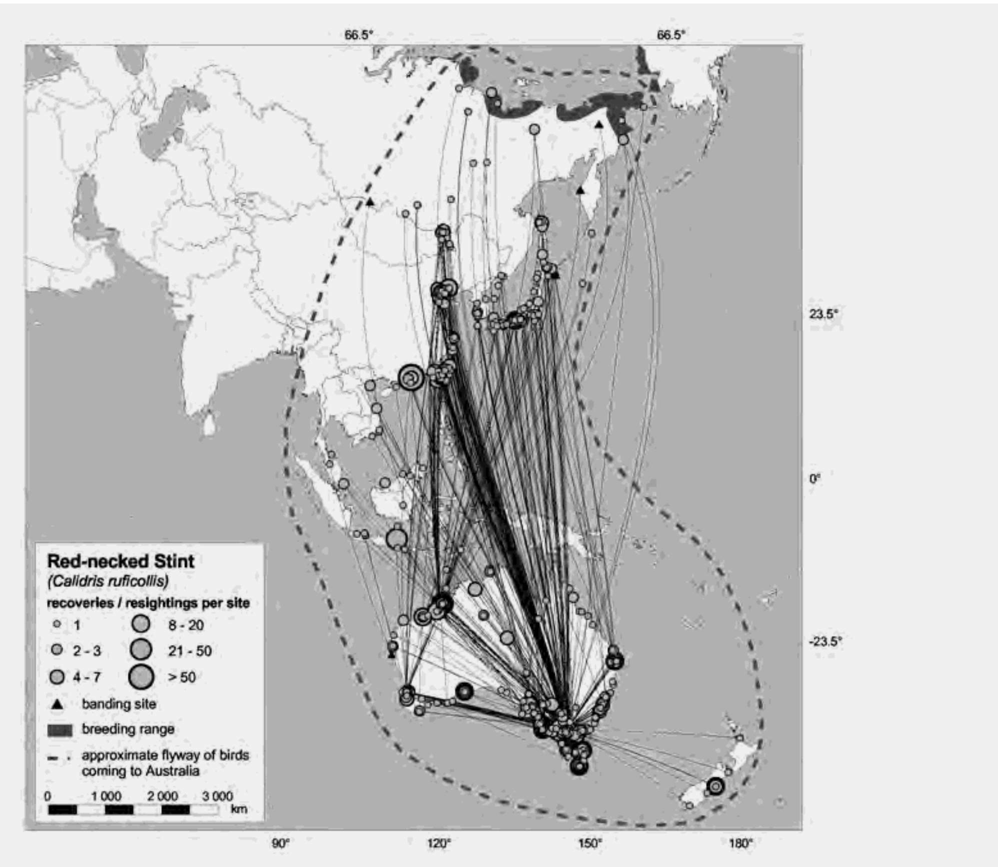

Figure 23. Red-necked Stint

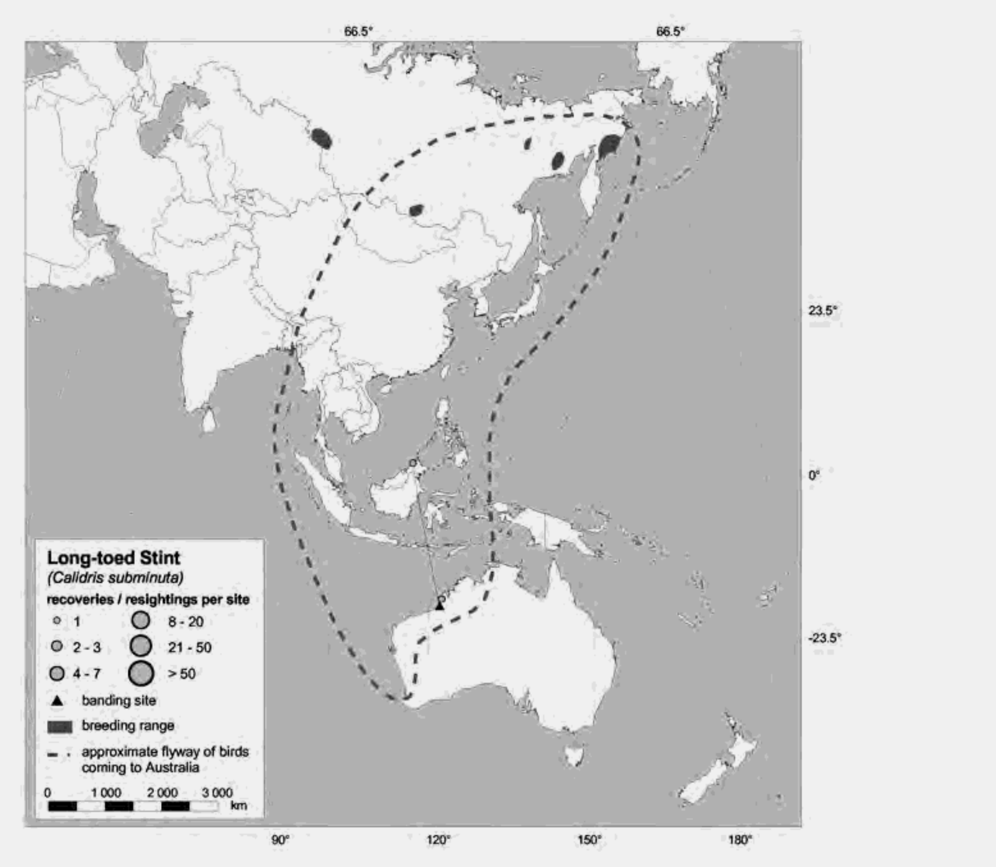

Figure 24. Long-toed Stint

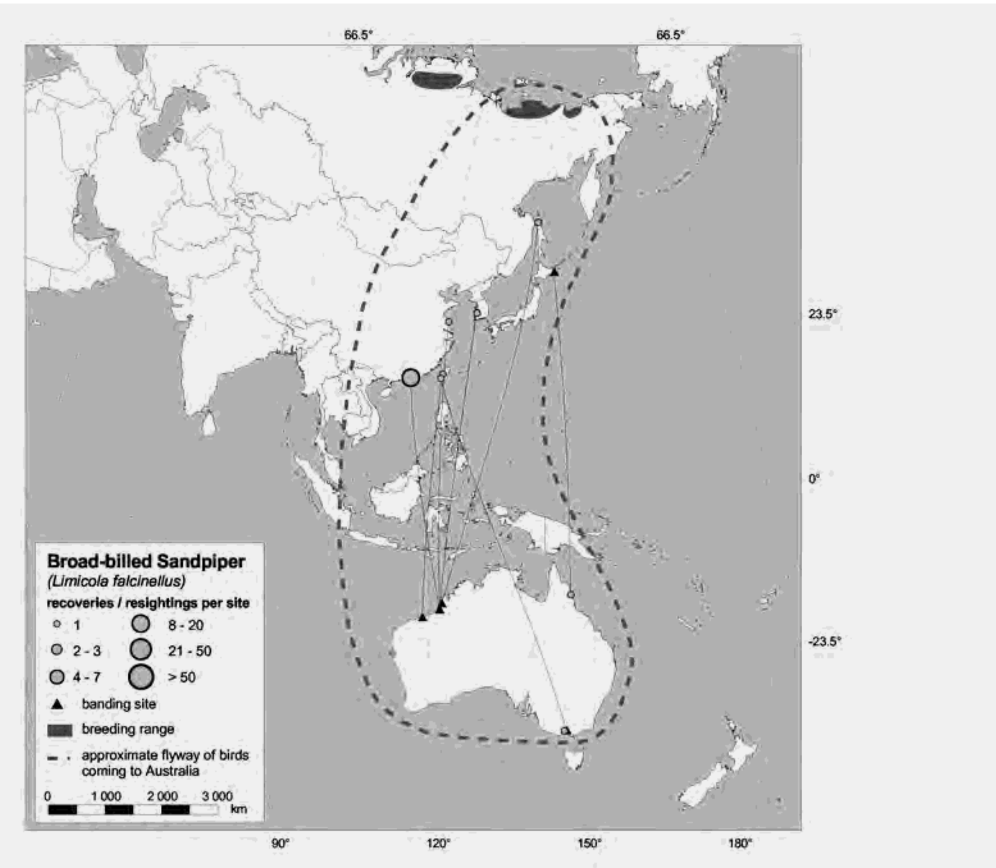

Figure 25. Broad-billed Sandpiper

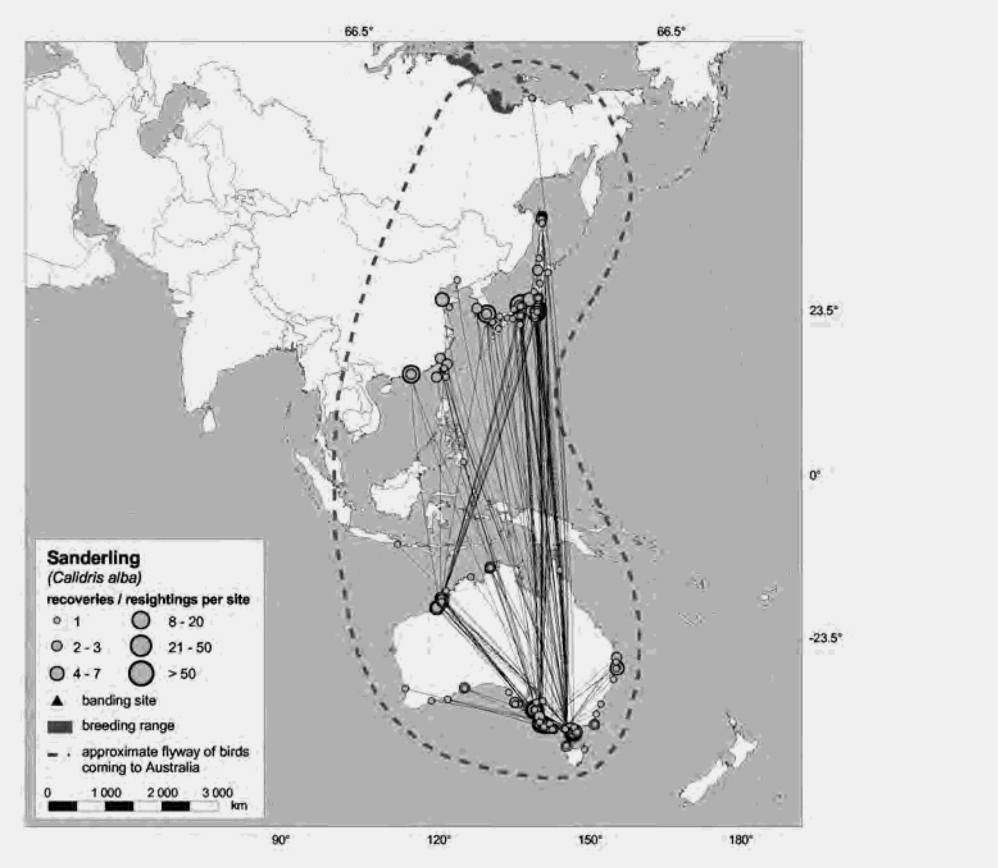

Figure 26. Sanderling

CHINA AND NEW ZEALAND SHOREBIRD SITE PARTNERSHIP: A MODEL FOR INTER-SITE CO OPERATION

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Yalu Jiang National Nature Reserve, Liaoning Province, China is perhaps the single most important staging site for migratory shorebirds in the East Asian–Australasian Flyway. It is clearly the most important site for the Alaskan-breeding *baueri* population of Bar-tailed Godwit. The Firth of Thames, New Zealand is also an important shorebird site during the non-breeding season. Both are East Asian–Australasian Shorebird Network sites. Miranda Naturalists' Trust and Yalu Jiang National Nature Reserve established a sister-site partnership in 2004. The partnership aims to promote public awareness and education programmes, provide training for reserve staff and facilitate further research on Bar-tailed Godwit. This partnership could serve as a model for similar inter–site relationships in the Flyway.

INTRODUCTION

Around 200,000 arctic-breeding shorebirds spend the austral summer in New Zealand. During their northward migration at least 90% of them stop to refuel at mudflats and estuaries on the Yellow Sea coasts of China and the Korean peninsula. Shorebird habitats around the Yellow Sea are under enormous pressure from pollution, reclamation, industrial development, over-exploitation of natural resources, hunting, and human disturbance (Barter 2002). Yet it is here that Bar-tailed Godwit *Limosa lapponica baueri*, Red Knot *Calidris canutus*, and other shorebirds from New Zealand must stop to refuel during northward migration to the Arctic breeding grounds. Without these Yellow Sea stopover sites they could not sustain the migration flight and reach the breeding grounds.

YALU JIANG NATIONAL NATURE RESERVE

The Yalu Jiang National Nature Reserve (YJNNR) is on the northern Yellow Sea coast of China close to the border with North Korea. It is known to be an important staging site for over 500,000 migratory water and shorebirds in the East Asian–Australasian Flyway (EAAF), including Bar-tailed Godwit from New Zealand. At least nine species occur in numbers of international importance as defined by the Ramsar convention at more than one percent of the flyway population. During a survey in 2004 the following internationally important species were recorded: Eurasian Curlew *Numenius arquata* 13,136 (37.5% of the flyway population); Bar-tailed Godwit 66,134 (20.3%); Eastern Curlew *Numenius madagascariensis* 3,874 (10.2%); Great Knot *Calidris tenuirostris* 32,880 (8.6%); Grey Plover *Pluvialis squatarola* 4,623 (3.7%); Dunlin *Calidris alpina* 34,841 (3.6%); and Eurasian Oystercatcher *Haematopus ostralegus* 224 (2.2%). Bar-tailed Godwit, nearly all the *baueri* subspecies, was the most common species. The most common leg-flag colours seen were white followed by orange, indicating birds from the North Island of New Zealand and Victoria, Australia respectively (Barter & Riegen 2004).

Yalu Jiang has been considered the second most important site for shorebirds yet found in the Yellow Sea, exceeded only by Saemangeum in South Korea (Riegen *et al.* 2006). However, with the completion of the sea wall in the 40,000 ha Saemangeum reclamation area in April 2006, Yalu Jiang is set to become the most important site in the region. The 101,000 ha Yalu Jiang reserve includes intertidal mudflats, fish and shrimp ponds, rice paddies and reed beds. The mudflats of YJNNR extend across the border and along the coast of North Korea. Yalu Jiang is by far the most important single site yet discovered for Bar-tailed Godwit on northward migration in Asia (Barter & Riegen 2004). It is thought that 90% of the New Zealand Godwit flock (*baueri*) can be found in the total area. Surveys of the 150 km of coastline immediately west of YJNNR in April/May 2005 found over 13,000 Bar-tailed Godwit (Barter *et al.* 2005). The *menzbieri* subspecies also occurs in the reserve although generally slightly later than *baueri* probably due to the fact the breeding grounds of *baueri* in western Alaska become ice-free sooner than those of eastern Siberia, the range of *menzbieri*.

MIRANDA NATURALISTS' TRUST

The Firth of Thames (37°13'S 175º23'E) east of Auckland, New Zealand is an internationally significant site for migratory shorebirds. It is major wintering area for arctic-breeding species in particular Bar-tailed Godwit and Red Knot. The Firth is one of six Ramsar sites of international importance in New Zealand.

Miranda Naturalists' Trust (MNT) is a non-governmental organization (NGO) based on the Firth of Thames. The Trust owns and operates the Miranda Shorebird Centre as an information and education centre, and as a base for on-going research and public advocacy. The Trust is funded through membership subscriptions, donations and revenue derived from accommodation and retail sales at the Shorebird Centre. However these funding sources generally only cover the running expenses of the centre itself. The Trust is reliant on grants and donations from other funding agencies for particular projects and equipment purchases.

Miranda Naturalists' Trust was initially formed to encourage people to visit the coastline and appreciate its wide range of flora and fauna. The Trust promotes education and public awareness of coastal ecology, shorebird research and conservation. Over 12,000 people visit the shorebird centre annually. The centre hosts visits by schools and university groups, a diverse range of community groups as well as many overseas tourists, in particular recreational birdwatchers. The Trust has developed educational resources and also runs regular training courses on general ornithology and coastal ecology, shorebird identification, and species management.

Statutory authority over the Firth of Thames Ramsar site lies with the New Zealand Department of Conservation. Coastal areas adjacent to the site lie within the responsibility of two regional councils and four district councils. As a non-government organisation (NGO), MNT has no statutory authority over the Firth of Thames shorebird site, but it does enjoy a close working relationship with official agencies. The Trust is recognized by these agencies as a principal source of knowledge and expertise on issues of coastal ecology and shorebird habitat management and is regularly consulted.

EVOLUTION OF THE SISTER-SITE PARTNERSHIP

Since the mid 1990s shorebird surveys have been made along most of the Yellow Sea coastline of China and South Korea. With the initial work almost complete, the need to survey significant individual sites more closely than initial surveys permitted was seen as the next priority. The surveys undertaken in 1999 and 2000 at Yalu Jiang indicated that large numbers of New Zealand Bar-tailed Godwit staged there. A further survey in April 2004 confirmed that over 50% of the *baueri* population were present on the reserve at that time.

Given the importance of the site, MNT recognized the need for research-based conservation programmes in the region and began looking for a role in which it could use its skills and expertise. In 2003 the Trust hosted a delegation of nature reserve managers from China led by Chen Kelin, director of Wetland International's China Programme. They were interested in seeing New Zealand reserves and the style of management. Discussions during this visit recognized a need to help educate the Chinese about shorebirds, and it was agreed that the first step should be to form a sister site partnership with a Chinese shorebird site. Yalu Jiang was an obvious choice for three reasons.

- Surveys and banding had shown that godwits banded in New Zealand were being seen at Yalu Jiang and vice versa.
- Yalu Jiang National Nature Reserve staff were very keen to participate in flyway activities.
- Access to the site was good, an important consideration if regular work were to be undertaken and the profile of shorebirds with local people was to be raised.

A memorandum of understanding (MOU) between the two sites was drawn up and in April 2004 a delegation from MNT lead by Chairman, David Lawrie, travelled to Yalu Jiang. At a ceremony in Dandong City on 26 April 2004 the partnership was officially launched with the signing of the MOU by David Lawrie and Yu Liansheng, Director General of the Dandong Environment Protection Bureau. The ceremony made the national television news in China and was taken very seriously by the Chinese who saw this partnership as a valuable joint venture and major step towards their understanding of migratory shorebirds.

OBJECTIVES OF THE PARTNERSHIP

The memorandum of understanding says, "The Sister Site Partnership exists to strengthen cooperation on shorebird conservation at these [two] sites in the East Asian–Australasian Flyway. Both parties fully realize the importance of conserving migratory shorebirds and their wetland habitats as a contribution to sustainable global development." Specific objectives are derived from this mission statement.

The long-term objective of the project is to promote shorebird and wetland conservation between Miranda and Yalu Jiang, and ensure the sister site partnership acts as a model for other shorebird sites on the East Asian–Australasian Shorebird Flyway. There are several more immediate objectives.

Enhancing awareness of shorebirds and their habitat requirements by:

a. Establishing sister school partnerships between schools near Yalu Jiang and the Firth of Thames and implement environmental education activities.
b. Producing publications in a range of media to enhance community awareness on wetlands and shorebird monitoring.
c. Developing a volunteer's group/network for Yalu Jiang to assist in the conservation and management of wetlands and shorebirds.

Exchanging information on the conservation status of migratory shorebirds, especially Bar-tailed Godwit by:

d. Designing a bilingual Chinese-English website for Yalu Jiang National Nature Reserve in cooperation with Miranda Naturalists' Trust.
e. Establishing an electronic network, including the use of existing publications, newsletters, email and websites between both parties.
f. Producing an annual report updating research and the status of shorebirds.
g. Holding working meetings at each site at two to three yearly intervals.

Training and building capacity by:

h. Conducting a series of staff exchange programs between YJNNR and Miranda.
i. Jointly organizing training courses on wader identification, surveys and banding for both sites.

Developing and implementing mutually agreed shorebird conservation projects by:

j. Jointly conducting comprehensive mapping and assessment of shorebird habitat to identify the distribution and threats to important shorebird areas in both sites.

k. Implementing a long term monitoring program for Bar-tailed Godwits to gather data on the species, its habitat and main threats at both sites.
l. Setting up a wetlands/shorebird centre for Yalu Jiang NNR modeled on the Miranda Shorebird Centre
m. Developing and implementing eco-tourism programs for Yalu Jiang NNR in conjunction with MNT.
n. Developing a draft Shorebird Management Strategy for the Firth of Thames and Yalu Jiang NNR.

PROGRESS TO DATE

The next stage in ensuring the success of the partnership occurred in April 2005 when a delegation led by the vice-mayor of Dandong, who had been at the signing ceremony, was hosted for a week at Miranda Shorebird Centre. The delegation also included Mr Yu Liansheng and Madame Yan Meifang, Director of YJNNR. A few weeks later the Mayor of Dandong also visited Miranda and left with both a greater understanding of migratory shorebirds and a pledge to do more at Yalu Jiang for shorebirds. These visits proved to be highly significant as it meant the major decision makers for YJNNR were now familiar with both MNT and the Firth of Thames site.

Staff training is recognized as an essential step in achieving MOU objectives. In early 2006 two staff members, one from YJNNR and the other from Wetlands International – China, arrived at Miranda for a ten-week stay. They were followed in March by two others. During their stays they studied site management, conservation methods in New Zealand, methods for educating schools and the general public about shorebirds and the need to protect habitat, and participated in field studies.

In April 2006 four members of MNT returned to Yalu Jiang to assist with the fourth comprehensive survey of the reserve (Riegen *et al*. 2006), this time covering an earlier period in the migration cycle. They also conducted training workshops for reserve staff from other Chinese nature reserves. The visit was a great success and it was very encouraging to see the enthusiasm that was developing. Advice offered to the YJNNR staff in 2000 about possible developments had been adopted with an area close to the city of Dongang being set up as a reserve with secure roost sites and a just completed visitors' centre. Bird hides to seat hundreds of people had also been built. These were officially opened in April 2006 with 300 guests who were able to view 30,000 Bar-tailed Godwit at close range.

PROPOSED JOINT PROJECTS FOR THE NEXT FIVE YEARS

There is still much work to be done at Yalu Jiang. Joint projects will involve suitably skilled MNT members visiting during the northward migration period (April-May). A continuous survey of the entire reserve throughout the migration period is planned. This is of particular importance to New Zealand given the significance of the site for Bar-tailed Godwit. It is important to determine whether New Zealand godwits fly direct to Yalu Jiang or stage at other sites further south and this will be determined by arrival dates at Yalu Jiang. A further priority will be to establish benthic studies of which very little has been done around the Yellow Sea. Understanding the value to shorebirds of the site is vital with the impending loss to reclamation of Saemangeum, South Korea. If the 400,000 shorebirds that use Saemangeum each year are to survive, they will have to find other suitable sites. With evidence already suggesting some birds move north into the Yellow Sea in stages, (Barter & Riegen 2004), Yalu Jiang may prove to be of critical significance for birds other than those currently known to use the site.

MNT and YJNNR will therefore be involved with the following projects each year until 2009:

- ongoing training in shorebird identification and behaviour biology;
- benthic studies;
- investigating appropriate conservation measures;
- shorebirds disturbance issues;
- shorebird surveys;
- daily monitoring of birds at one or two key roost sites;
- investigations of how shorebirds use the available habitat;
- investigating pollution and environmental degradation;
- continuing public awareness programmes and work with schools;
- setting up systems for ongoing research by reserve staff and academic institutions.

Staff from other reserves in China will also attend the training sessions greatly increasing the benefits of each visit. While such projects will be taking place within China, the aim is to achieve conservation outcomes for 'New Zealand' shorebirds along their migration flyway. The activities envisaged under this program reflect the pressing need for international cooperation for shorebird conservation, and the need to ensure protection throughout the whole migration route.

CONCLUSIONS

The YJNNR-Miranda partnership was established within the framework of the East Asian–Australasian Shorebird Site Network (EAASSN). It implements two key aims of the Shorebird Action Plan: appropriate management of Network sites and increasing the information base on shorebirds in the Flyway. The partnership is an important step for each country in meeting their obligations under the terms of the Bonn Convention on Migratory Species. It is hoped that this agreement will act as a model for similar agreements between other countries along the EAAF, further strengthening international conservation initiatives for migratory shorebirds.

Statutory authority and management responsibilities at Shorebird Network Sites generally lie with state agencies. Both Ramsar and the EAASSN are inter-governmental agreements involving obligations for each member nation. A salient aspect of the Miranda-Yalu Jiang agreement is that a community based NGO in New Zealand is engaged with state agencies in China. As indicated above, while Miranda Naturalists' Trust enjoys close working relationships with local and central government agencies, it has no statutory authority over the Firth of Thames shorebird site. However among its membership the Trust does have skills and expertise regarding shorebirds that central and local authorities do not possess. The Trust is therefore regularly consulted by those agencies. This may also be the case with NGOs at other sites in the Flyway. If not, then Miranda may well be a suitable model for such organizations.

Future sister-site partnerships elsewhere in the Flyway may well be formed between state agencies at both sites, but there is clearly a role for NGOs and community groups to be directly involved. It is desirable for any two sites contemplating forming a partnership to have established connections by way of bird movements. For instance individual banded birds recorded at both sites have proven to be an excellent hook for attracting government, public, and media interest.

Somewhat inevitably, funding for these programmes can be an issue. Initial work at Yalu Jiang was partly funded by the Australian Department of Environment and Heritage. Subsequently most on-ground costs have been generously met by the cities of Dandong and Dongang. As a non-profit making community group, MNT does not have the resources to fund the ongoing involvement of its members. To date members themselves have met most travel expenses to and from China, a situation that is clearly not sustainable. After considerable lobbying some funding has been secured from a regional office of the New Zealand Department of Conservation. For future work however, it remains desirable to get more central government involvement.

None of the work at Yalu Jiang would have happened without the input of the Miranda Naturalists' Trust and the willingness of everyone concerned at Yalu Jiang to make a difference. The work undertaken at Yalu Jiang by MNT is being closely watched around China and is being held up as a model worth copying. Other reserves in China are already taking a great deal of interest in the partnership and it is hoped other sites on the EAAF will also form partnerships, which will assist in achieving the conservation goals of the EAASSN.

ACKNOWLEDGEMENTS

Chen Kelin, Director Wetlands International, China and Warren Lee Long, Flyway Officer, Wetlands International – Oceania, Canberra have been invaluable in facilitating initial contacts and coordinating implementation of the project. The following have also been instrumental in the project: Mr Yu Liansheng, Director State Environmental Protection Agency, Dandong and Madame Yan Meifang, Director YJNNR along with reserve staff for their support and excellent hospitality. The mayor and vice-mayor of Dandong for their interest and support. Mark Barter whose prodigious efforts in surveying shorebirds around the Yellow Sea has provided the baseline data underlining many current projects and activities in the region, including the YJNNR-Miranda partnership. David Lawrie and the council of MNT. Finally, but particularly, Adrian Riegen, whose energy and vision has been the major impetus behind the growing involvement of MNT in the Flyway.

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POPULATION MONITORING IN AUSTRALIA: SOME INSIGHTS AFTER 25 YEARS AND FUTURE DIRECTIONS

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This paper provides an overview of the Australasian Wader Studies Group's Population Monitoring Program (PMP) over the last 25 years at sites around Australia and comments on its ability to monitor long-term population trends in several species. The PMP provides the only comprehensive long term data set on shorebird numbers available to planners and government agencies. In this analysis, some of the shorebird count data collected as part of the PMP have been used to describe population trends for selected migratory wader species found in southern Australia. Results highlight the declining population trend for Curlew Sandpiper *Charidris ferruguinea* and suggest declining trends for several other species. The importance of identifying the underlying demographic causes of these trends is emphasised. The need to identify trends early is suggested as a high priority given the habitat loss and other changes occurring in the flyway. Increasing the sensitivity of the PMP counts and addressing other shortcomings of the program require the development of a more robust and comprehensive monitoring design. Some recommendations are made for a National Shorebird Monitoring project.

INTRODUCTION

Throughout the world many wader populations appear to be declining (CHASM 2004, van de Kam *et al*. 2004). The IWSG workshop in Cadiz, Spain in 2003 (IWSG 2003) reported that population trend estimates were available for 41% of the 499 wader populations recognized in the world. For populations with known trends, 44% appear to be decreasing, 13% increasing, 39% stable and 4% extinct (Delany 2003). In the East Asian–Australasian Flyway, a disproportionate number of shorebird species have been classified as threatened (IWSG 2003), and the shorebirds using this flyway are under increasing threat from habitat destruction and loss (Milton *et al*. 2005). Over 80% of wetlands in east and south-east Asia are classified as threatened, with over half under serious threat (Barter 2002). Of inter-tidal wetlands in China and South Korea, in excess of 40% have been destroyed by land reclamation (Barter 2002). Further, the East Asian–Australasian Flyway holds the highest number of wader populations of any flyway and, unfortunately, the highest proportion of species on which there is no information on current population or trends (IWSG 2003). Not surprisingly, even less is known regarding the likely causes of population declines in the East Asian–Australasian Flyway. For that level of understanding it is first necessary to understand how and why the underlying demographic processes (recruitment and survival) are changing. Such knowledge can only be gained through long term demographic monitoring programs (Robinson *et al*. 2005). For Arctic breeding species the most appropriate and most feasible region in which to conduct such studies is the non-breeding grounds where many species spend several months in the same area. Australia and New Zealand have largely stable wader numbers during the middle of the non-breeding season (Watkins 1993) and these countries have the skilled volunteers required for monitoring. This has made Australasia an ideal region in which to contribute information on shorebird population dynamics. In fact it is the only region in the flyway where this level of monitoring can be done.

Information on population levels and trends is now increasingly required by governments at all levels to ensure long-term conservation of shorebird populations and to minimise impacts on their habitats. The international Ramsar convention requires updated information every nine years but the recent listing of migratory shorebirds under Australia's Environment Protection and Biodiversity Conservation Act 1999 (EPBCA) arguably requires more up-to date information. In addition, the bilateral international agreements of the China-Australia Migratory Birds Agreement (CAMBA) and Japan-Australia Migratory Birds Agreement (JAMBA) place further obligations on Australia to conserve migratory shorebird populations.

The Australasian Wader Studies Group (AWSG) has been monitoring wader populations at a number of important areas around Australia since the early 1980s through its operation of the Population Monitoring Program (PMP). The objective of the PMP has been to 'monitor, at selected sites, year-to-year changes in population levels of migratory and Australian breeding waders and attempt to account for these in terms of reproductive success and mortality' (Lane 1985). The PMP evolved from a funded program that ran from 1981 to 1985, and which had the objective of mapping the total distribution of waders in Australia. Over this period, 118 areas around Australia were surveyed following which 23 core sites were counted twice yearly. These core areas have continued to be counted since 1985, but most of the 118 areas have been counted only intermittently. Occasionally new core areas have been discovered and counted. The PMP was initiated in conjunction with the Australian National Parks and Wildlife Service (ANPWS) through the Royal Australasian Ornithologists' Union (RAOU) (now Birds Australia). The history of the development of the PMP is fully described elsewhere (Wilson 2001). Throughout this history, the PMP has only been possible with the assistance of a large and dedicated team of skilled volunteers.

To date the PMP has collected 25 years of data that have been used to estimate current wader populations and map their distributions throughout Australia. Details of the PMP counts are given in Rogers & Gosbell (2006). However, there has been relatively little analysis of the population trends for waders in Australia. Some examples of limited reviews are Driscoll (1997) and Wilson (2001). Additional reports have revealed regional or national declines in the populations of migratory waders in Australia for a handful of species that occur in large enough numbers at count sites. For example, for over 25 years the numbers of five species (Bar-tailed Godwit, Red-necked Stint, Curlew Sandpiper, Sharp-tailed Sandpiper, and Grey Plover) have declined at Pelican Point on the Swan River, Western Australia (Creed & Bailey 1998). Additional regional declines of Curlew Sandpiper have been noted; in south-east Australia (Wilson 2001), in Corner Inlet, particularly since 1994 (Minton *et al*. 2002), in the Coorong (Gosbell & Grear 2005), and at Swan Bay (Barter 1992). National declines in Curlew Sandpiper were also reported (Olsen & Weston 2003). Eastern Curlew were reported to have declined steadily by 2% per year since 1981 in south-eastern Tasmania (Reid & Park 2003, Wilson 2001). Further, regional declines were reported in south-east Tasmania for Bar-tailed Godwit and Eastern Curlew, with possible declines in Red-necked Stint and Common Greenshank (Olsen & Weston 2003).

It is now appropriate to question the extent to which the PMP can provide information on population trends in migratory waders that visit Australia. This paper partly addresses this question by presenting a simple example of one kind of trend analysis that can be performed. The analyses presented here should be viewed as exploratory, with significantly more work needed to investigate outliers, to describe trends for other species, to improve sensitivity, to detect less obvious trends, and to determine whether similar trends are found throughout Australia. This analysis concentrated on the southern region of the country, but comprehensive analyses of all regions are needed as a matter of urgency. The paper further outlines what the PMP has accomplished, and explores the limitations of the PMP in its current form. This paper then discusses the importance of filling gaps in knowledge related to shorebird population monitoring and its link with demographic monitoring. Finally, strategies the AWSG has formulated to improve the PMP are outlined.

METHODS

Data

Full analysis of PMP data has been made possible by the development over the last four years of an electronic database. Prior to this, all records were paper based and held at Birds Australia in Melbourne. The database was designed to accept counts from any source whether it was part of a regular PMP site count or an occasional count. Each count has been geographically referenced to enable subsequent use for a range of purposes. Further, each PMP area has had its boundary converted from paper to digital maps for use in a Geographic Information System, and each count location has now been referenced if it falls within the PMP area boundary. All historic counts held at Birds Australia are now in the database.

Figure 1 shows the location of the 29 current PMP sites, which have now been mapped to facilitate consistency in the area covered from year to year. These sites are clearly skewed with greater site densities near cities, and away from the areas of northern Australia where shorebird abundance is greatest (Driscoll 1997). Table 1 shows the distribution of migratory waders by region as derived from data presented

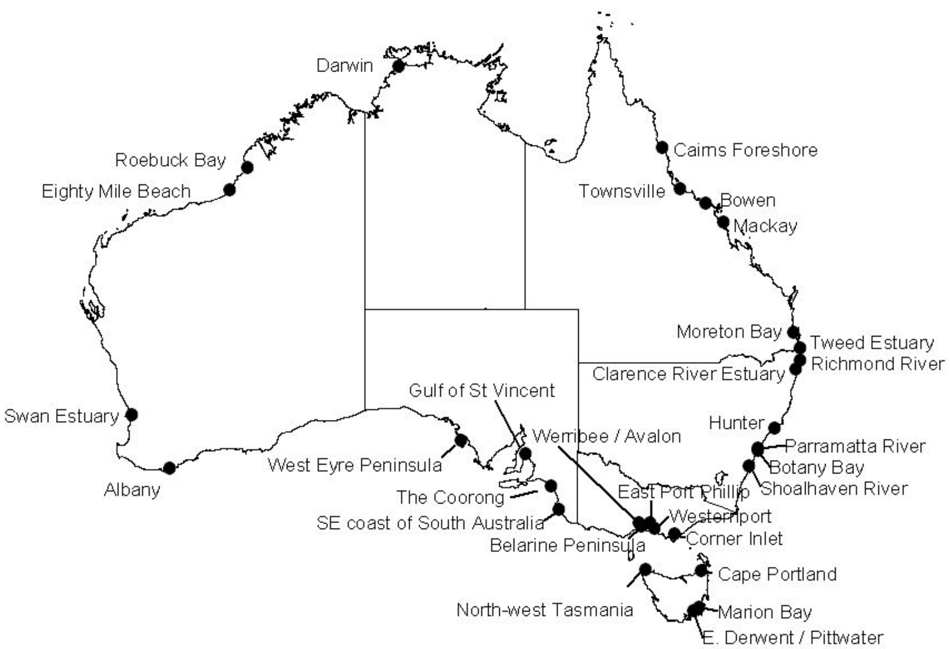

Figure 1. Map showing location of PMP count sites.

Table 1. Distribution of Migratory Waders indicating Minimum Population Estimate (MPE) and ratio (percentage) by Region. (Based on MPE's provided by Bamford *et al.* in prep.) Note that the figures provided for 'Percent by region' exclude Oriental Pratincole from the total.

Species	**Australian MPE**	**Southern WA**	**Northern WA**	**NT**	**Qld**	**NSW**	**Vic**	**Tas**	**SA**
Bar-tailed Godwit *Limosa lapponica*	185,000	3	54	8	26	2		0	1
Black-tailed Godwit *Limosa limosa*	70,000	0	17	36	40	6	0	0	1
Little Curlew *Numenius minutus*	175000	0	11	86	3	0	0	0	0
Whimbrel *Numenius phaeopus*	30000	2	25	5	67	1	1	0	0
Eastern Curlew *Numenius madagascariensis*	28000	1	8	7	64	4	13	2	1
Marsh Sandpiper *Tringa stagnatilis*	na								
Common Greenshank *Tringa nebularia*	19000	8	32	5	26	4	9	2	11
Wood Sandpiper *Tringa glareola*	na								
Terek Sandpiper *Xenus cinereus*	23000	4	26	17	48	3	0	0	0
Common Sandpiper *Actitis hypoleucos*	na								
Grey-tailed Tattler *Heteroscelus brevipes*	45000	11	27	11	49	1	0	0	1
Ruddy Turnstone *Arenaria interpres*	20000	15	18	10	4	3	3	28	18
Great Knot *Calidris tenuirostris*	360000	2	50	19	29	0	0	0	1
Red Knot *Calidris canutus*	135000	4	30	11	43	0	4	1	7
Sanderling *Calidris alba*	10000	8	30	3	2	2	10	5	40
Red-necked Stint *Calidris ruficollis*	270000	15	13	6	7	0	26	4	30
Sharp-tailed Sandpiper *Calidris acuminata*	140000	2	11	9	11	0	11	0	50
Curlew Sandpiper *Calidris ferruginea*	118000	28	17	4	4	4	13	4	25
Broad-billed Sandpiper *Limicola falcinellus*	10000	1	70	20	20	2	0	0	0
Pacific Golden Plover *Pluvialis fulva*	7500	3	7	13	40	13	9	7	7
Grey Plover *Pluvialis squatarola*	12000	9	17	17	18	1	4	2	29
Double-banded Plover *Charadrius bicinctus*	30000	0	0	0	2	2	27	7	3
Lesser Sand Plover *Charadrius mongolus*	25000	8	8	20	60	4	0	0	1
Greater Sand Plover *Charadrius leschenaultii*	73000	3	68	21	10	0	0	0	0
Oriental Plover *Charadrius veredus*	75000	0	80	7	7	0	0	0	1
Oriental Pratincole *Glareola maldivarum*	2880000	0	0	100	0				
Australian Pratincole *Stiltia isabella*	60000	0	25	75	3	0	0	0	0
Total MPE (region)		113010	603420	404430	402240	23200	133470	26630	213590
Percent by region		6	32	21	21	1	7	1	11

by Bamford *et al*. (in prep.). This indicates that no more than 7% of the migrant waders occur in Victoria whereas north-west Australia (Roebuck Bay and Eighty Mile Beach) has in excess of 30%. It is probable that more than half of the waders that occur in Victoria are counted annually, but the proportion is very much smaller for most of the other regions in Australia, particularly South Australia and the Northern Territory.

PMP counts were conducted by skilled volunteers during high tide when shorebirds are concentrated at roost sites. When possible these counts have been conducted at least twice yearly, in summer (January or February) and winter (June or July), but some sites have had multiple counts recorded throughout the year. Table 2 provides an indication of the consistency of count coverage and frequency across regions by comparing the summer and winter counts carried out for PMP sites by State and Territory. This table shows more or less continuous counts at six sites in Victoria, five in New South Wales, two in Queensland, three in the south-east of South Australia, three sites in Tasmania, and two sites in south-western West Australia. The frequency of counts in the remaining 14 PMP sites was considerably more intermittent.

The trends reported here were based on data collected at 14 PMP sites that had at least one summer count in most years from 1981 to 2005, and for which there were no known big changes in count coverage or methodology. These sites included: in Victoria - the Bellarine Peninsula, Corner Inlet, Western Port, and Werribee; in Tasmania - the Derwent-Pittwater area and Cape Portland; in New South Wales - Botany Bay, Clarence River, Hunter Estuary, Parramatta, and Shoalhaven; in Western Australia - the Swan Estuary and Albany; and in South Australia - the south-east coast. Possible trends were investigated for many species but analysis focused on the seven species that were best represented. These were Bar-tailed Godwit, Curlew Sandpiper, Eastern Curlew, Red-necked Stint, Ruddy Turnstone, Sanderling, and Sharp-tailed Sandpiper. Maximum counts for each species conducted in the summer months (November – February) were extracted from the AWSG database, however, it must be emphasized that the database is incomplete for some regions at this stage.

Analysis

Initially simple scatter plots of the raw data were fitted with least squares regression trend lines and plotted for each of the seven species in each of the 14 sites. These data are not shown here, but they allowed a visual assessment of possible trends, the linearity of the data, and outliers. After this visual assessment of data from individual sites, least-square regression lines were fitted to the sum of maximum annual

Table 2. PMP areas counted between 1986 and 2005. Highlighted areas are those in the current count program. S indicates summer count, W winter count, . no count.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
NEW SOUTH WALES																				
Clarence/Richmond	SW	SW	SW	SW	SW	SW	SW	SW	SW	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Clarence Estuary	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	. W	SW	. W	S .	SW	. W	S .	S .	S .	S .
Richmond Estuary	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	SW	SW	SW	SW	. .	. .	SW	SW	SW	S .
Hunter Estuary	SW	SW	SW	SW	. .	. .	SW	. .	. W	SW	SW	S .	. .	SW	. W	SW	SW	SW	SW	S .
Parramatta River	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	. .	SW	. W	SW	SW	SW	S .
Botany Bay	SW	SW	SW	SW	SW	S .	SW	. W	SW	SW	SW	SW	SW	SW	. .	. .	SW	SW	SW	S .
Shoalhaven Estuary	SW	SW	SW	SW	SW	. .	SW	S .	. .	SW	. .	SW	SW	S .	. W	. .	SW	SW	SW	S .
Tuggerah Lakes	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	SW	SW	SW	S .	SW	. .	S .	. .	. .	. .
Brisbane Waters	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	S .	. .	. .	. .
Hastings Estuary	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. W	S .	. .	. .	. .
VICTORIA																				
Corner Inlet East	SW	SW	SW	SW	SW	SW	S .	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .
Corner Inlet West	SW	SW	SW	SW	SW	SW	S .	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .
Western Port	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .	SW	SW	S .	SW	SW	SW	SW	S .
East Port Phillip Bay	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .
Altona	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	. .
Werribee/Avalon	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .	S .	SW	SW	SW	SW	SW	SW	SW	S .
Bellarine Peninsula	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .	SW	SW	SW	SW	SW	SW	SW	S .
QUEENSLAND																				
Cairns	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .	. .	SW	. W	S .	. W	SW	S .	S .	S .
Mackay	SW	SW	SW	SW	SW	S .	SW	SW	SW	SW	S .	. .	. W	. W	SW	. W	SW	. .	SW	S .
Moreton Bay	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .	. .	SW	SW	SW	SW	SW	SW	SW	S .
Townsville	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	S .	. .	SW	SW	. .	SW	SW	S .	S .	. .
Gladstone	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	S .	. .	SW	SW	. .	. .	. .	. .	. .	. .
Lockyer Valley	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	S .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Tweed Estuary	. .	. .	. .	. .	. .	. .	. .	. .	. .	SW	S .	. .	SW	SW	SW	SW	SW	SW	SW	S .
Bowen	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. W	SW	S .	SW	SW	S .	S .
SOUTH AUSTRALIA																				
Western Eyre Pen.	SW	SW	SW	S .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	. .	S .	. .	. .
South-East coast	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .
Gulf St Vincent	SW	SW	SW	S .	SW	. .	. .	. .	. .	SW	SW	. W	. .	. .	S .	. .	. .	. .	. .	. .
Coorong	. .	S .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	S .	S .	S .	S .	S .
Penrice	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	. .	. .	. .
Price	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	. .	. .	. .
Clinton CP	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	. .	. .	. .
Sandy Point	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	. .	. .	. .
Greenfields	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	S .	. .	. .	. .	. .
WESTERN AUSTRALIA																				
Rottnest Island	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. W	. .	S .	. .	. .	. .
Broome	. .	. .	. .	. .	. .	. .	. .	. W	SW	SW	SW	SW	SW	SW	SW	. W	SW	SW	SW	S .
Eighty Mile Beach	. .	. .	. .	. .	. .	. .	. .	. W	SW	SW	SW	SW	SW	S .	SW	. W	SW	SW	SW	S .
Albany area	SW	SW	SW	SW	. .	. .	. .	S .	SW	SW	SW	SW	S .	SW	SW	SW	SW	S .	SW	S .
Swan coastal plain	SW	SW	SW	SW	. .	. .	. .	SW	SW	S .	S .	SW	SW	SW	SW	SW	SW	SW	SW	S .
TASMANIA																				
E.Derwent/Pittwater	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	. .
Marion Bay	SW	. W	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	. .
Cape Portland	SW	SW	SW	SW	SW	SW	SW	S .	SW	SW	SW	SW	SW	SW	SW	SW	SW	S .	S .	. .
North-West Tasmania	. .	. .	. .	. .	. .	. .	. .	. .	. W	SW	SW	S .	SW	. .	SW	SW	SW	SW	SW	. .
NORTHERN TERRITORY																				
Darwin	SW	SW	SW	. W	. .	. W	S .	. .	SW	SW	. W	SW	. .	. .	. .	. .	. .	SW	SW	. .

counts from the seven areas in south-east Australia with the most complete data sets. The total, over the years 1981 to 2005, of annual maximum summer counts from these seven areas should give a fair representation of population trends in south-east Australia. The seven areas are the south-east coast South Australia, East Derwent / Pittwater area (Tas.), Cape Portland (Tas.), Corner Inlet (Vic.), Western Port (Vic.), Bellarine Peninsula (Vic.), and Werribee (Vic.).

Exploratory comparisons of species population trends between large regions were then conducted. The consistency and continuity of PMP counts in southern Victoria and Tasmania over 25 years has enabled a comparison to be made between these two regions. Accordingly, additional scatter plots were fitted to the sum of maximum annual counts from these two regions to determine if population trends would be similar in widely separated non-breeding areas. This was done for five of the seven species identified above. Sanderling and Sharp-tailed Sandpiper were not included because these species were not recorded in significant and consistent enough numbers to allow comparisons. The two regions comprise two Tasmanian sites (the East Derwent / Pittwater area and Cape Portland) and four Victorian areas (Corner Inlet, Western Port, Werribee, Bellarine Peninsula). Further, the count data were log transformed to facilitate comparison.

Statistical analysis followed methods outlined by Hoffman and Smith (2003). Preliminary analysis of trends included simple linear regression with standard t-tests to assess the significance of the regression coefficients. Year was transformed into an ordinal number with 1980 set as year zero, and used as the independent variable used to predict number counted. When diagnostics revealed problems with the assumptions necessary for linear regression, log-transformed annual maximum counts were used to recalculate the regressions (Bednarz *et al*. 1990). The assumptions necessary for linear regression include: constant variance of error terms (homoscedasticity), a linear relationship between count total and year, normally distributed error terms, and independence of error terms. Two-tailed Durbin-Watson tests were used to test for autocorrelation, a problem not uncommon in annual count data sets. In the absence of significant Durbin-Watson tests we considered $P < 0.05$ indicative of significant trends, but if Durbin-Watson tests were significant we considered trends to be significant only if $P < 0.01$ (Hatfield *et al*. 1996). Linear regression should not have resulted in erroneous conclusions when significant trends were indicated (Hoffman & Smith 2003).

RESULTS

Scatter plots for the seven species over south-east Australia are presented in Figures 2a to 2g. The plots reveal large variation in annual summer counts, and provide a good visual overview of trends in south-east Australia. The plots suggest that four of seven species tested have experienced long-term declines, specifically Bar-tailed Godwit, Curlew Sandpiper, Eastern Curlew and Sharp-tailed Sandpiper.

The comparisons between Tasmanian and Victorian locations are given in Figures 3a to 3e. Mostly, the trends between the two regions were similar, but in Tasmania there appeared to be a slight decline in population of Red-necked Stint while in Victoria there appeared to be a slight increase in the number observed (Figure 3d). Further, in some years there appeared to be an above average count recorded in one region while a below average count was recorded in another region.

No clear trends were evident for Ruddy Turnstone or Sanderling in the 14 sites tested using linear regression. In addition, no clear trends were apparent for Sharp-tailed Sandpiper due to the extreme variation in the numbers recorded at any site in any given year. Interestingly, Red-necked Stint also showed no clear trend throughout the PMP sites examined, but of the 13 sites where Red-necked Stint were recorded in sufficient numbers for analysis, populations appeared to be showing significant increases in one area (Bellarine Peninsula), and significant declines at four (Botany Bay, Cape Portland, Hunter Estuary, Shoalhaven River) (Table 3a).

For the remaining three species, all appeared to show at least some evidence of population decline that appeared to be occurring across multiple PMP sites. Least–square trend lines indicated declines in Bar-tailed Godwit populations at each of 12 sites with sufficient data. However, initial investigations suggested that none of these trends were significant (Table 3b). Eastern Curlew showed declines in 9 of 11 PMP sites, and those declines appeared to be significant at five sites (Table 3c). Interestingly, Botany Bay count data suggests significant increases of Eastern Curlew (Table 3c). Curlew Sandpipers showed declines in all 11 sites tested, with significant average declines of 3% to 4% per year observed at nine sites (Table 3d). Clearly, of all the trends we examined, the Curlew Sandpiper was most compelling with fair evidence that Curlew Sandpiper populations are declining in southern Australia, most obviously in areas in the south-east and in areas with more data.

For species not mentioned above, these analyses were less conclusive primarily due to a lack of sufficient data at the sites analysed to yield population trends using simple linear regression. Possible regional declines were however evident in Terek Sandpiper, Red Knot, Pacific Golden Plover, Great Knot, Lesser Sandplover, Grey Plover, Grey-tailed Tattler, and Black-tailed Godwit.

DISCUSSION

As outlined earlier, PMP data have been used to highlight declining population trends in the literature for six migratory waders that visit Australia. Further, initial scatter plots with fitted least-square trend lines through PMP count data suggest there is cause for concern regarding the possible declining populations of up to 13 species including those six. Unfortunately, the methods used here were only able to identify significant trends for two species. This lack of significant findings may be in part due to the lack of uniform distribution of waders in Australia, or more simply, the under-representation of many species in southern Australia count areas. The statistical tests conducted here did indicate significant declining population trends for the Curlew Sandpiper and Eastern Curlew. Data indicate that Curlew Sandpiper populations in southern Australia are declining by on average over 3% per year and if the conditions that led to this decline continue into the future, further reductions in numbers can be expected (Table 3d). For Eastern Curlew populations data show their populations have been declining by on average over 2% per year in five regions (Table 3c). These trends were evident despite likely random variation in things like recruitment rates, mortality rates, weather, and food availability, as well as possible annual variation in counts caused by the way an area was counted, and the inherent difficulties in analysing count data (Hilborn & Mangel 1997).

Of all the results investigated, the declining Curlew Sandpiper trend was perhaps the most compelling with a clear declining trend evident no matter how the data were examined. The number of Curlew Sandpiper in Victoria as

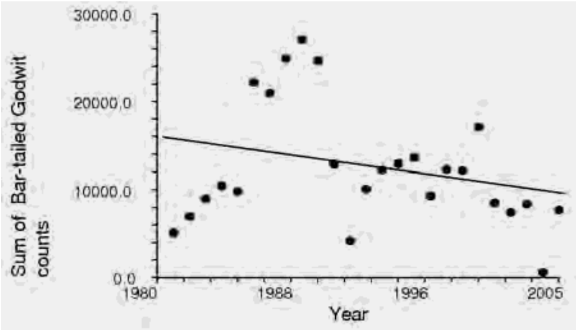

FIGURE 2a. Bar-tailed Godwit population trend SE Australia.

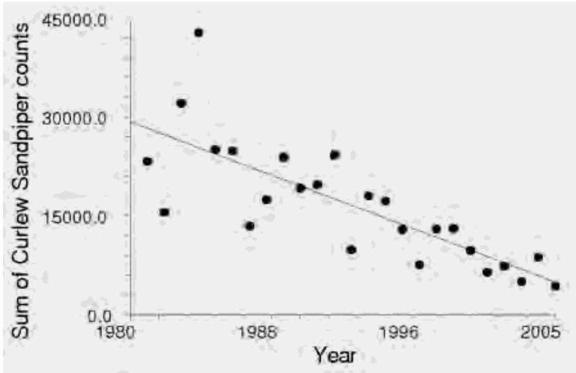

Figure 2b. Curlew Sandpiper population trend SE Australia.

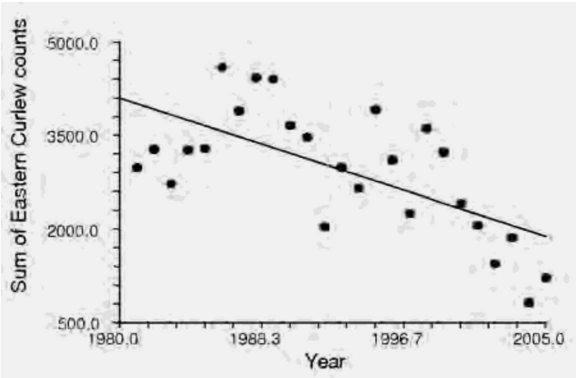

Figure 2c. Eastern Curlew population trend SE Australia.

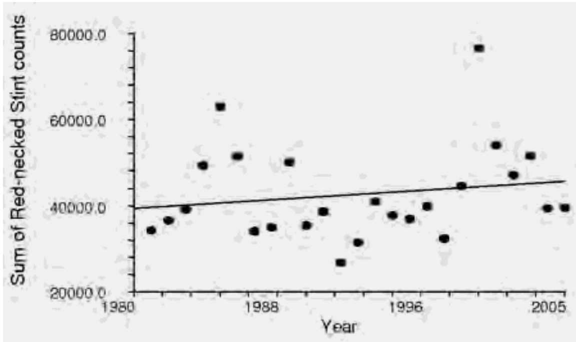

Figure 2d. Red-necked Stint population trend SE Australia.

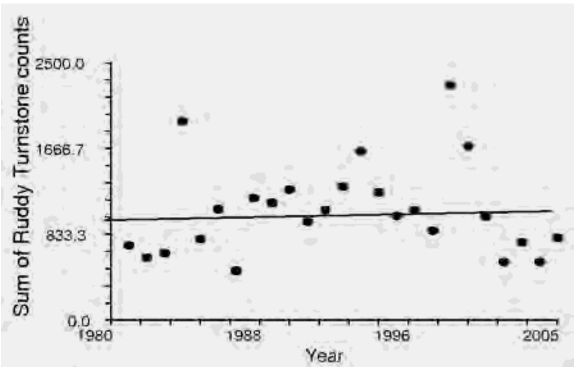

Figure 2e. Ruddy Turnstone population trend SE Australia.

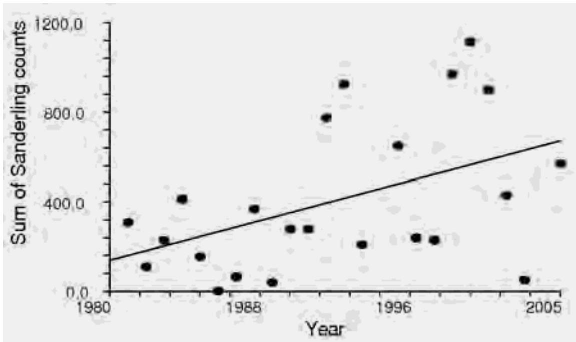

Figure 2f. Sanderling population trend SE Australia.

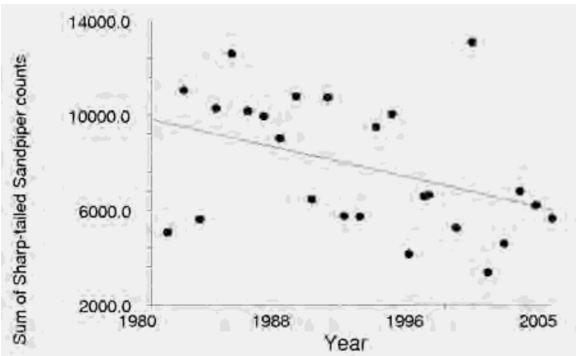

Figure 2g. Sharp-tailed Sandpiper population trend SE Australia.

Figures 2a–g. Least square trends for selected species using maximum summer counts summed across 7 shorebird area Australia. (South-east South Australia, East Derwent / Pittwater area (Tas.), Cape Portland (Tas.), Corner Inlet (Vic.), West (Vic.), Bellarine Peninsula (Vic.), and Werribee (Vic.))

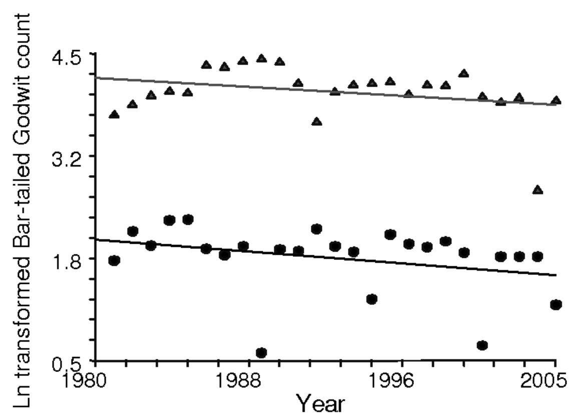

Figure 3a. Bar-tailed Godwit trends in Victoria and Tasmania

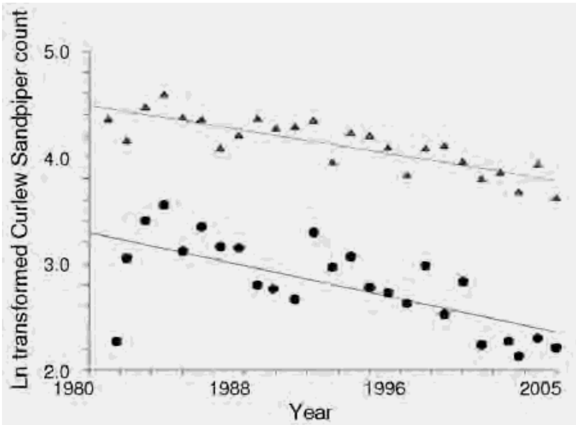

Figure 3b. Curlew Sandpiper trends in Victoria and Tasmania

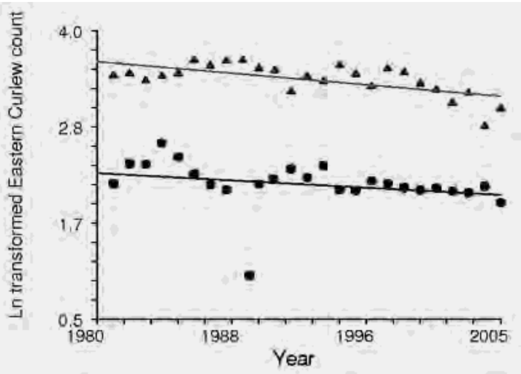

Figure 3c. Eastern Curlew trends in Victoria and Tasmania

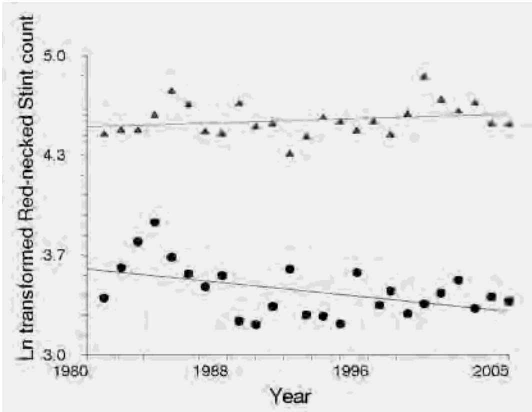

Figure 3d. Red-necked Stint trends in Victoria and Tasmania

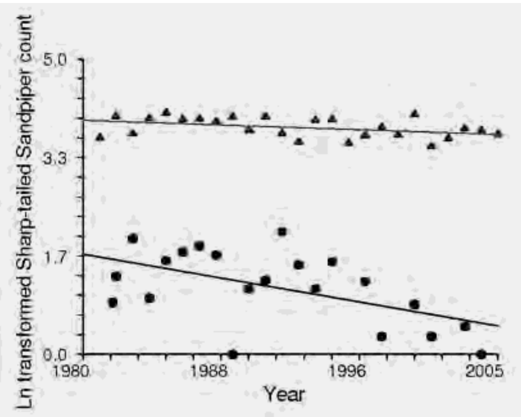

Figure 3e. Sharp-tailed Sandpiper trends in Victoria and Tasmania

Figures 3a–e. Comparisons of trends from 2 Tasmanian sites (the East Derwent / Pittwater area and Cape Portland) and four Victorian sites (Corner Inlet, Western Port, Werribee, Bellarine Peninsula). Data was log transformed to make comparisons (triangles = Victoria, circles = Tasmania).

Table 3. Population trends four species at selected locations throughout southern Australia based on annual AWSG summer counts from 1981–2005.

Key to notation

a = Autocorrelation present in data so significance level set at p <0.01
b = Assumptions of linear regression clearly not met, log-transformed data used, if log transformations did not change p-value significance then non-transformed values reported.
c = Lack of homogeneous variation and residuals not distributed normaly, but appeared to be driven mostly by few outliers which did not appear to be representative, therefore treated as normal.
d = Coefficients derived from log-transformed data
bold = significant p-value
\- = insufficient data
NS = not significant

3(a) Red-necked Stint

Region	n	Intercept	SE	Slope	SE	p-value <
New South Wales						
Botany Bay (region)	22	364	52.2	-12.7	3.6	**0.01**
Clarence River Estuary region	-	-		-		-
Hunter (region)	18	144	28.6	-4.8	1.9	**0.05**
Parramatta River (region)	-	-		-		-
Shoalhaven River (region)	18	512	109.2	-17.6	7.2	**0.05**
South Australia						
SE coast of SA (region)	25	1058	457.6	26.2	19.5	NS
Tasmania						
Cape Portland/NNE Tas region	25	1344	191.2	-28.8	12.9	**0.05**
E. Derwent / Pittwater (region)	25	8[d]	0.2	-0.0[d]	0.01	NS[abd]
Marion Bay (region)	23	189	225.3	14.5	14.5	NS[a]
Victoria						
Bellarine Peninsula (region)	25	4930	1349.8	225.4	90.8	**0.05**
Corner Inlet all	25	13444	3756.5	237.3	261.6	NS
Werribee / Avalon (region)	25	9014	2182.5	-16.7	146.8	NS[a]
Westernport (region)	24	5241	905.3	74.8	61.9	NS[b]
Western Australia						
Albany (region)	21	622	271.6	19.6	18.0	NS
Swan Estuary (region)	20	1024	433.9	-25.0	30.0	NS[a]

3(b) Bar-tailed Godwit

Region	n	Intercept	SE	Slope	SE	p-value <
New South Wales						
Botany Bay (region)	22	732	100.9	-10.9	7.0	NS[a]
Clarence River Estuary region	22	410	113.9	-0.9	7.9	NS
Hunter (region)	18	1949	357.8	-36.6	23.4	NS
Parramatta River (region)	23	231	44.6	-0.7	3.1	NS[a]
Shoalhaven River (region)	18	691	132.5	-15.1	8.8	NS[b]
South Australia						
SE coast of SA (region)	-	-		-		-
Tasmania						
Cape Portland/NNE Tas region	25	46	11.2	-1.3	0.7	NS[a]
E. Derwent / Pittwater (region)	25	90	15.9	-1.9	1.1	NS[ab]
Marion Bay (region)		-		-		-
Victoria						
Bellarine Peninsula (region)	25	571	180.2	-4.1	12.1	NS
Corner Inlet all	25	13719	2683.9	-152.8	186.9	NS[ab]
Werribee / Avalon (region)	25	18	5.4	-0.7	0.4	NS[ab]
Westernport (region)	24	572	96.8	-5.8	6.6	NS[ab]
Western Australia						
Albany (region)	21	52	14.5	-1.0	1.0	NSa
Swan Estuary (region)	-	-		-		-

3(c) Eastern Curlew

Region	n	Intercept	SE	Slope	SE	p-value <
New South Wales						
Botany Bay (region)	22	97	42.9	7.6	3.0	**0.05**[b]
Clarence River Estuary region	22	56	27.6	3.3	1.9	NS
Hunter (region)	18	515	123.5	-4.3	8.1	NS
Parramatta River (region)	-			-		-
Shoalhaven River (region)	18	229	55.4	-8.0	3.7	**0.05**[b]
South Australia						
SE coast of SA (region)	-	-		-		-
Tasmania						
Cape Portland/NNE Tas region	25	90	17.3	-2.5	1.2	0.05[ab]
E. Derwent / Pittwater (region)	25	146	17.4	-3.2	1.2	**0.05**[bc]
Marion Bay (region)	23	11	2.0	-0.5	0.1	**0.01**[a]
Victoria						
Bellarine Peninsula (region)	25	203	68.1	-4.7	4.6	NS[ab]
Corner Inlet all	25	1930	217.1	-35.3	15.1	0.05[a]
Werribee / Avalon (region)	25	27	4.7	-1.2	0.3	**0.001**[ab]
Westernport (region)	24	1588	185.2	-26.7	12.7	**0.05**
Western Australia						
Albany (region)	-	-		-		-
Swan Estuary (region)	-	-		-		-

3(d) Curlew Sandpiper

Region	n	Intercept	SE	Slope	SE	p-value <
New South Wales						
Botany Bay (region)	22	264	39.1	-12.0	2.7	**0.001**
Clarence River Estuary region		-		-		-
Hunter (region)	18	2183	315.5	-73.0	20.6	**0.01**[a]
Parramatta River (region)	23	6[d]	0.5	-0.1[d]	0.04	**0.01**[ad]
Shoalhaven River (region)	-			-		-
South Australia						
SE coast of SA (region)	25	578	102.5	-19.6	6.9	**0.01**
Tasmania						
Cape Portland/NNE Tas region	25	395	91.5	-15.2	6.1	**0.05**[b]
E. Derwent / Pittwater (region)	25	1499	231.9	-57.4	15.6	**0.01**[abc]
Marion Bay (region)	-	-		-		-
Victoria						
Bellarine Peninsula (region)	25	4473	549	-136.2	36.9	**0.001**
Corner Inlet all	25	6003	590.1	-229.4	41.1	**0.001**[b]
Werribee / Avalon (region)	25	10125	1801.6	-376.8	121.2	**0.01**[ab]
Westernport (region)	24	9[d]	0.2	-0.0[d]	0.02	0.05[ad]
Western Australia						
Albany (region)	-	-		-		-
Swan Estuary (region)	20	243	104.6	-9.2	7.2	NS[ab]

recorded at the six sites counted has reduced by 80% from 30,000 in the early 1980s to around 5,000 over the last three years. This decline appears to be widespread, occurring in Victoria, South Australia (in the south-east and the Coorong), Tasmania, south-west Western Australia, and New South Wales (Table 3d). In contrast, counts at Lake Macleod, Western Australia since 1999 have indicated use of that area by up to 40,000 Curlew Sandpiper on an annual basis (Hassell 2005). So is the cause a local problem (unlikely) or a reduction in numbers in the flyway? The decline is thought to be more likely a consequence of lower survival rates than of reduced breeding success (Rogers and Gosbell 2006) with lower survival rates most probably arising from influences at stopover sites. Furthermore it is interesting to note that Wetlands International (2002) indicates that while south-east Asian and Australasian populations of this species are decreasing, those of the African flyways, West Africa, East and Southern Africa, are increasing and stable respectively. More recently, populations in Southern Africa appear to have reduced (Les Underhill pers. comm.).

Interestingly, these analyses did not show any evidence of changing population trends for Ruddy Turnstone (Figure 2e), while evidence of increasing population trends for Sanderling was suggested (Figure 2f). However, it is likely that these two species violate the assumption of being found within a closed population more than other species, as they tend to be scattered along much longer stretches of coast. Further, there is some speculation that PMP counts at some sites have included more thorough counts recently along the long stretches of coast where these species are found (Minton pers. comm.). These factors are particularly true for Sanderling, which puts some doubt on the suggested increases reported here.

It is possible that further analysis might identify significant trends for more species in more regions. For example, tests of Bar-tailed Godwit trends show on average that populations appear to be declining throughout southern Australia, but not significantly. It is likely, given the consistency of the average trend, that if a way of accounting for the high variation in the Bar-tailed Godwit count data (Figure 2a, Table 3) were found, Bar-tailed Godwit trends would also be found to be declining significantly. Similarly, Figure 2g suggests that accounting for annual count variation might also show that Sharp-tailed Sandpiper populations are declining significantly. The methods used here were not able to accommodate the large year to year variation found in the data for these species. The large annual variability in south-east Australian counts (Figures 2a-g) may be due to a number of factors. These range from the recruitment rate which can vary considerably (Minton *et al*. 2005) depending on breeding conditions in the Arctic which may in turn be affected by such factors as weather (Boyd *et al*. 2005) and predator activity (van de Kam *et al*. 2004) to problems at stopover sites (Barter 2002). Refinement of what geographical area is counted as representing a closed population may account for some of this variation. That possibility was best illustrated here by the data points in Victoria and Tasmania when an unusually high count in one state was matched by an unusually low count in the other (Figures 3a – 3e). These kinds of swinging values suggest that some variation may be due to birds using different regions in different years. These possibilities need to be investigated further. In addition, the similarity in trends observed in different regions increases the likelihood that suggested trends are widespread, while opposite trends in different regions demonstrate the need for adequate sampling in multiple regions. With Red-necked Stint counts increasing at some count sites, and decreasing at other count sites it is hard to argue any clear overall trend (Table 3a), and this variation in possible trends further suggests that any trends observed in just one region need to be viewed critically.

Other species showing possible regional declines included: Terek Sandpiper, Red Knot, Pacific Golden Plover, Great Knot, Lesser Sand Plover, Grey Plover, Grey-tailed Tattler, and Black-tailed Godwit. Possible trends for these species need to be investigated further as sample sizes were fairly low for some of these species and there was considerable variation in apparent trends between regions. Further investigation might identify unrepresentative data points; such data may have come from counter inexperience, freak weather conditions, or incomplete counts. Some might also be accurate counts made when ornithological events occurred that were way outside known limits. An extreme example of this is the count of nearly three million Oriental Pratincole *Glareola maldivarum* on Eighty Mile Beach in north-west Australia when the world population was believed to be only 75,000 (Sitters *et al*. 2004). Once identified these unrepresentative data can be corrected by using a variety of statistical techniques, which often result in greater model sensitivity. Such techniques, however, require that the historical data needed, such as weather, is available. Route regression has perhaps been the most widely used technique to make these kinds of data corrections, but interestingly when two types of route regression and a nonparametric rank-trends test were used on the same data, the number of significant trends identified differed (Thomas & Martin 1996). More recently, still more techniques have been employed, such as; Poisson regression, the Mountford method, hierarchical models, and general additive models often with some form of the Monte-Carlo method incorporated (Royle & Wikle 2005, Link *et al.* 2006, Atkinson *et al.* 2006). These kinds of techniques can be used to not only make data corrections, but to model likely missing values, or account for spatial variation. However, these techniques while likely more sensitive than linear regression, are relatively time and resource intensive, the data needed to use some of these techniques is not available in the PMP data set, and there is no consensus on which is best. None of the potential findings using these kinds of techniques should be inconsistent with what we have reported here, as the relatively blunt instrument of linear regression is unlikely to identify a trend where there is not one. Regardless of what future analysis is performed it is clear that there is a need to conduct trend analysis in other parts of the country in order to potentially capture population trends for more species. At present the PMP is useful for detecting large changes in the number of waders visiting some parts of Australia (especially in the south and east) using linear regression. Additional work is needed to explore if smaller significant trends would be detected using other techniques for other species or in other regions.

Understanding the causes of population change

Identification of the potential causes for numeric changes in wader populations requires a knowledge of the demographic processes underlying such changes i.e. survival and recruitment, while accommodating the effects of immigration and emigration (Minton 2003, Robinson *et al*. 2005). There is an increasing awareness of the need to understand these processes and their influence on population numbers in order to inform conservation measures. In other words, for those species for which a declining trend is evident, has there been a reduction in breeding success or a decrease in survival or a combination of both? Further, knowledge of these processes enables analysis of things like population viability, and assessments of likely outcomes of adaptive management. Although considerable effort has been directed at establishing survival rates in waders, particularly in Europe, (Sandercock 2003), there has been little work done on survival rates in Australia apart from Ken Rogers (unpubl.) and some work in progress in north-west Australia by Alice Ewing. With the substantial quantity of data from the long running banding programs in Australia this is an area in need of urgent attention.

Declining populations of migratory waders are believed to be primarily due to reduced survival rates (rather than reduced recruitment) resulting from habitat loss to industry, aquaculture, pollution, land reclamations, and modifications to habitat caused by global climate change (Zöckler 2003). Barter (2002) describes the considerable threats to shorebird survival in the East Asian–Australasian Flyway arising from dramatic habitat loss in the Yellow Sea, a major stopover site where enormous reclamations have taken place over the last

20 years. While some of the effects of these changes are arguable, banding and population monitoring studies increasingly support the impact of feeding habitat loss as a cause of population declines, particularly at stopover locations (Barter 2005). The need to better understand the relationship between habitat degradation and population trends in the non-breeding regions of the flyway is important. Milton *et al*. (2005) indicate that improved predictive methods are required if we are to be confident of measuring significant declines in a reasonable time and certainly before populations are reduced to very low numbers.

Breeding success has been examined by using data on the proportion of juveniles captured during banding efforts over the last 25 years (Minton *et al*. 2005, Minton 2004). It has also been shown that winter (i.e. non-breeding season) counts from the PMP can be used to assess breeding success (Minton *et al*. 2005). Most migratory waders that spend the non-breeding period in Australia do not breed in their first year, therefore the numbers of birds spending the winter in Australia appear to give a measure of recruitment for some species. Wilson (2001) indicates that some species do not breed until their third year or older or alternatively undertake a partial migration, moving northwards within Australia. However the juvenile population of both Red-necked Stint and Curlew Sandpiper appear to remain sufficiently stable over winter to enable the winter count of these species to be used as an indication of the previous seasons breeding success in the Arctic (Minton *et al*. 2005). Minton (2005) indicates the difficulty in applying this methodology to other species such as Red Knot, Sharp-tailed Sandpiper or Eastern Curlew because either there are cohorts of at least two years that remain in the non-breeding area or at least some of the juvenile population move north in the winter. With increased emphasis on counting of key Ruddy Turnstone areas it may be possible to correlate the winter counts of this species with breeding success. Rogers & Gosbell (2006) demonstrate that a demographic model utilising the juvenile proportions from catching, is capable of predicting population counts for Red-necked Stint and Curlew Sandpiper in Victoria, suggesting that much of the variation in annual PMP count data is due to actual demographic variation.

Improving the PMP

This analysis has highlighted many areas where the PMP could be improved. One limitation involves the consistency and continuity of counts, which have varied considerably around the country over the years. One of the largest limitations of the data set has been the lack of reporting when there were changes in which roosts were covered for a site's count in any one year (Driscoll 1997, Wilson 2001). Further, due to the extreme remoteness of many parts of Australia, and the paucity of funded resources available to do counts, more areas were counted with greater frequency in places close to human population centres. It can be seen from Table 2 that there are several sites that are part of the PMP that need to have counting resumed. Two of the most important sites in north-west Australia, Eighty Mile Beach and Roebuck Bay, were counted in full in 1999 and 2001 (Minton *et al*. in prep.). These are also key sites in the MYSMA (Monitoring of Yellow Sea Migrants in Australia) program which started in 2004 (see later). The Gulf of Carpentaria has received little attention despite its importance as an Australian shorebird area and a potential major stopover site. The most recent counts were by Driscoll (using a microlight aircraft) and others between 1998 and November 1999 and showed the importance of this region, not only as a stopover site for both northward and southward migration, but also during the breeding season (austral winter) when relatively high usage was recorded compared with other shorebird areas in Australia (Driscoll 2001). Remoteness and costs due to the difficult logistics of counting, including difficulty of access and crocodiles during the wet season, have limited fieldwork in these remote areas. Clearly our knowledge of shorebird numbers and distribution would benefit from increased count frequencies at these important sites.

The PMP has been supplemented by 'one off' or 'occasional' counts for important coastal areas as well as inland areas. Several of the most important sites identified in Australia (Watkins 1993) have only been covered in this way. One example is the survey of Lake Macleod and Port Hedland area carried out by private enterprise on an annual basis since 1999. Inland sites, often ephemeral due to intermittent rainfall, are generally only counted occasionally. In some cases, these occasional counts are carried out more frequently but the data are often not passed on for entry into the database. The PMP would be strengthened greatly if all data were available for analysis, and if areas visited opportunistically were counted both more frequently and consistently.

There are a number of questions that the PMP will never be able to address in its current form. For example, trends for many resident and dispersed migratory waders can not be gleaned from the PMP's current form as many areas, and many habitats are poorly represented. While resident species are counted as part of the PMP there has been under-representation of resident shorebirds, and migratory waders that tend to be more dispersed. Notable exceptions to this lack of attention include Pied and Sooty Oystercatchers and more recently Australian Painted Snipe (Rogers *et al*. 2005). Milton (2003) has referred to the need to review the status of resident species, several of which may be at risk. See also Weston (2006).

Finally, the PMP is the only data set available to analyse population trends throughout Australia; the future emphasis should be on collecting data sufficient to allow examination of all species whose population trends are wanted, to cover those species distributions sufficiently to determine if trends are widespread, and to ensure counts are conducted in such a way as to maximise a site's count continuity over time. Improvements in sampling, count methodology, and analysis techniques all may contribute to improved population trend data for more species in more regions with greater sensitivity to smaller changes. It is imperative that any future design changes to the PMP allow comparability with previous data while seeking to improve the existing program.

Future directions of population monitoring in Australia

Detecting changes in populations

The East Asian–Australasian Flyway is one of eight shorebird flyways around the world and it supports over 8 million migratory shorebirds of which over 5 million come to Australia for the non-breeding season; 2 million when Oriental Pratincole are excluded (Bamford *et al*. in prep.). With more than 45% of the world's human population living within the boundaries of this flyway there are enormous economic and social pressures impacting on the resources of the region, which contribute to major threats to both coastal and inland wetlands. The most important region for migratory shorebirds is the Yellow Sea; its role as a major staging site is well documented (Barter 2002). This region is particularly important as a staging site during northward migration as birds prepare for their final flights into the breeding grounds and yet approximately 40% of the Yellow Sea intertidal areas have been reclaimed so far with more reclamation planned.

In 2003 it was recognised that the population monitoring data available was inadequate to enable early assessment of the impact of these reclamation works on shorebird populations that migrate to Australia. A program was designed and implemented which focussed on determining the impact (if any) on key species by an increased survey effort particularly in the non-breeding season. The program, Monitoring Yellow Sea Migrants in Australia (MYSMA), started in November 2004. A paper outlining the results of this program is presented elsewhere in this volume (Rogers *et al*. 2006).

Apart from the excellent data collected over the last two years, one of the other major outcomes of this program has been to identify areas for improvement in the current methodology. These include:

(i) a need to clearly state the goals of the PMP
(ii) a need to monitor additional key 'closed system' shorebird areas in Australia;
(iii) a need to understand the dynamics of shorebird areas in order to select the best times for counting and choose the appropriate roost sites for large and complex systems ;
(iv) a need to improve the methodology to account for observer differences;
(v) a need to improve the methodology to establish the magnitude of variances;
(vi) a need to ensure that the area being sampled is the same over time, and to report any changes in spatial coverage of any given count; and
(vii) a need to maximise the chances of meeting goals and answering specific questions by designing the best sampling methods possible.

Development of a National Shorebird Monitoring Project

The future development of the PMP will, of course, build on the knowledge and historical data gathered over the past 25 years. The inherent difficulties in executing such a large and important project on a voluntary basis with limited organisational support needed to ensure success is well recognised. In addition to the knowledge built up at each of the existing sites, additional count areas will need to be reviewed that fulfil a number of criteria ranging from being practical, geographically representative, represent habitat diversity (estuaries, lakes etc), to being representative for the range of shorebirds that occur in Australia. A key requirement will be that the areas are accessible and resources are available to conduct counts at regular intervals. This may mean that some key sites, such as the Gulf of Carpentaria, cannot be included in the ongoing program but will require 'one-off' surveys according to clearly defined protocols. One problem in Australia is the use by some species of ephemeral inland lakes and waterways. These are not well covered and yet can become important in understanding the movements of birds particularly during times of drought (Alcorn *et al.* 1994). The recent report by Birds Australia for the Australian Government Department of Environment and Heritage (DEH) on testing criteria to identify nationally important sites in Australia, (Clemens *et al.* 2006), will be useful as part of the shorebird area assessment process. In addition, the count methodologies will need to be standardised to ensure that consistency, roost characteristics and numbers are recorded, weather conditions are noted etc . A key input here would be the methodologies trialled in the MYSMA program by Rogers *et al.* (2006). Some modification of the count database may be required to accommodate the count procedures finally adopted.

The AWSG has developed the following recommended objectives for improvements to the PMP to form a major national shorebird monitoring project in conjunction with Birds Australia:

- To provide a basis for the development of indices of population change for individual species for publication in the State of Australia's Birds.
- To monitor shorebird populations in an ongoing, robust and scientifically defensible manner including sound sampling design.
- To fully document all PMP areas utilising GIS mapping techniques to assist in ongoing consistency of counts and to help explain trends for particular sites.
- To upgrade the database to ensure it is a robust, reliable information storage and retrieval system that can respond to new methodologies and can be easily interrogated for research and environmental studies.
- To supplement the database with the additional data in various formats and locations around the country.
- To gather data to supplement demographic monitoring.
- To increase the capacity, skills and number of shorebird counters throughout Australia.
- To raise the awareness of shorebirds, their habitat and the need to monitor them among all levels of government and the local community.

A fundamental problem to be addressed in a new monitoring program is that of the management and coordination. While the volunteer coordinators over the last 20 years have done a magnificent job in keeping the PMP going and publishing the results of the twice yearly counts in *Stilt* it is now essential that a dedicated, funded project manager/ coordinator be appointed. This person will be required to develop the program, establish criteria for shorebird area selection and count procedures as well as recruit and train additional volunteer counters around Australia. The subsequent analysis and feedback to counters and researchers is also an important part of the role. A three year strategy is now being developed jointly by the AWSG and Birds Australia to seek the funding of this program.

In conclusion, the extensive data from the PMP has been critical in expanding knowledge about shorebirds in Australia. First, early mapping of the total distribution of waders in Australia resulted in two major publications (Lane 1987, Watkins 1993). This formed the basis of the National Plan for Shorebird Conservation in Australia that identified important areas for shorebirds in the country (Watkins 1993). Since 1985 additional wader areas of international significance have been gradually discovered with some new areas added to the PMP. Often PMP data has been critical in designating important conservation areas such as Ramsar areas. Further, PMP data has been a critical component of work done to estimate shorebird populations (Bamford *et al.* in prep.). Further, the duration of the PMP has enabled the commencement of population trend analysis, which here has highlighted the declining population of Curlew Sandpiper, and raised the possibility of declining populations in up to twelve more species. Finally, the PMP has been one of the major achievements of the AWSG and has produced an extensive data set equal to any other country in the world albeit with limited volunteer resources. The PMP continues to be the corner stone of all monitoring work done on migratory waders that visit Australia, and it can continue to provide the empirical evidence of changing populations which should further help focus attention on areas where research is needed.

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CAUSES OF VARIATION IN POPULATION MONITORING SURVEYS: INSIGHTS FROM NON-BREEDING COUNTS IN NORTH-WESTERN AUSTRALIA, 2004–2005

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This paper reports on shorebird monitoring counts at three sites in north-western Australia (northern Roebuck Bay, Bush Point and Eighty-mile Beach) in 2004 and 2005. Each site encompasses a large area, usually with a number of different shorebird roosts (sub-sites). A sound understanding of local roosting behaviour of shorebirds enabled us to minimise or eliminate potential biases caused by overlooking birds. We estimated causes of error in shorebird counts at these sites by repeating surveys in quick succession, and examining the difference in count totals in relation to site, species, observer, sub-site and number of component counts. There were considerable differences between sites in the variability of count totals, and these were strongly and predictably influenced by the number of component counts required to carry out a full count of a site. Building on the methods of Rappoldt *et al*. (1985), we were able to use this information to quantify the stochastic error (proportional to the number of birds present) at each site. The coefficient of variation for a component count was estimated to be 30% in Northern Roebuck Bay and Bush Point, and 80% at Eighty-mile Beach. However as these errors are unbiassed, the effect of combining component counts is to reduce the relative error considerably; our modelling for the north-western Australian sites considered indicated that, with the current counting regime, it should be possible to give early warning of population (using an 80% significance level) changes of the order of 10–15% in most species between one year and the next. Close examination of the causes of count error at specific shorebird sites requires that all component counts are recorded, and repeat counts can provide much useful information. The approach offers the prospect of much-increased sensitivity in detection of population changes.

INTRODUCTION

Counts have been part of the armoury of shorebird biologists for many years. Data from shorebird counts have been used to assess the timing of migratory arrivals and departures (e.g. Thompson 1993, Farmer & Durbian 2006), to inform small-scale assessments of habitat quality, and to assess the conservation values of wetlands. In addition, shorebird counts are becoming increasingly important to conservationists assessing long-term population trends of shorebirds (e.g. Warnock *et al*. 1998; Marchant *et al*. 1998; Gosbell & Clemens 2006), and as measures of the success of habitat management undertaken at specific wetlands (e.g. Burton *et al*. 1996).

Shorebirds are easier to survey than most animals, as they typically live in open habitats and congregate in flocks. However, this does not mean that shorebird counts are easy to carry out or to interpret. The number of shorebirds recorded in a count is typically inexact as it is seldom possible to see every individual at one time and count them one by one. Technically, count totals are estimates of the numbers of birds present and are subject to statistical uncertainty. They are influenced not only by the number of shorebirds present, but also by other factors including conditions prevailing during the count, the size of the flocks in which they occur, the experience of the observers, and the accessibility of roosts (Rappoldt *et al*. 1985). The resultant uncertainty inherent in count estimates causes difficulties for analysts. Although shorebird count programs have in the past been successful in determining population trends of monitored species, many years of data have been required to do so (Underhill & Prys-Jones 1994; Gosbell & Clemens 2006). While it is desirable to detect long-term population changes in this way, more rapid detection of changes is needed for responsive conservation management. It would be helpful to be able to distinguish genuine population changes over fairly short time-frames from statistical uncertainty in shorebird counts.

Ideally, the best way to assess the uncertainty in counts would be to measure it directly through repeated counts in the same season. In a study of British count data, Atkinson *et al*. (2006) concluded that at least three counts per site per season were required at a migratory terminus to detect population declines of 50%. (It is not clear whether they were using the term "site" in the same sense as us; our definition of "shorebird site" is provided in the methods section.) However, frequent repetition of counts is not always feasible. Some constraints on frequency of shorebird surveys are physical. For example, many shorebird sites in Australia are counted on the biggest spring tides available; at most, suitable tide series will only be available at fortnightly intervals and suitable tide heights may not be reached on all spring tides. Seasonal changes in shorebird numbers (for example related to migration) may also leave shorebird counters with only a short window in which reproducible shorebird surveys can be conducted. Moreover, there are often logistical constraints that prevent surveys being undertaken as frequently as statisticians might desire. Shorebird sites usually consist of many different roosts, and counts need to be undertaken at all of these at about the same time if a complete count of a site is to be achieved. Such surveys often demand a large team, and may require financial support if, for example, there are roosts that are only accessible by boat. In practice, the counting strategies used at different sites are often influenced by local topography and the teams and resources available for surveying. This has been particularly problematic in Australia, where the convention at many sites has become to carry out two surveys per year, one in the austral summer and one in the austral winter (Gosbell & Clemens 2006).

In 2004 the Australasian Wader Study Group (AWSG) initiated the Monitoring Yellow Sea Migrants in Australia (MYSMA) project. Part of the impetus for this project was the need to find a more sensitive way to monitor shorebird populations in Australia. Another reason was the need to assess the effects of the impending completion of the Saemangeum sea-wall in South Korea, a large-scale reclamation of a tidal flat system which could cause considerable population declines in some shorebird species (Moores 2006; Rogers *et al*. 2006d). In this paper we report on shorebird population monitoring counts carried out at three sites in north-western Australia in the austral summers of 2004/05 and 2005/06. We have three objectives. First, we attempt to establish a baseline against which future shorebird counts in north-western Australia can be compared. Secondly, we attempt to identify and quantify the causes of variation in count data from the three study sites. Thirdly, we consider their implications for shorebird population monitoring in north-western Australia and elsewhere.

Background on sources of variation in counts

Definition of shorebird sites

If shorebird populations are to be monitored, they need to be surveyed on an appropriate spatial scale. Counts at individual roosts are not highly reproducible because shorebirds from particular feeding grounds will very often have a choice of several roosts that may be used in different conditions of tide, weather or disturbance (e.g. Handel & Gill 1992; Piersma *et al*. 1993; Rogers *et al*. 2006a, 2006b). Surveys carried out over very large geographical scales are logistically difficult, as all roosts in a survey area need to be visited: if they are not, there is a danger that an unknown proportion of the bird population present will be overlooked. In addition, for practical conservation purposes it is often important to understand population trends at a relatively small spatial scale.

In this paper we define a "site" as the smallest area of shorebird habitat that can be monitored in a reproducible manner. Such sites should ideally comprise feeding grounds with reasonably clear geographical boundaries, and all of the roosts used by shorebirds commuting to these feeding grounds; these roosts should not be used on an intermittent basis by birds from other feeding grounds. Such a site definition has sometimes been referred to as a "closed system" in Australian conservation circles. It is probably often impossible to define the boundaries of a site so that it meets all of these criteria perfectly. Nevertheless, we believe that the closer a "site" comes to meeting these criteria, the more reproducibly it can be monitored. Later in this paper we discuss the delineation of our three study sites, providing examples of the compromises that sometimes need to be made.

In some cases we also use the term "sub-site". We use it as a neutral term for an identifiable geographical location within a shorebird site; the total number of shorebirds at a site is the sum of the number at the component sub-sites. Sub-sites are defined by the way shorebirds use a site. They need not be contiguous and they can vary in size (see, for example, Figure 1).

Sources of variation in counts

In the planning stages of this study we identified several sources of potential variation in counts, discussed below. We then discovered that essentially the same sources of variation had already been identified and investigated in an important study by Rappoldt *et al*. (1985), which has, unfortunately, been rather neglected. Their study, carried out in the Dutch Wadden Sea, was based on a series of "counting experiments" in which a number of both experienced and inexperienced observers counted the same shorebird flocks in a variety of field settings, and in which their results were compared with the number of birds actually present (identified through photography or by flight counts of birds trickling into or out of roosts). A very important conclusion from Rappoldt *et al*. (1985) was that much of the variation in shorebird counts is caused by stochastic error that can be described by the ratio of standard deviation divided by the mean (i.e. the coefficient of variation, referred to as relative standard deviation [RSD] by Rappoldt *et al*. [1985]). In other words, this part of the variation in shorebird counts is predictable and is proportional to the number of birds present.

Although Rappoldt *et al*.'s (1985) terminology differed from ours, there were considerable conceptual similarities in our conclusions about the causes of variation in shorebird counts. We had identified these as:

1. **Observer error.** Different observers, counting the same flock of birds, will often obtain different results. Even a single observer, counting the same flock of birds twice, may come up with different results. Rappoldt *et al*. (1985) referred to this error as "within-situation error". Their counting experiments showed the co-efficient of variation for replicated counts of perched shorebirds in flocks to be 25%. They were unable to detect any systematic error in such counts; i.e. the counts obtained by different observers were randomly scattered around the number of shorebirds that were really present, with underestimates being as likely as overestimates.
2. **Site-specific error.** Different counting situations pose different challenges for observers. The visibility of individual birds in a flock may be influenced by a number of variables, including their distance from the observer, light conditions, the vegetation or substrate on which the birds are standing, the topography of the count area, or the density with which birds are packed. Rappoldt *et al*. (1985) referred to the combined effects of such variation as "between-situation error". Their counting experiments showed this coefficient of variation for perched shorebirds in flocks to be 27%. By combining this with the rate of within-situation error (i.e. stochastic error = $\sqrt{[25^2 + 27^2]}$), they calculated a total stochastic error for shorebird counts of a given

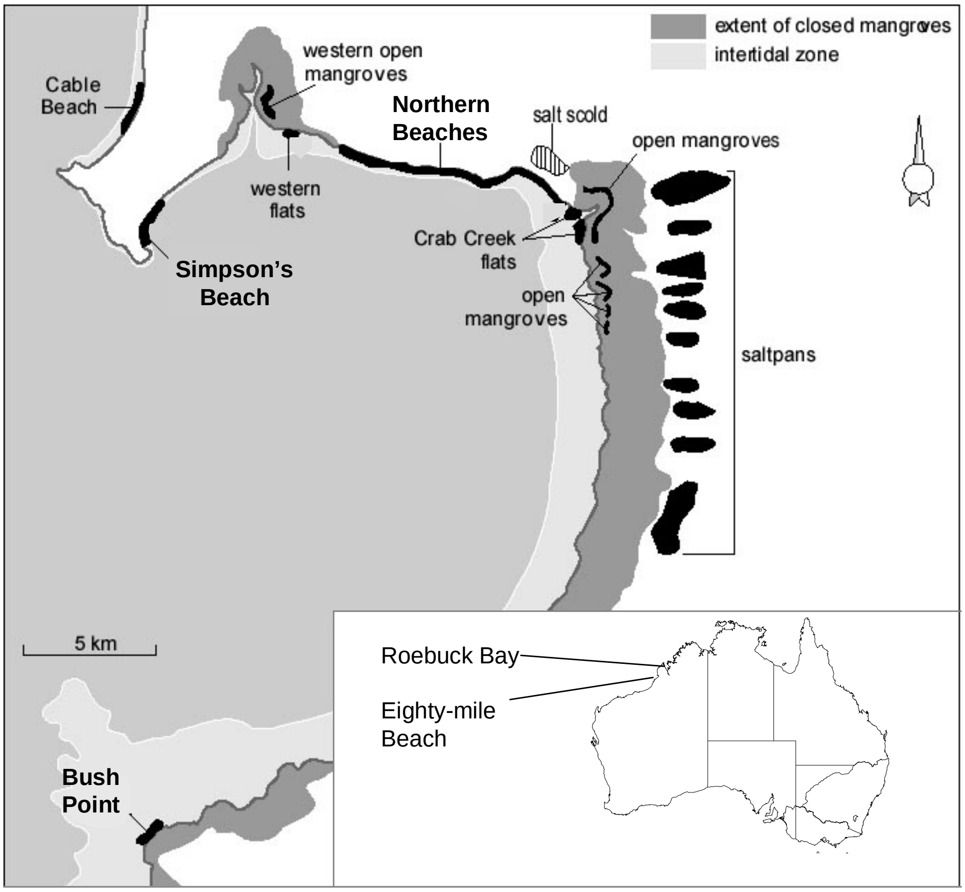

Figure 1. Location of the study sites (inset) and the shorebird roosts of Roebuck Bay. Many of these roosts are only used on neap tides, on spring tides or at night. On daytime tides of intermediate height, the only roosts used by shorebirds (and surveyed) were the Northern Beaches and Simpson's Beach. Bush Point, counted on spring tides, is in the south of the bay.

flock as 37%. While this error rate may seem high, it should be borne in mind that such errors are not systematic (i.e. unbiassed), and when combining a number of flock counts to calculate the number of shorebirds present in an area, the stochastic errors will tend to neutralise one another. In doing this for the entire Dutch Wadden Sea, Rappoldt *et al*. (1985) found that the stochastic error (i.e. coefficient of variation) in counts of the most abundant species lay between 5% and 12%.

3. **Bias.** Rappoldt *et al*. (1985) used the term "area errors" to refer to problems when not all birds which are present in an area are counted. Use of the term "error" in this sense is a little misleading, as such variation is systematic (skewed towards undercounting), and the resultant variation is therefore statistically different from predictable (stochastic) error. Rappoldt *et al*.'s (1985) results suggested that area errors are most likely to result when scattered individuals or entire flocks were overlooked, and that such problems were proportionately smallest for abundant species, in which the systematic error caused by missed birds was unlikely to exceed the stochastic error associated with counts of flocks. However, area errors were of much greater magnitude for scarce species. They noted that area errors were a potentially serious problem, as the magnitude of such errors is necessarily unknown, and recommended that field programs be designed to nullify their occurrence if possible. There are other potential sources of bias (i.e. systematic error in one direction), such as that which would be caused by a particular observer always counting lower than other observers, or that which would be caused by conducting a survey at different times in different years.

The variation in shorebird counts outside the sources of error and bias listed above can be partitioned further (see below) and includes the genuine population changes which are the real focus of population monitoring studies.

METHODS

Study sites and minimising bias

We carried out our surveys at three sites in north-western Australia (for a map of the general area, see Minton 2006): northern Roebuck Bay, Bush Point and Eighty-mile Beach. All field surveys were conducted between mid-November and mid-December, early in the non-breeding period of migratory shorebirds but after all should have arrived in Australia. This was done with two considerations in mind. First, if predictable movements of any species occur within the non-breeding season, it would introduce bias if we were to conduct counts at different times of year from one year to the next. Secondly, we wanted to conduct our counts when shorebirds were roosting on beaches. In Roebuck Bay and Bush Point, there are alternative shorebird roosts on saltmarshes, but these are only used by shorebirds when flooded by very high spring tides, or by recent rainfall (Rogers *et al*. 2006a, 2006b); when dry, these sites are too hot for roosting shorebirds (Rogers *et al*. 2006b). Climate is relatively predictable in north-western Australia, and by carrying out our counts before the wet season rains began in late December or early January, we were able to ensure that the surveys were conducted at times when potential saltmarsh roosts were inhospitable to shorebirds. Carrying out the counts at this time of year also had the practical advantage that counts were carried out before wet season rains made many access tracks impassable.

Shorebirds encountered during a survey do not always occur in a single flock; they may occur in several groups varying in size from a single bird up to several hundreds. As explained below, an essential part of the counting discipline was that all component counts were recorded by the scribe. Count totals are given in the Appendix.

Exact timing of surveys in this study was dependent on tide heights and was also influenced by team availability. All of the field surveys were led by CJH and each counting team was led by an experienced shorebird counter. Terns and gulls were also counted, and results from these species are also presented here as they also provide information on the extent of count error. Counting strategies at the three sites are described below. All of the sites are on the coast of north-western Australia (in the monsoonal tropics; Figure 1.) where extensive intertidal mudflats are used as feeding grounds by internationally significant numbers of a large variety of shorebirds. The high numbers and diversity of shorebirds present make counts in north-western Australia very time-consuming, and fieldwork needs to be planned carefully to ensure that counts are completed in the four hours or so available to counters at high tide. Different counting strategies were developed for each site to minimise the possibility of introducing bias by not counting all birds using the sites. Notes on the strategies at each site are provided below.

Northern Roebuck Bay

Despite its size (about 27 x 20 km), roosting habitat around Roebuck Bay is limited, as much of the coastline is fringed by dense mangroves which are unsuitable for roosting shorebirds. Roost choice of shorebirds in northern Roebuck Bay has been studied in some detail (Rogers *et al*. 2006a, 2006b). These studies showed that by day, birds can roost on exposed mudflats on neap tides, or in mangrove clearings or saltmarsh on spring tides. Neither habitat type is suitable for shorebirds on tides of intermediate height (6.0–8.2 m), when all of the mudflats in the bay are submerged and the roosts in saltmarsh and mangrove clearings are inhospitably hot. Counts were done in these conditions when, with one exception, the only suitable roosts for shorebirds in northern Roebuck Bay occur on a 9 km stretch of beaches along the northern shores (Figure 1). These beaches are readily accessed by road, and provide excellent viewing conditions, as all shorebird flocks on them can be scanned at reasonably close range from adjacent sand-dunes or low laterite cliffs without causing disturbance. However, shorebirds on these beaches are often disturbed by birds of prey or recreational beach users (Rogers *et al*. 2006c), and this sometimes causes difficulties during shorebird surveys, with counting teams having to retrace their steps and recount flocks after they have been disturbed and scattered. Counts were conducted by two teams during a single high tide, one starting in Broome and counting their way east, the other starting at Quarry Beach and also counting their way east. The exception noted above is Simpson's Beach on the southern side of the Broome peninsula. This 3 km beach is counted on foot by a third team.

Bush Point

This sandy point is in the south-western corner of Roebuck Bay. Although it is only *c*. 25 km from the northern beaches of the bay, species composition of roosting flocks differs and it is used as a roost by birds from different feeding areas. An intensive automatic radio-telemetry study of Red and Great Knots showed that there was virtually no movement of shorebirds between northern Roebuck Bay and Bush Point (Rogers *et al*. 2006b). Observations on incoming tides indicate that most or all birds roosting at Bush Point approach from adjacent mudflats of southern Roebuck Bay. Presumably there is some kind of cut-off on the intertidal flats to the east of Roebuck Bay, north of which birds typically commute to northern roosts, and south of which birds typically commute to the south of the bay. The location of this cut-off has not been pin-pointed, and it is possible that it lies in different places for different species or individual birds. However, assuming that the cut-off point does not change substantially over time, for monitoring purposes it seems reasonable to treat Bush Point and Northern Roebuck Bay as discrete shorebird sites.

When tides are high enough to reach the mangroves on the southern shores of Roebuck Bay, Bush Point apparently becomes the only suitable roost site for shorebirds in the southern half of Roebuck Bay, with no additional roosts having been found along the remote southern coastline of the bay in the course of several aerial surveys (unpublished independent observations by DIR, CJH, and C. Minton). Counts at Bush Point were therefore conducted, whenever possible, on tides higher than 8.0 m. Tides higher than 8.8 m were avoided, as such tides prevent vehicle access. On tides of about 8 m the potential roosting area at Bush Point occupies about 1–2 km of exposed sandflat. We found it was best to count the shorebirds in this area on foot with two teams with one starting at the mouth of Yardoogara Creek in the west and the other from the eastern end of the beach.

Eighty-mile Beach

Despite its name, Eighty-mile Beach is actually 143 miles (230 km) long. It abuts mudflats 0.5 to 4 km wide, and these are used as feeding areas by very large numbers of migratory shorebirds (Piersma *et al*. 2005). At high tide, these shorebirds roost on the adjacent beach, with their numbers often being augmented by Oriental Plovers and Little Curlews which feed on the plains inland (probably mostly at night), and roost on the beaches during the hottest time of day. Although Eighty-mile Beach looks remarkably uniform on casual glance, some regions of the beach are broader than others. Roosting shorebirds tend to avoid the narrower parts of the beach on spring tides, when long-shore commuting flights are sometimes seen. On lower tides however, they simply roost on the area of beach closest to the section of mudflats where they feed at low tide (Rogers 2005); such tides are also more suitable for counting because the beaches become broader and it is easier for counting teams to drive past shorebird flocks without disturbing them. On the basis of previous field surveys, tide heights between 6 and 7 m were considered most suitable for Eighty-mile Beach surveys.

A long stretch of beach needs to be surveyed at Eighty-mile Beach if counts are to be reproducible. Feeding grounds along this beach are likely to be dynamic, especially as cyclones can alter distribution patterns of sediment (Pearson *et al*. 2005; Honkoop *et al*. 2006), so it is likely that over time birds will make some long-shore movements and thus move into or out of a small counting area. However, counting shorebirds at Eighty-mile Beach is time-consuming, as very large numbers of birds are present and species diversity is high. In such conditions a single counting team can only cover ten kilometres of beach in a single high tide period. We only had the resources to survey 60 km of beach, deploying two counting teams over three consecutive daytime high tides in November 2004, and three counting teams over two consecutive daytime high tides in subsequent surveys. Longer survey periods were not possible, as tide heights became unsuitable. We surveyed the 60 km stretch of beach south of the Anna Plains access track in all surveys, treating each 5 km stretch of beach as a separate sub-site. In two previous surveys of the 230 km of Eighty-mile Beach, this particular 60 km stretch had been identified as the section with most shorebirds, holding *c*. 80% of the shorebirds found on the whole beach (unpubl. MS by D. Price, C. Minton and colleagues). Neither end of our survey area had clearly defined geographical boundaries, so there may have been movement of birds into or out of the north-eastern and south-western ends; we have assumed that error caused by such movements was negligible given the scale of the area we surveyed.

Data Analysis

Sources of error in counts

Rappoldt *et al*. (1985) showed, assuming that all component counts are subject to the same relative error, that the standard error of a count total is given by:

$$SE(\text{Total}) = CoV \,.\, SSF$$

where CoV is the stochastic error term (37% in Rappoldt *et al*.'s [1985] case described above), and SSF is a term we have called the Sum of Squares Factor, which is given by:

$$SSF = (\sum C_i^2)^{1/2} / \sum C_i$$

where C_i is the number of birds seen in the i^{th} component count.

It is clear from the above that the standard error of a count total is directly proportional to SSF. We don't actually need to know what the coefficient of variation is to examine how errors will vary by, for example, observer and site; we can gain this information exactly from examination of changes in the SSF.

Effects of count totals, observer and site on sum of squares factors

Variation in the sum of squares factor (SSF) was examined in relation to differences in counter, site, sub-site and species, initially using a multivariate regression approach. We only used the data from 2004 in this analysis, as the two surveys at each site were carried out only a week apart. The surveys carried out in 2005 were conducted over a month apart, and it was thus more likely that local movements might have caused additional count variation.

The largest value the SSF can take is 1, occurring when only a single group of birds is counted. We are interested in how much reduction in this is caused by each of the independent variables. The most convenient way of modelling this is by using SSF - 1 as the dependent variable and doing a regression analysis with no constant. The regression coefficients, or their combined effect, should therefore be negative.

Numbers of birds counted in sub-sites can vary from a single individual to several thousands. We therefore worked with the logarithm of the number of birds counted rather than the raw number. Sites and counters were categorical variables, represented in the data as binary variables (i.e., they can take the value of 0 or 1). Using binary variables in regression analysis is perfectly acceptable but we can only calibrate differences relative to a base case. We treated the counts carried out by CJH in Northern Roebuck Bay as the base case because CJH carried out more counts than any other observer, and because this was the most conveniently and frequently counted of our study sites. There were three other leaders of counting teams, DIR, Adrian Boyle (AB) and George Swann (GS); and two other sites, Eighty-mile Beach (EMB) and Bush Point (BP). Multiple regression analyses will not work if one variable is 100% correlated with a combination of the others, so only the variables DIR, AB, and GS were entered for counter, and EMB and BP for site. (This is all that is needed; for example, if we know what sub-sites three of the counters counted, those counted by the fourth counter are determined.)

Magnitude of error in counts

On our first inspection of the 2004 data it was evident that for some species, the differences between the number of birds seen on the first and second surveys were so substantial that they could not easily be explained by counting error. Presumably birds had moved into or out of the study sites between the first and second surveys. To identify species for which this was likely to be the case, we used a version of the z-test to calculate the "limiting coefficient of variation" (*LCoV*) for this difference to be significantly different at a specified confidence level (CL) from:

$$LCoV = \frac{Difference}{NumSD \,.\, (\sum C_{A,i}^2 + \sum C_{B,i}^2)^{1/2}}$$

where:

- *Difference* is the absolute difference between the counts of the first and second series;
- *NumSD* is the number of standard deviations different from zero corresponding to a specified confidence level (CL);
- *NumSD = NormInv(1-CL/2)* where *NormInv* is the inverse of a normal distribution with zero mean and unit variance (a function to calculate this is provided in standard spreadsheet packages). Here, we have chosen a value of 10% for the confidence level, CL (it is divided by two is because the test is two-tailed (either of the two counts can be the larger); and
- $\sum C_{A,i}^2$ is the sum of squares of the i component counts in the A^{th} series and similarly for the B^{th} series.

We calculated this limiting coefficient of variation for every species at each site and ordered each list from lowest to highest. The lists were examined and a subjective judgement made of those species for which the difference between the counts was likely to be due to random variation in the counts rather than to any significant difference in the numbers of birds present. It was then easy to find the pair of adjacent species in which the observed difference between the counts was considered not significantly different from zero at a given confidence level for one of the pair, and which was considered significantly different for the other of the pair. A round number between the values of limiting coefficient of variation for these two species was taken to be the coefficient of variation for the site.

Calculation of standard deviations is straightforward once a coefficient of variation for a site is available. Comparison of two counts is also straightforward since, except for cases where samples are too small to be relevant, the significance of a difference is found by dividing the difference by the standard deviation of the difference. The latter is found as the square root of the sum of the two variances being compared.

Finally, we consider the needs of the wildlife managers who need to know what size of reductions in species' population levels will be detected by monitoring. The basic approach is to determine the reduction in a species' numbers which will be detected at a minimum level of confidence. The problem is in not knowing what standard deviation applies to future counts. This parameter can be estimated from a statistical model which estimates the SSF with site and total count as the independent variables. In the context of this study, separate estimates are required of the size of reductions in species numbers which are significant for each site and for the aggregated total over the three sites combined. In the latter case, it is necessary to assume that, subject to statistical uncertainty, the same percentage reduction in numbers occurs at all sites. We have chosen a figure of 80% as the appropriate level of confidence. This is rather less than the figures of 90% or 95% generally used in statistical testing but the situation examined here is rather different. The intention is to give early warning that a species is in trouble so that any preventative actions can be taken to preclude a population collapse rather than to give a high degree of confidence that such a collapse has already occurred. The mechanics of the method are simple: (1) assume a percentage reduction in numbers of a species, (2) convert this to a number of birds, (3) calculate the standard deviation applying to this number of birds, (4) determine if the reduction is significant at the chosen confidence level (N.B. a one-tailed test as we are only considering reductions), and (5) if not, return to step (1) with a revised estimate of the percentage reduction which will be significant.

RESULTS

Sources of error in counts

The effects of observer, site, sub-site and number of birds on variation in the SSF in 2004 are examined in the multiple regressions summarised in Table 1. Model A contains all the variables and explains 85.0% of the variation in the data. The two imposing features are the dominating effects of Eighty Mile Beach and the LNCOUNT variable. Bush Point is not significantly different from Roebuck Bay. Of interest are the low SSFs of two observers, AB and GS. On the face of it, these imply that these counters made a greater number of smaller component counts than CJH but the result is not significant at the 5% level. Counts carried out by DR were apparently significantly higher than those of CJH, but this result could in part be due to interactions with other non-significant variables in the model. This is the only case of a significant positive coefficient in all the results. Since at least one bird must be counted, the combination of DIR and LNCOUNT is always negative.

Model B omits the site variables and is unsatisfactory, explaining only 74.1% of the variation in the data. The coefficients of all the counters are negative and statistically significant at the 5% level. In Model C we bring back the sites, which are clearly needed, and omit the variable representing logarithm of the count total. This is a something of an improvement explaining 75.9% of the variation in the data. All the coefficients are negative but that for DIR is not statistically significant.

Model D contains only the site variables and the variable describing the number of birds. It is very nearly as good as model (A) explaining 84.8% of the variation in the data (as opposed to 85.0%) but the coefficient for Bush Point is again not significant. Model E removes the Bush Point variable without apparently reducing the Multiple R^2; in fact there is a small reduction in the fifth figure after the decimal point.

It seems clear from these results that whilst there are differences between counters, these are negligible compared to the differences between sites and can be dropped from further consideration.

A plot of SSF by sub-site (Figure 2) shows that this parameter differs consistently between the three main sites considered. There were no separate sub-sites within Bush Point, so the observed SSF for that site is depicted as a straight line. On Eighty-mile Beach, the SSF observed in the different 5 km stretches of beach only varied slightly, ranging from about 0.5 to 0.6. In contrast, the SSF observed at roosts on the northern beaches of Roebuck Bay were consistently higher than those at Bush Point or Eighty-mile Beach. This difference cannot be explained by species composition differing between sites; a plot of SSF by species for each site (Figure 3) shows that within individual species,

Table 1. Multiple regressions examining the relationships between sum of squares factor and site, counter, and numbers of birds counted by sub-site (N=1,087). Dependent variable = SSF – 1; no constant in model. LNCount = natural logarithm of number of birds counted; DIR = Danny Rogers; AB = Adrian Boyle; GS = George Swann.

Effect	Coefficient	Std Error	t	P(2 Tail)
(A) By Site, Counter, and Number of Birds				Multiple R^2: 0.850
Eighty-mile Beach	-0.269	0.010	-26.500	0.000
Bush Point	0.001	0.020	0.074	0.941
DIR	0.039	0.013	3.075	0.002
AB	-0.023	0.013	-1.683	0.093
GS	-0.028	0.015	-1.785	0.074
LNCOUNT	-0.046	0.002	-25.700	0.000
(B) By Counter and Number of Birds				Multiple R^2: 0.741
DIR	-0.051	0.016	-3.128	0.002
AB	-0.103	0.017	-5.933	0.000
GS	-0.125	0.019	-6.428	0.000
LNCOUNT	-0.071	0.002	-39.200	0.000
(C) By Site and Counter				Multiple R^2: 0.759
Eighty-mile Beach	-0.427	0.010	-41.300	0.000
Bush Point	-0.206	0.023	-8.880	0.000
DIR	-0.021	0.016	-1.339	0.181
AB	-0.091	0.017	-5.454	0.000
GS	-0.072	0.020	-3.681	0.000
(D) By Site and Number of Birds				Multiple R^2: 0.848
Eighty-mile Beach	-0.270	0.010	-28.100	0.000
Bush Point	-0.008	0.020	-0.417	0.677
LNCOUNT	-0.046	0.002	-26.300	0.000
(E) By Site (Eighty-mile Beach only) and Number of Birds.				Multiple R^2: 0.848
Eighty-mile Beach	-0.269	0.009	-29.500	0
LNCOUNT	-0.046	0.002	-29.300	0

there is still a strong tendency for SSF to be highest in northern Roebuck Bay, lowest at Eighty-mile Beach and intermediate at Bush Point. It follows that counting error should be assessed separately for different sites.

The analysis so far has shown that the number of birds present and the site are the most important determinants of the SSF. The number of component counts was not considered in this determination yet it is likely to have some effect, partly because higher numbers of birds are likely to have more component counts and the more component counts there are, the lower will be the SSF. Figure 4 plots the SSF against the number of component counts for the three sites; each data point represents a species at a site. The model gives impermissible estimates of the SSF for one or two component counts but these situations do not occur in the data considered. The figure shows a remarkably consistent pattern and a simple two variable non-linear regression model explains nearly 90% of the observed variation in the SSF. In other words, if we know how many component counts there are, we can make a good estimate of the SSF. Clearly, a model which predicts the number of component counts from the total count would enable us to calculate SSF, and hence standard deviation, knowing only the count total. Such a model is illustrated in Figure 5. This model is calibrated on the natural logarithms of the variables of interest; this provides a data set which better meets the normality assumptions of analysis. It shows that the different sites' data points lie on different lines, but all three lines have the same gradient, indicating similar effects of increasing count sizes. This model explains over 90% of the observed variation in the SSF.

Magnitude of error in counts

In principle, the best way to estimate the stochastic error associated with counts at a particular site would be to measure it directly with repeated comparable counts. We carried out repeated counts in both 2004 and 2005. However, they were not comparable for all species, as in some species it was clear that there had been a change in numbers between the first and second count of the season that far exceeded the variation likely to be related to counting error. To identify those species for which a change of numbers of this magnitude had occurred, we examined species lists for each site in 2004 and 2005, ordered by increasing values of the limiting coefficient of variation (LCoV) (Table 2). The two

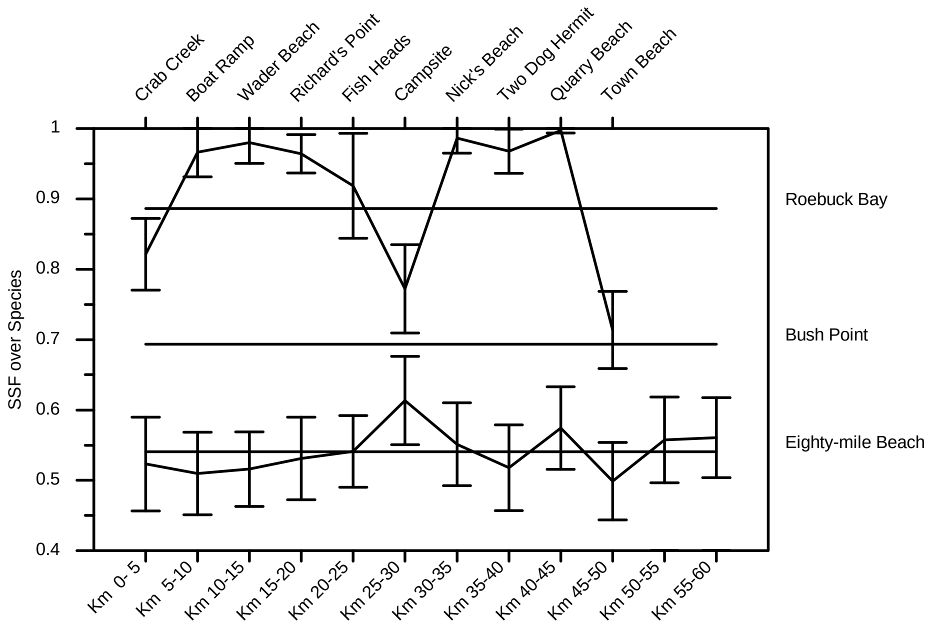

Figure 2. Average sum of squares factors by site and sub-site. Error bars are the 95% confidence limits on the mean. These are not given for Bush Point which has the value ± 0.04. Horizontal lines are the unweighted averages of SSF over sub-sites.

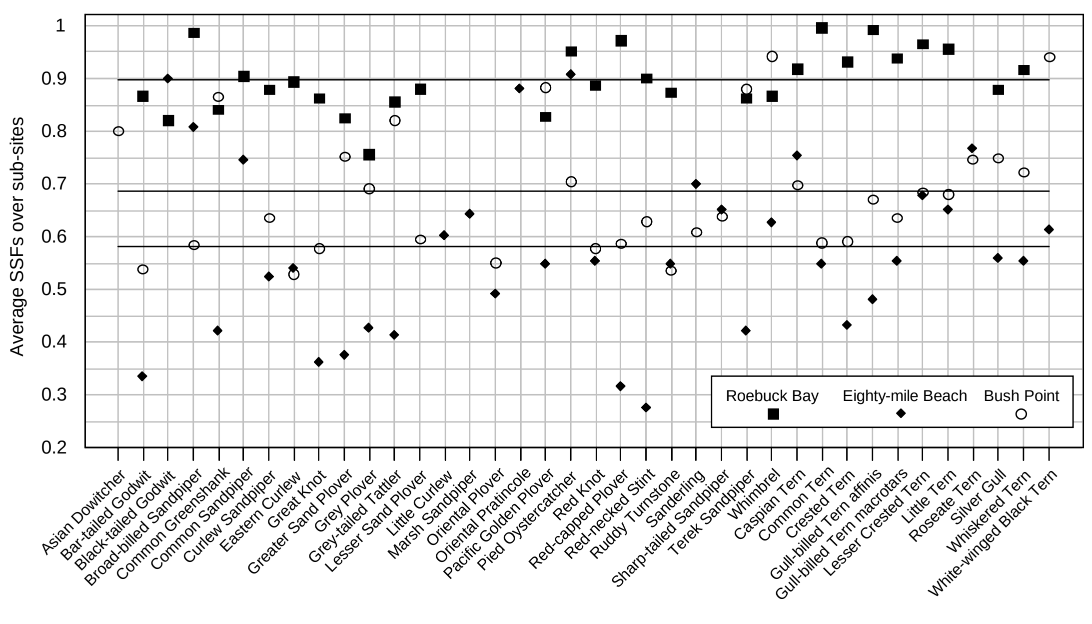

Figure 3. Average sum of squares factors by species and site. Data points for the following single flocks, for which the SSF is 1, are not shown: **Roebuck Bay** – Black-winged Stilt (25 birds), Little Curlew (31), Oriental Pratincole (1), Sharp-tailed Sandpiper (10), Sooty Oystercatcher (44); **Eighty Mile Beach** - Australian Pratincole (1), Black-winged Stilt (6), Common Redshank (1), Sabine's Gull (1); **Bush Point** – Little Curlew (30). Horizontal lines are the unweighted averages of SSF over species for each site.

counts will be considered significantly different (at 10%) for coefficients of variation less than LCoV but will not be significantly different for coefficients of variation higher than the LCoV. Species pairs, above which differences were considered insignificant, and below which they were considered significant, were based on subjective judgement. With these species pairs identified, we could then determine the minimum and maximum values of the site-specific coefficient of variation that lead to inclusion of all species not considered to have changed significantly in number, and the exclusion of those that had changed in number. Any value in this range would be acceptable; selecting round

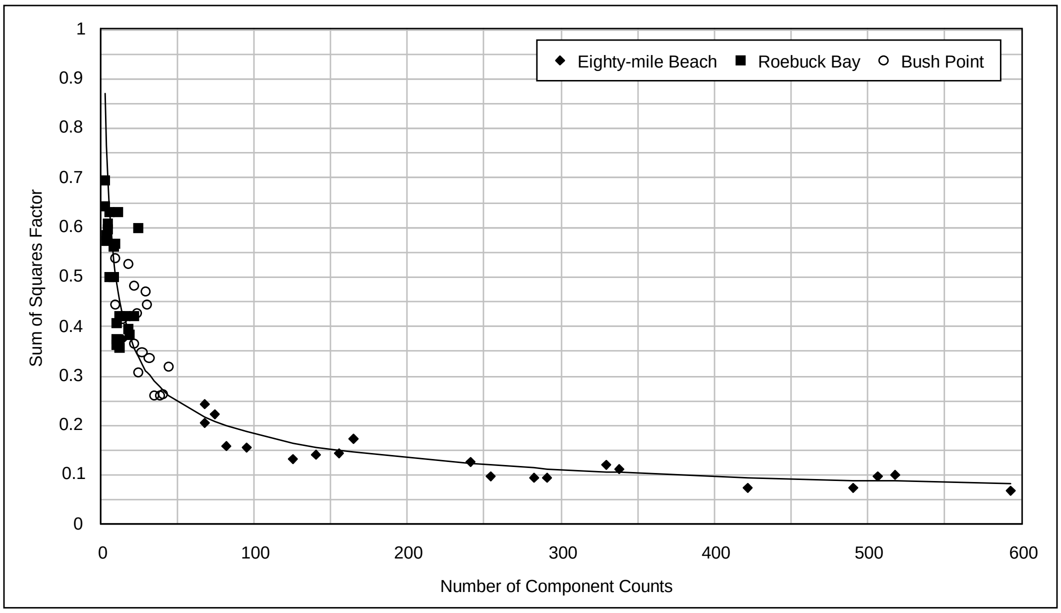

Figure 4. Species sum of squares factor by site and number of component counts. Trend line is given by SSF = a.(NumCnt)$^{-k}$ where a = 1.4195 (SE = 0.1044); k = 0.4455 (SE = 0.0180). Points are weighted by NumCnt. R^2 (Observed v. Predicted) = 0.889 (N = 59).

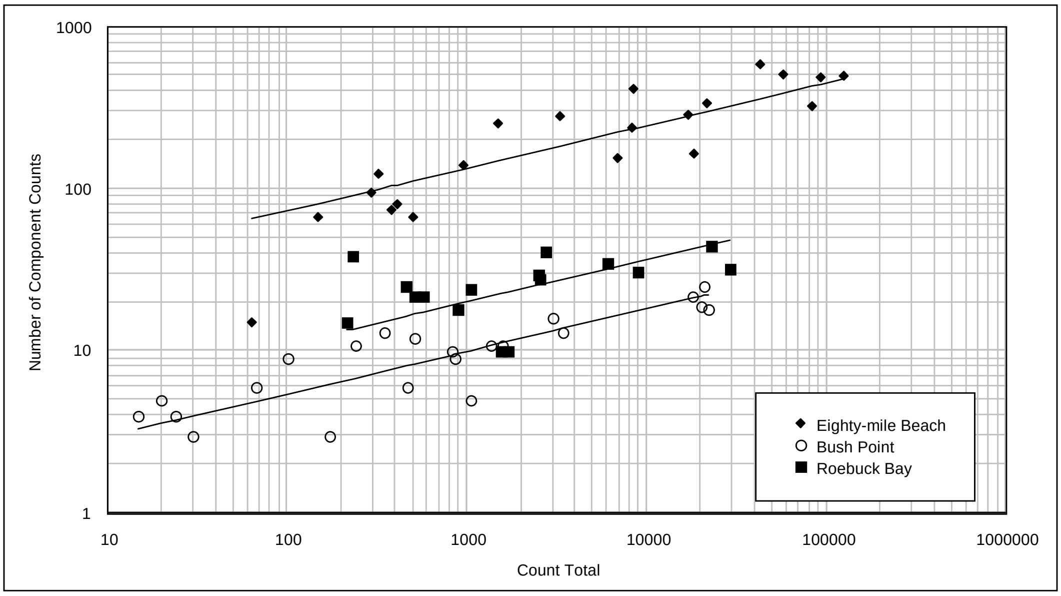

Figure 5. Number of component counts by species, site, and count total. Trend curves given by $\log_e$(NCC) = a + g.$\log_e$(Total) where: NCC is the number of component counts; Total is the count total; g = 0.26235 (SE = 0.02581); a = 3.0906 (SE = 0.2444) for Eighty-mile Beach, = 0.485609 (SE = 0.2070) for Bush Point, and = 1.1927 (SE = 0.2234) for Roebuck Bay. Data points are weighted by the natural logarithm of Total. R^2 (Observed v. Predicted) = 0.934 (N = 59).

numbers, we chose values of 30% for both Roebuck Bay and Bush Point and 80% for Eighty-mile Beach. These figures give consistent results for the two years of data and are used in subsequent analyses. Although this process was partially based on judgement, it was informed by the counters own perceptions of what species had changed in numbers, and it can be refined year after year as more and more comparisons are made. It could also be confirmed or otherwise with counting experiments similar to those carried out by Rappoldt *et al*. (1985).

At all three study sites, there were more species differing significantly in numbers between the first and second surveys in 2005 (which were held about a month apart) than there were in 2004 (held about a week apart; see Table 2). Significance was determined by seeing if the z-value (difference between counts divided by the square root of the sum of their variances) was significantly different from zero. For those species that did not change significantly in number between the first and second surveys of a season, we took the mean of the two counts as the best available total for the

Table 2. Limiting coefficients of variation by site. Selections from species lists, ordered by the magnitude of the difference of the first (A) and second (B) counts. For the upper grey-shaded species and those above it, differences between counts were judged not to be significantly different; for the lower grey-shaded species and those below it, differences between counts were considered to be significantly different. Any value for coefficient of variation between the limiting values for an adjacent pair is acceptable.

	2004				2005		
Species	**A count**	**B count**	**Limiting CoV**	**Species**	**A count**	A **count**	**Limiting CoV**
Roebuck Bay							
11 species				10 species			
↑				↑			
Terek Sandpiper	578	478	13.6%	Great Knot	13094	10201	22.7%
Grey-tailed Tattler	131	1475	14.4%	Black-tailed Godwit	1975	1246	24.0%
Curlew Sandpiper	1182	1392	16.5%	Gull-billed Tern *affinis*	476	294	24.9%
Gull-billed Tern *affinis*	398	596	17.4%	Silver Gull	80	118	28.0%
Little Tern	81	168	32.4%	Terek Sandpiper	1248	749	31.0%
Black-tailed Godwit	1076	641	34.7%	Gull-billed Tern *macrotarsa*	147	86	32.5%
Silver Gull	41	74	36.3%	Eastern Curlew	223	363	36.3%
Crested Tern	30	52	40.7%	Ruddy Turnstone	318	433	36.9%
↓				↓			
12 species				16 species			
Bush Point							
13 species				8 species			
↑				↑			
Grey-tailed Tattler	335	501	21.3%	Greater Sand Plover	14402	11541	16.7%
Little Tern	890	1335	25.7%	Whimbrel	190	143	20.0%
Bar-tailed Godwit	9350	13105	25.7%	Pied Oystercatcher	275	466	22.4%
Red-necked Stint	7311	10935	28.6%	Silver Gull	50	26	28.5%
Terek Sandpiper	340	725	36.2%	Oriental Plover	945	48	34.7%
Whimbrel	125	50	37.5%	Sharp-tailed Sandpiper	1	2	35.1%
Eastern Curlew	150	91	39.8%	Whiskered Tern	1072	630	36.3%
Common Greenshank	30	8	43.8%	Curlew Sandpiper	171	344	38.3%
↓				↓			
9 species				16 species			
Eighty-mile Beach							
20 species				16 species			
↑				↑			
Red-necked Stint	23288	20013	68.0%	Eastern Curlew	343	439	71.4%
Greater Sand Plover	33498	26180	74.3%	Marsh Sandpiper	126	220	77.0%
Red Knot	7341	11374	75.0%	Caspian Tern	32	19	77.1%
Broad-billed Sandpiper	19	39	78.2%	Gull-billed Tern *affinis*	1367	1014	77.7%
Whimbrel	52	99	91.9%	Terek Sandpiper	6692	8757	89.3%
White-winged Black Tern	1527	731	94.6%	Bar-tailed Godwit	46843	34626	92.4%
Red-capped Plover	3753	4812	103.0%	Whimbrel	44	86	105.8%
Sanderling	151	264	103.9%	Crested Tern	416	625	121.3%
↓				↓			
8 species				13 species			

year. The standard deviation of this mean was calculated using the mean of the SSFs of the two counts. For those species which the first and second surveys of a season differed significantly, we regarded the higher of the two counts as the better estimate of numbers present, as bias in these surveys was considered far more likely to have been caused by birds being overlooked or absent than through double-counting (a similar interpretation of area errors was drawn by Rappoldt *et al*. 1985).

The final count totals for each site (Table 3) show that three species of migratory shorebird increased significantly (using a significance level of 0.95) in number at Roebuck Bay while one decreased; three species increased significantly in number at Eighty-mile Beach while three decreased; two species increased significantly in number at Bush Point while none decreased. In general changes in numbers did not appear particularly consistent across sites, with no species showing significant changes in numbers of consistent direction at more than one site at the 95% level, although there were four such species at the 80% level. No species showed a significant decrease at more than one site at the 80% level. A better indication of the extent of regional changes in shorebird numbers can be obtained by combining the data from the three north-western Australian sites (Table 4). This compilation indicates that within migratory waders, significant increases in numbers (at the 80% significance

Table 3. Annual comparisons by site and species. P, the probability that the different numbers of birds were present in 2004 and 2005, is reported as n.s. (not significant) if less than 0.8; a dash is given for those species for which the number seen was < 30 in at least one year and a significance test was considered inappropriate.

Species	**Roebuck Bay**			**Eighty-mile Beach**			**Bush Point**		
	2004	**2005**	**P**	**2004**	**2005**	**P**	**2005**	**2005**	**P**
Shorebirds									
Black-tailed Godwit	1076	1611	> 0.80	15	17	-	0	0	-
Bar-tailed Godwit	11592	9909	n.s.	47515	46843	n.s.	11228	15761	> 0.80
Little Curlew	0	1	-	3476	1628	> 0.90	0	0	-
Whimbrel	415	437	n.s.	99	86	n.s.	125	167	> 0.80
Eastern Curlew	453	363	n.s.	410	391	n.s.	150	134	n.s.
Marsh Sandpiper	0	0	-	194	173	n.s.	0	0	-
Common Greenshank	277	274	n.s.	2227	3605	>0.95	30	22	-
Terek Sandpiper	528	1248	> 0.95	10910	8757	>0.80	725	773	n.s.
Common Sandpiper	17	15	-	0	2	-	0	0	-
Grey-tailed Tattler	1393	1818	> 0.90	8641	8151	n.s.	418	265	> 0.80
Ruddy Turnstone	361	433	> 0.80	205	198	n.s.	261	731	> 0.95
Asian Dowitcher	0	0	-	0	3	-	23	15	-
Great Knot	14697	11648	n.s.	64523	73897	n.s.	13230	11075	n.s.
Red Knot	1266	1220	n.s.	9358	10545	n.s.	803	937	n.s.
Sanderling	0	6	-	264	1000	> 0.95	1516	1454	n.s.
Red-necked Stint	4536	4789	n.s.	21651	17719	> 0.80	9123	9654	n.s.
Sharp-tailed Sandpiper	9	9	-	406	81	> 0.95	100	2	-
Curlew Sandpiper	1287	1487	n.s.	4206	5178	n.s.	490	344	> 0.80
Broad-billed Sandpiper	52	328	> 0.95	29	136	-	0	0	-
Pied Oystercatcher	54	45	n.s.	9	21	-	235	371	n.s.
Sooty Oystercatcher	22	23	-	0	0	-	0	0	-
Black-winged Stilt	0	161	-	0	0	-	0	0	-
Pacific Golden Plover	12	28	-	149	78	> 0.95	15	75	> 0.95
Grey Plover	117	288	> 0.95	736	626	n.s.	431	248	> 0.80
Red-capped Plover	1157	1145	n.s.	4812	7292	> 0.95	1743	1814	n.s.
Lesser Sand Plover	141	78	> 0.95	32	28	-	0	12	-
Greater Sand Plover	3089	3632	n.s.	33498	23435	> 0.95	10568	12972	n.s.
Oriental Plover	0	122	-	54815	43786	> 0.80	997	945	n.s.
Oriental Pratincole	0	0	-	54	0	-	0	0	-
Gulls & Terns									
Silver Gull	74	99	n.s.	188	415	> 0.95	58	50	-
Gull-billed Tern *affinis*	497	385	n.s.	1052	1191	n.s.	271	476	> 0.95
Gull-billed Tern *macrotarsa*	197	147	n.s.	606	903	> 0.90	40	85	> 0.95
Caspian Tern	9	18	> 0.95	29	26	-	20	23	-
Lesser Crested Tern	8	4	-	94	110	n.s.	39	27	-
Crested Tern	52	43	n.s.	609	625	n.s.	170	173	n.s.
Roseate Tern	0	0	-	6046	405	> 0.95	0	36	-
Common Tern	201	0	-	3987	1254	> 0.95	29	41	-
Little Tern	168	105	n.s.	436	763	> 0.80	1113	1225	n.s.
Whiskered Tern	15	87	-	430	800	> 0.90	587	1072	> 0.95
White-winged Black Tern	0	0	-	1527	966	> 0.90	91	1363	> 0.95

level) occurred in Black-tailed Godwit, Common Greenshank, Ruddy Turnstone, Sanderling and Broad-billed Sandpiper, while significant declines occurred in Sharp-tailed Sandpiper, Oriental Plover, and Lesser and Greater Sand Plovers.

Table 5 gives the percentage reductions relative to 2005 data in species numbers which will be significant at the 80% level. Larger reductions are even more likely to reflect real change and *vice versa*. These data are presented for all species with sufficient data to support the calculation. It is unlikely that significant reductions in numbers of uncommon birds will be of any conservation significance. For example, a reduction of 25%, i.e. three birds, in Lesser Sand Plover numbers at Bush Point are unlikely to ring any warning bells, particularly for a species which can easily be overlooked in mixed flocks. On the other hand, some might wish to keep on eye on this species in case the reduction one year is the start of a longer term trend. On balance, it seems better to retain such data points and leave it to potential users to decide which points matter. Excluding the high figures for Black-tailed Godwit and Little Curlew at Eighty-mile Beach (because the former is based on a very small count and the latter is basically an inland bird occasionally resorting to the beach to roost), limiting reductions range from 11.2% to 35.8%, with no obvious systematic difference between sites. The two right hand columns give the limiting reductions for the three north-west Australian sites combined. Combining

Table 4. North-west Australia comparisons by species. P, the probability that the different numbers of birds were present in 2004 and 2005, is reported as n.s. (not significant) if less than 0.8; a dash is given for those species for which the number seen was < 30 in at least one year and a significance test was considered inappropriate. SD is standard deviation. Inc/Dec indicates either an increase or decrease in numbers from 2004 to 2005.

Species	**2004 Total**	**SD**	**2005 Total**	**SD**	**Inc/ Dec**	**P**
Black-tailed Godwit	1091	183	1628	524	Inc	> 0.80
Bar-tailed Godwit	70335	6624	72513	6450	Inc	n.s.
Little Curlew	3476	806	1629	872	Dec	> 0.90
Whimbrel	639	89	690	145	Inc	n.s.
Eastern Curlew	1013	167	888	97	Dec	n.s.
Marsh Sandpiper	194	73	173	62	Dec	n.s.
Common Greenshank	2534	221	3879	479	Inc	> 0.95
Terek Sandpiper	12163	1981	10778	920	Dec	n.s.
Common Sandpiper	17	2	17	3	Inc	-
Grey-tailed Tattler	10452	1344	10234	1226	Dec	n.s.
Ruddy Turnstone	827	61	1362	174	Inc	> 0.95
Asian Dowitcher	23	4	18	3	Dec	-
Great Knot	92450	10287	96620	12157	Inc	n.s.
Red Knot	11427	2495	12702	2445	Inc	n.s.
Red-capped Plover	7712	610	10251	798	Inc	> 0.95
Red-necked Stint	35310	3522	32162	2633	Dec	n.s.
Sanderling	1780	393	2460	466	Inc	> 0.80
Sharp-tailed Sandpiper	515	99	92	15	Dec	> 0.95
Curlew Sandpiper	5983	874	7009	1037	Inc	n.s.
Broad-billed Sandpiper	81	17	486	51	Inc	> 0.95
Pied Oystercatcher	298	71	437	152	Inc	n.s.
Sooty Oystercatcher	22	9	23	8	Inc	-
Black-winged Stilt	-	-	161	40	-	-
Pacific Golden Plover	176	37	181	22	Inc	n.s.
Lesser Sand Plover	173	32	118	9	Dec	> 0.95
Greater Sand Plover	47155	5555	40039	4776	Dec	> 0.80
Grey Plover	1284	173	1162	116	Dec	n.s.
Oriental Plover	55812	7137	44853	6532	Dec	> 0.80
Oriental Pratincole	54	30	-	-	-	-
Silver Gull	320	53	564	85	Inc	> 0.95
Gull-billed Tern *affinis*	1820	287	2052	265	Inc	n.s.
Gull-billed Tern *macrotarsa*	843	138	1135	191	Inc	> 0.80
Caspian Tern	58	10	67	10	Inc	n.s.
Lesser Crested Tern	141	19	141	17	Inc	n.s.
Crested Tern	831	70	841	83	Inc	n.s.
Roseate Tern	6046	2275	441	100	Dec	> 0.95
Common Tern	4217	1625	1295	179	Dec	> 0.95
Little Tern	1717	397	2093	262	Inc	n.s.
Whiskered Tern	1032	205	1959	287	Inc	> 0.95
White-winged Black Tern	1618	402	2329	387	Inc	> 0.80

the sites allows smaller population changes to be detected than would be possible if each were considered separately.

DISCUSSION

In a perfect shorebird count, all birds sought would be visible at one time, and they would occur in numbers which permitted counting one by one. Survey conditions of that kind are rare, and although it is conventional to speak of a "shorebird count", a "count" is typically an educated estimate of the total number of shorebirds present, made by observers who have to move between different sub-sites, and count individual flocks in "blocks" of birds. Rappoldt *et al*. (1985) showed that these estimates have an error that can be calculated. They were able to do this by comparing results of different observers counting the same flocks of birds, and through comparisons of these totals with the number of birds actually present (determined by photography, or by counting the birds one at a time as they flew into roosts). Our approach was less direct; we determined the stochastic error rate of our counts by repeating them over a short time-frame and then carried out regression analyses to identify the sources of error. It is encouraging that such different approaches resulted in broadly similar conclusions.

In our study, differences between observers were negligible. This was in part because all the observers were experienced and had done shorebird surveys in the same settings before. It was also because our point of comparison was the differences between sites, which proved to be substantial; using the terminology of Rappoldt *et al*. (1985), between-situation errors far exceeded within-situation errors. The differences in site-specific errors in counts (as shown by

Table 5. Smallest reductions in species numbers from 2005 levels which will be significant at the 80% level.

Species	Bush Point		Eighty-mile Beach		Roebuck Bay		NW Australia	
	2005 Total	Reduc-tion	2005 Total	Reduc-tion	2005 Total	Reduc-tion	2005 Total	Reduc-tion
Black-tailed Godwit	.	.	17	47.1%	1611	28.2%	1628	27.9%
Bar-tailed Godwit	15761	17.1%	46843	11.8%	9909	14.2%	72513	8.8%
Little Curlew	.	.	1628	45.5%	.	.	1629	45.5%
Whimbrel	167	22.8%	86	20.9%	437	27.9%	690	18.9%
Eastern Curlew	134	23.9%	391	17.1%	363	17.6%	888	11.4%
Marsh Sandpiper	.	.	173	31.8%	.	.	173	31.5%
Common Greenshank	.	.	3605	13.8%	274	17.9%	3879	12.9%
Terek Sandpiper	773	17.2%	8757	11.2%	1248	20.8%	10778	9.6%
Common Sandpiper	.	.	.	.	.	.	17	16.7%
Grey-tailed Tattler	265	20.0%	8151	14.4%	1818	13.1%	10234	11.8%
Ruddy Turnstone	731	21.6%	198	19.7%	433	13.6%	1362	13.1%
Asian Dowitcher	.	.	.	.	.	.	18	16.7%
Great Knot	11075	17.9%	73897	14.5%	11648	17.2%	96620	11.6%
Red Knot	937	17.7%	10545	20.5%	1220	18.6%	12702	17.2%
Sanderling	1454	27.4%	1000	14.8%	.	.	2460	17.6%
Red-necked Stint	9654	13.7%	17719	12.5%	4789	15.4%	32162	8.5%
Sharp-tailed Sandpiper	.	.	81	19.8%	.	.	92	17.9%
Curlew Sandpiper	344	22.4%	5178	18.0%	1487	15.3%	7009	13.8%
Broad-billed Sandpiper	22	22.7%	136	23.5%	328	13.7%	486	11.4%
Pied Oystercatcher	371	35.8%	21	38.1%	45	20.0%	437	30.9%
Sooty Oystercatcher	.	.	.	.	23	30.4%	23	32.6%
Black-winged Stilt	.	.	.	.	161	23.0%	161	23.2%
Pacific Golden Plover	75	25.3%	78	17.9%	28	14.3%	181	13.5%
Grey Plover	248	28.2%	626	14.1%	288	17.0%	1162	10.8%
Red-capped Plover	1814	15.1%	7292	11.6%	1145	12.4%	10251	8.9%
Lesser Sand Plover	12	25.0%	28	21.4%	78	19.2%	118	10.9%
Greater Sand Plover	12972	21.4%	23435	14.5%	3632	15.2%	40039	11.2%
Oriental Plover	945	20.6%	43786	13.9%	122	23.0%	44853	13.6%
Silver Gull	50	28.0%	415	19.0%	99	22.2%	564	15.0%
Gull-billed Tern *affinis*	476	15.3%	1191	17.9%	385	27.5%	2052	12.6%
Gull-billed Tern *macrotarsa*	85	25.9%	903	19.7%	147	20.4%	1135	16.0%
Caspian Tern	.	.	.	.	.	.	67	15.2%
Lesser Crested Tern	.	.	110	17.3%	.	.	141	14.1%
Crested Tern	173	24.9%	625	13.8%	43	16.3%	841	11.6%
Roseate Tern	36	25.0%	405	23.0%	.	.	441	21.1%
Common Tern	41	29.3%	1254	15.1%	.	.	1295	14.6%
Little Tern	.	.	763	22.7%	105	26.7%	2093	12.9%
Whiskered Tern	1072	18.9%	800	23.6%	87	21.8%	1959	14.4%
White-winged Black Tern	1363	24.5%	966	14.8%	.	.	2329	15.8%

the sum of squares factors) between northern Roebuck Bay, Bush Point and Eighty-mile Beach remained even if the data were broken up by species or by sub-site. To some extent, this variation was likely to be caused by the effects of local habitats on shorebird viewing conditions. In northern Roebuck Bay, for example, it is generally possible to view shorebird flocks from the top of a cliff or dune, and with this additional height we were less likely to overlook small waders surrounded by larger species than we were in very flat settings such as Eighty-mile Beach. The number of component counts made as part of a total count is likely to have had a still larger effect. Figure 4 shows that there was a strong relationship between the SSF and the number of component counts.

Rappoldt *et al.* (1985) calculated the stochastic error (coefficient of variation) for a standing shorebird flock as 37%. While we agree that this is the best figure analysts can use in the absence of other information, we found that it can vary considerably from site to site: in our study it ranged from 30% (Roebuck Bay and Bush Point) to 80% (Eighty-mile Beach). For truly effective population monitoring, we believe it is essential to calibrate the stochastic errors of shorebird surveys on a site-by-site basis. This would require that observers carry out repeated counts within a single shorebird season, to obtain measures of the amount of variation recorded in surveys when essentially the same numbers of birds are present at the site. If resources were available, it would be better still to also carry out counting experiments in which different observers count the same flocks.

We were able to estimate stochastic variation in our north-western Australian counts, and we believe that the variation that remained reflected genuine changes in bird numbers. However, the nature of changes in numbers that occurred in particular species often differed between sites. A plausible explanation for this could be that birds moved between sites. Our own experience is not entirely consistent with the widespread mindset that shorebirds are completely sedentary during their non-breeding season. For example, in a detailed radio-telemetry study of Red and Great Knots in Roebuck Bay, Rogers *et al*. (2006a) found that individual birds tended to be site-faithful to particular feeding areas (and associated roost sites) in the short term, but that every few days or weeks (especially during neap tides) they would explore other sites, sometimes then returning to the original feeding area and sometimes settling somewhere else. Evidence that such explorations may actually take them out of Roebuck Bay is gradually emerging from colour-band resightings of Roebuck Bay birds on Eighty-mile Beach (CJH and T. Piersma, unpubl. data). Similar patterns of movement (with more frequent explorations) have been found in radio-telemetry studies of Red Knots in the Dutch Wadden Sea (van Gils *et al*. 2006), and are also suggested by studies of roost-site fidelity in Britain (Rehfisch *et al*. 1996, 2003). For shorebirds that can also use freshwater wetlands, the within-season variation in counts found during the non-breeding season is still more clearly defined (Alcorn *et al.* 1994).

Without a focussed study of movements of marked birds, it is difficult to tell whether changes in numbers of a species at a single site are caused by local movements or by a global population change, such as a decline caused by a succession of poor breeding seasons or loss of vital staging areas. However, it does seem reasonable to expect global population changes to be reflected on a broad geographical scale. Comparisons of population trends in a broad region with those at particular sites should therefore be a valuable tool in identifying the causes of population changes, and also in identification of specific sites where habitat management is proving particularly beneficial or detrimental to a particular species.

Even when data are available on a large geographical scale, apparent changes in numbers need to be interpreted with the biology of individual species in mind. For example, combining the three north-western Australian sites, we found that statistically significant increases (at the 80% significance level) occurred in five migratory shorebird species between 2004 and 2005, while significant decreases occurred in four. While the changes observed in some species (e.g. the increase of Ruddy Turnstone and the decrease of Greater Sand Plover) are of genuine interest, we attach little importance to the changes in some of the other species. Sharp-tailed Sandpiper only occurs as a passage migrant in our north-western Australian sites, so numbers observed are very sensitive to the time of year at which counts are made. Many Black-tailed Godwits and Common Greenshank are likely to disperse to inland wetlands when these habitats are suitable, so changes at our coastal sites from year to year might reflect rainfall history in the inland rather than local conditions. The change in numbers of Oriental Plover was heavily skewed by the very large numbers found at one particular site (Eighty-mile Beach), where this species uses the beaches not as a high-tide roost, but as a mid-day refuge from the heat of the inland plains where they feed; numbers on the beach could therefore reflect local temperatures and the time of day at which counts were performed. Lesser Sand Plover and Broad-billed Sandpipers are uncommon in the region and easily confused with similarly sized species at long range, so it is possible that the number seen on counts is more sensitive to observer error, specifically under-counting, than that of more abundant species. Comparisons of these species are unlikely to be reliable .

The variation in SSFs suggests that the geography of roost sites, and the number of birds that use them, play an important role in determining how a count is carried out and the number of component counts required. Figure 4 shows that the variation in sum of squares factors with numbers of component counts is independent of both species and site. Figure 5, relating numbers of component counts to the number of birds present, shows the same variation in relation to the effect of differing numbers of birds but with quantifiable differences between the three sites. Further research over a wider range of sites and conditions should fill out what is presently a rather sketchy picture. If a general understanding is obtained and can be linked to formal descriptors of roost sites, calibration of new sites may allow development of sums of squares factors from total counts and obviate the need for detailed calibration of sites as has been done here.

An example of what might be achievable is given in the development of the estimates of the size of future population reductions which will be significant at a given level. The method used was only possible because it was possible to estimate statistical errors in future counts on the basis of what had been learned about flocking behaviour. At the site level, average species count reductions of 21.8% at Bush Point, 17.8% at Eighty-mile Beach, and 18.1% at Roebuck Bay would be significant at the 20% level. For north-west Australia, the sites combined, a percentage reduction of only 13.3% would be similarly significant. Australia-wide, an even smaller consistent reduction would be significant.

The approach we have used at our north-western Australian sites was possible because we had a reasonably good understanding of the roosting behaviour of shorebirds there, especially in northern Roebuck Bay; we were thus able to schedule our surveys at times when it was possible to conduct a complete count at all of the roost sites being used by shorebirds. We could therefore attribute variation in counts that were repeated in quick succession to within- or between-situation error, as we knew that our data were not affected by biases caused by an unknown proportion of the birds roosting in sub-sites that were not surveyed.

This is not a luxury that is available to shorebird counters at all sites. In south-east Queensland, for example, shorebird counts are carried out regularly at mainland roosts, but there are also roosts on islands that cannot be accessed with the resources usually available to counting teams (D. Milton, pers. comm.; Milton & Driscoll 2006). An unknown proportion of birds are therefore overlooked during counts at such sites. There is much to be learned about estimating the uncertainty that this adds to shorebird counts. Elsewhere in this issue, Milton & Driscoll (2006) suggest that the generalised additive models of Atkinson *et al*. (2006) may be a suitable tool to detect population changes in partially sampled sites. This method has the advantages of flexibility, ease of computation and limited data requirements (only count totals are used). It can thus be applied to very large numbers of sites. However, it appears to be considerably less sensitive to detection of changes than the approach we have proposed, which we believe is likely to be of more direct use to habitat and bird managers. Despite this difference in opinion, we agree wholeheartedly with Milton & Driscoll's contention that increased frequency of counts will be the key to improved population monitoring. It is a particularly important consideration in Australia, where many shorebird population monitoring sites are currently only surveyed once per austral summer (Gosbell & Clemens 2006).

The most direct solution to the biases caused by overlooked birds in incompletely sampled sites would be to increase survey effort, so that comprehensive counts are carried out. We note with pleasure that the Queensland Wader Study Group plans to do exactly that in Moreton Bay in the summer of 2007/8 (Milton 2007). Even if broad-scale sampling of this kind is too expensive to repeat on a regular basis, a small number of comprehensive counts should help enormously in understanding the local roost choice issues that are ultimately responsible for much of the variation seen in high tide counts.

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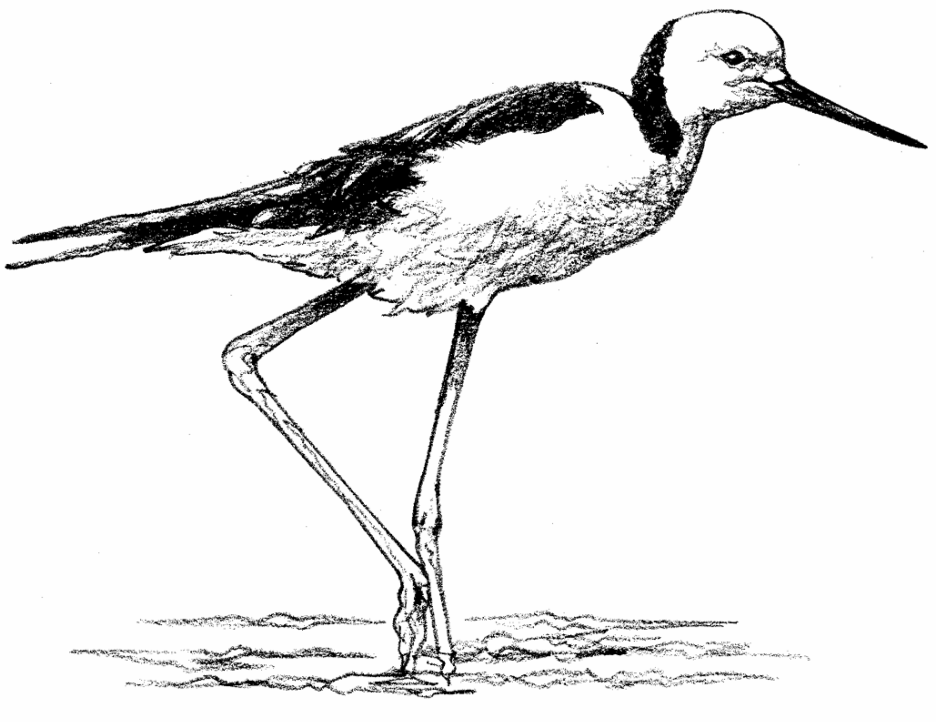

APPENDIX. SPECIES COUNT TOTALS BY SITE AND DATE

Count totals obtained in shorebird surveys in Northern Roebuck Bay (26 November and 1 December 2004; 15 November and 16 December 2005), Eighty-mile Beach (22-25 November and 2-3 December 2004; 13-14 November and 13-15 December 2005) and Bush Point (28 November and 29 November 2004; 16 November and 17 December 2005).

Species Site	Roebuck Bay				Eighty-mile Beach				Bush Point			
Survey	2004A	2004B	2005A	2005B	2004A	2004B	2005A	2005B	2004A	2004B	2005A	2005B
Shorebirds												
Black-tailed Godwit *Limosa limosa*	1,076	641	1,975	1,246	15	4	22	11	.	.	1	.
Bar-tailed Godwit *Limosa lapponica*	11,927	11,257	9,909	6,320	48,079	46,950	46,843	34,626	9,350	13,105	15,532	15,989
Little Curlew *Numenius minutus*	31	.	1	1	3,691	3,261	1,288	1,968	30	.	2	.
Whimbrel *Numenius phaeopus*	415	151	456	417	52	99	44	86	125	50	190	143
Eastern Curlew *Numenius madagascariensis*	413	492	223	363	419	400	343	439	150	91	136	132
Common Redshank *Tringa totanus*	.	.	.	.	.	1	.	.	.	.	.	.
Marsh Sandpiper *Tringa stagnatilis*	.	.	5	.	158	230	126	220	.	.	.	.
Common Greenshank *Tringa nebularia*	293	260	253	295	1,153	2,227	3,605	1,686	30	8	.	22
Terek Sandpiper *Xenus cinereus*	578	478	1,248	749	9,875	11,944	6,692	8,757	340	725	361	773
Common Sandpiper *Actitis hypoleucos*	8	17	11	15	.	30	1	3	.	.	1	.
Grey-tailed Tattler *Heteroscelus brevipes*	1,311	1,475	1,727	1,908	8,749	8,532	7,720	8,582	335	501	265	145
Ruddy Turnstone *Arenaria interpres*	100	361	318	433	119	205	218	178	92	261	726	736
Asian Dowitcher *Limnodromus semipalmatus*	.	.	1	.	.	.	1	4	1	23	15	2
Great Knot *Calidris tenuirostris*	15,233	14,160	13,094	10,201	58,589	70,456	68,893	78,900	7,102	13,230	11,075	4,122
Red Knot *Calidris canutus*	1,348	1,184	1,230	1,210	7,341	11,374	10,417	10,672	721	885	208	937
Sanderling *Calidris alba*	.	.	1	6	151	264	466	1,000	1,333	1,698	1,384	1,524
Red-necked Stint *Calidris ruficollis*	4,136	4,935	4,451	5,127	23,288	20,013	18,147	17,290	7,311	10,935	5,023	9,654
Sharp-tailed Sandpiper *Calidris acuminata*	9	1	1	9	406	106	81	38	2	100	1	2
Curlew Sandpiper *Calidris ferruginea*	1,182	1,392	1,430	1,543	4,079	4,332	4,547	5,809	31	490	171	344
Broad-billed Sandpiper *Limicola falcinellus*	52	12	74	328	19	39	138	133	.	15	11	22
Beach Stone-curlew *Burhinus neglectus*	.	.	.	2	.	.	.	.	.	.	.	.
Pied Oystercatcher *Haematopus longirostris*	54	17	7	45	9	9	22	19	242	228	275	466
Sooty Oystercatcher *Haematopus fuliginosus*	23	21	28	18	.	.	.	1	.	.	.	.
Black-winged Stilt *Himantopus himantopus*	25	.	162	159	.	6	.	.	.	.	.	.

Species	Site	Roebuck Bay				Eighty-mile Beach				Bush Point			
	Survey	2004A	2004B	2005A	2005B	2004A	2004B	2005A	2005B	2004A	2004B	2005A	2005B
Red-necked Avocet *Recurvirostra novaehollandiae*		.	.	.	1	.	.	1	.	.	.	.	.
Pacific Golden Plover *Pluvialis fulva*		6	12	8	28	135	162	30	78	16	14	21	75
Grey Plover *Pluvialis squatarola*		114	119	288	173	692	779	670	582	411	450	223	273
Red-capped Plover *Charadrius ruficapillus*		409	1,157	632	1,145	3,753	4,812	7,292	4,325	1,655	1,830	488	1,814
Lesser Sand Plover *Charadrius mongolus*		71	141	23	78	27	37	28	5		20	12	3
Greater Sand Plover *Charadrius leschenaultii*		3,150	3,028	3,360	3,903	33,498	26,180	24,370	22,499	12,113	9,023	14,402	11,541
Oriental Plover *Charadrius veredus*		.	1	122	1	31,521	54,815	1,491	43,786	377	997	945	548
Oriental Pratincole *Glareola maldivarum*		.	.	.	.	63	45	.	17	.	.	.	.
Australian Pratincole *Stiltia isabella*		.	.	.	.	.	1	.	.	.	.	.	.
Total Shorebirds		**41,964**	**41,312**	**41,038**	**35,724**	**235,881**	**267,313**	**203,496**	**241,714**	**41,767**	**54,679**	**51,468**	**49,267**
Gulls and Terns													
Silver Gull *Larus novaehollandiae*		15	4	80	118	193	183	415	146	67	48	50	26
Sabine's Gull *Larus sabini*		.	.	.	.	1	.	.	.	.	.	.	.
Gull-billed Tern *Sterna nilotica affinis*		398	596	476	294	1,179	924	1,367	1,014	250	291	476	254
Gull-billed Tern *Sterna nilotica macrotarsa*		199	194	147	86	547	664	955	851	35	44	85	84
Caspian Tern *Sterna caspia*		9	8	3	18	28	30	32	19	19	20	13	23
Lesser Crested Tern *Sterna bengalensis*		8	4	2	4	43	94	110	17	37	40	27	1
Crested Tern *Sterna bergii*		30	52	8	43	381	609	416	625	88	170	157	188
Roseate Tern *Sterna dougallii*		41	74	.	.	31	6,046	24	405	3		12	36
Common Tern *Sterna hirundo*		3	201	9	.	4,632	3,341	328	1,254	9	29	41	41
Little Tern *Sterna albifrons*		81	168	105	25	424	448	201	763	890	1,335	431	1,225
Whiskered Tern *Chlidonias hybridus*		372	.	87	4	432	427	795	804	488	686	1,072	630
White-winged Black Tern *Chlidonias leucopterus*		.	.	2	.	1,527	731	126	966	15	91	1,363	512
Total Gulls and Terns		**1,156**	**1,301**	**919**	**592**	**9,418**	**13,497**	**4,769**	**6,864**	**1,901**	**2,754**	**3,727**	**3,020**

THE BLIND MEN AND THE ELEPHANT: CONCERNS ABOUT THE USE OF JUVENILE PROPORTION DATA

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Juvenile proportion data in shorebirds are being used with increasing frequency to estimate recruitment and even breeding success. Although this area of investigation holds great promise, flaws in current study designs preclude great confidence in the broad-scale inferences being drawn. We present data from our own investigations on juvenile proportions in Bar-tailed Godwits *Limosa lapponica* in Alaska to illustrate the significance of some of these problems. We then explore issues of study design, specifically bias, precision, untested assumptions and the use of correlations for interpreting juvenile proportion data. The issue of bias is particularly important, because inferences about shorebird productivity are being expanded to geographic areas well beyond what the data legitimately allow. Until studies of juvenile proportions are more rigorously designed and implemented, we suggest that many of the inferences about shorebird productivity based on such data are premature and may lead to management decisions that are detrimental to the conservation of shorebirds.

INTRODUCTION

In recent years, there has been a growing appreciation of demographic data for understanding shorebird population dynamics (Minton 2003, Sandercock 2003, Minton *et al*. 2005a, Robinson *et al*. 2005, Rogers *et al*. 2005). Much of this attention has been directed at evaluating the proportion of juveniles on the non-breeding grounds in order to either estimate or index breeding success (e.g. Minton 2003, 2004). This pulse of interest has been accompanied by the development of site-specific approaches to sampling and analysis (e.g. Clark *et al*. 2004, Robinson *et al*. 2005, Rogers *et al*. 2005, Rogers 2006), and some considerations of the pitfalls that researchers face when attempting to estimate the proportion of juveniles in a local population (Minton 2003, 2004; Rogers *et al*. 2005).

Despite the growing interest in this field, a number of aspects of formal study design have not yet been adequately addressed. Among the most important are the issues of bias and precision. Minton (2003) identifies one of the most vexing sources of bias, the potential for non-uniform distribution of the age classes. Despite recognizing the biases that could derive from this problem at three different spatial scales, however, Minton (2003) concludes that standardization of annual sampling, particularly when multiple samples can be obtained, should minimize bias and allow annual comparisons of the proportion of juveniles at a site. In addition, he and his colleagues suggest that such comparisons accurately reflect conditions on the breeding grounds (e.g. Minton *et al*. 2005a, 2005c).

Recent applications of juvenile proportion data for estimating breeding success, however, seem to ignore the very issues that Minton (2003) identified. This surge of enthusiasm for extrapolating juvenile proportion data to the breeding grounds recalls the ancient parable about the blind men and the elephant. In its simplest form, three blind monks all encountered different parts of the same elephant. One found the tail, another grabbed a leg, and the third encountered the body. Limited to only feeling a portion of the beast, each monk then assumed that the portion he experienced adequately described the entire animal. Thus, they characterized the elephant as being like a rope, a tree, and a wall, respectively.

We argue that this parable is an apt metaphor for some current approaches to the use of juvenile population data. Small samples collected from few sites within limited portions of the non-breeding range are being expanded to draw inferences about reproductive success of entire flyway populations (Boyd *et al*. 2005, Soloviev *et al*. 2005). Although concerns about the scale of inference have been raised previously, they were not the focus of the authors' research (e.g. Clark *et al*. 2004), and no studies have addressed these concerns empirically.

Similarly, although energetic discussions are continuing about deriving estimates of precision from juvenile proportion data (Clark *et al*. 2004, Robinson *et al*. 2005, Rogers 2006), there has been little discussion about what level of precision is required for answering the specific questions we wish to answer. Although the general desirability of larger samples has been acknowledged (e.g. Rogers *et al*. 2005), a quantitative approach to sample size determination has been lacking. In addition to the issues of bias and precision, research efforts should be improved by rigorously addressing untested assumptions and testing alternate hypotheses for the patterns we find in juvenile proportions.

We decided that it would be helpful to bring many of these concerns together in one place so that researchers involved in collecting juvenile proportion data, and those new to the field, might have a common reference describing potential difficulties in this area. To facilitate such a review, we will: 1) present our findings regarding the distribution of age classes in Bar-tailed Godwits *Limosa lapponica baueri* staging in south-western Alaska; 2) address issues of study design, sample size, and scales of inference; 3) identify some untested biological assumptions regarding the connection between juvenile proportions on the non-breeding grounds and breeding success in the Arctic; and 4) urge caution about the use of correlations in justifying the use of juvenile proportion data. To highlight the importance of these points relative to conservation, we compare results of godwit population models that use juvenile proportion data collected alternatively in Alaska or Australia.

TERMINOLOGY

Throughout this paper we will refer to the proportion of first-year (PFY) birds, which is the number of juveniles detected divided by the total number of individuals aged. We contend that the link between PFY values and breeding success (number of young fledged per breeding adult) has not been well-demonstrated in most cases, so it is inappropriate to use the terms interchangeably (i.e. PFY data should not be referred to as breeding success data). Rogers *et al*. (2004) argue persuasively that first-year ratios (i.e. juveniles/adults) have more direct applicability to estimating recruitment than PFY. Minton (2004) discusses the added analytical problems caused by the component of subadult birds that do not migrate north to breed but are difficult or impossible to distinguish by plumage from breeders. To date, however, most authors continue to use first-year proportions; we have reluctantly retained that convention for the purposes of comparisons in this paper.

Geographic terminology relative to shorebirds' annual cycles can also be confusing or cumbersome. The "non-breeding grounds" can refer to any locations in a species' annual range except the breeding grounds *per se*. To avoid confusion in this paper, we will refer to post-breeding areas in south-western Alaska as the boreal staging grounds (BSG), and southern hemisphere areas as the austral non-breeding grounds (ANBG).

STUDY AREAS AND METHODS

We estimated the proportion of first-year birds present within flocks of post-breeding Bar-tailed Godwits staging in August and September at three coastal sites in south-western Alaska. We aged birds during six years (1999, 2001–2005) at Tern Mountain (60° 07'N, 164° 27'W), conducting our first counts each year between 1 August and 5 September and our last counts between 7 and 27 September. We aged birds at the Tutakoke River (61° 15'N, 165° 39'W) during 17–24 August 2002 and 5–9 September 2004 and at Egegik Bay (58° 11'N, 157° 32'W) during 2–5 September 2003 and 29 August–5 October 2005. Tern Mountain is approximately 150 km south-east of Tutakoke and 450 km north-west of Egegik. Juvenile and adult godwits are readily separated on the basis of plumage patterns at this time of year and we were able to age birds visually with spotting scopes. Sampling approaches were comparable to those described in Robinson *et al*. (2005) and Rogers *et al*. (2005). On most survey days we also counted or estimated the maximum number of godwits present.

We attempted to age a sample of all godwit flocks present each day, and we combined the counts at each site into a single, unweighted proportion for each survey date. Thus, within days we did not count any individual godwit more than once. On successive days, however, it is likely that there was frequent sampling of the same individuals; in effect, we were sampling with replacement and these sub-samples were not independent. For each site, we then calculated an estimate of the PFY annually, which was a simple unweighted proportion of all juveniles divided by the total number of birds aged across all survey dates. Although the number of birds at each site varied seasonally, we had no measure of turnover rates for juveniles or adults and thus no basis for determining appropriate weighting factors. We calculated 95% confidence limits of the proportions using standard statistical software (Minitab Release 14.2; Minitab Inc. 2003), which employs exact binomial methods for small samples and normal approximations for large samples.

Because the dates at which we collected juvenile proportion data varied greatly across both years and sites, we were interested in determining how consistent the PFYs were seasonally each year. For each of four years at Tern Mountain, we used a chi-square test of independence (Sokal & Rohlf 1981) to compare the proportions of adults and juveniles recorded during the core period (5–10 September) sampled most consistently across years with proportions recorded over the entire sampling period. We also used a chi-square test of independence to compare juvenile proportions across years within sites and between sites during the same years.

We compared PFY data from Tern Mountain with those collected at Victoria in south-east Australia (Minton *et al.* 2005a, 2005b, 2005c) during 1999 and 2001–2004 to see how concordant estimates were from the BSG and ANBG. To minimize the swamping effect of the much larger number of individuals aged on the BSG, we did not analyse the raw frequency data but instead simply did a nonparametric paired comparison of the PFY values from the two sites across the five years (Friedman's test, Sokal & Rohlf 1981). We also tested for simple correlation between annual values at the two sites.

We used a simple, deterministic model to project how godwit populations would be expected to increase or decline, given the proportions of juveniles that had been estimated at Tern Mountain, Alaska, and at Victoria, Australia. We used PFY values to estimate fertility (F, the number of female young produced per adult female per year), assuming a 1:1 sex ratio and using the following formula: $F = PFY/(1\text{-}PFY)$. On the BSG, (1-PFY) represents the proportion of the autumn staging population comprising breeding adults, but on the ANBG this group also includes an unknown component of subadults that did not migrate north to breed. Thus, using PFY on the ANBG should underestimate fertility because of the inflated denominator. We compared models using the mean annual PFY from either Tern Mountain or from Victoria (Minton *et al.* 2005a, 2005b, 2005c), using values from the same five years (1999, 2001–2004).

Basic demographic parameters for *Limosa lapponica baueri* are generally lacking, but we assumed that birds first bred in their fourth year (McCaffery & Gill 2001), and we applied the age-specific survival estimates of another large-bodied, long-distance migrant shorebird, the Bristle-thighed

Curlew *Numenius tahitiensis*. Marks & Redmond (1996) estimated 92% survival in first year, 93% in second, and 98% in third. These values are likely high for *Limosa lapponica baueri*, but over-estimating survival serves as a conservative buffer for the purposes of this exercise. We applied an estimate of adult survival (0.88) derived from *Limosa lapponica lapponica* (Evans & Pienkowski 1984). Keeping these demographic parameters consistent between models, we used PopTools (Hood 2004) to calculate the population growth rate, usually called lambda and denoted λ, under two scenarios, one utilizing a fertility estimate derived from Alaska, the other an estimate from Victoria, Australia.

RESULTS

Estimates of PFY varied dramatically in both space and time on the BSG (Table 1). Relatively few juveniles were recorded at Tern Mountain in any year except 2005, whereas counts at Egegik were dominated by juveniles and values at Tutakoke were greatly disparate. The PFY at Tern Mountain differed significantly (P < 0.001) each year from PFY at Tutakoke River (2002: χ^2 = 27.45, df = 1; 2004: χ^2 = 9620.46, df = 1) and from PFY at Egegik Bay (2003: χ^2 = 3258.39, df = 1; 2005: χ^2 = 9699.92, df = 1). At each site, PFY also varied significantly (P < 0.001) among years (Tern Mountain: χ^2 = 1260.50, df = 5; Tutakoke: χ^2 = 2204.41, df =1; Egegik: χ^2 = 727.48, df = 1).

We found high seasonal variability in the numbers of godwits that occurred at our study sites, as illustrated by a comparison of the maximum daily counts of godwits during 2005 at Tern Mountain and Egegik Bay (Fig. 1). In conjunction with this pattern, we found that sites varied in the degree to which PFY changed across the season, and that the degree of variability differed across years at the same site. When we compared the PFY at Tern Mountain during the core staging period (5–10 September) with the PFY calculated across the entire staging period, we found that the proportions were consistently low but significantly different in three of the four years for which we had comparative data. Values for the core and entire staging period were, respectively: 0.006 vs. 0.007 (2002; χ^2 = 0.67, df = 1, P = 0.41); 0.021 vs. 0.029 (2003; χ^2 = 13.17, df = 1, P < 0.001); 0.008 vs. 0.022 (2004; χ^2 = 100.68, df = 1, P < 0.001) and 0.078 vs. 0.085 (2005; χ^2 = 5.02, df = 1, P = 0.025). In both 2003 and 2005 at Egegik, however, there was dramatic seasonal variation in PFY. In both years, PFY values were relatively low upon arrival (*c*. 0.15) but climbed dramatically and remained high (0.6–0.9) for the remainder of the sample period.

When comparing the PFY that we estimated at Tern Mountain with that estimated by Minton *et al.* (2005a, 2005b, 2005c) in south-east Australia, we found large discrepancies in the numbers of birds aged and in the resulting PFY, although the size of the sub-populations sampled was similar at the two sites. The estimated population size of Bar-tailed Godwits in all of Victoria over this interval (1999, 2001–2004) was approximately 7,000; annual samples of aged birds from catches ranged from 36–282, and averaged 122 (Minton *et al*. 2005a, 2005b, 2005c). Annual peak numbers of Bar-tailed Godwits at Tern Mountain ranged from 4,000–20,000 and mean daily counts in early September ranged from 2,500–8,000. At Tern Mountain, annual samples of aged birds ranged from 1,490–37,000 and averaged 16,102. The mean annual PFY in the samples from south-east Australia was 0.15 (± 0.07 SE); from Tern Mountain, the mean annual PFY was just 0.018 (± 0.006 SE). Despite a 10-fold difference in mean PFY values, the small sample size of years (n = 5) precludes a very powerful test for differences between the two datasets (Friedman S = 1.80, df = 1, P = 0.18). Even if the mean PFY differed significantly, however, it is possible that the two datasets might generally track the same phenomena (e.g. annual breeding success) as correlated, if not identical, indices. We found no evidence for such comparability. PFY data from Victoria and Tern Mountain were not correlated (r = 0.29, P = 0.63).

Table 1. Spatial and interannual variability in proportion of first-year (PFY) Bar-tailed Godwits on the boreal staging grounds, south-western Alaska, from late August to late September. Sample size (*n*) is total number of birds aged visually, which likely included multiple counts of many individuals across successive days. Because rates of turnover of adults and juveniles at each site were unknown, annual estimates of PFY could be biased.

Site/year	PFY	95% CI	*n*
Tern Mountain			
1999	**0.030**	**0.026–0.036**	**4,329**
2001	0.000	–	1,490
2002	0.007	0.005–0.008	13,125
2003	0.029	0.027–0.031	37,000
2004	0.022	0.020–0.024	24,546
2005	0.085	0.082–0.087	55,631
Tutakoke River			
2002	0.020	0.015–0.026	2,411
2004	0.821	0.792–0.848	738
Egegik Bay			
2003	0.555	0.528–0.581	1,381
2005	0.898	0.887–0.908	3,467

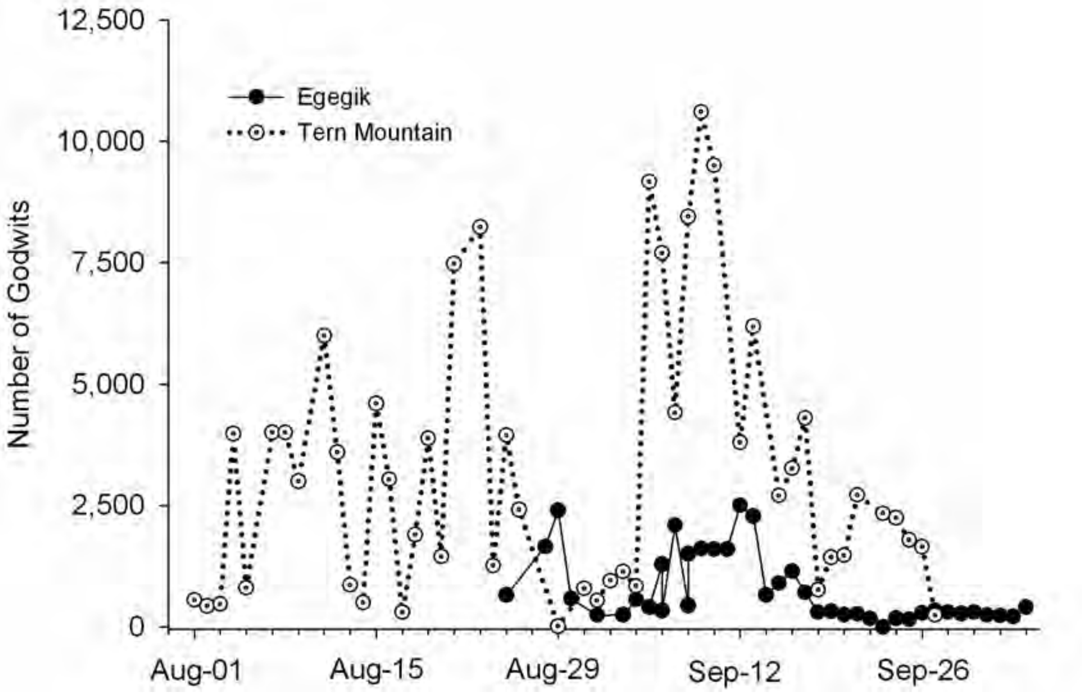

Fig. 1. Seasonal variation in the number of Bar-tailed Godwits at Tern Mountain (open circles) and Egegik Bay (solid circles) staging in south-western Alaska, 2005. Variability in numbers demonstrates that these "populations" are not closed to immigration and emigration. Without some measure of the turnover rates of adults and juveniles at these sites, an unbiased annual estimate of the age ratios is impossible to obtain.

For our population model, we calculated a fertility value of 0.018 and 0.176 from long-term averages of PFY values from Alaska and Australia, respectively. When applied in conjunction with the other demographic parameters detailed in Methods, fertility estimates from Alaska and Australia generated population growth rates of 0.90 and 1.02, respectively (i.e. a declining and an increasing population, respectively). Assuming no change to the underlying demographic parameters, the population of *Limosa lapponica baueri* would decline to half of its current size in 8 years under the scenario utilizing Alaska-derived fertility estimates, and double in 38 years under the Australia-derived scenario.

DISCUSSION

Implications of variability on the Boreal Staging Grounds

The extreme variability of PFY values among sites, among years, and across the post-breeding staging period in Alaska highlights the difficulties and dangers inherent in estimating this demographic parameter without a valid statistical sampling design. One of the primary difficulties was the problem of movement of birds through the study sites, with no adequate measure of the relative turnover rates of adults and juveniles.

The seasonal variation in PFY at Egegik was primarily a function of the early departure of adult birds from that site. Their departure resulted in a dramatic increase in PFY values, with essentially no corresponding change in the number of juvenile birds present. This example highlights the effect that variation in adult use patterns can have on reported PFY. Data from Tutakoke led to the same conclusion. In 2002, when a maximum of about 3,000 godwits occurred at the site, the estimated PFY was 0.02. In other words, about 60 juveniles were in the study area. In 2005, only about 60 godwits were present at Tutakoke, all juveniles; this would have generated a PFY value of 1.0 had we felt it valid to report a value derived from only one sample. Thus, comparable numbers of juveniles yielded radically different estimates of PFY simply because of annual differences in the magnitude of adult use of the site. Drawing inferences about range-wide breeding success from PFY data at this site would clearly have been inappropriate.

Such variation in the distribution of birds can be significant at the population level. For example, in 1997, we counted approximately 33,000 Bar-tailed Godwits using Egegik Bay (Gill & McCaffery 1999), over one-third of the highest number recorded that year during aerial surveys of all autumn staging areas in south-western Alaska. Since then, however, we have never found more than 5,000 godwits at Egegik. Survey results in 2005, for example, indicated that Egegik hosted no more than 6% of the Alaskan staging population (highest count of about 40,000 birds that year). If spatial variation of this magnitude in annual use patterns is not uniform among age classes, there is the potential for site-specific estimates of PFY to be seriously biased, if interpreted as estimates of the regional PFY.

In the absence of a formal sampling design, some might argue that annual productivity estimates could be generated from either the site(s) with the most data because they should be more representative of the overall population, or a combination of data from multiple sites. We are hesitant to endorse either approach. Consider our 2005 data from Tern Mountain and Egegik (Fig. 1). The daily mean number of godwits detected at Tern Mountain (3,404 $\pm$ 581 SE) was significantly higher than at Egegik (863 $\pm$ 132 SE; Mann-Whitney $U = 166$, $P < 0.001$), maximum daily counts varied by more than a factor of 4 (10,600 at Tern Mountain, 2,500 at Egegik), and the number of samples collected at Tern Mountain in 2005 (55,631) greatly exceeded those collected at Egegik (3,467). Despite these dramatic differences between sites, we are unable to conclude that Tern Mountain data adequately characterize Alaskan productivity in 2005. Similarly, although data from the two sites could be combined (e.g. by using weighted means) to generate a more "realistic" Alaskan estimate of PFY, there is no valid statistical rationale for such a combination.

The marked discrepancies between PFY values from Tern Mountain and those from south-east Australia are enlightening. It is clear that even though our sample sizes were quite large and estimates quite precise, estimates of PFY at Tern Mountain could be highly biased because of lack of closure of the population and no measure of relative turnover rates of adults and juveniles at the site. In addition, it was clear that PFY estimated at Tern Mountain differed from those at other post-breeding staging areas in Alaska and should not be considered representative of the entire BSG. Although we might hypothesize that the lack of correlation between the Tern Mountain and Victoria PFY values is because Tern Mountain supports a disproportionately high number of adults, the reverse argument could be made about Victoria. To date, there is no empirical basis for assuming either site is representative of the overall population.

In summary, we found that marked spatial and temporal variation in PFY among Bar-tailed Godwits from multiple study areas on the BSG precluded drawing valid inferences about annual population-wide breeding success. We find no *a priori* reason to assume that the types of variation we have found in both PFY (i.e. by site, by year, within year) and in the absolute numbers of adults using particular sites do not also occur on the ANBG. Until it is demonstrated that such variation does not occur on the ANBG, it is difficult to justify the use of PFY data for drawing inferences about breeding success. The lack of correspondence between PFY data collected within the same years at opposite ends of the flyway also raises concerns about our ability to accurately interpret such data.

Scales of inference and study design

McCaffery & Ruthrauff (2004) pointed out that biologists who study shorebirds on the breeding grounds often fail to limit their inferences to the proper spatial scale. This critique also applies to the use of PFY data on the non-breeding grounds. The proportion of juveniles in a particular batch of catches or at a limited number of sites may not represent juvenile proportions at larger spatial scales. Many other researchers have also noted the problem of the heterogeneous distribution of age classes within flocks (Clark *et al*. 2004, Harrington 2004, Battley 2005, Boyd *et al*. 2005, Rogers *et al*. 2005), while Clark *et al*. (2004) noted that the problem applies across a hierarchy of spatial scales, from the flock to the entire non-breeding range.

For example, although Minton *et al*. (2005a) refer to the PFY Red Knot *Calidris canutus* data as breeding success data (p. 77), they later explain why the very high values of PFY in this species probably *do not* accurately reflect breeding success. Because juvenile knots are spatially segregated from adults at two different scales (regionally and locally), catches of knots in south-east Australia have been strongly biased toward juveniles.

Bias in age-ratios due to spatial segregation of age classes is implied in data for other species. For example, the reported PFY in Ruddy Turnstones *Arenaria interpres* was 0.80 in 1991–1992 (Minton *et al*. 2005a). As noted previously (Rogers *et al*. 2004, Boyd *et al*. 2005), a true value >0.67 is biologically impossible. Thus, PFY values that even approach this threshold (as was reported in some years for Sharp-tailed Sandpipers *C. acuminata*, Red Knots, Bar-tailed Godwits, and Ruddy Turnstones; Minton *et al*. 2005a) must be viewed with scepticism; such values strongly suggest spatial variation in the distribution of age classes, and should not be expected to provide accurate quantitative assessments of breeding success. It remains to be demonstrated that more "realistic" (i.e. lower) values are any more accurate, because the problems of heterogeneous distribution of age classes are independent of the magnitude of PFY.

Despite the widespread acknowledgement of this concern, the results derived from small samples from a small number of sites are regularly used to draw large-scale inferences that are statistically invalid and scientifically unsound. There are actually two problems to be considered. The first is a problem of sample size: either too few sites have been sampled to characterize age composition within a region adequately, or too few birds have been sampled to estimate PFY with adequate precision. The second is that, even with multiple sites within a region, if sites have not been selected via a formal sampling design, there is no statistical basis for inferring that they represent the region. The impact of these problems escalates as the discrepancy between the valid area of inference and the assumed area of inference increases. The problems can be clarified if we look at scale hierarchically.

Researchers occasionally make the implicit assumption that PFY data from their study sites accurately reflect the true PFY at those sites. Given all of the factors that have been identified that might produce a bias in the PFY generated from small numbers of captures (e.g. Minton 2003), it is clear that that implicit assumption is often inappropriate. Depending on the scale of inference, standardization of sampling and obtaining multiple samples alone will not minimize bias and generate year-to-year comparability (*contra* Minton 2003). Even within a local site, one can only make the inference that the PFY data reflect the true PFY if one has used a statistically valid sampling design. Because of the spatial heterogeneity among shorebird flocks in age composition (Clark *et al.* 2004, Harrington 2004, Rogers 2006, this study), it is important to have a statistically valid sample of individuals from both within and among flocks distributed across the region of inference. Sampling more flocks will serve to reduce bias, and sampling more individuals will increase precision of the estimates. To say "more is better" only works once one has sampled across the region. With restricted geographical sampling, more is actually worse, because more data can seduce us into thinking that our samples are adequate when they still are not, plus time and effort have been spent to collect data that may provide a very precise “wrong” answer.

A few rules of thumb have been proposed for identifying an adequate sample size. Atkinson *et al*. (2003) used a minimum sample of 30 birds in a catch for generating estimates of recruitment, but did not explain the rationale for using this sample size. Minton *et al*. (2005a) also specified a minimum sample of 30, but in the same volume, Rogers *et al*. (2005) suggest that "samples of 50 or fewer birds are too small for any realistic estimate of age proportions" (p. 71). Instead, Rogers *et al*. (2005) suggest minimum sample sizes of over 500 for large populations, with results derived from samples between 100 and 500 requiring very careful assessment.

We examined this issue quantitatively by plotting the 95% confidence limits for estimated PFY values of 0.03, 0.10, 0.20, and 0.40, given they arose from samples of 30, 100, or 500 aged birds (Fig. 2). We selected these proportions to represent years of poor, moderate, good, and very good reproduction, respectively (see Minton 2004). We assumed that samples of birds were representative across the area of inference. By examining the degree of overlap of confidence intervals, one can readily see that with a sample size of 30 there would be little power to distinguish anything except a very good year from a poor year of reproduction. With a sample size of 100 birds, adjacent categories are still difficult to distinguish. With 500 birds, however, one could distinguish all four estimates from each other. Thus, we agree that Rogers *et al*.'s (2005) criteria are reasonable.

Questions of sample size and study design also apply at the regional level. Assume a researcher has sampled at a number of different sites within a region. Assume further that at each of those sites, an appropriate sample design was used and an adequate sample was obtained for generating a statistically valid PFY estimate with suitable precision at each site. It would still be inappropriate to then extrapolate those findings to the regional level if sites had not been selected via a valid *regional* sampling design and the number of sites sampled was inadequate to preclude spatial bias at that scale. Consider the *baueri* race of Bar-tailed Godwits. The population size in Victoria in recent years is about 7,000

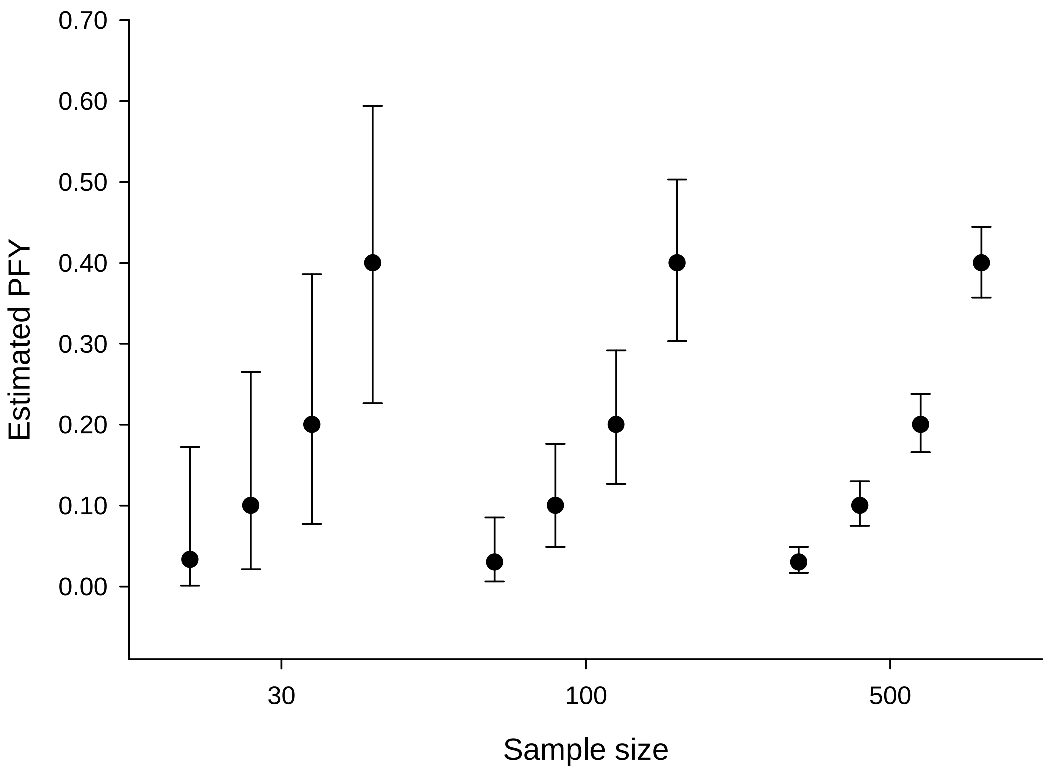

Fig. 2. Precision of estimates (95% confidence intervals) of proportions of first-year (PFY) birds given sample sizes of 30, 100, or 500 total birds aged. Proportions selected to represent years of poor (0.03), moderate (0.10), good (0.20), and very good (0.40) reproduction (see Minton 2004). Estimated variance assumes a representative sample of birds from across the population of interest.

birds (Minton *et al*. 2005a). Given the annual mean captures noted above of 122 godwits, regional (i.e. Victoria) PFY estimates are being made based on only a handful of flocks and a 2% sample of the population.

The same principle holds true at larger spatial scales (e.g. the flyway). The problems noted above (i.e. potential for site-specific bias because of the lack of a valid sampling design, compounded by small sample sizes) are exacerbated as the geographic scale of inference increases. For example Minton *et al*. (2005a, b, c) draw inferences about breeding success for various species within the East Asian–Australasian Flyway. Again, consider the *baueri* race of Bar-tailed Godwits; throughout the flyway, there are an estimated 155,000 birds (Wetlands International 2006). PFY data derived from Victoria may not be representative of the PFY for this population throughout the ANBG (i.e. elsewhere in Australia and New Zealand) if there is large-scale spatial variation in juvenile proportions. In a review of age-specific variation in wintering latitudes among eight species occurring on the ANBG, Nebel (2007) found evidence for an age bias in two species, no bias in a third, and inconsistent patterns among the other five species. These results indicate that it is premature to assume that age biases in distribution on the ANBG are not a problem.

This problem is not limited to an analysis of Bar-tailed Godwits. If one takes the largest sample of individuals in any year for each of the six other species treated in Minton *et al*. (2005a), and divides by the most recent flyway population estimates for those species (Bamford & Watkins 2005), one finds that PFY estimates are being derived from samples that never exceed 2.2% of the entire flyway population. In light of: 1) the site-specific biases that can derive from the absence of a formal sampling design; 2) extremely small sample sizes (of both individuals and sites); and 3) the small subset of the various species' ranges from which samples were derived, we contend that it is statistically and scientifically invalid to conclude that current PFY estimates from the ANBG reflect breeding success of any of these populations across their nesting range.

Underlying the questions about sample size adequacy and precision is an even more important and basic question, "Why are we collecting and analysing these data?" At one level, there is of course widespread recognition that demographic data are valuable, and that monitoring survival and productivity is important (Minton 2003, Sandercock 2003, Clark *et al*. 2004). We agree that demographic data can be inherently valuable, but not all such data are actually useful. The utility of the data will depend upon whether or not they allow us to answer specific questions with adequate precision. For example, how precise must parameter estimates be in order to be useful in population modelling? What magnitude of differences are we attempting to detect between years or regions, and why have we chosen such values? Until we have identified the specific questions we wish to answer, determined what magnitude of difference is biologically relevant, and determined what magnitude of difference we need to be able to detect, discussions about precision of estimates will remain largely academic.

Biological assumptions

There are also biological reasons to question the "breeding success" interpretations of PFY. We have identified four untested assumptions being made when PFY data are presented as a measure, or index, of breeding success. In order for PFY data to accurately reflect breeding success, one must assume that: 1) there is no variation in PFY over the sample period (i.e. the study system is closed and survival is equal between age classes); 2) juvenile settlement patterns on the ANBG are similar between years; 3) annual variation in juvenile survival during the period after fledging but before sampling is minimal; and 4) the proportion of subadult birds within sample flocks is minimal. Significant bias in PFY estimation is possible if any one of these assumptions is violated, yet the validity of these assumptions is unknown.

The assumption that PFY does not vary over the sample period implies not only that there is limited immigration to and emigration from the site but also that survival does not vary by age class. This assumption could be violated in different ways during the austral summer. If the two age classes vary in their propensity for within-season site-fidelity, site-specific estimates of PFY may be biased depending on when captures were made, particularly if there are seasonal trends in site fidelity. Similarly, if survival varies by age class (e.g. Cresswell & Whitfield 1994, Peach *et al*. 1994, Warnock *et al*. 1997), different PFY values could be generated early versus late in the season, independently of any movements in or out of the study area. Although Boyd *et al*. (2005) explicitly assume that survival is high for both age classes on the ANBG, this assumption should be tested, as should the assumption that there is no age-related variation in survival.

This same assumption limits our ability to accurately interpret the PFY values collected on the BSG. Because we have not addressed age-specific patterns in the length of stay at sample sites, we introduce potential bias to our estimates. If, for instance, the turnover rate of adult Bar-tailed Godwits at Tern Mountain were twice that of juveniles, we would inadvertently underestimate the number of breeding adults in the study system, thus overestimating PFY. A great body of evidence suggests that shorebirds exhibit seasonal (e.g. Semipalmated Sandpiper *Calidris pusilla*, Dunn *et al.* 1988; Dunlin *C. alpina*, Warnock *et al.* 2004; Western Sandpiper *C. mauri*, Warnock & Bishop 1998), site-specific (e.g. Pectoral Sandpiper *C. melanotos*, Farmer & Wiens 1999), and body-condition-related (e.g. White-rumped Sandpiper *C. fuscicollis*, Skagen & Knopf 1994) variation in length of stay at migratory stopover sites, and similar patterns likely occur with Bar-tailed Godwits on the BSG.

The second assumption rests on the belief that annual differences in numbers (and thus PFY) are a function only of differences in production of young on the breeding grounds and not spatial variation in settling of those young once they reach the ANBG (i.e. a constant proportion of each year's juveniles recruit to the same sites each year). If, however, there is annual variation in geographic patterns of settling by juvenile birds, then researchers could get a very biased picture of breeding success unless they sampled at, or statistically from, all sites within the entire ANBG. We are not aware of any studies that directly address the issue of proportional variation in annual recruitment patterns among shorebirds migrating to the ANBG. We do know, however, the tautological fact that juvenile birds cannot exhibit first-year site-fidelity to non-breeding sites. In addition, juvenile birds across a wide range of taxa appear as vagrants much more frequently than adults. Given this age-related variation in navigational accuracy, it would not be surprising to find wide variation among years in the proportion of birds recruiting to specific sites.

Although adult birds do have tendencies to show site fidelity on the non-breeding grounds, most studies have shown that it is a probabilistic phenomenon. Some adults do return and stay at the same sites used in previous years, and others apparently do not (e.g. Burton *et al*. 2005), and within species, there can be geographic variation in site-faithfulness (Myers *et al*. 1988). On the BSG, we have documented such variability at both Tutakoke and Egegik, as indicated by radical changes in numbers of adults between years at those sites (i.e. changes too large to be explained by variation in actual survival). We suspect that similar patterns of unknown magnitude occur on the ANBG. If the number of adult godwits returning to a site varies from year to year as a result of dispersion to other sites, the denominator of the PFY value can change independently of any change in the number of young present.

The third untested assumption is that annual variation in survival between fledging and subsequent sampling on the ANBG is small relative to annual variation in breeding success (Boyd *et al*. 2005, Minton *et al*. 2005a). This is based on "the well-known propensity of Arctic-breeding birds to exhibit wide variation in breeding success from year to year" (Minton *et al*. 2005a, p. 80). There are two problems with this assumption. First, there can be considerable variation, both within and among Arctic species, in the degree of annual variation in breeding success. Some populations may show relatively little annual variation in breeding success; in other populations where substantial variation exists, it may occur across very different ranges of values depending on the species, habitat, and geographic location. Second, this assumption is comparing a relatively well documented phenomenon with a very poorly documented phenomenon. There are lots of data addressing annual variation in breeding success of Arctic-breeding shorebirds; there are virtually no data regarding survival of juvenile birds from fledging to the middle of the austral summer.

In effect, this assumption rests on the implicit premise that an absence of data reflects an absence of variation when in fact we do not know how variable survival might be in the first half-year after fledging. Those six months include a host of stressful periods and transitions: travelling from breeding areas to staging areas, transitioning from upland/freshwater habitats to marine habitats (for many species), accumulating fat while staying safe from predators prior to migration, being exposed to diseases for the first time, the physiological and navigational challenges of migration itself, recovery from migration, site selection on and adjustment to the ANBG. Unlike the breeding season, when adult birds exhibit a number of behaviours to protect their offspring both in the eggs and as chicks, most juvenile long-distance migrant shorebirds confront the world without the assistance of parents. Given the range of time, conditions, and challenges experienced by juvenile shorebirds in their first half-year of independent life, it seems imprudent to conclude that annual variation in survival over that period is minimal and consistent among years when compared to annual variation in breeding success during the brief Arctic summer.

Finally, for PFY values from the ANBG to accurately reflect breeding success, one must also assume that the proportion of subadult birds in the population is both low and consistent from year to year. Counts made during the austral winter, however, demonstrate that a considerable proportion of the population of certain species (e.g. Bar-tailed Godwit, Ruddy Turnstone, Red Knot) are subadult birds (Hewish 1990, Sagar *et al.* 1999). These same birds, indistinguishable from breeding adults, are present during the austral summer period over which PFY values are calculated. This erroneously inflates the number of breeding adults, introducing a negative bias to PFY values. In order for PFY values to more accurately reflect breeding success, the population age structure of shorebird species in the ANBG must be better described and integrated into PFY calculations.

Correlations

We must be careful about how we approach an analysis of correlations in PFY data. Such correlations are used to implicitly justify the use of PFY data as an index for breeding success. Researchers might face several distinct pitfalls. The first is to assume that, even if data from both ends of the flyway (e.g. breeding success in the eastern Siberian Arctic and juvenile proportions on the ANBG) were not collected via a valid formal sampling design, a positive correlation between the datasets is evidence for both their adequacy and the reality of the correlation. Such a conclusion, however, is circular, and the correlation may be spurious. This does not mean that there may not be a real correlation between breeding success and the proportion of juveniles on the ANBG; such a correlation is both likely and logical. If the data have not been collected in a way that allows for an expanded scale of inference, however, we simply have no *scientific* basis for concluding that the correlation exists.

A second type of correlation involves the search for similar patterns in PFY among multiple species. The rationale seems to be that if two species that breed in the same general area and/or habitats exhibit comparable PFY values on the ANBG, then PFY values must be a useful index for breeding success. This logic is flawed, because other hypotheses have not been tested. For example, if the species also experience similar conditions after fledging (e.g. similar ecology, similar migration routes), then the comparable PFY data are just as likely to be the result of post-breeding conditions as breeding conditions. Similarly, two sympatric species could have very different levels of breeding success and then contrastingly different levels of survival en route to the ANBG. The net result could be very comparable juvenile proportions on the ANBG, arrived at via very different pathways (high breeding success—low post-fledging survival versus low breeding success—high post-fledging survival).

We also need to determine *a priori* how we will evaluate whether or not PFY data for multiple species are really correlated. For example, Minton *et al*. (2005a) state that PFY data from Red-necked Stint *C. ruficollis* and Curlew Sandpipers *C. ferruginea* showed a striking concordance over a 16-year subset of their data. They provided no rationale for selecting this particular 16-year interval for analysis, however, and their conclusion regarding this subset of data was based simply on inspection, not statistical analysis. When the entire 25-year data set was analysed statistically, the PFY data for the two species were not significantly correlated (i.e. $P > 0.05$). Minton *et al*. (2005a) then looked for, and found, a significant correlation ($P = 0.046$) between annual changes in PFY for the two species (i.e. the differences between the PFY in successive years). They concluded that "both species have synchronous increases or reductions in breeding success between years" (p. 81). By analysing the data differently, however, one could draw the opposite conclusion. For example, if one asked whether or not the PFY values for the two species went in the same direction each year, one would find that they went in the same direction during 11 years, and in opposite directions in 12 years. From this analysis one might conclude that there is no propensity for the two species to change in the same direction. In this analysis, predicting the direction of annual change in PFY of one species based on the change in the other is equivalent to tossing a coin.

This disparity in conclusions illustrates the need to proceed rigorously when selecting analytical methods (Anderson *et al*. 2001). Although exploratory analyses are useful in looking for potential relationships, once hypotheses are actually being tested, analytical method selection cannot be an iterative process that continues until we find one that supports our hypothesis. Instead, the most appropriate and powerful analytical approach must be selected prior to analysis, then conclusions should be based on the results of that analysis.

Dramatic variations on the breeding grounds apparently do have significant regional effects on shorebird breeding success. Lemming cycles on the Taimyr Peninsula and the effects of the eruption of Mount Pinutabo are examples of such extreme patterns (Summers & Underhill 1987, Underhill *et al*. 1993, Summers *et al*. 1998, Gantner & Boyd 2000). Correlations between breeding ground conditions and subsequent juvenile proportions on the ANBG, however, can be problematic in years with less extreme conditions. At least two sources of error can occur. First, general characterizations for Arctic conditions at sites or across regions can be misleading if conditions varied at some critical junctures of the season (Boyd *et al*. 2005). For example, a generally wet cool season may not have a significant negative effect on breeding shorebirds if brief spells of good weather coincided with critical intervals, such as egg-laying and hatching. Second, there is no statistical basis for generating regional characterizations (about weather, rodent cycles, shorebird nest success, etc.) from one or a few sites if those sites, as a group, have not been selected randomly. For example, Pitelka & Batzli (1993) found no regional synchrony in the timing of microtine population peaks among multiple sites on the North Slope of Alaska, nor did they find synchrony among locally co-existing species within years. Although it may be tempting to extrapolate locally derived data across large swaths of the Arctic, there is often no statistical basis for doing so (McCaffery & Ruthrauff 2004).

CONCLUSIONS AND RECOMMENDATIONS

Gunnarsson (2006) rhetorically asked, "Is recording of juvenile proportions during autumn passage useful or a waste of time?" (p. 28). Not unexpectedly, Gunnarson argues that recording such data is useful; the "waste of time" alternative was simply a straw man. We suggest that a slightly different question should be considered. Is *reporting* juvenile proportions *as a measure of breeding success* useful or a waste of time? We contend that unless significant improvements are made in how studies are conceived and conducted, Gunnarson's straw man has considerably more substance than in his original incarnation.

The importance of demographic data for shorebird conservation has been convincingly demonstrated (Sandercock 2003, Robinson *et al*. 2005) and championed (Minton 2003, Minton *et al*. 2005a). We must acknowledge, however, that PFY values, even if accurate, provide only a crude index to breeding success. For example, Minton *et al*. (2005a) suggest that PFY data from the ANBG allowed them to classify breeding success into five general categories ranging from very poor to very good. Although we argue that the kinds of estimates derived to date do not allow for valid inferences about reproductive success on the breeding grounds at even this crude level, properly designed studies may eventually do so. Even so, if we can only provide broad categories of breeding success, we should carefully evaluate the merits of such a program relative to the costs of collecting data. Even well designed PFY sampling may still leave us a long way from parameter estimates precise enough to be used in rigorous population models and hypothesis-testing.

We contend that it is premature to use PFY data from the ANBG as an index to breeding success in the Arctic. Efforts to date have often failed to convincingly demonstrate that PFY data accurately represent the true PFY at even a local scale, let alone at the regional, flyway, or global scale. Rogers *et al*. (2005) and this study have demonstrated that sufficiently large samples for analysis can be collected observationally (i.e. without capture) for many populations. This step in the right direction, however, must be put in context. Questions still remain about how best to choose flocks or individuals for such sampling. Discussion continues about how to calculate the most appropriate measure of precision (Clark *et al*. 2004, Rogers 2006). Although the need to sample at more sites is acknowledged (Minton *et al*. 2005a, Rogers *et al*. 2005), we have not yet seen an attempt to apply formal sampling theory in order to develop a valid sampling design for deriving a regional estimate of PFY. Finally, despite the temptation to do so, we cannot use our local data, even when rigorously derived, to make inferences about any region beyond the area from which the samples were actually drawn unless the local data are part of a larger rigorous study design (McCaffery & Ruthrauff 2004).

Results of our population modelling exercise emphasize the importance of properly collecting and interpreting PFY values. One would draw two very different conclusions about the population status of *Limosa lapponica baueri* depending upon whether one utilizes fertility estimates derived from Alaska or south-east Australia PFY values. Both population models are based upon fertility estimates derived from PFY values that, we argue, are of unknown accuracy and biological significance; as such, we acknowledge that the accuracy of both population models is dubious. Yet one projection is dire, the other optimistic. If we do not more critically evaluate our science, we are potentially ignoring the fate of the animals which we all strive to preserve. It is incumbent upon us to improve our methodologies and standardize our approaches.

In this context, we offer the following suggestions. We recognize that many of the historical capture sites throughout the ANBG are some of the few logistically feasible sites in the region. While we argue that PFY data collected at these sites are limited in application, these sites can meaningfully address many of the untested biological assumptions underlying the way in which PFY values are currently reported. Analysis of historical datasets, particularly of banded and colour-marked birds, could address the dearth of knowledge concerning age-specific survival rates, population age structure, site fidelity, and movement patterns of shorebirds in the ANBG, greatly aiding our ability to properly interpret PFY values (for such a synthesis, see Rogers & Gosbell 2006). As noted above, consideration should be made as to the extent to which these datasets reflect conditions beyond each site.

To the extent possible, programs to estimate PFY should be designed to account for spatial and temporal variability in age-related distribution across the region of inference. Even minor efforts at a network of sites systematically or randomly distributed across the region would help in interpreting patterns found at primary study sites. Finally, we suggest that one determine *a priori* what level of precision is required to answer specific, biologically relevant questions (e.g. was production of juveniles poor or moderate this year), and then calculate the sample sizes needed before beginning field work.

The elephant is a much more complex organism than the isolated tactile assessment of individual parts might lead us to believe. Similarly, flyway-wide shorebird population dynamics cannot be effectively characterized by extremely limited sampling. In saying this, we do not mean to imply that there are no correlations between breeding success and the proportion of juveniles occurring on the ANBG, nor do we suggest that such correlations are beyond the ability of science to detect and quantify. We do argue, however, that to date, most evaluations of the relationship between breeding success and juvenile proportions have lacked scientific rigor, specifically in terms of study design, sample size, testing assumptions, and exploring alternate hypotheses. Other researchers have recognized and skillfully addressed these same problems with other species (e.g. Marbled Murrelet *Brachyramphus marmoratus*, Peery *et al*. 2007), and we encourage similar efforts in our collective work. Until substantial improvements are made in these areas, we should refrain from generally concluding that juvenile proportions on the non-breeding grounds accurately reflect either conditions or actual shorebird breeding success in the Arctic.

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DEMOGRAPHIC MODELS FOR RED-NECKED STINT AND CURLEW SANDPIPER IN VICTORIA

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This paper examines the proposition that juvenile percentages of waders in Australia, as routinely monitored from cannon-netting catches, are good indices of breeding success. Simple demographic models are developed for Red-necked Stint and Curlew Sandpiper in Victoria. The models estimate the survival rate which maximises the correlation between the annual model predictions and population monitoring program counts since 1978/79 in Victoria. The overall correspondence is remarkably good although there are instances of substantial differences. Reasons for these differences are discussed. Overall, the results support the monitoring of juvenile percentages and the population monitoring program as effective methods to monitor wader populations in Australia. Comparison of true survival rates estimated in the model with apparent survival estimates obtained in 1995, and a sensitivity analysis, suggest that the long-term decline in Curlew Sandpiper numbers in Victoria is more likely to be due to reduced adult survival rates than to breeding failures or mortality between fledging and capture some six months later.

INTRODUCTION

Recent work has shown that populations of many wader species are declining worldwide (IWSG 2003). This has led to an increased emphasis on monitoring studies to detect changes in population (Gosbell & Clemens 2006, Rogers *et al*. 2006b) and in survival and recruitment rates (Robinson *et al*. 2005), the only two possible causes of changes in population levels.

In Australia, the monitoring of age proportions in cannon net catches by the Victorian Wader Study Group (VWSG) started in 1979/80 (Minton 2006a). The Australasian Wader Studies Group (AWSG) started its Australia-wide Population Monitoring Program (PMP) in 1981/82 (Gosbell & Clemens 2006). The AWSG has also been measuring age proportions in north-west Australia. These programs continue to this day. Results of these activities have been reported regularly in the pages of *Stilt* and elsewhere. For age proportions see Minton *et al*. (2005a) and references therein and Minton *et al*. (2005b, 2006). For population monitoring results see: Anon (2003); Harris (1994a, 1994b, 1995a, 1995b, 1996, 1997, 1999, 2000); Hewish (1986a, 1986b, 1987a, 1987b, 1988, 1990a, 1990b, 1992); Naismith (1992); Skewes (2002, 2003, 2004, 2005); Wilson (2001a, 2001b). Some previously unpublished work by KGR on survival rates of Red-necked Stint *Calidris ruficollis* and Curlew Sandpiper *C. ferruginea*, done in the mid-1990s, is reported here.

One of the reasons for the emphasis on monitoring in Australia is that effective monitoring in the rest of the flyway is so difficult. Breeding success is ideally estimated at the breeding grounds but these cover such an enormous area in difficult terrain and often vile weather conditions that annual long-term monitoring is impracticable. Studies at staging sites have their own problems not least that the populations are not stable and different ages usually migrate at different times. This makes systematic sampling difficult and creates severe analytical challenges. Monitoring wader populations in Australia faces nothing like these challenges being at the end of the migration route for all but three species which stage there before going on to New Zealand (Minton 2006b). Yet monitoring wader populations in Australia also has problems. It has long been recognised (e.g. Weston 1992) that juvenile proportions estimated in Australia can only be considered an index of breeding success. In cases of delayed maturity (Rogers *et al*. 2006a), where birds don't make their first northward migration and breeding attempt until late in their second year or older, this problem is exacerbated as the adult samples include non-breeding second year birds of which the juveniles cannot be the progeny. Estimates of true recruitment based on these proportions require assumptions on survival rates of birds of different ages. There are also difficulties in obtaining representative counts. Migrant shorebirds are found around a large proportion of the Australian coastline and also in the mostly arid interior. Sporadic rain events can create ephemeral wetlands, which are present in some years throughout the inland of Australia. The unpredictable occurrence and scale of these events, and the rate at which these wetlands dry out, can influence the timing of wader arrivals at more easily monitored coastal sites (Alcorn *et al*. 1994).

The combined effects of survival and recruitment over several years lead to the populations monitored in the PMP wader counts in any particular year. Demographic models are needed to explain changes in count, and presumably population, numbers. To date, no such approach to understanding wader populations in Australia has been made, possibly because of the difficulties in collecting appropriate data as outlined above. The aim of this study was to develop demographic models of populations in Victoria, Australia for two species to see if the data that are available can provide insight into population changes. The Red-necked Stint is the species most commonly caught in cannon-net catches in Victoria. Curlew Sandpipers have been caught in good numbers in all but the most recent years but the PMP counts have shown a steep decline in numbers, noted by Wilson (2001a) from *c.* 30,000 in 1982 to about a fifth of that number today.

METHODS

Population Monitoring Program Counts

The Australasian Wader Studies Group has undertaken annual PMP counts since 1985 (Gosbell & Clemens 2006). This evolved from the RAOU (now Birds Australia) wader counting project 1981–1985. The PMP initially comprised 23 core sites around Australia which were counted by volunteers twice each year. Counts are carried out in the summer (January/February) after adults and juveniles have returned to the non-breeding sites and when populations are relatively static. A second count is carried out in the winter (June/July) which, in some species, may provide an indication of young birds that have not returned to the breeding grounds. Currently 29 sites are included in this program although not all have been continuously counted (Gosbell & Clemens 2006). The results of these counts have been regularly reported in summary form in *Stilt* (see previous references).

Monitoring Recruitment

A regular part of the VWSG banding programme is estimating the percentage of first year birds in catches in the November to March period each year. The data, presented and discussed in Minton *et al*. (2005a, 2005b, and 2006), are used here. Rogers *et al*. (2004) argue that true recruitment (the ratio of number of juveniles one year to the number of adults the previous year [White & Burnham 1999]) is better estimated by the juvenile ratio (the ratio of the number of juveniles to the number of adults) than by the more commonly reported juvenile proportion (the number of juveniles divided by the total number of birds present). Minton (2004) described the subtraction of an estimate of the number of second-year birds (i.e. non-breeders) present from the denominator of the expression to calculate the juvenile proportion. This expression assumes that the same survival rate applies to all ages of birds. Converting this adjustment to juvenile ratios gives the canonical expression $R_i = r_i.(1 + r_{i-1})$ where R_i is the adjusted juvenile ratio for year i and r_i is the unadjusted ratio. The adjusted ratio is in fact an estimate of true recruitment and is referred to here as the recruitment estimate or just simply recruitment if the context is clear. Standard deviations of the adjusted ratio R_i are calculated by a Monte Carlo method (see, for example, Manly 1997). In this a random sample is taken of the each juvenile proportion assuming a binomial distribution using the method of Press *et al*. (1986). The proportions are converted to ratios and the adjusted ratio calculated. This process is repeated many times and the standard deviation of each adjusted ratio calculated from the results.

Cumulative Sums of Recruitment Estimates

The cumulative sum technique is a powerful method for detecting underlying trends in noisy time series data (Woodward and Goldsmith 1964). In the context of this study, annual differences from the long-term average recruitment (i.e. over the whole period of the data) are accumulated from season to season and plotted against season. A sequence of points with a constant gradient indicates a period over which the recruitment rate has been constant. A positive gradient shows a period over which recruitment has been higher than the long-term average and *vice versa*.

Demographic Model

Five simplifying assumptions are made in the model presented here:

- that population monitoring counts give unbiased estimates of the population present each year;
- that the adjusted ratios are unbiased estimates of annual recruitment rates;
- that there is no emigration to, or immigration from, other populations;
- that, in any year, breeding success rate is the same for second-year and older birds. Due to delayed maturity, the first-year birds do not breed for the two species considered here; and
- that the same annual survival rate applies to all ages of bird in all years.

Given a number of birds in three age groups (first-year birds or juveniles, second-year birds, and birds in their third year or older), the model estimates the number of birds in each group which survive to the following year and how many young they produce. The relationships between demographic parameters are readily defined. With the notation:

$n_{i,j}$ Number of birds at age i in year j
s_i Survival rate of age i birds to age $i+1$
R_i Recruitment rate of age i birds

the number of birds surviving from one year to next is given by:

$$n_{i,j+1} = s_i \, . \, n_{i,j}$$

and the progeny of the $n_{i,j}$ birds, assuming half of mortality occurs in each half of the year, is given by:

$$n_{1,j+1} = R_i \, .\{n_{i,j} - n_{i,j} \, . \, (1 - s_i) / 2\} = R_i \, . \, n_{i,j} \, .(1 + s_i) / 2$$

Knowing the number of birds present in each age group in one year and the survival and recruitment rates, the numbers of birds present in each age group in the following year are readily calculated. This process is repeated for all years for which we have estimates of juvenile proportions.

Calibration of the model requires finding the survival rate which maximizes the correlation, specifically the correlation coefficient, between model estimates and PMP counts. The survival rate estimate is found with an iterative procedure (effectively informed trial and error).

Starting values for model

One thousand birds in their third year or older are assumed. The number of first-year birds is found as the young of 1,000 adults breeding at the long-term recruitment rate. The number of second-year birds is found as the number of these first-year birds which survive to their second year. It is not possible to calculate the adjusted juvenile ratio for the first year because we don't have the corresponding ratio for the previous year. The average recruitment rate is therefore used as an initial estimate. Experimentation showed that results were not sensitive to starting value assumptions.

Confidence Limits
Waders are long lived birds. For example, for a species for which the annual survival rate is 80%, the average life expectancy is four and a half years but 10.7% of birds will still be alive after 10 years. The population estimate for a year is therefore a consequence of breeding and survival of birds over several preceding years. The standard error of the population estimate is calculated by another Monte Carlo calculation (Manly 1997) similar to that described earlier. In this case though, the asymmetric 90% confidence limits on the population estimate are also found.

Sensitivity Analysis
The sensitivity of the survival rate estimate is examined by calculating the percentage change of the population estimate after 26 years that would follow from a 1% change in survival rate round the optimum point (a.k.a. the elasticity). Elasticity with respect to recruitment rates is also examined.

Apparent Survival Rates
Little work has been done on the survival rates of Australian waders. In 1995, KGR (unpubl.) estimated apparent survival rates on VWSG banding data for Red-necked Stints and Curlew Sandpipers using the program SURGE (Clobert *et al*. 1987). The SURGE model is incorporated into the recaptures only model in Program MARK (White & Burnham 1999). The survival estimate of this model is known as apparent (or local) survival because it is not possible with capture/ recapture data to distinguish between mortality and emigration. In the absence of any immigration, this model necessarily underestimates true survival (as estimated by the demographic model).

RESULTS

Red-necked Stint

Table 1 presents the data for Red-necked Stints. Totals caught and juvenile proportions are taken from Minton *et al*. (2005a and 2006). The juvenile ratio consistently underestimates recruitment (as estimated by the adjusted juvenile ratio), the size of the bias depending on breeding productivity the preceding year. The underestimation, equal to the product of the unadjusted ratios of each year and the year preceding, is less than 0.05 of the adjusted ratio in 81.5% of the years of Table 1. The juvenile proportion gives even larger underestimates of adjusted recruitment, only underestimating within 0.05 in 48.1% of years.

The upper part of Figure 1 plots the estimated recruitment (the adjusted juvenile ratio) for Red-necked Stint against the season of capture. This appears to show a general picture in which, despite something of a switchback nature, recruitment appears to have been increasing until 2001/02 since when there has been a sudden drop off in the rate. The

Table 1. Red-necked Stint age ratio data. Juvenile proportions from Minton *et al*. (2005)

Year	Total Caught	Juvenile Proportion		Juvenile Ratio		Adjusted Juvenile Ratio		PMP Count
		Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	
1978/79	871	0.170	0.013	0.205	0.018	.	.	.
1979/80	3,229	0.064	0.004	0.068	0.005	0.083	0.006	.
1980/81	2,205	0.056	0.005	0.059	0.005	0.063	0.006	.
1981/82	2,542	0.160	0.007	0.191	0.010	0.202	0.011	42,524
1982/83	1,518	0.080	0.007	0.087	0.008	0.103	0.010	35,082
1983/84	1,515	0.065	0.006	0.069	0.007	0.075	0.008	41,262
1984/85	3,640	0.180	0.006	0.219	0.009	0.235	0.010	33,822
1985/86	2,280	0.180	0.008	0.219	0.012	0.267	0.015	47,880
1986/87	2,795	0.068	0.005	0.073	0.005	0.089	0.007	30,530
1987/88	4,896	0.210	0.006	0.266	0.009	0.285	0.010	30,285
1988/89	5,436	0.138	0.005	0.160	0.006	0.203	0.008	25,560
1989/90	2,314	0.007	0.002	0.007	0.002	0.009	0.002	37,184
1990/91	3,824	0.143	0.006	0.166	0.008	0.167	0.008	27,677
1991/92	1,994	0.291	0.010	0.410	0.020	0.478	0.024	25,732
1992/93	4,340	0.038	0.003	0.039	0.003	0.055	0.004	33,699
1993/94	6,015	0.148	0.005	0.174	0.006	0.181	0.007	35,014
1994/95	3,191	0.186	0.007	0.229	0.010	0.269	0.012	40,244
1995/96	1,804	0.251	0.010	0.334	0.018	0.411	0.022	38,465
1996/97	3,526	0.119	0.005	0.136	0.007	0.181	0.010	33,409
1997/98	4,232	0.078	0.004	0.085	0.005	0.096	0.006	37,592
1998/99	4,854	0.324	0.007	0.479	0.015	0.520	0.016	31,862
1999/00	4,885	0.227	0.006	0.293	0.010	0.434	0.016	42,988
2000/01	5,815	0.132	0.004	0.153	0.006	0.197	0.008	50,617
2001/02	6,351	0.345	0.006	0.526	0.014	0.606	0.016	53,036
2002/03	3,357	0.130	0.006	0.150	0.008	0.229	0.012	43,478
2003/04	5,470	0.230	0.006	0.299	0.010	0.344	0.011	56,579
2004/05	6,051	0.098	0.004	0.109	0.005	0.142	0.006	47,839
2005/06	4,034	0.074	0.004	0.080	0.005	0.089	0.005	.

cumulative sums (Woodward and Goldsmith 1964) plotted in the lower part of the figure give a slightly different interpretation. This shows recruitment was steady at a value lower than the long-term average until 1990/91 after which it gradually increased to a higher level which was maintained from about 1997/98 until 2001/02, since when recruitment has levelled out at around the long-term average. In the last two years for which there are data, recruitment has taken a steep downward turn to the average level of the 1980s and 1990s with 2005/06 dropping to the lowest since 1992/93 and the third lowest on record; it would be of major concern if this trend were maintained into the future.

Figure 2 shows the population projections of the model against the annual population monitoring counts. The general picture corresponds to what might be expected from the cumulative sums of recruitment discussed above. Trend lines through the model and the count data points would be almost identical, were it not that the expected large surge in numbers in 2002 was not reflected in the PMP counts. The last four years are not the only points of concern. Most of the count totals are outside the 95% confidence limits of the population model. Indeed, only six points are within the limits. Clearly, there is some process affecting the Red-necked Stint counts which we do not know about. The annual variations in the counts are much greater than can be explained by the observed recruitment rates.

Curlew Sandpiper

Curlew Sandpiper data are shown in Table 2. No birds of this species were reported by Minton *et al*. (2005a) in 1978/79. Catch sizes and count totals are much lower than those for Red-necked Stint but sufficient birds were caught in most years to allow good estimates (small standard deviations) of the juvenile proportions. Figure 3 presents the adjusted juvenile ratio plots. The cumulative sum part of the figure shows a relatively steady recruitment rate until 2000/01 except for two magnificently productive years in 1988/89 and 1991/92. Since 2001/02, recruitment higher than the overall average has been maintained with the last two years being particularly good.

The population figures shown in Figure 4 show a remarkably good fit between the model and the PMP counts. The first two years of PMP counts are the only ones where the fit is particularly poor.

Survival Rates

Table 3 presents, for the two species considered: the average recruitment rate estimated over the data of Tables 1 and 2; the true survival rates estimated in the model calibration; and the model outputs of apparent survival rates and annual recapture probabilities from program Surge. Parameters could only be estimated before 1987/88 for Curlew Sandpiper because earlier data had not been computerised when these analyses were made. Results of a number of models (e.g. by different locations in Victoria) have been combined to give the models presented here. The parameter estimates in these cases are the average of those estimated for the component models weighted by the inverse of the variance of the estimates.

The point of particular interest here is that apparent survival of adults in the year after banding is substantially lower than annual survival in subsequent years. The sample in the year after banding includes birds in their second year as well as older birds. The two ages of bird are only distinguishable on plumage and feather wear before the end of October (Bamford *et al*. 2005). For Red-necked Stint, apparent survival of birds from their first to their second year is intermediate between those of the two age categories of older birds.

DISCUSSION

A simple demographic model replicates well the general pattern of population changes of the Red-necked Stint and Curlew Sandpiper over the last 25 years in the Victorian coastal wetlands (Figs 2 & 4). There are several cases where the model projections apparently differ significantly from the PMP counts. The latter are estimates of unknown precision of the numbers of birds present and, were the count standard errors known, many of the smaller apparent differences would probably be shown to be not significant. An inherent problem with the demographic model arises because adjacent annual population estimates are not independent. An extreme value of the juvenile proportion in one year affects the estimates at a diminishing rate in subsequent years whereas annual population counts are independent.

There are two periods, the early years for Curlew Sandpiper and the later years for Red-necked Stint, where the discrepancies between the models and the counts are massive. The two areas of greatest concern are the apparent gross overestimation by the model of the population of Red-necked Stints from 2002/03 onwards and the underestimation of Curlew Sandpiper numbers before 1983/84. The Red-necked Stint problem arose from the exceptional season of 2001/02. This had the highest number of birds, the highest number of juveniles, and the highest juvenile percentage recorded in Victoria, 34.5% against the long-term median of 16.6% (Minton *et al*. 2005a). Juvenile percentages were well in excess of the median value at nine of the ten locations where birds were caught; the exception, the Western Treatment Plant at Werribee, provided 41% of the total sample with a juvenile percentage of 16.9%. As noted above, exceptional results can occur if appropriate circumstances combine. The low Curlew Sandpiper counts in the first two years in which they were counted could have arisen from the counts possibly not being comprehensive because not all sites where they occurred were known.

Any monitoring, whether of juvenile proportions or population counts, rests on the implicit assumption that the same population of birds is being monitored each year. This assumption is generally held to apply to the species considered here. See, for example studies by Rogers *et al*. (1996) and Minton *et al*. (2006c) which both report high levels of site fidelity. Should unusual circumstances apply in a particular year, which lead to a breakdown of this assumption, inconsistencies between population predictions and population counts could occur.

Coastal Victoria is near the end of the flyway (small numbers go as far as Tasmania) yet not all birds reach even

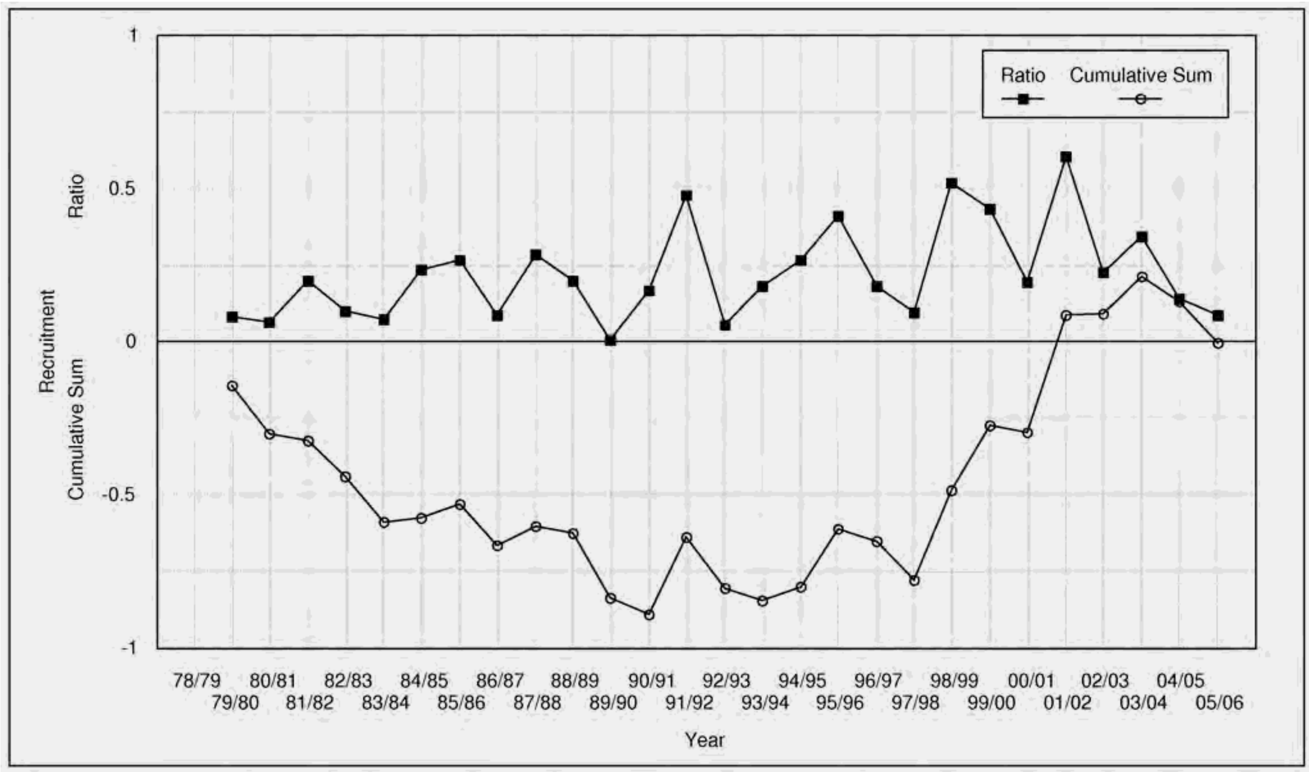

Figure 1. Red-necked Stint. Adjusted juvenile ratios. The upper figure shows the estimated ratios. The lower figure shows the cumulative sum relative to the long-term average of 0.223. By convention, the Australian wader year starts 1 August.

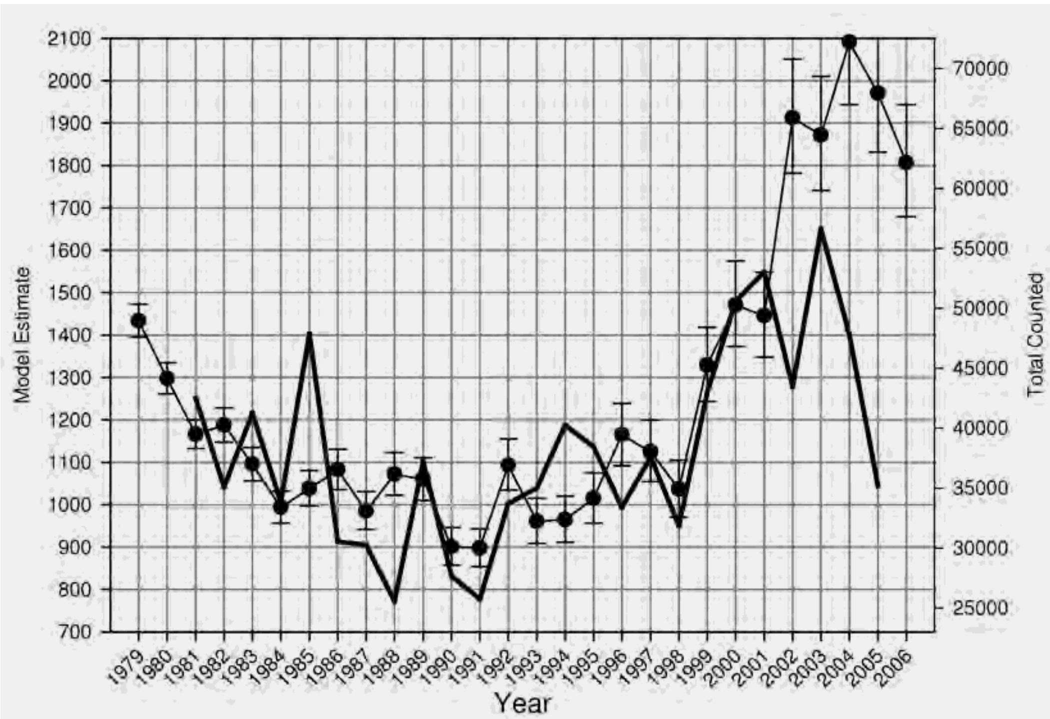

Figure 2. Red-necked Stint population projections. Thick lines are the Population Monitoring Program count totals; counts were in January of the year indicated. Thin lines are the model projections of this paper. The latter are made relative to an arbitrary starting population so ordinates have been normalised to illustrate the correlation between changes in the model and the counts. Error bars are 95% confidence limits. Data from 2002 onward were not used in the calibration of the population model. This gave a correlation coefficient of 0.661 (N = 21) and a constant survival rate of 85.1%. Average recruitment rate was 0.2236.

Table 2. Curlew Sandpiper age ratio data. Juvenile proportions from Minton *et al*. (2005)

Year	Total Caught	Juvenile Proportion		Juvenile Ratio		Adjusted Juvenile Ratio		PMP Count
		Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	
1978/79	.	.	.	.	.	.	.	.
1979/80	1,922	0.069	0.006	0.074	0.007	.	.	.
1980/81	279	0.100	0.018	0.112	0.022	0.120	0.024	29,272
1981/82	210	0.095	0.020	0.105	0.025	0.117	0.028	16,997
1982/83	842	0.150	0.012	0.176	0.017	0.195	0.020	37,731
1983/84	730	0.074	0.010	0.080	0.011	0.094	0.013	28,849
1984/85	1,175	0.046	0.006	0.048	0.007	0.052	0.007	21,188
1985/86	832	0.089	0.010	0.098	0.012	0.102	0.013	18,872
1986/87	1,333	0.049	0.006	0.051	0.007	0.056	0.007	19,567
1987/88	942	0.170	0.012	0.205	0.018	0.215	0.019	14,508
1988/89	879	0.321	0.016	0.472	0.034	0.569	0.042	18,206
1989/90	889	0.003	0.002	0.003	0.002	0.005	0.003	15,421
1990/91	963	0.106	0.010	0.118	0.012	0.119	0.012	12,550
1991/92	437	0.453	0.024	0.828	0.080	0.927	0.090	27,766
1992/93	2,232	0.003	0.001	0.003	0.001	0.005	0.002	13,097
1993/94	1,239	0.174	0.011	0.210	0.016	0.211	0.016	18,368
1994/95	954	0.096	0.010	0.107	0.012	0.129	0.014	17,959
1995/96	506	0.059	0.010	0.063	0.012	0.070	0.013	14,471
1996/97	636	0.088	0.011	0.097	0.014	0.103	0.015	8,326
1997/98	934	0.210	0.013	0.266	0.021	0.291	0.024	13,051
1998/99	737	0.041	0.007	0.042	0.008	0.054	0.010	13,313
1999/00	1,016	0.203	0.013	0.254	0.020	0.265	0.021	12,137
2000/01	381	0.068	0.013	0.073	0.015	0.092	0.019	6,801
2001/02	419	0.274	0.022	0.378	0.041	0.406	0.045	7,467
2002/03	402	0.149	0.018	0.175	0.025	0.242	0.034	6,418
2003/04	233	0.146	0.023	0.171	0.032	0.201	0.037	6,563
2004/05	156	0.218	0.033	0.279	0.054	0.326	0.064	.
2005/06	558	0.267	0.019	0.364	0.035	0.466	0.049	.

this far, with some stopping at the ephemeral wetlands of inland Australia (Alcorn *et al*. 1994). If conditions in the inland get really bad, as can happen, particularly after several years of drought, the results could be an exceptional influx of birds to coastal Victoria. Conversely, in years when the inland is in good condition, fewer birds could reach Victoria.

The population monitoring counts are assumed to be unbiased estimates of the numbers of birds present. Situations can occur when not all of the population is counted. For example, many birds can be missed if the counter is unfamiliar with how the birds use an area. This could occur initially when areas had been little studied, if a counter new to an area was used, or if weather on the scheduled count day was inclement. Even if all birds are counted, there will be statistical error associated with the count total. The size of this error is unknown but it is likely to be larger the higher the number of birds counted (see Rogers *et al*. 2006b). Means of improving the quality of population monitoring counts are discussed in Gosbell & Clemens (2006).

The demographic model estimates true annual survival rates of 85% for Red-necked Stint and 80% for Curlew Sandpiper. These are consistent with the estimates of apparent survival of 72% and 73% in that true survival cannot be less than apparent survival. The seven year period for which estimates were possible (Table 3) for Curlew Sandpiper, quite by chance, coincided with a period of higher than average recruitment (Fig. 3), a period in which PMP counts remained relatively stable (Fig. 4). The similarity of the results for the two species suggests that their survival rates and emigration were also similar at that time. There is no reason to suppose that conditions within Australia have changed for the two species, so the lower true survival rate estimate for Curlew Sandpipers may indicate an increase in adult mortality. The lower apparent survival rate in the year following banding for birds in their second year and older, independently confirmed (B. Dettmann pers. comm.), can be caused by greater emigration or higher mortality of these birds than of birds in their third year or older; either or both of these effects might occur. The non-juvenile sample contains birds in their second year which are indistinguishable from adults at the time when age proportion data are collected (Bamford *et al*. 2005). There is some evidence (KGR unpubl.) that lower apparent survival rates for Red-necked Stints in the year following banding do not occur every year but, when they do, they tend to be lower in the year following one of good recruitment. This suggests that the lower apparent survival in some years is due to higher mortality of birds in their second year making their first northward migration – breeding – return to Australia cycle or to their relocation to an area in Australia different from that from which they left. That the two species do not migrate together and have different breeding areas could account for differential mortality in second year birds.

Recruitment rate is not a true measure of breeding success. It is recruitment to the Australian non-breeding

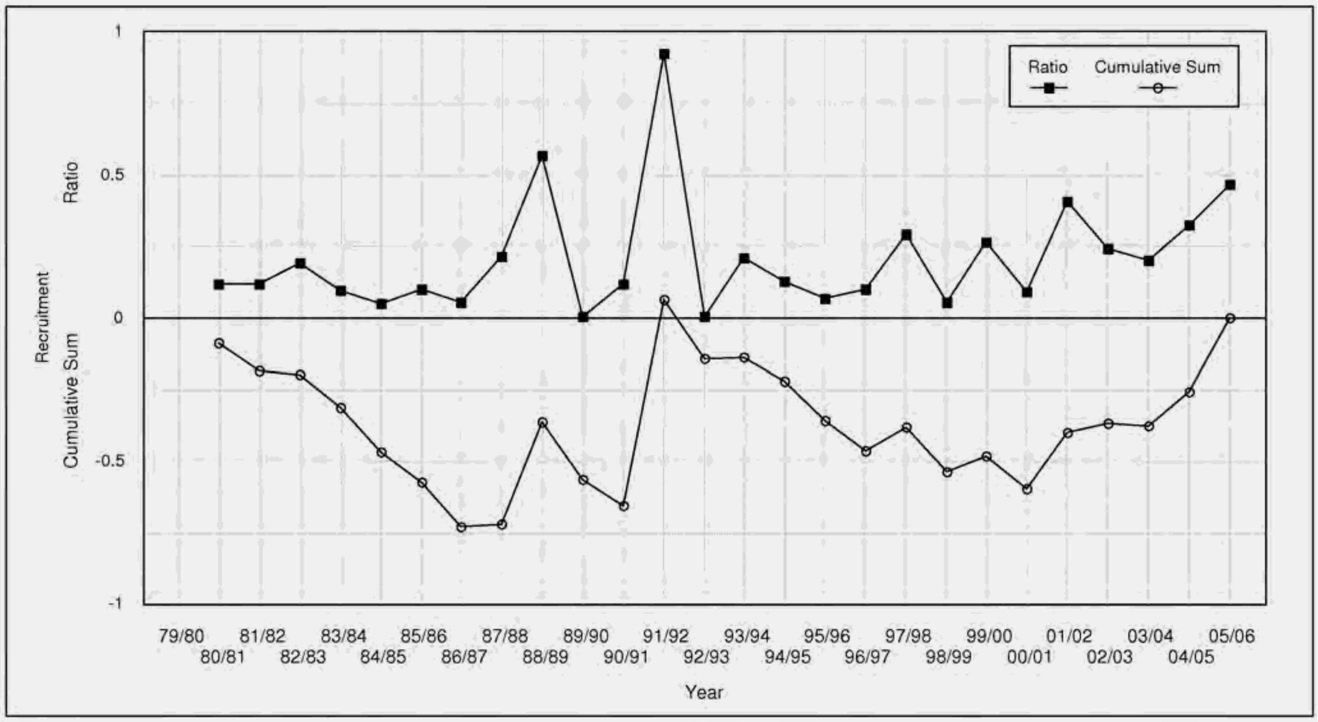

Figure 3. Curlew Sandpiper. Adjusted juvenile ratios. The upper figure shows the estimated ratios. The lower figure shows the cumulative sum relative to the long-term average of 0.209. By convention, the Australian wader year starts 1 August.

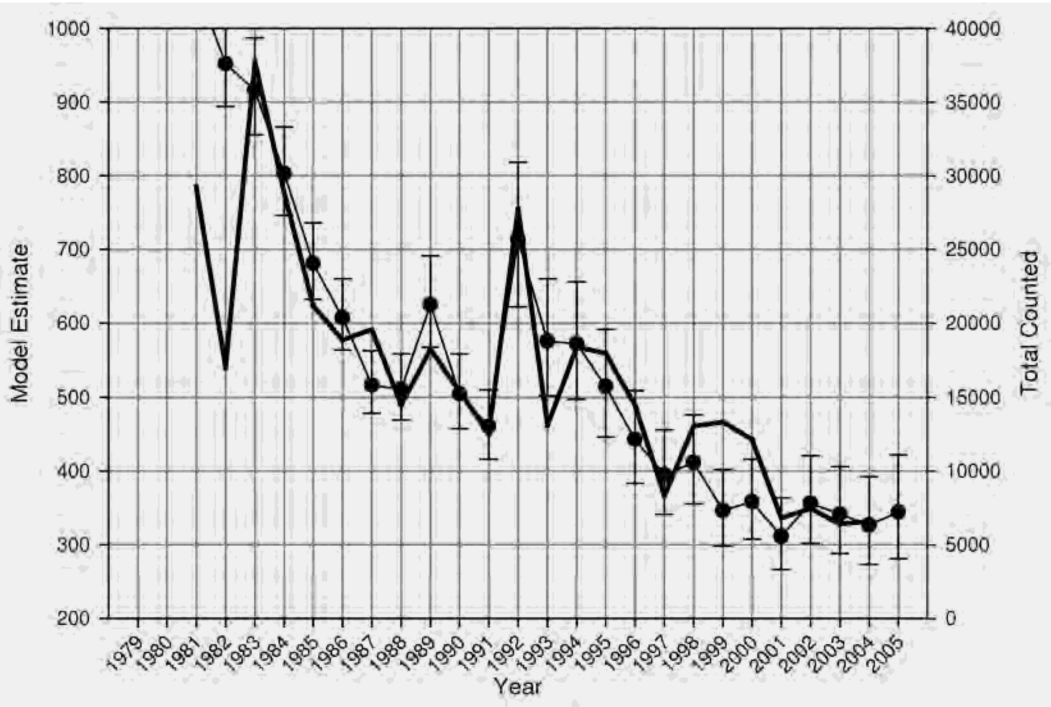

Figure 4. Curlew Sandpiper population projections. Thick lines are the Population Monitoring Program count totals; counts were in January of the year indicated. Thin lines are the model projections of this paper. The latter are made relative to an arbitrary starting population so ordinates have been normalised to illustrate the correlation between changes in the model and the counts. Error bars are 95% confidence limits. Data up to 1982 were not used in the calibration of the population model. This gave a correlation coefficient of 0.945 (N = 23) and a constant survival rate of 80.5%. Average recruitment rate was 0.2088.

Table 3. Demographic parameters. The Curlew Sandpiper sample analysed contained no juveniles

Parameter	Red-necked Stint		Curlew Sandpiper	
	Estimate	S.E.	Estimate	S.E.
Average Recruitment (%)	22.4		20.9	
True Survival Rate (%)	85.1	-	80.5	-
Apparent Survival Rate (%)				
1st Year	68.6	2.99	-	-
2nd Year and older in year after banding	63.7	1.63	39.9	7.72
3rd Year and older	72.3	0.49	73.1	3.69
Recapture Rate (%)				
1979/80	15.7	0.90	-	-
1980/81	15.4	0.85	-	-
1981/82	12.5	0.70	-	-
1982/83	11.9	0.70	-	-
1983/84	4.8	0.39	-	-
1984/85	8.9	0.61	-	-
1985/86	7.8	0.62	-	-
1986/87	18.1	0.99	-	-
1987/88	24.2	1.21	6.0	2.03
1988/89	20.6	0.89	3.8	1.42
1989/90	11.5	0.66	7.5	2.20
1990/91	27.3	1.18	12.9	3.01
1991/92	5.6	0.45	4.8	1.32
1992/93	22.9	1.17	11.5	2.94
1993/94	29.7	1.34	10.2	2.27

population. Many birds which fledge successfully will not survive to start their first southward migration, many more will not survive that migration, and there could well be further mortality in Australia before the November to March period over which juvenile proportions are estimated. It is of interest that the sum of true recruitment and average juvenile ratio is 107.5% for Red-necked Stint and 101.4% for Curlew Sandpiper. A total of 100% would ensure a stable population in a species which bred in its first year. For species which exhibit delayed maturity, a higher total is required to compensate for the lack of breeding in the first year. In this respect, the Red-necked Stint seems to be in a far more favourable position than does the Curlew Sandpiper.

This study has shown that annual variations in population monitoring counts can be explained by recruitment rate variations estimated from juvenile proportions measured in Australia. The acceptable fits on the two species considered validate the use of juvenile proportions as an index of recruitment and argue strongly for the continuance of the program, certainly for the species commonly caught. Cannon netting may not be the best method for monitoring juvenile proportions of species which are only caught in small numbers. Telescope ageing (Rogers *et al*. 2005) is a proven technique, which gives results consistent with cannon netting, but so far only attempted for three of the most common species. This may be the only realistic possibility for species which are less common or which cannot be caught in sufficient numbers to determine age proportions with acceptable precision.

For Curlew Sandpiper, the decline in numbers in Australia is most likely a consequence of a reduction in adult survival rates. Two considerations suggest this. First, true survival rates as estimated by this study are five percentage points lower for Curlew Sandpiper than for Red-necked Stint (Table 3). Secondly, population growth is more sensitive to changes in survival rate than to changes in recruitment. A 1% higher survival rate in conjunction with observed juvenile ratios would have led to a 27.2% increase in the population after 26 years. A 1% increase in all juvenile ratios, keeping survival rate constant, would have led to a 26 year population increase of only 3.8%. Another way of looking at this is to look at the increases required for the 26-year population to be the same as the starting one. This requires an annual survival rate increase of 5.8%, whereas an average recruitment rate increase of 38.2% is required to achieve the same end.

This study started off as a simple exercise to validate the monitoring of juvenile proportions as an index of breeding success. Figures 2 and 4 provided this validation. The paper went further when it showed the adjusted juvenile ratio, derived from the juvenile proportions, to be an unbiased estimate of recruitment to the Victorian population of Red-necked Stints and Curlew Sandpipers. The demographic model developed was calibrated by fitting annual population monitoring counts to annual population growth estimates. In so doing, it not only validated the population monitoring program, it also produced estimates of true survival rates, something not possible just using capture and recapture data. Examination of these rates in relation to estimates of apparent survival from 1985, and a sensitivity analysis, suggest that the decline in Curlew Sandpiper numbers is more likely to be a result of reduced adult survival than poor recruitment.

There is considerable scope for improving the model. It is based on some apparently very strong assumptions, the same survival rate for all age classes for example, which could benefit from more detailed testing and evaluation. Adding more parameters to the model would make calibration more difficult and require a more sophisticated estimation procedure than that used here. This could have the advantage of giving standard errors of estimated parameters but could stretch the data too thin if calibration of too many parameters is attempted. A further concern with the model is that imprecision in the PMP count totals is ignored because it is unknown; on-going work in this area (Rogers *et al*. 2006b) might inform on this.

The two species studied here have quite different histories. The Red-necked Stint appears to be in good shape with higher numbers present than at any time in the past. Even higher numbers are expected from the model and there is uncertainty as to the reason for the discrepancy. Also concerning are the very low recruitment rates for the last two years for which we have data. For Curlew Sandpiper the situation looks fairly grim. There would seem to be a long-term imbalance between recruitment and survival rates that has led to a long-term decline in numbers. The culprit is more likely to be adult survival rates than poor recruitment. The only good sign here is that the population, although low, has not declined in last six years of the study period.

The two most important lessons from this study are the absolute importance of both counting the numbers of birds present and monitoring both recruitment and survival. Monitoring without counting might be a stimulating intellectual exercise but is rather purposeless if there are no empirical facts to explain. Monitoring either survival or recruitment in the absence of the other can give no idea of how the population might be changing. This paper commented on the sum of true survival rate and recruitment rate. It begs two questions. What should this number be for a species to be viable? What number is the species achieving? Answering those questions is the challenge that confronts us all.

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ARE WE NEGLECTING THE NON-MIGRATORY SHOREBIRDS OF THE EAST ASIAN–AUSTRALASIAN FLYWAY?

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A recurrent debate within the Australasian Wader Study Group (AWSG) is whether resident (non-migratory) shorebirds are being neglected in favour of migratory species in terms of research and conservation efforts. This paper examines whether migrants have attracted a disproportionate research and conservation effort from the AWSG, by using articles published in *Stilt* as an index of effort. More articles (223 cf. 110) and more pages (912 cf. 267) have been dedicated specifically to migrants. Articles on migrants (4.3 ± 2.2 [mean ± standard deviation] pages) were longer than those on residents (2.5 ± 1.8 pages). These differences might reflect the fact that there are more migrants in the East Asian–Australasian Flyway since the ratio of migrant to resident species is 1.4:1 or 2:1 depending on which species are considered to use the flyway. Even when corrections are applied for this imbalance (for the 1.4:1 ratio only), a disproportionate number of pages and articles have still been devoted to migrants. Overall, it appears that there is a bias towards research and conservation effort on migratory species, with the cumulative magnitude of the bias to date equating to the number of pages in 3.8 average-length editions of *Stilt*. I speculate on some of the causes of the apparent bias.

INTRODUCTION

The Australasian Wader Studies Group (AWSG) has stimulated a good deal of research and conservation on many species of shorebirds in eastern Asia and Australasia. Both migratory and resident (non-migratory) shorebirds fall within the scope of the AWSG's mission and have attracted research and conservation attention from the group. While State-based wader study groups also exist, some of which are very active and productive, the AWSG is the pre-eminent national Australian shorebird study group. This 50th edition of *Stilt* stands testament to the success of the AWSG.

At various meetings of the AWSG over the last five or so years, there has been a lively debate about the differing amounts of research and conservation effort directed at resident and migratory species of shorebird. Specifically, it has been suggested that resident species are being neglected in favour of migratory species. There is some evidence for this view. Piersma *et al.* (1997) reviewed the state of knowledge of plovers and sandpipers of the world, and noted that species with restricted distributions were poorly known in many areas. If only regular Australian species are considered (after Priest *et al.* 2002), then all resident species were classified by Piersma *et al.* (1997) as 'not or poorly studied', 'little studied' or they had received 'some study'. While most regular Australian migrants (68.6%) also fell into the same categories, the remaining 31.4% were regarded as 'well', 'very well' or 'extensively' studied (Figure 1). Clearly, migrants have broad distributions which overlap with more investigators, and many of the studies reviewed by Piersma *et al.* (1997) were not conducted in Australia, or indeed, on populations which visit Australia. Nevertheless, the overall global state of knowledge at the species level seems somewhat higher for Australian migrants over residents, albeit in the context that most species were understudied.

If residents are not receiving research attention, then this is of particular concern because resident shorebirds appear to be more threatened in terms of international conservation status. While 19 species that regularly use the East Asian–Australasian Flyway (EAAF) are considered Globally Threatened, only four of these species are migratory (Milton *et al.* 2005). It is also possible that resident shorebirds may be more effective as bioindicators in Australia, because they possibly occupy a wider range of habitats and a greater geographical range.

This paper examines the question as to whether there has been a bias in effort toward migratory species of shorebirds by the AWSG. It is hoped that this paper will either put the matter to rest, or flag a group of shorebirds that might deserve more attention in the next 25 years. In doing so, it is hoped this paper can flag research opportunities, whether it be for the AWSG or for other workers.

METHODS

The general approach I have used is to:

1. determine the ratio of migratory to resident species within the EAAF by: (i) defining the EAAF, (ii) determining which shorebirds occur within the EAAF, and (iii) assigning a movement status to those species;
2. quantify the research and conservation effort which has been directed towards resident and migratory shorebirds by: (i) examining published articles in *Stilt* and (ii) where possible classifying them with respect to their subject matter; and
3. compare the actual representation of resident versus migratory shorebirds in EAAF (Step 1) with the effort directed at them (Step 2). Such a comparison should reveal whether any bias exists (either towards residents or migrants).

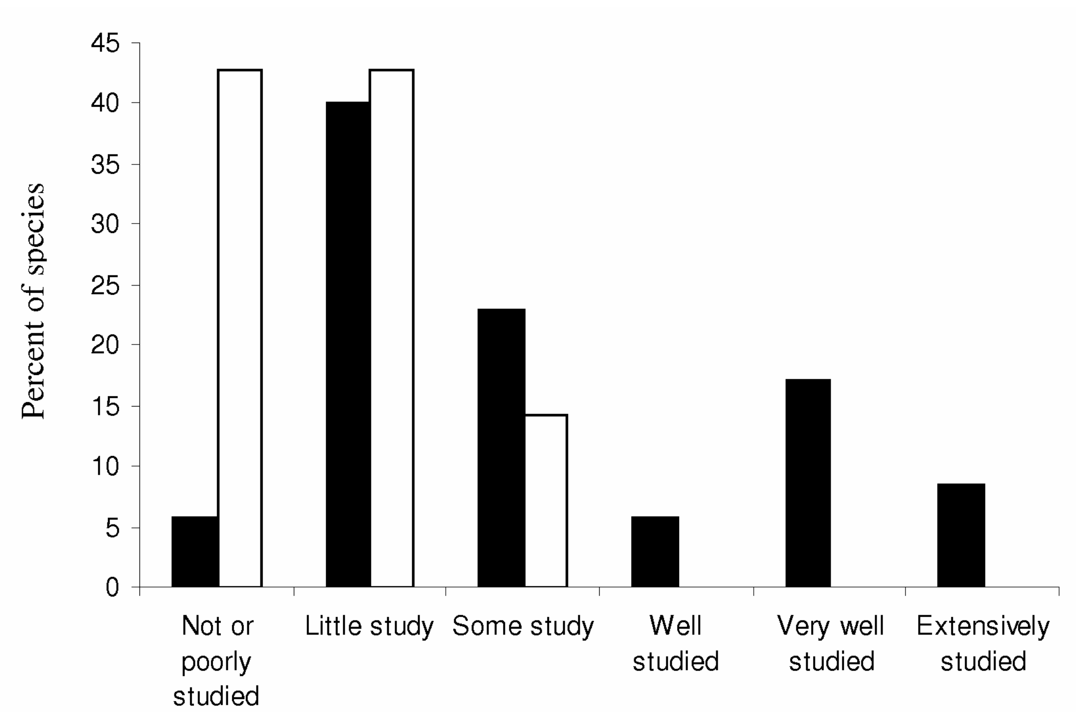

Figure 1. The percentage of plover and sandpiper species that regularly occur in Australia (after Priest *et al.* 2002) classified according to how well studied they are (after Piersma *et al.* 1997). Migrants are shown as black bars (n=35) and residents (n=7) as open bars.

The approach used is described in more detail below, and relies on a series of assumptions, which are also documented below.

Assumptions

My analysis and approach is based on a number of assumptions. It assumes:

- That the pre-1981 (i.e. pre-AWSG) state of knowledge on residents and migrants was equivalent and poor.
- That there has been no significant enhancement in the knowledge of residents or migrants, published elsewhere, which may have influenced the opportunity or perceived need to publish on either residents or migrants.
- That residents and migrants require similar research and conservation effort per species. It is possible that species with more complex life cycles or ecologies may legitimately require more research effort to reach an adequate state of knowledge. However, it cannot be argued that migrants necessarily have a more complex life cycle compared with residents, many of which are nomadic and some of which exploit the most unpredictable and ephemeral of habitats.
- That the activities of the AWSG are independent of other shorebird study groups (unlikely) or at least that the activities of those groups are either 1) not overly influential on AWSG activities or 2) are themselves not biased between migrants and residents. An analysis of State wader study group bulletins would be interesting, but is beyond the scope of this paper.

The ratio of resident to migratory species within the EAAF

Defining the East Asian–Australasian Flyway

Flyways are relatively arbitrary with respect to their boundaries, both because of poor knowledge of actual migration routes and because it appears that flyways overlap with one another. Here, I use the definition of EAAF provided in Howes and Bakewell (1989), although I also include Alaska which is in their written description but not their diagram. This definition contains countries east of *c.* 85°E, and west of the Pacific rim (*c.* 140–160°E). I define the flyway according to Table 1, although several countries which I have excluded (New Caledonia and eastern India) are close to the margins of the flyway and may in some instances be included in the flyway by other workers.

Determining which shorebirds occur within the East Asian–Australasian Flyway

I derived the list of shorebirds in the EAAF, and used the distributional maps, taxonomy, taxonomic order and nomenclature, of Hayman *et al.* (1986). I exclude the hybrid, Cox's Sandpiper *Calidris paramelanotos* and other Chardriiformes which are generally not considered shorebirds by Hayman *et al.* (sheathbills, gulls and terns). I treated the Plains Wanderer *Pedionomus torquatus* as a shorebird and have added it to Hayman *et al.*'s list (after Christidis and Boles 1994), and I have accepted the Australian Painted Snipe *Rostratula australis* as a full species (after Lane and Rogers 2000).

Table 1. Countries regarded as being within the East Asian - Australasian Flyway (after Howes and Bakewell 1989). Countries are listed roughly in order from north to south.

Country	Qualifier
USA (Alaska)	Western part
Russia	East of c. 120°E
Mongolia	All
China*	All
Japan	All
North Korea	All
South Korea	All
Burma	All
Vietnam	All
Laos	All
Thailand	All
Philippines	All
Cambodia	All
Malaysia	All
Indonesia	All
Papua New Guinea	All
Timor Leste	All
Australia	All
New Zealand	All

* Including Taiwan and Hong Kong

Assigning a movement status to shorebirds in the East Asian–Australasian Flyway

The categorisation of species into movement patterns is not precise. There are great variations within the traditional categories of 'sedentary', 'resident', 'nomadic', and 'migratory' (see, for example, Marchant and Higgins 1993). 'Resident' is defined as breeding more or less throughout the range, and rarely moving regularly between countries. 'Migratory' is defined as more or less regular movements involving distinct breeding and non-breeding parts of the range. Another common element to the definition of 'migratory' is that movements are relatively long-distance, and I have arbitrarily defined migratory movements as being international. Although this is a common concept it is problematic given that countries are different sizes, and that political boundaries are irrelevant to bird movements. Thus, Wrybill *Anarhynchus frontalis* are considered 'resident' even though they are migrants within New Zealand. Nevertheless, my application of the terms 'resident' and 'migratory' reflect their generally accepted use, and closely follow the definitions of Marchant and Higgins (1993).

Quantifying research and conservation effort

Stilt is the biannual bulletin of the AWSG, and its cover carries the line "The bulletin of the East Asian–Australasian Flyway". It is the main publication produced by the group, the only other regular publication being the newsletter *Tattler*. Thus, I assume that *Stilt* is reflective of AWSG activities, and it was used as the primary information source for this paper (49 volumes were available for analysis).

Each volume of *Stilt*, 1–49, was assessed for its content using the index (volumes 2–45, and 47–49) or a page by page check (volumes 1 and 46[1]). Thus, classification of articles was based on titles. Articles, regardless of their type (Report, Short Communication, Paper etc.), were classified as either 1) focussing on migratory species, 2) focussing on resident species or 3) focussing on a combination of migratory and resident species. Book reviews were excluded, as were articles specifically dealing with species which I had not defined as shorebirds e.g. terns. I also excluded one article from volume 12 because it focused on the hybrid Cox's Sandpiper, and one from volume 25 because its subject matter was outside EAAF. The number of articles, and the number of pages upon which the articles were printed, were summed for each volume. Some subjectivity was required because articles were not always clearly bounded (i.e. were not clearly separated one from the other), especially in earlier volumes. Obscure titles also caused some difficulty with assigning some articles to the categories.

While the vast majority of AWSG research outcomes are published in *Stilt*, there are some exceptions, most notably proceedings of conferences (e.g. Straw 2005). Additionally, I acknowledge that *Stilt* does not exclusively publish the results of AWSG activities, rather it is available to authors from throughout EAAF, whether they are AWSG members or not. Finally, I am unaware of any deliberate editorial policy which may have biased the results of this investigation, certainly none have been evident among the editors I consulted (K. Rogers, D. Milton and J. Campbell pers. comms and pers. obs.) and no particular policy is evident in the instructions to authors. While it is possible that the use of the word "Flyway" on the cover of the bulletin, and in the instructions to authors, has encouraged material on migrants, I doubt the effect of such word use is significant.

RESULTS

Table 2 lists those species that clearly occur within the EAAF. Species close to the margins but which I excluded are: Indian Courser *Cursorius coromandelicus*, Yellow-wattled Lapwing *Vanellus malabaricus*, Killdeer *Charadrius vociferous* and Greater Yellowlegs *Tringa melanoleuca*.

My analysis of shorebirds in the EAAF was based on normal geographical distributions of species as mapped in Hayman *et al.* (1986), and so excludes vagrants. The number of shorebirds in the Hayman *et al.* (1986) list, and adding the Plains Wanderer and Australian Painted Snipe, totals 216 species. Of these, 118 (55%) occur within the EAAF; 78 are migratory and 40 are resident. Thus, there are about two migratory species for every resident species. However, this includes a suite of migrants that breed in Alaska and do not migrate within EAAF. If only those migrants which move or reside within the flyway are considered (97 species), then the ratio of migrants to residents is about 1.4 to 1 (Table 3). This is the most appropriate ratio of migrants to residents to use for EAAF. However, *Stilt* is dominated by Australian

[1] The printing of the index on the back page of *Stilt* 46 failed but a correctly printed loose-leaf contents page was distributed (K. Rogers pers. comm.).

Table 2. The movement status of shorebirds which occur in the East Asian - Australasian Flyway. Taxonomy, nomenclature and order follow Hayman *et al.* (1986), although Plains Wanderer has been added (after Christidis and Boles 1994) and Australian Painted Snipe has been treated as a full species (after Lane and Rogers 2000).

Species	**Movement Status**	**Migratory within EAAF?**
Plains Wanderer *Pedionomus torquatus*	Resident	
Pheasant-tailed Jacana *Hydrophasianus chirurgus*	Migratory	Yes
Bronze-winged Jacana *Metopidius indicus*	Resident	
Comb-crested Jacana *Irediparra gallinacean*	Resident	
Painted Snipe *Rostratula benghalensis*	Resident	
Australian Painted Snipe *Rostratula australis*	Resident	
Eurasian Oystercatcher *Haematopus ostralegus*	Migratory	Yes
American Black Oystercatcher *Haematopus bachmani*	Resident	
Variable Oystercatcher *Haematopus unicolour*	Resident	
Chatham Island Oystercatcher *Haematopus chathamensis*	Resident	
Pied Oystercatcher *Haematopus longirostris*	Resident	
Sooty Oystercatcher *Haematopus fuliginosus*	Resident	
Crab Plover *Dromas ardeola*	Resident	
Ibisbill *Ibidorhyncha struthersii*	Resident	
Black-winged Stilt *Himatopus himantopus*	Resident	
Black Stilt *Himantopus novaezelandiae*	Resident	
Banded Stilt *Cladorhynchus leucopcephalus*	Resident	
Red-necked Avocet *Recurvirostra Americana*	Resident	
Stone-curlew *Burhinus oedicnemus*	Migratory	No
Bush Thick-knee *Burhinus magnirostris*	Resident	
Great Thick-knee *Esacus recurvirostris*	Resident	
Beach Thick-knee *Esacus magnirostris*	Resident	
Australian Pratincole *Stiltia Isabella*	Migratory	Yes
Oriental Pratincole *Glareola maldivarum*	Migratory	Yes
Little Pratincole *Glareola lactea*	Resident	
Northern Lapwing *Vanellus vanellus*	Migratory	Yes
Grey-headed Lapwing *Vanellus cinereus*	Migratory	Yes
River Lapwing *Vanellus duvaucelii*	Resident	
Red-wattled Lapwing *Vanellus indicus*	Resident	
Javanese Wattled Lapwing *Vanellus macropterus*	Resident	
Banded Lapwing *Vanellus tricolour*	Resident	
Masked Lapwing *Vanellus miles*	Resident	
Grey Plover *Pluvialis squatarola*	Migratory	Yes
Pacific Golden Plover *Pluvialis fulva*	Migratory	Yes
American Golden Plover *Pluvialis dominica*	Migratory	No
Ringed Plover *Charadrius hiaticula*	Migratory	No
Semipalmated Plover *Charadrius semipalmatus*	Migratory	No
Long-billed Plover *Charadrius placidus*	Migratory	Yes
Little-ringed Plover *Charadrius dubious*	Migratory	Yes
Malaysian Plover *Charadrius peronii*	Resident	
Kentish Plover *Charadrius alexandrinus*	Migratory	Yes
Lesser Sandplover *Charadrius mongolus*	Migratory	Yes
Greater Sandplover *Charadrius leschenaultia*	Migratory	Yes
Oriental Plover *Charadrius veredus*	Migratory	Yes
Eurasian Dotterel *Eudromias morinellus*	Migratory	No
Red-capped Plover *Charadrius ruficapillus*	Resident	
Double-banded Plover *Charadrius bicinctus*	Migratory	Yes
Black-fronted Plover *Charadrius melanops*	Resident	
Red-kneed Dotterel *Charadrius cinctus*	Resident	
Hooded Plover *Charadrius rubricollis*	Resident	
Inland Dotterel *Peltohyas Australia*	Resident	
New Zealand Dotterel *Charadrius obscurus*	Resident	
Shore Plover *Thinornis novaeseelandiae*	Resident	
Wrybill *Anarhynchus frontalis*	Resident	
Black-tailed Godwit *Limosa limosa*	Migratory	Yes
Hudsonian Godwit *Limosa haemastica*	Migratory	No
Bar-tailed Godwit *Limosa lapponica*	Migratory	Yes
Asiatic Dowitcher *Limnodromus semipalmatus*	Migratory	Yes
Little Curlew *Numenius minutes*	Migratory	Yes
Whimbrel *Numenius phaeopus*	Migratory	Yes
Bristle-thighed Curlew *Numenius tahitiensis*	Migratory	No
Eurasian Curlew *Numenius arquata*	Migratory	Yes
Far Eastern Curlew *Numenius madagascariensis*	Migratory	Yes

Continued …

Table 2 (Continued). The movement status of shorebirds which occur in the East Asian - Australasian Flyway. Taxonomy, nomenclature and order follow Hayman *et al.* (1986), although Plains Wanderer has been added (after Christidis and Boles 1994) and Australian Painted Snipe has been treated as a full species (after Lane and Rogers 2000).

Species	Movement Status	Migratory within EAAF?
Spotted Redshank *Tringa erythropus*	Migratory	Yes
Redshank *Tringa totanus*	Migratory	Yes
Greenshank *Tringa nebularia*	Migratory	Yes
Marsh Sandpiper *Tringa stagnatilis*	Migratory	Yes
Spotted Greenshank *Tringa guttifer*	Migratory	Yes
Lesser Yellowlegs *Tringa flavipes*	Migratory	No
Green Sandpiper *Tringa ochropus*	Migratory	Yes
Solitary Sandpiper *Tringa solitaria*	Migratory	No
Wood Sandpiper *Tringa glareola*	Migratory	Yes
Terek Sandpiper *Xenus cinereus*	Migratory	Yes
Common Sandpiper *Actitis hypoleucos*	Migratory	Yes
Spotted Sandpiper *Actitis macularia*	Migratory	No
Wandering Tattler *Heteroscelus incanus*	Migratory	Yes (?)
Grey-tailed tattler *Heteroscelus brevipes*	Migratory	Yes
Ruddy Turnstone *Arenaria interpres*	Migratory	Yes
Black Turnstone *Arenaria melanocephala*	Migratory	No
Surfbird *Aphriza virgata*	Migratory	No
Red-necked Phalarope *Phalaropus lobatus*	Migratory	Yes
Grey Phalarope *Phalaropus fulicarius*	Migratory	No
Eurasian Woodcock *Scolopax rusticola*	Migratory	Yes
Amami Woodcock *Scolopax mira*	Resident	
Dusky Woodcock *Scolopax saturate*	Resident	
Celebes Woodcock *Scolopax celebensis*	Resident	
Obi Woodcock *Scolopax rochussenii*	Resident	
New Zealand Snipe *Coenocorypha aucklandica*	Resident	
Chatham Islands Snipe *Coenocorypha pusilla*	Resident	
Wood Snipe *Gallinago nemoricola*	Migratory	Yes
Pintail Snipe *Gallinago stenura*	Migratory	Yes
Common Snipe *Gallinago gallinago*	Migratory	Yes
Jack Snipe *Lymnocryptes minimus*	Migratory	Yes
Solitary Snipe *Gallinago solitaria*	Migratory (?)	Yes
Japanese Snipe *Gallinago hardwickii*	Migratory	Yes
Swinhoe’s Snipe *Gallinago megala*	Migratory	Yes
Short-billed Dowitcher *Limnodromus griseus*	Migratory	No
Long-billed Dowitcher *Limnodromus scolopaceus*	Migratory	No
Red Knot *Calidris canutus*	Migratory	Yes
Great Knot *Calidris tenuirostris*	Migratory	Yes
Sanderling *Calidris alba*	Migratory	Yes
Spoon-billed Sandpiper *Eurynorhynchus pygmaeus*	Migratory	Yes
Western Sandpiper *Calidris mauri*	Migratory	No
Semipalmated Sandpiper *Calidris pusilla*	Migratory	No
Red-necked Stint *Calidris ruficollis*	Migratory	Yes
Little Stint *Calidris minuta*	Migratory	No
Temminck’s Stint *Calidris temminckii*	Migratory	Yes
Broad-billed Sandpiper *Limnicola falcinellus*	Migratory	Yes
Long-toed Stint *Calidris subminuta*	Migratory	Yes
Least Sandpiper *Calidris minutilla*	Migratory	No
Baird’s Sandpiper *Calidris bairdii*	Migratory	No
Pectoral Sandpiper *Calidris melanotos*	Migratory	Yes
Sharp-tailed Sandpiper *Calidris acuminata*	Migratory	Yes
Rock Sandpiper *Calidris ptilocnemis*	Migratory	Yes
Dunlin *Calidris alpina*	Migratory	Yes
Curlew Sandpiper *Calidris ferruginea*	Migratory	Yes
Buff-breasted Sandpiper *Tryngites subruficollis*	Migratory	No
Ruff *Philomachus pugnax*	Migratory	Yes

Table 3. The number of migratory and resident shorebirds in EAAF, and those that occur regularly in Australia.

Data	Number of migratory species	Number of resident species	Ratio of migrants to resident
EAAF	78	40	1.950:1
EAAF excluding Alaska	57	40	1.425:1
Australia*	36	18	2.000:1

* After Priest *et al.* (2002).

content, and the ratio of regular migrants to residents in Australia is also close to 2 to 1 (see Table 3). Thus, for the purposes of analysis I used both ratios (1.4:1 and 2:1).

The categorisation of articles in *Stilt* located 333 articles which could be assigned specifically to either migratory or resident shorebirds. Of these 67.0% and 33.0% dealt with migratory and resident shorebirds respectively. A total of 1179 pages (42.0% of 2805 pages) held material specific to either migrants or residents; of these 77.4% held material specific to migrants and 22.6% held material specific to residents. Overall, 69.4% of volumes of *Stilt* carried more articles and 83.7% of volumes carried more pages on migrants (12.2% and 8.2% of volumes had the same number of articles and pages respectively, on migrants and residents). Thus, only 18.4% of volumes had more articles, and 8.2% had more pages, on residents.

It is possible that these patterns may have varied over time. Figure 2A shows the percentage of all articles which are specific to migrants or residents in each volume. Articles on migrants have dominated apart from the period from the late 1980s to the mid-1990s. Figure 2B shows the percentage of pages in each volume that contained specific material on

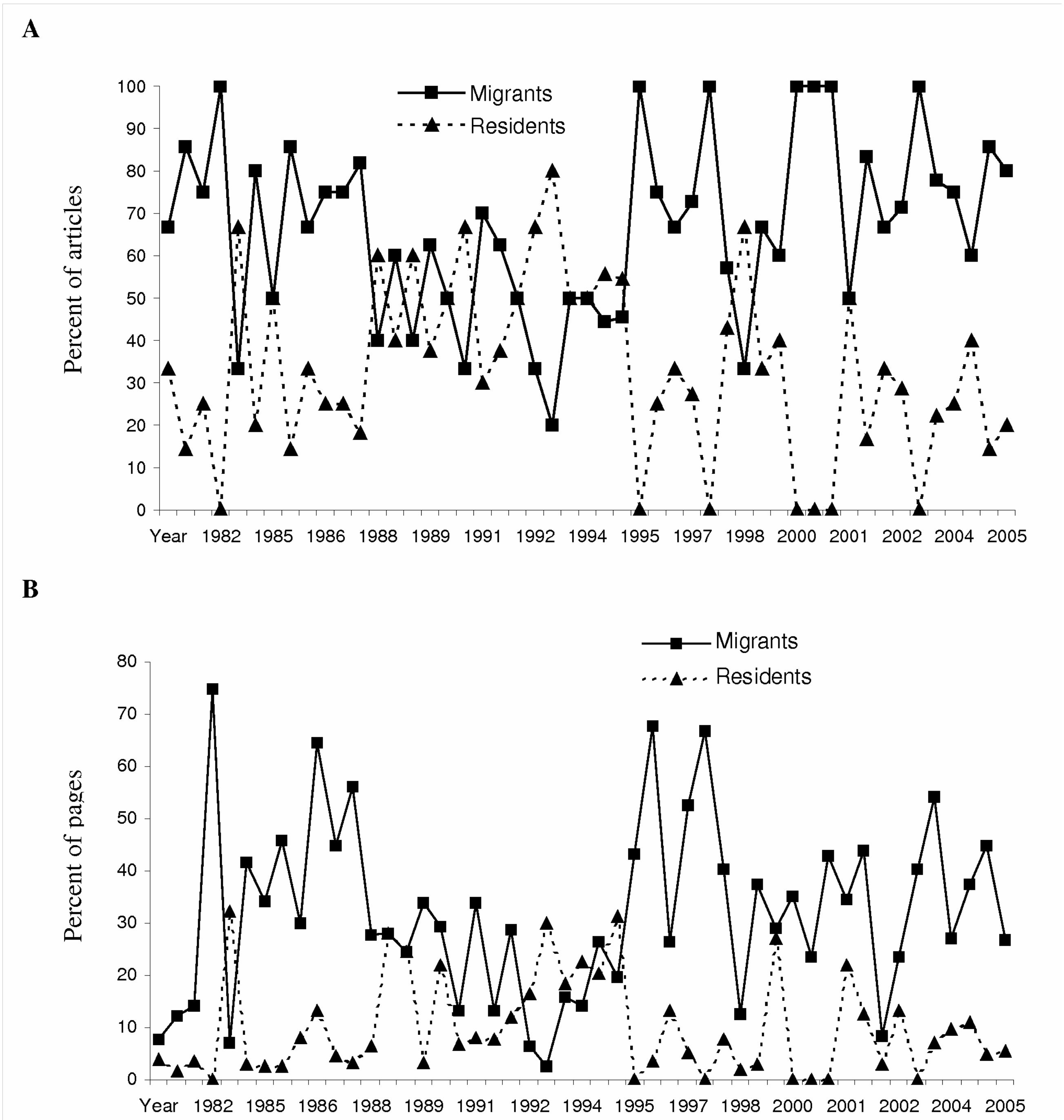

Figure 2. For those article which were specific to migrants or residents, (A) the percentage of articles, and (B) the percentage of all pages containing material specific to migratory and resident shorebirds published in *Stilt*, 1981-2006.

migrants and residents. A similar pattern is evident, with the percentage of pages on residents and migrants being roughly similar in the period from the late 1980s to the mid-1990s, while the percentage of pages devoted to migrants was generally higher than that devoted to residents during other times.

On average, volumes contained more articles and pages, and articles were longer, for migrants compared with residents (Table 4). It should be noted that the measures analysed were not independent. For migrants, for example, Spearman rank correlation coefficients (r) were: 0.573 between the number of pages and the average length of articles; and 0.704 between the number of articles and the number of pages.

While it is clear that migrants have been the subject of more articles, which occupied more pages, and were on average longer than those articles on residents, the question as to whether there is a bias requires further investigation because there are simply more migrants than there are residents in EAAF (see Table 3) and this could explain the differences. Table 5 compares the numbers of articles and pages that would be expected if there were no bias, with the actual number of articles which have been published. There is a clear bias towards the number of pages devoted to migrants regardless of the ratio of migrants to residents used. For the number of articles, there is a statistically significant bias towards migrants for the 1.4:1 ratio of migrants to residents, but not for the 2:1 ratio. Thus, indications of bias towards migrants are evident when the imbalance in the number of species has been accounted for statistically.

DISCUSSION

The AWSG has a long and prominent history of contributing to the knowledge of all shorebird species, both migrants and residents, in the East Asian–Australasian Flyway. In view of the limited knowledge we have of shorebird biology and given the threats that many of these species face, it is clear that we need more research and conservation effort on all shorebirds, including migrants. This paper is intended to aid planning for future efforts, and to highlight research opportunities to other workers who may wish to study shorebirds in Australia, by identifying apparent biases in the research and reporting of studies between migrant and resident shorebird species.

Has there been a bias?

Stilt has devoted more pages and articles to migrants than to residents. Whether or not this represents bias depends on the ratio of migratory to resident shorebird species used. The 1.4:1 ratio is arguably the most appropriate given that *Stilt* is the bulletin of EAAF, and that a number of Alaskan shorebirds do not really use EAAF but occur within a small part of it (a part of the flyway typically excluded from many flyway maps). On this basis, there is a bias in the number of articles published such that more articles are published per migrant than per resident species. The result with respect to the number of pages devoted to migrants and residents is even clearer; there is a bias towards more pages being devoted specifically to migratory species, regardless of the ratio of migrants to residents assumed.

One surprising result was that articles on migrants tended to be longer than those on residents. It is not clear why this is the case, though with a relatively small pool of authors, some of whom effectively specialise in either migrants or residents, the difference could simply reflect different writing styles among a small number of authors.

How large is the bias?

Residents have had up to 27 fewer articles and 219 fewer pages devoted to them than expected under the scenario that no bias existed (at the 1.4:1 ratio of migrants to residents). At the average numbers of pages in an edition of *Stilt* to date (57.2 ± 15.7 pages; 24–92), this equates to 3.8 editions.

Table 4. Comparisons of the number of articles, number of pages, and length of articles on migratory and resident shorebirds published in *Stilt*.

Measure	Migrants	Residents	Statistical comparison
Number of articles	4.6 ± 2.2 (1-9)	2.2 ± 1.6 (0-6)	Wilcoxon Z = -4.563, p < 0.001
Number of pages	18.6 ± 10.7 (1-40)	5.4 ± 5.2 (0-20)	Wilcoxon Z = -5.240, p < 0.001
Length of article (number of pages)	4.3 ± 2.2 (1-11)	2.5 ± 1.8 (0.5-8)	Wilcoxon Z = -3.629, p < 0.001

Table 5. The expected number of articles and pages under the scenario that there is no bias versus the actual number published on migrants and residents, for the ratios of 1.4:1 and 2:1 migrants to residents (M:R). Chi-squared tests involve one degree of freedom. N.B. Expected values are calculated using the exact ratios from Table 3. For convenience, these are referred to throughout the text as the rounded values 1.4:1 and 2:1.

Item	Number	Expected M:R ratio	Observed M:R ratio	Chi-square	Probability
Articles	333	1.4:1	2.027:1	9.25	<0.01
Pages	1179	1.4:1	3.416:1	168.16	<0.01
Articles	333	2:1	2.027:1	0.01	0.91
Pages	1179	2:1	3.416:1	60.60	<0.01

Thus, 80.1% of expected articles and 54.9% of expected pages on residents have actually been published, respectively. Even if it is assumed there are two migrants for every resident species in EAAF, only 67.9% of expected pages dedicated to residents have actually been published. Thus, for the number of pages, the bias seems to be substantial.

The above calculations do not account for changes in layout or font size that could affect the number of words, or the amount of tabulated information, per page. The font size has not remained constant, and a relatively recent change has seen roughly 20% more words per page (K. Rogers in litt.). There was also a change from one column (volumes 1–9) to two columns of text (volumes 10 onwards). It is not thought that adjustment for these effects would lead to substantial change in the estimates given above.

Why is there a bias?

The way in which research and conservation efforts are allocated across taxa is poorly understood in general. Allocations could be made on the basis of needs (e.g. perceptions of threat) or opportunities (e.g. gaps in research knowledge or suitable, accessible study sites). Rarely are needs or opportunities critically assessed (but see Milton *et al.* 2005), rather they are based on perceptions, which generally reflect expert opinion and the best available information. Additionally, human motivational factors are likely to play a major role, particularly where volunteers make the major contribution (see Weston *et al.* 2003, Weston *et al*. 2006).

This study does not directly address the causes of the bias it has uncovered, but possible causes include:

- The extensive movements of migrants mean they occur in more countries and are accessible to more researchers than residents. It seems likely that there are more species of migrants than residents in most or all countries within EAAF.
- The migrations undertaken by trans-equatorial, long-distance migratory shorebirds inspire many novices and researchers, apparently more than the fascinating breeding strategies of residents.
- On average, migrants may aggregate more frequently, and in higher numbers, making them easier to study.
- Migrants appear to be less geographically widespread in Australia than residents (Figure 3). Many concentrations of migrants occur in coastal Australia where the bulk of the human population occurs (Yapp 1986). Exceptions include species which concentrate in the north. Migrants may also more often use habitat that is accessible to counters and researchers, though again there are exceptions, such as the Little Curlew which occurs in extensive tracts of remote grassland.
- The AWSG is a relatively small group, with about 300 members. A proportion of the membership is active, and only a fraction has assumed responsibility for running activities and engaging in the strategic direction of the group. The interests of a small number of people therefore have the potential to influence the activities of the group.

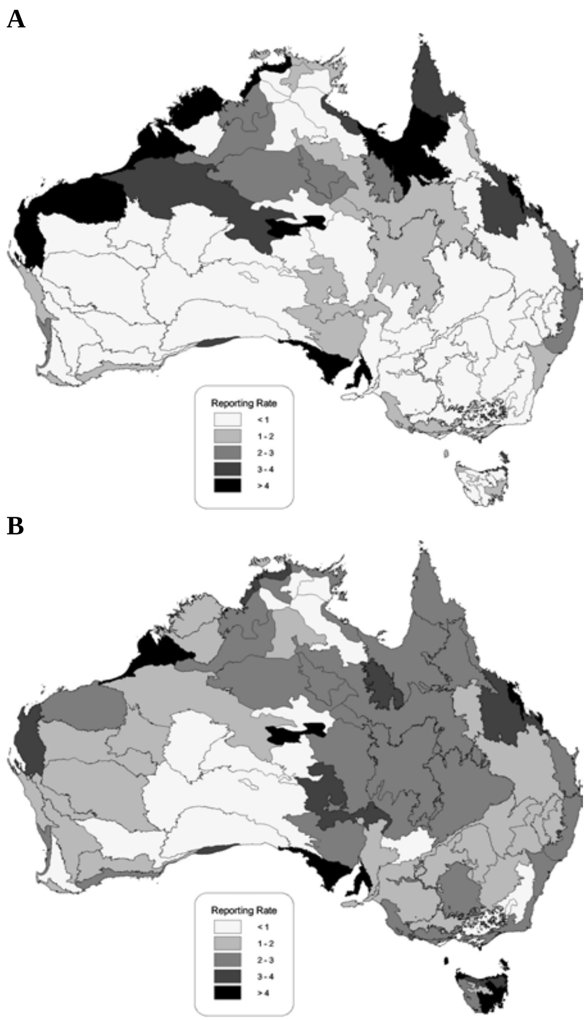

Figure 3. The percentage of all New Atlas of Australian Bird records (1998 to present) which were (A) migratory shorebirds (October to February) and (B) resident shorebirds. The areas shown are IBRA (Interim Biogeographic Regionalisation of Australia) regions. Reporting rates are the percentage of surveys that report shorebirds. Data were provided by Birds Australia.

- It is possible that research on resident species lends itself to more individualistic investigators, while migrants more frequently require the human resources that the AWSG can offer. For example, nest watches require very different human resources, and skills, to those required for cannon-netting teams!
- The Australian Government, which has responsibility for migratory shorebirds (e.g. under national legislation [the Environment Protection and Biodiversity Conservation Act], international agreements [e.g. the Japan and China Migratory Bird Agreements]), and has been a major supporter and funder of the AWSG (for example, through the Natural Heritage Trust). The State Governments, which have additional responsibilities for resident shorebirds (though the Australian Government plays a leading role for threatened residents, such as Australian Painted Snipe), have not been as prominent as a source of funding. There are exceptions (e.g. the South Australian Department of Environment and

Heritage which has supported the Coorong Project). This may be partly because States have tended to support the state wader study groups instead of the national group, and that there is effectively a demarcation between regional groups which focus on residents and the national group which focuses on migrants. It could be regional groups are less inclined to publish in *Stilt*.

The AWSG has attempted to initiate specific projects on resident waders (Thomas 1988), and has enthusiastically maintained ongoing projects on resident species, such as the Hooded Plover and Pied Oystercatcher counts. Thus, I suggest any such bias has been deliberately minimised by the leadership of the AWSG. In many ways, the causes of bias are irrelevant as we look to the future. Whether the bias is 'corrected' or not, the next 50 editions of *Stilt* will see a wealth of study on both resident and migratory shorebirds. An analysis similar to the one presented here, but involving 100 editions of *Stilt*, will be an interesting exercise for future authors.

ACKNOWLEDGEMENTS

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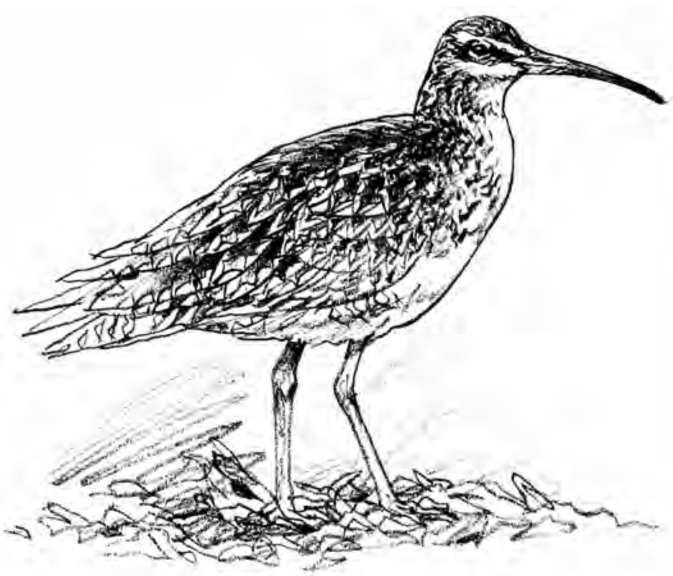

THE HISTORY OF WADER STUDIES IN NORTH-WEST AUSTRALIA

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Background

The Australasian Wader Studies Group (AWSG) was formed following a meeting in mid-1980 in Melbourne organised by Norman Wettenhall, who was then president of the RAOU (now Birds Australia). It was attended by representatives from all the states and other individuals and organisations interested in wader studies in Australia. It was decided that the initial priorities of the AWSG would be to organise a comprehensive census of waders throughout coastal and inland Australia and to encourage more widespread banding activities. Funding for a count coordinator for a five-year program was obtained from the federal government and John Martindale was appointed to this position.

Whilst it was relatively straightforward to organise comprehensive counts in areas close to centres of population the task of counting wader populations in the remote and often extremely inaccessible areas of northern Australia was obviously much more difficult. Aerial surveillance was clearly necessary for many areas. Good on-ground accessibility is however a prerequisite for banding activities wherever in Australia they are conducted.

Major fieldwork in northern Australia started when two light planes set off from Melbourne on 21 August 1981. Over the next few days they carried out a low-level survey of the southern half of the Gulf of Carpentaria. After then attending an RAOU (now Birds Australia) conference in Katherine, Northern Territory, two members of the team went to Darwin and from where they carried out further aerial survey work (from a Commonwealth Coastal Surveillance aircraft) along the coast to Derby in the northern part of Western Australia. The two light aircraft flew direct from Katherine to Broome where the team met up again on 27 August. Two vehicles carrying additional personnel and equipment from Melbourne and Perth also joined the team.

The Start

It had been decided that the Roebuck Bay, Broome and Eighty Mile Beach areas of north-west Australia were the most appropriate places to start detailed counts and banding in the northern half of Australia (Fig. 1). This was because another RAOU research team had in 1980 seen very large numbers of waders at both locations and had advised that ground accessibility was good.

An initial aerial survey of Roebuck Bay and the whole of the coast down to the southern end of Eighty Mile Beach took place on 28 August. Over the next seven years almost all wader study visits to north-west Australia were

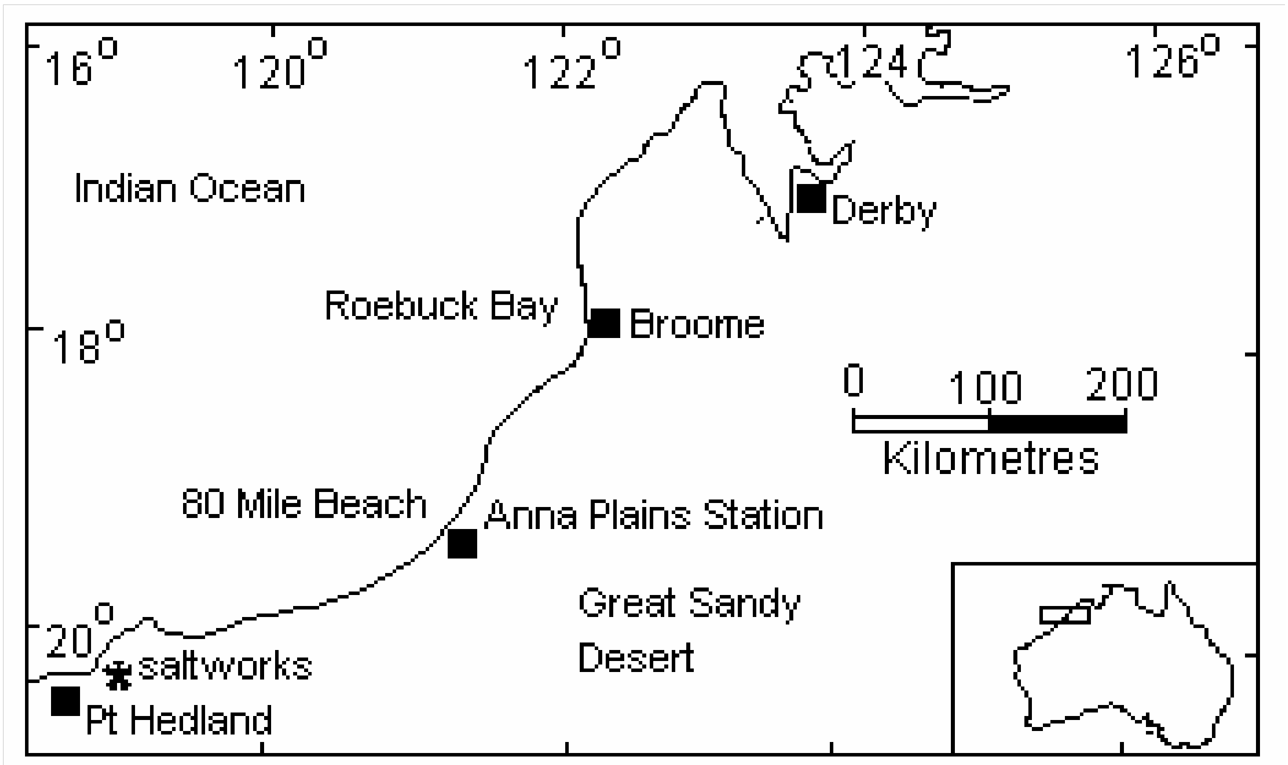

Figure 1. Map of north-west Australia.

accompanied by a light aircraft piloted by Don Jeans. This was extremely important in determining the geography of the area, especially access points to Eighty Mile Beach, which enabled counts of considerable lengths of shoreline to be made relatively easily.

The team moved from Broome to camp in the bush adjacent to the shore on the north side of Roebuck Bay. The first cannon netting catch was made on 30 August at Quarry Beach, Roebuck Bay; 778 birds were caught, rather more than had been intended. Bush Point, the largest but most remote and inaccessible wader roost on Roebuck Bay, was visited for the first time on 31 August. Creeks had to be swum and some difficulty was found in retracing steps after the count resulting in Grant Pearson's jocks, which had been placed on a high stick to mark a creek crossing, failing to be retrieved! In later years two cannon netting visits to Bush Point were made, the access difficulties being bypassed by a 25 km trip from Broome in a 12 person hovercraft.

After two more small cannon net catches at Roebuck Bay the team made a brief visit on 3 September to count the waders on the northern part of Eighty Mile Beach. The diary for this day starts off with "This was a memorable day". The number of waders seen was more than any of the participants had ever seen previously anywhere. The Great Knot numbers were astounding, the 22,000 counted being much higher than the previous known world population. Part of the team and one of the aircraft made it back to Broome that evening but the ground survey team and the other aeroplane were overtaken by darkness and had to make an unplanned overnight stay at Anna Plains Station.

In such a way did wader studies in north-west Australia start.

Expeditions

A total of 23 special "expeditions" have been made under the auspices of the AWSG to north-west Australia to catch, band and count waders and terns. There have been additional visits of individuals or small teams when counting and/or photography were the objectives and no banding was undertaken. Most of the expeditions have involved 20 to 25 people being in the field at any one time, but team sizes up to 35 have occasionally occurred. In the earlier years the majority of expeditions were either in the period covering northward departures (March and April) or in the arrivals period (August to early November). Even as early as the third expedition, in August and September 1982, 66 different people participated, 15 of whom drove up from Melbourne in a hired minibus. The largest expedition was over a continuous 13 week period from early August to early November 1998 when 117 people from 17 different countries participated. It has been a tradition since the early days that around half of the team each year has come from overseas, particularly experienced wader banders from the UK and wader counters and banders from Asia, mainly trainees. In these earlier years the participation of some of these people was financed by the Australian government, but the Japanese Bird Migration Research Centre supported six participants in 1998, not all from Japan.

Banding has been undertaken at both Broome and Eighty Mile Beach on all except three expeditions. It also took place at adjacent inland locations on Roebuck Plains and Anna Plains when conditions were suitable. The Cargill Saltworks, near Port Hedland, was "discovered" by Roger Jaensch, Mike Bamford and Doug Watkins during the second north-west Australia expedition in March/April 1982. It was visited on all but two of the expeditions before 2000, but on only one occasion for banding since then. With the saltworks being more than 600 km from Broome, it is logistically difficult to fit visits into the current three-week long expeditions.

Initially the aim was to catch and band birds for migration studies. It was only when considerable progress had been achieved in this area that, in recent years (from 2000 to 2005) the timing of expeditions was varied to fill in gaps in the moult, biometric and weight data in the May to July and mid-November to February periods. In more recent years, the aim has been the annual monitoring of breeding success via the proportion of young birds in catches. This requires relatively stable wader populations and visits outside the migration seasons.

Logistics

Getting all the required equipment to north-west Australia and ferrying people around when up there has occasionally produced significant logistical problems. This has been especially so for visits in the wet season, usually late December to early March but right through until the end of April after a particularly severe wet. One expedition experienced 200 mm of rainfall in less than 24 hours when it was camped at Eighty Mile Beach. Even when dry, there are frequent soft patches of sand on the upper parts of the beach which can be a problem at any time of year.

Bush camping at Roebuck Bay was originally the only option. However after Broome Bird Observatory was established in 1988 – with considerable help from expedition members in creating the septic tank and drainage systems – expeditions have always been based there when operating at Roebuck Bay. At Eighty Mile Beach in the early years, camping was in the dunes adjacent to the beach, six km from the nearest tree. More recently, especially for visits in the hot wet season, base accommodation has been provided by Anna Plains Station (seven km from the coast). One of the particular attractions of visits to Anna Plains has been the "hot bore" where bath temperature water gushes out into a wonderful spa-type tank, a great restorer after an arduous day in the field.

North-west Australia has a tropical climate – the latitude of Broome is 18ºS. In the dry season (April to November) it is relatively free of insects. But during and immediately after the wet season mosquitoes can be a problem and other insects, such as myriads of small flying beetles, can be a real problem when camping (they taste very bitter!). Flies just occasionally appear in plague proportions, when there is a hot easterly wind coming out of the Great Sandy Desert. Unfortunately Port Hedland Saltworks can have mosquitoes and flies at any time during the year.

Health problems in the super clean environment of north-west Australia have been negligible over the years. Care has to be taken however that minor abrasions do not turn into tropical ulcers. Minor accidents have included one person accidentally putting a wooden splinter 30 cm. long through his arm and another participant having the glass window from an old Land Rover finish in her face and lap after an Australian Bustard crashed into the vehicle. Both persons (but not the bustard) recovered quickly after treatment at Broome Hospital.

Banding

The main activity on most expeditions has been catching and banding waders. Some counts have been made on all expeditions, but the major census work in more recent years has been carried out by specialist counting teams (Rogers *et al*. 2006d). Cannon netting has been the principal means of catching birds at Roebuck Bay and at Eighty Mile Beach. Occasionally, night time mist netting has been undertaken near Broome, at Roebuck Plains and at the Broome Sewage Farm. Mist netting has also taken place at Eighty Mile Beach but only on a limited scale because the large number of sharks prevents normal mist netting techniques being used.

At Port Hedland Saltworks mist netting has been used extensively. It was particularly effective in the 1980s but has deteriorated in recent times because of major changes in the water inflow systems. The most memorable mist net catch was 236 Broad-billed Sandpipers in one evening on 8 April 1988. Wading around in the soft mud there is an energy consuming exercise, particularly in March and April when temperatures are at their highest. In March 1988 a team of six wader banders from the UK arrived at Port Hedland airport at 11 p.m. They were out at the mist nets within two hours and over the next 48 hours were active mist netting by night and cannon netting by day with the temperature never falling below 39 ºC – quite a rapid transition from a northern hemisphere winter.

One of the great benefits of the mist netting elements of the north-west Australia banding program has been that a much wider range of species is caught. On some of the expeditions when mist netting was carried out up to 35 different species of wader were caught.

Cannon netting in north-west Australia presents different challenges to those met in most other locations around the world. For example there the problem is quite often one of trying to get few enough birds in the catching area to make a safe catch, rather than the more common problem of assembling enough birds in the net area to make a worthwhile catch. Because of the high temperatures, usually 30 to 40 ºC, it is necessary to remove birds from nets quickly and also to set up shade over the keeping cages immediately. Optimum techniques for handling cannon net catches in this tropical environment have now been developed. The use of small mesh nets, from which birds can be extracted quickly, has been particularly beneficial.

Because of the climate it has been necessary to limit the size of catches in north-west Australia. Depending on weather conditions a catch of 100 to 400 birds is usually targeted, and catches of more than 500 birds have rarely been made. However, because there are so many birds present and these are relatively easy to move into the catching area the average cannon net catch of 160 is little different from that in the cooler environment of temperate Victoria. The largest catch in north-west Australia was 2,042 on 29 August 1998, a nice cool day. This catch contained 1,001 Great Knot. The largest expedition total was 15,012 birds in 71 cannon net catches spread over thirteen weeks from August to early November 1998.

The technique for moving birds towards and into the catching area, "twinkling", normally requires a cautious pedestrian approach to the birds. At Eighty Mile Beach, it involves the use of vehicles. After the net has been set the vehicles are moved to about two kilometres each side of the net. About an hour before high tide they start pushing birds toward the nets, from both directions simultaneously. The wader flocks often allow a close approach providing excellent viewing and photography opportunities for the twinklers. An unusual catching hazard at Eighty Mile Beach is the harmless shovel-nosed (milk) shark; these live in the shallow tide edge and have twice been caught in the front of the net.

Altogether over the 25 year period since wader banding started in north-west Australia 101,012 waders of 47 different species have been caught (Table 1). Approximately 9% of these have been recaptures of previously banded birds, either local or from elsewhere. Great Knot, Bar-tailed Godwit, Red-necked Stint, Greater Sand Plover and Curlew Sandpiper dominate the species totals. Seventeen species have now been banded in numbers greater than 500.

Some of the more interesting catches have been:

- Little Curlew. A total of 1290 have been caught. 347 of these were in four catches in late March/early April 1985 just before they left on northward migration. Digging holes for cannons in rock-hard clay on Roebuck Plains in 42 ºC heat provoked Professor Weishu, from China, to comment that "this is just like the Cultural Revolution"!
- Asian Dowitcher. So far, 107 have been caught. Initially most were mist netted at Port Hedland Saltworks. However in recent years they have mainly come from the occasional bird mixed in with larger catches of other waders on the north shores of Roebuck Bay.
- Oriental Plover. The majority of the world population of this species congregates to feed on the grasslands adjacent to Eighty Mile Beach in October/November. Most of these birds adjourn to the beach shores in the hottest part of the day. The 465 Oriental Plovers caught so far have mainly come from cannon netting on the beach, but some have been mist-netted at night on the plains.
- Red-necked Phalarope. Twenty-three were caught at Port Hedland Saltworks when a flock swam close enough to the bank of a shallow salt lagoon for a small cannon-net to reach them.
- Oriental Pratincoles. A total of 472 have been caught. The largest number (250) was in early February 2004 when a massive concentration, estimated at 2.8 million (Sitters *at al*. 2004), occurred in the Eighty Mile Beach/Anna Plains/other adjacent grasslands area.
- Common Redshank. Eight have been caught, mostly at Roebuck Bay. North-west Australia is the only place where this species regularly occurs in Australia. The main non-breeding areas are north of the Equator.

Table 1. Waders caught in north-west Australia 1981-2005

Species	Newly Banded	Retraps/ Controls	Total
Bush Stone-curlew	2	-	2
Pied Oystercatcher	246	38	284
Sooty Oystercatcher	58	7	65
Masked Lapwing	174	9	183
Grey Plover	288	14	302
Pacific Golden Plover	34	1	35
Red-kneed Dotterel	227	21	248
Lesser Sand Plover	424	102	526
Greater Sand Plover	10028	1254	11282
Oriental Plover	465	-	465
Little Ringed Plover	1	-	1
Red-capped Plover	1147	33	1180
Black-fronted Plover	171	7	178
Black-winged Stilt	601	11	612
Banded Stilt	94	-	94
Red-necked Avocet	232	20	252
Ruddy Turnstone	1531	286	1817
Eastern Curlew	189	6	195
Whimbrel	303	7	310
Little Curlew	1261	29	1290
Wood Sandpiper	84	4	88
Grey-tailed Tattler	5934	720	6654
Common Sandpiper	60	11	71
Common Greenshank	270	5	275
Common Redshank	7	1	8
Marsh Sandpiper	212	2	214
Terek Sandpiper	6111	623	6734
Pin-tailed Snipe	3	-	3
Swinhoe's Snipe	6	-	6
Painted Snipe	6	-	6
Asian Dowitcher	103	4	107
Black-tailed Godwit	703	18	721
Bar-tailed Godwit	10665	1182	11847
Red Knot	5359	426	5785
Great Knot	18041	1520	19561
Sharp-tailed Sandpiper	1446	34	1480
Pectoral Sandpiper	2	1	3
Little Stint	1	-	1
Red-necked Stint	13750	1505	15255
Long-toed Stint	54	5	59
Curlew Sandpiper	9406	861	10267
Sanderling	678	10	688
Broad-billed Sandpiper	1255	75	1330
Ruff	1	-	1
Red-necked Phalarope	23	-	23
Australian Pratincole	32	-	32
Oriental Pratincole	472	-	472
Total (47 Species)	**92160**	**8852**	**101012**

- Broad-billed Sandpiper. The total caught in north-west Australia is now 1330. The majority of these have been banded at Port Hedland Saltworks, but small numbers have also been caught at Roebuck Bay.

In addition to birds banded by special expeditions to north-west Australia, wader catching has regularly been carried out by locally based teams since 1991 (Table 2). Initially this was by the wardens at Broome Bird Observatory (starting with Bryce Wells and Gail Hooper) but in recent years has been organised by resident local wader enthusiasts Chris Hassell and Adrian Boyle. Over the years this local team has accounted for 13,734 of the birds caught in north-west Australia (Table 3).

Some 60% of the birds banded in north-west Australia have been caught at Roebuck Bay and 30% at Eighty Mile Beach (Table 2). Fewer birds have been banded at Port Hedland Saltworks (5.5%) because of the limited opportunities for cannon netting. But catching there has made a particularly valuable contribution to the study of several species which don't occur elsewhere in such good numbers - Asian Dowitcher, Marsh Sandpiper, Sharp-tailed Sandpiper and Lesser Sand Plover.

Recoveries

Table 4 gives details of the 401 waders banded in north-west Australia which have subsequently been recovered elsewhere; 372 of these were overseas. Recoveries are dominated by Great Knot and Bar-tailed Godwit. It was their flights direct to the Yellow Sea in China/Korea which was the first major discovery in relation to movements of birds banded in north-west Australia. There have also subsequently been several recoveries in Russia, many at breeding locations.

Another important early discovery from banding was that many of the small/medium size waders which spend the non-breeding season in south-east Australia use the north-west Australian coast as a migratory stopover site on both northward and, especially, southward migration. As most of these species occur in inland Australia in only small numbers it is clear that most probably make the 3,000 km trans-continental flight non-stop.

There have also been 117 birds recaptured in north-west Australia after they had been previously banded elsewhere (Table 5). The original banding locations are rather different from recovery locations because they reflect the limited number of locations within the flyway which, until recently, have been regular wader banding sites.

Flagging

Adding a yellow plastic leg flag to birds in north-west Australia started in August 1992. Since then 63,526 waders have been marked in this way (Table 6). The number of overseas flag sighting reports is much higher than the corresponding number of metal band recoveries, although the increase is not as great as that generated by flagging in south-east Australia. To date, 1905 sightings have accrued, 1495 of these at sites in Asia, 242 in New Zealand, and 168 at other locations in Australia (Tables 7 and 8). The 21 sightings in Russia have been particularly valuable in providing information on the specific breeding areas of north-west Australia wader populations.

Perhaps the most exciting flag sighting of all was a yellow-flagged Asian Dowitcher which was seen at its nest in northern Mongolia in June 2006. A flagged Curlew Sandpiper seen in Sri Lanka in August 2005 was unusually far west. Most difficult to explain are the 212 Red Knot and 30 Bar-tailed Godwit sightings in New Zealand of birds flagged in north-west Australia. These represent 8% of Red

Table 2. Annual wader catches at different locations in north-west Australia 1981-2005. Totals include retraps and controls. NWA refers to AWSG-organised expeditions (23 visits). BBO refers to Broome Bird Observatory/NW Wader Study Group banding activities (15 years). DW refers to Doug Watkins.

Year	Bander	Roebuck Bay Inc. Bush Point	Roebuck Plains	80 Mile Beach	Anna Plains	Port Hedland Saltworks	Derby	Total
1981	NWA	1189	-	-	-	-	-	1189
1982 (Mar/Apr)	NWA	619	-	-	-	131	-	750
1982 (Aug/Sep)	NWA	1908	-	1025	225	461	-	3619
1982 (Nov)	NWA	2	-	2	-	83	-	87
1983	NWA	1148	-	1491	-	958	-	3597
1985	NWA	2647	164	552	183	581	-	4127
1986 (2 visits)	NWA	156	-	169	-	54	-	379
1988	NWA	3798	-	2056	-	646	-	6500
1990	NWA	3407	298	1216	9	544	-	5474
1991	BBO	75	-	-	-	-	-	75
1992	NWA	4141	117	1599	2	295	-	6154
1992	BBO	1383	11	-	-	-	-	1394
1993	NWA	664	-	-	-	-	-	664
1993	BBO	694	-	-	-	-	-	694
1993-94	DW	-	-	-	-	-	85	85
1994	NWA	3386	260	2010	131	318	-	6105
1994	BBO	1426	13	-	-	-	-	1439
1995	BBO	935	1	-	1	-	-	937
1996	NWA	4012	39	3460	-	624	-	8135
1996	BBO	1095	23	-	-	-	-	1118
1997	BBO	420	21	-	-	-	-	441
1998	NWA	7914	126	6193	-	779	-	15012
1998	BBO	835	31	-	-	-	-	866
1999	BBO	902	87	-	35	-	-	1024
2000	NWA	1270	-	406	-	-	-	1676
2000	BBO	1582	-	-	-	-	-	1582
2001 (Jan)	NWA	865	17	850	47	-	-	1779
2001 (Sep/Nov)	NWA	3446	281	4446	21	283	-	8477
2001	BBO	606	29	-	-	-	-	635
2002	NWA	2130	66	937	269	-	-	3402
2002	BBO	725	8	-	-	-	-	733
2003	NWA	1125	-	380	-	-	-	1505
2003	BBO	423	371	-	-	-	-	794
2004	NWA	1684	-	1123	31	-	-	2838
2004	BBO	536	687	-	1	-	-	1224
2005 (Feb/Mar)	NWA	798	52	1784	141	-	-	2775
2005	BBO	682	95	-	1	-	-	778
2005 (Nov/Dec)	NWA	1727	-	1271	14	-	-	3012
	Total	**60355**	**2797**	**30970**	**1111**	**5757**	**85**	**101075**

Table 3. Sources of Waders banded in north-west Australia 1981 – 2005. Retraps and controls are included.

Source	Number
AWSG NW Expeditions	87256
Broome Bird Observatory/NW Wader Study Group	13734
Doug Watkins (at Derby 1993–1994)	85
TOTAL	101075

Knot, and 3% of Bar-tailed Godwit, flag sightings in New Zealand, the remainder being from eastern Australia. Originally, it was thought that there was geographical separation of the two subspecies of Red Knot in Australia with subspecies *piersmai* occurring in the north-west Australia and subspecies *rogersi* occurring in eastern Australia and New Zealand. In Bar-tailed Godwit, subspecies *menzbieri* was thought to locate in north-west Australia and subspecies *baueri* in the east.

There have also been 897 sightings in north-west Australia of waders flagged elsewhere (Table 9); 432 of these were from overseas. These are increasingly being dominated by sightings of birds from Chongming Dao, near

Table 4. Recoveries more than 200 km from banding location in north-west Australia

Species	China (mainland)	Russia	Taiwan (China)	Hong Kong (China)	New Zealand	Viet-nam	Korea	Philip-pines	Japan	Total Overseas	VIC	WA	NSW	SA	Qld	Total Aust.	Total
Great Knot	161	32	-	2	-	-	-	1	-	**196**	-	-	-	-	1	**1**	**197**
Bar-tailed Godwit	62	19	-	-	-	-	1	1	-	**83**	-	-	-	-	-	**0**	**83**
Red-necked Stint	2	2	-	-	-	-	-	-	-	**4**	11	1	-	1	-	**13**	**17**
Curlew Sandpiper	5	1	1	5	-	2	-	-	-	**14**	9	-	2	-	-	**11**	**25**
Red Knot	11	5	-	1	8	-	-	-	-	**25**	1	1	-	-	-	**2**	**27**
Grey-tailed Tattler	2	2	10	1	-	1	-	-	2	**18**	-	-	-	-	-	**0**	**18**
Terek Sandpiper	4	5	1	1	-	-	2	1	-	**14**	-	-	-	-	-	**0**	**14**
Greater Sand Plover	2	-	1	-	-	4	-	-	-	**7**	-	-	-	-	-	**0**	**7**
Ruddy Turnstone	2	2	-	-	-	-	1	-	-	**5**	-	-	-	1	-	**1**	**6**
Broad-billed Sandpiper	-	1	1	-	-	-	-	-	-	**2**	-	-	-	-	-	**0**	**2**
Sanderling	1	-	-	-	-	-	-	-	-	**1**	1	-	-	-	-	**1**	**2**
Asian Dowitcher	-	-	-	-	-	-	-	-	-	**0**	-	-	-	-	-	**0**	**0**
Eastern Curlew	-	1	-	-	-	-	-	-	-	**1**	-	-	-	-	-	**0**	**1**
Little Curlew	-	-	-	-	-	-	-	-	-	**0**	-	-	-	-	-	**0**	**0**
Marsh Sandpiper	-	-	-	-	-	-	-	-	-	**0**	-	-	-	-	-	**0**	**0**
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	1	-	**1**	-	-	-	-	-	**0**	**1**
Whimbrel	-	1	-	-	-	-	-	-	-	**1**	-	-	-	-	-	**0**	**1**
Total	**252**	**71**	**14**	**10**	**8**	**7**	**4**	**4**	**2**	**372**	**22**	**2**	**2**	**2**	**1**	**29**	**401**

Table 5. Waders recaptured in north-west Australia which had been banded elsewhere (more than 200 km away in Western Australia)

Species	Hong Kong (China)	Russia	China (main-land)	Korea	Taiwan (China)	Japan	Total Over-seas	VIC	WA	SA	Tas	NT	Total Aust.	Total
Red-necked Stint	-	1	-	-	1	2	**4**	17	1	-	3	-	**21**	**25**
Curlew Sandpiper	6	1	-	-	2	-	**9**	22	2	1	-	-	**25**	**34**
Red Knot	5	5	-	-	-	-	**10**	3	7	-	-	-	**10**	**20**
Great Knot	-	4	5	5	-	-	**14**	-	2	-	-	1	**3**	**17**
Terek Sandpiper	3	-	-	2	-	1	**6**	-	-	-	-	-	**0**	**6**
Sanderling	-	-	-	-	-	-	**0**	2	-	4	-	-	**6**	**6**
Grey-tailed Tattler	-	-	-	-	3	1	**4**	-	-	-	-	-	**0**	**4**
Bar-tailed Godwit	1	-	2	-	-	-	**3**	-	-	-	-	-	**0**	**3**
Greater Sand Plover	-	-	-	-	1	-	**1**	-	-	-	-	-	**0**	**1**
Asian Dowitcher	-	-	-	-	-	-	**0**	-	-	-	-	-	**0**	**0**
Little Curlew	-	-	-	-	-	-	**0**	-	-	-	-	-	**0**	**0**
Marsh Sandpiper	-	-	-	-	-	-	**0**	-	-	-	-	-	**0**	**0**
Ruddy Turnstone	-	-	-	-	-	-	**0**	-	-	1	-	-	**1**	**1**
Total	**15**	**11**	**7**	**7**	**7**	**4**	**51**	**44**	**12**	**6**	**3**	**1**	**66**	**117**

Table 6. Waders Leg-flagged in north-west Australia (yellow). Data includes all AWSG N.W. Australia Expedition and Broome Bird Observatory/NWWSG catches.

Species	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Total**
Pin-tailed Snipe	-	-	-	-	-	-	1	-	-	-	-	-	1	1	**3**
Swinhoe's Snipe	-	-	-	-	-	-	-	-	-	-	2	3	-	-	**5**
Black-tailed Godwit	72	5	17	-	12	7	223	37	3	92	50	40	28	52	**638**
Bar-tailed Godwit	468	184	1171	249	1795	16	1283	12	281	899	458	173	271	651	**7911**
Little Curlew	17	-	1	1	-	-	235	73	-	299	264	-	-	17	**907**
Whimbrel	-	1	13	-	42	16	87	-	15	47	34	1	1	29	**286**
Eastern Curlew	12	5	12	-	6	-	41	-	6	48	6	1	32	10	**179**
Common Redshank	-	-	1	-	-	-	3	-	-	-	-	-	1	-	**5**
Marsh Sandpiper	16	-	8	-	1	-	7	-	1	47	3	12	20	35	**150**
Common Greenshank	3	-	19	-	5	-	45	-	1	24	25	13	18	78	**231**
Wood Sandpiper	7	-	1	-	1	1	2	-	-	-	9	20	8	19	**68**
Terek Sandpiper	484	93	465	19	765	10	859	17	219	620	178	10	230	475	**4444**
Common Sandpiper	-	-	2	-	1	-	6	-	2	10	18	6	13	-	**58**
Grey-tailed Tattler	305	157	393	33	542	30	624	44	104	1159	224	88	96	427	**4226**
Ruddy Turnstone	114	103	180	7	106	5	187	1	43	46	10	2	44	59	**907**
Asian Dowitcher	12	15	13	10	3	-	5	-	19	11	6	1	-	1	**96**
Great Knot	843	63	822	198	2140	15	2217	188	807	2311	603	165	389	1728	**12489**
Red Knot	376	2	286	40	638	1	562	64	269	461	161	24	253	189	**3326**
Sanderling	4	-	4	-	44	-	389	-	4	131	64	-	-	29	**669**
Little Stint	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
Red-necked Stint	611	42	835	36	1355	241	2329	249	139	1556	698	245	264	594	**9194**
Long-toed Stint	10	-	11	-	1	-	4	2	-	-	1	16	2	2	**49**
Pectoral Sandpiper	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Sharp-tailed Sandpiper	31	-	129	-	16	2	234	3	-	25	30	129	272	75	**946**
Curlew Sandpiper	1018	16	474	117	453	10	1753	21	165	575	278	420	90	280	**5670**
Broad-billed Sandpiper	84	-	102	1	138	4	86	11	13	33	12	-	8	18	**510**
Ruff	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Red-necked Phalarope	-	-	-	-	-	-	-	-	-	22	-	-	-	-	**22**
Painted Snipe	-	-	-	-	-	-	-	-	-	-	6	-	-	-	**6**
Pied Oystercatcher	43	-	36	1	3	1	19	7	16	21	10	35	16	7	**215**
Sooty Oystercatcher	-	-	1	-	19	-	1	-	-	14	-	10	13	-	**58**
Black-winged Stilt	-	7	42	-	26	-	21	9	-	1	21	126	95	99	**447**
Red-necked Avocet	-	-	29	-	3	-	1	-	-	-	46	54	-	-	**133**
Pacific Golden Plover	1	-	1	-	2	-	5	-	-	1	7	2	6	6	**31**
Grey Plover	46	3	31	-	48	15	25	-	1	3	65	-	2	9	**248**
Little Ringed Plover	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Red-capped Plover	10	-	145	4	10	1	135	3	1	40	96	69	79	185	**778**
Lesser Sand Plover	45	10	65	-	71	-	24	-	-	12	3	-	6	9	**245**
Greater Sand Plover	724	20	660	39	912	10	1829	40	191	1260	328	100	335	734	**7182**
Oriental Plover	45	-	2	-	2	-	157	3	-	11	17	1	63	95	**396**
Black-fronted Dotterel	-	-	14	-	3	7	4	15	-	4	2	17	52	10	**128**
Red-kneed Dotterel	2	-	27	-	18	9	-	6	-	-	10	2	21	10	**105**
Masked Lapwing	2	-	12	-	-	3	1	-	-	-	33	21	75	1	**148**
Oriental Pratincole	-	-	1	-	1	-	-	-	-	49	-	24	251	64	**390**
Australian Pratincole	-	-	-	-	-	-	3	-	-	-	-	8	11	1	**23**
Total (45 species)	**5406**	**726**	**6026**	**755**	**9182**	**404**	**13407**	**805**	**2300**	**9832**	**3779**	**1839**	**3066**	**5999**	**63526**

Table 7. Sightings of north-west Australia flagged waders within Australia more than 200 km from flagging location. Data to 28/9/06

Species	WA	VIC	NSW	SA	QLD	NT	TAS	Total
Red Knot	10	6	20	-	4	2	3	**45**
Curlew Sandpiper	13	17	3	3	-	-	-	**36**
Red-necked Stint	6	21	1	2	-	-	-	**30**
Sanderling	-	3	-	13	-	-	-	**16**
Sharp-tailed Sandpiper	7	3	-	-	-	1	-	**11**
Eastern Curlew	7	-	-	-	-	-	-	**7**
Ruddy Turnstone	1	2	-	3	-	-	-	**6**
Great Knot	2	-	-	-	-	1	-	**3**
Bar-tailed Godwit	-	-	3	-	-	-	-	**3**
Black-tailed Godwit	-	-	2	-	-	-	-	**2**
Marsh Sandpiper	2	-	-	-	-	-	-	**2**
Grey-tailed Tattler	-	-	-	-	2	-	-	**2**
Pied Oystercatcher	1	-	-	-	-	-	-	**1**
Black-winged Stilt	1	-	-	-	-	-	-	**1**
Red-necked Avocet	1	-	-	-	-	-	-	**1**
Greater Sand Plover	1	-	-	-	-	-	-	**1**
Masked Lapwing	1	-	-	-	-	-	-	**1**
Total	**53**	**52**	**29**	**21**	**6**	**4**	**3**	**168**

Shanghai in China, which has become a major wader banding and flagging site in the last three years. The sightings of birds flagged elsewhere in Australia are predominately of birds from Victoria but South Australia is becoming increasingly important, especially if the different numbers of birds flagged in each area are considered.

Counting

The aerial surveys and ground counts in the 1981 to 2001 non-breeding periods showed that there were up to three-quarters of a million waders present in north-west Australia. Counts of up to 170,000 have been made in Roebuck Bay, with around 100,000 counted on occasions at Bush Point. The estimated population at Eighty Mile Beach was 550,000 based on counts in the early years, but a more detailed count in 2001 indicated a population of around 470,000 on this 212 km long shoreline. Counts of up to 65,000 waders have been made at Port Hedland Saltworks but numbers present there since modifications were made in the 1990s have dropped to a much lower level of around 5000 to 10,000. The most notable feature of the wader populations at Port Hedland Saltworks in the past was the very large number of Broad-billed Sandpiper – often 1000 to 2000 and with a peak count of 5000 in March 1987. Asiatic Dowitcher also used to reach a peak of around 110 in most years and the Red-necked Pharalope flock has occasionally been up to 50 birds.

The total estimated population of each species in the Broome, Eighty Mile Beach, and Port Hedland areas of north-west Australia in the 1980s included 180,000 Great Knot, 100,000 Bar-tailed Godwit, 90,000 Red Knot, 60,000 Greater Sand Plover, 50,000 Red-necked Stint and 50,000 Little Curlew. Since then population changes, habitat alterations and improved counting techniques have resulted in revised figures for some species as a result of the intensive counting of waders at Roebuck Bay, Bush Point and at Eighty Mile Beach as part of the AWSG's MYSMA Project (Rogers *et al*. 2006d).

Equipment and Finances

Much of the original cannon-netting and mist-netting equipment used in north-west Australia was initially provided by the Victorian Wader Study Group and most of the logistical support equipment (cooking etc.) by the Western Australian Department of Conservation and Land Management (CALM). Gradually a stock of the relevant equipment has been built up in north-west Australia, largely financed by participants in the various expeditions, and it is no longer necessary to bring up major items from south-east Australia each time.

Expeditions have been almost entirely self-funded, although, as mentioned earlier, the costs of some participants from Asia and Russia have occasionally been paid by the Australian and Japanese governments. Each member has put in a daily contribution (currently $25) towards the cost of food and other equipment/overheads, and a further contribution towards transport costs ($210 per week). The largest expedition budget was in 1998 when expenditure was approximately $70,000. Most expeditions have operated close to break even.

People

A very large number of people have been involved in the north-west Australia expeditions and locally organised banding activities over the years. Several individuals have already been mentioned. Other regular expedition participants in the earlier years include Grant Pearson, Doug Watkins, Brett Lane, Ira Savage and Angela and Roz Jessop. Roz Jessop has been involved in almost every expedition since 1982 and has been one of the joint leaders in all of the expeditions over the last 15 years. Many overseas visitors have participated several times, especially Humphrey Sitters, Nick Branson, and Daphne and Mike Watson from the UK.

Table 8. Overseas Sightings of north-west Australia-flagged Waders. Data to 5/9/06

Species	Hong Kong (China)	Korea	China (main-land)	New Zealand	Taiwan (China)	Japan	Russia	Indo-nesia	Mon-golia	Brunei	Malay-sia	Viet-nam	Sri Lanka	Philip-pines	Singa-pore	Thai-land	Total
Great Knot	75	171	83	-	37	8	2	-	-	-	1	-	-	-	-	-	**377**
Bar-tailed Godwit	8	125	140	30	8	4	9	-	-	-	-	-	-	-	-	-	**324**
Red Knot	15	2	17	212	4	-	-	-	-	-	-	-	-	-	-	-	**250**
Curlew Sandpiper	188	-	8	-	22	1	-	4	-	-	-	-	1	-	-	1	**225**
Red-necked Stint	40	2	52	-	11	22	5	9	3	3	1	-	-	-	-	-	**148**
Grey-tailed Tattler	8	5	1	-	99	18	-	-	-	-	-	-	-	-	-	-	**131**
Greater Sand Plover	54	-	-	-	33	-	-	-	-	-	-	1	-	-	-	-	**88**
Terek Sandpiper	44	13	3	-	6	-	-	-	-	-	-	-	-	-	-	-	**66**
Sanderling	2	3	-	-	-	24	3	-	-	-	-	-	-	-	-	-	**32**
Black-tailed Godwit	-	12	2	-	7	-	-	3	-	-	-	-	-	-	-	-	**24**
Broad-billed Sandpiper	15	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**18**
Eastern Curlew	-	7	2	-	-	-	2	-	-	-	-	-	-	-	-	-	**11**
Grey Plover	-	3	7	-	-	1	-	-	-	-	-	-	-	-	-	-	**11**
Ruddy Turnstone	2	1	1	-	3	1	-	-	-	-	-	-	-	1	-	-	**9**
Common Redshank	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**6**
Asian Dowitcher	-	-	1	-	4	-	-	-	1	-	-	-	-	-	-	-	**6**
Sharp-tailed Sandpiper	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**4**
Common Greenshank	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**
Lesser Sand Plover	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	**3**
Common Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	**1**
Total	**463**	**347**	**319**	**242**	**235**	**79**	**21**	**16**	**4**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**1737**

Table 9. Waders sighted in north-west Australia which had been flagged elsewhere. Data to 9/10/2006

Species	China (main-land)	Japan	Korea	Taiwan (China)	Russia	Hong Kong (China)	New Zealand	Total Overseas	VIC	SA	NSW	WA (South)	Total Aust.	Total
Bar-tailed Godwit	180		5				1	**186**	22	1			**23**	**209**
Great Knot	167	8	13					**188**	5				**5**	**193**
Curlew Sandpiper		1				2		**3**	151	33			**184**	**187**
Red-necked Stint	1	2			3			**6**	127	14		1	**142**	**148**
Red Knot	2						1	**3**	46			2	**48**	**51**
Sanderling								**0**	14	18			**32**	**32**
Ruddy Turnstone								**0**	5	18			**23**	**23**
Grey-tailed Tattler	1	6		10				**17**					**0**	**17**
Black-tailed Godwit	10	4						**14**	2				**2**	**16**
Terek Sandpiper	12							**12**					**0**	**12**
Sharp-tailed Sandpiper								**0**	4		1		**5**	**5**
Grey Plover	1							**1**	1				**1**	**2**
Whimbrel	1							**1**					**0**	**1**
Common Greenshank	1							**1**					**0**	**1**
Total	**376**	**21**	**18**	**10**	**3**	**2**	**2**	**432**	**377**	**84**	**1**	**3**	**465**	**897**

Other studies

From the early 1980s the radar at the meteorological station in Broome was used to watch flocks of birds departing from Roebuck Bay at the beginning of their northward migration in March and April. This showed that almost all birds were leaving in a north-north-westerly direction and that the main departures coincided with periods when winds were between the east and south at elevations up to about 8,000 feet.

Subsequently migratory departures were studied by observations made on the beach near the Broome Bird Observatory in Crab Creek Bay. Systematic observations commenced in 1991 and have been continued ever since. It appears that this part of Roebuck Bay is a pre-departure assembly area for many wader species. Most birds leave between 4 and 6 p.m., i.e. in the two hours before darkness. The average flock size is around 100 birds, but several thousand Great Knots have occasionally been seen departing at the same time. As many as 5000 birds have been recorded leaving on a single evening. The scale of the visible departures can be judged by 36,000 birds being seen departing between 25 March and 17 April 1993.

Current objectives

There has been a gradual evolution in the objectives of banding studies in north-west Australia. The initial priority of the fieldwork was banding as many birds as possible in order to obtain information on migration. Once this was achieved, the emphasis changed to the collection of biometrics and moult data. We now have (a) an outline of migration routes and key stopover sites for the main species obtained from recoveries and flag sightings, (b) some idea of breeding areas (although surprisingly not a single Curlew Sandpiper report yet from the breeding regions of Siberia), and (c) extensive biometric and moult data for all the relevant age groups in all months of the year for all the major study species and the emphasis has gradually changed to demography. Since the 1998/99 season efforts have been made to obtain a large enough sample of the main species each year in order to obtain an estimate of the breeding success in the previous Northern Hemisphere summer. This necessitates expeditions being in the period between early November and early March, outside the main migration seasons.

No detailed study of survival rates of north-west Australian waders has yet been undertaken. In a preliminary study, Milton *et al*. (2005) estimated mean survival rates from recapture histories for Bar-tailed Godwits and Great Knots in north-west Australia as 81% and 82%. However, they did not examine inter-annual variation in detection or survival. The study focussed on assessing population viability of these species under different possible habitat loss scenarios that may cause additional mortality. A new study to estimate survival rates started in February 2005 when individually identifiable engraved leg flags (with two or three letters and/or numbers) were introduced for the larger main study species. They were not attached to smaller species because of perceived difficulties in reading the engraved flags on these birds. The geography, light and weather conditions at Roebuck Bay are ideal for re-sighting opportunities. So far there have already been some 10,000 re-sightings from *c*. 3000 birds fitted with engraved flags. A Ph.D. student (Alice Ewing) is now working on this project but many sightings have also been made by local wader enthusiasts and casual visitors to Broome Bird Observatory. These demographic studies are intended to be continued for at least a further five to ten years.

Feathers for subsequent analysis for the carbon and nitrogen stable isotopes are now systematically being collected also in north-west Australia. These could, in due course, add considerable refinements to the existing migration studies. For example, the technique has been fantastically successful in determining the origin (non-breeding area) of individual Red Knots caught at staging areas such as Delaware Bay in the Americas.

Throughout the 26 year history of wader studies in north-west Australia, veterinary specialists have participated regularly in wader banding expeditions and collected blood samples and cloacal swabs to test for avian-borne diseases. The intensity of sampling has increased in recent times since the highly pathogenic H5N1 strain of avian influenza was recognised as a serious potential problem to human health. Over the years a wide range of diseases, to which birds have previously been exposed, has been found. Testing has shown a low incidence (less than 1%) of any form of avian-borne disease in waders.

The AWSG wader expeditions to north-west Australia have been the catalyst for a number of studies on the ecology of Roebuck Bay and Eighty Mile Beach. In part, this is because the expeditions raised awareness in the ornithological world that north-western Australia has outstanding wader populations, and that these (unlike those in other major tropical shorebird sites) are readily accessible to wader researchers. In addition, the expeditions brought together wader specialists in friendly settings where they could assess and discuss the research possibilities. A highlight has been the collaboration developed between Theunis Piersma and other Dutch researchers (from Groningen University and the Royal Netherlands Institute of Sea Research), Grant Pearson and others from the Western Australian Department of CALM, and Broome Bird Observatory. Between them, these institutes have established a large benthos-study program in north-western Australia, including a regular benthos monitoring program in Roebuck Bay (de Goeij *et al*. 2003) and a series of large-scale benthic surveys in Roebuck Bay (e.g. Pepping *et al*. 1999; Piersma *et al*. 2005; Piersma *et al*. 2006). These surveys, in combination with the knowledge of shorebird biology in north-western Australia obtained through the AWSG expeditions, have underpinned focussed academic studies on such diverse topics as migration behaviour and energetics (e.g. Battley *et al*. 2000, 2001, 2004, 2005; Tulp *et al*. 1994), heat stress (Battley *et al*. 2003), benthos distribution and diversity (Honkoop *et al*. 2006; T. Compton and colleagues in prep.), foraging ecology (e.g. Tulp & de Goeij 1994; Rogers 2006), roost choice (Rogers *et al*. 2006a) and the effects of human disturbance (Rogers *et al*. 2006b, 2006c). The research programs in north-western Australia have heightened local awareness of shorebirds and their conservation values (e.g. Rogers *et al*. 2003), and thus played a role in the development of the Roebuck Bay Working Group, a Broome-based community group who are working towards a management and conservation plan for Roebuck Bay.

North-west Australia is one of the top areas in the world both for number of species and total number of waders with 50 wader species and usually, apart from extraordinary occurrences like the nearly three million Oriental Pratincoles, up to three quarters of a million birds recorded in the region. Due to ease of access, it is likely to continue as the best location for studies of wader species which occur mainly in northern parts of Australia. As a base for field-work the Broome Bird Observatory is crucial to the continuance of activities in Roebuck Bay as is use of the Anna Plains Station for work at Eighty Mile Beach.

ACKNOWLEDGEMENTS

So many people have contributed in so many different ways to the success of wader studies in north-west Australia that it is impossible to name them all here. Studies would never have got off the ground and been sustained without the enormous help provided by Grant Pearson from CALM, over the first 10 to 15 years especially. Norman Wettenhall's success in persuading Lord MacAlpine to donate two small buildings to form the initial Broome Bird Observatory facility was also crucial. The subsequent donation of the accommodation block by Woodside Petroleum consolidates this as a base for wader studies in the Broome area. The facilities and accommodation provided at Anna Plains Station over the years, especially by the current owner John Stoate, have also been fundamental to being able to mount wader expeditions at times of the year when the climate is at its most inhospitable. John Stoate is also thanked for creating and managing two small freshwater lagoons as habitats for waders and for wader banding. Danny Rogers and Grant Pearson provided very helpful comments on this manuscript. Finally, enormous thanks are due to everybody who has participated in the fieldwork in north-west Australia over the last 26 years.

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MEASUREMENTS, WEIGHTS AND PRIMARY WING MOULT OF ORIENTAL PLOVER FROM NORTH-WEST AUSTRALIA

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This paper describes the measurements, weights and primary wing moult of Oriental Plover caught in north-west Australia. There is no bimodality in any measurement, confirming that there is negligible sexual size dimorphism. All adult birds arrive in north-west Australia in September – November in suspended primary moult, typically having replaced six to eight primaries. Primary moult is completed before the beginning of February. Few juveniles carry out any primary moult whilst in Australia. Adults and juveniles have almost identical patterns of pre-migratory weight gain in February before their departure in March to the breeding areas.

INTRODUCTION

The Oriental Plover *Charadrius veredus* breeds in Mongolia and north-east China and spends the northern winter mainly in Indonesia and northern Australia (Marchant & Higgins 1993). The total flyway population is estimated to be 70,000 birds (Wetlands International 2002). A preliminary description of Oriental Plovers in Australia is in Rogers *et al.* 1990. Adults start to arrive in the coastal areas of north-west Australia from early September, with the main arrivals in October and November. Juveniles do not arrive in large numbers until October and November. Peak numbers of Oriental Plover in the Anna Plains Station and Eighty Mile Beach area, the stronghold of this species in Australia, are now known to reach 58,000 in late October and the first half of November (AWSG unpublished data).

The birds feed on insects, mainly feeding on inland pastures and other areas of short or medium/low vegetation. Near the coast, birds often roost on the shore during the hotter middle part of the day, and this provides opportunities to catch birds with cannon nets when they are concentrated on the beaches at high tide. Birds have also been caught by mist-netting at night on inland paddocks.

A high proportion of birds arriving on the coast disperse inland over the ensuing weeks and carry out their pre-migratory fattening at inland locations before setting off on their northward migration in March. Because Oriental Plover are relatively restricted in their range and because they mainly occur at inland locations in widely dispersed groups, few have been caught and banded. In February 2005, however, many more Oriental Plover than usual stayed in the coastal area, probably because it was exceptionally dry inland. This provided an opportunity to sample the population when pre-migratory fattening was taking place. All of the data were collected during Australasian Wader Studies Group (AWSG) expeditions to north-west Australia which started in 1981.

METHODS

Between September 1982 and February 2005, 432 Oriental Plover were caught in north-west Australia. Age, bill length, head-bill length, wing length (maximum chord), weight, and the state of primary moult were recorded on all birds using the conventions described in Marchant & Higgins (1990). The extent of the breeding plumage of birds caught in February 2004 and 2005 was estimated using a scale of zero, trace, 25%, 50%, 75% and 100%.

Birds were aged using the following criteria. Adults arrive in Australia in suspended primary moult but they always have at least one well-worn or growing outermost primary until primary moult is completed. Most juveniles (93% of those caught) retained all their juvenile primaries which had become slightly worn by February, whilst three birds had carried out a partial wing moult and four were in, or had completed, a conventional primary moult. Adults had broad chestnut-buff fringes to their inner median and lesser coverts, whereas juveniles had normally retained some narrower pale buff fringes to their coverts, scapulars and tertials (Prater *et al.* 1977). Only ten birds were identified as being in their second year of life, on the basis of criteria discussed in the section on primary moult. Unless specifically stated, the term 'adults' includes all birds not aged as juveniles. All measurements are in millimetres and all weights in grams.

The Type 2 model of Underhill & Zucchini (1988) is used to calibrate adult primary moult. Because this moult is partial, with only outer primaries being replaced, the data are inverted so the method calculates moult parameters with respect to the end of moult, rather than the more conventional start of moult. The relative masses of Grey Plover *Pluvialis squatarola* primaries from Underhill & Summers (1993) are used as proxies for those of the Oriental Plover, which have not been measured, in all the moult calibrations.

RESULTS

Age distribution

The age distribution of the 432 birds caught in north-west Australia is shown in Table 1. The high proportion of juveniles in November and February suggests that, at least in some years, a disproportionate number of juveniles remains in the coastal regions after the adults depart inland.

Table 1. Age distribution of the 432 Oriental Plover used in the analysis

Month	Juveniles	Second-year birds	Adults	Total birds caught	Proportion of juveniles
September	3	8	66	77	4%
October	22	-	160	182	12%
November	23	2	23	48	48%
December	2	-	6	8	25%
January	-	-	-	-	-
February	50	-	57	107	47%
March	1	-	2	3	33%
April	3	-	4	7	43%
Total	104	10	318	432	

Breeding plumage

The extent of breeding plumage was estimated for 50 adults and 49 juveniles caught in February 2004 and February 2005. For birds caught in the period 4–7 February 2004, 7 out of 13 adults had 50% or more breeding plumage, but none of the 5 juveniles had any trace of breeding plumage. However, for birds caught in the period 23–26 February 2005, 19 out of 37 adults and 13 out of 44 juveniles had 50% or more breeding plumage.

Biometrics

Figures 1 to 3 show that there is no evidence of bimodality in the distributions of bill length, head-bill length, and wing length. This indicates that, as is the case for most Plovers, there is negligible sexual size dimorphism and biometric parameters do not need to be estimated separately for each sex.

Parameter estimates for bill length and head-bill length are given in Table 2. The means and standard deviations of the two age groups are almost identical. Similar estimates of adult and juvenile wing lengths are given in Table 3. Adult wing lengths are analysed separately for September-December when all birds in the sample had old outer primaries, and for February-April when all birds in the sample had newly-grown outer primaries.

Mean wing length differed significantly between adults with new wings and those caught with abraded wings ($Z = 4.36$, $p < 0.01$). The shortening amounts to 1.6% over some 7–8 months and is less than has been found for other wader species, for example 4% for Red Knot *Calidris canutus* and 2.5% for Sanderling *Calidris alba* over 10½ months (Pienkowski & Minton 1973). The mean wing length of juveniles was significantly less than that of adults with new wings ($Z=5.62$, $p < 0.01$), an effect that is normal for wader species (Stewart 1963).

Measurements of museum specimens (quoted in Prater *et al.* 1977, Marchant & Higgins 1993) are typically 0.5–1.1 mm for bill length and 0–5 mm for wing length shorter than the measurements from live birds given here. This result is consistent with the normal tendency for slight shrinkage of museum specimens (see, for example, Green 1980).

Figure 4 shows the histogram of weights of adults and juveniles in October and February. The weight distributions of adults and juveniles are very similar in these two months, as they are in other months. Parameter estimates are given in Table 4 for those periods where there are data on more than ten birds. It is notable that there is no difference in the pattern of weight gain of juveniles and adults. This, together with the acquisition of breeding plumage, suggests that both juveniles and adults are preparing in February for the same migratory flight.

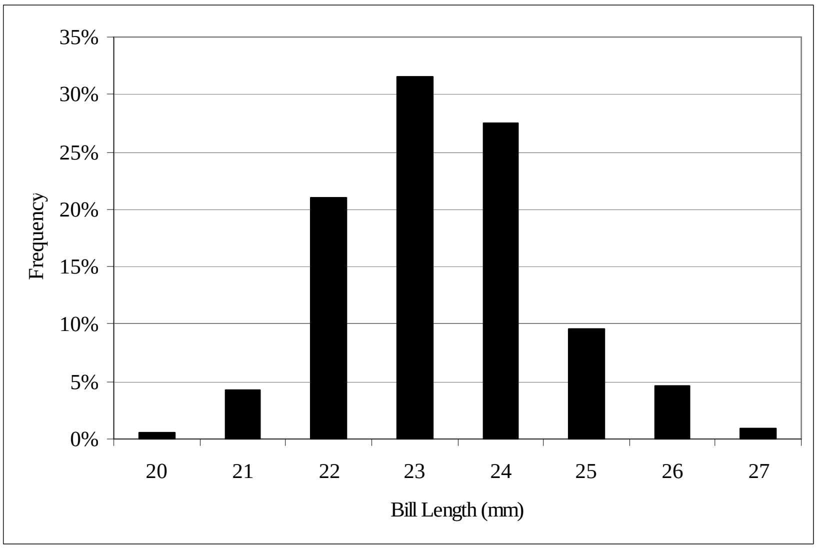

Figure 1. Adult bill length distribution. Bars show percentage of birds in each bill length range

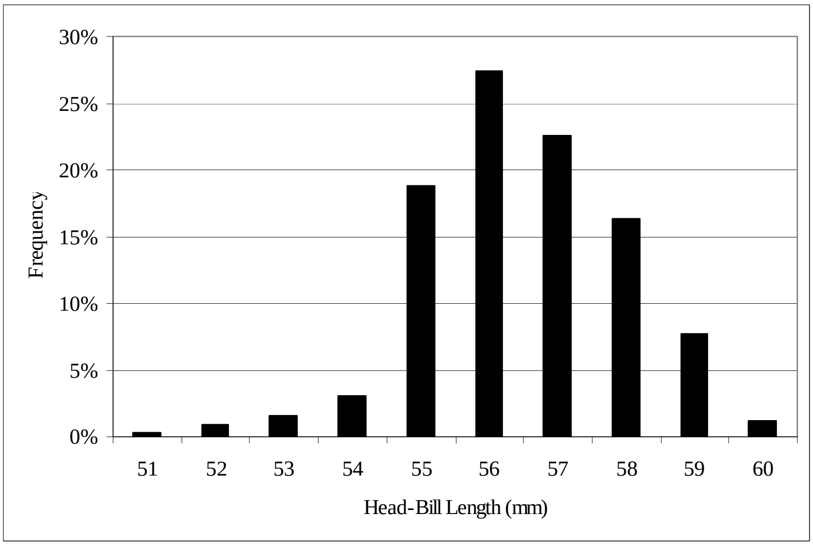

Figure 2. Adult head-and-bill length distribution. Bars show percentage of birds in each head-and-bill length range

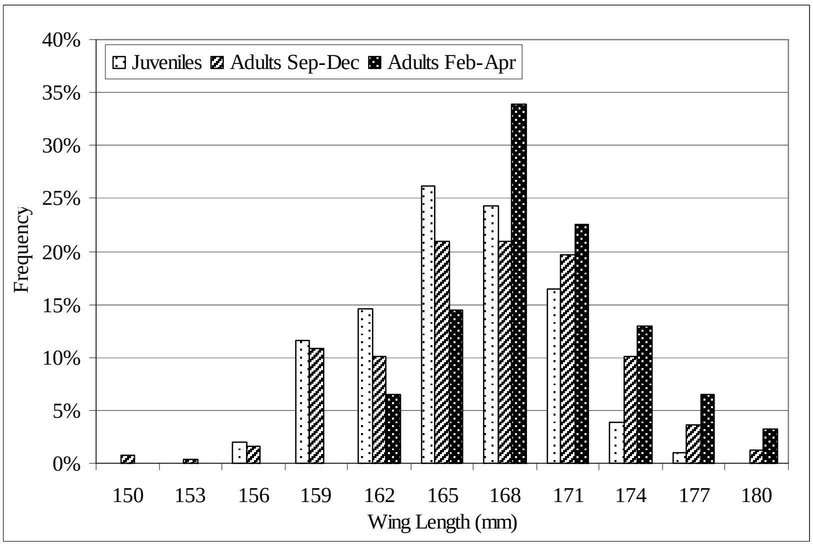

Figure 3. Wing length distributions. For each age group, bars show percentage of birds in each 3 mm wing length range centred on the values shown

Comparisons of the weights of adults in suspended and active wing moult in October and November (when adults in both suspended and active moult are present together) are given in Table 5. There is no significant difference between the weights of moulting and non-moulting birds (Z = 1.83, $p > 0.05$).

Primary moult

Adults

Every adult caught in September had replaced at least five inner primaries and had suspended the moult before arrival in north-west Australia. Table 6 gives the numbers of adults found in suspended and active primary moult during September-December, with the number of inner primaries which each bird had replaced. Early arriving birds tend to have replaced fewer primaries. Of September arrivals, 41% had replaced six or fewer primaries; the figure is 4% for post-September arrivals. Figure 5 plots moult scores against date for the period September – February. The wide scatter of points in these figures reflects the complex pattern of birds arriving in north-west Australia at different times with

Table 2. Bill and head-and-bill length parameters. Mean (S.D.; Range; Sample Size)

Age group	Bill	Head-bill
Adults	23.4 (1.18; 20.2-27.4; 324)	56.6 (1.50; 51.0-60.1; 324)
Juveniles	23.4 (1.06; 21.5-26.5;104)	56.2 (1.37; 52.8-59.8; 104)

Table 3. Wing length parameters. Mean (S.D.; Range; Sample Size)

Age group	Wing length
Adults (Feb-Apr)	169.8 (4.10; 161-181; 62)
Adults (Sep-Dec)	167.0 (5.41; 150-179; 249)
Juveniles	166.0 (4.28; 156-177; 103)

moult suspended at different stages, and perhaps with different periods before wing moult is resumed from the suspended state. Because most birds were caught in October, it is not surprising that 86% of active moults were recorded in this month.

Only data on active and completed moults are used in calibrating the Underhill-Zucchini moult model. Suspended moults are not included, as most of these hold no information on the date of moult completion. The average date for the completion of this moult is 15 January and it takes 1.86 days to replace 1% of primary feather mass (Table 7). Table 8 gives the estimated resumption dates and durations for the moult; these differ depending on how many primaries have to be replaced. The model estimates 15 January as the average date for the completion of this moult.

Juveniles

Of the 104 juveniles caught, nearly all (93%) had moulted no primaries. Five of the seven exceptions were in February: of these, two had three, and one had four, fully-grown outer primaries; one was at an early stage of a complete primary moult with four new primaries and two growing; and the fifth had almost completed a full primary moult. The other two exceptions were birds in April which had completed a full primary moult.

Second year birds

It is difficult to distinguish second year birds from adults and only ten birds in the sample were so identified. Identification was based on the different primary feather generations in the wing as described below.

- Five of these birds, caught in September 1982, had between 6 and 8 newly-moulted inner primaries and between 4 and 2 very old retained outer juvenile primaries. These birds must have moulted their inner primaries in the preceding months before returning to Australia.
- Two birds, caught in September 1998, had 5 and 7 newly-moulted inner primaries respectively, with the remaining outer primaries being slightly worn; these outer feathers may possibly have been replaced during the birds' first year (as occurred in three of the examples of juvenile moult referred to above).
- Two birds had fully grown primaries of three ages: newly grown inner primaries, very old (retained juvenile) central primaries, and slightly worn outer primaries which must have been replaced during the birds' first year.
- One bird was in active wing moult, with seven newly-moulted inner primaries, two growing primaries, and one very old outer retained juvenile primary.

DISCUSSION

To date there has been no sighting of an Oriental Plover marked in Australia at any stop-over site in Asia, so there is no information from banding and flagging to indicate the key areas used by Oriental Plovers on their journeys to and from the breeding grounds. Some relevant conclusions relating to the migration of Oriental Plovers can nevertheless be drawn from the data available.

Arrival and departure

The study confirms that adult Oriental Plovers begin to arrive in north-west Australia from the breeding areas in September. Although some juveniles are present in north-

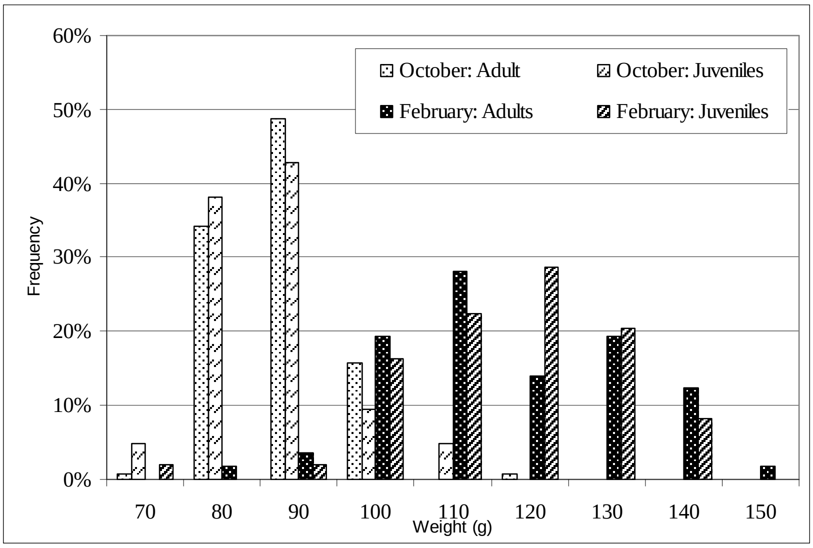

Figure 4. Adult and Juvenile weight distributions for October and February. For each month, bars show percentage of birds in each 10 gm weight range centred on the value shown

Table 4. Monthly weight parameters. Mean (S.D.; Range; Sample Size)

Age / Month	Weight
Adults	
September	95.1 (8.53; 78-114; 61)
October	88.8 (6.93; 74-118; 158)
November	95.2 (7.52; 80-111; 23)
February (first week)	104.5 (7.51; 96-118; 13)
February (fourth week)	120.0 (15.15; 85-153; 44)
Juveniles	
October	87.1 (8.29; 74-110; 21)
November	94.1 (9.69; 75-113; 23)
February (fourth week)	119.5 (11.95; 90-139; 45)

Table 5. Adult weight parameters of birds in primary moult. Mean (S.D.; Range; Sample Size)

Primary Moult	October	November
Active	88.3 (6.62; 74-118; 117)	95.5 (8.42; 81-111; 13)
Suspended	90.5 (7.58; 77-105; 41)	94.7 (6.96; 80-115; 9)

Table 6. Numbers of adults in primary moult

Moult Type / Month	Number of fully-moulted inner primaries						
	3	4	5	6	7	8	9
	Suspended moult						
September	-	-	3	24	35	4	-
October	-	-	1	-	26	12	1
November	-	-	-	1	6	2	-
December	-	-	-	-	-	-	-
	Active moult						
September	-	-	-	-	-	-	-
October	1	2	7	29	66	15	-
November	-	-	2	6	4	1	-
December	-	-	-	-	3	2	1

west Australia as early as September, the main arrival of juveniles does not occur until mid October, some six weeks after the first arrival of the adults.

Both adult and first-year Oriental Plovers go into breeding plumage in February, although there is considerable variability between individuals in the timing. It appears, on the basis of the small sample available, that first-year birds do not start to go into breeding plumage in early February; but by late February there is little difference between adults and first-year birds in this respect. Separate observations (CM) indicate that all Oriental Plover still in north-west Australia at the end of March are in full breeding plumage.

Adults and first-year birds leave Australia having put on similar amounts of pre-migratory fat. Most birds have left by the end of March, with the last individuals departing in the first two or three days of April. This departure is about a month earlier than that of some wader species which breed in Asia and spend the northern winter in Australia (P. Collins *et al.* in prep). Oriental Plover also have shorter distances to travel to their Asian breeding grounds compared with Siberian-breeding species. These effects enable Oriental Plover to start breeding at least a month earlier than other species.

The departure of first-year birds contrasts with the position of most Siberian-breeding wader species spending the Austral summer in Australia: first-year birds of most species remain in Australia at the end of their first year and do not migrate northwards for the first time until the end of their second year or later. Oriental Plover therefore behave in a similar manner to inland freshwater waders which return to the breeding grounds at the end of their first year and probably breed for the first time when they are a year old.

Weights

The average weights of adults fell between September and October, and the weights of both adults and juveniles rose between October and November. In this period, birds are recovering from the weight loss during migration, and resuming primary moult. The increase in adult weights between October and November suggests that birds have sufficient food available to enable them to complete the later stages of their primary moult without needing to draw upon energy reserves.

The results for February derive from catches in only two periods: 4–7 February 2004 and 23–26 February 2005. The combined juvenile and adult average weight for 23–26 February 2005 (119.7 g) is appreciably greater than that for 4–7 February 2004 (101.9 g). There is no evidence that feeding conditions in late February 2005 were especially good, and it seems likely that birds remained at the coast only because the feeding conditions were poorer than usual

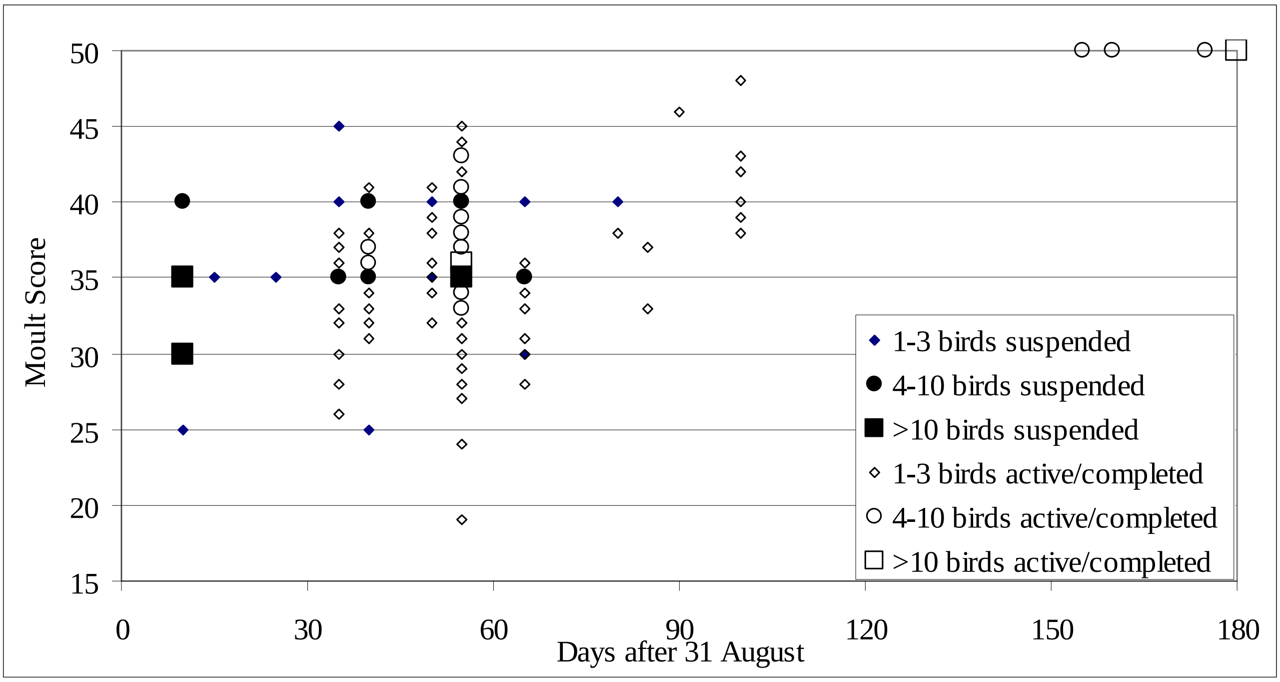

Figure 5. Distribution of moult score by date.

inland. Indeed, February 2004 was probably the better year for feeding on the coast; a plague of locusts attracted exceptional numbers of Oriental Pratincoles *Glareola maldivarum* to the area (Sitters *et al.* 2004). It is therefore likely that the high weights apparent in February 2005 (with peak weight of 153 gm) are part of the normal progression from the relatively low weights during the October-January period, when most birds are also moulting, towards the departure weights reached before migration in March. The average rate of weight gain in February for adults and juveniles combined over 19 days is 0.77% (SD = 0.14 % pts). This is of the same order of magnitude, perhaps on the low side, as those recorded for coastal waders prior to migration from north-west Australia (Barter & Minton 1998).

Average departure weights in March are likely to be at least 130 g, about 44% above the likely average arrival weight of about 90 g. This is a smaller increase than the typical 50–80% weight gain achieved by most of the wader species in north-west Australia before their northward departure for Siberia (Barter & Minton 1998). Using the models of Summers & Waltner (1979) and Castro & Myers (1989), and assuming migratory flight at 70 km/h and departure weights in the range 130–150 g, these weights should be sufficient for a non-stop flight of 3,500–5,000 km and enable at least some birds to reach Vietnam or southern China non stop;

Table 7. Adult primary moult. Underhill & Zucchini Type 2 model results. Parameter estimates (standard errors) are in days. Days is the number of days after 31 August.

Sample sizes		Parameter estimates			End Date
In moult	Completed moult	Days to grow 1% of feather mass	Mean End day	S.D. End day	
139	63	1.864 (0.108)	167.6 (4.76)	21.7 (1.47)	15 Jan

Table 8. Estimated dates for the resumption of primary moult depending on number of primaries replaced in suspended moult

Number of primaries		% of Primary feather mass to be grown	Duration (days)	Estimated resumption date
Already replaced	To be grown			
5	5	72.6%	135	2 Sep
6	4	62.1%	116	21 Sep
7	3	49.4%	92	15 Oct
8	2	34.8%	65	11 Nov

other birds may need to make at least one stop on their migration between north-west Australia and the Asian mainland.

Primary Moult

All adults arrive in Australia in suspended moult, having already completed a substantial part of their primary moult elsewhere. Of waders caught on The Wash in England, the only species for which advanced suspended moult is found is the Grey Plover which regularly suspends primary wing moult at the end of October with between one and three primaries still to be moulted, and then resumes primary moult the following March/April (Branson & Minton 1976). For Grey Plover, the need to put on pre-winter fat deposits is a priority, requiring some birds to suspend their primary moult at the onset of cold weather. In the case of Oriental Plover, however, their relatively late arrival in Australia, probably related to the availability of food, requires them to carry out much of their primary moult either on the breeding grounds or at unknown stop-over locations somewhere in Asia.

Following the resumption of wing moult in October – November, there is normally only one feather growing at a time. This is in contrast to the position for waders occurring in the northern hemisphere, where birds with seven fully-moulted inner primaries will often have 2–3 feathers in active growth, but where they are under pressure to complete their moult rapidly ahead of the onset of winter (Branson 1981). In the case of Oriental Plover, however, moult does not need to be completed until mid January, at which point energy is needed for the birds to put on weight to fuel their northward migration.

Few juvenile Oriental Plovers undertake any wing moult in Australia, in contrast to the position for other wader species which spend the northern winter in Australia where the replacement of at least a few outer juvenile primaries commonly occurs, and sometimes the whole wing (Marchant & Higgins 1993). A possible reason is that, because juvenile Oriental Plover do not arrive in Australia until November and leave in March, they have less time available than most other species to carry out any primary moult. Moreover, first-year Oriental Plover are likely to begin their first full primary moult as early as July, in line with adults, so they do not have to retain their juvenile feathers for as long as juveniles of high Arctic breeding species which may not begin to replace their primaries until the second November of their life.

Conservation

For part of each year, soon after their arrival in Australia at the end of their southward migration, the majority of the world population of Oriental Plover is critically dependent on the grassland habitats of Anna Plains Station and elsewhere adjacent to Eighty Mile Beach and Roebuck Bay, Broome. It is important that these areas be maintained in a condition which is suitable for Oriental Plover feeding. Research is needed to determine the grazing regime which will realise this condition.

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AN ASSESSMENT OF SHOREBIRD MONITORING IN QUEENSLAND BY THE QUEENSLAND WADER STUDY GROUP

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The Queensland Wader Study Group (QWSG) will be one of the groups active in any reinvigoration of a national wader population monitoring program (PMP). One of its main objectives has been to undertake an extensive regular wader counting program since it was formed in 1992 as a special interest group of the Queensland Ornithological Society. Counters make monthly counts at roost sites along the Queensland coast, mostly in the south-eastern corner, especially around Moreton Bay. Given this distribution of counters, what species of wader can the QWSG realistically monitor?

To answer this question, we examined the QWSG count database and summarised the distribution and frequency of counts in different regions of Queensland and compared these patterns with the distribution of important wader populations in Queensland. There are 13 species of wader with more than 10% of their Flyway or Australian population found in Queensland. Of these, eight are most abundant in the Gulf of Carpentaria. Effective monitoring in the Gulf of Carpentaria is impractical due to the major logistical challenges of making regular counts at multiple roosts in this remote region. However, QWSG may be able to monitor populations of species that are abundant along the east coast of Queensland.

At the end of September 2006, the QWSG database had over 165,000 records from 14,800 separate counts made at 940 roost sites in Queensland. When these counts are grouped by region, we found that 68% were made in south-eastern Queensland and a further 10% in the Hervey Bay-Great Sandy Strait region. In these two regions, there are nine species of wader that occur in internationally or nationally significant numbers (more than 1% of the Flyway population). It will be important to monitor these species (Bar-tailed Godwit, Whimbrel, Eastern Curlew, Common Greenshank, Terek Sandpiper, Grey-tailed Tattler, Pied Oystercatcher and Pacific Golden Plover) as part of a national PMP. However, only four species were counted at more than five roosts being monitored by QWSG. All these roosts are in one region (south-eastern Queensland).

To increase the coverage of the important wader species, QWSG will need to encourage new members to count at known roosts with substantial populations of important species currently under-represented in counts; these include Common Greenshank, Terek Sandpiper, Pied Oystercatcher and Pacific Golden Plover. Coverage of entire systems of roosts will be logistically impractical as most are large, with many roosts that are difficult to access. As a compromise, we need to improve our understanding of seasonal and local use of different roosts by these key species. This will help interpret the data already collected by the current count program and improve the accuracy of population estimates and detected trends.

INTRODUCTION

Several international treaties, including the Ramsar and the Bonn CMIS Conventions, have objectives to sustain populations and ranges of waders and other waterbirds. An effective population monitoring program is needed to assess the fulfilment of these objectives and guide management actions. Governments in Australia do not have the capacity to monitor wader populations that are spread around the coastline and throughout the interior. Most of the monitoring of wader populations in Australia has been done by local non-government organisations (NGOs) such as the Australasian Wader Studies Group and regional groups. These groups rely on a large number of dedicated volunteers who vary in their abilities and enthusiasm and the coverage and frequency of counts at each site can vary over time. This variability directly affects the capacity of the groups to collect suitable information that can be used for statistical assessment of wader population trends.

One of the most active regional groups is the Queensland Wader Study Group (QWSG). It was formed in 1992 by a small group of wader enthusiasts under the leadership of PD. An objective of the group from its inception has been to undertake regular monitoring of wader populations in Queensland. To meet this objective, QWSG set up a monthly wader high tide roost count program and this has run ever since. However, the count data collected have not been assessed to determine if they are capable of detecting trends in populations of individual species. Counts are made at selected high tide wader roost sites on the spring high tide each month. Most roosts monitored by QWSG are in south-eastern Queensland, but QWSG has members along the Queensland coast (over 5,000 km) who submit counts as part of this program.

In this paper, we will (a) examine the temporal and spatial coverage of the QWSG monitoring program and review its current status, (b) make a preliminary assessment of the strengths and weaknesses of the program for providing estimates of trends in abundance and total population estimates of the most common species of wader in Queensland, (c) identify those species of wader whose populations can be effectively monitored in Queensland with this program, and (d) suggest changes to the program that could improve its ability to assess the status of wader populations and help contribute to an enhanced national wader monitoring program.

QWSG COUNT PROGRAM

The QWSG count program has three key people who are important to its maintenance and data quality. The person with the most critical role in the success of any count program is the count coordinator. For QWSG, this has been Ms Linda Cross for the last eight years. In this capacity, Linda is responsible for checking the accuracy of counts as they arrive from the counters and following up with any that may be unusual or possibly contain a mistake. She also keeps in regular contact with most counters to hear about how their site is going and make sure the count sheets are submitted shortly after counting. New members and potential members can be helped with their wader identification skills by more experienced wader experts at wader identification days. These training days are the only regular QWSG group activity and are usually very popular. The interest and skills of new people are assessed during training to ascertain their potential for participating in the regular count program. Once their counting skills are established, new counters are allocated a site close to their home. Count dates are identified early in the year and publicised in the QWSG newsletter “Queensland Wader”. This appears quarterly and in it Linda provides feedback to counters of interesting or unusually high wader numbers as well as band recoveries of locally-banded waders and Queensland records of birds banded elsewhere. All these activities help substantially to encourage the continuing participation of counters and enhance a sense of contribution to a worthwhile cause.

The other key people are probably less influential to the success of the program. These are the data entry person and the database manager. Both are important if counters are to get regular feedback on the overall status of the populations they are contributing to monitoring.

QWSG Count Program coverage

The distribution of counts from the QWSG count program is biased towards south-eastern Queensland where the majority of members live (Table 1; Fig. 1). Over three quarters of all counts in the database have been made in south-eastern quarter of Queensland (Hervey-Wide Bay and south-east Queensland) and the level of effort declines with distance from the main population centre in Brisbane. The distribution of counts is also not strongly related to the distribution of waders. The moderate sampling effort in the Gulf of Carpentaria, where the greatest numbers of waders occur (Driscoll 1997a), has been largely made during a single extended project led by PD in 1997–2000.

In order to have an effective national wader monitoring program that is capable of assessing trends in the abundance of the majority of species, counts need to be made regularly in areas where the majority of the population occurs. In Queensland, there is a poor correlation between the distribution and intensity of counting effort and bird abundance for many species (Table 2).

IMPORTANCE OF QUEENSLAND WADER POPULATIONS

Driscoll (1997a) summarised counts of 24 of the 36 migratory and 18 resident species of wader that regularly occur in Australia (Priest *et al.* 2002). Of these, Queensland contained more than 10% of the East Asian–Australasian Flyway population of nine species (Table 2). The majority of these species were most abundant in the south-eastern Gulf of Carpentaria. Queensland populations of a further five species were more than 10% of the estimated Australian population. This gave a total of 13 species that occurred in

Table 1. The regions of the Queensland coast identified by Driscoll (1997) and the number of sites and counts of waders recorded from that region in the QWSG database as of September 2006. * = includes counts made on offshore islands. Percentages of the total count and the mean number of counts/site are given in brackets.

Region	Code	Latitude range (ºS)	Longitude range (ºE)	Start	Finish	Number of sites (Mean counts/site)
Gulf of Carpentaria	GOC	15.0–18.9	< 141.8	May 95	May 05	40 (6)
Central W Cape York	CWC	11.8–12.6	141.8–142.0	Aug 01	Aug 01	3 (1)
Cape York*	CY	<13.5	142.0–143.7	Mar 86	Apr 03	82 (2)
Princess Charlotte*	PCB	13.5–14.0	143.7–144.5	Mar 86	May 95	14 (4)
Cooktown*	CKT	14.0–16.0	144.2 –145.5	Oct 81	Jul 97	37 (3)
Cairns	CNS	16.0–18.0	145.5– 46.2	Feb 94	Apr 05	11 (18)
Townsville	TOW	18.0–19.0	146.0– 46.4	Oct-95	Jul 99	13 (2)
Upstart	CUP	19.0–20.2	146.4– 48.5	Oct-93	Apr 06	48 (10)
Central coast	CEC	20.4–22.0	148.5– 49.5	Apr-88	Jul 06	118 (8)
Shoalwater	SLW	22.0–23.0	149.5– 50.8	May-94	Jan 05	135 (1.5)
Curtis coast	CUC	23.0–24.5	150.8– 53.0	Nov-85	May 06	82 (10)
Hervey-Wide Bay	HWB	24.5–26.0	151.0– 53.0	Jan-88	Jul 06	104 (14)
South-east	SEQ	26.0–28.2	>153	Mar 92	Jul 06	190 (52)
Inland freshwater	INL	All	All	Jan 93	Dec 05	76 (1)
TOTAL				**Mar 86**	**Jul 06**	**940 (16)**

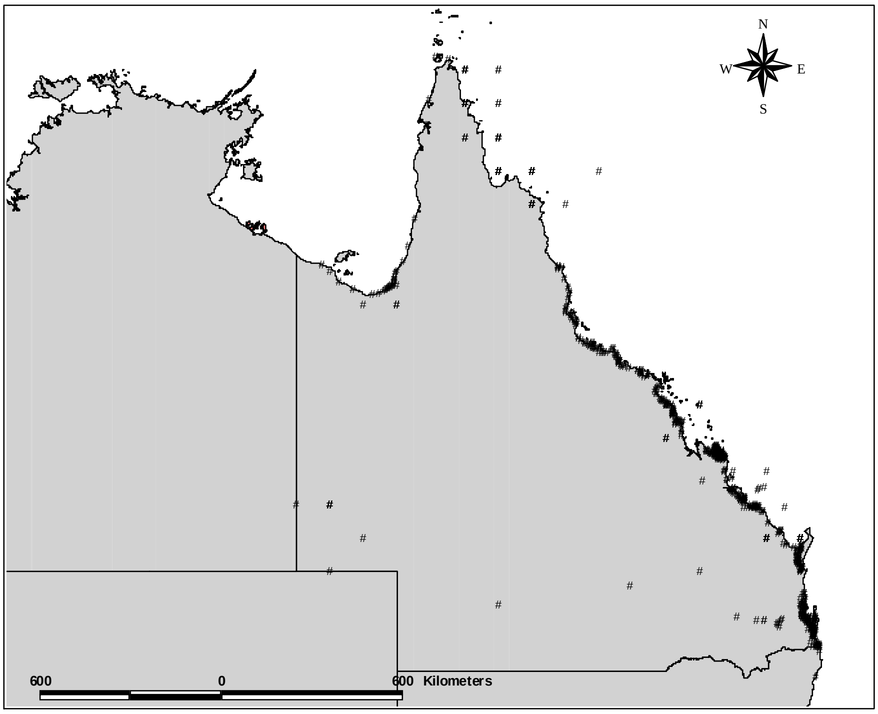

Figure 1. Map of the locations of wader roosts in the QWSG count database.

Table 2. The percentages (%) of the total estimated Queensland population of the 24 most abundant wader species (from Driscoll 1997) that occur in regions with more than 5% (750 counts) (Table 1: SEQ, HWB, CUC and CEC) and where these counts have been made across the entire period of the QWSG count program. The significance of the Queensland population is based on comparisons with national (Watkins 1993) and Flyway estimates (Bamford and Watkins 2005) (NAT = nationally significant: >10% of national population estimate; INT = Internationally significant: > 10% of East Asian-Australasian Flyway estimate [EAAF]; ns = not significant). Species in **bold** are those with a significant Queensland population that is found in substantial numbers in the four regions where there is potentially adequate survey coverage to undertake an assessment of population trends.

Species	**SEQ (%)**	**HWB (%)**	**CUC (%)**	**CEC (%)**	**Region where most abundant (%)**	**Significance of Qld population**
Black-tailed Godwit	0.6	< 0.1	< 0.1	0.6	GOC (92.0)	INT (34% EAAF)
Bar-tailed Godwit	**34.1**	**29.8**	**5.6**	**8.2**	**SEQ**	**INT (15% EAAF)**
Whimbrel	**12.7**	**19.4**	**3.6**	**2.7**	**SLW (42.0)**	**INT (31% EAAF)**
Eastern Curlew	**25.6**	**34.3**	**8.3**	**4.0**	**HWB**	**INT (49% EAAF)**
Marsh Sandpiper	5.4	1.8	3.4	1.4	GOC (80.7)	NAT (19% Aust)
Common Greenshank	**11.2**	**24.5**	**8.3**	**3.0**	**GOC (33.8)**	**NAT (22% Aust)**
Terek Sandpiper	**8.3**	**22.6**	**3.4**	**4.4**	**GOC (24.5)**	**INT (23% EAAF)**
Grey-tailed Tattler	**24.3**	**42.6**	**4.9**	**2.7**	**HWB**	**INT (45% EAAF)**
Ruddy Turnstone	24.9	3.2	0.9	21.4	GOC (26.6)	ns
Great Knot	1.6	1.7	0.3	6.8	GOC (71.2)	INT (24% EAAF)
Red Knot	1.2	5.4	< 0.1	3.2	GOC (79.5)	ns
Red-necked Stint	2.5	4.5	2.2	2.3	GOC (72.2)	INT (18% EAAF)
Sharp-tailed Sandpiper	5.2	5.6	1.9	9.6	GOC (43.2)	ns
Curlew Sandpiper	21.3	6.5	4.2	0.7	GOC (57.0)	ns
Broad-billed Sandpiper	0.1	< 0.1	< 0.1	< 0.1	GOC (93.8)	ns
Pied Oystercatcher	**29.5**	**15.0**	**6.9**	**11.2**	**SEQ**	**NAT (32% Aust/EAAF)**
Black-winged Stilt	11.3	7.4	3.4	15.9	GOC (31.7)	ns
Red-necked Avocet	31.4	< 0.1	3.0	0.1	GOC (41.0)	ns
Pacific Golden Plover	**6.0**	**20.4**	**0.2**	**4.1**	**GOC (43.3)**	**NAT (51% Aust)**
Grey Plover	14.0	14.3	2.3	7.5	GOC (45.7)	ns
Red-capped Plover	3.3	9.4	2.4	2.5	GOC (57.2)	ns
Lesser Sand Plover	**11.2**	**10.7**	**2.6**	**10.3**	**GOC (29.6)**	**NAT (84% Aust)**
Greater Sand Plover	5.9	4.4	3.9	2.9	GOC (64.3)	ns
Masked Lapwing	9.9	20.0	5.0	8.2	HWB	ns

Queensland in nationally or internationally significant numbers, based on the arbitrary 10% criterion (Table 2: Black-tailed Godwit, Bar-tailed Godwit, Whimbrel, Eastern Curlew, Marsh Sandpiper, Common Greenshank, Terek Sandpiper, Grey-tailed Tattler, Great Knot, Red-necked Stint, Pied Oystercatcher, Pacific Golden Plover and Lesser Sand Plover). The Queensland populations of these species would need to be monitored as part of any national population monitoring program.

QWSG COVERAGE OF WADER SPECIES

The population coverage of the QWSG count program can now be objectively assessed given the list of species that have substantial populations in Queensland (Table 2; Fig. 1). The data show that few species occur in significant numbers in the regions where the majority of the survey effort is undertaken (south-east Queensland, Hervey-Wide Bay, Curtis coast and Central coast). South-east Queensland and Hervey-Wide Bay were the only regions where there was both good survey coverage and also significant populations of wader species. Nine species of wader had more than 10% of their Queensland population in one or both of these regions (Table 2). The Hervey-Wide Bay region was important for all nine species (boldface in Table 2), whereas south-east Queensland was only important for five species (Bar-tailed Godwit, Eastern Curlew, Grey-tailed Tattler, Pied Oystercatcher and Lesser Sand Plover).

South-east Queensland is also near the southern limit of the eastern Australian distribution of several species that still occur in their hundreds – Black-tailed Godwit, Great Knot, Terek Sandpiper and possibly Grey Plover. Some of these species have already shown a recent decline in their detection rate during the Australian Bird Atlas (Barrett *et al.* 2003). Thus, monitoring local populations of these species may also be of benefit as changes in the flyway population are more likely to be detected at the extremes of the species' distribution (e.g. Eastern Curlew in Tasmania: Close & Newman 1984; Reid & Park 2003).

Having established the important species for which the QWSG count data may have adequate coverage, a more detailed assessment of their local coverage within each region is required. There are a large number of potential roosts that have been identified in each region (Figs 2 and 3). However, there are insufficient counters to monitor wader numbers at each roost each month. For monitoring to be comprehensive, entire systems of roosts used by waders need to be counted at the same time (Driscoll 1997b). This would be logistically challenging in south-east Queensland and Hervey-Wide Bay due to the size of each system. A more realistic expectation would be to count groups of roosts that are known to be regularly used by a subset of the birds on different tides or seasons. In this way, a consistent proportion of the regional population could be counted and be representative of the system as a whole. The current QWSG count program covers the major roosts in south-east Queensland of all the key species, except possibly Pied Oystercatcher. The coverage in Hervey-Wide Bay is much less comprehensive and could be a focus region for future expansion of the count program.

Given it will be unlikely that QWSG (and the PMP) can count many complete roost systems, we need to count the birds several times each non-breeding season to estimate the within-season variability. A recent study in the UK has shown quite clearly that a minimum of three counts are

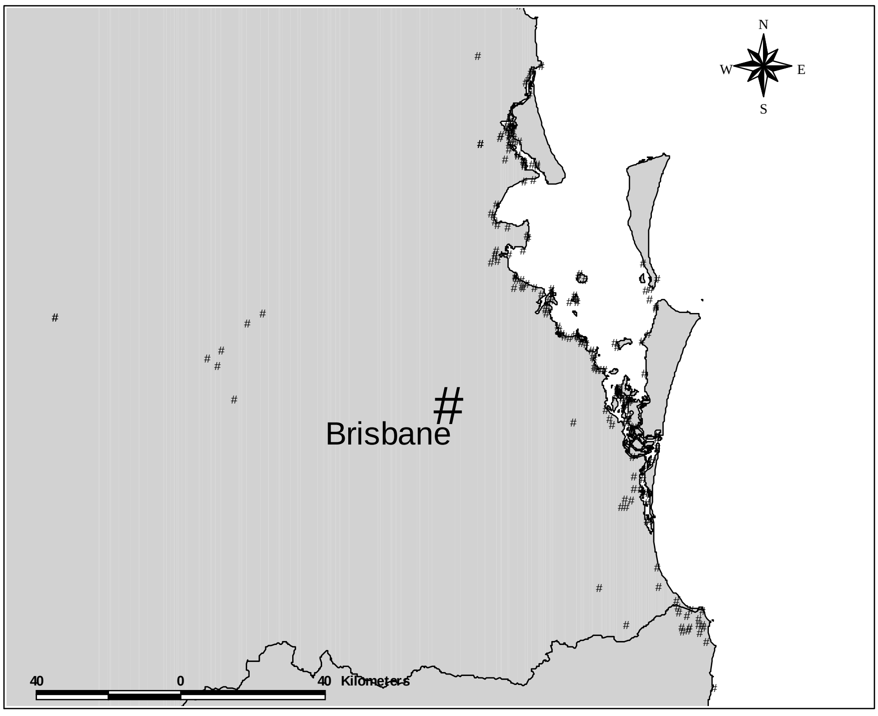

Figure 2. Location of wader roosts in south east Queensland in the QWSG count database.

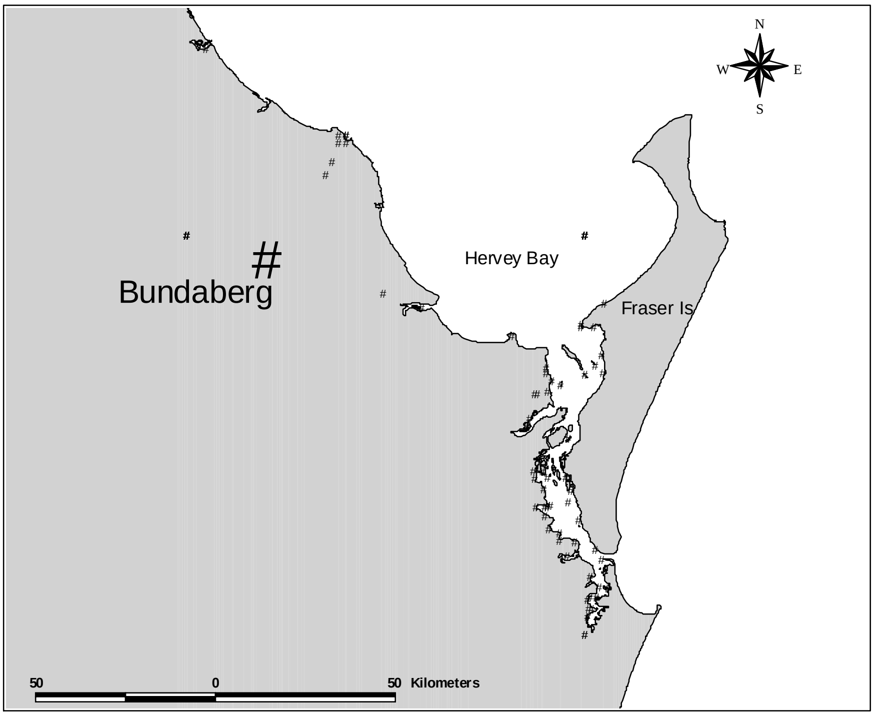

Figure 3. Locations of wader roosts in the Great Sandy Strait region of south east Queensland that are recorded in the QWSG count database.

required within each non-breeding season (summer) for 25 years to detect changes of even 50% in species with low count variability at a site (Atkinson *et al.* 2006). The degree of statistical precision improves as the number of counts increases within a season if six counts are made. For species with greater temporal and spatial variability in their counts, such as Red Knot, the situation was much worse. An 80% decline in the abundance of these species could not be detected after six counts with less than 20% error after 25 years (Atkinson *et al*. 2006). On this basis, the current national PMP of the AWSG with only a single count per season at each site will be unlikely to detect overall population trends with any degree of confidence unless they can count a consistent proportion of the regional population.

Of the nine species with nationally or internationally-significant numbers in south-east Queensland or Hervey-Wide Bay regions, only Bar-tailed Godwit, Eastern Curlew, Whimbrel and Grey-tailed Tattler populations are being counted at multiple roosts (more than 5) in a region where they are abundant and are potentially representative of the population in that region (Table 3). The results indicate that the large populations of Common Greenshank, Terek Sandpiper and Pacific Golden Plover in the Hervey-Wide Bay region are not being effectively monitored at present. If an effective national PMP is to be established, new counters will be needed to monitor roosts of these species in the Hervey-Wide Bay region. Common Greenshank, Terek Sandpiper and Grey-tailed Tattler are extremely difficult to count in the Hervey-Wide Bay region due to their preference for small, widely dispersed roosts in isolated locations that require boat access. A large proportion of the Terek Sandpiper and Grey-tailed Tattler population in Hervey-Wide Bay also roosts in mangrove trees with similar access requirements. Effective monitoring of the populations of these species needs a team of dedicated counters probably with funding support.

Other species with substantial populations in the region such as Pacific Golden Plover and Pied Oystercatcher roost at more accessible sites and could be easily monitored regularly at larger roosts that are currently not counted. Large roosts for these species are known in both Hervey-Wide Bay and south-eastern Queensland and new counters could be encouraged to visit these roosts in preference to others that support larger numbers of species already adequately covered by the existing count program.

There are many reasons for QWSG undertaking a wader counting program, besides the more obvious one to monitor populations. Count data have contributed to wader conservation efforts by NGOs, local and state government by identifying of critical wader habitats, providing activities for members and assessing the relative importance of sites. Ideally, identifying changes in abundance of ± 30% in five years of the nine key species in southern coastal Queensland would be a desirable target. However, this will require at least three counts each summer at five or more sites (Atkinson *et al*. 2006). This target will prove difficult for QWSG to achieve for four of the species with substantial populations in Queensland. This coverage will still not account for regional effects on populations and any detected changes in abundance may only be related to local factors.

Table 3. The number of roost sites in south-eastern Queensland and Hervey-Wide Bay where more than 20 birds of the nine species with significant populations regularly occur during the non-breeding season (Oct-March) that are counted at least 3 times each season during the last 5 yrs.

Species	South-eastern Queensland		Hervey-Wide Bay	
	No. sites	Count frequency/year	No. sites	Count frequency/year
Bar-tailed Godwit	26	3 - 6	4	3 - 7
Whimbrel	20	3 - 6	1	7
Eastern Curlew	14	3 - 6	2	5 - 7
Common Greenshank	2	3 - 5	1	7
Terek Sandpiper	1	5 - 6	2	3 - 7
Grey-tailed Tattler	7	3 - 6	2	3 - 7
Pied Oystercatcher	4	3 - 6	2	3 - 7
Pacific Golden Plover	9	3 - 6	nil	nil
Lesser Sand Plover	3	3 - 6	3	3 - 7

A FUTURE POPULATION MONITORING PROGRAM

The QWSG count program will play a vital role if a revitalised PMP program is going to be successful at obtaining a reliable estimate of the populations of species in internationally or nationally significant numbers in Queensland. The key person in this program is the QWSG count coordinator, Ms Linda Cross. Her dedication to that role, broad knowledge of waders, attention to detail and inter-personal skills have all contributed greatly to the effectiveness of the current count program and the accuracy of the data produced. Any expansion of this coverage to meet nationally-desirable targets in species coverage must take the increased workload into account. Any PMP program needs to consider funding part-time state count coordinators to undertake the recruitment, liaison and data checks at a scale where inter-personal relationships with the counters can be maintained effectively (Driscoll 1997b).

Other changes to the QWSG count program will be needed and these should focus on two aspects: (1) improving the coverage of roost systems in south-east Queensland and Hervey-Wide Bay of key species not well covered by the current program (Common Greenshank, Terek Sandpiper, Pied Oystercatcher, Pacific Golden Plover and Lesser Sand Plover); (2) increase the number of other systems of roosts in other regions of the state covered by the program. This may require promotional work and awareness raising in the targeted regions to recruit additional counters. If these changes can be implemented, the Queensland coverage as part of a national PMP project should be able to detect similar changes in regional wader populations to that in the United Kingdom (Atkinson *et al.* 2006). It will also be a major contribution towards enabling the national PMP to provide a sensitive index of the status of waders that occur in nationally and internationally numbers.

CONCLUSIONS

This assessment shows that the large amount of volunteer effort expended over the last 14 years and almost 15,000 separate roost counts can be used to reliably assess trends in abundance of probably four species. Most species with large populations in Queensland are most abundant in the Gulf of Carpentaria. This region is remote and most roosts are difficult and expensive to access. This makes these birds impossible to count with the regularity needed to assess trends in their abundance.

Nine species of wader occur in internationally or nationally-significant numbers in south-east Queensland or Hervey-Wide Bay where most QWSG members reside. Future expansion of effort by the QWSG should focus on gaining regular counts from additional roosts or groups of roosts, where additional species with large populations in these regions. Specifically, roosts with large numbers of Common Greenshank, Terek Sandpipers, Pied Oystercatchers and Pacific Golden Plover need to be added to the count program. Regular counts from other parts of the state with large populations of these and other species would also be valuable for assessing trends in wader abundance. QWSG has had some success in recruiting new counters in regional areas through the national Shorebird Project funded by the National Heritage Trust. We now have additional counters providing regular data from the Mackay region, where internationally significant numbers of Grey-tailed Tattler and Lesser Sand Plover occur. Further surveys and wader promotion in key regions of the Queensland coast by QWSG could also lead to an improved coverage of species with nationally and internationally-significant numbers in Queensland.

ACKNOWLEDGEMENTS

We thank all the QWSG counters who have undertaken surveys for the group. We give our special thanks to Ms Linda Cross and Ms Joyce Harding who have made such a large contribution to the on-going viability of the QWSG count program.

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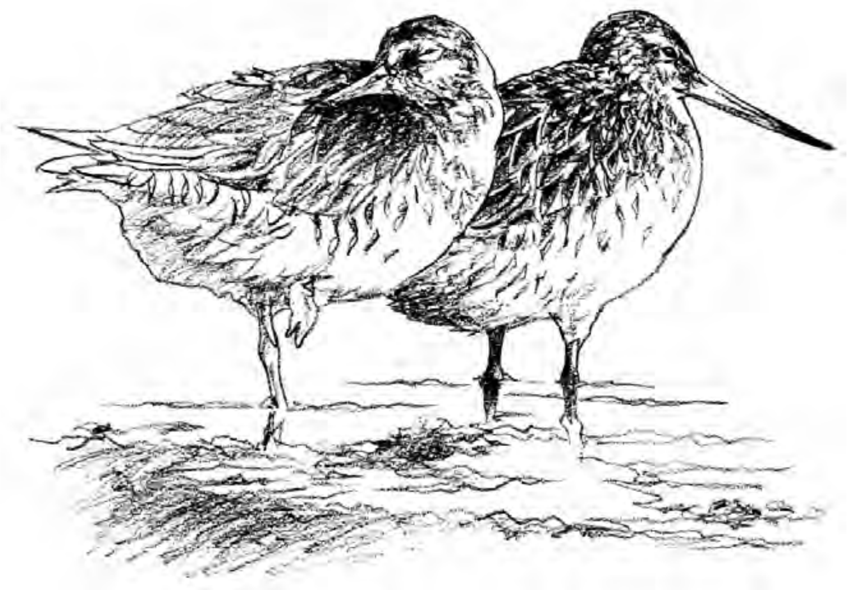

SOUTH AUSTRALIAN WADER STUDIES – AN OVERVIEW

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This overview of wader studies in South Australia comprises contributions from people working in the field who have some connection with the Australasian Wader Studies Group (AWSG). It is biased not only towards the interests of those contributors but to the issues of the day, with the strong slant towards the Coorong reflecting the level of community concern for the health of the Murray/Darling system. It must be remembered that this is only part of the picture of the accumulation of wader data in South Australia. Locations referred to throughout the review are shown in Figure 1.

The AWSG Hooded Plover monitoring program is not included in this review, despite SA being actively involved from its commencement in 1980. The AWSG Population Monitoring Program (PMP) is outlined as part of this review. Of the 33 sites of importance identified by Watkins (1993) only 11 are still being regularly monitored. Others may be being monitored irregularly or informally. One of our challenges is to encourage wader enthusiasts to check their notebooks and share the data they have.

South Australia has five Ramsar sites: Banrock Station Wetland Complex (1,375 ha), Bool and Hacks Lagoon (3,200 ha), Coongie Lakes (1,980,000 ha), Riverland (30,600 ha) and The Coorong, Lake Alexandrina and Lake Albert (140,500 ha). This report only covers two of these, and only one of those in any depth. The important sites of the upper Spencer Gulf are only mentioned briefly, as part of contributions on banding and counting. This is not to imply that there is no research available on the areas of the state not reviewed.

It is hoped that this review will initiate a system that will see the pooling of wader research across the state, regardless of the source of the data. University research, wetlands operated by private enterprise, the SA Department of Environment and Natural Resources, volunteer effort and groups such as the South Australian Ornithological Association, the AWSG and the Victorian Wader Study Group can all contribute to the overall accumulation of accessible data that will provide a solid basis from which informed decisions affecting flyway management can be made.

The overview consists of 15 papers and short notes, referred to as chapters for ease of reference, which conveniently considered in six groups. A brief summary of the chapters is given below.

Eyre Peninsula

1. Jane Cooper describes the counting project she started in 1979. Initially covering a 200 km section of the isolated west coast of the Eyre Peninsula, it has been extended to cover all of the important wader sites of the peninsula. Targeted monitoring of resident species is also undertaken.

Gulf St Vincent

2. David Close makes an assessment of the wader sites within the Gulf. He notes the use of stormwater to create wetlands north of Adelaide. He points to the need for further counting to determine whether an observed decline in the number of palaearctic waders is significant.

The Coorong, Lake Alexandria and Lake Albert

3. Waterbird research in the Coorong region, South Australia: past, present, future: David C. Paton & Daniel J. Rogers. The University of Adelaide is involved in research into many aspects of the Coorong environment.
4. Waterbird Monitoring – The Coorong and Lakes Alexandrina and Albert Ramsar Site, 2001–2004: Russell Seaman. A project commenced in 2001, and ongoing, surveying almost 60 sites along the shorelines of the Coorong, and Lakes Alexandrina and Albert, to determine the species richness and abundance of all waterbird species.
5. The Birdaking Project: Rob Tanner. Shorebird counts in a difficult to access stretch of the Coorong. This project is an example of how an enthusiastic volunteer can contribute to the understanding of an area.
6. Lake Alexandria and Lake Albert: John Eckert. In contrast to the problems of increasing salinity facing the Coorong, the lakes are facing problems caused by the freshening of the system.

The Lower South East

7. Bool Lagoon. A personal look at The Bool, with the sad message that this important wetland has only received water from the Mosquito Creek Catchment once in the last 10 years.
8. Wader Sites of the Lower South East: Maureen Christie. A review of coastal and near coastal sites from the Victorian border through to The Coorong.

Resident Waders

9. Banded Stilt *Cladorhynchus leucocephalus* Breeding at Lake Eyre North in Year 2000: Chris Baxter. A review of the series of breeding attempts at Lake Eyre North in 2000. This breeding event produced about 50,000 young. This is the author's précis of a longer paper of the same name which appeared in the *South Australian Ornithologist*. A small breeding event of 2005–06 in The Coorong is the subject of a separate article in this issue of Stilt (Gosbell & Christie 2006).
10. Declining Hooded Plover population on Kangaroo Island, South Australia: Terry Dennis. Chronicling the

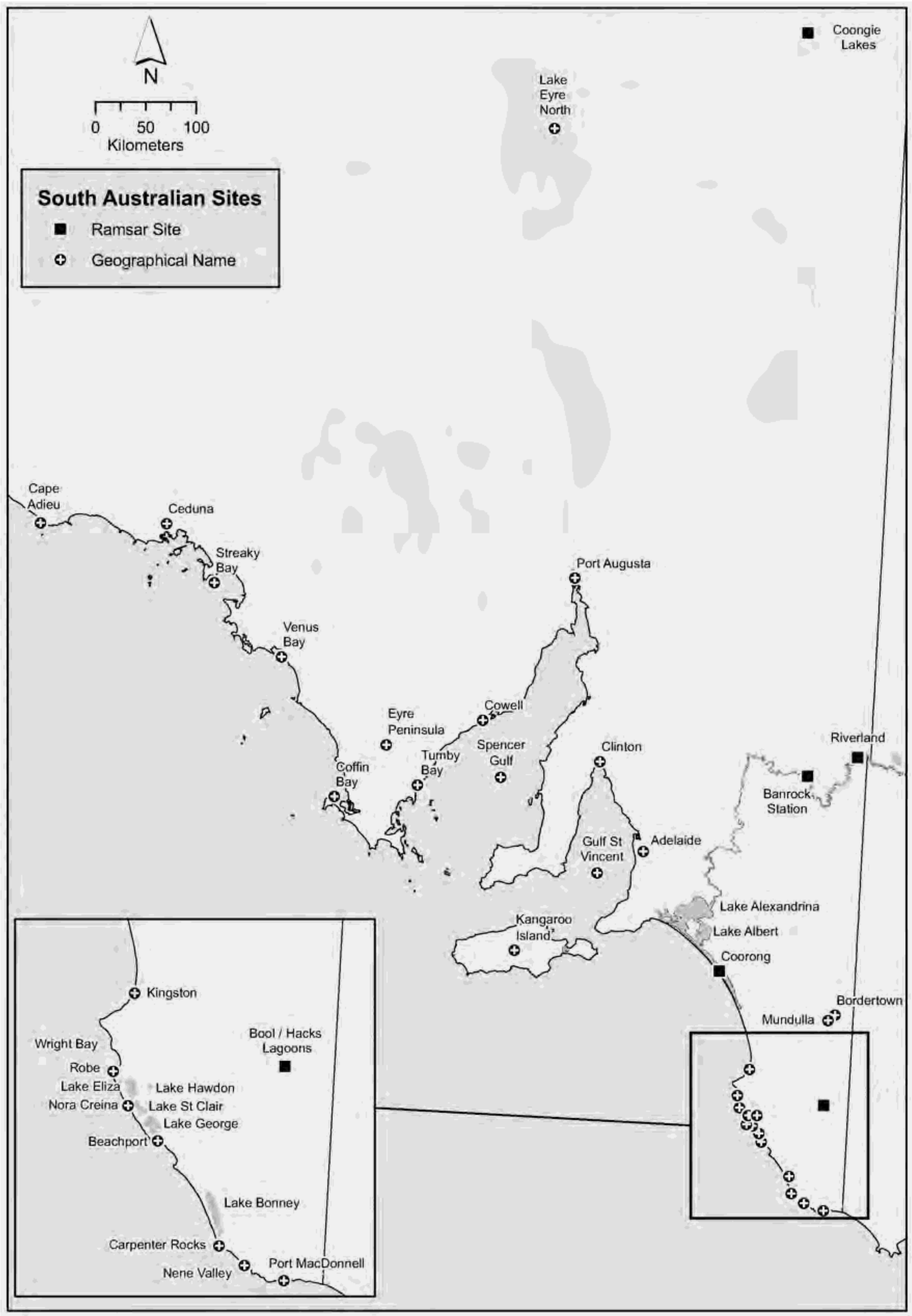

Figure 1. South Australian wader sites.

pressures that beach nesting species are facing along an increasingly urbanised coast. This is the author's précis of Dennis & Masters (2006).

11. Conservation of the Bush Stone-curlew *Burhinus grallarius* in the South East of South Australia: Dan Harley. Incredibly the stronghold of this species in the South East is within the town boundaries of Mundalla and Bordertown.

Research Resources

12. Waders in the collection of the South Australian Museum: Philippa Horton. Museum collections become increasingly important as researchers use modern tools such as DNA analysis.
13. Banding and flagging waders in South Australia: Maureen Christie. A summary of banding activities in South Australia since the commencement of banding here in 1957.
14. The AWSG monitoring program in South Australia: Ken Gosbell.
15. Wader-related references for South Australia: David Edey.

ACKNOWLEDGEMENTS

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CHAPTER 1. EYRE PENINSULA

A CHRONOLOGY OF SHOREBIRD SURVEYS ON THE EYRE PENINSULA

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EARLY YEARS

I first started monitoring shorebirds on the Eyre Peninsula and surrounding areas in 1979 when I moved to Streaky Bay, and was asked by David Close to survey likely shorebird sites in the area for the Australasian Wader Studies Group (AWSG) National Wader Count. I monitored these sites, using AWSG National Wader Count Protocols, a minimum of three times a year over the following 27 years. Results from these counts were used in preparation of Lane (1987) and Watkins (1993). Streaky Bay, Baird Bay, Sceale Bay, Tourville Bay, Murat Bay, Coffin Bay wetlands, Gunyah Beach and Sleaford Bay were identified as areas containing internationally significant populations of at least one species of migratory shorebird (Watkins 1993). Within the Spencer Gulf ten species of international significance and 12 species of national significance were identified by Watkins (1993), making it the highest-ranked site in South Australia for the number of species of international significance.

INCREASING COVERAGE, AWARENESS AND SUPPORT

In 1993 Tod River Estuary, Louth Bay to Tumby Bay and Tumby Bay to Pt Neill were added to the sites visited (Table 1). These sites have a large proportion of resident shorebirds, notably Hooded Plover, and few migratory shorebirds. Two inland sites, Pillana Lagoon and Lake Malata, known to be used by shorebirds, were also added at this time.

In 2000 I was invited to join Jim Wilson's team on Eyre Peninsula (EP) as part of a state-wide count of shorebirds in South Australia (Wilson 2000). As a consequence, I worked at raising the profile and importance of shorebird monitoring on Eyre Peninsula, writing articles, creating interpretive displays and posters for Field Days and forums, and talking to community groups.

In 2002–2003 a further comprehensive count of the Eyre Peninsula was organised by a small group of amateur bird watchers who had submitted data for the AWSG counts in the 1980s; Jane Cooper, Peter Needle, Trevor Cox and Colin Gill. The Ark on Eyre Small Grants Fund (DEH SA) covered our fuel expenses and the purchase of a telescope. That year we counted from Cape Adieu in the Far West, to Franklin Harbour on Eastern Eyre Peninsula. Although one of the aims of the trip was to spend more time counting the Ceduna Bays, many of the sites there are difficult to reach by land and require boat access.

Since 2004 there has been increased support from government agencies, NGOs and local rangers. The 2004–2006 *Resident Sea/Shorebird Nesting Count Venus Bay & Baird Bay* program by the Friends of Streaky Bay District Parks was initiated by the Senior Ranger, South Australian National Parks and Wildlife Service (NPWSA), at Venus Bay Conservation Park, in collaboration with the Friends of Streaky Bay District Parks, and funded by the Wildlife Conservation Fund (DEH SA). The aim is to provide accurate baseline data on the number and location of nesting seabirds and shorebirds, most significantly Pacific Gulls,

Table 1. Sites with two or more incidental visits between 1979 and 2006 (none of these sites are on the BDBSA).

Location	Number of major sites	Years of counting	Number of visits per year
Venus Bay multi-site (6) complex	2	1979–2006	2
Wagunyah CR (coastal)	1	1979–2006	2
Fowler's Bay CR (coastal site)	1	1979–2006	2
Pt Sinclair	1	1979–2006	2
Pt Bell	1	1979–2006	2
Davenport Creek	1	1979–2006	2
Denial Bay	2	1979–2006	2
Murat Bay	3	1979–2006	2
Laura Bay	2	1979–2006	2
Acraman Creek CP	2	1979–2006	2
Anxious Bay (Walker's Rock) (added 2005)	2	1979–2006	2 now 3
Mt Camel Beach	1	1993–2006	2
Sheringa Beach	1	1993–2006	2
Sheringa Lagoon (Round Lake)	1	1993–2006	2
Pt Drummond (Convention Beach)	2	1993–2006	2
Greenly Beach	3	1993–2006	2
Coffin Bay NP	5	1993–2006	2
Tod River Estuary	2	1993–2006	2
Louth Bay to Tumby Bay	4	1993–2006	2
Tumby Bay to Pt Neill	3	1993–2006	2
Pillana Lagoon	1	1993–2006	2
Lake Malata	1	1993–2006	2

Silver Gulls, Fairy Terns, and Pied and Sooty Oystercatchers. Local pest management programs have provided funds to cover vehicle expenses for shorebird monitoring along the coast from Streaky Bay to Coffin Bay in 2005–2006. While these focus on Hooded Plovers, we have increased our coverage of Sanderling populations on the same high energy beaches.

SCOPING THE SHORELINE PROJECT

In early 2006 Birds Australia, in the capacity of its NHT-funded project *Bird monitoring in NRM Regions*, approached the Eyre Peninsula community, the Natural Resources Management Board (NRM) and Government agencies to develop long-term bird monitoring programs to guide decision making in the region. It was decided that a focus on resident shorebirds, and on the threats facing them, would complement existing research and on-ground works, and highlight the need to develop the region's coastal environments sustainably. The Hooded Plover is the flagship species for the *Scoping the Shoreline* project.

There are still no available published data on the level of disturbance impacting on resident shorebirds on sandy beaches on Eyre Peninsula, although there are reliable records of resident shorebirds sharing the popular beaches with locals, tourists and professional fishermen. Although more than 20 years of available survey data (Tables 1 & 2) indicate the location of priority sites for these birds, little work has been formally undertaken to assess breeding success. Now, six coastal communities and 38 volunteers have registered their commitment to this project for a minimum of two years. Volunteer training days were conducted throughout October 2006. Thirty sites from Coorabie to Cowell will be surveyed seasonally.

The overwhelming endorsement of the *Scoping the Shoreline* project by the smaller local coastal communities, and their willingness to contribute, can be attributed to their relationship with the four NRM Officers who live and work in their towns, and who are actively involved in accessing and sharing information and ideas. Their enthusiasm has attracted a much broader range of amateur bird enthusiasts whose general interest in natural history is rarely fostered in locations so far from large regional centres. For the first time in 27 years we have a viable network of amateur birdwatchers living close to the areas they are surveying and keen to learn more!

Table 2. Sites with a visitation rate of two or more visits per year between 1979 and 2006.

Location	No. major sites	No. sub-sites	Years of counting	2006	No. visits/ year	Database
Baird Bay multi-site complex	1 or 2	2	1979–2006	Yes	2	BDBSA
Corvisart Bay	4	2	1979–2006	Yes	3	BDBSA
Sceale Bay CP & Yanerbie complex	2	2	1979–2006	Yes	3	BDBSA
Streaky Bay multi-site complex	2	7	1979–2006	Yes	3	BDBSA
Lake Newland CP multi-site	2	3	1979–2006	Yes	3	

Note: BDBSA = Biological Survey Database South Australia, Department of Environment and Heritage (DEH)

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CHAPTER 2. GULF ST VINCENT

WADER COUNTING IN GULF ST VINCENT

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Gulf St Vincent, in which the metropolitan area of Adelaide is situated, is shaped roughly like an inverted hairpin, oriented north–south, with the bend at the northern end. Port Adelaide is about half-way up the eastern side (34º 50'S, 138º 30'E). The areas most valuable for waders are found from there along 90 km of coast to the northern end, and from the northern end 40 km southward along the western side to Ardrossan (34º 26'S, 137º 55'E). Most sites are legally protected by inclusion in the reserve system of the National Parks and Wildlife Service, by lying within an Army Proof Range, or by lying within the commercial saltfields of Price and Dry Creek (formerly Penrice or ICI).

Other sites are protected by their inaccessibility. One is the artificial breakwater and adjacent sandbank at Outer Harbor, which together form an island. Others further north adjoin impassable mangroves and little-used samphire flats. On the western side, south of Ardrossan, there are scattered sites, of which the most important is Troubridge Shoal, an island 10 km from the mainland. The two main sites for waders in the Gulf (Dry Creek and Price Saltfields) were mentioned by Doug Watkins, on the basis of counts in the early 1980s (Watkins 1993), as the second and fourth most important in South Australia.

Only in February 1981 were all sites in the Gulf counted within two days. This exercise recorded 49,687 overseas migrants (22 species) and 10,795 Australian-breeding waders (8 species). The count was organised by David Close and Roger Jaensch, and the results are summarised in Lane (1987). The results of comprehensive counts in all seasons, in some of the years between 1976 and 1985, of the two main sites and of the third in importance (Clinton Conservation Park), were published by Close & McCrie (1986). A note on Eastern Curlew numbers in South Australia and Tasmania was published by Close & Newman (1984). Since 1985, there have been comparatively few organised counts of the Gulf. The last counts of the main sites were in 2001. Notes of all species frequenting the Greenfields Wetlands (see below) have for many years been kept by their ornithological manager J.B. Cox. Ecological studies have also been completed. One, supervised by David Paton, was produced as a dissertation by Farrelly (1998).

The counts show that the Gulf provides the following: a feeding and roosting ground during the northern winter for many species of Arctic migrants; a staging post during the southern autumn for several Arctic species which are migrating northward; a breeding area for some other species of wader; a southern summer feeding ground for several Australian-breeding species which in the winter and spring are found on freshwater swamps inland; and a feeding ground at all times of year for Banded Stilts and Red-necked Avocets, which breed in inland salt lakes. Various factors combine to make January-early February the period of peak numbers for all species except Banded Stilt and Red-necked Avocet, which may peak in any season. Numbers of the last two are determined by water levels in their breeding sites.

Comparison of earlier and later counts suggests a big decline in numbers of Palearctic migrants. In two counts in January or early February 2000 and 2001, the numbers at the three main sites were only half the average recorded in three or more February counts in 1979–85. (One count on 11 March 2001 at Clinton was included). The recorded decline in numbers of Curlew Sandpipers was somewhat greater than this. The decline in the two saltfields might have been caused by changing management practices; but a similar decline was also recorded in the natural site of Clinton. There is no bias caused by choice of season or difference in counting method to explain the drop in numbers at these three sites.

Only two wader sites in the Gulf are known to have deteriorated since the early 1980s. One is the very minor one of Aldinga Reef south of Adelaide, which has suffered from intensive usage by people, resulting from suburban sprawl. The other is the seasonal freshwater site of Buckland Park (adjoining the Dry Creek Saltfields), less than one kilometre inland from the coast. This has been saved by the government and Adelaide University from the threat of development, but has suffered from a long-term decline in the periodic influx of freshwater down the Gawler River, so that in some years it remains dry. No other possible threats to wader habitat are apparent to this writer. There is some housing development north of Adelaide, at Thompson's Beach and Port Parham, but so far on too small a scale to threaten wader habitat.

On the positive side, wetlands important for waders have been created since 1985 for detention of stormwater immediately north of the Adelaide conurbation. These are partly freshwater and partly saline, and are known as the Barker Inlet and Greenfields Wetlands. A marine site that has expanded is the sandbank adjoining the Outer Harbor breakwater. Measures are being taken to reduce the flow from the metropolitan area of stormwater and treated sewage, a flow which has killed extensive areas of seagrass, and possibly caused the release of silt. Further comprehensive counts of the Gulf are needed to determine whether the decline observed at the three main sites is significant. The counts should be done in the period of peak numbers, January to mid-February.

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CHAPTER 3. THE COORONG, LAKE ALEXANDRIA AND LAKE ALBERT

WATERBIRD RESEARCH IN THE COORONG REGION, SOUTH AUSTRALIA: PAST, PRESENT, FUTURE

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The Coorong and Lower Lakes lie near the mouth of the Murray River, and provide a diverse range of wetland habitats that are used by waders and other waterbirds. The Coorong wetlands consist of a large lagoonal body of water that stretches from the Murray Mouth some 110 km to the southeast along the coast. The lagoon is relatively shallow, rarely deeper than 3 m, can be up to 5 km wide, and is protected from the Southern Ocean by the Sir Richard and Younghusband Peninsulas. Salinities in the Coorong gradually increase from estuarine near the Murray Mouth to hypermarine (saltier than sea water) in the south. As such, the Coorong is an excellent example of a reverse estuary. On the other hand, Lakes Alexandrina and Albert are now permanently fresh and have been since the 1940s, following the construction of the Barrages in the late 1930s. The Barrages prevent freshwater leaving the Lakes and entering the northern Coorong except when the Barrage gates are open. Water levels in the lakes are now maintained at a relatively constant level of around 0.7 m AHD. The Barrages also prevent marine waters moving upstream into the southern sections of the two Lakes, so with the construction of the Barrages the estuarine regions of the River Murray were greatly reduced.

The combination of fresh, estuarine and marine wetlands supports a diversity of waterbird communities and this diversity of habitats and birdlife was the main reason the Coorong and Lower Lakes were listed as a Wetland of International Significance under the Ramsar Convention in November 1985. In the 1980s the Coorong supported large numbers of migratory and endemic waders, various piscivorous birds, including pelicans, terns, grebes and cormorants, as well as waterfowl, particularly teal, shelduck and swans. For example, more than 60,000 Red-necked Stints, 50,000 Sharp-tailed Sandpipers, 40,000 Curlew Sandpipers and 5,000 Red-capped Plovers regularly used the Coorong during summer. In addition, over 70,000 Banded Stilts, 60,000 Hoary-headed Grebes, 50,000 Grey Teal and 7,000 Australian Pelicans used the Coorong in some years, the latter breeding on islands in the southern lagoon. Other significant species included Whiskered, Fairy, Caspian and Crested Terns – the last three species also breeding in the southern Coorong.

Counts of shorebirds using the Coorong commenced in the 1980s. Many of these were summer counts conducted by the AWSG (summarised in Watkins 1993, Jaensch & Barter 1988). The University of Adelaide also counted waders and other waterfowl using the southern lagoon of the Coorong in different seasons during 1984–85. These surveys are especially useful for making comparisons with more recent censuses, and give us the best picture regarding declines in the use of the Coorong by many waterbird species (see below).

In addition to these waterbird counts, a number of researchers have also been interested in other biotic components of the system, many of which have a direct bearing on the quality of the Coorong as waterbird habitat. This research included studies into the physical nature of the Coorong (e.g. Noye 1973), as well as the distribution of submerged aquatic plants, macro-invertebrates and fish fauna along the Coorong (e.g. Geddes & Butler 1984, Geddes 1987). The latter work showed that, as salinities became increasingly hypermarine along the Coorong, the estuarine flora and fauna were replaced by species better suited to the saltier conditions. Other research investigated the performances of key species of fish like the Small-mouthed Hardyhead *Atherinosoma microstoma* to changes in salinity (Molsher *et al*. 1994). Paton (1982, 1986) documented some of the food chains of the water birds in the Coorong, and Paton *et al.* (2001) also investigated relationships between migratory waders, mudflats and aquatic food resources in the estuarine regions of the Coorong.

Other research investigated the potential for human recreational activities (various types of boating, as well as walking along the shore) to disturb waterbirds, including shorebirds in the Coorong (Paton *et al*. 2000). Buick & Paton (1989) deployed artificial nests and estimated that off-road vehicles driving along the ocean beach of Younghusband Peninsula had the potential to destroy at least 80% of Hooded Plover nests on the beach. This led to a seasonal closure of an extensive section of the ocean beach during the plover's breeding season.

In the mid- to late 1990s, monitoring programs were established for key assets – including birds – that might be affected by the influx of freshwater into the hypermarine southern Coorong from the Upper South East Drainage scheme. The scheme had Federal Government approval to release a ten-year rolling average of up to 40 gigalitres of freshwater annually into the southern Coorong. There were concerns that doing this could ultimately lead to freshening the southern Coorong to such an extent that much of the hypermarine systems of the Coorong could be lost (e.g. Paton 2000, 2002a). There were also concerns that the water coming off agricultural land could bring significant nutrients and also small levels of pollutants (e.g. heavy metals) that might accumulate in the Coorong. Some of the aquatic invertebrates inhabiting the southern Coorong are sensitive to small amounts of these pollutants (Brooks *et al.* 1995). The extent to which this could happen depends on the volumes that were released. To date the volumes are typically around 10 GL and, although dampening the salinities in the immediate vicinity of the Salt Creek outlet, there are no other measurable impacts.

Counts of waterbirds and waders over the last five years (e.g. Wilson 2001; Gosbell and Christie 2004, 2006a; Paton 2005; Gosbell & Grear 2005) have demonstrated significant reductions in the numbers of shorebirds and other water birds in the Coorong. For example, Gosbell & Grear (2005) report an 80% decrease in the numbers of migratory shorebirds between the early 1980s and 2001 (based on AWSG surveys), particularly for those species for which the Coorong is internationally significant (e.g. Red-necked Stint, Sharp-tailed Sandpiper and Curlew Sandpiper). Other species have also shown significant declines, including Red-capped Plover from 5,700 to fewer than 1,000, and Fairy Tern from 1,500 to 300 (Paton 2005). Even Australian Pelicans have declined dramatically, and in recent years few if any have bred, yet in the 1980s to 1990s several thousand bred annually in the Coorong. These declines in numbers of birds are not unexpected given reductions in key components of the birds' food chains. For example, in the southern Coorong the key aquatic plant *Ruppia tuberosa*, and the key species of fish, the Small-mouth Hardyhead *Atherinosoma microstoma* have almost disappeared (Paton 2005).

The more recent waterbird surveys have also confirmed the global importance of the Coorong to a range of waterbird species. Based on complete annual counts between 2000 and 2006, Paton *et al.* (in prep.) found that 12 waterbird taxa (species or subspecies) use the Coorong at levels of abundance that meet Criterion 6 of the Ramsar Convention (i.e. >1% of the global population is regularly found on the site), and that, for many of these taxa, abundance levels well exceed this criterion. For example, up to 36% of the estimated global population of Banded Stilts were found on the Coorong lagoons in January 2006; while, among migratory shorebirds, up to 21% of the global population of Sharp-tailed Sandpipers have been recorded (based on global population estimates provided by Wetlands International [2002]). The value of the Coorong to shorebirds has also been confirmed by the AWSG censuses (Gosbell and Grear 2005), but the significance of the Coorong is not limited to shorebirds; Grey Teal, and the nationally threatened Fairy Tern, also continue to use the Coorong in significant numbers (Paton 2005).

Much of the recent ecological research in the Coorong has focussed on the links between waterbird habitat and the hydrology of the Coorong and Lower Lakes. Reductions in flow from the Murray-Darling Basin to the Coorong have drastically altered the physical and biotic nature of the wetlands, such that their value as habitat to different waterbird species has changed. The region is listed as one of six Significant Ecological Assets along the River Murray by the Living Murray scheme of the Murray-Darling Basin Commission (Murray-Darling Basin Commission 2005). Reduced flows have a number of impacts, including increasing the probability of the Murray Mouth closing, resulting in the loss of a tidal prism at the northern end of the Coorong, which has serious implications for available foraging habitat for shorebirds (Paton 2002b). Reduced flows also result in higher salinities and alter the seasonality of water depths in the southern Coorong. Higher salinities and the maintenance of inadequate water depths in recent years have altered the food-webs for the Coorong, particularly those of the southern Coorong with the near-extirpation of two key food resources: the aquatic macrophyte *Ruppia tuberosa*, and the only fish species that can inhabit the hypermarine southern lagoon, the Small-mouthed Hardyhead.

For some waterbirds, the loss of these key species has obvious implications for the piscivores that nest in the south lagoon; there are few if any obvious alternative food sources to Hardyheads, while the loss of *R. tuberosa* eliminates the primary food source for waterfowl. However, concurrent booms in populations of Australian brine-shrimp *Parartemia zietziana* and the chironomid *Tanytarsus barbitarsus* make the link between salinity, water depth and food availability more complex than the simple loss of key food species might suggest. Some species of birds have benefited from these changes. For example, Banded Stilts and Red-necked Avocets have not only increased in abundance, they have also bred in the southern Coorong for the first time (Gosbell & Christie 2006b; Paton *et al.* unpubl.).

While the links between Murray-Darling flows and the ecological status of the Coorong are now established, further ecological research is required to predict the response of the Coorong to alternative water management scenarios. As a result, an ambitious multidisciplinary research program (CLLAMMEcology) has been recently established under CSIRO's *Water for a Healthy Country* flagship program. CLLAMMEcology is a collaborative research program between the University of Adelaide, Flinders University, SARDI Aquatic Sciences and CSIRO. Fish and macro-invertebrate biologists, botanists, experts in trophodynamics, ornithologists and modellers are all involved. The ornithologists will be collecting data to predict the responses of key bird species to changing conditions in the Coorong. The aim of the work is to be able to predict the benefits that will accrue if and when water for environmental purposes is returned to the River.

In addition to documenting changes in distributions and abundances of waders and other waterfowl along the Coorong (as has been measured in the past), the foraging performances of the birds will also be documented and used to assess the quality of habitats from a bird's perspective. These changes in behaviour will be linked to measured changes in their food supplies. Such fine-scale measures will become particularly important in determining the response of migratory shorebirds, whose abundance might change as a result of modifications to habitats away from the Coorong (both breeding and staging areas, and alternative overwintering areas).

While the situation for shorebirds in the Coorong continues to look grim, the increased knowledge that will be provided by the CLLAMMEcology project will mean that we at least have the right tools for the community (through its politicians) to make informed decisions on the Coorong's management. Hopefully these decisions will result in the Coorong's restoration as a truly significant, and remarkable, wetland system.

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CHAPTER 4. THE COORONG, LAKE ALEXANDRIA AND LAKE ALBERT

WATERBIRD MONITORING - THE COORONG AND LAKES ALEXANDRINA AND ALBERT RAMSAR SITE, 2001–2004

RUSSELL SEAMAN

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The Department for Environment and Heritage SA, Coorong District, implemented an ongoing intensive waterbird-monitoring program in 2001. Nearly 60 sites along the shorelines of the Coorong and Lakes Alexandrina and Albert are surveyed to determine the species richness and abundance of all waterbird species. David and Margaret Dadd survey the entire length of the Coorong on a fortnightly basis during summer, autumn and spring and on a monthly basis during the winter months. They also undertake surveys at Lake Albert and Alexandrina on a monthly basis in conjunction with John Eckert, who concentrates his survey effort on the north-western sections of Lake Alexandrina. From these data major trends and patterns have been analysed by addressing three different themes that are inherent in the data set, namely: time, space and species.

Table 1 shows that 921,350 birds were observed over the five-year period (2001–2005), averaging 410 individuals per site visit. A total of 78 different species were identified. There has been an overall increase in the diversity of species observed, and an overall decline in the average number of individuals observed, per site visit since 2001. Although the number of birds observed peaked in 2003, the average number of individuals observed per site peaked in 2001, and has been declining, at least until 2005 when there was also a large drop in bird numbers. The increase in species diversity is understandable given the increase in the number of different sites visited over time. The decline in average number of individuals observed per site visit is evident in the aggregated results, but when the data are presented for regions, individual sites and species, and for smaller time increments (i.e. monthly), more complex patterns are revealed.

The most frequently sighted species was Australian Pelican *Pelacanus conspicillatus* (with 1,480 observations). Other frequently sighted species were; Black Swan *Cygnus atratus* (1,332), Whiskered Tern *Chlidonias hybridus* (1,083), Great Cormorant *Phalacrocorax carbo* (859), Great Crested Grebe *Podiceps cristatus* (847), Australian Shelduck *Tadorna tadornoides* (817), and Caspian Tern *Sterna caspia* (777). The diversity and abundance of shorebird species forms an important component of the dataset. Site fidelity is of particular interest and will be examined in detail in the future.

A series of summary reports and one major report are currently in production and will be available later in 2006. Further information on the bird monitoring program is available from Russell Seaman, Coorong Ecologist for DEH on (08) 8555 0139.

Table 1. Summary statistics of bird counts from 2001 to 2005.

	2001	2002	2003	2004	2005	Total
No. of species observed	34	49	68	72	62	78
No. of birds observed	22,750	78,720	359,311	357,928	102,641	921,350
No. of site visits	37	180	893	888	230	2,228
Average no. of birds per visit	615	437	402	403	446	414

CHAPTER 5. THE COORONG, LAKE ALEXANDRIA AND LAKE ALBERT:

THE BIRDAKING PROJECT

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Having the idea is the easy bit! The wind was fresh, there were white caps out in the channel and the guy who was supposed to be doing the project with me hadn't turned up for our first, reconnaissance visit. It was not an auspicious start but the choice was to scrap the project or get on with it. I got on with it!

The research permit from the Department of Environment and Heritage is to provide shorebird counts in the bays and inlets and on the sandbars, along a 13 km stretch of the Coorong's Younghusband Peninsula opposite the Tauwitchere and Ewe Island Barrages, to supplement the official shorebird count which is done from the road running along the top of the Barrages. Many of these bays and inlets are not visible from the barrages so the Birdaking project proposal was to access them by sea-kayak, paddling from Rumbleows Fishing Camp on the Nurrung Peninsula to Mosquito Bay and back, a distance of 27 km.

The Department insisted that every bird count must be accompanied by a ten-digit position reference from a Global Positioning System receiver. Learning to use one was one of the challenges. Having done so we can now provide the department and the project with precise information about where the waders prefer to feed. Over time this information will become comprehensive.

The Birdaking project started in November 2005. I began alone and spent the first three visits learning about the area. It was necessary to find the best routes in and out of the bays and around the sandbars, to work out the best routine to get the job done, as well as to address risk management issues as wild weather is not uncommon in the Coorong. My shorebird identification skills also required some work and the AWSG has been really supportive and helpful here. The system now in place takes us up to Panmurang Point where we drop off camping gear to lighten the kayaks and have an early lunch. Then we begin counting all the way along to Mosquito Bay. The last site is a freshwater pool in the reed beds at the back of this bay favoured by Greenshank. We complete the 17 km day by paddling back to our campsite, set up camp and review the day's observations over a drink and a meal. Rob Martin joined the project for the June survey and a sharp frost that June night didn't put him off!

Next morning we walk into the four small hidden bays behind Panmurang Point and do counts, then pack gear into our sea-kayaks and, weather permitting, count the birds on the sandbars between the camp and Rumbleows Fishing Camp. If the weather doesn't permit, we can get back to the car in about 90 minutes. Because we can get close to the birds we can do these counts using binoculars. There is not enough room in a sea-kayak for larger optics!

CHAPTER 6. THE COORONG, LAKE ALEXANDRIA AND LAKE ALBERT

LAKES ALEXANDRINA AND ALBERT

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There has been a substantial decline in the number of migratory waders frequenting Lakes Alexandrina and Albert at the lower end of the River Murray over the last 50 years. These lakes abut the Coorong and are part of the Ramsar area. Wader movement between the two systems is easy. In the 1960s flocks in excess of a thousand of each of Sharp-tailed Sandpipers, Curlew Sandpipers and Red-necked Stints were frequently encountered, with the latter two often being well represented in winter. Such flocks are not often found now, and Curlew Sandpiper flocks in particular seldom exceed a hundred. Winter numbers are also much reduced. Red Knots which occasionally came in flocks of up to 100 are now seldom seen, and only in small numbers. The Eastern Curlew used to frequent the lakes in some numbers when estuarine and marine crabs were present. After the closing of the Barrages in about 1940 the crabs declined, although some persisted in backwaters and brackish swamps for nearly two decades; however Eastern Curlew have been absent from the lake since the mid-1960s.

There has been a significant loss of area of feeding habitat during this time. In the early 1960s water couch *Paspalum* sp. was virtually unknown in lakeside swamps. The gradual leaching of salt from the brackish lakeside swamps has allowed the steady invasion of this grass into most of the shallow waters connected to the lakes. Most of the former shallow brackish mudflat areas have now been transformed into dense grassland offering little opportunity for wader feeding. Some places are still too brackish to have been invaded and, later in summer when waters too deep for *Paspalum* to survive in dry down to low levels, some significant feeding areas still become available. Heavy grazing slows the spread of the couch, as does retaining salinity in swampy areas. Endeavours to maintain some of the favoured feeding habitat in the Tolderol-Mosquito Point area aids the persistence of a limited wader population in the lakes, but this would probably only be 25% of that which used to use the area in the 1960s. Depressingly, this loss of feeding area will inevitably continue and, if current moves to remove all grazing stock from the lake margins succeed, the process will be accelerated.

One encouraging facet of the situation is that despite the substantial overall decline, several of the rarer species fond of freshwater habitat, namely Long-toed Stint, Pectoral Sandpiper, Wood Sandpiper and Marsh Sandpiper, still maintain a regular presence in the area. Since their numbers were always modest it is not easy to assess the extent of their decline. However Black-tailed Godwits, which appear to favour the lakes for at least part of their seasonal requirement, have declined to probably 30% of their former numbers. The Tolderol Game Reserve and its surrounds is the main area for sighting these rarer species. It is also a site which provides a number of leg-flag sightings. It has the potential to provide a much greater area of prime wader habitat if managed to its full advantage.

It seems ironic that the lakes are suffering from the freshening process which gradually leaches salt and thereby allows greater loss of feeding area, whereas the Coorong is suffering from the lack of freshening flows to decrease salinity and allow a recovery to a state more favourable for waders.

CHAPTER 7. THE LOWER SOUTH EAST
WADERS OF BOOL LAGOON

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Bool Lagoon Game Reserve (3,030 ha) and the adjoining Hacks Lagoon Conservation Park (198 ha) are located midway between Adelaide and Melbourne in the lower South East of South Australia. Both were dedicated in 1967 and are managed by the SA Department of Environment and Heritage. The values of these wetlands were recognised in 1985 when they were listed as a Ramsar site. In 1988 facilities were opened to provide visitors with guided walks on specially constructed boardwalks, a bird hide and viewing platforms. With regular winter rainfall in Mosquito Creek Catchment providing good flows of water into this low-lying marshy area, water birds find breeding habitats and migratory waders summer feeding grounds.

In 1981 keen birdwatchers recorded sightings of unusual migratory waders and large numbers of the regular Sharp-tailed and Curlew Sandpipers, Common Greenshanks and Red-necked Stints feeding on muddy flats. Wood Sandpiper, Marsh Sandpiper, Pectoral Sandpiper, Ruff, Pacific Golden Plover, Grey Plover, Little Ringed Plover and Long-toed Stint were added to the list. The early 1990–91 seasons were very wet and several sightings of Bar-tailed Godwit and Common Redshank were made. Three Australian Painted Snipe were noted in December 1990.

Latham's Snipe can be found from September in most years, preferring the swamps of areas such as Mary Seymour Conservation Park to the open Bool Lagoon feeding grounds. Small numbers of Double-banded Plover are regular migrants, while nomadic Red-kneed Dotterel often feed on mudflats among other waders. Red-capped Plover are fairly common, even on dry swamp beds, but Black-fronted Dotterels cannot be found in great numbers, usually only in pairs around Bool Lagoon.

Since 1996 there has been a decline in the wetlands with below average rainfall, resulting in no flow into Bool Lagoon except in 2004. Consequently the appearance of waders there has been rare and spasmodic. 2006 has been the driest season on record, with no surface water at all.

CHAPTER 8. THE LOWER SOUTH EAST
WADER SITES IN THE LOWER SOUTH EAST, SOUTH AUSTRALIA

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INTRODUCTION

It has long been acknowledged that the 350 km section of South Australian coast from the Victorian border through to the Murray Mouth holds several sites of importance for waders (Lane 1987). The westernmost section of this is The Coorong which is dealt with elsewhere in this review (Paton & Rogers 2006, Seaman 2006, Tanner 2006, Eckert 2006). Recent studies on the movements of Ruddy Turnstones and Sanderling (Shorebirds South East unpublished data) indicate that the remaining 220 km from Wright Bay to the Victorian border need to be seen as a chain of complexes rather than individual small sites. The site, in fact, continues even further to the east – with the sites of significance in the South East of South Australia being contiguous to the Discovery Bay Shorebird Network site in Victoria.

Watkins (1993) identified the following sites as being of either national or international importance: The Victorian site of Discovery Bay (Sanderling, Hooded Plover) and the South Australian sites of Cape Northumberland to Green Point (Sanderling, Ruddy Turnstone, Pacific Golden Plover), Carpenter Rocks (Ruddy Turnstone, Pacific Golden Plover), Canunda National Park (Sanderling), Rivoli Bay (Ruddy Turnstone and Sanderling), Beachport to Nora Creina Bay (Sanderling), Guichen Bay (Sanderling) and Wright Bay (Ruddy Turnstone and Pacific Golden Plover). Adjacent to the coast are a number of lakes and ephemeral wetlands, situated in the corridors between a series of present day and relict coastal dunes, that are also important for shorebirds, including Lake Eliza (Banded Stilt) and Lake George (Banded Stilt, Curlew Sandpiper, Red-necked Stint). Counting as part of the AWSG PMP program has been carried out continuously since 1982 on two sites – Cape Northumberland to Green Point, and Pelican Point. Since 2001 various other sites have also been counted.

Hooded Plover, Red-capped Plover and Pied Oystercatcher breed on many of the beaches. Red-capped Plover also breed on the inland wetlands; and Hooded Plover use some of the lakes as a refuge during winter. South Australia has participated in the national Hooded Plover survey, co-ordinated by the AWSG, every two years during the breeding season since 1980. In addition to this, an annual survey has been carried out in the South East. Started in 1988 by local volunteers, the Beach Users Group, and covering the Victorian Border to the Murray Mouth area, this survey has continued annually until the present, although with a slightly reduced coverage. Reports prepared by Iain Stewart of the early surveys appear in *Stilt* issues nos. 14, 19 and 22. All data collected are lodged with the DEH.

IMPORTANT WADER AREAS

Victorian Border to Cape Northumberland

Although not identified by Watkins (1993) as an important area, the beach from the Victorian border to Green Point has been surveyed opportunistically since 2001. A flock of Sanderling regularly moves up and down this section of coast; for example, 2,000 were seen at the Piccaninnie Ponds outlet on 2 February 2006. The area from Green Point to Cape Northumberland has been counted since 1982 as part of the AWSG Population monitoring project. Watkins (1993) reported a maximum count of 1,106 Sanderling for this area and flocks of over 1,000 are still common. The Sanderling move up and down the coast, presumably reflecting changes in food availability. A favourite feeding location is Brown Bay. It is thought that these Sanderling also feed along Discovery Bay – a flock of 607 was seen at the eastern end of the Bay on 6 October 2005. This flock included at least 18 with SA flags. Movements extend from Discovery Bay to at least Stony Point, with two known roost sites at Danger Point and Stony Point. The relationship of this flock with the flock that uses the beaches of Canunda National Park is unknown. It has been suggested that it may be the same flock. There is a strong possibility that, at the very least, there is a great deal of intermingling and mixing between flocks.

This section remains of international importance for Ruddy Turnstone, with 454 on 10 February 2004. However, recent counts of Pacific Golden Plover usually result in numbers short of National Significance (100) – with 76 in the 15 February 2002 count.

The area is also important for Little Tern, with a small colony nesting regularly at the Glenelg River estuary (Victoria), and nesting at Danger Point in 2004/05, 2005/06 and 2006/07 (Shorebirds South East unpublished data).

Included in this section is the township of Port MacDonnell. A sandy beach which has formed behind the town breakwater is an important site, especially for waders in the non-breeding season.

The whole area, Discovery Bay (Victoria), Green Point, Danger Point, Stony Point, French Point, Port MacDonnell and Cape Northumberland should be considered as one site of international importance.

Cape Northumberland to Carpenter Rocks

The area between Cape Northumberland and Douglas Point is difficult to access and has rarely been surveyed. However, as a flock of 20 Ruddy Turnstone seen there on 4 April 2006 included three with flags, future surveying is planned as part of the site fidelity project. Observations of individually flagged Ruddy Turnstone suggest that the balance of this section, Nene Valley to Blackfellows Caves to Pelican Point to Carpenter Rocks, should be considered as one site and counted together. A subsection of the complex from Pelican Point to Blackfellows Caves has been counted as one site since 1982 as part of the PMP. Watkins (1993) listed this site as internationally significant for Ruddy Turnstone and Pacific Golden Plover. In the expanded section (about 15 km) counts of Ruddy Turnstone exceeding the 1% international criterion are regularly observed, for example 466 on 1 February 2005, 355 on 11 February 2004 and 433 on 20 February 2003. Pacific Golden Plover are also in numbers of National Significance, with 130 on 20 February 2003. A single flock of 120 Ruddy Turnstone on 4 July 2006 underlines the importance of this site, and raises the issue of how we rate the importance of numbers in the austral winter.

This area is of international importance for Ruddy Turnstone and Pacific Golden Plover.

Canunda National Park

The coastline of Canunda National Park continues to be monitored and Sanderling in numbers of International Significance regularly use the beaches, There was a count of approximately 250 on 7 November 2003 and on 10 November 2000 there was one flock of 150 feeding along the water's edge, while a flock of 300 roosted at nearby Pether's Rocks (Iain Stewart pers. comm.). As discussed under the Victorian Border to Cape Northumberland section, there is a strong possibility that Sanderling which use these two areas may be part of the same flock. As the VWSG carries out banding at both sites, future analysis of retrap data should help to resolve the issue.

With the roost site of Pethers Rocks close to a main vehicle access point and the beaches subject to high vehicle traffic, this important area for Sanderling needs monitoring for disturbance during the austral summer.

Lake Bonney, SE

Several sections of Lake Bonney SE are known to support waders when water levels are falling. It has also been suggested that it may be used as a refuge in extremely rough weather. There are insufficient data to inform on how important the lake is.

Lower South East Coastal Lakes Complex (Inland Beachport to Robe)

Watkins (1993) lists two of these lakes with Internationally Important numbers: Lake George for Red-necked Stint, Curlew Sandpiper and Banded Stilt; and Lake Eliza for Banded Stilt. Counting of the lakes as a complex started in 2002 in response to an appeal from the AWSG to establish whether the lakes were being used by Sharp-tailed Sandpipers. Since then they have been counted each summer as part of the AWSG count of The Coorong and South East Coastal Lakes. They have also been counted each winter since then. The Friends of Shorebirds SE have just completed the field work associated with a year-long study of the ephemeral Lake Hawdon South. This consisted of monthly counts coupled with mapping of water levels. These data are yet to be analysed. Most lakes seem to support migratory waders in numbers of National or International Significance (see Table 1). These lakes need to be added to the sites of significance for South Australia.

Future surveys could see this area being extended eastwards to include Mullins Swamp, Lake Frome and Lake Bonney SE.

Canunda National Park to Wright Bay

Watkins (1993) identified four sites of significance in this section: Rivoli Bay (Ruddy Turnstone and Sanderling), Beachport to Nora Creina Bay (Sanderling), Guichen Bay (Sanderling) and Wright Bay (Ruddy Turnstone and Pacific Golden Plover). There are no recent counts available to us.

Stinky Bay, at Nora Creina, remains an important site for both Sanderling and Ruddy Turnstone, with the VWSG regularly banding there. It is now visited regularly as part of the Ruddy Turnstone monitoring project.

There are no recent data for any of the other sites in this section and more information is needed.

Ephemeral salt lakes Kingston to the Coorong

The chain of ephemeral salt lakes between Kingston and the Coorong are usually dry in summer, but provide important winter and spring feeding grounds for a range of species.

Lakes McIntyre and Paranka Lagoon have been counted annually as part of the winter Coastal Lakes count. This site raises the question of the number of waders needed to rank a site as Internationally Important during the austral winter, with 1990 Red-necked Stint at Paranki Lagoon and 1340 at Lake McIntyre on 5 July 2004.

DISCUSSION

The Surveyor-General, George Goyder, described the pre-drainage condition of the 1864 South East countryside, "… from Salt Creek southward, the area of the South East is equal to 7,600 square miles and in every wet season half of that is under water" (quoted in Turner & Carter 1989). Drainage schemes have led to the loss of most of these wetlands. Today there is an awareness of the need to maintain environmental flows, but there is much debate as how best to achieve this. In wet years, large areas of pasture still become inundated throughout the system and become ephemeral wetlands. These areas are often utilized by species such as Sharp-tailed Sandpipers, with 3,000 using Legoes Swamp in January 2005.

Ephemeral wetlands and inland lakes are under constant pressure from drainage, and the lowering of water-tables associated with agricultural and industrial harvesting of ground water mean that less water is available to sustain our wetlands. Conversely, wader habitat in some wetlands has been reduced because of water levels being kept too high.

Challenges

The idea that the area be regarded as a series of complexes, rather than small, individual sites, is helpful because it accommodates the movements of birds between individual roosts and feeding locations within the area. Defining the boundaries of the different wader sites is difficult. When plotted on a map, each site merges into the next one. It is hoped that results from the Ruddy Turnstone engraved flag project will improve our understanding of how the sites relate one to another.

Many sections of the South East coast have not been monitored in recent years. This is not to say that no counts have been made by members of the birdwatching community. Anyone who does have counts, whether for individual species or for complete flocks, is encouraged to submit their figures to help fill gaps in our data base.

Table 1. Recent count results for the South East Coastal Lakes (Gosbell & Christie 2006, Christie unpublished data). National level of significance (NS) calculated using the flyway population in Bamford *et al*. (in press) and the percentage of the population coming to Australia given by Watkins (1993).

Lake	Species	Month of Count	Count	IS 1% criterion	NS 1% criterion
Lake George	Red-necked Stint	Feb-05	8,920	3,150	2,362
	Sharp-tailed Sandpiper	Feb-05	2,818	1,600	1,600
	Banded Stilt	Feb-02	> 60,000	2,060	2,060
Lake St Clair	Double-banded Plover	Feb-04	510	500	300
	Pacific Golden Plover	Feb-03	106	1,000	100
Lake Eliza	Banded Stilt	Feb-05	30,000	2,060	2,060
	Pacific Golden Plover	Feb-06	170	1,000	100
Lake Hawdon North	Double-banded Plover	Jul-05	600	500	300
Lake Hawdon South	Marsh Sandpiper	Jul-05	230	650	65
	Sharp-tailed Sandpiper	Feb-05	6,440	1,600	1,600
Foxes and The Pub Lake	Latham's Snipe	regularly	c. 50	360	360

The Future

A regional shorebird conservation group called Friends of the Shorebirds South East was formed in 2005. This group aims to:

- Continue the current banding, flagging and counting programs;
- Improve public awareness of shorebirds, and issues affecting them;
- Respond to any localised threats, especially those affecting nesting shorebirds;
- Expand the number of sites being counted regularly;
- Seek to have a protocol developed that recognises the importance of over-wintering areas to migratory shorebirds; as some of these birds move to New Zealand in the second year of life the argument could be made that they are staging sites;
- Contribute to local government, NRM Boards and DEH programs by providing information on shorebirds and their needs.

The coastal area in the South East of South Australia is coming under increasing pressure, with land formerly used for farming being subdivided for residential and rural living. With increasing population in coastal areas and increasing tourism, increased pressure on our beaches is putting nesting waders at risk. In addition, urbanisation of the coast makes it more difficult to implement effective fox and feral cat control due to restrictions on bait placement.

One of the consequences of sustained, localized disturbance is that waders may shift to alternative feeding sites. A wader must feed to meet its immediate energy requirements and, if disturbance reduces food intake rate below a critical level, the birds must emigrate or starve (Cayford 1993). The significance of disturbance to roosting and foraging waders in the South East has not been quantified and a project to assess disturbance is being undertaken this summer by Friends of Shorebirds SE, at the initiative of WWF and with the support of the Department of Environment. Two sites have been selected for monitoring – Danger Point and Pethers Rocks, Canunda. Disturbance to nesting shorebirds will also be investigated. It is interesting that, at the artificially created site at the Port MacDonnell breakwater, which is in the centre of town, human disturbance, including dog walking, came first. But, despite these disturbances, waders feed on reefs exposed at low tide, and roost in piles of wrack along the foreshore.

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CHAPTER 9. RESIDENT WADERS

BANDED STILT *CLADORHYNCHUS LEUCOCEPHALUS* BREEDING AT LAKE EYRE NORTH IN 2000

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INTRODUCTION

The Banded Stilt *Cladorhynchus leucocephalus* is an endemic Australian wader that specializes in breeding on small isolated islands in vast ephemeral inland salt lakes. Its non-breeding distribution is mainly coastal and inland South Australia, Western Australia and Victoria (Marchant and Higgins 1993). Total population estimates range from 133,000 (Robinson and Minton 1989) to *c.* 200,000 birds (Marchant & Higgins 1993).

Banded Stilts feed almost exclusively on brine-shrimps *Paratemia* sp., and breed irregularly and intermittently when water conditions are suitable, generally immediately after heavy rains. They typically nest in close-packed colonies numbering thousands on small islands in large inland salt lakes in South Australia (Lakes Eyre, Torrens and Callabonna) and Western Australia (Lakes Grace, Marmion, Ballard, Barlee and others). Generally the clutch is three or four (occasionally two or five) eggs in a sand scrape. One or two days after hatching, the precocious young are escorted to water by adults to begin feeding. They generally form large juvenile crèches with few adults present (Marchant & Higgins 1993).

THE LAKE EYRE BREEDING EVENT IN 2000

From early March to late August 2000, 34 field trips were undertaken to Lake Eyre North (LEN) to monitor and manage the Banded Stilt breeding population for National Parks and Wildlife South Australia (NPWSA). Field work consisted of two main activities: (1) Aerial and ground monitoring of all Banded Stilt movements – particularly those associated with breeding; and (2) Monitoring and managing Silver Gull numbers and gull predation at or near Banded Stilt breeding colonies. Aerial surveys and transportation of field crews to remote LEN islands were carried out using NPWSA Cessna aircraft and a chartered Bell Jet Ranger helicopter.

Banded Stilts started nesting on Hughes Island, LEN, in late February 2000. By the start of April it was determined that Hughes Island was host to *c*. 18,000 pairs of breeding Banded Stilts. Unfortunately, this breeding event failed due to severe predation of stilt eggs and young by 2,000+ pairs of Silver Gulls breeding nearby. Only 322 stilt chicks were observed to reach the water and they were considered to be at high risk of gull predation.

Banded Stilts were observed nesting a second time on Hughes Island on 25 May 2000. About 4,000 stilt nests containing freshly laid eggs were being incubated by adults. Unfortunately, once again hungry gulls were harassing sitting adults and the stilt nests were under constant threat. Large numbers of gulls were ever intent on scavenging stilt eggs to feed themselves and their hungry chicks and runners at the northern end of the islet. The stilt colony was destroyed by gull predation and deserted by 31 May 2000 (pers. obs.). Sadly, this was the second failed Banded Stilt breeding event in year 2000.

NPWSA personnel arrived on Hughes Island one day too late to intervene and protect the breeding stilts. A trial baiting of Silver Gulls was then carried out using alpha-chloralose bread baits distributed within the gull breeding rookery. The purpose of the trial baiting was to gauge the effectiveness of this anaesthetizing narcotic drug in order to be ready to act if a third stilt nesting attempt were to occur. The trial was successful and 270 Silver Gulls were killed; they were buried on the islet.

On 4 July 2000, an estimated 18,000 pairs of Banded Stilts started nesting on Ibis Island, LEN, *c*. 30 km east of Hughes Island. NPWSA acted promptly as it was critical that the stilt nesting succeeded this time. Water levels in LEN were drying up and hence the time left for this opportunist breeder to successfully recruit large numbers of young into its population was running out. During 6–8 July a NPWSA team, assisted by volunteers, prepared and distributed 6,000 alpha-chloralose bread baits into the breeding Silver Gull colony on North Ibis Island. This baiting was enormously successful with most of the gulls present being killed.

Banded Stilt nesting was estimated to have started on Ibis Islet about 27 June and a 19–21 day incubation period meant that first young would appear about 15–17 July. Stilt nesting proceeded without mishap and first chicks were indeed noted in nests on 17 July. The first chicks left their nests for the brine-shrimp–rich waters of LEN on 19 July. This nesting event was monitored very closely by NPWSA and an estimated 50,000 advanced young were dispersed throughout the shallows of Southern LEN (mostly Belt Bay and ABC Bay) by 28 August 2000 (pers. obs.). Dispersal of most adults and young from LEN to permanent wetlands further south started in early September as LEN continued to dry up.

On 27 July 2000, just when the first nesting event on Ibis Island was ending, a second wave of nesting commenced, representing the fourth breeding attempt by Banded Stilts for the year. By 1 August the colony had increased to *c*. 5,000 pairs, but alas the lake dried back very quickly and the breeding stilts abandoned their nests about 11 August 2000.

CONCLUSIONS AND RECOMMENDATIONS

It is generally accepted that maintaining a healthy population of Banded Stilts, which breeds only irregularly on vast ephemeral inland salt lakes, is dependent on achieving outstanding breeding success when the opportunity arises, i.e. during the boom or bust cycle (Minton 1989). The losses inflicted by Silver Gulls on Banded Stilt eggs and recently hatched young at LEN in the year 2000 indicate their predatory capabilities. These events clearly illustrate the magnitude of the problem that conservation managers face in protecting future Banded Stilt breeding colonies from Silver Gull predation.

A Banded Stilt Management Plan and an Action Plan for Banded Stilt Breeding Success, would provide wildlife managers with clear guidelines on how to best manage this species. To achieve this there needs to be immediate and ongoing funding and support for scientific research into this poorly understood species. It may be wise to list this species as nationally vulnerable until further scientific research reveals its exact conservation status.

The reduction and ongoing control of Silver Gull populations at state and national levels would be a major boost to the breeding success of Banded Stilts. Primarily, a Silver Gull Management/Action Plan needs to be developed and implemented to facilitate the successful reduction of Silver Gull numbers artificially inflated by scavenging from rubbish tips, aquaculture, parks and gardens etc.

It is strongly recommended that the conservation initiatives mentioned here are formulated and implemented in the near future. There is a definite need to be proactive in protecting Banded Stilt populations, particularly during sensitive and all important breeding events, to ensure the long-term conservation of this magnificent Australian endemic species.

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CHAPTER 10. RESIDENT WADERS

DECLINING HOODED PLOVER POPULATION ON KANGAROO ISLAND, SOUTH AUSTRALIA

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The importance of beaches as places for human recreation is universally recognised and is culturally embedded in the Australian lifestyle. However, beaches in Australia are rarely recognised as wildlife habitats with intrinsic ecological values. Consequently, adverse changes to beach environments occur due primarily to poor planning and management, resulting in: inappropriate and uncontrolled recreation; degradation from waste and stormwater disposal; invasion by exotic flora; and urbanisation and over-development in the coastal precinct (James 2000). Kangaroo Island is no exception to these trends with expanding residential development on coastal sub-divisions, an increasing population and a growing tourist industry.

In response to sustained destination marketing by tourism operators and the South Australian Tourism Commission, Kangaroo Island is a popular destination for both national and international visitors to South Australia. As a result growth in visitor numbers reached or exceeded 10% per annum between 1992 and 1997 (Manidis Roberts Consultants 1997). There were an estimated 160,000 visitors to Kangaroo Island in 2000/2001, with the majority arriving during the austral spring-summer breeding season of the Hooded Plover. Across southern Australia, beach-dwelling bird species such as the Hooded Plover are declining as a direct result of growing coastal urbanisation and the increased use of beaches for recreation activities (Hanisch 1998; Dowling and Weston 1999).

In the mid-1980s the total Hooded Plover population in South Australia was estimated at around 540 individuals (Bransbury 1987). By 1994, based on national survey data, Natt and Weston (1995) estimated the population at *c*. 470; with more than a third of these being found on Kangaroo Island, the island was considered a significant national refuge for the species (Schulz 1995). However, recent analysis of reliable survey data from the twenty-year period between 1985 and 2004 presents evidence of an alarming downward trend in the Hooded Plover population there. These data reveal an overall decline from 144 adults in 1985 over 45 km of typical habitat to 110 in 2004, with a significant decline in the number of breeding pairs from 62 pairs in 1985 to 47 in 2004 over the same habitat. This represents an overall decline of 1.65 pairs per year, which equates to *c*. 50 years before extinction (Dennis and Masters 2006).

On long continuous beach habitat in South Australia, Hooded Plover nesting pairs were found to be separated by an average linear distance of *c.* 800 m (Bransbury 1991). On Kangaroo Island in the early 1980s, over a 37 km sample of similar habitat, 51 pairs were found separated by an average distance of 724 m. Over this same habitat in 2004 just 35 pairs were found, averaging 1,056 m apart. Not surprisingly, the greatest declines were found to have occurred on the eastern and northern coastlines, where nearly all beaches were rated by Dennis and Masters (2006) as highly disturbed habitats in 2004 (Figure 1). They found localised extirpations had occurred on some beaches there and predicted these to become general within 20 years.

These apparent ongoing trends within the Hooded Plover population on Kangaroo Island represents substantially reduced breeding effort, implying that unless mitigating management strategies are developed and implemented in the near future, the Hooded Plover population on Kangaroo Island will decline further and be found only on remote low-use beaches.

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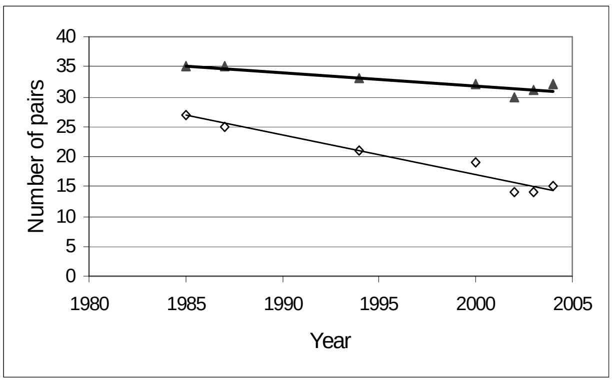

Figure 1. Trends in the number of Hooded Plover pairs on Kangaroo Island between 1985 and 2004, comparing the more disturbed eastern and northern beaches (open diamonds) with the exposed and remote western and southern beaches (solid triangles).

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CHAPTER 11. RESIDENT WADERS

CONSERVATION OF THE BUSH STONE-CURLEW *BURHINUS GRALLARIUS* IN THE SOUTH EAST OF SOUTH AUSTRALIA

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While the Bush Stone-curlew *Burhinus grallarius* is still widespread and common in northern Australia, it has undergone substantial declines throughout south-eastern Australia, to the extent that it is now locally extinct in several districts (Boehm 1960; Mack 1970; Attiwill 1972; Badman 1979; Barrett *et al*. 1994; Smith *et al*. 1994). The principle reasons for the species' decline appear to be predation by the introduced Red Fox *Vulpes vulpes* and destruction of its preferred woodland habitat for agriculture (Johnson & Baker-Gabb 1994; Gates 2001). Other activities that threaten the species include the removal of fallen timber from sites for firewood or 'tidying up', and potentially the use of certain insecticides. To date, few quantitative data have been collected on the impact of these various threats. However, Webster & Baker-Gabb (1994) noted that an increased intensity in farming activities and the removal of fallen timber were key factors in the species' decline in northern Victoria.

Nationally, the Bush Stone-curlew is listed as '*Near Threatened*' (Garnett & Crowley 2000). It is listed as '*Endangered*' in New South Wales and Victoria and '*Rare*' in South Australia (Department for Environment and Heritage 2003; Department of Sustainability and Environment 2003; NSW *Threatened Species Conservation Act* 1995, Schedule 1). In the South East region of South Australia, the species is considered to be '*Endangered*' (Carpenter & Reid 2000; SENRCC 2003). In an assessment of 72 sites in northern Victoria, Webster & Baker-Gabb (1994) found that Bush Stone-curlews disappeared or declined on 71% of private properties over six years (1985–1991). This trend clearly suggests that populations in south-eastern Australia warrant listing on the Commonwealth's *Environment Protection and Biodiversity Conservation Act* 1999.

As a species that roosts, feeds and nests on the ground, the Bush Stone-curlew appears to be particularly vulnerable to predation by the introduced Red Fox. Gates (2001) identified fox predation as the most significant threat to the species on mainland Australia. Notably, stone-curlews have survived in large numbers in several regions supporting feral cat populations but lacking foxes (e.g. Kangaroo Island and northern Australia).

In South Australia, the stronghold of the Bush Stone-curlew is Kangaroo Island, which is estimated to support 1,500–4,000 birds (Gates 2001). The species also occurs on several smaller offshore islands (e.g. Thistle Island), southern Eyre Peninsula, along the Murray River near Berri and in the South East of the state (Gates & Paton 2005). There are also scattered records from inland areas in the vicinity of the Lake Eyre drainage basin (Marchant & Higgins 1993; Garnett & Crowley 2000; Gates & Paton 2005). Figure 1 shows the contraction of the range of Bush Stone-curlew in South Australia.

The species has disappeared from approximately 90% of its former range on the South Australian mainland. Regions where the species appears to be locally extinct include the Lower Lakes of the Murray River near Meningie, the Adelaide Plains, Fleurieu Peninsula, north of Adelaide between Clare, Burra and Eudunda, the Yorke Peninsula, between Port Pirie and Port Augusta, the Flinders Ranges, northern Eyre Peninsula and possibly in the far north of the state (Gates 2001; Gates & Paton 2005).

The substantial decline that the Bush Stone-curlew has undergone across mainland South Australia is also reflected in the state's South East. One early settler to the Tatiara district noted that in the 1880s, 'Curlews were as common as sparrows are today' (Fry 1947). However, during the past 50 years, the stone-curlews have virtually disappeared from the Lower South East, and are now extremely rare and localised in the Upper South East. As few as 12 pairs, and probably no more than 18, may remain across the entire region. Hence, the total population probably comprises fewer than 40 birds. Approximately 97% of their preferred woodland habitat in the region has been cleared for agriculture (Croft *et al*. 1999). The only concentration of birds is in the community parklands of Mundulla and Bordertown, where

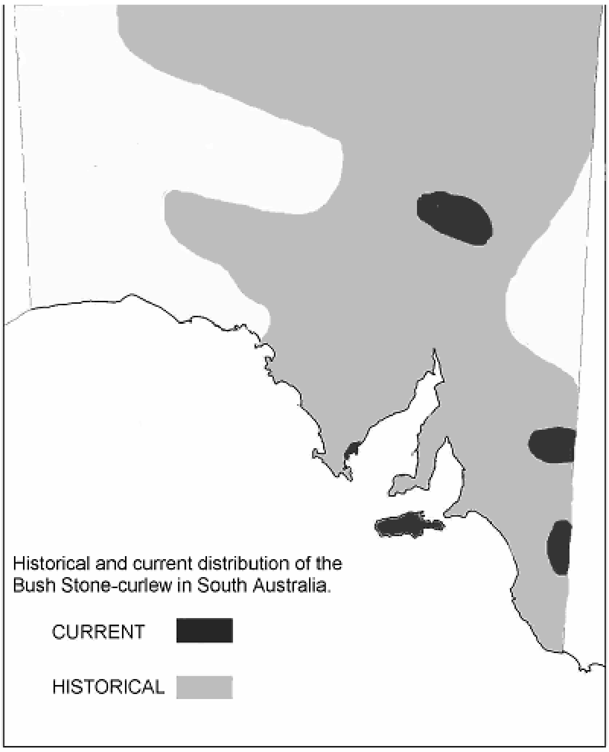

Figure 1. The distribution of the Bush Stone-curlew in South Australia. The species' range at the time of European settlement is marked in grey, and sites where it is still found today are highlighted in black. Distribution is based on records collated by Gates (2001).

approximately 18 individuals survive. A small number of birds also occur on private properties at the outskirts of these towns and at Hynam (to the east of Naracoorte). Very small numbers may also persist in woodland remnants in the Bangham and Wrattonbully districts. In the past two decades, the species has become locally extinct at Custon, Teatrick and Wolsely and, without direct intervention, it is likely to become extinct throughout the region during the next 40 years.

In the South East of South Australia, Bush Stone-curlews inhabit open grassy woodlands characterised by: (i) short grasses and few shrubs (permitting good visibility of their surrounds); and (ii) fallen timber and leaf litter on the ground (providing camouflage). Providing these requirements are met, the species is able to persist in highly modified landscapes, such as agricultural areas retaining some tree cover. In several regions, the species also occurs in close proximity to human habitation (Marchant & Higgins 1993).

Optimal sites for Bush Stone-curlews in the South East have an over-storey of Grey Box *Eucalyptus microcarpa* or Buloke *Allocasuarina luehmannii*. Both vegetation communities are associated with heavy, fertile soils, and thus have been extensively modified and selectively cleared for agriculture. Both vegetation communities are listed as '*Endangered*' in the region, with less than 3% of each remaining (Croft *et al*. 1999). At the time of European settlement, they are estimated to have covered approximately 39,000 ha (Croft *et al*. 1999). Today, they cover less than 1000 ha combined (Croft *et al*. 1999). Notably, there are only 52 ha of these vegetation communities in the region's conservation reserve system (Croft *et al*. 1999). Other potential stone-curlew habitat in the South East includes woodlands dominated by River Red Gum *Eucalyptus camaldulensis* var. *camaldulensis* and Blue Gum *Eucalyptus leucoxylon*, both of which are listed as '*Vulnerable*' vegetation communities in the South East (Croft *et al*. 1999).

The South Australian *Native Vegetation Act* 1991 has largely brought a halt to the destruction of woodland habitats in the South East. Most of the remaining woodland cover in the Bordertown and Hynam districts, where curlews persist, consists of small remnants along roadsides or on private land. The majority of remnants on private land are heavily grazed, and much of the landscape comprises scattered, mature Red Gums amid pasture, with no regeneration of native vegetation.

None of the sites known to support resident breeding pairs of stone-curlews in the South East is protected in the conservation reserve system. Thus, recovery of this species is entirely reliant on off-park initiatives. Most of the remaining pairs occur in community parklands at Bordertown and Mundulla. These sites are managed by Tatiara District Council. It is unclear why the species has persisted better within the townships than in surrounding agricultural areas; however this pattern is also seen at some other localities (e.g. Horsham in western Victoria). Without the support, cooperation and assistance of private landholders, there is little scope to expand the species' distribution into areas formerly occupied beyond Mundulla and Bordertown.

None of the extant populations is presently considered to be viable in the medium to long term (≥ 20 years). Based on the numbers of birds that survive in the region, only one district (Bordertown-Mundulla) presents an opportunity to secure a self-sustaining population in the short-term. Thus, management efforts to conserve the species are being concentrated there.

A low rate of juvenile recruitment is currently thought to be a key factor limiting stone-curlew populations in the South East. Data obtained at Bordertown and Mundulla during Spring 2004 and 2005 indicate that chicks are successfully reared in just 20% of nesting attempts (D. Harley, unpubl.). Just one chick was recruited into the population at Bordertown and Mundulla during the 2004 nesting season, and just two chicks were recruited during 2005. This may be inadequate to sustain the population in the medium to long term, and needs to be increased to at least five young per annum if population recovery is to occur. It should be noted that the species may have always experienced a high rate of nesting failure, but this would not have been a problem in the past when there were far more pairs distributed throughout the landscape.

Seventy-five percent of clutches successfully hatch at least one young (D. Harley, unpubl.). Chick mortality, presumably due to foxes, cats and dogs, appears to be the obstacle limiting recruitment. It has been suggested that Laughing Kookaburras *Dacelo novaeguineae* may also be responsible for some of the chick mortality detected at Bordertown and Mundulla, although this has not been confirmed. Elsewhere, Australian Ravens *Corvus coronoides* have previously been observed to attack unattended chicks (Johnson & Baker-Gabb 1994).

A range of initiatives are currently underway to conserve Bush Stone-curlews at Bordertown and Mundulla. These include: re-stocking sites with fallen timber; maintenance of short grass cover by slashing or pulse grazing; regular fox control throughout the stone-curlew nesting season; protection of nest sites using portable electric fencing; monitoring breeding success and recruitment; colour-banding adults and juveniles; regular community meetings to review progress; production of a newsletter *(The Curlew Crier)*; and regular local media stories and community education. Future activities may include erecting signage around the towns about stone-curlew conservation, the introduction of a cat curfew and a 'dogs on leashes' policy in parkland areas. The Department for Environment and Heritage has prepared a Regional Action Plan for the species in the South East that describes long-term strategies necessary to create the conditions for population recovery in the South East.

In addition to the South East, efforts to recover Bush Stone-curlew populations are also underway in the South Australia's Murraylands, northern Victoria, and southern and central New South Wales. It has had a Flora and Fauna Guarantee Action Statement and a recovery plan prepared for it in Victoria and New South Wales, respectively (Davidson & Robinson 1992; Department of Environment and Conservation NSW 2006). Permanent predator-proof electric fences have been erected for the species at one site in western Victoria and several localities in southern New South Wales. An *in situ* captive-breeding program is also underway in southern New South Wales. In 2001, a trial release of captive-bred Bush Stone curlews was conducted at Venus Bay Conservation Park on Eyre Peninsula. Of 11 birds that were released, just two were known to be alive after 6–12 months had elapsed (Peeters 2003). Seven birds were confirmed to have died, one due to raptor predation, two due to crop impaction caused by feeding on a large quantity of snails, and four by starvation (Peeters 2003).

There is currently no formal recovery team for the Bush Stone-curlew in south-eastern Australia. However, a strong Bush Stone-curlew communication network has been established across New South Wales, Victoria and South Australia, involving landholders, biodiversity officers and university researchers. This is largely due to the efforts of Leanne Wheaton of the Nature Conservation Working Group based in southern New South Wales. 'Curlew Summits' to discuss the species' conservation in south-eastern Australia were held at Albury in 2004 and Rutherglen in 2006.

It is essential that the number of stone-curlews is increased in South Australia's South East for a viable, self-sustaining population to be conserved. This will rely on the successful recruitment of chicks into the population. Given that the species is able to persist within small woodland remnants (< 50 ha) in a partially cleared landscape and breed in close proximity to human settlements, the potential for recovery of this species is high, although it is likely to be a long-term process. Significantly, the species has considerable potential to be adopted as an '*icon species*' in the Bordertown district. A Bush Stone-curlew field day held at Angela and Charlie Goode's property at Hynam in August 2004 (also home to a long-time resident pair of stone-curlews) attracted more than 50 people from the region, highlighting the level of interest in the species.

The effectiveness of actions implemented during the coming decade will probably determine whether stone-curlews will survive in the South East in the medium–long term. Hopefully, in time, the nocturnal cries of the curlew will again be a common sound throughout the Upper South East of South Australia.

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CHAPTER 12. RESEARCH RESOURCES

WADERS IN THE COLLECTION OF THE SOUTH AUSTRALIAN MUSEUM

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The South Australian Museum began collecting zoological specimens from its inauguration in 1856. The Museum then undertook a massive program of exchanges with interstate and particularly overseas museums. It is therefore impossible to assess what waders were collected in South Australia through the remainder of the 19th Century because many would have been exchanged, particularly the resident species. Further specimens were lost in the late 1800s due to poor storage conditions.

From January 1911, however, the Bird Collection became an individual identity, registration of specimens began, and the emphasis changed to building up a good collection of Australian species. What remained of the ‘Old Collection’ was then registered in the 1920s and 1930s, and in the case of the waders this was almost entirely of overseas specimens. These are particularly valuable as many are migratory species in breeding plumage. Collection of waders within South Australia expanded in the 1920s, with the combined efforts of Museum collectors and local private ornithologists. This continued through to the 1970s and early 1980s when Curator of Birds Shane Parker oversaw the filling of many gaps in the collection, and, with the help of several dedicated private ornithologists, focussed collecting efforts into building a significant research collection. Since the mid-1980s relatively few waders have been added to the collection.

The largest component of the wader collection consists of study skins. Spirit-preserved specimens and skeletons are also held. Another significant component is of eggs. Most of these were donated by private collectors, who often obtained migratory wader eggs by exchange with overseas collectors. Most clutches were collected in the late 1800s and early 1900s.

Table 1 gives approximate figures for holdings in the collection of species recorded for South Australia. The figures for skins are of study skins only, not mounted display specimens.

All of these specimens provide distributional data, and the skins are a valuable resource for checking identities, and plumage changes with age and wear. For migratory species they can also allow the study of breeding plumage development, both in overseas skins and those collected in Australia shortly prior to departure for the breeding grounds. The eggs and skeletons provide further information on the biology and relationships of waders, and the skeletons are useful in identifying the fossil wader fauna in Australia. Spirit specimens can be used for anatomical studies.

Numerous species not recorded for South Australia are also held in the collection. For example there are 28 other species of Scolopacidae and 17 other species of Charadriidae, and most of these are represented by skins. They are potentially useful for checking the identity of vagrant species.

For specimens collected since the mid 1970s as much data as possible have been obtained from each specimen. In addition to the basic collecting details, weights and measurements have been made, soft-part colours noted, gonads detailed, and stomach contents retained. These all contribute to the knowledge that can be gained from the collection. Since 1994 liver and muscle tissue samples have been retained from most specimens and these are held in the Museum’s frozen tissue collection. They are available for molecular studies of population structures and relationships. For species not represented in the frozen tissue collection, DNA samples can be obtained from feather bases or toe-pad samples taken from the study skins.

Table 1. Wader species recorded in South Australia, with numbers of specimens held at the South Australian Museum. SA skin = skins collected in South Australia, I/st. skin = skins collected interstate, O/s skin = skins collected overseas, Egg cl = clutches of eggs (all locations), Skel = skeletons (all locations), Spirit = specimens preserved in formalin/ethanol.

Common name	**Scientific name**	**SA skin**	**I/st. skin**	**O/s skin**	**Egg cl**	**Skel**	**Spirit**
Plains-wanderer	*Pedionomus torquatus*	16	9	-	5	8	7
Latham's Snipe	*Gallinago hardwickii*	21	4	1	5	1	0
Common Sandpiper	*Actitis hypoleucos*	3	10	10	18	0	0
Grey-tailed Tattler	*Heteroscelus brevipes*	8	12	2	0	0	0
Hudsonian Godwit	*Limosa haemastica*	0	0	0	0	0	0
Bar-tailed Godwit	*Limosa lapponica*	8	14	0	4	0	0
Black-tailed Godwit	*Limosa limosa*	4	1	2	11	0	1
Eastern Curlew	*Numenius madagascariensis*	10	2	0	0	1	0
Little Curlew	*Numenius minutus*	3	1	0	1	0	0
Whimbrel	*Numenius phaeopus*	1	6	3	7	0	0
Lesser Yellowlegs	*Tringa flavipes*	0	0	2	0	1	0
Wood Sandpiper	*Tringa glareola*	12	0	8	4	0	0
Common Greenshank	*Tringa nebularia*	30	4	6	9	3	1
Marsh Sandpiper	*Tringa stagnatilis*	6	2	3	3	2	2
Common Redshank	*Tringa totanus*	0	0	0	5	0	0
Terek Sandpiper	*Xenus cinereus*	2	0	3	4	0	0
Ruddy Turnstone	*Arenaria interpres*	15	11	8	11	2	2
Short-billed Dowitcher	*Limnodromus griseus*	0	0	3	0	0	0
Sharp-tailed Sandpiper	*Calidris acuminata*	80	27	1	0	8	6
Sanderling	*Calidris alba*	15	0	4	0	7	1
Baird's Sandpiper	*Calidris bairdii*	0	0	2	0	0	0
Red Knot	*Calidris canutus*	14	1	6	0	0	7
Curlew Sandpiper	*Calidris ferruginea*	47	7	6	0	1	6
White-rumped Sandpiper	*Calidris fuscicollis*	0	0	3	0	0	0
Pectoral Sandpiper	*Calidris melanotos*	5	0	5	0	1	1
Little Stint	*Calidris minuta*	2	0	5	0	0	0
Red-necked Stint	*Calidris ruficollis*	115	18	6	0	25	17
Long-toed Stint	*Calidris subminuta*	7	0	0	0	0	0
Great Knot	*Calidris tenuirostris*	7	9	0	0	0	0
Broad-billed Sandpiper	*Limicola falcinellus*	2	0	1	4	0	0
Ruff	*Philomachus pugnax*	0	0	4	0	0	0
Buff-breasted Sandpiper	*Tryngites subruficollis*	0	0	1	0	0	0
Grey Phalarope	*Phalaropus fulicaria*	0	0	3	0	0	0
Red-necked Phalarope	*Phalaropus lobatus*	1	0	4	2	0	0
Painted Snipe	*Rostratula benghalensis*	8	2	2	12	2	1
Comb-crested Jacana	*Irediparra gallinacea*	0	9	0	37	3	0
Bush Stone-curlew	*Burhinus grallarius*	19	5	-	62	16	8
Sooty Oystercatcher	*Haematopus fuliginosus*	22	6	-	31	5	2
Pied Oystercatcher	*Haematopus longirostris*	15	5	-	37	4	2
Banded Stilt	*Cladorhynchus leucocephalus*	54	2	-	63	22	47
Black-winged Stilt	*Himantopus himantopus*	25	7	3	61	2	5
Red-necked Avocet	*Recurvirostra novaehollandiae*	28	4	-	41	10	6
Inland Dotterel	*Charadrius australis*	40	9	-	62	7	8
Double-banded Plover	*Charadrius bicinctus*	29	8	0	8	1	0
Little Ringed Plover	*Charadrius dubius*	0	0	3	0	0	0
Ringed Plover	*Charadrius hiaticula*	0	0	5	12	0	0
Greater Sand Plover	*Charadrius leschenaultii*	5	11	1	0	0	0
Lesser Sand Plover	*Charadrius mongolus*	4	1	8	0	0	0
Red-capped Plover	*Charadrius ruficapillus*	64	11	-	114	11	17
Oriental Plover	*Charadrius veredus*	3	5	1	0	0	0
Black-fronted Dotterel	*Elseyornis melanops*	31	25	0	79	6	5
Red-kneed Dotterel	*Erythrogonys cinctus*	17	14	0	49	2	1
Pacific Golden Plover	*Pluvialis fulva*	10	18	6	2	0	0
Grey Plover	*Pluvialis squatarola*	10	4	7	2	1	0
Hooded Plover	*Thinornis rubricollis*	40	1	-	49	6	0
Masked Lapwing	*Vanellus miles*	68	19	0	108	12	6
Banded Plover	*Vanellus tricolor*	24	8	-	97	7	7
Oriental Pratincole	*Glareola maldivarum*	2	4	1	5	0	0
Australian Pratincole	*Stiltia isabella*	13	5	0	39	7	2

CHAPTER 13. RESEARCH RESOURCES
BANDING AND FLAGGING WADERS IN SOUTH AUSTRALIA

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BANDING WADERS IN SOUTH AUSTRALIA

Most current banding of migratory waders in South Australia (SA) is conducted as part of the Victorian Wader Study Group (VWSG) long term project. Banding is carried out during an intensive week of banding by an annual expedition, and supplemented by an enthusiastic local team based in the lower South East. It is therefore profitable to discuss banding waders in South Australia under two headings; banding and flagging by the VWSG, and all other banding.

ALL OTHER BANDING IN SA

The Australian Bird and Bat Banding Scheme (ABBBS), has kindly supplied figures for banding in South Australia – a total of 6,448 bandings by 39 banders of 36 species. Consultation with individual banders has resulted in this figure being increased to 6,840 bandings by 40 banders. These figures have been used to compile Table 1. Most of this banding was completed pre-1990. Species breakdown is provided for all who banded more than 100 waders.

Highlights are a long term project by Alan Lashmar on Kangaroo Island which started in 1966. Drift fences with walk-in traps were set up over mud flats. Nine species of migratory wader were banded, resulting in two recoveries in Chongming Dao, China – a Red-necked Stint banded 16 February 1975 recovered 15 May 1981; and a Sharp-tailed Sandpiper banded on 29 February 1984 recovered in April 1984. Terry Dennis worked with Alan from 1985 and expanded the work to include colour banding Hooded Plover. Birds for this study were captured by hand, mainly at night. A paper on population trends has been published (Dennis & Masters 2006), and future analysis of the data collected on the 284 colour banded birds should reveal mortality rates as well as insights into pair fidelity and site fidelity.

Max Waterman's 14 species and 2,247 bandings is a significant contribution to the overall total. His banding of a Grey-tailed Tattler in 1964 at the ICI Saltfields, near Adelaide, added this species to the South Australian species list. But most notable were the overseas recoveries of Red Knot banded at Ward Spit, near Port Germein – three from China (Shandong Yantai, Rui'an Zhejiang and Shangdong Shouguang) and two from Russia (Ust Aldanski Yakut Assr and Chita Mogochinsky). A Red-necked Stint banded by Ms K. Shurcliff at the ICI Saltfields in 1979 was recovered in Chongming Dao – the first overseas recovery for SA.

Work on Wally Klau's project in the Upper Spencer Gulf is suspended partly because of access problems, but it remains current. With only 125 Red-necked Stint banded, three recoveries (one in Ta-Tu-Hsi, Taiwan on northern migration and two in Western Port, Victoria) represent an above average return. The movements from South Australia to Victoria fit the migration pattern of birds moving from north-west Australia to south-east Australia (Minton *et al.* 2006).

Bush Stone-curlew have been the subject of several recent studies – Jody Gates has completed a radio-tracking study on Kangaroo Island (Gates 2001) and has just started another study in the Riverland. A project based in the Upper South East is the subject of a separate contribution in this article.

VICTORIAN WADER STUDY GROUP PROJECT

The VWSG extended its long term study on waders in Victoria into the South East of South Australia with the aim of investigating the migratory patterns of Ruddy Turnstone and Sanderling. There was the added incentive that it was difficult to catch sufficient numbers of both these species in Victoria to make an adequate assessment of breeding success. In 1993, on its first visit, 160 Sanderling were caught. This first visit was in response to local bird-watchers reporting Sanderling with Victorian flags. Since then, the annual summer expedition to South Australia has become an enjoyable fixture of the VWSG program. From the beginning, local residents have been involved in a variety of ways – any shortcomings in amenities at Feast's Green Point shack is more than compensated for by the beach being less than ten metres from the door and the hospitality of the Stewarts at Rendelsham is legendary; tales abound of crayfish suppers washed down by copious quantities of red wine provided by Ren DeGaris!

Locals always enthusiastically support the visiting team and in 2000 they began catching in their own right. Adrian Boyle led the first catch on 27 Nov 2000, resulting in a catch of one Ruddy Turnstone (a re-trap) and one Red-necked Stint. The South Australian team is now officially Friends of Shorebirds SE, a volunteer group under the umbrella of the SA Department of Environment and Heritage Friends network. This year an important milestone was reached, with over 1,000 birds having been caught by the SA group. This represents 10% of the total caught by the VWSG in SA. More importantly, they have begun to fill in the gaps in the database, especially with catches of birds in the Australian winter .

Table 1. Wader species banded in South Australia

Species	Lashmar & Dennis	Waterman	Shurcliff	Mac-Namara	Klau	Hood	33 Others	Sub-total	VWSG Exped-itions	VWSG SA Team	Grand Total
Latham's Snipe	-	-	-	-	-	-	9	**9**	-	-	**9**
Bar-tailed Godwit	-	1	-	-	-	-	-	**1**	14	-	**15**
Marsh Sandpiper	-	2	-	-	-	-	-	**2**	-	-	**2**
Wood Sandpiper	-	2	-	-	-	-	-	**2**	-	-	**2**
Common Greenshank	-	2	-	-	-	-	1	**3**	-	-	**3**
Common Sandpiper	1	-	-	-	-	-	2	**3**	-	-	**3**
Grey-tailed Tattler	-	1	-	-	-	-	-	**1**	1	-	**2**
Ruddy Turnstone	7	6	-	12	-	-	-	**25**	2053	289	**2367**
Great Knot	-	1	-	11	-	-	-	**12**	-	-	**12**
Red Knot	-	947	-	77	-	-	-	**1024**	-	13	**1037**
Sanderling	-	-	-	-	-	-	1	**1**	3351	26	**3378**
Red-necked Stint	841	514	496	316	125	37	41	**2370**	2442	327	**5139**
Long-toed Stint	7	-	-	-	-	-	1	**8**	-	-	**8**
Pectoral Sandpiper	-	-	-	-	-	-	-	**0**	1	-	**1**
Sharp-tailed Sandpiper	328	185	26	2	6	38	73	**658**	293	101	**1052**
Curlew Sandpiper	40	21	48	31	2	23	14	**179**	771	17	**967**
Painted Snipe	-	-	-	-	-	3	-	**3**	-	-	**3**
Bush Stone-curlew	-	-	-	-	-	-	31	**31**	-	-	**31**
Pied Oystercatcher	62	9	-	-	-	-	-	**71**	8	11	**90**
Sooty Oystercatcher	10	3	-	-	-	-		**13**	-	3	**16**
Black-winged Stilt	6	29	9	-	-	1	48	**93**	-	-	**93**
Banded Stilt	1	172	-	-	-	-	-	**173**	-	334	**507**
Red-necked Avocet	-	11	41	-	-	-	18	**70**	-	16	**86**
Pacific Golden Plover	3	-	-	-	-	-	-	**3**	33	-	**36**
Grey Plover	-	1	-	4	-	-	-	**5**	-	-	**5**
Red-capped Plover	747	118	172	27	204	18	87	**1373**	32	-	**1405**
Double-banded Plover	24	-	-	-	-	-	-	**24**	32	9	**65**
Lesser Sand Plover	9	-	-	-	-	-	-	**9**	-	-	**9**
Oriental Plover	-	-	-	-	-	-	2	**2**	-	-	**2**
Inland Dotterel	-	35	-	-	-	-	-	**35**	-	-	**35**
Black-fronted Dotterel	-	9	-	-	5	-	8	**22**	-	3	**25**
Hooded Plover	340	31	-	-	-	2	15	**388**	6	3	**397**
Red-kneed Dotterel	-	91	-	-	26	-	1	**118**	-	-	**118**
Banded Lapwing	-	40	-	-	2	-	9	**51**	-	-	**51**
Masked Lapwing	10	9	-	-	1	-	30	**50**	13	-	**63**
Australian Pratincole	-	7	-	-	-	-	1	**8**	-	-	**8**
Total	**2436**	**2247**	**792**	**480**	**371**	**122**	**392**	**6840**	**9050**	**1152**	**17042**

Almost all SA banded birds are also flagged. Originally, an orange flag was placed on the right tarsus. From 1999 onwards two flags have been placed, orange on the right tibia and yellow on the right tarsus. Since October 2002 both flags have been placed on the right tibia of Curlew Sandpiper, Sharp-tailed Sandpiper, Bar-tailed Godwit and other medium to large waders. An engraved orange flag on the right tibia and a plain yellow flag on the right tarsus have been used for Ruddy Turnstone since November 2004. The total caught to 30 July 2006 is 10,212 of 18 species. This includes the SA team contribution of 1,154. The month of catching is shown in Table 2. There are several qualifications to be made about these figures. First, they relate to the total number of waders caught. As they also include retraps, these figures should not be used to calculate sightings/bandings/recoveries ratios. There is also no distinction made between the numbers flagged with an orange flag on the tarsus, and those with the much brighter code of orange over yellow. Although orange on the tarsus has not been used since 1998, waders wearing this configuration are still seen in the field.

The principal targets of both teams continue to be Ruddy Turnstone and Sanderling, with the aim of making an assessment of their annual breeding success by determining the proportion of juvenile birds in catches. More is also being learnt about departure dates for Ruddy Turnstone. This year, two catches at the same site on 6 March and 17 April showed weight gains for adults of an average 40%. Greatest gain was from 98 g to 148, a staggering 51%. Juvenile weights over the same period dropped marginally. The heaviest weight recorded in SA was 180 g on 29 April 2004. The latest date on which adult Turnstone have been seen is 1 May. The local team is making a significant contribution, with small catches of Turnstones in the austral winter.

November 2004 saw the start of a new study on Ruddy Turnstone. The primary focus is site fidelity and movement along the coast, but as time goes on we also hope to obtain data on survival rates. To 30 July 2006, 521 engraved orange flags had been placed on the tibia, with plain yellow flags on the tarsus. Despite problems with ink fading on flags, sightings within the study area are slowly accumulating.

Table 2. Numbers of waders caught by VWSG by month.

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Bar-tailed Godwit	-	3	-	-	-	-	-	-	-	3	8	-	**14**
Grey-tailed Tattler	-	-	1	-	-	-	-	-	-	-	-	-	**1**
Ruddy Turnstone	240	385	495	545	38	16	46	37	39	93	164	244	**2342**
Red Knot	-	-	-	1	-	12	-	-	-	-	-	-	**13**
Sanderling	392	423	1785	263	-	-	-	5	-	63	304	142	**3377**
Red-necked Stint	66	674	890	166	4	20	49	62	18	256	291	273	**2769**
Pectoral Sandpiper	-	1	-	-	-	-	-	-	-	-	-	-	**1**
Sharp-tailed Sandpiper	27	164	19	-	-	-	-	-	-	128	51	5	**394**
Curlew Sandpiper	50	217	272	25	-	2	7	5	-	85	120	5	**788**
Pied Oystercatcher	2	-	-	5	-	-	-	-	-	-	2	10	**19**
Sooty Oystercatcher	-	-	-	3	-	-	-	-	-	-	-	-	**3**
Banded Stilt	185	149	-	-	-	-	-	-	-	-	-	-	**334**
Pacific Golden Plover	-	-	31	1	-	-	-	-	-	-	-	1	**33**
Red-capped Plover	-	6	6	15	-	-	-	5	-	8	6	2	**48**
Double-banded Plover	-	1	15	21	-	4	-	-	-	-	-	-	**41**
Black-fronted Dotterel	-	-	3	-	-	-	-	-	-	-	-	-	**3**
Hooded Plover	1	-	1	-	-	-	-	-	-	-	-	7	**9**
Masked Lapwing	-	-	6	3	-	-	-	-	-	-	-	4	**13**
Total	**963**	**2023**	**3524**	**1048**	**42**	**54**	**102**	**114**	**57**	**636**	**946**	**693**	**10202**

Interestingly the only sightings from outside the study area are from overseas, one at Mai Po Marshes, Hong Kong (northward migration), and two in Taiwan (one northward migration and one southward migration).

South Australia makes a significant contribution to the accumulation of flag sighting data with an encouraging number of sightings being submitted by members of the public. The 563 sightings of Australian flags, and six sightings of international flags, are summarised in Table 3. Peter Langdon had the honour of recording our first overseas flag, with a Japan-flagged Red-necked Stint seen at Port Augusta on 27 January 2002. Colin Rogers followed up with a Curlew Sandpiper, flagged in Hong Kong, seen at Price Saltworks on 12 October 2002. However, Sharp-tailed Sandpipers banded at Chongming Dao are the stars, with Terry Dennis seeing one at Tolderol Game Reserve on 19 January 2006 and another at Goolwa on 12 January 2006; and Bob Green seeing two at Stony Point, Port MacDonnell, on 17 September 2006. Several individually colour banded Double-banded Plover from New Zealand have also been seen in SA, with one individual being seen at the same site over two winters. Records of individually banded Pied and Sooty Oystercatchers have helped build up a picture of how these birds travel along the SA coast to the Murray mouth, with one vagrant travelling as far west as the Yorke Peninsula.

South Australian flags are also regularly reported from elsewhere. A total of 398 Australian and 273 overseas sightings is a creditable return (Tables 4 & 5). Sanderling have generated 334 overseas sightings, 67 being from Japan. The overseas figures are inflated by 82 sightings in New Zealand generated from a total of 11 flagged Bar-tailed Godwit. Bar-tailed Godwit is a species that is usually seen in the South East of SA in very small numbers. Monitoring associated with the Turnstone project has resulted in counts of 42 Bar-tailed Godwit in October 2004 and 77 in October 2005, suggesting that they may pass through on their way to New Zealand. These sightings confirm that juveniles make

Table 3. Sightings of birds flagged elsewhere seen in South Australia. South Australian resightings more than c. 100 km from banding location.

Species	Victoria	South Australia	Western Australia	Total Australia	China (main-land)	China (Hong Kong)	Japan	New Zealand	Total
Red-necked Stint	217	11	3	**231**	-	-	1	-	**232**
Sanderling	99	31	13	**143**	-	-	-	-	**143**
Curlew Sandpiper	61	4	3	**68**	-	1	-	-	**69**
Red Knot	60	-	-	**60**	-	-	-	-	**60**
Ruddy Turnstone	17	4	3	**24**	-	-	-	-	**24**
Sharp-tailed Sandpiper	9	-	-	**9**	4	-	-	-	**13**
Crested Tern	11	-	-	**11**	-	-	-	-	**11**
Great Knot	7	-	-	**7**	-	-	-	-	**7**
Banded Stilt	2	-	5	**7**	-	-	-	-	**7**
Eastern Curlew	2	-	-	**2**	-	-	-	-	**2**
Double-banded Plover	0	-	-	**-**	-	-	-	1	**1**
Caspian Tern	1	-	-	**1**	-	-	-	-	**1**
Total	**486**	**50**	**27**	**563**	**4**	**1**	**1**	**1**	**570**

Table 4. Sightings of South Australian flagged birds seen elsewhere in Australia by state and species. South Australian resightings more than c. 100 km from banding location.

Species	Victoria	Western Australia	South Australia	Northern Territory	New South Wales	Tasmania	Queensland	Total Australia
Sanderling	168	22	31	4	7	-	1	**233**
Red-necked Stint	48	22	11	-	-	2	-	**83**
Curlew Sandpiper	9	34	4	-	-	-	-	**47**
Ruddy Turnstone	3	18	4	6	-	1	-	**32**
Bar-tailed Godwit	-	1	-	-	-	1	-	**2**
Sharp-tailed Sandpiper	1	-	-	-	-	-	-	**1**
Total	**229**	**97**	**50**	**10**	**7**	**4**	**1**	**398**

Table 5. Sightings of South Australian flagged birds by country and species

Species	Australia	New Zealand	Japan	China (Hong Kong)	China (Taiwan)	Russia	Korea	China (main-land)	Indo-nesia	Thai-land	Total
Sanderling	233	-	67	6	4	12	7	5	-	-	**334**
Red-necked Stint	83	-	4	4	5	3	2	3	2	-	**106**
Bar-tailed Godwit	2	82	-	-	-	-	1	-	-	-	**85**
Ruddy Turnstone	32	15	9	6	11	-	1	-	-	-	**74**
Curlew Sandpiper	47	-	-	16	3	-	-	-	1	1	**68**
Sharp-tailed Sandpiper	1	-	-	-	3	-	-	-	-	-	**4**
Total	**398**	**97**	**80**	**32**	**26**	**15**	**11**	**8**	**3**	**1**	**671**

this journey, with many of the sightings coming from a catch of eight juvenile Bar-tailed Godwit banded by the VWSG in November 2005. Red Knot is another species that is usually seen along the SE coast in twos or threes. In 2006 however a flock of 300 over-wintered at Lake George. Eleven of these were banded and flagged on 12 June. As they are the only knot flagged orange/yellow on the upper, a sighting at Farewell Spit, South Island, New Zealand on 7 October 2006 was one of these juveniles.

The brightness of the orange/yellow combination could help account for the high reporting rate of SA flags throughout the flyway.

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CHAPTER 14. RESEARCH RESOURCES

THE AWSG POPULATION MONITORING PROGRAM IN SOUTH AUSTRALIA

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From 1981 to 1985 the Royal Australia Ornithologists' Union (RAOU), undertook a comprehensive survey of shorebirds in much of Australia in order to establish sites of importance, their numbers and distribution. This formed the basis of the National Plan for shorebird conservation in Australia (Watkins 1993). In 1986 the Australasian Wader Studies Group (AWSG) initiated a regular count program based on the findings of this study; see Wilson 2001 for details. Essentially this Population Monitoring Program (PMP) has counted between 20 and 29 sites in February and June each year, the results of which are published regularly in *Stilt*.

Watkins (1993) indicated that South Australia, at that time, had the third-highest number, 33, of either nationally or internationally important areas in Australia. The highest ranked area in South Australia is Spencer Gulf followed by the Coorong and Price and Penrice Saltworks (formerly ICI Saltworks). Around Port Lincoln and the western Eyre Peninsula there was a cluster of four sites of national and international significance. The other important region for shorebirds in the state was in the South East, where there were nine important sites between Wright Bay and Port Macdonnell. More recent estimates by Bamford *et al*. (in prep.) indicate that 11% of migrant waders to be found in Australia occur in South Australia compared to over 30% found in northern Western Australia and 7% in Victoria.

In 1986 there were three major regions in South Australia included in the PMP, these being Gulf St Vincent, western Eyre Peninsula and the South East coast. An overview of the counts for each of these areas is provided by other authors in these notes. However, it is of concern that the only region for which there has been a continuous record since the 1980s is the South East. While Cooper (2006) has provided one of the most complete and long running counts of the west coast, these do not cover all the sites in the original program because of the enormous areas involved. This is despite Spencer Gulf being ranked the highest ranked area in South Australia by Watkins (1993). In regard to Gulf St Vincent, Close (2006) has pointed out that 'since 1985 there have been few organized counts of the Gulf'. Again this includes the important areas of Price and Penrice Saltworks which were second and fourth ranked in the State (Watkins 1993). Some of the implications of incomplete or complete lack of regular counting are pointed out in the commentary on the PMP provided by Gosbell & Clemens (2006). Without regular and rigorous counts it is impossible to establish species population trends or provide information required by international conventions such as Ramsar or for management of the EPBC Act.

Recognising the need to update the knowledge of shorebird populations in South Australia, Jim Wilson organised a comprehensive count of much of the coast from the Victorian border to Ceduna in 2000 (Wilson 2000). This revealed substantial decreases in populations of migratory shorebirds in Gulf St Vincent (75%) and the Coorong (49%). However several new sites of international importance were identified on the west Eyre Peninsula at Venus Bay, Eyre Island and St Peter Island. Cooper (2006) outlines a further count made of these areas in 2003.

As a result of the large decline in shorebird numbers in the Coorong observed in 2000, the AWSG has undertaken an annual survey each summer (February) since 2001 in response to a request from the Department of Environment and Heritage. In comparing these counts with those of the 1980s, the decline in numbers can be monitored and management actions recommended (Gosbell & Christie 2006). This demonstrates the importance of maintaining rigorous and consistent records for important sites over long periods.

With wader populations declining worldwide (CHASM 2004) coupled with habitat changes taking place in important stopover sites in the East Asia–Australasia Flyway such as the Yellow Sea (Barter 2002), it is even more important to maintain a comprehensive monitoring program. There is an urgent need to revitalise the PMP in South Australia in order that current data are available for the important sites previously identified.

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CHAPTER 15. RESEARCH RESOURCES

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Note: This list does not include references published in *Stilt* for which see Phillipps (2006).

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THE BREEDING OF BANDED STILT AND RED-NECKED AVOCET IN THE COORONG, SOUTH AUSTRALIA: DECEMBER 2005 – FEBRUARY 2006.

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In July 2005, a large roost of 100,000 Banded Stilt *Cladorhynchus leucocephalus* was observed in the South Lagoon of The Coorong. In January 2006 there was evidence of some breeding having taken place with the observation of several young chicks in the care of adult birds. During the annual AWSG wader survey undertaken on 4 and 5 February 2006 a count of 1,006 juvenile Banded Stilt was made. In January Red-necked Avocet *Recurvirostra novaehollandiae* were also observed breeding along the margins of the South Lagoon. This is the first time that either of these species has bred in the Coorong. The conditions in the Coorong have progressively deteriorated over the last eight years due to the lack of freshwater inflows from the Murray River leading to extreme hypersalinity in the South Lagoon with resultant change in environmental conditions. This caused a large hatch of brine shrimp and an abundance of other food sources such as chironomid larvae. Several attempts were made to find the breeding colony of the Banded Stilt and to assess the degree of success of this event. In addition, teams from Victoria and South Australia banded and flagged a total of 334 chicks. While these events are interesting, they result from a severe worsening of water quality conditions in the Coorong exacerbated in recent years by the lack of river flows over the barrages. While this problem persists, it is essential that monitoring the water quality and biodiversity throughout the Coorong is undertaken to provide information for land and water managers to improve this critical situation and to ensure the restoration of the values which made it a Ramsar site.

INTRODUCTION

The Coorong is a body of water, some 140 kilometres long, confined by the coastal dunes of the Younghusband and Sir Richard Peninsulas. The Coorong is the natural drainage point for the extensive Murray-Darling Basin. The Ramsar Convention accorded the Coorong and Lakes Alexandrina and Albert Wetlands the status of Wetland of International Importance in 1985. The national and international significance of the site has recently been further acknowledged by it being nominated as one of six Significant Ecological Assets within the river Murray catchments as part of the 'Living Murray Initiative' (DWLBC 2005). The area is the traditional home of the Ngarrindjeri people for whom the land and waters of the site are a living body (Ngarrindjeri Ramsar Working Group 1999). See Figure 1 for map.

The Coorong is separated into the North and South Lagoons by rocky shallows and a narrow connection at the Needles and Parnka Point. The lagoons are relatively shallow ranging from mudflats to water 2 to 3 metres deep and vary in extent both with the season and the tide. Although it is a coastal lagoon with an estuarine influence, it is not a typical estuary. Fresh water from the River Murray occurs near the barrages and Mouth while salinities generally increase with distance from this area, particularly in the South Lagoon. For this reason it can be considered a 'reverse estuary' (Geddes 2003). The ecology of the Coorong is essentially influenced by the flow of water from the barrages at the Murray Mouth, the tidal signature at the Mouth, and any inflows from Salt Creek to the South Lagoon. In February 2006 the salinity levels of the South Lagoon were at historically high levels and had a significant impact on the aquatic biota and dependant birdlife.

The first evidence of a possible breeding event was when mating was observed early in December. In early January, Banded Stilt chicks were sighted by a local resident following which extensive searches for breeding colonies were undertaken. These were continued as part of the scheduled population survey of shorebirds (waders) in the Coorong that the Australasian Wader Studies Group (AWSG) undertook in February 2006. A report of this survey was published in May 2006 (Gosbell & Christie 2006). Two of the key observations of the surveys were first, the large number of Banded Stilt *Cladorhynchus leucocephalus* present in the South Lagoon and secondly, the breeding activity of both Banded Stilt and Red-necked Avocet *Recurvirostra novaehollandiae.* The initial objective of the surveys was to ensure the safety of the breeding colony and to arrange any predator control that was considered necessary. Also, as this is thought to be the first record of such breeding events in the Coorong, there was the added objective of establishing the nesting behaviour, distribution and breeding success of these species. The opportunity was also taken to band and leg flag Banded Stilt to assist the study of future movements. The banding was carried out by the Victorian Wader Study Group (VWSG) and Friends of Shorebirds SE.

Banded Stilt

The Banded Stilt is an endemic Australian wader that is mainly found in Western Australia (WA), South Australia (SA), Victoria, and, to a lesser extent, New South Wales in both coastal and inland locations (Marchant & Higgins 1993). The eastern population is thought to be separate from the Western Australian population (Minton *et al*. 2000). The total population estimate is 206,000 (Watkins 1993) with the sites of significance being The Coorong, SA, 77,000; Lake

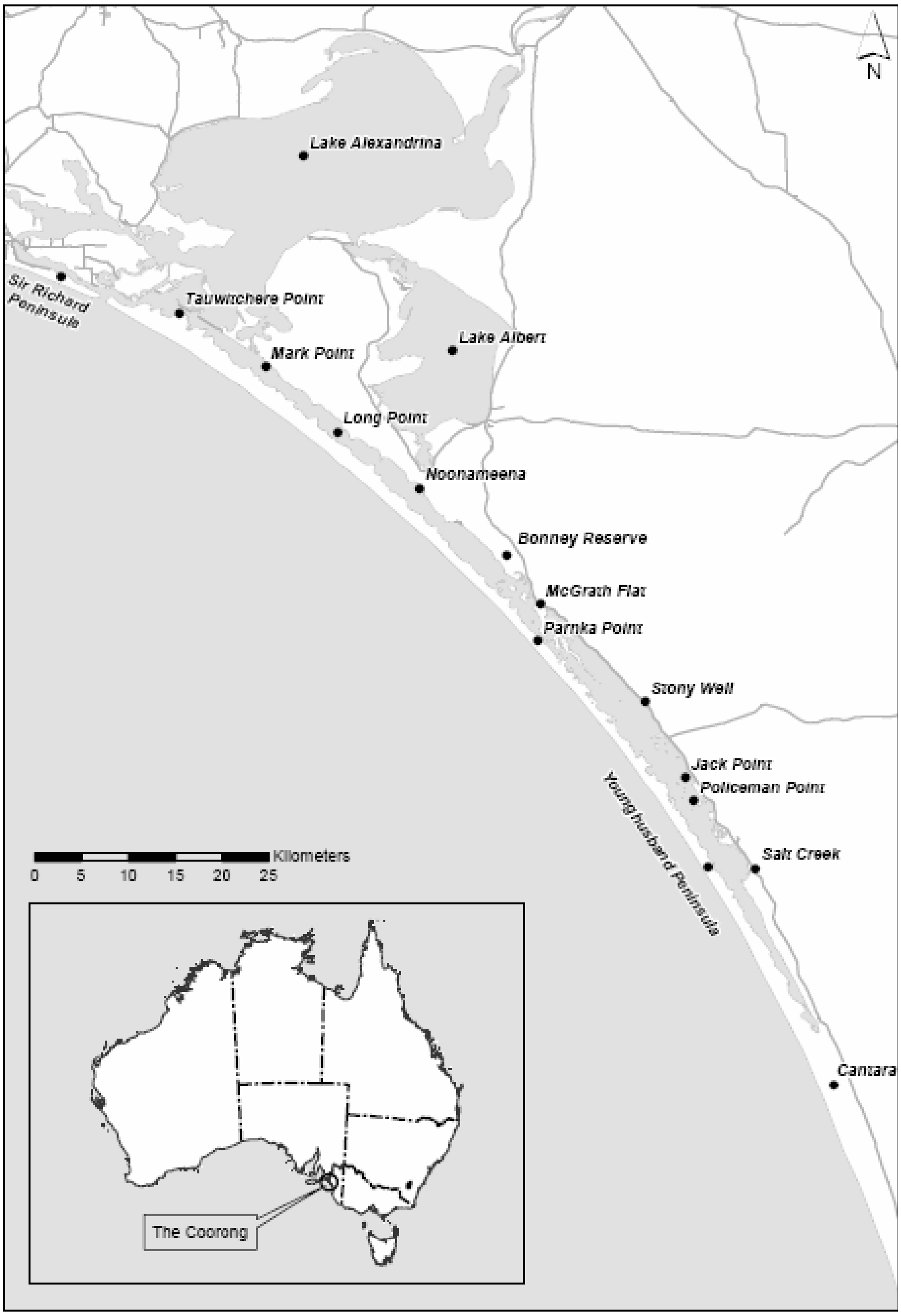

Figure 1. Map of Coorong.

Eyre, SA 30,000 and up to 45,000 birds in over 23 sites in WA (Marchant & Higgins 1993). When not breeding, large compact flocks in the tens of thousands are found in coastal or near coastal shallow lakes, saltfields and tidal mudflats or saltmarsh. They are nomadic and dispersive, their movements influenced by the effect of weather on water levels, salinity and food availability which includes crustaceans, insects and vegetation. Movements are often dictated by the presence of their major food which is brine-shrimp, *Parartemia* sp. (Marchant & Higgins 1993, Hayman *et al*. 1998, Baxter, 2003). They are sporadic, opportunistic breeders usually travelling to large inland salt lakes such as Lake Eyre, Lake Torrens or Lake Callabonna in SA following heavy rains where they form huge colonies on low islands (Minton *et al*. 2000, Minton 1989, Bellchambers & Carpenter 1992). A number of inland lakes in WA have been recorded as supporting breeding colonies of up to 179,000 nests. They breed on small islands in lakes, sometimes on sandspits or on stony soil. The clutch size is generally one to five, usually 3–4 eggs in a scrape in sand (Robinson & Minton 1989; Marchant & Higgins 1993). Chicks remain at the nest until all eggs have hatched, then leave to form large crèches, usually within one to two days of hatching. The white downy chicks are precocial and are fully feathered at six weeks.

Banded Stilt are recorded as having bred in SA in only six of the past 70 years and these events have been restricted to Lake Callabonna, Lake Eyre and Lake Torrens (Baxter 2003). There are no confirmed records of breeding at coastal locations such as the Coorong. There is, however, a reported sighting by a fisherman (Glen Hill pers. comm.) of a small breeding event (*c*. 50 chicks) in April 2005 in an area similar to that observed in this report.

Red-necked Avocet

The Red-necked Avocet is an elegant endemic wader with an unmistakable long, slender strongly-upcurved black bill, diagnostic chestnut head, white body and black and white wings (Hayman *et al*. 1986). They are gregarious and are typically encountered in large flocks in freshwater, brackish or hypersaline waters including saltfields (Marchant & Higgins 1993). They are often found in company with Banded Stilt. They occur largely in the southern coastal areas between Melbourne and Perth.

Like the Banded Stilt they are opportunistic breeders and are dispersive in response to rainfall and changing water levels. They breed in a variety of habitats ranging from flooded paddocks to inland salt lakes on low islands; nests are also variable but typically on bare ground or low vegetation scantily lined with vegetative or shell material. They breed in anything from single pairs to colonies of up to 150 pairs (Marchant & Higgins 1993). The total estimated population is 107,000 (Watkins 1993) with the highest recorded counts being Lake Eyre, SA, 95,000; far northwest lakes of NSW, 6,850; and the Coorong, SA, 5,400 (Lane 1987). The clutch size is usually four eggs and the chicks are precocial and leave the nest at hatching, following the parents who feed them. Red-necked Avocet are recorded as having bred at similar inland lake sites to those detailed for Banded Stilt. There are no known records of them breeding in the Coorong proper, but breeding has been recorded in a samphire swamp near Dog Lake, which is part of the Coorong & Lakes Ramsar site (Anon 2000).

There are three historical records of breeding activity in the Coorong area. Arnold (1927) reports breeding activity on Hindmarsh Island in 1926 but found no nests before leaving the island. His host's record of the birds of the island (Newell 1927) does not mention avocet breeding so maybe the attempt was unsuccessful. The other record is a clutch of four eggs in the S.A.White collection (Philippa Horton pers. comm.), probably taken by White himself, from between Meningie and Cooke Plains in September 1924. In wet years Avocet are known to have bred in saline areas of the Lower South East around Naracoorte (J. Bourne pers. comm.).

Conditions in the Coorong 2005/2006

The major factor impacting on the aquatic environment is salinity which varies from fresh to brackish in the Lakes to hypersaline conditions in the South Lagoon where the influences of tides and freshwater inflows are negligible under current conditions (see Figures 2 and 3*)*. Relative salinities between North and South Lagoons fluctuate seasonally between winter and summer (see Figure 2). While there has been a general decline in the health of the Coorong since 1981, this has been more rapid since 2001 with salinities in the southern lagoon now exceeding four times that of sea water (36 mg/l) (Figure 3). This has been exacerbated by the extended drought in south-eastern Australia since 2000. The lack of freshwater inflows and lack of tidal influence south of Pelican Point has progressively led to the Coorong lagoons acting as a sink for sea water. This has caused a severe decline in the abundance and distribution of key estuarine flora and fauna species particularly in the southern lagoon (Phillips *et al.* 2005). These hypersaline lagoons with salinities exceeding 100 parts per thousand total dissolved solids (ppt TDS) have been found to be almost devoid of macrofauna (Dittmann *et al.* 2006). The macrobenthic survey carried out in 2004 found two well defined benthic communities, one in the region of the Murray Mouth characterized by polychaetes while in the south lagoon it is characterized by insects (Chironomidae) (Dittmann *et al.* 2006).

In January 2004 and 2005, Paton (2005) recorded salinities of 100 ppt TDS (cf. sea water of 36 ppt TDS). Paton states that "Aquatic food sources have declined throughout the Coorong. In the South Lagoon the abundance of *Ruppia tuberosa* and turions and hardyhead fish have declined considerably, particularly for the two southernmost sections. The abundances of chironomid larvae did not follow this trend and were higher in January 2005 than in some previous years in several sections. The higher abundances of chironomid larvae recorded in 2005 might be a consequence of low numbers of hardyhead fish, which would typically feed on chironomid larvae." This regime is favourable to species such as Banded Stilt and Red-necked Avocet resulting in the presence of large numbers of the former and the breeding activity for both species which is reported here.

Background to the current study

Each year, usually in early February, the AWSG conducts a wader survey in the Coorong (Gosbell and Christie 2006). Banded Stilt and Red-necked Avocet are almost always found in the Coorong and the South East coastal lakes, in particular Lake George. Both species have been recorded using these areas, particularly in the summer, by a number of sources (Marchant and Higgins 1993). However, on 21 July 2005, three large flocks and smaller scattered groups totalling about 100,000 Banded Stilt were observed (MC pers. obs.) off Fat Cattle Point and the bay to the north (see Fig. 4). Over the period 30 September to 3 October 2005 a Birds SE campout was held at Cantara (Fig. 4). During this event it was estimated that between 113,000 and 150,000 Banded Stilt were in huge roosting flocks in the lagoon between Parnka Point turnoff and Hack Point (Anon 2005). Following this, large numbers of Banded Stilt were regularly seen between Policeman Point and in Thompson Bog (Josie Lord pers. comm.). On the basis of their calls, large numbers were often believed to be behind Rabbit Island (Chris Thompson pers. comm.). When fewer birds were seen at these locations it is likely that they were dispersed throughout the South Lagoon or in flocks on the Younghusband Peninsula shore. It was noticed at Woods

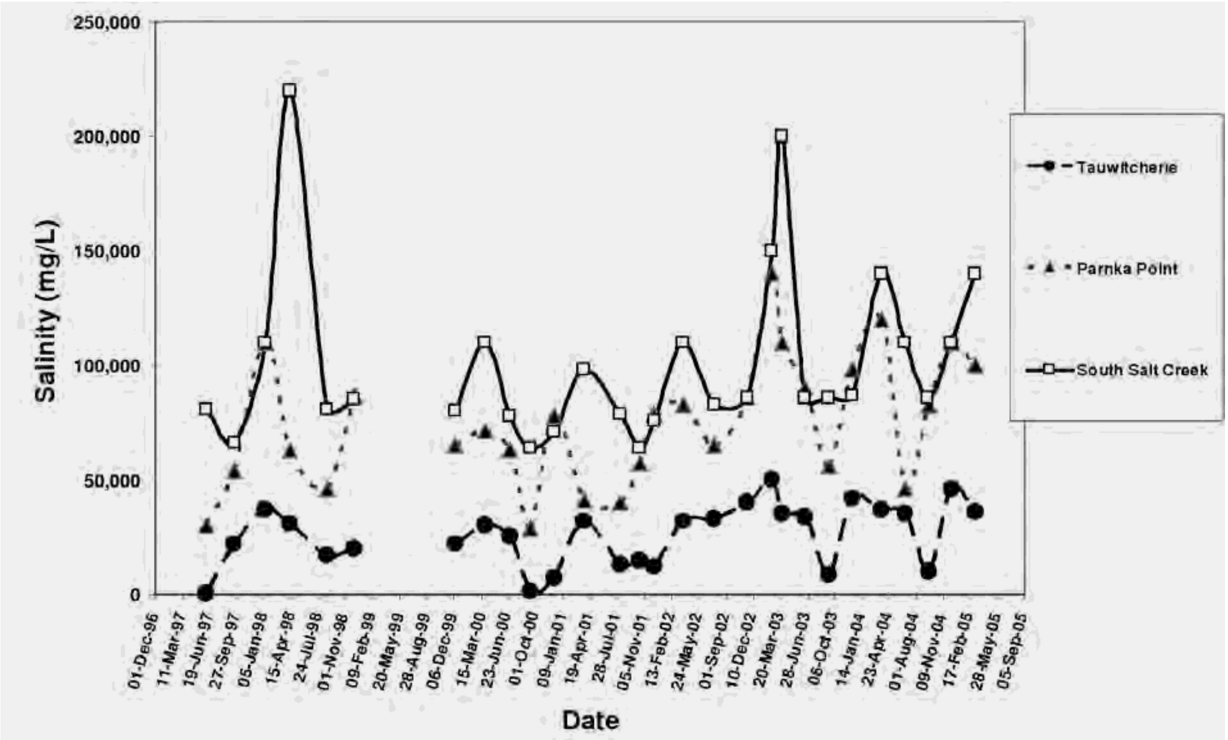

Figure 2. Salinity fluctuations in the Coorong with time (Data and chart from Department of Environment and Heritage (SA).

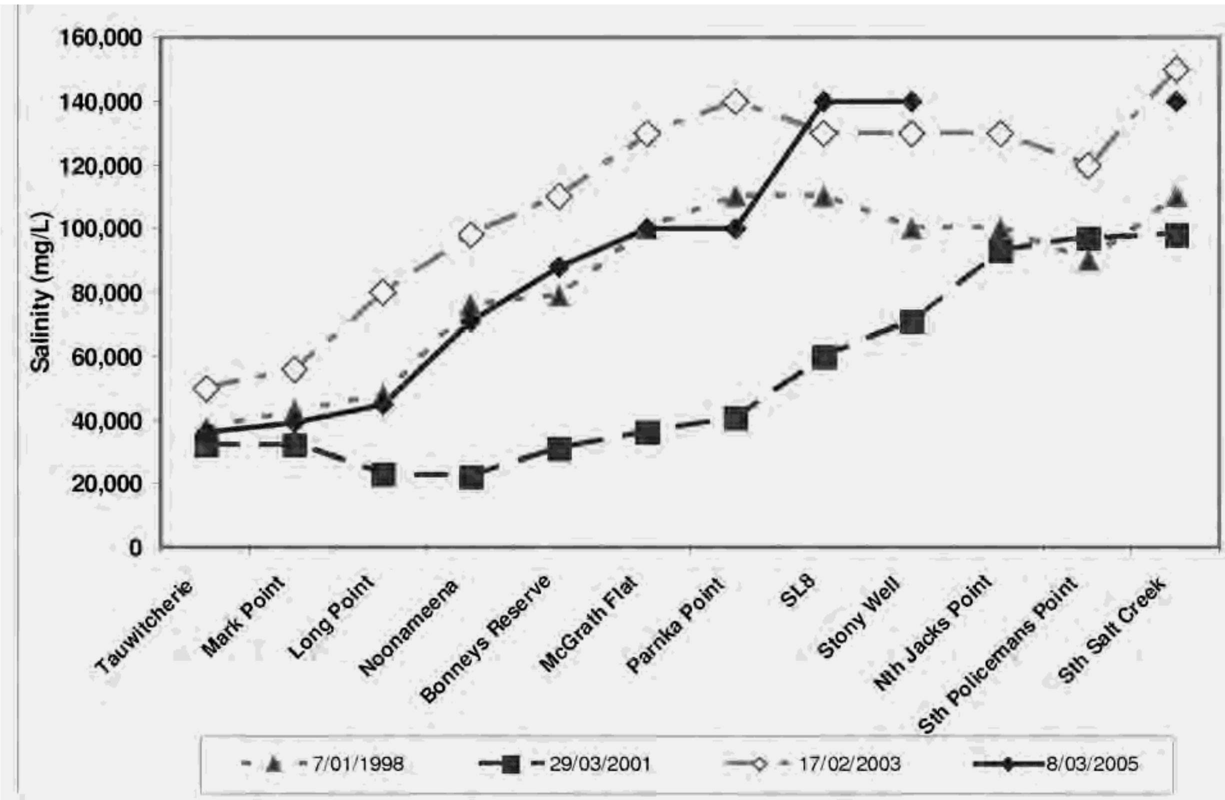

Figure 3. Longitudinal salinity gradients in Coorong for years 1998 to 2005 (Data from Department of Environment and Heritage (SA).

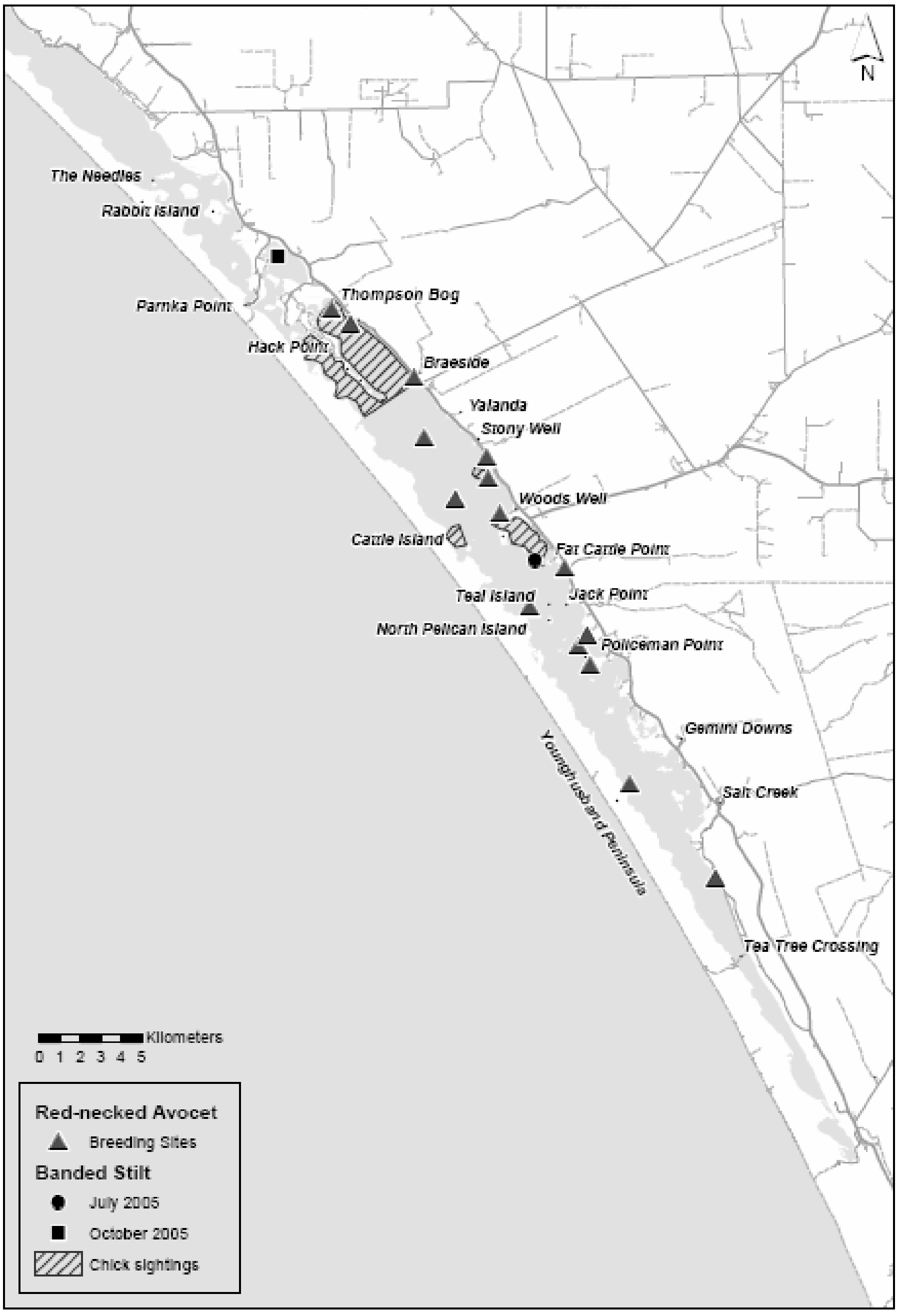

Figure 4. Map of the Coorong showing location of Banded Stilt and Red-necked Avocet chicks, Jan – Feb 2006

Well that stilts, which had roosted there overnight, left in the morning flying to the west, and returned from that direction in the evening (Pam Gillen pers. comm.). Essentially the same areas were being used in February when the AWSG survey was undertaken. Details are in Gosbell and Christie (2006). Figure 5 shows the recorded populations of Banded Stilt in AWSG surveys of the Coorong from 1982 to 2006.

Fieldwork January – March 2006

Search for the Banded Stilt Colony

The initial phase of the fieldwork was searching for the Banded Stilt colony. This started on 12 January at the area where the first chicks were found. During the following week, the search area was extended, so that soon the eastern shore of the South Lagoon had been searched by car and on foot. The Younghusband Peninsula shore and the shores of the many small islands from Salt Creek to Stony Well had been scanned, and Cattle Island had been searched on foot. On the 20 January an aerial search was conducted southwards from midway along the North Lagoon, along the full length of the South Lagoon, and as far south as Cantara. The swampy land to the east of the highway was dry and considered unsuitable for nesting. From the air, we were able to identify several potential nesting sites, one of which we were able to access on foot the following morning. Old nests were found on a small reef in the northern end of Thompson

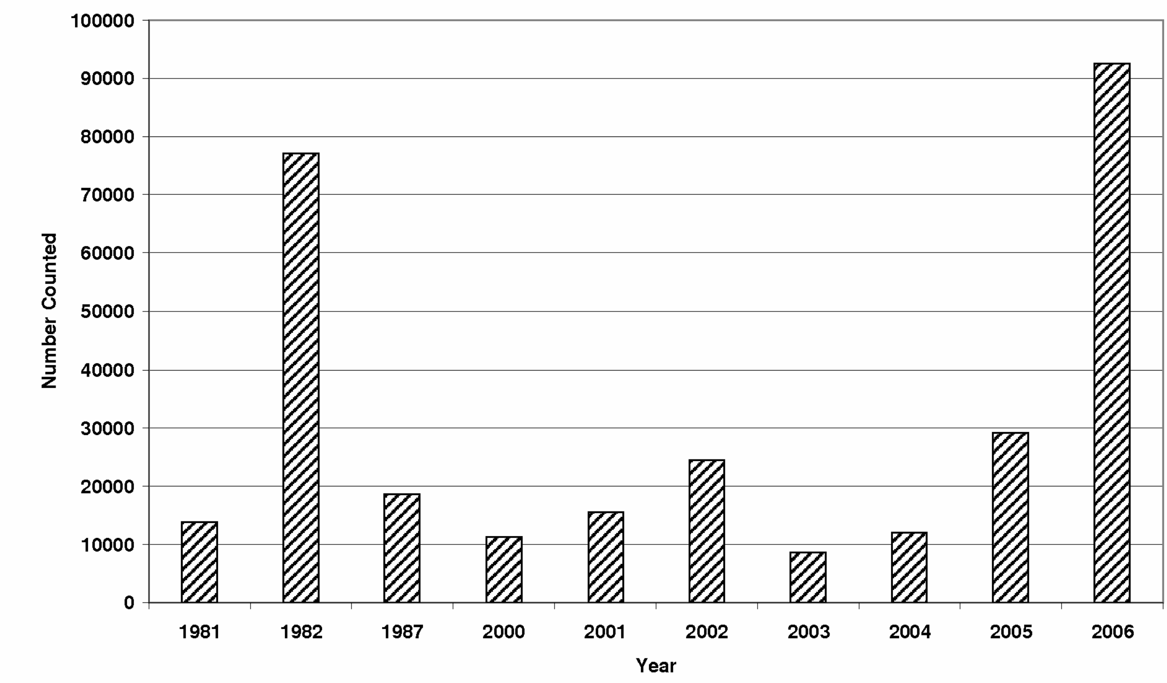

Figure 5. Chart showing population of Banded Stilt in the Coorong during AWSG counts 1981 – 2006.

Bog. Photographs of these nests were recognised by a local resident, who was able to direct us to a nesting site near Stony Well that had been abandoned by 16 December 2005. Both sites were readily accessible to foxes.

On 24 January, on the point at the southern boundary of Thompson Bog, the remains of several old scrapes were noticed. They were found in an area that had been visited by the survey group regularly over the preceding week. That they were not noticed earlier illustrates how difficult it is to find nests once the incubation period is finished. Without sitting birds to draw an area to attention, it would only be possible to find scrapes with surveys on foot and, even then, it would be easy to overlook a small site. With chicks first seen in the Woods Well area, it is also likely that there was a breeding site in that vicinity.

The searches also challenged our view of where Banded Stilt will nest. It had been assumed that they would be nesting on islands, or the Younghusband Peninsula shore. In the event, all the scrapes that were found were on or near the eastern shore of the Coorong.

Banding and Flagging of Banded Stilt Chicks.

Chicks were banded with numbered metal bands and two coloured leg flags, the South Australian flyway code of orange over yellow, both flags on the tibia. The first flags were placed on four downy chicks found feeding on the water's edge at Thompson Bog on 20 January. They were caught by scooping them up in hand nets whilst they were swimming in shallow water. They were released in a group, swimming off together to be joined quickly by an adult. Both flags were visible on the swimming chicks, but they did not affect the chicks swimming technique. The majority of chicks were caught using this method, except for the final session on 11 February when they were captured from a boat. These chicks were fully feathered and most approaching fledging but several chicks flew to evade capture. In all, 334 chicks were banded of which all but one were leg flagged.

Breeding of Red-necked Avocet

Coincidental to the search for Banded Stilt nests, Red-necked Avocet were also found nesting. Initially the importance of this was not realised, and the search for avocet nests was conducted as secondary to the Banded Stilt survey. This is, however, the first confirmed breeding of this species in the Coorong. All nests were found in small depressions amongst sharp broken limestone outcrops. In most instances, nests were lined with small shells. All stages of nests were found with up to four eggs, chicks plus egg, or empty. Breeding was spread throughout the South Lagoon and occurred over several months.

DISCUSSION

Conditions of the Coorong

The presence of Banded Stilt in the Coorong in record numbers indicates that the Coorong, particularly the South Lagoon, has undergone major change. That this species and Red-necked Avocet underwent the first recorded breeding event in history is further evidence of the magnitude of the change in environmental conditions. The hypersalinity of these waters has seriously impacted on the biodiversity of plant and animal life found in this area. The paucity of aquatic flora and macrobenthic fauna has led to a dominance of brine shrimp and chironomid larvae in several areas of the South Lagoon.

Distribution

Gosbell & Christie (2006) show that the use of the southern areas of the Coorong by shorebirds has been progressively reducing since the 1980s. In 2006, 75% of migratory waders were utilizing the area north of The Needles compared to proportions ranging from 45% to 65% over the eight previous years of records. On the other hand record numbers of Banded Stilt were found in the South Lagoon in February 2006 following previous observations in excess of 100,000 birds in July and October 2005. At the same time there were either few or no Banded Stilt found in the traditional sites of western Victoria, Lake George or Port Augusta (P. Collins, pers. comm., KG and MC pers. obs.) leading to the view that almost the whole of the south-eastern Australian population of Banded Stilt was attracted to the Coorong from July 2005 to March 2006.

Breeding success

The number of Banded Stilt observed in the AWSG Wader Survey in February 2006 was 92,500 (Gosbell & Christie 2006). However, as the number of juveniles counted on the survey was 1,006, this indicated a relatively small breeding event when compared to events such as Lake Eyre in 2000 where approximately 18,000 pairs nested and recruited around 50,000 young (Baxter 2003). The reasons for this low recruitment rate are not fully understood but are possibly a combination of uncertain food resources, lack of suitable nesting sites and predator activity. In a year when traditional breeding sites are unsuitable, even this small number of chicks is a bonus for the species. Of course, if this were to become an annual event it would be a substantial benefit to the population; it may even be possible to facilitate such an event by ensuring suitable and safe nesting sites.

Nesting sites were very difficult to find for several reasons. Firstly, hatching had finished and secondly, nesting had occurred in sites usually considered atypical of the species. Two major sites were found, one on the eastern shore of the Coorong, the other on the sandy eastern shores of small offshore rocky reefs in shallow bays. Based on the density of the scrapes located, the first site had the potential of producing 1,800–2,400 chicks and was deserted by 16 December 2005. On two occasions during January, two chicks of an age consistent with this site were observed. The fate of any others is unknown. The adults may have abandoned the nests without completing laying or they may have been subject to predation from foxes or Silver Gulls. The latter would have been feeding young at the time. Alternatively, the advanced young may have come from another, unknown site.

On the same basis the second site had the potential of 500 – 700 chicks, and yet 1,006 chicks were observed. With several nearby areas not searched, it seems likely that there were several locations each with a relatively small number of scrapes. Without knowing the full extent of the colony, it is not possible to judge whether they had been subjected to any significant predation. The scrapes found, although on an offshore reef, were not beyond the reach of foxes. No predation by Silver Gulls was witnessed, but the stilt chicks were possibly already old enough to escape predation by the time they were under observation. At that time Silver Gull breeding was well advanced, with the majority of parents no-longer feeding young. A fresh water release from Morella Basin was also providing a prime gull feeding site at that time.

Unlike the Banded Stilt, the Red-necked Avocet appeared to experience a relatively successful breeding event although it was difficult to judge how much predation this species experienced. Breeding was spread throughout the South Lagoon and occurred over several months. A breeding colony of Silver Gulls were observed with nesting avocets in mid January (in the vicinity of Policeman Point) and a small number of predated eggs were found in early February (in the vicinity of Stony Well). The control and protection afforded to the chicks by the parents probably minimised predation following hatching. The survey in February counted 2,400 birds. A complete count of nests and juveniles was not undertaken during this count although there were many observations of parent birds shepherding groups of two to four young. Over the term of the complete survey, 140 nests were counted. As large areas of suitable habitat were either not counted, or only superficially counted, this can be considered a significant breeding event.

Movements

Little is known of the movements of Banded Stilt, and of interactions between the populations of Western Australia and south eastern Australia. In 1995, 800 chicks were banded and flagged with a yellow flag on the tibia at Lake Ballard, WA (Clive Minton pers. comm.) At least two yellow flagged birds were sighted in the Lake Eyre breeding population in 2000 (Baxter 2003). Another was sighted at Fosters Point, Lake George on 28 April 2001 (Iain Stewart pers. comm.). It is hoped that the banding and flagging of the chicks in the Coorong will add to this knowledge.

What of the future?

The abnormal conditions of the Coorong, particularly in the South Lagoon, attracted the large numbers of Banded Stilt and contributed to the unique breeding events of this species and the Red-necked Avocet. It is not possible to predict future conditions in the Coorong or its usage by these species. A requirement of being a Ramsar site is for management to maintain the ‘ecological character’ of the Coorong and Lakes Alexandrina and Albert wetlands (Phillips *et al.* 2005). Management strategies that lead to the water quality in the southern lagoon being restored to conditions previously applying would eventually encourage the return of a more diverse flora and fauna. However, if immediate actions are not taken and conditions in the southern lagoon remain the same it is possible that another influx of Banded Stilt and Red-necked Avocet may occur to utilise the plentiful food resources that are likely to be found in the hypersaline conditions. If, however the salinity levels became higher the brine shrimp would be killed off together with any chance of further breeding (Savage 1964). The impact of anthropogenically caused salinisation has become increasingly important not only in south-eastern Australia but its effect on wildlife is a conservation issue of global concern (Hannam *et al.* 2003).

The observations of these breeding events provides several guidelines for the future. The most important is to initiate a continuous monitoring program following the first indications of any ‘breeding frenzy’ of Banded Stilt. This will hopefully provide for the early location of colonies which will enable any predator threats to be monitored and appropriate actions to be taken.

ACKNOWLEDGEMENTS

Monitoring of this breeding event was organised at short notice, during the Christmas/New Year holiday season, and at the height of the summer bushfire season. Under such circumstances, the response from all concerned was remarkable. Thanks to Brenton Grear of the Mt Gambier Regional Office of the Department of Environment and Heritage (DEH), for support with funding and resources. Staff of the Coorong National Park were helpful in many ways, Simon Oster organised the aerial survey, Karen Laudenbach and Chris Thompson helped in the field, Joanne Flavel provided office backup.

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Thanks also to Roz Jessop who organised applications for banding and flagging permits and to Australian Bird and Bat Banding Scheme and DEH SA who granted permits at short notice.

Many people also contributed from their store of Coorong knowledge. David Paton made available data from his surveys and knowledge gleaned from many years of Coorong work. Former Rangers from the early 60's through to the present shared their insights. Russell Seaman from the Ramsar team provided data. Doris Graham and Rob Clemens researched Birds Australia breeding records, and Philippa Horton researched SA records. Darren Herpich, DEH Mt Gambier, is gratefully acknowledged for producing the maps.

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THE HISTORY AND ACHIEVEMENTS OF THE VICTORIAN WADER STUDY GROUP

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THE START

The origin of wader banding activities which ultimately led to the formation of the Victorian Wader Study Group (VWSG) goes back to 1975. David Robertson had recently arrived in Australia from Malaysia, where he had been involved in successful mist netting of waders in salt pans at a local commercially operated salt works. Discovering that little had been done in the way of wader banding in Australia – just a little in the Perth area in the 1960s and in the Hunter area of New South Wales in the 1970s – he set about trying to mist net waders in Victoria.

Several attempts by David and Minnie Robertson at the Cheetham Salt Works, Altona during 1975 were largely unsuccessful and only nine waders were caught. On 7 March 1976 they tried for the first time at North Spit, adjacent to Werribee Sewage Farm (now the Western Treatment Plant) and were immediately more successful. Twenty-six waders were caught that first night followed by 68 on a second visit a week later. Mist netting was carried out in almost every month for the rest of the year resulting in a total catch of 620 birds. Wader banding activities in Victoria were thus launched in earnest.

MIST NETTING

The team of people participating in the wader mist netting activities at Werribee was gradually reinforced, mainly by young Monash University students/recent graduates, and mist netting activities continued throughout 1977 and 1978 with a further 1832 birds being caught. The process was an arduous one. Lines of mist nets were set out at intervals in the North Spit Lagoons and these were manned throughout the night, which included a high tide period. Part of the team was deployed almost continuously in extracting birds from the nets, which were spread out over a kilometre or so, and bringing them back in bird bags to banding station. There, protected by a large tent, the rest of the team was involved in banding the birds and recording age, biometric and moult details before releasing the birds. Some people were allowed to take a two hour break for sleep but many would work the whole night through. The process was often assisted by a flagon of port being passed around at regular intervals!

Catch totals were quite variable, often because of wind conditions. Catches of over 400 birds were made twice, the largest being 452 on the night of 24 February 1979. But as cannon netting was gradually introduced the frequency of mist netting declined during 1979 and only occasional mist netting attempts have been made since. The last large mist netting catch was 262 birds on 29 February 1992.

CANNON NETTING

The first cannon net for the VWSG was constructed in November and December 1978. The net making-up process, carried out at Werribee Sewage Farm, itself had one small drama when a tiger snake made its way across the open area we were using. One team member, Kevin Bartram, decided he would pick it up but in doing so he was bitten on the thumb. The whole episode was captured by Daphne and Ralph Keller on film. Kevin was driven off to the Geelong Hospital but when no reaction had occurred after three hours it was concluded that no venom had been injected, although blood had come out of the wound, and he returned to the team.

The first cannon net catch, of 8 birds, was made on 31 December 1978 at North Spit, Werribee. Further small trials in early 1979 were followed by a hugely successful concentrated effort at North Spit on the Labour Day weekend of 9–12 March. In five catches in this four-day period, 2333 birds were caught almost all Red-necked Stint (1798) and Curlew Sandpiper (495). Dick Veitch came over from New Zealand especially to take part and on his return home constructed a cannon net and carried out the first cannon netting of waders in New Zealand. Altogether 7922 waders were caught in 1979, with cannon netting lifting catching effectiveness to a much higher level compared with mist netting.

Cannon netting has been carried out ever since, with 199,369 waders being caught to the end of 2005 (Table 1). Catching effort has been consistent over the years though the total number of birds caught each year has varied between 3503 and 12,944, with an average of 7384. Initially most cannon netting was carried out at Werribee, on both the North Spit and the South Spit. Activity has gradually extended to locations throughout coastal Victoria in order to obtain samples from different local populations and to increase the number of species caught in worthwhile numbers. In all, 36 species have now been banded with nine reaching totals of more than 1000 birds (Table 2).

Various sites in Westernport were visited; Yallock Creek was especially productive. Andersons Inlet, at Inverloch, proved difficult to master but eventually has become one of the prime Red-necked Stint monitoring areas. Corner Inlet, which has the largest population and diversity of waders in Victoria (30,000–40,000 birds of 26 species), proved to be a logistical nightmare with boat transport required to reach most sites and with weather conditions frequently being windy. More than one boat has been damaged over the years and twice part of the team has had to be left overnight on offshore islands when darkness overtook the return ferrying activities. Fortunately there was always plenty of covering material for bedding. Wind conditions were so bad on the first major visit in December 1981 that the unnamed island

Table 1. VWSG Annual Wader Catch Totals. Data to end 2005.

Calendar Year	New	Retrap	Total
1975	9	-	9
1976	616	4	620
1977	482	12	494
1978	1296	42	1338
1979	7436	486	7922
1980	6121	1206	7327
1981	4561	869	5430
1982	3774	796	4570
1983	2875	628	3503
1984	4272	1045	5317
1985	4073	1051	5124
1986	7144	2057	9201
1987	5350	1559	6909
1988	8019	2697	10716
1989	5437	1584	7021
1990	4094	1950	6044
1991	3224	850	4074
1992	4652	861	5513
1993	8831	2588	11419
1994	4839	1753	6592
1995	2708	625	3333
1996	5263	1035	6298
1997	4366	1050	5416
1998	8083	1408	9491
1999	6515	1591	8106
2000	10350	2594	12944
2001	4839	1320	6159
2002	10421	2162	12583
2003	8495	2854	11349
2004	5110	1224	6334
2005	6320	1893	8213
Totals	**159575**	**39794**	**199369**

off Manns Beach was ironically christened Dream Island by Annie Rogers, a name which has remained ever since and probably now has become part of the official cartography. On that first visit we actually camped out on Dream Island for four days (a major logistical exercise in itself) and with three days of temperatures in the 40s several people got their feet severely sunburned, one person's swelling to the size of a football!

Subsequently, in order to increase the numbers of Sanderling and Ruddy Turnstone caught, the VWSG spread its activities into the southeast corner of South Australia in 1993 (Christie 2006). Numbers of birds caught in each of the different areas over the years are given in Table 3. Although the Werribee Sewage Farm area is no longer such a dominant component of the fieldwork program, more birds have still been caught there (58,838 – 29% of the total) than at any other location.

Over the years the VWSG has made 1106 cannon netting catches, at an average of 41 per year. The average catch size is 172 but the range is big (from 1 to 2800). In most years at least one catch of over 1000 birds has been made and in 1993, three such catches were made. Well remembered are the 2563 Red-necked Stints caught in one net at Inverloch on 20 November 1993. The team had to wait for more than a nail-biting hour, with the birds sitting in front of the net, for the tide to ebb sufficiently for the net to be fired safely. A team of 30 people was present and all birds were banded and released within four hours, the task being completed in semi darkness.

THE FORMATION OF THE GROUP

From the early days the Victorian Ornithological Research Group (VORG) had supported and encouraged the wader catching activities and had adopted these as one of its projects. However when activities expanded rapidly in 1979 as a result of the introduction of cannon netting, it was decided that the Victorian Wader Study Group, a free standing organization, should be formed. This was done at a meeting of regular fieldwork participants on 2 June 1979. David Robertson and Clive Minton were elected as co-convenors, Julie Strudwick as Treasurer, and Peter Dann, Brett Lane, Ira Savage and Daphne and Ralph Keller were appointed committee members. The first committee meeting took place on 22 June.

It is interesting that the original objectives of the Group, published in the first edition of the Victorian Wader Study Group Bulletin in January 1980 (Minton 1981), are still the same as the core objectives of fieldwork programs at the present time. They are summarized below:

a) migration routes and stopover sites;
b) return patterns – site faithfulness;
c) population turnover;
d) weights, especially those associated with migration, and moult. It appears that 'morphometrics' was unintentionally left out of the specified objectives, even though it has always formed an important part of activities;
e) moult and age;
f) survival rates (from capture/recapture data); and
g) annual breeding success (from the proportion of juvenile birds in catches).

The Mission Statement, formulated later and reproduced below, states that the Group's principal objective is the collection of information in a scientific manner as a basis for conservation activities.

"The principal aim of the Victorian Wader Study Group is to gather, through extensive planned fieldwork programs, comprehensive data on waders and terns throughout Victoria on a long-term basis.

This scientifically collected information is intended to form a factual base for conservation considerations, to be a source of information for education of a wider audience, to be a means of generating interest of the general community in environmental and conservation issues, and to be a major contribution to Australian, Flyway and Worldwide knowledge of waders and terns."

Only ten formal committee meetings were ever held, the last being on 30 March 1983. Since then, although the Group has formally elected officers annually and now has a much larger committee, liaison between committee members has been on a more informal basis via discussions during fieldwork, and by email exchanges and the telephone. The Group was formally incorporated in 1987. Although a

Table 2. VWSG Wader Catches 1975 to 31 December 2005.

Species	New	Retrap	Total
Latham's Snipe *Gallinago hardwickii*	347	14	361
Black-tailed Godwit *Limosa limosa*	4	-	4
Bar-tailed Godwit *Limosa lapponica*	3494	453	3947
Short-billed Dowitcher *Limnodromus griseus*	1	-	1
Whimbrel *Numenius phaeopus*	28	_	28
Eastern Curlew *Numenius madagascariensis*	814	72	886
Marsh Sandpiper *Tringa stagnatilis*	2	-	2
Common Greenshank *Tringa nebularia*	498	60	558
Terek Sandpiper *Xenus cinereus*	33	1	34
Grey-tailed Tattler *Heteroscelus brevipes*	38	3	41
Ruddy Turnstone *Arenaria interpres*	2651	915	3566
Great Knot *Calidris tenuirostris*	616	82	698
Red Knot *Calidris canutus*	4346	672	5018
Sanderling *Calidris alba*	3096	1156	4252
Little Stint *Calidris minuta*	7	-	7
Red-necked Stint *Calidris ruficollis*	102447	28612	131059
Long-toed Stint *Calidris subminuta*	1	-	1
Pectoral Sandpiper *Calidris melanotos*	2	-	2
Sharp-tailed Sandpiper *Calidris acuminata*	8231	393	8624
Curlew Sandpiper *Calidris ferruginea*	24171	4706	28877
Cox's Sandpiper *C. acuminata* x *C. ferruginea* hybrid	1	-	1
Broad-billed Sandpiper *Limicola falcinellus*	5	-	5
Pied Oystercatcher *Haematopus longirostris*	2255	1186	3441
Sooty Oystercatcher *Haematopus fuliginosus*	747	206	953
Black-winged Stilt *Himantopus himantopus*	38	-	38
Banded Stilt *Cladorhynchus leucocephalus*	152	-	152
Red-necked Avocet *Recurvirostra novaehollandiae*	368	5	373
Pacific Golden Plover *Pluvialis fulva*	252	24	276
Grey Plover *Pluvialis squatarola*	155	23	178
Red-capped Plover *Charadrius ruficapillus*	656	183	839
Double-banded Plover *Charadrius bicinctus*	3577	995	4572
Lesser Sand Plover *Charadrius mongolus*	115	11	126
Greater Sand Plover *Charadrius leschenaultii*	31	3	34
Black-fronted Dotterel *Charadrius melanops*	57	4	61
Hooded Plover *Charadrius rubricollis*	28	1	29
Red-kneed Dotterel *Erythrogonys cinctus*	136	11	147
Masked Lapwing *Vanellus miles*	175	3	178
36 Species	159575	39794	199369

separate legal entity it has in effect operated as the Victorian arm of the Australasian Wader Studies Group (AWSG) ever since this was formed in 1981. This arrangement is formalized by an exchange of letters.

PEOPLE

A great many people have been VWSG members and/or have participated in its fieldwork activities over the years. The total is probably several thousand individuals because cannon netting teams have typically been of 15 to 25 people. Formal membership of the Group has levelled out at around 150 in recent years.

It is impossible to mention individually all those people who have made contributions to VWSG's success over the years. Some of those involved in earlier days, in addition to the Committee members already mentioned, are listed below.

In the early mist netting activities Margaret Considine, Simon Bennett, Chris Corben, Anita Smythe, Boyd Wykes and David and Penny Paton were regular members of the teams. Also, particularly active from the early days of cannon netting, were John Dawson, Brenda and Mick Murlis, Angela and Roz Jessop, Peter Hermans, Dave Cropley, John and Phil Starks, Berrice Forest, Jeff Davies, and the Rogers family (Ken, Annie, Danny, and Maryam). Mark Barter and Graeme and Margaret Rowe were heavily involved from the mid 1980s onwards, Mike Weston was active for a period (especially whilst he was doing his Honours Degree on Pied Oystercatchers at Werribee), and Doris Graham joined in the early 1990's and has been a prominent member ever since.

In the early days almost everyone had to learn everything from scratch, including how to extract birds from nets, how to age birds and how to record biometrics and moult. Nowadays the Group has a large proportion of its members capable of undertaking all these activities. Nevertheless there is a steady turnover in participants, with newcomers present at almost every fieldwork session.

RECOVERIES

One of the most tangible outcomes of VWSG catching and banding activities is the recoveries which are reported of

Table 3. Location of Waders Caught in Victoria and South Australia.

Location	To Dec 2004	2005	Total
Victoria			
Werribee	57881	847	58728
Western Port/ Flinders	49033	4038	53071
Queenscliff/ Swan Bay	28876	796	29672
Anderson Inlet (Inverloch)	22228	-	22228
Corner Inlet	21008	1520	22528
Sandy Point/ Shallow Inlet	1587	187	1774
Laverton	956	-	956
Mud Islands	753	-	753
Killarney Beach	426	-	426
Geelong (Point Henry/ Belmont Common)	257	-	257
Bendigo SF	143	-	143
Seaford Swamp	98	-	98
Braeside/ Croyden	79	-	79
Gippsland Lakes	40	-	40
Toowong	10	-	10
South Australia			
Canunda/ Carpenter Rocks/ Brown Bay/ Beachport	7761	825	8586
Total	191136	8213	199349

birds which have moved to other locations (Table 4). These now total 487 of 16 different species. The majority have occurred in Asia, particularly at stopover sites used during northward and southward migration. But a small number have also occurred on the breeding grounds and it is these, especially those in the high Arctic, which are always the most exciting.

The long distance record was held for many years by a Curlew Sandpiper which was banded at Werribee S.F. in January 1988 and later recaptured by Pavel Tomkovich in its breeding area in the Taimyr Peninsular, north-western Siberia, on 24 June 1991, a distance of 13,100 km. The circumstances of this recovery were particularly interesting. An aggressive male bird had been noticed carrying a metal band. A stuffed decoy was erected in front of a small spring net. The banded bird immediately attacked the decoy and was captured.

Another surprising recovery which occurred in the early days of the VWSG banding activities also involved a Curlew Sandpiper. It was originally mist netted at Werribee in November 1976 and was recaptured on 29 August 1980 at Point Calimere in south-east India. This is the furthest west at which any wader banded in the flyway has so far been recovered. More recently one of the most important recoveries was a Red Knot banded as a chick in the Chukotsk region, in the far north-east of Siberia, in July 2003. This bird was recaptured at Corner Inlet in July 2004. This was the first direct proof of the location of the breeding grounds of the Red Knot population which visits Victoria.

A total of 68 waders originally banded overseas have been subsequently recaptured in Victoria (Table 5). A further 172 had been banded in Australia more than 200 km from the recapture location. The total of 240 "inward" movements is surprisingly high – nearly 50% of the "outward" recovery movements.

FLAG SIGHTINGS

The placing of an orange plastic leg flag on the legs of waders caught in Victoria started in December 1990. Mark Barter was the initiator. After some initial scepticism from some members of the group, this new technique was enthusiastically welcomed. The principal objective was to increase the rate at which information was gathered on migration routes. It has proved dramatically successful, with a reporting rate overseas nearly 20 times the recovery rate. An increasing proportion of the birds handled has been given flags and in recent years almost all newly caught birds are now flagged. Up to the end of 2005, 74,914 waders of 32 different species have been leg-flagged (Table 6).

Sightings of flagged birds away from their marking locations have grown rapidly over the years as awareness of flags has become more widespread and people have learned where to report their sightings. A total of 7583 reports had been received up to the end of July 2006, with 5544 of these being overseas, in 15 different countries. They involve 24 different species (Table 7). Nearly half (3448) have been in New Zealand, this being the result of considerable movements of Victorian Red Knot and Bar-tailed Godwits to that country but also because of the enthusiasm and expertise of wader observers there. Most revealing have been the 294 sightings of Bar-tailed Godwits in Alaska as previously there was no direct proof that this is where the Victorian Bar-tailed Godwits went to breed. One of these sightings was in June 2004 at Deadhorse, near Prudhoe Bay, in the northeast of Alaska. This movement was 13,100 km, equalling the record distance moved by the earlier Curlew Sandpiper recovered in northwest Siberia.

There have also been many (2039) flag sightings within Australia of birds that have moved to other states and to locations within Victoria away from the flagging areas (Table 8). The rate of growth in the number of sightings from year to year (Table 9) is only partially as a result of the greater number of flagged birds in circulation. Much more it is related to flag awareness and flag sighting effort in the different countries used by wader populations which are leg-flagged in the non-breeding season in Victoria.

TERNS

Terns have always been an integral part of VWSG activities since 1979. Effort has been concentrated on two areas, the banding of chicks of terns which breed in Victoria and the cannon netting of adults of species which visit from the Northern Hemisphere.

In terms of numbers Crested Tern chicks dominate. More than 30,000 have been banded, mostly since 1985 when habitat management was implemented at Mud Islands in Port Phillip Bay to make available to the terns an area which was safe from storm tides. The result has been spectacularly successful in increasing the number of breeding pairs of Crested Terns in the central section of the Victorian coast, from under 1000 pairs in 1985 to around 5000 pairs in each of the last two years. The greatly improved breeding success of the Mud Islands colony led to its growth and then the initiation of a new colony at The Nobbies on Phillip Island. This has now grown to more than 3000 pairs in ten years.

More than 600 Caspian Tern chicks have also been banded. Recoveries, supplemented in more recent years by flag sightings, have shown that, like the Crested Terns, they mainly migrate to the northern New South Wales coast and southeast Queensland for the austral winter. Much smaller numbers of Fairy Tern chicks have been banded (just over 200) because most nests each year are flooded out by storm tides, resulting in poor breeding success.

More than 2000 fully-grown Common Terns and over 700 Little Terns have been cannon netted in the Gippsland Lakes. Subsequent recoveries and flag sightings have shown that all the Common Terns and most of the Little Terns are from populations which breed in the Northern Hemisphere. The Little Terns come mainly from Japan whilst the Common Tern breeding areas spread up into central Siberia.

EQUIPMENT

All the cannon-netting equipment used by the Group derives from a design created in 1967 in England. Some evolution has taken place but in general this has only been minor. Perhaps the most significant change has been the increasing use of small mesh nets from which it is much easier to extract birds. These do, however, have some disadvantages including it not being possible to fire the net successfully into a strong wind and needing to lift the net and captured birds out of any water more quickly for the safety of the birds.

Ira Savage made an enormous contribution to the manufacture and maintenance of the cannon-netting equipment for the first ten or more years of the group. Paul Buckhorn and Rod Macfarlane have taken on this role in recent years, including designing and constructing a special trailer to carry equipment into the field.

Firing boxes have evolved, not surprisingly into more and more sophisticated electronic designs. Each new person

Table 4. Recoveries >200km from banding location for birds banded in Victoria. Data are taken from the ABBBS database as of 27 July 2006.

Species	New Zealand	China (mainland)	Russia	Hong Kong (China)	Taiwan (China)	Vietnam	Indonesia	Japan	Malaysia	India	Korea	Mongolia	North Korea	Papua New Guinea	Solomon Is	Thailand	Vanuatu	Total Overseas	NSW	VIC	SA	Tas	WA	Qld	NT	Total Australia	Total
Pied Oystercatcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	73	27	16	13	-	-	-	**129**	**129**
Red-necked Stint	-	18	11	-	2	5	2	2	1	-	-	1	-	-	-	-	-	**42**	-	18	8	29	19	-	1	**75**	**117**
Curlew Sandpiper	-	20	8	8	1	2	4	-	-	1	-	-	-	-	-	1	-	**45**	7	7	3	2	22	-	-	**41**	**86**
Red Knot	43	7	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	**55**	-	-	-	-	3	1	1	**5**	**60**
Double-banded Plover	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**27**	-	-	-	-	-	-	-	**0**	**27**
Sanderling	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	**3**	-	-	20	-	2	-	-	**22**	**25**
Bar-tailed Godwit	4	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	**7**	1	-	-	-	-	1	-	**2**	**9**
Great Knot	-	6	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	**8**	-	-	-	-	-	1	-	**1**	**9**
Ruddy Turnstone	-	-	-	-	3	-	-	1	-	-	-	-	-	1	-	-	-	**5**	-	-	-	1	-	-	-	**1**	**6**
Eastern Curlew	-	1	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	**5**	-	-	-	-	-	-	-	**0**	**5**
Sharp-tailed Sandpiper	-	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	**5**	-	-	-	-	-	-	-	**0**	**5**
Sooty Oystercatcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	-	1	1	3	-	-	-	**5**	**5**
Grey Plover	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	**0**	**1**
Lesser Sand Plover	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	**0**	**1**
Pacific Golden Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	-	-	-	-	-	1	-	**1**	**1**
Red-necked Avocet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	-	1	-	-	-	-	-	**1**	**1**
Total	**74**	**58**	**29**	**8**	**7**	**7**	**6**	**6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**204**	**81**	**54**	**48**	**48**	**46**	**4**	**2**	**283**	**487**

becoming involved in this area is surprised by the shortcomings in their newly designed product which emerge in the arduous conditions in which the equipment is used. It does appear however that the current design of firing box, which costs more than $600 to make, is the most reliable yet.

In the early days the Group could not afford portable radios. A field telephone was used for communication between the firing hide and banding station but handkerchiefs or arm signals had to be used for more distant communications. On one occasion at Corner Inlet, the net was fired when the catching area observer took a handkerchief out of his pocket to blow his nose! Fortunately there was already a nice catch of Bar-tailed Godwits in the catching area

Perhaps the saddest stories related to equipment concern two large cannon nets which were stolen. One disappeared from a storeroom in the shearing sheds at Werribee where we were allowed to keep our equipment. The other disappeared during the night from a sandy spit on Spermwhale Head in the Gippsland Lakes. We had left an overnight guard sleeping in his car nearby, but he heard nothing. It appears that a small dinghy involved in night time shrimp catching had been pulled across the spit and thereby encountered the well camouflaged net. Finding a 30 x 13 metre net would have been a dream come true for a fisherman. It was suggested that the guard attach a string to his big toe on a future occasion so that he would be awoken by anyone tampering with the equipment. On another occasion a saboteur threw cannons and projectiles into deep water from an overnight stockpile on the end of one of the islands in Corner Inlet.

The VWSG, like all other cannon-net users, has experienced a range of practical problems in the field over the years. Nevertheless it has been a highly successful technique for studies dependent on catching birds

OTHER ACTIVITIES

In the early years the VWSG was invited to take its cannon netting equipment to other states in order to assist in the development of banding activities. Successful visits were paid to Tasmania, New South Wales, South Australia and, later, to the Northern Territory. VWSG equipment and many VWSG members were involved in the initiation of wader banding in north-western Australia in August 1981. VWSG members have strongly supported the activities there since then.

VWSG cannon netting equipment has also been loaned out for use over the years for catching a wide variety of other species. These have generally been for situations where researchers have not found it possible to develop other satisfactory techniques for catching adult birds of their study species. Examples include White Ibis, Australian Pelican, Satin Bowerbirds (184 caught, plus a number of other species), and Long-billed Corellas.

The VWSG organized the first state-wide count of waders on 1–2 December 1979. In the early years, organizing these counts was an important VWSG activity, but after the formation of the AWSG, the National Count Coordinator took over responsibility. Nevertheless, a substantial proportion of the persons involved in the twice-

Table 5. Waders recaptured in Victoria which had been banded elsewhere (or >200 km away in Victoria). Data are taken from the ABBBS database as of 27 July 2006.

Species	New Zealand	Japan	China (Taiwan)	China (Hong Kong)	China (mainland)	Korea	Russia	Singapore	Thailand	Vietnam	Total Overseas	VIC	Tas	WA	NSW	SA	Qld	NT	Total Australia	Total
Red-necked Stint	-	1	-	1	1	-	-	-	-	-	**3**	18	24	16	4	4	1	-	**67**	**70**
Curlew Sandpiper	2	-	4	2	-	-	1	1	1	1	**12**	7	14	10	11	3	2	2	**49**	**61**
Double-banded Plover	43	-	-	-	-	-	-	-	-	-	**43**	-	-	-	-	-	-	-	**0**	**43**
Pied Oystercatcher	-	1	-	-	-	-	-	-	-	-	**0**	27	-	-	-	1	-	-	**28**	**28**
Sanderling	-	-	-	-	-	-	-	-	-	-	**1**	-	-	1	-	8	-	-	**9**	**10**
Red Knot	3	-	-	-	-	1	-	-	-	-	**4**	-	-	2	-	1	1	-	**4**	**8**
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	-	-	**0**	-	-	-	7	-	-	-	**7**	**7**
Latham's Snipe	-	3	-	-	-	-	-	-	-	-	**3**	-	-	-	2	-	-	-	**2**	**5**
Lesser Sand Plover	-	-	-	-	-	-	-	-	-	-	**0**	-	-	-	2	-	-	-	**2**	**2**
Bar-tailed Godwit	-	-	-	-	-	-	-	-	-	-	**0**	-	-	-	-	1	-	-	**1**	**1**
Great Knot	-	-	-	-	-	-	-	-	-	-	**0**	-	-	-	-	-	1	-	**1**	**1**
Grey-tailed Tattler	-	1	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	**0**	**1**
Red-necked Avocet	-	-	-	-	-	-	-	-	-	-	**0**	1	-	-	-	-	-	-	**1**	**1**
Ruddy Turnstone	-	1	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	**0**	**1**
Sooty Oystercatcher	-	-	-	-	-	-	-	-	-	-	**0**	1	-	-	-	-	-	-	**1**	**1**
Total	**48**	**7**	**4**	**3**	**1**	**1**	**1**	**1**	**1**	**1**	**68**	**54**	**38**	**29**	**26**	**18**	**5**	**2**	**172**	**240**

Table 6. Waders Leg Flagged in Victoria (orange)

Species	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Latham's Snipe	-	-	-	-	40	-	110	56	70	-	2	-	-	-	-	-	-	**278**
Black-tailed Godwit	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	1	**4**
Bar-tailed Godwit	-	1	157	6	64	-	43	173	16	84	388	324	196	80	208	256	223	**2219**
Whimbrel	-	-	-	-	16	-	-	-	-	2	-	2	-	1	-	-	4	**25**
Eastern Curlew	-	-	8	-	73	88	87	4	37	35	91	27	18	18	38	-	20	**544**
Marsh Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	**2**
Common Greenshank	-	-	21	21	51	-	1	109	131	19	-	-	-	1	41	24	-	**419**
Terek Sandpiper	-	-	2	2	2	2	-	-	-	-	-	1	-	1	-	-	-	**10**
Grey-tailed Tattler	-	-	-	-	-	-	-	3	1	-	-	-	-	1	-	-	-	**5**
*Ruddy Turnstone	-	99	188	37	35	1	194	129	194	372	75	54	34	22	20	154	1	**1609**
Great Knot	-	-	2	-	4	-	3	36	31	21	21	53	38	78	3	20	3	**313**
Red Knot	-	-	302	26	88	1	52	59	295	289	175	334	377	681	54	176	246	**3155**
*Sanderling	-	-	163	-	191	1	47	328	148	342	51	118	36	37	26	140	64	**1692**
Little Stint	-	-	-	1	-	-	-	-	-	-	1	-	1	-	2	-	-	**5**
Red-necked Stint	-	799	1259	2516	2282	1661	1384	3065	1434	3224	4215	6038	2570	5792	5839	3489	4502	**50069**
Pectoral Sandpiper	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**1**
Sharp-tailed Sandpiper	-	4	250	111	71	21	69	145	155	474	212	105	18	670	1068	421	299	**4093**
Curlew Sandpiper	146	462	367	1255	808	839	469	753	270	633	770	1162	417	373	517	51	164	**9456**
Cox's Sandpiper	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Broad-billed Sandpiper	-	-	-	-	-	1	-	-	-	-	-	-	2	-	-	-	-	**3**
Black-winged Stilt	-	-	-	-	-	-	-	-	-	-	-	-	3	2	1	14	-	**20**
Banded Stilt	-	-	-	-	-	-	-	-	-	-	-	151	-	-	-	1	-	**152**
Red-necked Avocet	-	-	-	-	5	-	-	-	27	-	-	46	-	6	-	56	-	**140**
Pacific Golden Plover	-	10	10	1	-	-	-	6	-	10	13	-	14	-	-	-	-	**64**
Grey Plover	-	-	-	1	-	-	6	-	22	-	-	21	-	24	1	2	9	**86**
Red-capped Plover	-	-	-	-	-	19	-	-	29	3	10	2	2	12	4	6	10	**97**
Double-banded Plover	-	-	-	-	-	8	-	-	-	40	24	98	3	90	19	46	18	**346**
Lesser Sand Plover	-	-	-	14	6	8	9	13	-	4	1	-	-	-	-	-	-	**55**
Greater Sand Plover	-	-	-	-	3	6	-	-	-	2	4	-	1	-	-	-	-	**16**
Black-fronted Dotterel	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	**2**
Red-kneed Dotterel	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	**3**
Masked Lapwing	-	-	-	-	-	-	1	-	4	-	-	2	5	4	1	12	1	**30**
32 Species	**146**	**1375**	**2729**	**3992**	**3739**	**2656**	**2475**	**4881**	**2867**	**5554**	**6053**	**8538**	**3735**	**7895**	**7844**	**4870**	**5565**	**74914**

* Includes Ruddy Turnstone and Sanderling flagged with orange (only) in the south east of South Australia between 1993 and 1998.

yearly wader count program in Victoria over the last 26 years have been VWSG members.

The Group has had an active conservation officer for the last 15 years and has regularly provided data and views on issues and provided information for land management purposes. It has also undertaken direct conservation work, the most significant of which was a fox control program, funded by Coast Action/Coast Care, in Corner Inlet.

FINANCES

The Group has existed fairly frugally for most of its history, with a $10 annual subscription in 1979 rising to only a $20 subscription at the present time. Most of the activities of the Group have been financed by the volunteer members themselves. Vital assistance with funding to purchase key pieces of equipment has been provided over the years by the Victorian Department of Sustainability and Environment (and its predecessors) and other generous organisations and individual donors. The result is that the Group now has an excellent range of equipment in good condition and a modest positive bank balance.

ANALYSES AND PUBLICATIONS

The importance of analysing and publishing the data by the Group has been recognised since formation. As early as 1981 the Committee encouraged joint authorship of papers by suggesting that those having significant input whether by major contribution to the fieldwork or by carrying out the analysis or preparing text for the paper be included. Over the years many members of the VWSG have contributed to papers and articles in a wide range of journals and technical publications. A huge effort to computerise the Group's data was put in by Mark and Terry Barter in the late 1980s and early 1990s. Since then Ken Gosbell has organised the input of data by a team of VWSG members. An upgrade of the database program, especially in the data input area, has recently been completed by Heather Gibbs. This has been the foundation for over 250 papers using the VWSG's data which have now been published in the scientific literature. Most of these have appeared in the AWSG journal, *Stilt* (63 papers and 80 reports). However other papers and short notes have appeared in Emu, Ibis, Arctic Birds, the International Wader Study Group Bulletin and a range of other journals. The VWSG has also produced a substantial bulletin, 29 issues so far, and 52 papers or technical notes have appeared in this. It is now produced annually but two smaller bulletins were produced in some early years. A further 50 papers

Table 7. Total number of sightings by species and country of Victorian-flagged waders. Data to 31 July 2006.

Species	New Zealand	Australia	Hong Kong (China)	USA	China (mainland)	Korea	Japan	Taiwan (China)	Indonesia	Russia	Mongolia	Malaysia	Vietnam	Brunei	East Timor	Thailand	Total
Red Knot	2420	314	4	-	17	5	5	18	-	2	-	-	-	-	-	-	**2785**
Bar-tailed Godwit	980	153	-	294	87	200	56	-	-	-	-	-	-	-	-	-	**1770**
Red-necked Stint	30	783	214	-	136	13	50	101	45	35	25	4	2	1	1	1	**1441**
Curlew Sandpiper	-	345	376	-	17	-	1	44	22	2	-	1	1	-	-	-	**809**
Sanderling	-	172	13	-	5	4	109	4	1	2	-	-	-	-	-	-	**310**
Great Knot	-	77	4	-	8	20	2	6	-	-	-	-	-	-	-	-	**117**
Sharp-tailed Sandpiper	-	53	2	-	5	9	-	11	1	-	-	-	-	-	-	-	**81**
Eastern Curlew	-	43	-	-	4	12	16	3	-	1	-	-	-	-	-	-	**79**
Ruddy Turnstone	11	33	1	-	1	5	4	18	-	-	-	-	-	-	-	-	**73**
Greater Sand Plover	-	14	9	-	-	-	-	1	-	-	-	-	1	-	-	-	**25**
Grey Plover	-	2	-	-	1	1	19	-	-	-	-	-	-	-	-	-	**23**
Lesser Sand Plover	-	15	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**16**
Red-necked Avocet	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**13**
Black-tailed Godwit	-	5	-	-	1	2	-	1	-	-	-	-	-	-	-	-	**9**
Double-banded Plover	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**8**
Terek Sandpiper	-	1	1	-	1	3	-	-	-	-	-	-	-	-	-	-	**6**
Grey-tailed Tattler	-	5	-	-	-	-	1	-	-	-	-	-	-	-	-	-	**6**
Common Greenshank	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**2**
Broad-billed Sandpiper	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**2**
Banded Stilt	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Latham's Snipe	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Whimbrel	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Pectoral Sandpiper	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Pied Oystercatcher	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Pacific Golden Plover	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Red-capped Plover	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Total	**3448**	**2039**	**625**	**294**	**283**	**274**	**263**	**209**	**69**	**42**	**25**	**5**	**4**	**1**	**1**	**1**	**7583**

using VWSG data are currently in preparation or are planned.

Other articles have regularly been produced for the Birds Australia magazine *Wingspan*, for *The Babbler* (the quarterly publication of the Victorian group of Birds Australia), and for the AWSG newsletter, *The Tattler*. VWSG activities have occasionally been shown on television, and information on them has been provided frequently to the radio and print media.

EVOLUTION OF OBJECTIVES AND ACTIVITIES

There has been a gradual change in the emphasis of VWSG fieldwork over its 29-year history. Initially the main target was to get birds banded in order to discover their migration routes, stopover sites, destinations and return patterns. Achieving this was initially dependent on recoveries and recaptures but movement data have been greatly supplemented by flag sightings over the last 16 years. Whilst the prime interest has always been the migratory waders that breed in the northern hemisphere, the Group did undertake an intensive project for ten years (1979–1988) on Double-banded Plover. Over 400 movements between New Zealand and Australia were recorded and it was shown that only the population breeding in the centre of the South Island came to Australia in the winter.

Pied and Sooty Oystercatchers, "resident" species, have also been intensively studied for the past 18 years. These species are more mobile than previously thought with Pied Oystercatchers moving as far northwards as the northern New South Wales coast and as far westwards as the mouth of the Murray River in South Australia. Pied Oystercatchers tend to go southwards, out to the Bass Strait islands, but one went as far as Matsuyker Island off the south-west coast of Tasmania.

Data on the biometrics and moult of the various species were gradually built up over the years and fieldwork has became increasingly directed at filling gaps in the data. This information, particularly on moult, has also greatly assisted in the correct ageing of birds in the hand. Weight data have also been important in determining migration dates and in helping to predict likely flight distances and destinations.

Around 20% of the waders caught by the Group are retraps of birds banded in earlier years. The oldest Red-necked Stint and Curlew Sandpiper recaptured were close to 20 years old, whilst Pied Oystercatcher, Bar-tailed Godwit and Eastern Curlew reached 22. In most other species, birds of at least 15 years of age have been recaptured. However the average lifespan (3–5 years) of waders is much shorter than this.

During the last 15 years the emphasis of fieldwork programs has gradually moved towards obtaining information on annual breeding success and on survival rates – the key parameters determining population levels. The "summer program" now largely revolves around obtaining adequate catch samples of each species at a range of sites in the November – March period, which is when populations are most stable. The proportion of juvenile/first year birds in catches is used in an index of their breeding success in the previous northern hemisphere summer. The VWSG now has an invaluable set of catch data stretching back for 28 seasons on Red-necked Stint and 27 seasons on Curlew Sandpiper and nearly as long on several other species. Continuing this data collection will be the main priority into the foreseeable future.

Table 8. Total number of sightings within Australia of Victorian-flagged waders away from the flagging location. Data to 31 July 2006.

Species	SA	WA	QLD	NSW	Vic	TAS	NT	Total
Red-necked Stint	215	193	47	76	161	77	14	783
Curlew Sandpiper	61	153	31	60	15	25	-	345
Red Knot	60	55	111	69	1	7	11	314
Sanderling	99	18	4	11	32	4	4	172
Bar-tailed Godwit	-	22	92	35	3	1	-	153
Great Knot	7	5	53	2	-	1	9	77
Sharp-tailed Sandpiper	9	6	10	11	13	-	4	53
Eastern Curlew	2	-	28	11	-	2	-	43
Ruddy Turnstone	17	6	-	4	-	4	2	33
Lesser Sand Plover	-	-	14	1	-	-	-	15
Greater Sand Plover	-	-	13	1	-	-	-	14
Red-necked Avocet	-	-	-	4	9	-	-	13
Black-tailed Godwit	-	2	-	3	-	-	-	5
Grey-tailed Tattler	-	-	5	-	-	-	-	5
Banded Stilt	2	-	-	-	-	-	-	2
Grey Plover	-	1	-	-	1	-	-	2
Latham's Snipe	-	-	-	-	1	-	-	1
Whimbrel	-	-	1	-	-	-	-	1
Common Greenshank	-	-	-	1	-	-	-	1
Terek Sandpiper	-	-	1	-	-	-	-	1
Pectoral Sandpiper	-	-	-	1	-	-	-	1
Broad-billed Sandpiper	-	-	-	-	1	-	-	1
Pied Oystercatcher	-	-	-	1	-	-	-	1
Pacific Golden Plover	-	-	-	1	-	-	-	1
Red-capped Plover	-	-	-	-	1	-	-	1
Double-banded Plover	-	-	-	-	1	-	-	1
Total	472	461	410	292	239	121	44	2039

The VWSG will continue to help others in their studies. Most recently this has involved making birds available to veterinary experts for cloacal swabbing and for blood sampling to test for avian-borne diseases, especially the H5N1 strain of Avian Influenza. Another addition to the portfolio of VWSG study techniques in recent years is the collection of blood samples for DNA testing to facilitate sex segregation for some biometric analyses and to examine differential migration patterns of the sexes (the most extreme case being Grey Plover, where almost all the birds in Victoria are females).

Feathers are now being systematically collected for studies based on stable isotope analysis. By analysing feathers which were grown at a known location, this technique is proving an increasingly helpful tool for obtaining more detailed information on the migration of different wader populations and sub-populations.

And the future hope is to be able to use satellite transmitters to track individual birds along their migratory path. The appetite was whetted in 1998 when the VWSG assisted the Queensland WSG by putting satellite transmitters on to eight Eastern Curlews. The hope is that satellite transmitters will soon have been proved to have become small enough to be successfully carried by species such as Bar-tailed Godwits. It is still unclear whether they make a stopover on northward migration between leaving Victoria and arriving on the Chinese coast.

It will be fascinating to look back in another ten years' time and see how these new elements of our studies have contributed to knowledge and in what further ways fieldwork has evolved. I am sure that the initiators of wader mist netting activities in 1975 couldn't have foreseen that wader studies would grow and be sustained in such a way that the VWSG has banded more waders in almost every year since then than any other wader banding operation in the world.

ACKNOWLEDGEMENTS

The achievements of the VWSG would not have been possible without the enthusiastic and sustained efforts of a large number of people over a 29 year period. David Purchase, of the Australian Bird and Bat Banding Scheme, is thanked for his considerable help and encouragement in the early days. The ABBBS and the state wildlife authorities are thanked for granting permits. Landowners – particularly Melbourne Water at Werribee Sewage Farm – are thanked for allowing access. Parks Victoria frequently assisted with boat transport. Various Government bodies, Trusts and individuals have generously provided financial assistance over the years, particularly for the purchase of equipment, Roz Jessop, David Robertson, Ken Rogers, and an anonymous referee are thanked for their comments on a draft of this paper. Heather Gibbs and Helen Vaughan kindly prepared the tables.

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Table 9. Total number of sightings of Victorian-flagged waders each year. Data to end July, 2006

Year	New Zealand	Australia	Hong Kong (China)	USA	China (main-land)	Korea	Japan	Taiwan (China)	Indo-nesia	Russia	Mon-golia	Malay-sia	Viet-nam	Brunei	East Timor	Thai-land	Total
1990	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	5
1991	10	18	1	-	-	-	2	-	-	-	-	-	-	-	-	-	31
1992	25	39	2	-	-	-	10	1	1	-	-	-	-	1	-	-	79
1993	18	88	53	-	-	-	8	2	1	-	-	-	-	-	-	1	171
1994	14	76	26	-	-	-	7	1	-	2	-	-	1	-	-	-	127
1995	13	37	7	-	-	-	13	3	-	1	-	1	1	-	-	-	76
1996	23	39	10	-	-	-	26	1	-	11	-	-	1	-	-	-	111
1997	23	52	28	-	2	4	34	8	2	1	-	-	-	-	-	-	154
1998	41	135	96	-	1	7	32	-	-	1	-	-	-	-	-	-	313
1999	70	128	55	14	3	8	36	12	-	8	1	-	-	-	-	-	335
2000	95	150	50	1	2	13	24	18	1	5	16	1	1	-	-	-	377
2001	173	187	55	18	7	10	31	19	-	1	1	-	-	-	-	-	502
2002	342	194	43	22	32	18	17	21	-	2	-	-	-	-	-	-	691
2003	572	206	50	74	4	4	8	26	-	1	-	1	-	-	-	-	946
2004	378	228	61	53	107	21	10	36	6	3	7	1	-	-	-	-	911
2005	1091	281	53	112	88	38	5	52	51	5	-	1	-	-	-	-	1777
2006	559	181	31	-	37	151	-	9	7	1	-	-	-	-	1	-	977
Total	3448	2039	625	294	283	274	263	209	69	42	25	5	4	1	1	1	7583

SHOREBIRDS IN NEW ZEALAND

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New Zealand's coast supports up to 166,000 northern hemisphere breeding waders, including internationally important populations of Bar-tailed Godwit and Red Knot, during the austral summer. Some 163,000 local breeding waders occur on the coast during winter. Most taxa of endemic waders are threatened, the Black Stilt being critically endangered. Habitat loss and predation by introduced mammals are the greatest threats.

INTRODUCTION

New Zealand, with a land area of 270,500 km^2, is situated at the southernmost point of the East Asian–Australasian Flyway, between 33^o and 47^{o}S. The coastline is some 15,134 km long (Anon 2006); two-thirds of it is hard rocky shore, the remaining third being soft sand, silt and gravel (Taylor & Smith 1997). An introduction to coastal environments in New Zealand is given by Morton & Miller (1973) and Morton (2004).

Nationwide counts of waders co-ordinated by the Ornithological Society of New Zealand were made in summer and winter from 1983 to 1994. Endemic waders breed on coasts (Northern New Zealand Dotterel, Variable Oystercatcher), on braided river beds (Wrybill, Black Stilt), subalpine mountain tops (Southern New Zealand Dotterel) and densely vegetated subantarctic islands (snipe); population estimates of these species were derived from winter counts, whereas estimates for northern hemisphere breeders were made from summer counts. These counts showed that New Zealand's coast supported some 166,000 northern hemisphere breeding waders during the austral summer and about 163,000 New Zealand breeding waders in winter (Sagar *et al*. 1999).

The first human arrival, of Polynesians some 2000 years ago (Worthy & Holdaway 2002), is thought to have set in train the first wave of bird extinctions due to introduced mammalian predators (notably Pacific Rat [kiore] *Rattus exulans*). Subsequent introductions by European settlers caused further waves of extinction with impacts continuing to the present day (see below).

Habitat changes following human settlement also have had marked impacts on some wader species. The felling of forests and the opening of pasture lands opened the way for colonisation of New Zealand by Australian species such as the Pied Stilt (Holdaway 1995, Worthy & Holdaway 2002) and, more recently, the Spur-winged Plover (Barlow 1972), whilst also allowing Pied Oystercatchers to expand their breeding range out of braided river beds (Sagar *et al.* 2000). Human induced habitat changes in the Auckland Islands also may have allowed the population of Banded Dotterels to increase (Walker *et al.* 1991). In contrast, the building of hydro-electric power schemes and the spread of exotic plants in riverbeds has resulted in less breeding habitat for species such as Black-fronted Terns and Wrybills.

Mangroves *Avicennia resinifera* occur in the northern part of the North Island, south to about 38^o (Wardle 1991) and currently cover some 22,500 ha (MAF 2006). In recent years encroachment of tidal areas by mangrove has increased, apparently due to increased sediment and nutrient runoff, and is becoming a topic of public debate (Green *et al*. 2003), with concern about the loss of high-tide wader roosts in the Firth of Thames (Woodley 2005).

ENDEMIC WADERS

Eighteen taxa representing at least 13 species of wader breed in New Zealand, of which 10 are endemic. Population estimates are given in Table 1. Information on the distribution and movements of endemic waders in New Zealand has recently been summarised by Dowding & Moore (2006) and is not considered further here.

ARCTIC-BREEDING MIGRANT WADERS

New Zealand lies at the South-eastern extremity of the East Asian–Australasian Flyway and receives relatively few migrant Arctic-breeding shorebirds, especially when compared with Australia. A total of 47 species has been recorded (Tables 2 and 3) but of these only three occur in internationally significant numbers – Bar-tailed Godwit, Red Knot and Ruddy Turnstone.

Coastal wader surveys have been conducted at some sites by members of the Ornithological Society of New Zealand (OSNZ) since the 1950s. A national wader census project between 1983 and 1994 resulted in coverage of all main wader sites throughout the country with winter (June/early July) and summer (November/early December) counts (Sagar *et al.* 1999). Wader counts continued, but on a less formal basis, between 1994 and 2003 (Southey in prep.) and since 2003 have been reinstated as an official OSNZ project, with support from the Department of Conservation (OSNZ unpubl.). Population estimates of the more regularly occurring species are given in Table 2; vagrant species are listed in Table 3. Note that the estimates based on Sagar *et al.* (1999) were derived from censuses from 1984–1994 and may be out of date; updated national estimates are not yet available.

Count data at a national level are too few to allow detailed analysis of national population trends. However, medium- to long-term data sets exist for certain major sites,

Table 1. Population estimates of waders breeding in New Zealand. After Dowding and Moore (2006) if not otherwise indicated.

Species	**Population estimate**	**Comments**
New Zealand Pied Oystercatcher *Haematopus finschi*	130,000	Population increasing
Variable Oystercatcher *Haematopus unicolor*	4,500	Population increasing
Chatham Island Oystercatcher *Haematopus chathamensis*	c. 170 mature individuals	Subject to ongoing management
Pied Stilt *Himantopus himantopus leucocephalus*	30,000	Population trend not known
Black Stilt *Himantopus novaezelandiae*	c. 50	Population declining due to predation and interbreeding with Pied Stilt
Southern New Zealand Dotterel *Charadrius obscurus obscurus*	c. 250	Increased from a low of 62 in 1992 due to intensive management
Northern New Zealand Dotterel *Charadrius obscurus aquilonius*	c. 1,700	Population declining
Banded Dotterel *Charadrius bicinctus bicinctus*	50,000	Population declining
Auckland Island Banded Dotterel *Charadrius bicinctus exilis*	730	Population trend not known
Black-fronted Dotterel *Charadrius melanops*	1,700	Colonised in 1950s
Spur-winged Plover *Vanellus miles*	abundant	Colonised in 1930s
New Zealand Shore Plover *Thinornis novaeseelandiae*	c. 120 mature individuals	Largely confined to 2 islands in the Chathams group
Wrybill *Charadrius (Anarhynchus) frontalis*	4,500-5,000	Population declining
New Zealand Snipe *Coenocorypha aucklandica*	20,000[2]	Population trend not known
Chatham Island Snipe *Coenocorypha pusilla*	At least 1,000 pairs	Confined to 4 islands in the Chathams group
Snares Island Snipe *Coenocorypha [aucklandica] huegeli*	1,100[1]	Population trend not known
Antipodes Island Snipe *Coenocorypha [aucklandica] meinertzhagenae*	8,000[1]	Population trend not known
Campbell Island Snipe *Coenocorypha* undescribed taxon	<50[2]	Population now expanding from Jacquemart Island to Campbell Island (Miskelly and Fraser 2006)

Notes: [1]After Wetlands International (2006). [2]After Barker *et al.* (2005).

Table 2. Population estimates of arctic-breeding shorebirds occurring regularly in New Zealand. After Sagar *et al*. (1999).

Species	**Population estimate**
Greater Sand Plover *Charadrius leschenaultii*	<10
Lesser Sand Plover *Charadrius mongolus*	<10
Pacific Golden Plover *Pluvialis fulva*	649
Grey Plover *Pluvialis squatarola*	<10
Ruddy Turnstone *Arenaria interpres*	5,069
Red Knot *Calidris canutus*	58,637
Sanderling *Calidris alba*	<10
Curlew Sandpiper *Calidris ferruginea*	86
Sharp-tailed Sandpiper *Calidris acuminata*	81
Pectoral Sandpiper *Calidris melanotos*	<10
Red-necked Stint *Calidris ruficollis*	175
Eastern Curlew *Numenius madagascariensis*	34
Whimbrel *Numenius phaeopus*	117
Bar-tailed Godwit *Limosa lapponica*	101,698
Black-tailed Godwit *Limosa limosa*	<10
Hudsonian Godwit *Limosa haemastica*	<10
Grey-tailed Tattler *Tringa brevipes*	<10
Greenshank *Tringa nebularia*	<10
Marsh Sandpiper *Tringa stagnatilis*	<10
Terek Sandpiper *Tringa terek*	<10

particularly the Manukau Harbour and Firth of Thames (continuous since 1960/1961; Battley *et al*. 2007) and Farewell Spit (periodic since 1961, continuous since 1983; Schuckard 2002). These reveal that there have been substantial changes in numbers of Bar-tailed Godwits and Red Knots at these sites. Godwits showed two general population peaks in the Manukau Harbour and Firth of Thames – one in the mid-1960s and one in the early-mid 1990s. Over a shorter time scale, numbers of godwits at four of the most important sites in New Zealand (Kaipara and Manukau Harbours, Firth of Thames, Farewell Spit) declined substantially from the mid-1990s to mid-2000s, with a decrease of almost over 20,000 birds (Figure 1). The national population may currently be considerably lower than the 101,000 estimated by Sagar *et al*. (1999).

Red Knots increased in the Manukau Harbour from less than a thousand birds in the early 1960s to 10–20,000 birds in the 1980s (Battley *et al.* 2007). This increase overlapped

Table 3. Vagrant waders recorded in New Zealand after Sagar *et al*. (1999), Turbott (1990), Heather and Robertson (1996), Hill (2006), Petch *et al*. (2002).

Species
Painted Snipe *Rostratula benghalensis*
Oriental Pratincole *Glareola maldivarum*
Red-capped Dotterel *Charadrius ruficapillus*
Ringed/Semipalmated Plover *Charadrius hiaticula/semipalmatus*
Red-kneed Dotterel *Erythrogonys cinctus*
Oriental Plover *Charadrius veredus*
Japanese Snipe *Gallinago hardwickii*
Great Knot *Calidris tenuirostris*
Dunlin *Calidris alpina*
Baird's Sandpiper *Calidris bairdii*
White-rumped Sandpiper *Calidris fusicollis*
Little Stint *Calidris minuta*
Western Sandpiper *Calidris mauri*
Long-toed Stint *Calidris subminuta*
Broad-billed Sandpiper *Limicola falcinellus*
Stilt Sandpiper *Micropalama himantopus*
Ruff *Philomachus pugnax*
Asiatic Dowitcher *Limnodromus semipalmatus*
Little Whimbrel *Numenius minutus*
Bristle-thighed Curlew *Numenius tahitiensis*
Upland Sandpiper *Bartramia longicauda*
Wandering Tattler *Tringa incana*
Common Sandpiper *Tringa hypoleucos*
Lesser Yellowlegs *Tringa flavipes*
Red-necked Phalarope *Phalaropus lobatus*
Grey Phalarope *Phalaropus fulicarius*
Wilson's Phalarope *Phalaropus tricolor*

with a long-term decline in knot numbers on Farewell Spit (from 27,000 in 1961 to 6800 in 2001; Schuckard 2002) but the timing of the changes do not mean there has been a simple redistribution of birds between these sites (the steepest decline on Farewell Spit was when numbers in the Manukau Harbour were fairly stable). It is evident that factors affecting Arctic shorebird populations in New Zealand are not constant among sites. Preliminary analyses of numbers of Arctic waders in the Manukau Harbour and Firth of Thames indicate that while for some for species changes in productivity are at least partly behind their population changes (peaks in total numbers coincide with increases in overwintering immature birds), habitat changes have affected the distribution and numbers of other species at a local scale.

WETLANDS OF INTERNATIONAL IMPORTANCE FOR WADERS

Cromarty & Scott (1996) reviewed wetlands throughout New Zealand and listed sites of international importance according to the Ramsar criteria then current. Among the 73 sites listed, there were 19 which were identified as having particular wader values.

The only population estimates for Northern Hemisphere waders in New Zealand currently available are those given by Sagar *et al.* (1999). The Ramsar criteria for identifying sites of 'international' importance based on waterbird numbers are:

Criterion 5. A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds

Criterion 6. A wetland should be considered internationally important if it regularly supports 1% of the individuals of a population of one species or subspecies of a waterbird (based on Wetlands International 2006)

Taking the results of the 1983–1994 censuses (Sagar *et al*. 1999), and current total population figures (Wetlands International 2006) there are 15 sites which should be considered as internationally important for Arctic-breeding waders (Table 4).

Dowding & Moore (2006) list the 22 main sites of international importance for endemic waders (Table 5). It should be noted that due to the very small populations of species such as Chatham Island Oystercatcher and Black Stilt, sites regularly supporting one bird are considered to be internationally important under the Ramsar criteria; these sites are not listed in Table 5.

Four of the six listed Ramsar sites in New Zealand are of importance to waders (Table 6). None of these has a current management plan, although one for Farewell Spit is in preparation. The ecology of waders on Farewell Spit was studied by Battley (1996), and Battley *et al.* (2005a) detail the benthos of the Farewell Spit tidal flats. Rance & Cooper (1997) and Thompson & Ryder (2003) provide information about Waituna Lagoon. Brownell (2004) provides information about the ecology of the Firth of Thames site and Battley & Brownell (2007) give more information on changes in numbers of waders and summarise relevant knowledge about wader foraging ecology. Information about the Manawatu estuary is available from the Ramsar Sites Information Service (http://www.wetlands.org/rsis/). A proposal to extend the Waituna Lagoon Ramsar Site to include Awarua Bay (Cromarty & Scott 1996) has yet to be implemented.

A review of rivers of national/international importance was undertaken by Chadderton *et al*. (2004); this includes a number of rivers with wader values.

THREATS TO WADERS

The arrival of humans (initially Polynesians, later Europeans) in New Zealand together with their attendant camp followers and deliberately introduced species (especially rats *Rattus exulans, R. norvegicus, R. rattus*, cats *Felis catus*, mustelids *Mustela erminea, M. nivalis, M. furo*, and European Hedgehogs *Erinaceus europaeus*), have had a marked impact on many shorebird species in New Zealand and predation by introduced mammals continues to seriously threaten a number of species (Dowding & Murphy 2001). Population recovery once predators have been removed can be spectacular (Miskelly & Fraser 2006).

Three endemic taxa are known to have become extinct (Table 7) – snipe possibly having become extinct on the North and South Islands by the time of European arrival (Worthy & Holdaway 2002, but see Tennyson & Martinson 2006). Ranges of some species have become severely

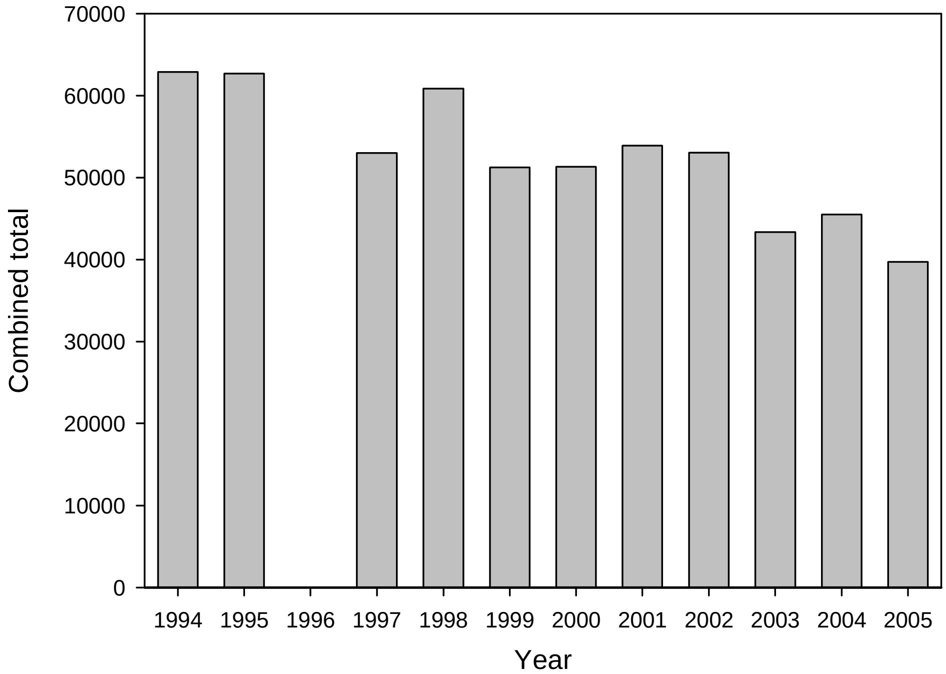

Figure 1. Decrease in numbers of Bar-tailed Godwits in the Kaipara and Manukau Harbours, Firth of Thames and Farewell Spit. Counts are from OSNZ censuses conducted in November/December (first three sites) or are the higher of censuses in November or February (Farewell Spit).

Table 4. Coastal wetlands in New Zealand of international importance for Arctic-breeding waders.

Site	**Criteria**			
	20,000 waders	**Bar-tailed Godwit**	**Red Knot**	**Ruddy Turnstone**
Parengarenga Harbour, Far North	.	+	+	+
Houhora Harbour, Far North	.	.	+	.
Rangaunu Bay, Far North	.	+	+	.
Whangarei Harbour, Northland	.	+	+	.
Kaipara Harbour, North Auckland	+	+	+	.
Manukau Harbour, Auckland	+	+	+	.
Firth of Thames, South Auckland	+	+	+	.
Tauranga Harbour, Bay of Plenty	.	+	.	.
Ohope Spit, Ohiwa Harbour, Bay of Plenty	.	+	.	.
Kawhia Harbour, Waikato	.	+	.	.
Farewell Spit, Northwest Nelson	+	+	+	.
Motueka Estuary, Tasman Bay	.	+	.	.
Waimea Inlet, Tasman Bay	.	+	.	.
Avon-Heathcote Estuary, Canterbury	.	+	.	.
Invercargill Estuary, Southland	.	+	.	.

restricted – for example, Shore Plovers used to occur at inland sites in the South Island, and fossils of New Zealand Dotterel have been found at high altitude in northwest Nelson (Worthy & Holdaway 2002). Hybridisation with Pied Stilt remains a serious threat to the Black Stilt (Greene 1999). Four species are currently considered to be nationally critical/globally endangered (Table 8).

Human impacts on coastal environments are increasing with habitat loss due to infilling/reclamation, subdivision for urban development adjacent to shores (with associated disturbance and pet animals), mangrove encroachment in the northern harbours, shellfisheries, aquaculture and sea level rise. The introduction of exotic organisms, both deliberate, e.g. the cord-grass *Spartina* (Partridge 1987) and accidental, e.g. the oyster *Crassostrea gigas* (Dinamani 1971), has resulted in widespread impacts in many coastal areas. Green (2006) provides an introduction to current estuarine management issues.

Loss of shorebird nesting habitat in braided rivers is occurring as a result of encroachment by vegetation (mostly

Table 5. Sites of international importance for endemic waders in New Zealand after Dowding and Moore (2006).

Site	Pied Oyster-catcher	Variable Oyster-catcher	Pied Stilt	Black Stilt	New Zealand Dotterel	Banded Dotterel	Wrybill
Sites of international importance for two or more taxa							
Parengarenga Harbour, Far North	.	+	+	.	+	+	+
Houhora Harbour, Far North	.	+	+	.	+	+	+
Rangaunu Harbour, Far North	.	+	+	.	+	.	.
Whangarei Harbour, Northland	+	+	+	.	+	+	+
Mangawhai Estuary, Northland	.	+	.	.	+	.	.
Kaipara Harbour, North Auckland	+	?	+	+	+	+	+
Manukau Harbour, Auckland	+	.	+	+	+	+	+
Firth of Thames, South Auckland	+	.	+	+	+	.	+
Aotea Harbour, Waikato	+	.	+	.	.	+	.
Kawhia Harbour, Waikato	+	.	+	+	.	+	.
Matarangi Spit, Coromandel	.	+	.	.	+	+	.
Tauranga Harbour, Bay of Plenty	+	+	+	+	+	+	+
Ohiwa Harbour, Bay of Plenty	.	+	.	.	+	+	.
Farewell Spit, Northwest Nelson	+	+	+	+	+	+	.
Tasman Bay	+	+	+	+	.	.	.
Avon-Heathcote Estuary, Canterbury	+	+	.	+	.	.	.
Lake Ellesmere, Canterbury	.	.	+	+	.	+	+
Wainono Lagoon, Southland	.	.	+	+	.	+	.
Awarua Bay, Southland	.	+	.	.	+	+	.
Sites of critical importance for single taxa							
Upper Waitaki Basin, central South Island	.	.	.	+	.	.	.
Paterson Inlet, Stewart Island	.	.	.	.	+	.	.
Auckland Islands	.	.	.	.	.	+	.

Table 6. Designated Ramsar Sites in New Zealand which are important for waders.

Site	Date listed	Area (ha)
Farewell Spit, Northwest Nelson	13 August 1976	~ 11,388
Waituna Lagoon, Southland	13 August 1976	~ 5,923
Firth of Thames, South Auckland	29 January 1990	~ 7,800
Manawatu river mouth and estuary, Manawatu	27 July 2005	~ 200

Table 7. Extinct wader species in New Zealand. Taxonomy follows Holdaway *et al*. (2001). Probable cause of extinction follows Tennyson and Martinson (2006).

Species	Probable cause of extinction
Forbes' Snipe *Coenocorypha chathamica*	Pacific Rat *Rattus exulans*, cat *Felis catus*
South Island Snipe *Coenocorypha iredalei*	Weka *Gallirallus australis*, Pacific Rat, Ship Rat *Rattus rattus*, cat
North Island Snipe *Coenocorypha barrierensis*	Pacific Rat, cat

exotic), which often is exacerbated by changing flow regimes due to water abstraction for irrigation and hydroelectric schemes (O'Donnell 2004).

Recovery plans have been prepared by the New Zealand Department of Conservation for New Zealand Dotterel (Dowding 1993, Dowding & Davis 2007), Chatham Island Oystercatcher (Anon. 2001), Chatham Island Snipe (Aikman *et al*. 2001), and Black Stilt (Maloney & Murray 2002).

RESEARCH

Until recently research on waders in New Zealand has been largely focused on the biology of threatened endemic species, viz.: Chatham Island Oystercatcher (Schmechel 2001), Black Stilt (Pierce 1996), Wrybill (Davies 1991, 1997; Hay 1984; Riegen & Dowding 2003), New Zealand Shore Plover (Davis 1994a, 1994b), New Zealand Dotterel (Dowding 1994, 1999, Dowding & Chamberlain 1991, Dowding & Murphy 1993), and snipe species (Miskelly 1999a, 1999b, Miskelly & de Lange 2006). Studies of other native species include Pied Oystercatcher (Baker 1973, 1975, Sagar & Geddes 1999, Sagar *et al.* 2000, Sagar *et al*. 2002), Variable Oystercatcher (Baker 1973, Crossland 2001), and Banded Dotterel (Pierce 1989, 1999). Remarkably, a new population of Shore Plover was discovered as recently as 1999 (Bell & Bell 2000), although this is now thought extinct (Dowding *et al.* 2005), and a possible new snipe taxon discovered (Barker *et al*. 2005).

Research on migratory, arctic-breeding waders has included banding and migration studies (Battley 1997, 1999, Riegen 1999, Battley & Piersma 2005, Riegen *et al*. 2005), as well as counts (see above). Individual colour banding of

Table 8. Threat status of New Zealand waders.

Species	Hitchmough *et al.* (2005)	IUCN (2006)
Black Stilt *Himantopus novaezelandiae*	Nationally critical	Critically endangered
Chatham Island Oystercatcher *Haematopus chathamensis*	Nationally critical	Endangered
New Zealand Shore Plover *Thinornis novaeseelandiae*	Nationally critical	Endangered
Southern New Zealand Dotterel *Charadrius obscurus obscurus*	Nationally critical	Endangered
Wrybill *Charadrius frontalis*	Nationally vulnerable	Vulnerable
Banded Dotterel *Charadrius bicinctus*	Gradual decline	Lower risk/Least concern
Northern New Zealand Dotterel *Charadrius obscurus aquilonius*	Sparse	Endangered
Chatham Island Snipe *Coenocorypha pusilla*	Range restricted	Vulnerable
Auckland Island Banded Dotterel *Charadrius bicinctus exilis*	Range restricted	
Auckland Island Snipe *Coenocorypha [aucklandica] aucklandica*	Range restricted	Near threatened
Snares Island Snipe *Coenocorypha [aucklandica] huegeli*	Range restricted	
Antipodes Island Snipe *Coenocorypha [aucklandica] meinertzhagenae*	Range restricted	

Bar-tailed Godwit, Red Knot and Ruddy Turnstone started in 2003 to investigate movements within New Zealand and this has already provided extensive information within New Zealand as well as overseas (P.F. Battley, D.S. Melville, and R. Schuckard unpubl.), and has allowed elucidation of other aspects of the ecology of Bar-tailed Godwits (Battley 2006a, 2006b).

Surveillance studies for avian influenza A virus, which are ongoing, have principally sampled Red Knot and Wrybill.

THE FUTURE

Endemic species

The taxonomy of the New Zealand snipe requires elucidation to ensure that all taxa are adequately protected and managed. Work is in progress to determine the taxonomic status of New Zealand oystercatchers. Predator control will be a continuing management requirement for species such as Black Stilt, New Zealand Dotterel, and increasingly Wrybill.

Arctic-breeding species

The migration routes and use of stopover sites used by waders between New Zealand and their breeding grounds remain poorly known. Some Red Knots use northern Australia on northward migration but there is no detailed information on how many do so, how predictably, and whether those that do not stop there migrate direct to the Yellow Sea area or have other stopover sites. A further complication is if New Zealand hosts a mix of knots of the subspecies *rogersi* and *piersmai* (Tomkovich & Riegen 2000) that may have different migration schedules (Battley *et al.* 2005b). Locating the staging areas of Red Knots in the Yellow Sea on northward migration, and all southward migration staging sites, is a high priority. Whether Bar-tailed Godwits migrate direct to Asia from New Zealand is unknown (Battley & Piersma 2005). Resightings of colour-banded birds in Asia 11 days after last being seen in New Zealand (P.F. Battley unpubl.) indicates a quick migration of some individuals but does not rule out the possibility of a short stopover *en route*. The bulk of the population seems to reach Asia many weeks after migration starts in New Zealand, suggesting that some birds may make stopovers on their way north. Satellite telemetry studies of Bar-tailed Godwits during the northward migration in 2007 should allow the identification of any stopover area(s) used by birds that do not migrate directly to the Yellow Sea region. Global climate change is likely to affect weather patterns over the Pacific (Vecchi *et al*. 2006) and if wind patterns change this could seriously impact southward migrating Bar-tailed Godwits which are thought to make the 11,000 km journey non-stop with considerable wind assistance (Gill *et al.* 2005). The breeding grounds of Ruddy Turnstones visiting New Zealand are unknown and further work is required.

Censuses of non-breeding arctic shorebirds in New Zealand and Australia are the only practical way to determine population trends for a number of taxa. ‘Implementation of statistically robust methodologies to monitor shorebird populations in priority countries’ (including New Zealand and Australia) was a priority action in the *Action Plan for the Conservation of migratory shorebirds in the East Asian–Australasian Flyway: 2001–2005*. The timing of counts requires further consideration to ensure that these are undertaken at a time when populations are as stable as possible, and they should be coordinated in both countries (Wilson 2001). The ability to assess the proportions of juveniles in populations to measure breeding success (Minton *et al*. 2005) is limited in New Zealand due to relatively low catching activity and the tendency of young knots at least to occur predominantly in Australia, but the field identification of juvenile Bar-tailed Godwits is possible (http://osnz.org.nz/nzwaderstudy.htm#juv) and should be encouraged.

There is increasing demand for coastal and estuarine monitoring by local authorities to meet their obligations under the Local Government Act and the amended Resource Management Act. At present this usually relates to physico-chemical properties, but a wider ecological approach is being encouraged (Robertson *et al.* 2002). Understanding of the distribution of waders in relation to environmental variables is at an early stage (Whelan *et al*. 2003) but there is potential for including shorebirds in local authority ‘state of the environment’ monitoring.

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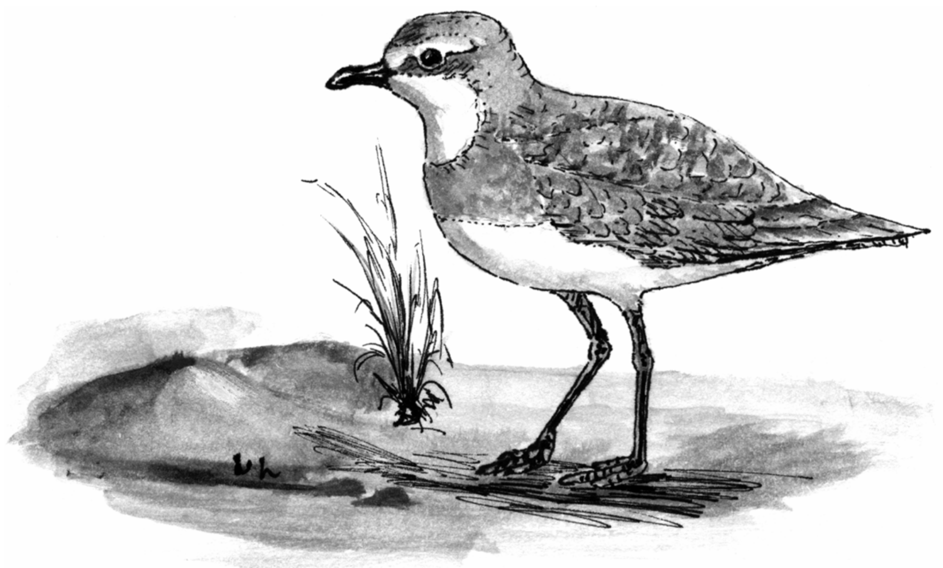

PAPERS IN AUSTRALIAN WADER STUDY GROUP JOURNALS 1980–2006

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This is principally a list of papers, articles and notes which have been published in ***Stilt***, the bulletin of the Australasian Wader Studies Group. However, selected articles from the ***Victorian Wader Study Group Bulletin*** (VWSG Bulletin) and from ***An Occasional Stint*** (AOS), the now defunct bulletin of the Tasmanian Wader Study Group, are also included. Articles are covered under seven headings:

- Species accounts
- Research and conservation
- Reports/workshops
- Overseas counts
- Australian counts
- Banding and flagging reports
- Recoveries, sightings and movements

It is intended that this list be regularly updated and accessible on the AWSG website in future.

SPECIES ACCOUNTS

With one exception (Australian Painted Snipe), species sequence and nomenclature follow *Dickinson, E.C. (Editor) 2003. The Howard & Moore Complete Checklist of the Birds of the World. 3rd Edition. Christopher Helm, London.*

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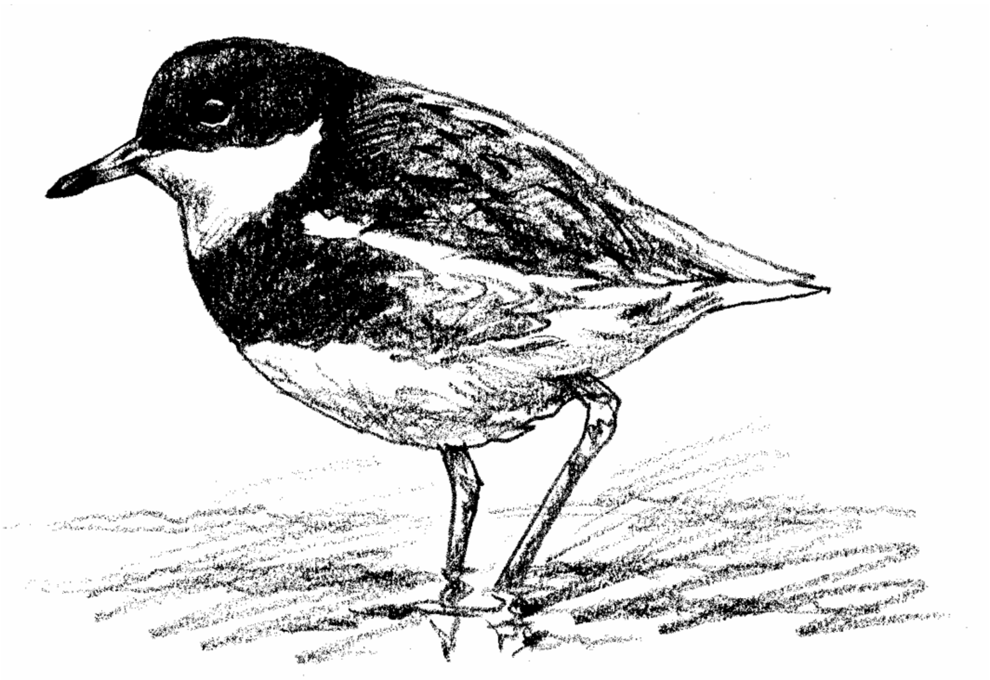

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Vignettes:
Rob Mancini, pp. 14, 61, 191, 223, 248, 325
Annie Rogers, p. 57
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Late publication. Due to the special nature of this edition of *The Stilt*, publication was delayed, with the actual publication date being **April 2007**. We suggest referencing articles from this edition in the following format:

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Back Issues:
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The closing dates for submission of material are **1 March** and **1 September** for the April and October editions respectively. **Extensions to these dates must be discussed with the Editor.** Contributors of research papers and notes are encouraged to submit well in advance of these dates to allow time for refereeing. Other contributors are reminded that they will probably have some comments to consider, and possibly incorporate, at some time after submission. It would be appreciated if this could be done promptly.

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