Status and Conservation of Shorebirds in the East Asian-Australasian Flyway

Proceedings of the Australasian Shorebirds Conference
13-15 December 2003, Canberra, Australia

Edited by Phil Straw

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Foreword

The first Australasian Shorebird Conference (ASC) was held in Brisbane immediately prior to the 6th Conference of the Contracting Parties (COP6) of the Ramsar Convention in 1996. The 1996 ASC provided the impetus for the launch of the East Asian-Australasian Flyway Reserve Network during Ramsar COP6 and proved to be a milestone in shorebird conservation in the Flyway. The first ASC was attended by 145 delegates from 16 countries providing a truly international forum for shorebird conservation in the region. The proceedings from that conference have gone out of print long ago and were unfortunately produced before publications were automatically kept in electronic format.

A second ASC at Phillip Island, Victoria in June 1999 focused on national issues, the third ASC was held in 2000 taking advantage of the fact that the 2nd Southern Hemisphere Ornithological Congress was being held in Brisbane to maximise the number delegates at a combined event. This, the 4th ASC was held immediately after the second Southern Ornithological Congress in Canberra again to take advantage of a combined attendance. This ASC also took advantage of the meeting of the Shorebird Working Group of the East Asian-Australasian Flyway as well as a meeting of Flyway site managers. The success of the ASC is based on the fact that the AWSG is one of the most active specialist groups in the Asia Pacific Region, having worked in close liaison with shorebird specialists throughout the region for close to 25 years.

The decision to produce a comprehensive set of proceedings after a conference cannot be taken lightly. A great deal of work is involved in bringing together the efforts of authors once they have returned home to their invariably busy lifestyles. However it is felt that this conference contributed a wealth of information not previously published that is essential in providing an overview of what is known and, perhaps more importantly, providing a focus on what we do not know and the challenges facing researchers and conservationists in the Asia Pacific Region, in particular the East Asian-Australasian Flyway.

Another consideration in producing this document was the need to satisfy authors that papers would receive widespread exposure, equal to a prestigious internationally circulated journal. This publication satisfies that, in that it has been produced as a special publication of the International Wader Study Group and Wetlands International, and AWSG ensuring that it reaches as wide a circulation as possible among shorebird researchers and conservationists globally. Fortunately, in this case, electronic copies will be available well into the future at minimal cost. These proceedings will be available in time for the 5th ASC to be held in Nelson, New Zealand in December 2005.

Phil Straw
Conference Convenor

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Keynote Presentation

An Overview of Australia's International and Domestic Activities to Conserve Migratory Shorebirds

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Abstract

The Australian Government, working with the Government of Japan, has led efforts to conserve migratory shorebirds in the East Asian- Australasian Flyway. This work has been supported by a large number of enthusiastic volunteers and non-government organisations.

The Australian Government Department of the Environment and Heritage has actively promoted the development and implementation of the Asia-Pacific Migratory Waterbird Conservation Strategy and associated Action Plan for the Conservation of Migratory Shorebirds in the East Asian – Australasian Flyway. Recently a partnership under the World Summit on Sustainable Development has been initiated to continue promotion of migratory waterbird conservation across the flyway.

Within Australia, the arrangements for conservation of migratory shorebirds have significantly progressed with the recognition of migratory species as a matter of national environmental significance and subsequent protection under the Environment Protection and Biodiversity Conservation Act 1999 which took effect in July 2000. A Wildlife Conservation Plan for Migratory Shorebirds is being prepared under the Act to provide for the research and management actions necessary to support survival of migratory shorebirds. This plan will provide a strategic approach to management of migratory shorebirds and promote activities in Australia which support flyway conservation outcomes.

This paper provides an overview of Australia's formal and informal initiatives to encourage conservation of migratory shorebirds and their habitats across the flyway and the measures to conserve shorebirds and their habitat in Australia.

Introduction

Australia is the southern destination on the migration route for approximately 2 million of the 5 million shorebirds in the East Asian – Australasian Flyway (Bamford *et al* in prep). Thirty six of the fifty-four species of shorebirds in the flyway regularly visit Australia, arriving each year in our spring and spending the summer on coastal beaches, mudflats and shallow inland lakes, before departing in the autumn on their migration up to 13,000km north through the countries of East Asia to breeding grounds in the Arctic tundra of the Russian Federation, Alaska and China (Watkins 1993).

Along the way, the birds are threatened by both disturbance and competition with human activities, pollution and hunting. The greatest threat, however, is habitat loss and degradation. The flyway region encompasses more than 45% of the world's human population, many of whom live in countries with rapidly growing economies (Barter 2002). The growth of the human population and the economies of the flyway are bringing considerable pressure to bear on wetland habitats essential to the survival of migratory shorebirds.

Migration makes shorebirds particularly vulnerable to loss of habitat. They rely on a series of wetlands along their migratory path, where they can stop, rest and refuel for the next leg of their journey. The loss of these 'staging sites' can result in birds arriving at the breeding grounds in poor condition and being unable to breed successfully or not being able to complete their migration. The risk is compounded by the reproductive strategies of shorebirds. They are typically long lived species – recoveries of banded Eastern Curlew *Numenius madagascariensis*, Great Knot *Calidris tenuirostris* and Terek Sandpiper *Xenus cinereus* recorded by the Australian Bird and Bat Banding Scheme show that they live as long as 13, 14 and 16 years respectively. They also have relatively low reproductive rates, so mortality and reduced reproductive success can have dire consequences for the viability of shorebird populations.

The Australian Government has therefore given priority to promoting cooperation among the countries of the East Asian – Australasian Flyway to ensure that a network of important habitats are maintained across the flyway to support migration of shorebirds.

Figure 1: the East Asian – Australasian Flyway (map prepared by Wetlands International)

International cooperation to conserve Migratory Shorebirds and their habitat in the East Asian – Australasian Flyway

For nearly 30 years, Australia has played an important role in international cooperation to conserve migratory birds in the East Asian – Australasian Flyway. This cooperation began with the migratory bird bilateral agreements with the Government of Japan and later the People's Republic of China. It has evolved to include regional cooperative action under the *Asia-Pacific Migratory Waterbird Conservation Strategy* and most recently a partnership initiative under the World Summit on Sustainable Development. Much of this work has been implemented in partnership with the Ministry of the Environment, Japan, and Wetlands International.

Migratory Bird Bilateral Agreements

Bilateral agreements provide a formal framework for cooperation between two countries on issues of mutual interest. Australia currently has two bilateral agreements relating to conservation of migratory birds, one with Japan signed in 1974 – *the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment* (JAMBA) – and the other with the People's Republic of China signed in 1986 – the *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment* (CAMBA). Both agreements include a list of birds which migrate between Australia and the respective countries. In both cases the majority of listed species are shorebirds. The agreements require the parties to protect migratory birds from take or trade except under limited circumstances, protect and conserve habitats, exchange information, and build cooperative relationships. The JAMBA also includes provisions on cooperation for conservation of birds in danger of extinction. Australian government officials and non-government representatives meet every two years with their Japanese and Chinese counterparts to review progress in implementing the agreements and to explore new initiatives to conserve migratory birds.

In April 2002, the governments of Australia and the Republic of Korea agreed to develop a bilateral migratory bird agreement similar to the JAMBA and CAMBA. The proposed agreement will formalise Australia's relationship with Republic of Korea in respect to migratory bird conservation and will provide a basis to collaborate in the protection of migratory shorebirds and their habitat.

Other countries in the flyway have similar bilateral migratory bird agreements. In all there are eleven such agreements involving Australia, Japan, the Russian Federation, People's

Republic of China, Republic of Korea, Democratic People's Republic of Korea, India, and United States of America (Asia-Pacific Migratory Waterbird Conservation Committee 2001).

The JAMBA, CAMBA and the other bilateral agreements across the flyway provide an important mechanism for pursuing conservation outcomes for migratory birds, including migratory shorebirds. The bilateral nature of the agreements does, however, limit their ability to influence conservation across the flyway. The Governments of Australia and Japan have, therefore, sought to encourage cooperation on migratory bird conservation involving all of the countries in the flyway.

Asia Pacific Migratory Waterbird Conservation Strategy

In 1994, the Japanese and Australian governments organised an international workshop on the "Conservation of Migratory Waterbirds and their Wetland Habitats in the East Asian-Australasian Flyway" under the auspices of the JAMBA. The workshop recognised that an international migratory waterbird conservation strategy was needed for the region. The workshop called for a strategy to be prepared that identified the major issues, outlined the range of priorities for action, and set out a time table for implementation and evaluation (Anon 1996).

The result was the Asia-Pacific Migratory Waterbird Conservation Strategy 1996-2000 which was produced by Wetlands International and the International Waterfowl and Wetlands Research Bureau-Japan Committee (Anon 1996). The development and subsequent implementation of the strategy and its second iteration for the 2001-2005 period has received strong support and extensive funding from the Ministry of the Environment, Japan, and the Government of Australia through the Natural Heritage Trust.

The 2001-2005 strategy outlines eight key elements to promote the conservation of migratory waterbirds and their habitats:

1. Action plans for species-groups and globally threatened species.
2. Effectively managed networks of sites that are internationally important formigratory waterbirds.
3. Raised awareness of waterbirds and their link to wetland values and functions throughout the region and at all levels.
4. Increased capacity of government agencies and non-government organisations to implement conservation actions for migratory waterbirds.
5. An enhanced knowledge base and increased information exchange for the sound management of migratory waterbirds and their habitats.
6. Harmonised national and state policies and legislation as a foundation for the conservation of migratory waterbirds and their habitats.
7. Enhanced organisational relationships at all levels to increase cooperation and deliver greater conservation benefits.
8. Adequate planning and resources to implement the strategy (Asia-Pacific Migratory Waterbird Conservation Committee 2001).

An international committee, the Asia-Pacific Migratory Waterbird Conservation Committee, is responsible for monitoring the implementation of the strategy. The committee is chaired by Japan and currently comprises representatives of seven governments (Australia, China, India, Indonesia, Japan, Russia and U.S.A.), the Convention on Wetlands, the Convention on Migratory Species, international NGOs (Wetlands International, BirdLife International and World Wide Fund for Nature), a representative of the United Nations Development Programme/Global Environment Facility and chairs of the three technical Working Groups (for Anatidae, cranes and shorebirds) (Asia-Pacific Migratory Waterbird Conservation Committee 2001).

The strategy has been successful in promoting international cooperation and raising awareness of the need to work together to promote waterbird conservation. A wide range of international and national activities have been undertaken, primarily through the implementation of flyway action plans for conservation of shorebirds, cranes and Anatidae (ducks, geese and swans), and the establishment of networks of sites of international importance for these species groups (Asia-Pacific Migratory Waterbird Conservation Committee 2001).

Given that the cranes and Anatidae covered by the other action plans do not regularly migrate to Australia, the Action Plan for the Conservation of Migratory Shorebirds in the East Asian-Australasian Flyway has been of greatest interest to Australia.

Action Plan for the Conservation of Migratory Shorebirds in the East Asian – Australasian Flyway and the East Asian – Australasian Shorebird Site Network

The action plan was developed to guide a regional program of key actions to conserve migratory shorebirds. The primary tool for implementing the action plan is the East Asian – Australasian Shorebird Site Network which links internationally important shorebird sites and their managers across the flyway to provide for improved management and increased public awareness and education activities. The action plan also recognises the importance of a strong scientific base to guide decision making.

The shorebird site network operates as a cooperative environmental program, involving site management bodies and local communities, working for the conservation of wetlands of international importance for migratory shorebirds (Wetlands International 2003). The site network is supported by a Shorebird Flyway Officer working with Wetlands International and funded by the Australian Government's Natural Heritage Trust.

The network includes sites which regularly support >20,000 migratory shorebirds; or, regularly support > 1 % of the individuals in a population of one species or subspecies of migratory shorebird; or, support appreciable numbers of an endangered or vulnerable population of a migratory shorebird. Site managers in the flyway develop proposals to add new sites to the network and obtain endorsement from their governments.

At the time of publication, 36 sites had been nominated to the Network by 11 countries. Australia currently has 11 sites. Wetlands International is currently preparing a report which estimates the populations of shorebirds in the East Asian-Australasian Flyway and, using the shorebird site network criteria, identifies the internationally important sites of the flyway (Bamford and Watkins, in prep). For the network to be successful, it needs to include at least 25% of internationally important sites across the flyway. At present the network includes approximately 10% of internationally important sites. Australia is seeking to increase the profile of the network to ensure that this target is reached.

Building the Network: the Conservation and Sustainable Use of Sites of International Importance to Migratory Birds in East-Asia, South East Asia and Australasia World Summit on Sustainable Development partnership

At the World Summit on Sustainable Development in Johannesburg, South Africa in September 2002, Australia, Japan and Wetlands International co-sponsored a partnership initiative titled Conservation and Sustainable Use of Sites of International Importance to Migratory Birds in East-Asia, South East Asia and Australasia. The intention of the partnership was to provide a cooperative framework for conservation of migratory waterbirds and their inland and coastal habitats across the region and to support the Asia-Pacific Migratory Waterbird Conservation Strategy 2001-2005. An outline of the partnership is available online at www.johannesburgsummit.org/html/sustainable_dev/p2_managing_resources/2008_conservation_migratory_birds.pdf.

However, as the launch of the WSSD Type II Partnership initiative has been postponed and the Strategy is now in its final year, there was an opportunity to refocus the objectives of the WSSD Type II Partnership to coincide with development of a more formal future framework for the conservation of migratory waterbirds.

In November 2004, the Governments of Australia and Japan hosted a meeting of officials from 13 governments, along with key non-government and intergovernmental organisations from across the flyway to discuss the partnership. The meeting supported the development of the partnership and formed a working group to draft a partnership text and five year action plan. These documents are being negotiated with a view to launching the partnership for signature at the 9th Conference of Parties to the Ramsar Convention in late 2005. The Australian Government will also promote the partnership at the 8th Conference of Parties to the Convention on Migratory Species in 2005.

The partnership aims to build on the achievements of the Asia-Pacific Migratory Waterbird Conservation Strategy and its associated action plans for conservation of Anatidae, cranes and shorebirds. It focuses on expanding the site network concept and provides a mechanism for governments of the flyway to formally engage in network and sustainable development activities. The Australian Government views the partnership as a useful framework for future regional cooperation to conserve shorebirds in the flyway and for expansion of the shorebird site network.

Conserving Migratory Shorebirds in Australia

In order to provide for conservation of migratory shorebirds in Australia and meet its obligations under the international arrangements outlined above, the Australian government takes a range of legislative, program and policy initiatives. These include protecting shorebirds as a matter of national environmental significance under the Environment Protection and Biodiversity Conservation Act 1999, preparing a national framework for shorebird conservation in the form of a Wildlife Conservation Plan for Migratory Shorebirds, investing in conservation of migratory shorebirds under the Natural Heritage Trust and working with the State and Territory governments to conserve shorebirds and their habitat.

Environment Protection and Biodiversity Conservation Act 1999

The Environment Protection and Biodiversity Conservation Act 1999 entered into force on 16 July 2000. The Act defines the role of the Commonwealth government in environment protection and biological conservation. This is achieved through Commonwealth leadership on matters of national environmental significance, while acknowledging the responsibilities of the States and Territories for natural resource management defined by the Australian Constitution. The Act compliments legislation in each of the States and Territories and enables the jurisdictions to collectively provide a national scheme of environmental protection and biodiversity conservation.

The Act recognises migratory species, including migratory shorebirds, as a matter of national environmental significance, along with Ramsar wetlands, nationally threatened species and ecological communities, World Heritage Properties, Commonwealth marine areas, and Nuclear actions (including uranium mining).

The list of migratory species under the Act includes all migratory species listed under international agreements to which Australia is a party (the Convention on Migratory Species, JAMBA and CAMBA) for which Australia is range state. There is provision under the Act for species listed under any new agreement that may be approved by the Commonwealth Minister for the Environment and Heritage in the future, such as the migratory bird bilateral with the Republic of Korea, to be included.

Environmental Impact Assessment

The Act regulates actions that will, or are likely to, have a significant impact on matters of national environmental significance. An action includes a project, development, undertaking or any activity or series of activities. An action that will, or is likely to, have a significant impact on a matter of national environmental significance will be subject to a rigorous environmental assessment and approval regime under the Act. Actions that are taken in contravention of the Act may attract civil and criminal penalties.

A person proposing to take an action that is likely to have a significant impact on a matter of national environmental significance must refer the action to the Commonwealth Minister for the Environment and Heritage. The Minister will decide whether the action requires approval under the Act. Administrative guidelines are available to assist proponents to determine whether actions are likely to have a significant impact on a matter of national environmental significance, and so need to be referred to the Minister (available from www.deh.gov.au/epbc/assessmentsapprovals/guidelines/index.html).

If the Minister decides that an action requires approval under the Act, then an environmental assessment of the action will be undertaken. After assessment, the Minister decides whether to approve the action and, if so, what conditions to impose to ensure the protection of the affected matters of national environmental significance.

The Act provides for the community to engage in the decision making process by commenting on actions that have been referred to the Minister, and by bringing actions which could be in breach of the Act to the attention of the Australian Government Department of the Environment and Heritage. Further information is available on the Department's website at www.deh.gov.au/epbc. Possible breaches of the Act may be reported by contacting compliance@deh.gov.au.

To date a wide range of proposed actions with potential to impact on migratory shorebirds have been referred under the Act. They include aquaculture, infrastructure, urban, commercial, redevelopment, tourist, recreation and mining developments.

Some of the areas of concern for listed migratory shorebirds have been:

- Loss, fragmentation or alienation of habitat (eg reclamation of mudflats or modifications of shorelines for residential and industrial development, construction of transport corridors across important habitat, alterations to hydrology of shallow wetlands)
- Noise and physical disturbance (eg construction works, aircraft operations)
- Pollution (eg discharge from industrial activities and run-off of agricultural chemicals)
- Mortality through collision (eg wind farms, powerlines and aircraft).

The following measures have been identified to limit impacts on migratory shorebirds:

- Modifying design and siting of developments to avoid interactions with shorebirds and their flight paths
- Limiting timing of construction activities to minimise impacts (eg avoiding construction near roost sites while migratory species are present at the site)
- Provision of alternate roost sites
- Water quality monitoring and sediment/erosion controls.

The implementation of the Act has presented new challenges for the Department. In order to effectively assess and mitigate the impacts on listed migratory shorebirds, the department needs information on:

- Location of important habitats, including the diversity and abundance of shorebirds using sites
- How shorebirds use important habitat, and the location and ecological requirements of feeding and roosting areas within sites,
- How shorebirds move within and between important sites,
- Responses of shorebirds to various forms of disturbance, and
- Approaches to and effectiveness of artificial roost sites.

Wildlife Conservation Plan

In addition to the environment protection provisions, the Act also provides for development of plans to conserve listed species. A *Wildlife Conservation Plan for Migratory Shorebirds* is currently being prepared under the Act to provide a national framework for migratory shorebird conservation in Australia. The plan will set out actions required to conserve migratory shorebirds and their habitats in Australia, and is being prepared in consultation with interested stakeholders.

As this is the first wildlife conservation plan being prepared under the EPBC Act, the Department of the Environment and Heritage has been keen to consult as broadly and comprehensively as possible, in order to produce a plan that is robust and contributes positively to the protection and conservation of migratory shorebirds.

In February 2004 the Department wrote to a range of stakeholders, inviting participation on the development of the plan. The invitation was also posted on the Department's website. Around 130 organisations and individuals responded and requested to be on the consultation mailing list. An issues paper was finalised on 25 June 2004 and was distributed to all interested stakeholders and posted on the DEH website to facilitate identification of issues which should be considered in preparing the plan. The Department received around 40 submissions from the consultation process.

A discussion draft of the plan has since been prepared and the Department will be conducting 3 public forums to further input to the development of the plan before preparing a formal consultation draft of the plan. It is anticipated that the final plan will be available early in 2006.

Investing in Migratory Shorebird Conservation through the Natural Heritage Trust

Since its inception in 1996/1997, the Australian Government has provided more than $2.5 million from the Natural Heritage Trust for migratory shorebird conservation. Many of the projects described elsewhere in this volume have been made possible by Trust funding. The goal of the Trust is to stimulate activities in the national interest to achieve the conservation, sustainable use and repair of Australia's natural environment. Conservation of important wetlands and migratory shorebirds are key components of the Trust.

Trust investment to date in shorebird conservation has focussed on:

- **Supporting Australia's international efforts** to promote shorebird conservation in the flyway, including core funding for the Asia Pacific Migratory Waterbird Conservation Strategy and the Action Plan for Conservation of Migratory Shorebirds in the East Asian – Australasian Flyway, to ensure that migratory shorebirds which visit Australia are conserved elsewhere in their migratory range.
- **Investing in activities under the JAMBA and CAMBA**, including training and capacity building for shorebird site managers in China.
- **Supporting and promoting the East Asian – Australasian Shorebird Site Network**, including conducting training for site managers in Australia and production of posters in the languages of the flyway.
- **Encouraging community participation in shorebird conservation** in Australia, through grants to community groups to conserve habitats under the Shorebird Conservation Project coordinated by World Wide Fund for Nature – Australia.
- **Collecting important information on shorebirds**, including supporting the Australasian Wader Studies Group in collating and analysing shorebird population counts, which are used on a national basis to identify important habitats, and developing and implementing a Colour Flagging Protocol for Migratory Shorebirds in the East Asian–Australasian Flyway which promotes coordinated shorebird migration research across the flyway (available on line at http://www.tasweb.com.au/awsg/protocol.htm).
- **Communication and Education products** including posters and brochures, a curriculum package titled Feathers, Flyways and Fastfood: Notes for Schools (available online at www.deh.gov.au/biodiversity/migratory/waterbirds/shorebirds/index.html) and A Year on the Wing, an online interactive documentary (available at www.abc.net.au/wing).

In its second phase, from 2002/2003 to 2006/2007, the operation of the Natural Heritage Trust has been refined to ensure more strategic investments in environmental outcomes. Under the Trust extension, funds are delivered at three levels: regional investments, national investments, and a local action component - the Australian Government Envirofund. Regional investments are the principal delivery mechanism for the Trust and follow, where appropriate, the model being used for the National Action Plan for Salinity and Water Quality. Under this model, investment is made on the basis of an integrated regional natural resource management plan, incorporating the major natural resource management issues in the area. Regional priorities, including those relating to migratory shorebirds and their habitats, will need to be reflected in these plans for funding to be secured. Further information on the Trust is available from www.nht.gov.au.

Developing the Shorebird Site Network in Australia

The Commonwealth, State and Territory Governments of Australia are working together to increase the number of sites in the East Asian – Australasian Shorebird Site Network. In the National Objectives and Targets for Biodiversity Conservation 2001-2005 (available online at www.deh.gov.au/biodiversity/publications/objectives/index.html) the Commonwealth, State and Territory governments have agreed to increase the number of Australian sites in the Shorebird Site Network from the current 11 sites to 36 sites by the end 2005.

Two sites in Victoria, Discovery Bay and Shallow Inlet are in the process of being included in the site network following preparation of nomination documents by the Victorian Wader Studies Group with funding from the Australian Government's Natural Heritage Trust. Nomination documents are currently being prepared for a further 8 sites.

Conclusion

Australia has placed a high priority on conservation of migratory shorebirds in the East Asian – Australasian Flyway. Through an integrated program of international and domestic policy frameworks and funding investments, significant progress has been achieved.

Achieving conservation of migratory shorebirds requires a continued effort by the Australian Government, matched by those of the other governments in the flyway. Much of this work relies on the activities of and information collected by groups such as the Australasian Wader Studies Group to inform decisions about management. The ongoing contribution of these groups is essential to effective conservation of migratory shorebirds in the flyway.

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Endangered Endemic Species

The Breeding Bottleneck: Breeding Habitat and Population Decline in the Australian Painted Snipe

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Abstract

The Australian Painted Snipe Rostratula (benghalensis) australis *is a striking wader of inland wetlands. Records from the Atlas of Australian Birds indicate that it has suffered a great decline since the 1950's, particularly in its apparent former stronghold in the Murray-Darling Basin. The Australian Painted Snipe project was initiated by the Threatened Bird Network and the AWSG in 2001, with the broad intention of learning enough about the species to propose conservation actions. We summarise progress so far. One of our main activities has been compiling a database of past Painted Snipe records, starting with published literature and Atlas records, and attempting to contact the original observers to obtain extra details. Whenever possible, categorical descriptions of structural habitat were obtained for previous records of Australian Painted Snipe, especially of breeding records. These records indicate that although Australian Painted Snipe can be found in a wide range of wetland habitats, their requirements are much more stringent when breeding. Continuous reed-beds and stands of reed-like vegetation are avoided, as are rice fields and areas with no surrounding low cover. Nesting typically occurs in ephemeral wetlands drying out after an influx of fresh water, provided they have complex shorelines (nests are almost invariably placed on small islands) and a combination of very shallow water, exposed mud, dense low cover and (sometimes) some tall dense cover.*

This combination of habitat attributes appears to be a successional stage of ephemeral wetlands in southern and inland Australia. We contend that the decline of Australian Painted Snipe can be attributed to loss of breeding habitat through intensive water management and agricultural development, especially in the Murray-Darling Basin, through: (1) reduced frequency of flooding of previously suitable habitat, exacerbated by loss of much fresh water to irrigation and other diversions; (2) water levels being stabilised in remaining wetlands so that water becomes too deep, or continuous reed-beds develop; (3) changes to vegetation through increased cropping, and possibly through altered fire regimes in some sites. Such processes are also likely to be detrimental to several other inland shorebird species. There is encouraging evidence that human management of water levels and creation of artificial wetlands can restore Painted Snipe breeding habitat, but successes so far have been serendipitous. There is an urgent need for research on how existing water regimes and environmental flows can be managed to provide breeding habitat for Painted Snipes and other inland shorebirds.

Introduction

Australia is predominantly arid, with about 70% of the continent receiving less than 500 mm of rainfall per year. The inland nevertheless has extensive and varied wetland systems, many of which are only temporarily inundated, and these are used by a large and diverse assemblage of waterbirds (Kingsford and Norman 2002; Taylor 2003). The Australian Painted Snipe, *Rostratula benghalensis australis*, is one of the most striking of these species, but it is rarely seen and little is known about it.

A recent review of the taxonomic and conservation status of the Australian Painted Snipe (Lane and Rogers 2000) resulted in some startling and disturbing conclusions. The Australian Painted Snipe has traditionally been treated as a subspecies of the Greater Painted Snipe *Rostratula benghalensis*, a widespread species occurring through much of Africa, southern and eastern Asia. However, the review undertaken of measurements, plumage characteristics and some fragmentary information on vocalisations suggested there were substantial differences between Australian Painted Snipe and the Greater Painted Snipe of Asia and Africa. As a result, Lane and Rogers (2000) argued that the Australian Painted Snipe has long been isolated from Greater Painted Snipe, and should be regarded as a full species, *Rostratula australis*. This idea is now being tested through analyses of blood samples obtained from six Australian Painted Snipe in north-western Australia (Hassell 2002). Early analyses of DNA extracted from these samples indicate that Australian birds are indeed very divergent from Greater Painted Snipe in Malaysia and South Africa (Baker 2002). We are now confident that it will soon be widely accepted that Australian Painted Snipe is a full species, though the change cannot be regarded as "official" until the genetic analyses have been published in full or the Australian checklist is revised.

The traditional lumping of Australian and Greater Painted Snipe is probably responsible for a widespread assumption in published literature that what applies to Greater Painted Snipe in Asia and Africa also applies to Australian Painted Snipe. In fact, published assertions that Australian Painted Snipe are polyandrous, and that they are crepuscular or nocturnal, appear to have no solid basis; assertions that Australian Painted Snipe have a loud and distinctive advertising call, and that they occur in paddy fields, are probably incorrect. More seriously, the assumption that Australian Painted Snipe is a widespread and secure species turned out to be in need of investigation. Lane and Rogers (2000) carried out an analysis of records from the database of the Atlas of Australian Birds, concluding that the Australian Painted Snipe has been undergoing a serious decline since at least the 1950's, and that it is very rare. Accordingly they advocated classification of the Australian Painted Snipe as Endangered.

In 2001, prompted by the recent review of the status of the Australian Painted Snipe, the Threatened Bird Network (TBN) and the Australasian Wader Studies Group (AWSG) started a Painted Snipe project. The project is not funded directly (though we have certainly benefited indirectly from funding to the TBN and Wetlands International), and its work is carried out by volunteers. The broad objective of the project is to encourage research on, and conservation, of the Australian Painted Snipe. Our approaches include:

(1) Raising awareness of the species. We have attempted to do this through presentations to regional bird-watching groups, radio interviews, postings to the "Birding-aus" mailing list, and publication of articles in newsletters, including "Painted Snippets", an occasional Painted Snipe Newsletter circulated by the TBN. Direct contact with bird-watchers who have seen Painted Snipe in the past has been particularly helpful. Our general impression is that these approaches have been successful in raising the profile of the species within the bird watching community, but that more extension work will be needed, especially with land managers and government departments.

(2) Lobbying for appropriate conservation listing under state and federal government listings. Current conservation listings of the Australian Painted Snipe are presented in Table 1; several government departments have now revised and upgraded their conservation listings of Australian Painted Snipe. Perhaps most significantly, the Australian Painted Snipe has now been listed as "Vulnerable" under the Environmental Protection and Biodiversity Conservation (EPBC) Act (1999). Under this federal act of parliament it is an offence to undertake an action (such as land development) that may have a significant impact on a nationally threatened species without approval from the Minister for the Department of Environment and Heritage. Accordingly there is an obligation on landowners to conserve Australian Painted Snipe habitat, and a (less clearly defined) obligation upon the federal government to encourage such conservation.

(3) Provision of information and encouragement to people undertaking Painted Snipe research or conservation action. The existence of the Painted Snipe project has provided birdwatchers with a central point of Painted Snipe contact, with the result that Painted Snipe observations are now generally reported and available for analyses, rather than simply being enjoyed and forgotten. In several cases we have been able to assist research or conservation activities related to Painted Snipe. For example, the existence of the project made it possible for Lew Oring to find an Australian Painted Snipe population to study during a sabbatical visit. We were able to provide advice that helped in establishing a wetland reserve on the Gold Coast (southern Queensland) at a site where Australian Painted Snipe have bred, and we were able to provide advice for a partial closure of Hird's Swamp (northern Victoria) to hunters in the 2004 duck-shooting season.

(4) Conducting surveys for the species. A series of national searches for Painted Snipe in apparently suitable wetlands has produced a number of sightings for incorporation into the database (see below). The surveys have also played a helpful role in raising the conservation profile of the bird.

(5) Building a database of as many past records as possible.

In this paper, we attempt to identify the "bottleneck" that must now restrict Painted Snipe numbers. We discuss the difficulties involved in surveying for Australian Painted Snipe, and we make use of past Painted Snipe records to identify the distribution and habitat requirements of Australian Painted Snipe, especially while breeding. The implications of our findings are discussed.

Table 1. The Conservation Status of the Australian Painted Snipe

Government	Painted Snipe listing and date of last revision	Government Act
Federal	Vulnerable (2003)	EPBC Act 1999
Queensland	Vulnerable (2002)	Nature Conservation Act 1992
NSW	Endangered (2004)	Threatened Species Conservation Act 1995
Victoria	Critically endangered (2002)	DSE Conservation Listing[1]
SA	Rare (1972)	National Parks and Wildlife Act (1972)
WA	Rare (2003)	Wildlife Conservation Act (1950)
NT	Vulnerable (2002)	Territory Parks and Wildlife Conservation Act 2000.

[1] *Listed as Threatened under the Flora and Fauna Guarantee Act 1995.*

Methods

Australian Painted Snipe are capable of being extremely cryptic, and they are generally difficult to find. The species does not always occur in dense cover, often feeding on wet mudflats or in shallow water, and often roosting unobtrusively in situations that are reasonably open (though usually shady). Accordingly, many available records are of birds that have been found by chance when scanning the edges of wetlands; the white harness-shaped marking separating their breast from the folded wing is often the plumage character that captures an observer's attention. However, in some overgrown wetlands scanning for Painted Snipe is unlikely to succeed and in general, a Painted Snipe that is trying to avoid detection will manage to do so. The bird is adept at using low vegetation or small depressions in the ground as cover, and can crouch and turn the body so that any conspicuous plumage markings are concealed. In a study in Queensland, it was found that Australian Painted Snipe usually crouched and remained concealed when a human observer approached, but if the observer remained still and quiet for about 15 minutes, the bird would resume its normal activity (L. and K. Oring unpubl.). For this reason, prolonged scanning is advisable.

Scanning is a time-consuming method for searching for Australian Painted Snipe, and in large wetlands it is often necessary to flush the birds in order to see them. Australian Painted Snipe are distinctive in flight, with their dark heads, clean white underparts and long legs either dangling or trailing beyond the tail making them easily distinguished from *Gallinago* snipe. Unlike *Gallinago* snipe, they rarely give alarm calls on take-off, and in general their broader wings make their flight appear more buoyant (it can be reminiscent of a jacana). Distinctive though their appearance is, our general impression has been that experience helps in picking up Australian Painted Snipe in flight; observers who have seen the species in flight before are more likely to find the bird than inexperienced observers. Perhaps this in part comes from experienced observers tending to look further into the distance. Australian Painted Snipe will sometimes take off when the observer is at least 50 m away, but on subsequent flushing attempts they will remain crouched unless the observer approaches very closely.

Neither scanning nor flushing are guaranteed to reveal Painted Snipe even if the birds are present, and it would be desirable to have more effective sampling methods. Innovative approaches that have had some success include spotlighting at night (C.J. Hassell and D.I. Rogers unpubl.), searching for discarded feathers, and searching small islands for nests in wetlands where breeding is possible (P. Slater pers. comm.). The ideal search method might eventually turn out to be playback of tape recordings of calls, but at this stage this is not possible because the advertising call of female Australian Painted Snipe (assuming they have one!) has never been recorded. Experimental playing of Greater Painted Snipe advertising calls from Korea, and of contact calls of Australian Painted Snipe, elicited no response at all at wetlands where Australian Painted Snipe were known to be present (L. and K. Oring unpubl.).

In this paper we have used all available Painted Snipe records, regardless of the approach used to find the birds. Our starting point was a literature search, and an examination of the database of the Atlas of Australian Birds. This Birds Australia database consists of lists of bird species seen by birdwatchers at a given locality over a specified time period (usually one day). Data were collected systematically from 1977 to 1981 (the "First Atlas") and from 1998 to present (the "New Atlas"); in addition, Birds Australia compiled historical records (from before 1979) through an extensive search of published literature (the "Historical Atlas"). Another helpful source of records was the Nest Record Scheme (NRS), a Birds Australia database consisting of confirmed breeding records. This database includes locality and date of nest observations, and many fields relating to breeding biology that were not analysed in this study. Observers contributing Painted Snipe nest records to the NRS often wrote additional details on breeding habitat on their nest record cards and we have used some of these in this analysis. Finally, we have been collating Painted Snipe records made since 2000, and have added earlier Painted Snipe records to this database if they were not already included in one of the Atlas databases. In many cases, the data available in Atlas records, the NRS and published literature did not include all habitat details that we wanted. In such cases we attempted to contact the original observers for further information. Usually the observer could remember further details; Painted Snipe sightings usually turned out to be remembered very clearly as this is such an uncommon and charismatic bird. In addition to the biological details we obtained from this approach, we found it a good strategy for publicising the species. Observers usually wanted to chat about the species, were often unaware of its conservation interest and some subsequently took part in Painted Snipe surveys or local conservation work of Painted Snipe habitat. In some cases they put us in contact with other observers holding other Painted Snipe records of which we were previously unaware.

We classified Australian Painted Snipe records as "breeding" if nests or chicks were found. Although Australian Painted Snipe are difficult birds to find, once found it is usually possible to assess whether or not they are breeding. Like most shorebirds, they nest on the ground; they usually nest very close to water, and are often anxious to return to the nest when disturbed. After chicks leave the nests, they are accompanied by an adult that returns quickly to the chicks if they are disturbed (e.g. Lowe 1970), and often defends the chicks with spectacular spread-wing threat displays (Hindwood 1960) or equally conspicuous broken-wing displays (e.g. Fairley and Bonnin 1982). As Painted Snipe are usually watched for some time when observers have found them, and their behavior around nests and chicks is reasonably conspicuous and easily interpreted, we think that the great majority of records for which no breeding evidence was found were indeed non-breeding records. For grammatical convenience we refer to them as "non-breeding" records in the remainder of this paper, although it is possible that a minority of the records might have been of birds with undetected breeding activity.

Results

Atlas data on the distribution of Australian Painted Snipe are summarised in Figure 1. Australian Painted Snipe are widespread birds, and there is a scattering of records from much of inland Australia. During the period of the Historical Atlas, much the most obvious concentration of records was in the Murray-Darling Basin, especially the Riverina of Victoria and New South Wales. Other areas with apparent concentrations of records included the Queensland Channel Country, the Fitzroy Basin of central Queensland, and south-eastern South Australia (and adjacent parts of Victoria). Further concentrations of records around population centres (Adelaide, Melbourne, Sydney, Newcastle and Brisbane) are difficult to interpret; they may reflect the relative abundance of shallow wetlands on extensive sub-coastal plains in these regions, but are also probably influenced by the higher number of observers around population centres. Interpreting the low number of records from much of inland and northern Australia is also difficult. To some extent it must surely reflect the lack of observer effort in these remote regions, especially the inland, at times when retreating water was present. Nevertheless, there is no evidence for Painted Snipe densities being relatively high in central or northern

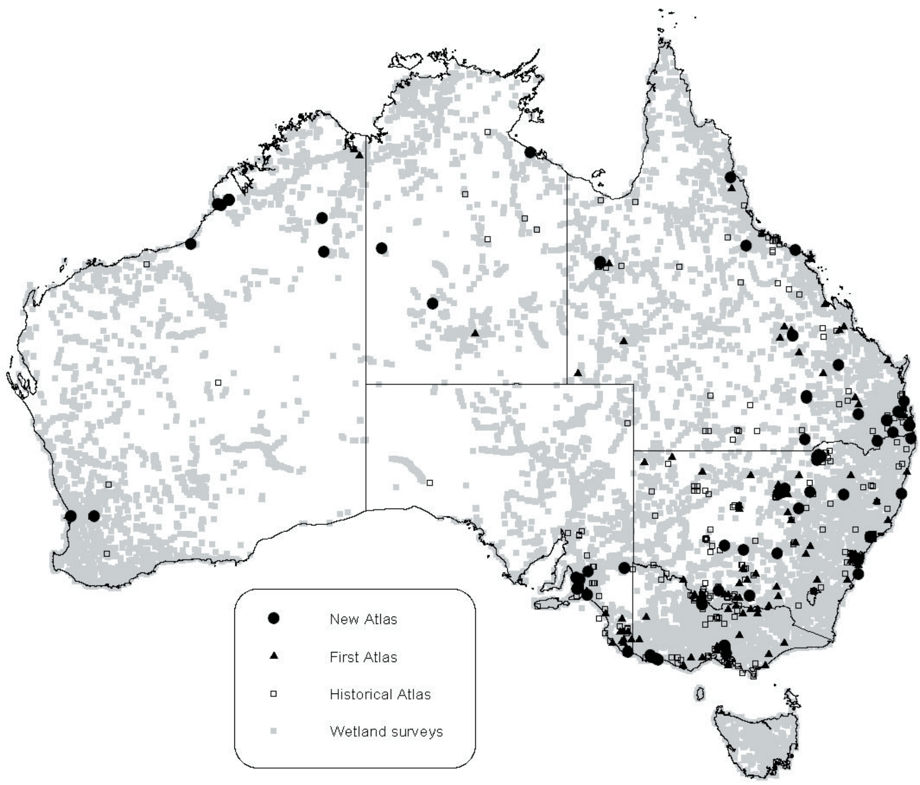

Figure. 1. Distribution of Australian Painted Snipe as shown by Atlas records. The grey shading depicts one-degree squares in which surveys of wetland habitats were undertaken by the New Atlas. Records from the Historical Atlas (1836 to 1977) are indicated by open squares, from the First Atlas (1977-81) by solid black triangles, and from the New Atlas (1998 to present) by solid black circles.

Australia, even in those few areas where there has been reasonably intensive observer effort. For example, there are few records from the shallow freshwater wetlands near Broome (Hassell and Rogers 2002) or Darwin (Jaensch 2003a), although during the dry season, the vast monsoonal wetlands of these areas contract to small lakes and other wetlands that attract reasonable numbers of birdwatchers.

The pattern of Painted Snipe distribution during the First Atlas was broadly similar to that shown by the Historical Atlas. The First Atlas data were collected in a period with generally high levels of inland rainfall and again, many of the Painted Snipe records obtained came from the Murray-Darling Basin, especially the Riverina. A rather different distributional pattern is shown by data collected during the New Atlas period. There was a general decline in reporting rates, despite the presence of larger numbers of observers and of greater awareness in the bird-watching community that Painted Snipe records are worth reporting. During the New Atlas period, a higher proportion of records came from coastal sites than previously. There were very few records from the Murray-Darling Basin, despite the fact that this region experienced severe drought during the New Atlas period, conditions which would concentrate remaining waterbirds into small and relatively easily explored areas. Painted Snipe had either moved to a different wetland region, or died off.

Reporting rates of the Australian Painted Snipe have been declining since the 1950's (Lane and Rogers 2000). However the comparison of Painted Snipe reporting rates in the Historical, Field and New Atlas has to be done cautiously, because survey methodology has changed over the years. For example, during the New Atlas individual surveys covered smaller areas and were of shorter duration than those carried out for the Field Atlas (Barrett et al. 2003). A helpful route around these potential biases is to compare Painted Snipe reporting rates with those of other waterbird species. Such a comparison is shown in Figure 2. The data come from the "Eastcoast" database (Griffioen & Clarke 2002: combined data from several Atlas databases with incidental records removed) and the New Atlas. They indicate that the Australian Painted Snipe has declined severely in relation to other waterbird species since the 1950's. Nobody could seriously argue that general waterbird populations have increased or even held status quo in that period. Bearing this in mind there can be little doubt that the decline of the Australian Painted Snipe is real. Quantifying the decline is difficult, but from Figure 2 it would appear that the current population of the Australian Painted Snipe may only be a tenth of that of the 1970's.

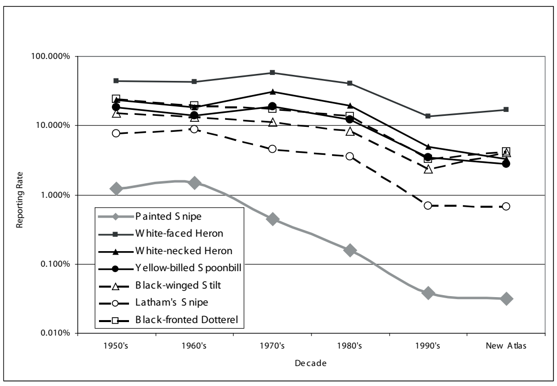

Figure 2. Reporting rates of Painted Snipe and several other waterbird species in Australia since 1970. The decline of the Painted Snipe is

Table 2.
Breeding records used in this analysis; for some of the records indicated there were several nests active concurrently at the same site. Location is approximate (site of the nearest centre or named landmark). "Month" is the extrapolated month of laying, and availability of data for the following habitat variables is indicated: (A) Heavy recent rain; (B) Presence of shallow water or exposed mud; (C) Wetland Type; (D) Landform; (E) Salinity; (F) Water distribution; (G) Vegetation cover; (H) Water level; (I) Tall reeds; (J) Land Tenure. Sources of data are summarised in the footnotes below the table.

Site and year	Month	A	B	C	D	E	F	G	H	I	J	Source
Taylor's Lagoon, n. WA (1999)	Aug.	y	y	y	y	y	y	y	y	y	y	1
Monkeyjarra, n. WA (1960)	Mar.	y	y	y	y	y	y	y	y	y		1,2
Monkeyjarra, n. WA (1961)	Mar.	y	y	y	y	y	y	y	y	y		1,2
Brookman Creek, n. WA (1890)	Aug.											3
Tarrabool Lake, NT (1993)	May	y	y	y	y	y	y	y	y	y	y	4
Mt Carbine, Qld. (1993)	May			y								5
Ayr, Qld. (1953)	Feb.	y	y	y	y	y	y	y	y	y		6
Torilla Plains, Qld. (2003)	Apr.	y	y	y	y	y	y	y	y	y	y	7
Hope Island, Qld. (2002)	Jan.	y	y	y	y	y	y	y	y	y	y	8
Minden, Qld. (1985)	Dec.	y	y	y	y	y	y	y	y	y	y	9
St George, Qld. (c. 1920's)				y		y	y	y		y		6
Cunnamulla, Qld. (1908)	Dec.		y					y			y	3
Diamantina Floodplain, Qld. (2001)	Jan.	y	y	y	y	y	y	y	y	y	y	10
Moree, NSW (1917)	Oct.	y	y	y	y	y		y		y	y	11
Minmi Swamp, NSW (1972)	Dec.	y	y	y	y	y	y	y	y	y	y	12
Windsor, NSW (1959)	Nov.		y	y		y	y	y		y		13
Windsor, NSW (1973)	Jan.	y	y	y	y	y	y	y	y	y	y	12, 14
Griffith, NSW (1976)	Nov.	y	y	y	y	y	y	y	y	y		15
Gunbar, NSW (1984)	Feb.	y	y	y	y	y	y	y	y	y	y	12
Moulamein, NSW (1939)	Jan.	y	y	y	y	y			y			16
Barratta Station, NSW (1956)	Nov.	y	y	y	y	y			y			17
Moonee Swamp, NSW (1955)	Oct.	y										17
Finley, NSW (1975)	Jan.	y										18
Barham, NSW (1975)	Dec.	y	y	y	y	y	y	y	y	y	y	19
Weimby, NSW (1984)	Oct.		y	y	y	y	y	y	y	y	y	12
Lake Cooper, Vic. (1931)	Nov.	y	y	y	y	y	y	y	y	y		20
Bullock Ck, Vic. (1884)	Oct.			y	y	y		y				21
Macorna, Vic. (1968)	Dec.	y	y	y	y	y	y	y	y	y	y	22
Racecourse Lake, Vic. (1956)	Nov.	y	y	y	y	y	y	y	y	y		6
Mystic Park, Vic. (1956)	Dec.	y	y	y	y	y	y	y	y	y		6
Mystic Park, Vic. (1973)	Dec.	y	y	y	y	y	y	y	y	y		12
L. Tutchewup, Vic. (1973)	Dec.	y	y	y	y	y	y	y	y	y	y	12
Port Fairy, Vic. (2001)	Dec.	y	y	y	y	y	y	y	y	y	y	23
Narracoorte, SA (1943)	Oct.			y	y	y	y	y	y		y	24
Narracoorte, SA (1965)	Aug.			y	y	y	y	y	y		y	24
Strathalbyn, SA (1979)	Nov.		y	y	y	y	y	y	y	y		25
Camden Swamp, SA (1933)	Oct.	y	y	y	y	y	y	y	y	y		6

Sources: 1. Hassell and Rogers (2001); 2. P. Slater, pers. comm.; 3. North (1913); 4. Jaensch (2003a); 5. Crowhurst (1994); 6. Lowe (1963); 7. Jaensch et al.2004; 8. R. D'Argent and T. Pacey, pers. comm.; 9. Leach et al. (1987); 10. Jaensch (2003b); 11. Morse (1918); 12. Nest Record Scheme, unpublished. 13. Hindwood (1960); 14. Muller (1974); 15. Moffat (1977); 16. Lansell (1940); 17. Hobbs (1961); 18. Rogers 1976); 19. Thomas (1975); 20. Bright and Taysom (1932); 21. Campbell (1901); 22. Lowe (1970); 23. S. Dooley pers. comm.; (24) A.R. Attiwell unpubl., per J.M. Bourne; (25) Fairley and Bonnin (1982).

much greater than that of other species.

Table 3.
Comparison of habitat preferences of breeding and non-breeding Australian Painted Snipe. The null hypothesis tested was that different habitat types are used in the same proportion by breeding and non-breeding birds. The probability that this was so was tested with odds proportions (Quinn and Keough 2002). The table gives the probability that there is no association between breeding and the attributes compared.

Habitat attribute	Comparison made	Probability of no difference
Wetland type	Permanent vs Temporary	$P < 0.002$
Landform	Basin vs Flat/ floodplain	$P < 0.034$
Shoreline	Simple vs Complex	$P < 0.038$
	Complex vs Complex with islands	$P < 0.025$
Vegetation cover	Mixed tall & low vs Patchy low	$P < 0.016$
	Continuous low vs Patchy low	$P < 0.236$
Water level	Dryer than usual vs High drying out	$P < 0.001$
	High drying out vs High rising/full	$P < 0.001$
Tall dense reeds	None vs Patchy	$P < 0.020$
Tenure	Reserve vs Private	$P < 0.127$

Table 4.
Comparisons of frequency of habitat use in breeding and non-breeding Painted Snipe, in cases where a particular habitat type did not occur at any of the breeding sites. In such situations odds-proportion tests (Table 3) could not be used. Here we use binomial theory to calculate the probability of NOT observing a particular habitat type among the breeding records, if it is assumed that habitat choices for breeding are in the same proportion as those observed for non-breeding.

Habitat attribute	Habitat type (% of such records among non-breeding birds given in brackets)	Probability of breeding data set including no such records.
Wetland type	Tidal (1.0%)	0.727
	Dry (1.9%)	0.527
Salinity	Saltwater (0.9 %)	0.747
	Brackish (10.9 %)	0.025
Tall dense reeds	Extensive (2.8 %)	0.538
Shoreline	All wet (1.1 %)	0.739
	All dry (6.5 %)	0.155
Water level	Dry (3.8 %)	0.333
	Typical (19.2 %)	0.300
Landform	Channel (25.5 %)	0.200
Vegetation cover	Mostly bare (10.1 %)	0.960
	Patchy tall cover (9.2 %)	0.120

Habitat preferences of Australian Painted Snipe are summarised in Figure 3, and a summary of the sources of information on breeding records is presented in Table 2. We are still tracking down or vetting habitat data from historical records, and expect our final sample sizes to be perhaps doubled for non-breeding records, and increased to a lesser extent for breeding records. Nevertheless, we consider our database sufficient for some early analyses of habitat preferences.

In general, habitat choices of non-breeding birds appeared to be quite broad. Most records came from freshwater wetlands that lacked extensive beds of reed like vegetation but had adjacent low cover. Beyond these generalisations it was harder to detect trends in the water levels, shoreline structure or landforms preferred by Painted Snipe, and there were occasional records from unexpected habitats. These included a bird seen feeding on intertidal mud, near saltmarsh on a small estuary; several records of birds beside very sparsely vegetated stock dams, and a few records of birds seen several hundred metres from water, e.g. in pindan woodland near Lake Taylor (WA), and a tomato field near Jerilderie (NSW). Some of these reports of birds in aberrant habitats might have involved transient birds exploring for new wetlands. In some cases (especially when there were multiple sightings), birds at "aberrant" sites were probably roosting in the middle of the day, and would have fed elsewhere in mornings and evenings.

Breeding records, with variable levels of documentation, were available for 37 sites (Table 2). With the single exception of an early breeding record in August, all breeding records from southern Australia (South Australia, Victoria, New South Wales and south-eastern Queensland) involved birds that must have laid eggs between October and early February. In northern Australia, most breeding records came from March to May, a time when wetlands are usually in the early stages of drying out after wet season rains. However, two breeding records in August suggest that the timing of breeding in northern Australia may be somewhat flexible, perhaps dependent on annual variation in times at which wetlands dry out.

On first glance, breeding records appear to come from several habitats; vegetation in which breeding has been reported on more than one occasion include flooded samphire plains, lignum swamps, and sites in which grasses (often tussocky) abut wetlands. Despite the floristic variation, these breeding habitats had many structural characters in common, and there were significant differences between breeding and non-breeding habitat (Figure 3, Tables 3 and 4). The great majority of breeding records came from temporary freshwater wetlands with surrounding low cover (ranging from patchy to continuous), no extensive reed-beds and complex shorelines (often with islands); breeding was usually observed shortly after wetlands started to dry out after being flooded. Thirty of the 37 breeding records came from sites at times when they consisted or had areas of very shallow water, exposed mud or a combination of the two. We do not have comparable data for the remaining breeding sites or non-breeding sites.

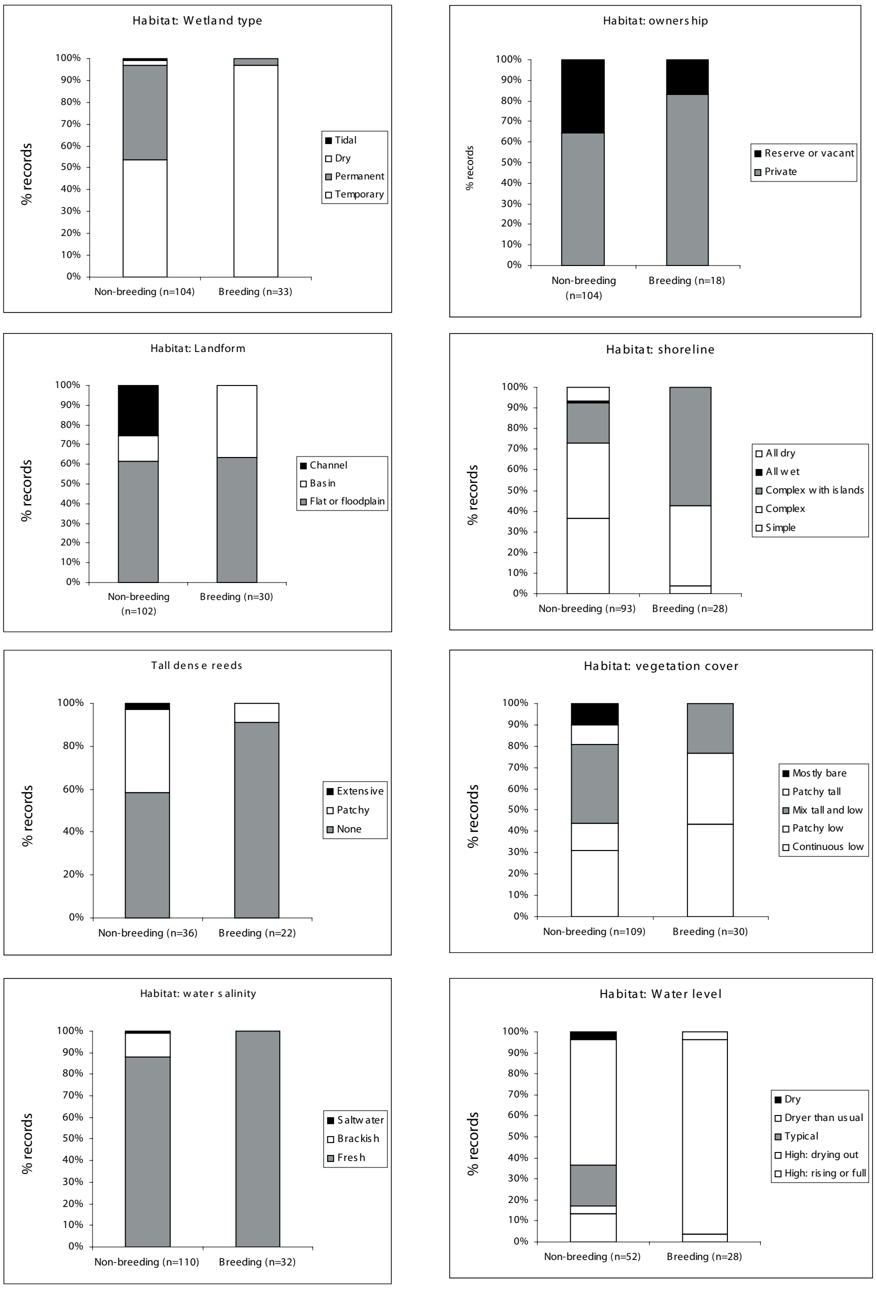

Figure 3. Habitat attributes of breeding and non-breeding Australian Painted Snipe.

Discussion

Available data indicate that Australian Painted Snipe can use a broad range of wetland habitats during the non-breeding period. However, habitat requirements during breeding appear to be much more restricted. Nesting occurs in temporary freshwater wetlands just after they have received an influx of fresh water; the wetlands need to be of low relief with a combination of complex shorelines, shallow water and exposed mud, and preferably small islands. If islands are not available, small mounds of vegetation will be built up so that the nest can be placed in a situation surrounded by water (McGilp 1934; Lowe 1963). We have no evidence that the identity of wetland vegetation is important to nesting Australian Painted Snipe, but the structure of the vegetation is important: patchy to continuous low vegetation in and/or surrounding the wetland is essential, and extensive reed-beds (or similar vegetation) are avoided.

We do not know why Australian Painted Snipe have these nesting habitat requirements, but some plausible suggestions can be put forward. The preference for nesting very close to water (preferably on small islands) is probably a device to avoid predation. Painted Snipe never fly to the nest, presumably as this would draw attention to the site, instead making a cautious approach by walking or swimming (e.g. Lowe 1963; Hassell and Rogers 2002). Walking through water is likely to prevent birds leaving a scent-trail that could be followed by ground-dwelling predators. The preference for low cover is also likely to be a mechanism to avoid predation. Painted Snipe can conceal themselves very effectively in low cover. In taller cover they probably find it harder to see approaching predators, and especially thick vegetation such as reed-beds might also prevent adults from taking off rapidly when danger approaches. Thick reeds might also harbour higher densities of potential predators such as Purple Swamphens *Porphyrio porphyrio*.

Most observations of foraging Australian Painted Snipe suggest that they feed on benthos, a likely explanation for their preference for sites with very shallow water or exposed mud. An abundance of benthos and perhaps of insects is likely to be particularly important to Painted Snipe chicks. Like most shorebird chicks, they are precocial, and feed themselves. It is quite possible that they lack the foraging proficiency of adults and are therefore only likely to survive in sites of high prey availability.

Almost all available breeding records of Australian Painted Snipe come from temporary wetlands. We do not consider this a coincidence of sampling. Temporary wetlands have two main attributes that we consider ideal for breeding Painted Snipe and we do not think this combination of attributes is shared by any other widespread wetland habitat in Australia. First, temporary wetlands experience a bloom of productivity when flooded after a period of being dry. When a wetland dries out, vegetation and zooplankton die, as do animals that feed on zooplankton (except for those that vacate the wetland). Remnant organic matter decomposes, leaving free nitrates and phosphates in the bed of the wetland. When reflooding occurs, this material is available to support growth of algae and vascular plants. This bloom of plant growth is closely followed by a rapid bloom of zooplankton, initially uninhibited by predators. The zooplankton bloom in turn supports an eruption of zooplankton predators, including high densities of benthic animals that are ideal prey for Painted Snipe and other shorebirds. In the period soon after flooding, temporary wetlands are therefore extremely rich environments (Crome and Carpenter 1988).

The second attribute of temporary wetlands that we consider important to Australian Painted Snipe is the structure of the vegetation. Reed-like vegetation such as cumbungi (*Typha domingenisis and T. orientalis*), common reed (*Phragmites australis*) and sedges (*Cyperaceae*) grows best in warm, shallow fresh water, and will usually proliferate and fill the shallow regions of a freshwater wetland if it is flooded for long periods. When a wetland dries out for long periods, reeds die out (though their rhizomes or tubers may persist underground) and the habitat becomes more open. This is likely to be important to Australian Painted Snipe, given that the species avoids dense reed-beds. Temporary water regimes probably play a large part in preventing wetlands from becoming too overgrown for Australian Painted Snipe.

A large proportion of the temporary wetlands of Australia have been lost or altered since European settlement. This deterioration of habitat has been especially severe in the Murray-Darling Basin, the apparent former stronghold of the Australian Painted Snipe. Water regimes in this region are now dominated by irrigated agriculture; it is estimated that about 70% of the Murray-Darling water is used in irrigation, and water movements are controlled by an enormous and complex system of weirs, irrigation catchments and channels (White 1997). Much of the floodwater that formerly spread over the floodplains and into temporary wetlands is now absorbed by irrigation systems and reservoirs, with the result that floods of the Murray now occur about once every fourteen years; it used to flood about once every three years (White 1997). In addition, many of the temporary wetlands of the basin have been altered by the enormous water-engineering system, becoming sinks for saline irrigation waste-water, or permanent irrigation storages in which reeds proliferate, or in which water levels are too deep for Australian Painted Snipe.

We know very little about whether the suitability of temporary wetlands for Australian Painted Snipe has changed in northern and central Australia. The species does occur in these regions, though available distribution data suggest that it was not the original stronghold. Water catchments in central and northern Australia are not irrigated as intensively as the Murray-Darling Basin, and human population density is generally lower. However, schemes for developing these catchments for irrigation remain on the agenda of some organisations and some development has occurred in the last decade.

Much of the northern and inland region is used for broadscale grazing by cattle and/or sheep. Grazing tends to be concentrated around wetlands during the dry season, making wetland vegetation potentially vulnerable to change. The long term impacts of grazing on the perennial vegetation of inland wetlands are not adequately known. Permanent waterholes with no control over stock undoubtedly suffer vegetation loss. However Australian Painted Snipe apparently make greater use of temporary wetlands, and stock to some extent avoid boggy swamps and associated biting insects.

Concerns have also been expressed that savannah vegetation around wetlands in northern Australia may be changing because of altered fire regimes (White 1997). Over some time scales, fire may not necessarily be detrimental to Painted Snipe habitat (e.g. in the Riverina, fire is used as a management tool in canegrass wetlands as it prevents the formation of dense, rank stands). However, the long term effects of persistent burning are poorly known. The spread of noxious weeds may also be problematic. One such weed is *Parkinsonia aculeata*, a thorny shrub that already infests over 80,000 ha of wetland habitats in the semi-arid and subhumid tropical area of Australia, and is considered likely to spread (Thorpe and Lynch 2000, CRC for Australian Weed Management et al. 2003). It replaces native vegetation with dense, tall thickets, a habitat that Australian Painted Snipe are unlikely to use.

Greater Painted Snipe often use ricefields, and they are indeed considered the most important habitat for that species in Japan (Maeda 2001). There is now a large irrigated rice industry in the Murray-Darling Basin, but we have no evidence to suggest that these ricefields are important to Australian Painted Snipe. Australian rice is sown into shallow flooded paddies in October and November, and water levels are then increased to 20-25 cm in January. This is done to insulate rice plants from temperatures lower than 15° C, at the time in which meiosis in the flowering heads occurs, as such temperature decreases reduce the amount of grain set (White 1997). Water is drained from the paddies shortly before harvesting time (in March or later), so there are only two short periods when water levels in Australian ricefields are shallow enough to be of potential use for breeding of Australian Painted Snipe. A pair of Painted Snipe once nested on a bund between two ricefields in December 1974 (Thomas 1975) in the period when the paddies were shallow just after sowing (E. Thomas, pers. comm.). There are no other ricefield records from Australia, and it is possible that with the faster-growing strains of rice now planted, the shallow-water period just after sowing is too short for Australian Painted Snipe to breed. All breeding records of Australian Painted Snipe from southern Australia are from the period between October and early February, so it would appear that the drying period before harvesting rice is too late in the season, and probably too brief, to allow breeding by Australian Painted Snipe.

The development of intensive irrigated agriculture, and associated loss of temporary wetlands in the Murray-Darling Basin has coincided with the decline of the Australian Painted Snipe since the 1950's. Given that temporary wetlands appear to be essential for breeding of the species, we argue that the primary cause of the decline of Australian Painted Snipe has been loss of breeding habitat. Furthermore, we suggest that loss of breeding habitat may well influence other inland-breeding shorebirds; species such as the Red-kneed Dotterel *Erythrogonys* cinctus, Black-winged Stilt *Himantopus himantopus* and Red-necked Avocet *Recurvirostra novaehollandiae* have often been found nesting near Painted Snipe and may have similar habitat requirements when nesting. The Australian Painted Snipe has become so rare that it has been possible to detect its decline with historical presence/absence data, but data of this kind may not be sensitive enough to detect the less dramatic declines that may have occurred in other species.

Irrigated agriculture is of considerable importance to the Australian economy, so it is unrealistic to expect that Australia will ever again have the abundance of natural temporary wetlands that existed before European settlement. However, remaining temporary wetlands merit protection, and there are encouraging signs that water regimes of wetlands in managed catchments can be artificially manipulated in such a way that Painted Snipe breeding habitat is created. For example, Australian Painted Snipe have recently bred at Hird's Swamp in the Victorian Riverina, after Parks Victoria and the Field and Game Authority undertook extensive restoration work (including vegetation control and environmental flows) at the swamp in an attempt to increase its biodiversity. At Hope Island on the Queensland Gold Coast, a population of Australian Painted Snipe moved into and bred in a wetland accidentally formed by a leaking water main (T. Pacey, R. D'Argent, pers. comm.).

The most important strategic measure needed to conserve the Australian Painted Snipe is to ensure that there is a suitably large allocation of water for temporary wetlands. Authorities and land-owners responsible for managing temporary wetlands also need information on how their water allocations can be used to create or restore Painted Snipe breeding habitat. How much water should be allocated to a particular wetland, how long should it spend "dry" to maintain its long-term health, at what time of year should environmental flows be made, and does the water allocation need to be accompanied by work on vegetation or feral predator control? This information does not yet exist, so at present wetland managers can only make educated guesses about the best management strategies to follow. There is an urgent need for research on the responses of Australian Painted Snipe and more easily studied shorebird species (e.g. Red-kneed Dotterel, Red-necked Avocet and Black-winged Stilt) to changes in water levels on temporary wetlands.

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Managing the Hooded Plover – Information Gaps and Research Needs

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Abstract

Information on threatened species is often incomplete and fragmentary with significant contributions sometimes in rather obscure publications or buried within lengthy management plans. This paper critically reviews the information available on the threatened Hooded Plovers from a management and conservation perspective.

More than 170 publications on the species were found. These have been published more frequently in recent years. There was a high number of management plans compared with major research studies. The bulk of information is derived from the eastern population. Only a small proportion of published information is directly relevant to conservation and management.

Threats to Hooded Plovers are identified. Limited resources require that efforts to conserve this highly dispersed species be strategic thus necessitating that a critical evaluation of the major threats and management options be undertaken. Three main areas of concern were identified - low reproductive success, availability of breeding habitat and the effectiveness of management techniques. Future research should be directed towards an understanding of the effectiveness of management techniques and a better understanding of certain critical aspects of the ecology of Hooded Plover (e.g., mortality and fate of chicks; factors influencing territory stability).

Introduction

The threatened Hooded Plover *Thinornis rubricollis* (after Christidis & Boles 1993) is a medium sized plover endemic to southern Australia. The species occurs in two allopatric populations (Garnett & Crowley 200, Marchant & Higgins 1993). The eastern population occurs on the south-east mainland of Australia and in Tasmania. The western population occurs in southern Western Australia. Birds in both populations occur on ocean beaches, however, in Western Australia, the species also occurs on lakes which are sometimes hundreds of kilometres from the coast (Marchant & Higgins 1993).

Like Hooded Plovers themselves, those responsible for on-the-ground management of the species and its habitat are also dispersed. The widespread, low-density distribution of Hooded Plovers represents a challenge for managers who have limited resources and a multitude of management decisions to make. The communication between these managers and management agencies has not always been as comprehensive as would be desirable, and important findings have at times had limited circulation.

A body of information exists on Hooded Plovers, largely collected by groups such as Birds Australia, the Australasian Wader Study Group (AWSG), the Phillip Island Nature Park, the Little Tern Taskforce, private individuals and agency staff. This information includes estimates of population size, distribution, site usage, breeding success and survival. Although some of this information has been analysed and published, there remains a need for thorough synthesis of what is known about Hooded Plovers.

Much of the most significant research on Hooded Plovers has been conducted since the last comprehensive review of the species' biology (presented in Marchant & Higgins 1993). Although Garnett & Crowley (2000) incorporated a considerable amount of more recently published and unpublished information, there remains a need for a comprehensive and critical review.

This review identifies information gaps and research priorities. It is based on Weston (2001, 2003a). However, the literature review upon which this paper is based was updated to include all known literature up to early October 2003.

Sources of Information

This study is based on 174 publications dealing in some substantial way with Hooded Plovers. Of these, 60.9% (106) were in journals, 21.3% (37) were in newsletters, 6.3% (11) were abstracts, 6.9% (12) were reports, 4.0% (7) were university theses, and 0.6% (1) were in magazines. Thus, 78.2% appeared in reviewed or semi-reviewed sources. Very few are targeted at the general public.

Results

Most of the publications were specific to Hooded Plovers with only a few including other species or topics (8.0%, 14). Of all publications, 16.7% (29) contained a request for assistance or information, 4.6% (8) reviewed existing information, and 1.7% (3) were popular articles. Although 70.7% (123) of publications contained original observations or data, only 21.9% (38) could be classified as major studies (those with replication and analysis, and excluding one-off counts regardless of their geographical scope). Overall, 161 publications were specific to one State. Of these, 44.1% (71) referred to Victoria, 24.2% (39) to Western Australia, 9.9% (16) to South Australia, 11.8% (19) to Tasmania, and 9.9% (16) referred to New South Wales. Thus, 75.8% (122) of State-specific publications deal with the eastern population of Hooded Plovers.

Of all publications, 8.0% (14) deal with banding or sexing techniques. Breeding biology is discussed in 19.0% (33) of publications; social biology or behavior in 6.9% (12); habitat in 5.2% (9); foraging ecology in 4.0% (7) and taxonomy in 1.7% (3). Threatening processes or mortality are discussed in 14.4% (25) of publications and declining populations or range contraction in 4.0% (7). Management of Hooded Plovers is mentioned in 19.5% (34) of publications. These percentages do not necessarily add to 100% because one publication may deal with several subject areas.

Without doubt, major studies are the greatest contributor to knowledge about the Hooded Plover. Of these publications (38), 42.1% (16) dealt with breeding biology; 28.9% (11) dealt with threatening processes; 34.2% (13) dealt with management; 15.8% (6) dealt with foraging ecology; 18.4% (7) dealt with social biology or behaviour; 15.8% (6) dealt with sexing or banding techniques; 10.5% (4) dealt with habitat and 5.3% (2) dealt with decline or range contraction. Again, these percentages do not add to 100%.

The major studies dealing with management (not management plans) are: Baird & Collins (1996); Baird & Dann (1999); Buick & Paton (1989); Dann & Baird (1997); Dodge et al. (2003); Dowling (1997, 1999); Dowling & Weston (1999); Keating & Jarman (2002, 2003); Weston (2000a,b) and Weston & Morrow (2000). All of these publications are based on the eastern population. Management plans constituted 2.3% (4) of the publications. The plans were: Schulz (1992); Baker-Gabb & Weston (2001); Weston & Morrow (2000) and Raines (2002). Thus, there was a management plan for every three major studies on management.

The number of publications available on Hooded Plovers has been growing through time, and it is projected that over 100 articles will be published on the species this decade (Figure 1). Major studies are also being published more frequently, with the last five year period (1998-2002) being responsible for 44.7%.

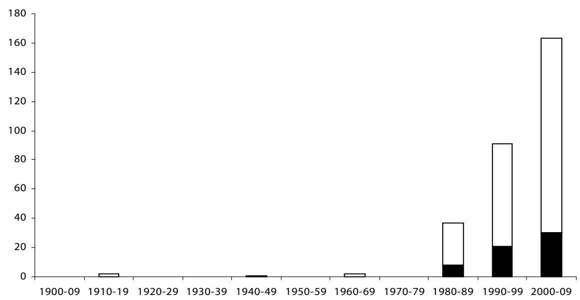

Figure 1. The growth in the number of publications on Hooded Plovers. The figure for 2000-2009 is a projection of the rate of publications 2000-2003. The black portions of the bars represent major studies.

In total, 166 publications were specific to either the eastern or western population. Of these, 76.5% (127) dealt with eastern rather than western birds. However, this imbalance is not likely to continue because, for western birds, the rate of publication has recently more closely followed the rate of publication concerning eastern birds (Figure 2).

Discussion

An overview of available information

It is not the intent of this paper to provide a detailed summary of all information available on the Hooded Plover. Instead, this review aims to determine those aspects that are of greatest importance to the conservation and management of the species and this is presented in two parts.

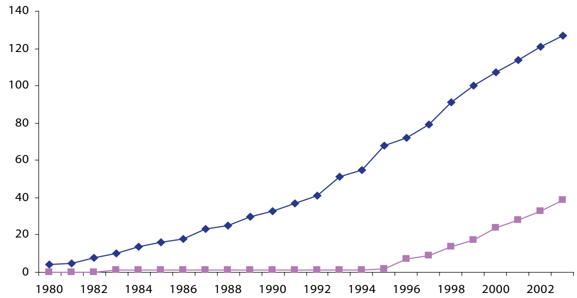

Figure 2. The cumulative number of publications on Hooded Plovers for each population (the upper line represents eastern birds and the lower line represents western birds).

Firstly, the available information is examined to identify those aspects of the species' biology or life cycle that are problematic from a conservation point of view. This strategic overview focuses on the areas where management could benefit the conservation of the species. The second part of this review summarizes the information available on subjects identified as important by the strategic review. This section is presented in some detail.

A comprehensive overview of the life cycle of the Hooded Plover is given in Weston (2000a). This study determined survival rates in all major phases of the life cycle and demonstrated that the main periods when mortality occurred were during the egg (nesting) and chick (brood-rearing) phases. Also, it was shown that at the calculated survival rates the adults are not expected to live long enough to replace themselves. A review of threatening processes also revealed that most are thought to act by reducing reproductive success rather than affecting the survival of flying birds (Weston 2001). Management for this species should therefore focus on the nesting and brood-rearing phases, because these are the major periods of mortality and the major reason that populations decline. Moreover, relatively localized eggs and chicks are more easily managed than mobile juveniles (Weston, unpublished data).

In addition to these high mortality phases of the life cycle several longer term processes have been identified as potentially harmful to breeding habitat, particularly in eastern Australia (Schulz 1992, Park 1994, Weston 2000a). Breeding habitat of any species is a critical resource. Changes in breeding habitat are potentially long-term or permanent, so habitat is another area of importance for the conservation and management of the species.

Finally, the effectiveness of management techniques in terms of their ability to alleviate threats or increase populations is another primary area of interest. Increased resources are flowing to management efforts and management plans are being implemented but such efforts will probably always be limited by available resources. It is imperative that the available resources be used in such a way as to maximise the conservation benefit to Hooded Plovers.

Egg phase

Basic biology

Hooded Plovers lay two or three eggs, and occasionally lay one or four eggs (Weston et al. 1998). Their nests are usually simple structures on the beach or in nearby dune areas (Marchant & Higgins 1993). Nests are known to move, always downhill, up to about four metres (Weston 2000a, J. Fallaw pers. comm.). Hooded Plovers do not begin incubating in earnest until the clutch is complete (Weston 2000a). This species is said to have an unusually long incubation period (c. 26-28 days, Weston 2000a) thus exposing the eggs to a high risk of failure (Lane 1987). In fact, the incubation period is no longer than other related species; however it is long relative to egg size (Weston 2000a). Infertile eggs are incubated much longer than a normal incubation period, up to 59 days (Hanisch 1998, Weston 2000a). The breeding season is lengthy, and in Victoria nests have been found from August to February (Weston 2000a). There is a peak in the number of nests between about October and December (Dowling & Weston 1999, Weston 2000a). Pairs rapidly re-nest a number of times each breeding season, following loss of eggs or chicks. Occasionally, pairs will re-nest after fledging young. Pairs may nest in all major habitat types (beach, foredune, dune) in one season (Weston 2000a).

Mortality, survival and threatening processes

Table 1 shows the nest fates recorded in major studies of Hooded Plover nesting success. These studies all used the regular diurnal checking method to determine nest fates, although Weston (2000a) observed raven predation from an observation hide. Some forms of nest fate may be readily detectable while others are not. A number of sources report only the percentage of successful nests rather than the detailed nest fates. Thus, all available success rates of nests are shown in Table 2.

Other recorded examples of egg predation include losses to Goannas (Schulz 1995) and Pied Oystercatchers *Haematopus longirostris*. Snakes are suspected of taking eggs and rats were implicated as predators of two nests in Tasmania. Cats and dogs are nest predators (Hanisch 1998, Keating & Jarman 2003, P. Kambouris in litt.) and some nocturnal native mammalian predators may also take nests (Berry 2001).

Disturbance by humans has also been suggested as a cause of lowered nest success (Dowling & Weston 1999). Suggested reasons are predation in the absence of a defending adult and thermal stress to the embryos in the eggs (Schulz & Bamford 1987, Weston 2000a). A study in Victoria suggested that thermal stress probably caused egg failure but predation of eggs during disturbance did not increase (Weston 2000a). However a study in Tasmania showed increased rates of egg failure together with loss by predation at nests on disturbed beaches (Hanisch 1998). In this latter study the increased rates of predation may have been due to increased predator populations rather than to disturbance itself.

Table 1. Nest fates from different studies. These data are sourced from Dowling & Weston (1999), Hanisch (1998), Weston (2000a), Weston & Morrow (2000), Berry (2001) and Keating & Jarman (2003). The percentage of nests is shown unless indicated otherwise.

Fate	Cause	NSW South and Far South a 2002/2003	Mornington Peninsula NP	Central Victoria excluding Mornington Peninsula NP	Western Victoria	South Eastern Tasmania; Disturbed [a]	South Eastern Tasmania; undisturbed [a]	Mt William NP, North Eastern Tasmania
n (nests)		25	171	124	14	16	9	54
Successful	Hatched	47.5	39.8	21.8	21.4	14.6	29.6	31.5
Failed	Fox	8.5	1.8	5.6	28.6			
	Raven	10.2		4.8				11.1
	Cat	10.2						
	Dog							
	Unknown predator					60.0	39.0	51.9
	Crushed by motorbike or vehicle				28.6			1.9
	Crushed by humans		30.1	1.0				
	Eggs rolled-out			1.6	14.3			
	Flooded	5.1	1.8	2.4		8.0	34.0	3.7
	Abandoned		1.8	4.8	7.1	7.0		
	Non-viable	10.2				13.0		
	Human interference			1.0				
	Unknown	8.5	24.0	57.3				

[a]Figures represent proportion of eggs.

Hooded Plover defensive strategies

Hooded Plovers use three strategies to defend their nests: crypsis, aggression and distraction. Crypsis is the main defensive strategy of Hooded Plovers, the combination of secretive adult behavior and highly camouflaged nests and eggs. The typical response of incubating birds to danger is for them to leave the nest and return at a later time. Of all encounters with intruders (human and potential predators) that caused a response, 90.9% (n=580) resulted in absence from the nest. Alternatively the incubating bird would crouch over the nest (9.1%). Despite thousands of people passing close to nests, no nest was located (Weston 2000a), indicating the high effectiveness of Hooded Plovers at keeping nests hidden from humans (but increasing the risk of crushing). Even when nests had a close-encounter with a potential predator, they remained safe on 97.6% of occasions (after Weston 2000a).

Hooded Plovers are also aggressive when defending nests. They attack and drive off a variety of birds including: other species of plovers, oystercatchers, sandpipers, gulls, parrots, and passerines (Marchant & Higgins 1993, Schipper & Weston 1998a, Weston 1998a, b, Weston 2000a). However, they do not attempt to drive off ravens; instead they usually use a cryptic response (pers. obs.). Like other waders, Hooded Plovers give distraction displays. Such displays are rarely given during the egg phase (Weston 2000a), but nesting birds have been seen giving distraction displays to humans, ravens and magpies (Hanisch 1998, Weston 2000a, unpublished data).

Brood-rearing phase

Basic biology

Like most other shorebirds, Hooded Plover chicks are precocial. The adults do not feed the young but brood them and guide the anti-predator behavior of the chicks (Marchant & Higgins 1993). Although chicks from all nest habitats are led to the beach (Dowling & Weston 1999, Weston 2000a), observations revealed that in large blowouts, it can take over one and a half days before the chicks reach the beach (pers. obs.). Young chicks predominantly feed in the upper beach (Bear 2000, Weston 2000a). Broods are mobile, moving up to 2 km during a day. Growth rates are presented in Weston (2000a). Chicks fledge at about 35 days after hatching, at which time they often leave their natal territory (Marchant & Higgins 1993, Weston 2000a). Ressom (2001) reports chicks spending up to 42 days with their parents. Territorial parents have been seen chasing and fighting with their fledged offspring (Weston 1998a). Once departure from the territory occurs, the juveniles may travel hundreds of kilometres along the coast (unpublished data). They may breed in the breeding season after hatching, but most begin breeding in the second breeding season after hatching (Weston 2000a). They may breed at considerable distances from their natal territory, or they may breed near the natal site (Dowling & Weston 1999, Weston 2000a).

Table 2. Success rates of Hooded Plover nests. The number of nests and the percentage of nests that hatched are shown (unless indicated otherwise).

State	Location	n (nests)	Percentage Hatching	Source
NSW	South and Far South Coasts	59[a]	40.7	Keating & Jarman 2003
Vic.	Phillip Island	52[a]	26.9	B. Baird in litt.
Vic.	Mornington Peninsula NP	171	39.8	Dowling & Weston 1999
Vic.	Central Victoria excluding Mornington Peninsula NP	124	21.8	Weston 2000a
Vic.	Western Victoria	14	21.4	Weston & Morrow 2000
SA	Coorong	6	31.0	Buick & Paton 1989
SA	Kangaroo Is	9	22.0	Bransbury 1991
Tas.	South Eastern Tasmania; Disturbed	16	18.8	Hanisch 1998
Tas.	South Eastern Tasmania; Undisturbed	9	33.3	Hanisch 1998
Tas.	Mt William NP, North Eastern Tasmania	54	31.5	Berry 2001

[a] proportion of eggs

Mortality, survival and threatening processes

Low chick survival plays a major role in the poor reproductive success of Hooded Plovers (Weston 2000a). The causes of mortality of chicks are so poorly known that most chick deaths are reported as occurring for unknown reasons (Weston 2000a). Chicks typically disappear, so it is very difficult to know what caused their deaths – their bodies are rarely found (pers. obs.). A summary of likely causes of chick mortality is presented in Weston (2001) and Burke et al. (2004). Chick mortality is greatest in the youngest chicks (Dowling & Weston 1999, Weston 2000a, B. Baird in litt.).

Fewer success rates are available for fledging compared with hatching. An additional problem is that fledging rates are expressed differently by different researchers and this hampers comparisons. The available fledging rates are presented in Table 3.

It has been suggested that disturbance causes mortality in chicks (Schulz & Bamford 1987). The only available information on disturbance to broods (Weston 2000a) showed disturbance disrupted brooding and so thermal stress might kill chicks. Failure by adults to defend their chicks during disturbance did not, however, lead to brood failure. Foraging time for broods decreased and the range of habitats used for foraging changed with increasing levels of disturbance. Energetic stress is therefore another potential mechanism through which disturbance could decrease chick survival. Young chicks have been observed unbrooded for periods up to 4 hours during disturbance (Weston 2000a).

Table 3. The available information on fledging success and overall reproductive success.

State	Location	n (chicks)	Percentage Fledging	No. fledged per pair per season	Source
NSW	South Coast and Far South Coast (2002/2003)	24	54.2	0.8	Keating & Jarman 2003
Vic.	Phillip Island (2000/2001)	14	71.4		B. Baird in litt.
Vic.	Mornington Peninsula NP	128	27.3		Dowling & Weston 1999
Vic.	Central Victoria excluding Mornington Peninsula NP	56	19.6	0.2	Weston 2000a
Vic.	Western Victoria		8.3[a]	0.0 – 0.4	Weston & Morrow 2000
SA	Coorong			0.2	Buick & Paton 1989
SA	Kangaroo Is			1.0	Buick & Paton 1989
Tas.	South Eastern Tasmania; Disturbed	7	42.9	0.3	Hanisch 1998a
Tas.	South Eastern Tasmania; Undisturbed	8	75.0	0.9	Hanisch 1998a

[a] These figures had to be estimated based on other statistics cited.

Measures of fledging rates per pair provide information on overall reproductive success, of which brood survival is only one component. These measures can be made by using non-breeding season counts, and determining the proportion of juveniles. In eastern Victoria in autumn 1993, 9.7% of the 340 birds located were juveniles (Heislers & Weston 1993). In western Victoria in May 1998, 15.8% of the 235 Hooded Plovers counted were juveniles (Ressom 1998). If the flock counts of Cooper (1997) that occurred before the end of April are considered, then the proportion of juveniles in north east Tasmania varied between years from 2.3% to 18.2% (n varied from 32 to 57 counts). The proportion of juveniles reported from Western Australia is difficult to interpret because of the (apparently) poorly defined breeding season there.

Hooded Plover defensive strategies

Chicks respond to disturbance and threats by crouching and freezing. Chicks are camouflaged and difficult to detect when crouched. Chicks often hide next to seaweed and in footprints, and occasionally under boulders and bushes or in rock crevices. Chicks often run before hiding, and most hiding occurs in the foredunes and dunes (Weston 2000a). Chicks will also swim to avoid capture (pers. obs.). When disturbed or threatened, brood-rearing adults usually move away from chicks, and either retreat and watch, or use aggression or distraction tactics. When adults respond by moving away, there is a risk of adults losing their chicks. On some occasions, adults engage in distinct chick-searching behavior following a disturbance. Brood-rearing adults fed little and spent a considerable amount of time being vigilant – they also had a lower average body mass than at any other time during their life cycle (Weston 2000a). Brood-rearing adults are extremely aggressive to intruding Hooded Plovers; very occasionally this aggression escalates to violent attacks (Weston 1998a).

Breeding habitat

Habitat preference

In eastern Australia, Hooded Plovers almost exclusively nest on or adjacent to ocean beaches but occasionally nests are located up creek mouths and on the shores of near-coastal lakes (Weston 2000a, 2001). Only in Western Australia does the species commonly nest away from the coast (Marchant & Higgins 1993, Newbey 1996, Singor 1999). For coastal nesters, chicks move to the beach after hatching. They feed mostly on the beach but still use the dunes and foredunes where they hide and are brooded (Dowling & Weston 1999, Weston 2000a).

Anecdotal accounts of habitat preference suggest that wide, gently sloping beaches with beach cast seaweed, backed by sparsely vegetated dunes are the preferred habitat (e.g., Lane 1987). The only systematic studies of Hooded Plover habitat are from Tasmania. Hanisch (1998) investigated nest habitat in Tasmania and found that Hooded Plovers preferred to nest in heterogeneous microhabitats on beaches that were wide. Importantly, the study areas were dominated by Marram Grass *Ammophila arenaria,* and so it seems likely that habitat preference in already modified environments was measured. High rates of nest flooding was also reported in this study. Berry (2001) has a chapter on nest site preference from studies in north east Tasmania in an area where Marram Grass was also present. Substrate was the dominant factor in nest site selection, with birds preferring to nest in the wrack. No nest site characteristic influenced the outcome of nesting but higher sample sizes are required to confirm this conclusion. Bear (2000) examined Hooded Plover population densities and nesting densities in relation to physical and biological characteristics of the habitat in south eastern Tasmania. Although beaches could be divided into distinctly different types based on their physical and biological characteristics, the densities of birds and nests did not vary between the beach types. Importantly, densities did not vary between beaches with native vegetation on the dunes versus those with Marram Grass.

There is a growing body of information on nest site microhabitat (Table 4). This information highlights the important role of dunes and foredunes as nesting habitat.

Detrimental habitat processes

The two main processes likely to affect Hooded Plover habitat are 1) dune morphology and vegetation, and 2) rising sea levels. Habitat processes could work on Hooded Plovers in two broad ways: by exclusion from habitats or by displacement within habitats. There is little data on whether Hooded Plovers leave habitat as it is modified by processes such as invasion by Marram Grass. Hooded Plovers do occur in areas where Marram Grass is common, for example, in western Victoria. Different habitat types did not appear to affect the densities of birds or nests in Tasmania (Bear 2000).

Habitat processes could alter breeding sites within the habitat. For example, overgrown or steep dunes may encourage the birds to nest on the beach, and rising sea-levels may encourage the birds to nest in the dunes. Recreational pressure tends to be concentrated on the beach (Weston 2000a), and so may also alter habitat use. Combined, these processes act in different directions, 'squeezing' the band of suitable habitat.

Management effectiveness

Many populations of Hooded Plovers are being actively managed (Dowling & Weston 1999, Baker-Gabb & Weston 2001, Raines 2002). However, little information is available on the effectiveness of management techniques. Weston (2001) identified 111 management options for Hooded Plovers, and examined evidence for their effectiveness. Since then, some further information has become available on the response to oil spills (Weston 2003b). Overall, the effectiveness of 68.5% (76) is unknown because they have not been tested. In total, 30.6% (34) have been shown to be effective and 0.9% (1) has been shown to be ineffective.

Identification Of Information Gaps And Research Needs

Information gaps

For the purposes of this review research needs are defined as those areas where there is inadequate information either to understand the operation or impact of threatening processes affecting the species or to manage the species. In other words, the research needs identified are those relevant to conservation and management and they are not intended to provide a complete list of possible research projects.

Many biological studies have peripheral benefits that can aid conservation or management. Given current funding priorities, there is a growing temptation for academic studies to be presented as conservation biology, despite the fact that the benefit in terms of conservation or management may be marginal (see Sutherland 1998). This review will identify only those research needs with tangible and significant benefits in terms of managing or conserving the Hooded Plover.

The following issues are derived from the detailed summaries presented above.

Egg phase

Two major information gaps were identified with regard to the egg phase. These were: 1) that much of the nest mortality occurs from unknown causes and 2) regional variation in the causes of nest mortality are apparent but the extent and nature of this variation is yet to be determined. In many areas there are no data on nest success or the fate of nests.

Brood-rearing phase

Two major information gaps were identified with regard to the brood-rearing phase: 1) the causes of chick mortality are virtually unknown, despite the fact that mortality of chicks is high, and 2) the factors influencing the survival rate of chicks are unknown.

Breeding habitat

The habitat requirements and preferences of Hooded Plovers on the mainland need to be identified, and this constitutes the major information gap with regard to breeding habitat.

Management

Four major information gaps were identified with respect to managing Hooded Plovers. These were: 1) the effectiveness of public awareness and educational campaigns for changing recreational behavior is unknown, 2) the effectiveness of many management techniques when used in isolation is unknown, 3) methods for maintaining and rehabilitating breeding habitat are unknown and 4) effective methods for control of native predators and scavengers (e.g., ravens) are not known.

Suggested research needs

The following research needs are required to address the information gaps identified above. They omit research which is currently underway.

Egg phase

Firstly, the use of new techniques (e.g., remote infra-red cameras) to investigate the fate of eggs is needed. In particular, these technologies should focus on nocturnal nest fates. Secondly, an investigation of hatching success and nest fate in areas where no data are available (i.e., eastern Victoria and Western Australia) is required. Such data need to be comparable with those data collected elsewhere.

Table 4. The nest habitats of Hooded Plovers. N/A indicates that categories were not used by particular authors.

State	Location	n (nests)	Percentage on beach	Percentage in foredune	Percentage in dunes	Source
Vic.	Mornington Peninsula NP	171	25.0	16.0	32.8	Dowling & Weston 1999[a]
Vic.	Central Victoria excluding Mornington Peninsula NP	146	27.4	30.8	41.8	Weston 2000[a]
Vic.	Western Victoria	22	68.2	27.3	4.5	Weston & Morrow 2000
Vic.	Wilsons Promontory NP	11	9.1	0.0	90.9	unpubl. data
Vic.	Waratah Bay	5	60.0	40.0	0.0	unpubl. data
Tas.	Mt William NP	51	66.7	21.6	11.8	Berry 2001
Tas.	South East	25	96.0	N/A	4.0	Hanisch 1998

[a] additionally, 20.5% were cliff top nests and 7.0% of nests were in unknown habitats.

Brood-rearing phase

Research is needed to determine the causes of chick mortality. It is important to discover if chicks will use artificial chick shelters and, if so, to determine the ideal spatial pattern for the arrangement of chick shelters. This technique is highlighted because it has the possibility of reducing predation, crushing and disturbance.

Breeding habitat

More study is needed to determine the breeding habitat preferences of Hooded Plovers. In addition to physical attributes of the habitat, disturbance can also be treated as a habitat variable. The habitat factors influencing territory stability require investigation. A comparison of breeding success in pristine habitat versus highly modified habitat would be enlightening, as would modelling the decline of habitat to estimate rates of decline and identify areas most at risk from deteriorating habitat. An investigation of methods of rehabilitating dunes colonised by invasive dune stabilising plants and the determination of how rates of colonisation by invasive plants can be reduced or controlled (e.g., through changed fire regimes), is recommended.

Management

In theory, any management technique where the effectiveness has not been tested is a potential research need. However, priority areas can be identified. The following research addresses those management techniques which tackle threats affecting both egg and chick phases of the breeding cycle. Additionally, the management techniques to be investigated tackle significant and widespread threats, with an emphasis on promoting coexistence of humans with plovers and long-term, sustainable, solutions.

The following research needs are identified: 1) determination of the most effective methods for changing the behavior of people using the beach, both in the short and long term, 2) investigation of ways of improving compliance with dog laws, 3) assessment of the effectiveness of fox, dog and cat control on Hooded Plover reproductive success and determination of the most effective methods and protocols for predator control, and 4) development and testing of practical methods of raven management on beaches.

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Factors that Mediate Compliance to Temporary Beach Closures: Refining a Technique to Manage Human Disturbance of Shorebirds.

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Abstract

*Increasing recreational use of coastal beaches has resulted in disturbance to many shorebird populations. Species such as the Hooded Plover (*Thinornis rubricollis*) are threatened partly because of human disturbance and by inadvertent crushing of eggs and chicks by beach users. Temporary beach closures (TBCs) represent one technique used to manage human disturbance to Hooded Plovers during peak visitation times. This study tested three TBC designs currently in use to determine which design results in the highest level of compliance among beach users. Compliance with TBCs was high but varied with age, sex and the TBC design. Beach users participating in the most common recreation activities had the highest levels of compliance.*

Introduction

In Australia, the conflict between recreation and shorebirds is greatest in the coastal zone (Priest et al., 2003). There has been a growing effort to develop management techniques for the conservation of coastal shorebirds (e.g., Dowling and Weston, 1999). However, there is little information available on the effectiveness of these management techniques (Weston, 2001).

It has been suggested that the conflict between humans and shorebirds is greatest for species exclusively confined to the coast. The eastern population of the Hooded Plover (*Thinornis rubricollis* Gmelin, 1789) is one such species. Hooded Plovers nest in solitary pairs on sandy, ocean beaches often favoured by people for recreation activities (Weston, 2001). The Hooded Plover has a longer breeding season than most shorebirds extending from August to March (Marchant and Higgins, 1993). This period coincides with peak recreation use of beaches throughout coastal Victoria (December-February) (Weston, 1994; 1995). Disturbance to the Hooded Plover is believed to have contributed to the decline of this species over the past two decades. The Hooded Plover is a threatened species and is listed as Critically Endangered in New South Wales and Vulnerable in Victoria and South Australia. Current Victorian population estimates are less than 500 birds (Garnett and Crowley, 2000; Weston, 2001).

This study uses the Hooded Plover as a model for examining the effectiveness of TBCs in managing human disturbance to shorebirds. Temporary Beach Closures are a management technique aimed at excluding beach users from Hooded Plover breeding sites through barriers, signs and education (Weston, 1997). They are a promising tool, being one of a suite of techniques associated with increases in reproductive success (Dowling and Weston, 1999). Temporary Beach Closures are also cost effective, permit coexistence between beach users and Hooded Plovers and help inform beach users of the species' plight (Weston, 2001). A number of TBC designs are used by Hooded Plover managers along the Victorian coast however their effectiveness has not been tested (Weston, 1997). This study compares and contrasts three TBC designs in use and examines factors that mediate beach users' compliance with TBCs. By understanding what factors mediate compliance with TBCs, designs can be improved and educational awareness campaigns can be developed. This paper presents the preliminary results from an honours project which investigated the merits of three TBC designs.

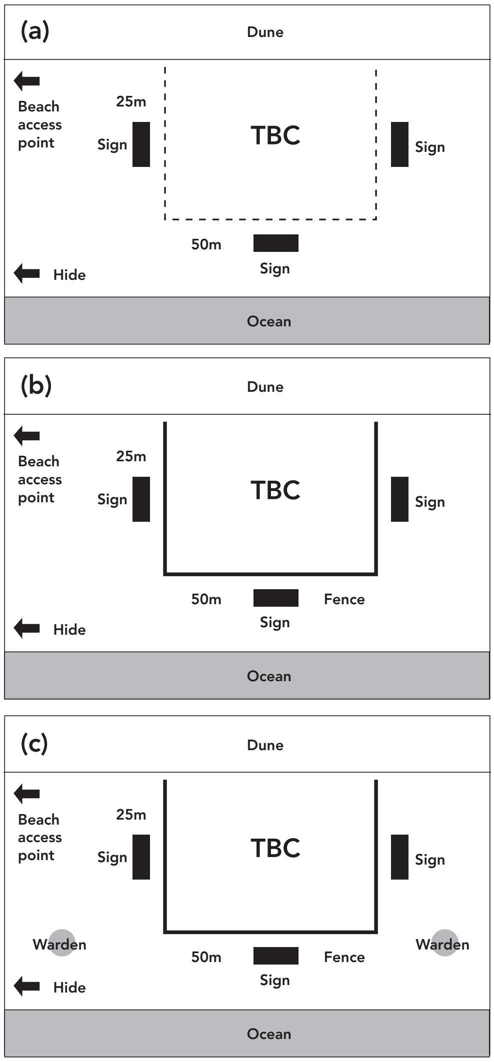

Figure 1
Three temporary beach closure (TBC) treatments were tested:

(a) TBC sign treatment - three signs, two positioned 60 m apart, perpendicular to the dune base, one ~ 30 m from the dune base;

(b) TBC fence treatment - signs used as per the sign treatment plus a fence (25 x 50 m) made of nylon rope and 14 plastic star-pickets; and

(c) TBC warden treatment - signs and fence used as per treatments above plus two wardens.

Methods

The study was conducted at 15 beaches along the southern coast of central Victoria (December 2002 - March 2003). Beaches were located between Apollo Bay in the west and Wilson's Promontory in the east. Study sites were selected because they are the habitat favoured by the Hooded Plover during its breeding season and were popular high-use, recreational areas. Beaches were linear, sandy, high-energy ocean beaches. In order to avoid disturbance, TBCs were positioned at potential but non active Hooded Plover breeding sites. Observations were made for one day during daylight hours from a stationary position, either from a hide (beach sun shelter) or a high vantage point.

Three TBC designs (treatments) were tested (Figures. 1a-c). Each site was randomly allocated one of the three treatments and each treatment was replicated five times. The TBC treatments are described below.

Sign treatment

The sign treatment consisted of three signs (90 x 120 cm) (Figure 2). Signs were constructed of a light-weight plastic with information and instructions for the beach user in large, bold print. The signs urged beach users to stay outside the area, and if they wished to move along the beach past the TBC, to do so by walking along the waters' edge. The sign treatment was the basic TBC design and the two other designs represent this basic design with additional features.

Two signs were positioned 60 m apart, perpendicular to the dune base and facing outwards. One sign was 30 m from the base of the dunes, parallel with the water's edge and facing seaward (Figure 1a).

Figure 2. The temporary beach closure (TBC) sign applied to all treatments. Signs had a written message for beach users: "TEMPORARY BEACH CLOSURE. Due to shore bird (Hooded Plover) nesting in this area, human disturbance on the beach or in the dunes will cause breeding failure. If you walk along the beach, walk quickly close to the waters edge, do not sit in the area, do not enter the sand dunes, dogs and horses strictly prohibited. Thank you for protecting the endangered Hooded Plover. Further information…" Phillip Island Nature Park (PINP) supplied the signs although management name, phone number and logo were covered to enable their use at all beaches. A colour drawing of the Hooded Plover was included for identification purposes.

Fence treatment

The fence treatment combined the sign treatment with a rope fence (25 x 25 x 50 m, Figure 1b). The fence was constructed of brightly coloured nylon rope (7 mm) and 14 plastic star-pickets placed at regular intervals (~7 m). The fence was positioned five metres inside the boundary of the signs, and ran parallel with the shoreline and to the base of the dunes, forming a rectangular shape. Because the fence bordered the base of the dunes, this acted as a natural barrier and therefore the rope and pickets were not used at the rear of the TBC.

Warden treatment

The warden treatment combined the sign treatment and the fence treatment with two volunteer wardens (Figure 1c). Wardens were positioned approximately ten metres on either side of the TBC, level with the seaward facing sign. The role of the wardens was to provide information about the Hooded Plover and the TBC to beach users without revealing the TBC was for study purposes.

Compliance

Each beach user that approached within 50 m of a TBC was recorded as being compliant or non-compliant. Non compliance was defined as a beach user entering the TBC area within the three signs. If a dog entered a TBC treatment, the dogs' owner was recorded as non-compliant. Compliance or non-compliance with a TBC treatment was recorded along with an individuals' age, sex and their recreation activity. A beach users age was estimated and placed into one of seven age groups; 0-15 yrs, 16-25 yrs, 26-35 yrs, 36-45 yrs, 46-55 yrs, 56-65 yrs and 65+ yrs. Recreation activities were divided into seven groups according to movement, activity focus, and position on the beach (Table 1).

Results

Of the total number of beach users that encountered a TBC, most complied (95%). However, non-compliance varied significantly in relation to TBC treatment. When comparing treatments, non-compliance was greatest for the TBC sign treatment followed by the fence treatment and thirdly the warden treatment (Figure 3).

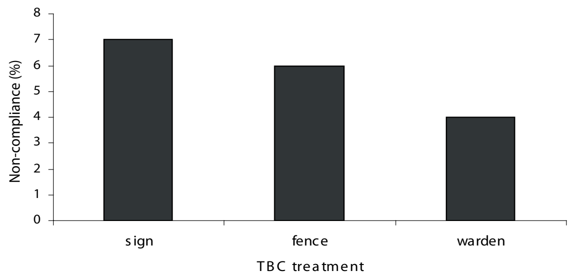

Figure 3. The proportion of humans that approached a temporary beach closure (TBC) and did not comply. Non-compliance was defined as a human or dog entering the 25 x 50 m area between the three TBC signs (see Figure 1a-c). The proportion of non-compliance in each TBC treatment is shown: TBC sign treatment (n = 36), TBC fence treatment (n = 28), and TBC warden treatment (n = 20).

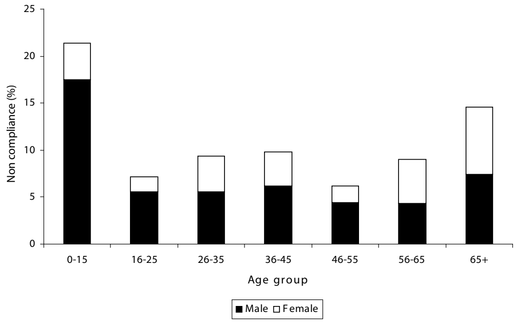

Figure 4. The proportion of beach users in each age group and their sex that approached a temporary beach closure (TBC) treatment within 50 meters and did not comply. Non-compliance was defined as a human or dog entering the area between the three TBC signs (see Figure 1).

Compliance with TBC treatments varied between the age and recreation activity of beach users. Non-compliance was greatest in the youngest age group (0-15 yrs); followed by the eldest age group (65+ yrs) and lowest in the 46-55 yrs age group (Figure 4). In all age groups, males were less compliant than females. Compliance varied considerably between recreation activities. Non-compliance was greatest in the dune activity group however, this group consisted of only one activity and because of the small sample size these results should be interpreted with caution (Figure 5). Non-compliance was also substantial in the roaming activity group. Although the dog activity group had the same number of participants as the water activity group, dog walkers were less compliant and for dog walkers that did not comply, most had their dogs off the lead. The recreation activity group with the greatest number of participants, the linear activity group had the lowest non-compliance.

Table 1. The recreation activities recorded during each observation period were categorised and placed into one of seven activity groups. Groups were arranged according to the main focus of the activity and where it took place on the beach.

Group	Position	Activity
Linear-activity	Shoreline	Walking Bike riding Jogging Baby-stroller walking
Dog-activity	High tide mark to shoreline	Dog walking (lead) Dog walking (no lead)
Roaming-activity	Dune base to shoreline	Ball games Kite flying Beach combing Rock pool rambling
Water-activity	Shoreline to wave zone	Surfing Swimming Fishing
Fixed-activity	Dune base to shoreline	Picnicking Sand play Sun-baking
Motorised-activity	High tide mark to shoreline	3-wheel drive vehicles 4-wheel drive vehicles
Dune-activity	Dunes	Dune surfing

Discussion

TBCs can only be effective if they are associated with substantial levels of compliance (Weston 1997; 2001). Compliance with TBCs was high but varied with a beach users' age, sex and recreation activity. The results suggest that all three TBC treatments are a worthy management option, however, in terms of reducing human disturbance to shorebird populations the warden treatment was most effective. Research on the attitude of beach users and how it translates into compliant or non-compliant behavior may further aid in the management of human disturbance to shorebirds. Previous studies suggest that knowledge derived from education can have strong impact on responsible behavior (Eagles and Demare, 1999; Musser and Diamond, 1999).

In order to improve compliance with TBCs, management strategies could target the worst offenders. A focus on altering the behavior of children, the elderly and males on beaches could result in greater compliance with TBCs. Education with a positive conservation message could be delivered in the home, school and to the broader community (Eagles and Demare, 1999; Musser and Diamond, 1999). If non-compliance is unintentional, then increasing the detect-ability of TBC signs may improve compliance rates (Gramann and Bonifield, 1995).

The most practical TBC treatment will represent a balance between effectiveness and investment of time and other resources. In this study, the fence treatment achieved high compliance and it was simple, easy to apply and cost effective. Although the warden treatment produced greater compliance among beach users, the marginal increase in compliance may only be significant on beaches with high visitation, and did not outweigh the significant investment required to organise volunteers.

A number of questions remain regarding TBCs. This study examined compliance during peak summer visitation; however compliance during other months and times of day could also be established. The effectiveness of TBCs on mitigating threats to shorebird chicks is yet to be understood, as is the effect of different sized TBCs.

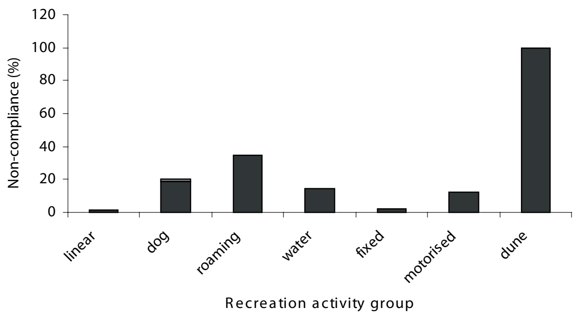

Fig.5. The proportion of humans engaged in each recreation activity that approached a temporary beach closure (TBC) and did not comply. Non-compliance was defined as a human or dog entering the 25 x 50 m area between the three TBC signs (see Fig. 1a-c). Activities were categorised into seven groups according to activity focus and the location on the beach (see Table 1). Activity groups consisted of: 'linear activity' (n = 1), 'dog activity' (n = 22), 'roaming activity' (n = 18), 'water activity' (n = 22), 'fixed activity' (n = 2), 'motorized activity' (n = 1), and 'dune activity' (n = 2).

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Gains and Losses in the New Zealand Shore Plover (*Thinornis Novaeseelandiae*) Recovery Programme 1993-2003

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Abstract

The New Zealand Shore Plover (Thinornis novaeseelandiae) *is an endemic plover with a total population of less than 200 birds. It disappeared from the mainland of New Zealand during the 19th century and has been confined to one or two small islands in the Chathams archipelago for the past 100 years. Because of its small population size, the Shore Plover is classified as Endangered. This paper outlines the recovery effort undertaken in recent years, with particular emphasis on attempts over the past decade to found new populations of shore plover on the Chatham Islands and around mainland New Zealand. On the Chatham Islands, birds have been re-introduced to Mangere Island and are breeding; however, the island has little suitable habitat and the long-term future of this population is not clear. A previously unknown population on a small reef was discovered in 1999 but had declined to effective extinction within four years of discovery. Around mainland New Zealand, first attempts to found a new population were made on Motuora Island, where a total of 75 birds were released between 1994 and 2000. Two pairs bred on Motuora but rates of dispersal were high and predation by avian predators occurred, and a population did not establish. The second attempt, on a privately owned island, began with a release in 1998 and has been successful, with a resident population of about 55 birds, including 11 breeding pairs present in autumn 2003. Modelling of demographic data suggests that in the absence of a predator irruption or a drastic fall in productivity, this population is established and self-sustaining. In 1993, the species totalled about 150 individuals, most of them in one location. There have been gains and losses, but in 2003 the total and effective populations in the wild were slightly larger than in 1993. Most importantly, the immediate risk of extinction has been reduced by the founding of a second population.*

Keywords: *Shore Plover, Thinornis novaeseelandiae*, threatened species, Chatham Islands, translocation, conservation, recovery programme

Introduction

The New Zealand Shore Plover (*Thinornis novaeseelandiae*) is a threatened endemic shorebird and one of the rarest plovers in the world. The present distribution of the species suggests that it is highly susceptible to predation by introduced mammals (Dowding & Murphy 2001). Until the 1870s it occurred on mainland New Zealand, but following the introduction of rodents and cats it became confined to the Chatham Islands, about 800 km east of New Zealand (Davis 1987). With the spread of predators to main Chatham Island and then to Pitt and Mangere Islands, its range became further restricted. For the past century, the species has probably numbered less than 200 individuals and, until very recently, been confined to one or two small islands.

In recent times, the bulk of the population has been on South East Island (Rangatira). Banding and monitoring of this population by the New Zealand Wildlife Service began in the 1960s (Flack 1976), and it has been studied and monitored more intensively since the mid-1980s (Davis 1994a, 1994b). The greatest threat to the South East Island population is undoubtedly the introduction of predators, although habitat changes have caused a gradual decline. Fire and disease are also potential threats. The urgent need to establish further populations has been repeated often (Flack 1976, Davis 1987, Dowding & Kennedy 1993).

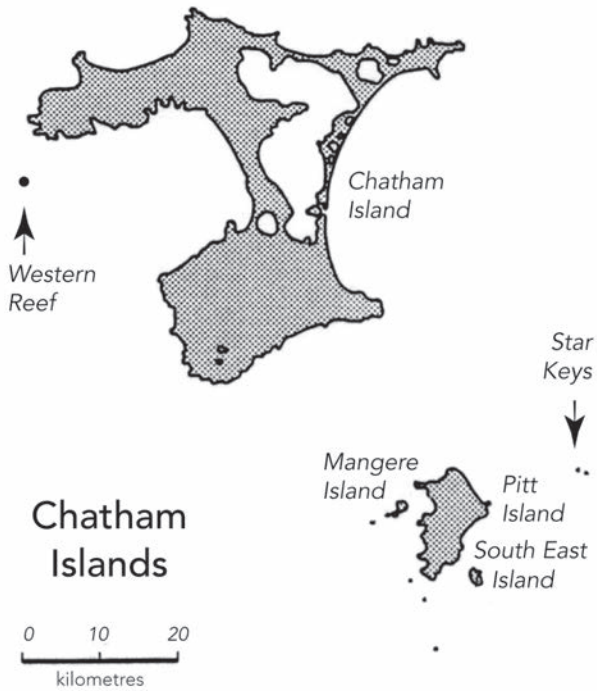

Figure 1. Map of Chatham Islands showing locations mentioned in the text.

The shore plover is currently recognised internationally as Endangered because of its very small population (BirdLife International 2000). In the New Zealand Department of Conservation's national threat classification (Molloy et al. 2001), the species is classed as Nationally Critical (Hitchmough 2002), the highest category of threat.

A recovery programme for the species has been set up with the aim of protecting existing populations and establishing new ones. As part of the programme, a captive population is maintained at two institutions and juveniles are bred for release. The current recovery plan (Aikman et al. 2001) sets out the programme for the ten years 2001-2011 and has a goal of maintaining or establishing shore plover at five or more locations with a combined population of 250 or more by 2011.

This paper outlines the recovery effort undertaken over the past decade, with particular emphasis on the successful establishment of a new shore plover population. In 1993, the species was clearly extremely vulnerable, with a total population of about 150 individuals, 85% of them in one location. There have been gains and losses, but in 2003 the total wild population is slightly larger than in 1993 and there are more breeding pairs. Most importantly, the immediate risk of extinction has been reduced by the founding of a second self-sustaining population on an island off mainland New Zealand. Further releases are planned on the Chatham Islands and around mainland

Methods and study sites

Chatham Islands

A map of the Chatham Islands (Figure 1) shows locations mentioned below. The population on South East Island (220 ha) is monitored annually. Counts of the total population and the number of territorial pairs are undertaken at the start and end of the breeding season. Band sightings are recorded and juveniles are banded.

Each January from 2001-2003 inclusive, 13-15 juveniles were captured on South East Island, banded and transferred to an aviary on Mangere Island (140 ha). Following a holding period of 1-2 weeks, the birds were released. Shore plovers on Mangere Island are monitored during the breeding season and juveniles are banded.

Following the discovery of a small, previously unknown population on the 8 ha Western Reef in 1999 (Bell & Bell 2000), it was surveyed nine times between February 1999 and June 2003. The reef lies 5 km off the north-western corner of Chatham Island and is exposed to the prevailing weather; access is difficult because landing requires calm seas.

Mainland New Zealand

The release strategy was outlined by Aikman (1999). Eggs were transferred from South East Island to two institutions on mainland New Zealand in the early-mid 1990s and used to found a captive population (Aikman *et al*. 2001). Juvenile birds reared in captivity from this stock were transferred to aviaries at the release site and held for variable periods. Following release, birds were monitored intensively for one month, with less-intensive monitoring after that time. The two main factors governing the choice of release sites were (a) the absence of mammalian predators and (b) the existence of suitable coastal habitat for feeding, nesting and brood rearing.

Motuora

The Motuora Island programme was described and results were reported and analysed by Davis & Aikman (1997), Taylor et al. (1998) and Aikman (1999).

Release Site 2

The second release site chosen was a privately owned island off the coast of mainland New Zealand. Permission to release and manage shore plover was granted by the owners on condition that the programme was not publicised, and the site is therefore referred to here as Release Site 2 (RS 2).

Since breeding began in 1999/2000, there has been intensive management and monitoring of shore plover each breeding season, with the island permanently manned from October or early November to February or early March. There have been numerous day trips outside this period, as well as trips of several days duration for annual releases.

Avian predators have been controlled at RS 2. Southern black-backed gulls *(Larus dominicanus)* were considered a major threat to breeding success and a colony of about 200 pairs was controlled to very low levels in November 1999. Periodic control of small numbers of gulls, Australasian harriers *(Circus approximans)* and Australian magpies *(Gymnorhina tibicen)* has continued during each breeding season. Where possible, loss of nests to flooding has also been managed.

A database of annual survival was created. Presence or absence of each bird was recorded in late summer or autumn (from late February onwards) after most breeding activity was completed. A second database of productivity (chicks fledged per pair per season) was also set up. These databases were used to calculate estimates (mean and standard deviation) of productivity, juvenile (first year) survival, and adult (second and subsequent year) survival. The results presented below are based on sightings to 5 April 2003. The viability of the population was modelled using the programme Vortex 9.14 (Lacy *et al.* 2003; Miller and Lacy 2003). This programme incorporates demographic and environmental stochasticity and also allows for simulation of removal (harvesting) or supplementation (further releases). Based on the amount of habitat available at RS 2 and the density of birds on South East Island, the carrying capacity of RS 2 was estimated at about 200 birds. Trends were examined over a 50-year period.

Results

Chatham Islands

South East Island

Over the past three decades, the population appears to have been roughly stable, with 40-45 pairs breeding each year and a post-breeding total (including juveniles) of 110-140 birds. However, there is evidence that the population is at carrying capacity. Productivity has been high enough to allow population growth, but the constant number of pairs and the presence of a pool of non-breeding adults suggests that all breeding territories are occupied (Davis 1994a). Within the past decade, a gender bias has developed among the non-breeding birds; this pool contained equal numbers of males and females in the mid-1980s (Davis 1987) and in 1992/93 (Dowding & Kennedy 1993). However, there is now a consistently higher proportion of males and only one of eleven colour-banded non-breeding adults seen in January 2002 was female (Dowding 2002).

Mangere Island

There have been three recent transfers of wild-reared juveniles from South East Island to Mangere Island, of 15 birds in January 2001, 13 in January 2002 and 15 in January 2003. One pair bred successfully in 2001/02 and two pairs bred in 2002/03, fledging a total of four juveniles to date. Suitable habitat is probably limited on Mangere Island and dispersal rates have been relatively high. However, some birds that dispersed have returned to South East Island and a few of these have established.

Western Reef

The discovery in 1999 of a previously unknown population of shore plover on Western Reef (see Figure 1) was documented by Bell & Bell (2000). When first surveyed in February 1999, the reef held 21 birds (15 adult males, 5 adult females and one juvenile). Relatively few trips have been possible since, but the population has declined to effective extinction within four years of discovery (Figure 2). Shore plover on Western Reef were genetically distinct from those on South East Island (Lambert *et al.* 2000). Following consideration of management options (Dowding 2003), the last surviving bird, an adult male, was taken into captivity in June 2003. Offspring of this bird will be used to produce juveniles for release on Star Keys (see Figure 1), in an attempt to re-integrate Western Reef genes into the wider Chatham Islands shore plover population.

Mainland New Zealand

Motuora Island

The results of releases on Motuora Island were described by Aikman (1999). There were losses to predation by Moreporks (*Ninox novaeseelandiae*) and high rates of dispersal to the mainland, where most plovers were probably quickly killed by mammalian predators. However, breeding did occur on Motuora Island. Two pairs attempted to breed during the 1998/99 season (Watson 1999). The male of one pair disappeared during incubation and the female (a one-year-old) abandoned the nest, which contained fertile eggs. The second pair hatched two chicks and successfully fledged one of them, although the fledgling was probably later taken by a harrier (Watson 1999). This second pair bred again in 1999/2000 and again hatched two chicks and fledged one.

Two birds have survived from the Motuora programme. A captive-reared male released in 1998 and a wild-bred male (the chick fledged on Motuora in 1999/2000) are currently resident on Beehive Island, a very small island (0.8 ha) free of mammalian predators 6 km from Motuora.

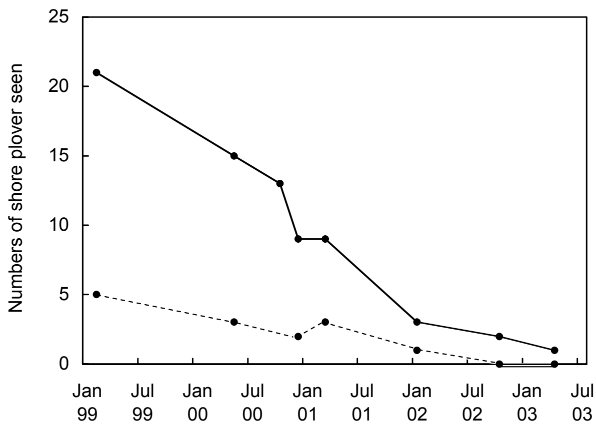

Figure 2 Decline of the shore plover on Western Reef, Chatham Islands, 1999-2003. Total population (solid line) and adult females (dashed line).

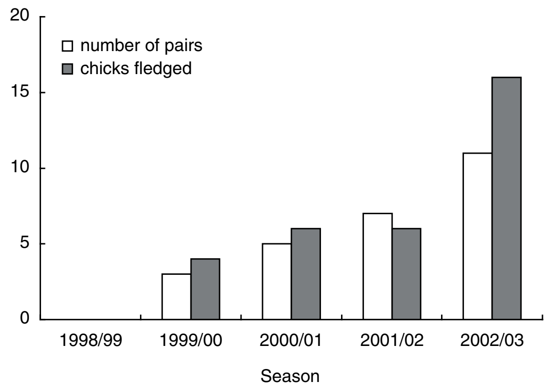

Figure 3. Number of pairs attempting to breed (open columns) and chicks fledged (solid columns) at Release Site 2 since releases began in 1998.

Release site 2

Table 1 summarises releases of captive-reared shore plover at RS 2 to March 2003.

Breeding was first recorded in the 1999/2000 season. Since then, the number of pairs attempting to breed has increased each season (Figure 3) and by autumn 2003 the total resident population was about 55 birds.

Data on first-year survival are now available for five cohorts of captive-reared birds and three cohorts of wild-bred birds. The sample of locally bred birds is still small, but to date there is no evidence that their survival to one year is significantly better than that of captive-reared birds (Fisher's Exact test, P=0.276). Mean first-year survival (captive-reared and wild-bred birds combined) was 0.49.

There was no difference in first-year survival of hand-reared and parent-reared birds. Of 25 hand-reared birds released, 11 (44%) survived to one year compared to 19 (49%) of 39 parent-reared birds released; this difference was not significant (Fisher's Exact test, P=0.80).

During analysis of first-year survival, an unexpected trend emerged. The data are limited, but first-year survival of released birds may be decreasing as the programme proceeds. Figure 4 shows that survival to one year was very similar for the first three release cohorts (0.55-0.60), but has subsequently fallen.

Mean annual survival from one year onwards was 0.85. However, survival from year one to year two may be lower than in subsequent years, and Vortex requires separate values for second-year and subsequent survival. Survival from one to two years was 0.81. From two years on, survival was 0.94, but it should be noted that this figure is based on a very small total sample, including the death of only one bird. Average productivity over the past four seasons has been 1.23 chicks fledged per pair per year (range 0.86-1.45).

Table 1. Shore plover releases at Release Site 2 August 1998 – March 2003

Release date	Number of birds released	Days held in aviary
22-08-98	15	10
15-07-99	11	3
03-05-00	13	1
16-05-01	13	1
25-05-02	9	2
22-10-02	4	1
13-03-03	10	2
Total	75	

The capacity of the population to increase (r) was estimated at a range of productivity values; when r is positive, the population has the capacity to increase, and when r is negative, it will decrease. Vortex also calculates a percent probability that the population will become extinct within the stipulated time. This basic model (Figure 5) assumed no supplementation (i.e. no further releases). This suggests that if productivity remains at its present level (1.23), the population will continue to grow (r=+0.078, an average growth rate of 8.1% per year) and the probability of extinction is 0%. This is the 'basic' scenario.

A second set of simulations was run, assuming that there is further supplementation (releases of about 12 juveniles per year for the next two years are planned); this is the 'basic+supp' scenario. Under this scenario the population will grow slightly faster (r=+0.084, average growth rate of 8.8% per year) and the probability of extinction is again 0%.

Population growth over a 50-year period under the 'basic+supp' scenarios was estimated; the model suggests that with two further releases the population will reach 100 birds in about 4 years and plateau at about 190 birds in 25-30years. Under current conditions, the shore plover population at RS 2 is therefore already self-sustaining, with or without further releases. However, it seems very unlikely that productivity will remain as high as 1.23, once intensive management throughout the breeding season is discontinued.

Unfortunately, the extent to which productivity will fall cannot be reliably estimated. However, Vortex can be used to assess what average level of productivity is required if the population is to persist. The 'basic+supp' scenario was repeated at a range of productivity values, and the size of the population estimated over a 50 -year period for each productivity level (Figure 6). This suggests that at average productivity of 0.6 or lower, the population will not persist in the long term. At productivity of 0.7 the population may stabilise at about 100-110 individuals. At 0.8 and above, the population will persist and will stabilise at between 130 and 190 individuals.

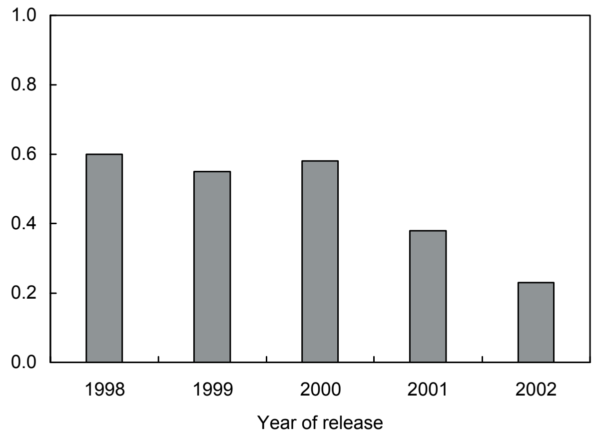

Figure 4. First-year survival of juvenile shore plovers released at Release Site 2, 1998-2002

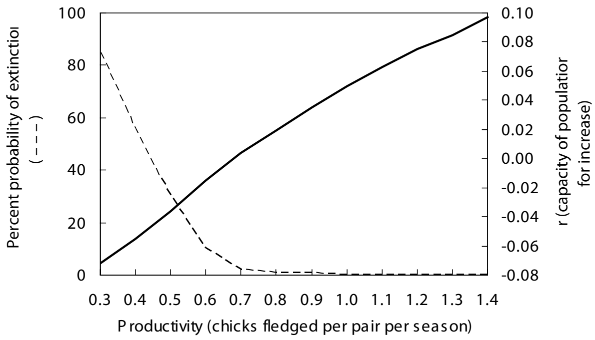

Figure 5. Probability of extinction (PE) and capacity for increase (r) of the shore plover population at Release Site 2 during the next 50 years

Two other aspects of breeding biology noted at RS 2 are of interest. During the 2001/02 season, one pair double-brooded, fledging one chick from their first breeding attempt and two from a subsequent attempt. Second, at least two birds have bred at one year old. A female raised in the 1999/00 season first bred in 2000/01; she hatched two chicks but neither survived. A male raised in the 2001/02 season first bred in 2002/03, when he successfully fledged two chicks. Both birds that bred at one year were wild-bred on the island.

Summary

The changes in total numbers and in pairs breeding at each of the sites described above are summarised in Table 2. Largely due to the successes at RS 2, the total population has grown, as has the number of pairs (the effective population).

Table 2: Changes in numbers and distribution of the New Zealand shore plover between 1993 and 2003.				
Location	**1993**		**2003**	
	Birds	Pairs	Birds	Pairs
South East Island	130	43-45	130	43-45
Mangere Island	0	0	6	2
Western Reef	~21	~5	0	0
Motuora Island	0	0	0	0
Beehive Island	0	0	2	0
Release site 2	0	0	50	11
Totals	**151**	**48-50**	**188**	**56-58**

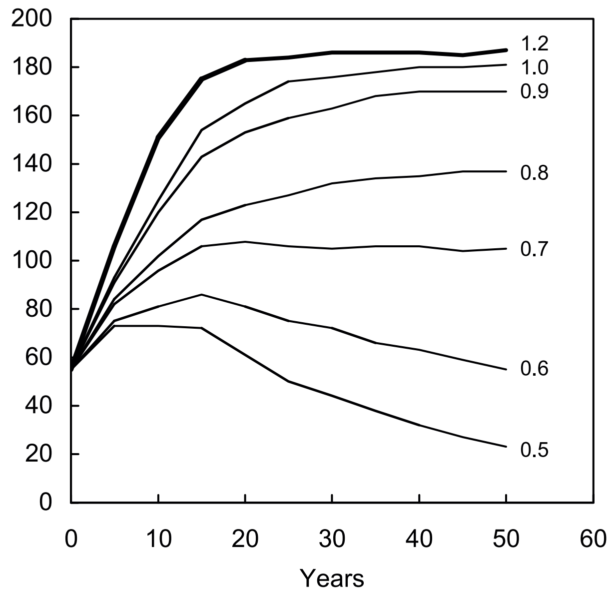

Figure 6. Projected size of the shore plover population at Release Site 2 over the next 50 years at a range of productivity values

Discussion

Chatham Islands populations

South East Island

Over the past decade, the population on South East Island has been roughly stable. However, it has declined over the past 40 years. Fleming (1939) estimated that 70 pairs were present on the island in 1937. South East Island was farmed until 1961, at which time shore plovers were breeding on pasture in the central part of the island. Following the removal of stock, pasture became overgrown and the number of pairs declined (Flack 1976). There is continuing encroachment of vegetation, particularly on The Clears, an area of exposed salt meadow above the southern coast. Breeding and feeding habitat on the south coast are also being degraded as a large fur seal rookery expands. Together, these factors seem likely to result in a further gradual decline in the number of breeding pairs and in the overall carrying capacity of South East Island. The gender bias that has developed among non-breeding adults may also reflect this resource limitation. Other predator-free islands nearby (Mangere Island and Star Keys) are small or have limited habitat. The most effective long-term measure to secure the future of the Chatham Islands shore plover population would be the removal of mammalian and avian predators (cats, pigs and weka *Gallirallus australis*) from Pitt Island so that shore plovers can establish there.

Mangere

Much of the coastline of Mangere Island consists of cliffs or steep boulder beaches, which are not suitable breeding habitat for shore plover. There is a small area of rock platform which, based on the density of pairs on South East Island, may hold 4-6 pairs. Unless birds begin breeding on the small area of salt meadow or on other vegetated areas of the island, it seems likely that the shore plover population on Mangere will always be small. Flack (1976) considered that the shore plover population on Mangere in the 19th century was too small to be self-sustaining and was probably maintained by dispersal from nearby Pitt Island.

Western Reef

Almost the entire shore plover population on South East Island is banded. None of the 20 adult birds seen on Western Reef in February 1999 were banded; coupled with the genetic evidence, this suggests that there has been little (if any) recent interchange between the populations. The two islands are about 80 km apart; shore plover are probably quite capable of flying this distance but in doing so are likely to encounter Pitt Island and Chatham Island, both of which have introduced mammalian predators. It is possible that the Western Reef population is a relict population from main Chatham Island and has been isolated there since the arrival of cats and rats on Chatham Island about 1840.

The reason for the rapid decline on Western Reef is unknown, but the fact that there were only five females present among 20 adult birds (Figure 2) suggests that the population was not healthy at the time of discovery. There is no evidence of introduced mammals on the reef, but there is a large and rapidly expanding fur seal rookery, which may have degraded shore plover habitat.

Mainland New Zealand

Motuora Island

A high proportion of shore plovers released on Motuora Island disappeared quickly after release. Dispersal (possibly related to harassment by Moreporks (*Ninox novaeseelandiae*) and other avian predators) were the main factors identified by Aikman (1999).

Although a shore plover population did not establish on Motuora Island, information useful to the recovery programme was gained. The project confirmed that captive-reared birds were capable of breeding successfully in the wild. The two chicks produced in 1998 were probably the first shore plover chicks hatched around mainland New Zealand for about 130 years. It also demonstrated that in addition to the rock platforms and salt meadow used for breeding on South East Island, shore plover readily use sandy beaches. The project also served to highlight the importance of avian predators, at least in the early stages of a re-introduction attempt.

Release site 2

Early releases of adult shore plovers on Mangere Island were unsuccessful (Flack 1976). However, the release strategy proposed by Aikman (1995), involving the soft release of captive-reared juveniles, has apparently been successful to date on RS 2. Control of avian predators (particularly southern black-backed gulls and Australasian harriers) appears important, at least during the establishment phase of the new population. Ongoing monitoring at RS 2 should reveal the extent to which this control is necessary in the longer term.

The finding that survival of hand- and parent-reared birds did not differ on Motuora Island (Aikman 1999) or at RS 2 (this paper) is a positive result for the recovery programme. The number of juveniles bred for release can safely be increased each season (without compromising their later survival) by removing first clutches from pairs in captivity, raising these broods by hand and allowing pairs to re-lay and raise second broods themselves.

The apparent decline in first-year survival of released birds may be an artefact of the small sample sizes involved (≤ 15 birds per year), or it may be real. There are no obvious reasons why such a decline should occur, but it could be related either to increased levels of avian predation (as predators increasingly key into shore plover as prey) or to increasing social pressures (resulting in higher dispersal rates) as the shore plover population grows.

Double-brooding has not previously been recorded in the much-studied population on South East Island, probably because that population is at carrying capacity and resources are believed to be limiting. Breeding in the wild at one year has also not been recorded on South East Island, although it has occurred in the captive population. Two one-year-old birds (a male and a female) have bred at RS 2 and a female bred at one year of age on Motuora Island, demonstrating that both sexes may be physiologically capable of breeding at that age in the wild. Both RS 2 birds were locally bred, while the Motuora bird was captive-reared. Again, breeding at one year of age is likely to have occurred because the space limitations and resource constraints that exist in a population at capacity probably did not yet exist at RS 2 or Motuora Island.

The possibility of harvesting wild-bred juveniles from RS 2 in future to assist with the founding of new populations will depend on productivity levels there once the intensity of management is reduced. Preliminary modelling (data not shown) suggests that the removal of 5-6 juveniles per year for three years would not affect the viability of the population as long as productivity at RS 2 remained above 0.8.

Outlook

With a total population of less than 200 individuals, the shore plover is still highly endangered. However, in the past decade the total number of birds has increased, the number of breeding pairs has increased, and a second secure population has been established. Most importantly, a technique for founding new populations is available and there is a better understanding of the factors governing the success of releases. Additional populations are required, however, to reduce the threat of extinction further and increase the total population size. The recovery plan (Aikman *et al*. 2001) requires establishment of a self-sustaining population at one new site by 2005 (already achieved at Release Site 2), and at two further sites by 2011. Ensuring the long-term survival of all shore plover populations will require strict quarantine measures to prevent the arrival of mammalian predators as well as contingency plans to deal with any invasions that do occur.

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Assessing Shorebird Propulations at the Australian end

A Tour of Selected Significant Coastal Shorebird Sites in the Top End of the Northern Territory of Australia

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Introduction

1990 there were relatively few aquatic bird surveys of Australia's Northern Territory (NT) wetlands, and even fewer of its coast and offshore islands. The most extensive work to that time concentrated either on the wetlands of Kakadu National Park, or in the case of the NT Parks and Wildlife Service, on one species – the Magpie Goose. Further, the Magpie Goose surveys were restricted to the annual aerial counting of geese (and one or two other waterbirds) on set transacts across selected wetlands.

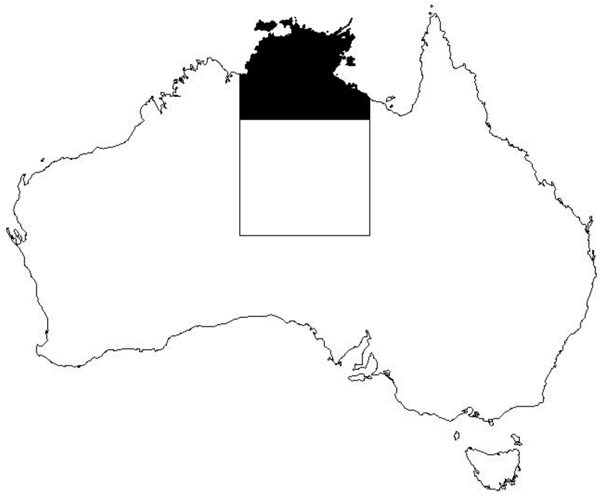

Figure 1. The Top End (area shown in solid black) of the Northern Territory of Australia.

In early 1990, whilst involved with these Magpie Goose surveys, I began a program to increase the number of species counted and the area covered. These extra surveys initially began as a series of detour flights whilst en route home from the day's goose surveying. However, with the finding of many important and previously undocumented wildlife sites, these detours soon expanded into surveys of their own. They developed into a major and separate project involving aerial and ground surveys of the coast, islands and wetlands of the Top End. The Top End (Figure 1) is defined as the northern part of the NT, above latitude 16° 35'S.

This project had three main phases. The first phase was to locate and document the distribution and status of a wide range of different faunal groups in the Top End, of which very little was known prior to these surveys. In this phase, major emphasis was given to finding sites significant for these faunal groups. This phase is almost completed, and the first three reports (Chatto 2000a, 2001 and 2003) in a major series dealing with the distribution and status of different groups of fauna have been written. Web site addresses for completed reports in this series are given at the end of this paper.

The second phase, now underway, involves setting up long-term monitoring programs at selected sites, or for selected species, to assess their on-going status. Selection of most of these sites will be based on information collected in phase 1. The third phase will involve drawing up management plans where necessary.

Between 1990 and 2002, the entire coastline of the NT, (measuring more than 10, 000 km, and comprising more than 800 islands, were surveyed by air and on the ground. In addition more than 1,000,000 hectares of wetland adjacent to this coast was also surveyed. These surveys targeted a wide range of fauna but concentrated primarily on seabirds, waterbirds, shorebirds, coastal raptors, marine turtles, cetaceans, dugongs and flying foxes; overall more than 130 species were recorded. These faunal groups were selected because most were reasonably abundant and, more importantly, could be identified from the air the main method of survey in such remote and inaccessible country. Other species of fauna were recorded on the ground, but the above groups represent the vast majority of the fauna recorded during the phase 1 surveys.

Methods and Project Effort

This brief summary of methods and effort is provided to demonstrate the vast scale of the project. The large amount of data collected and the long time-span of the survey improves our chances of understanding the significance of this large area to Top End wildlife.

During this 13-year period I spent more than 500 days in the field and completed more than 2,500 hours of low level flying and over 3,500 ground surveys. Over 600 separate ground sites were surveyed, some once, some up to twenty times over 13 years.

I collected in excess of 65,000 records (approximately three times as many in air surveys as on the ground) totalling over 5 million animals. A record was a single count of a species, or a species group, at a particular location or time. Many animals could not be identified to species from the air, so species categories were devised. A species category might include a pair of similar species, such as Great and Red Knots, or many species, such as an all-encompassing 'wader species' category.

With such a diversity of species being surveyed and such an extensive area to cover, many records were estimates rather than precise counts. This was particularly the case for aerial surveys and for occasions when large numbers of wildlife were surveyed from the ground.

The initial data were collected primarily as the basis for planning future wildlife management activities and phase 2 of the project; which will involve a higher percentage of full counts. I considered it more important in phase 1 to estimate numbers at 10 sites in a day than to make accurate counts at three sites. I was interested to know if we were dealing with tens, hundreds, tens of hundreds, or thousands of individuals.

More than 6,000 photos were taken during the project. Most were habitat shots providing a baseline for comparison with future photos to detect any changes in the environment.

This short paper deals only with shorebirds, and is presented in the form of a tour around the Top End coast, dropping in at a few important shorebird locations to illustrate what progress has been made to date.

Results

Shorebirds were found throughout the survey area. Figure 2 shows the sites where more than 13,000 separate shorebird records were made during the surveys. The records represented over 2 million individual birds. More than 40 species of shorebird were recorded in the survey area and most species were recorded on numerous occasions. Little effort was made to search for rare or vagrant species within areas or flocks, so it is likely that some species were overlooked. Some species normally categorised as shorebirds, such as Black-winged Stilt, Red-necked Avocet, Australian Pratincole, Oriental Pratincole and masked lapwing have been excluded from consideration in this presentation as, for the purposes of my project, I considered them to be more appropriately placed with the waterbirds. With their inclusion, the number of records on this map, particularly in the blue wetlands areas, would be considerably greater.

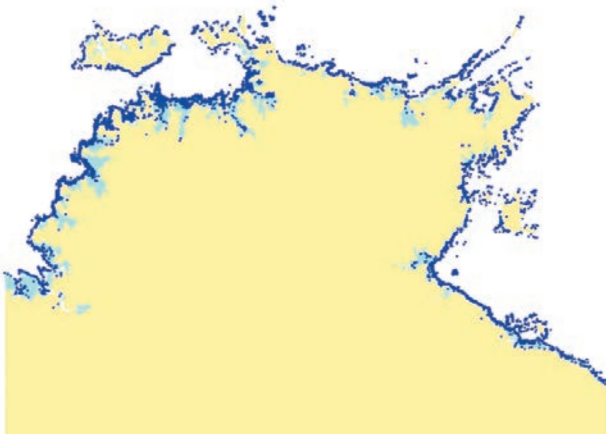

Figure 2. Distribution of all shorebird records obtained throughout the project.

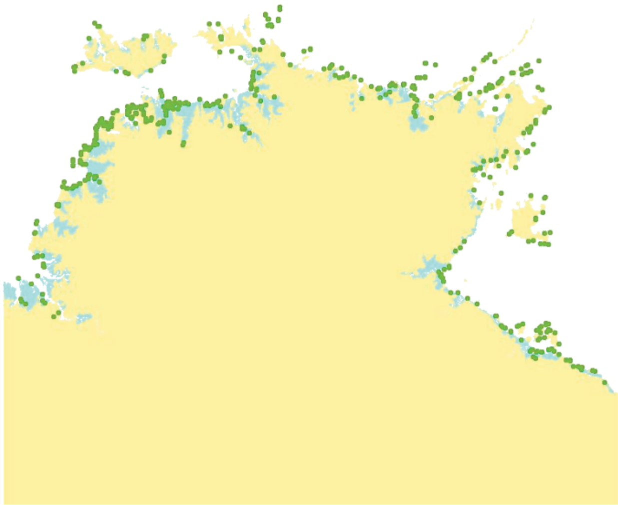

Figure 3. Distribution of all ground sites where shorebirds were recorded.

Many of the records in Figure 2 were obtained from aerial surveys and hence were identifiable only to species group level. Figure 3 shows the distribution of sites where shorebirds were recorded in ground surveys. Ground surveys allowed most birds to be identified to species level, so this map shows a large number and wide distribution of shorebird records that were identified to individual species

As previously mentioned, one of the more important aspects of the project was to locate and document the important faunal sites. For the purposes of this presentation, these are shown by mapping the significant records for shorebirds over the period of the project. To do this, a number was allocated to each species or species group that was considered to be significant in terms of number of individuals. All records greater than this figure were then mapped as Figure 4.

What is considered a significant number varies between species (for example 3,000 for Great Knots, 30 for Common Sandpipers) and is fairly arbitrary, but the main purpose is to identify important sites for shorebirds in the Top End. Such a method means that two or more nearby records that fall just under the significant figure, but together exceed it, will not be represented on this map. Given the long time-span of the surveys, it is unlikely that such areas would fail to be represented by at least one count of a species or species group that exceeded the significant number. The figure shows there are many significant shorebird sites around the NT coast and adjacent wetlands.

The figure also indicates the five sites that will be discussed here. I will start with the most easterly of these sites and travel around the coast in a westerly (anti-clockwise) direction.

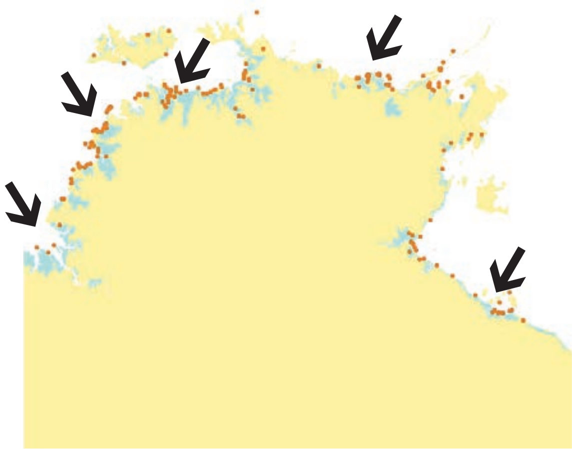

Figure 4. Distribution of significant shorebird records and location (black arrows) of the five sites to be visited in this presentation.

Site 1: Port McArthur

The first of the sites to be considered in this presentation is the Port McArthur coast in the south-east of the Top End, opposite the Sir Edward Pellew Islands. I have chosen approximately 70 km of coastline from south of South-West Island in the Sir Edward Pellew Islands (15° 45'S 136° 10'E) to Pelican Spit (15° 52'S 136° 58'E). The section has a wide intertidal area and there are extensive saline flats behind the coast, as can be seen by Plate 1.

As with each site we will be visiting today, I will deal mainly with the coast and tidally affected wetlands just in from the coast, rather than the extensive hinterland of wetlands and floodplain systems that extend up to 80 km inland.

Plate 1. The Port McArthur area in the SE of the Top End of the NT.

Shorebird counts in excess of 20,000 birds have been recorded at this first site, so it would qualify for East Asian-Australasian Shorebird Site Network (EAASN) listing. It is a very complex area to survey and none of the numerous surveys I conducted over the years would have located all shorebirds present. In addition, the species (Black-winged Stilts etc.) that I excluded from the shorebird records (see above) would increase the numbers in this area if included.

This is only one of many sites in the Top End that would qualify for EAASN listing. Although the data have been collected that prove the sites would qualify for EAASN listing, no Top End sites have been listed as yet. Further information on five such sites can be found in Chatto (2000b). The main reason the sites have not yet been listed is because there has been no real need to do so; nearly all the sites are very remote, undeveloped and undisturbed. Listing of such sites might attract attention to them and lead to disturbance.

Another characteristic of each of the five selected sites is 'significant single flock counts', here defined as counts at a single roost or wetland. This site has 10 shorebird species for which counts were over of the 1% of the estimated Australian population for that species based on Watkins (1993), and counts for five species were greater than the international 1% level. Many of these 10 species have counts of more than the 1% Australian level at a number of places within the sites. Other species would also have total site counts (i.e. all individuals within the total site area) that would total more than this 1% figure. These are not included here because it raises the issue of just how far you stretch an area of count to get sufficient numbers to exceed this 1% figure. Here I only refer to those species that have at least one flock count at one place within each of the overall sites that is in excess of the 1% figure.

I also refer to the 'most abundant species', over all surveys, for each of the five sites. This is found by totalling all counts of each species, recorded to species level, over all surveys and showing them as a percentage of all species counts combined. This parameter is further detailed in Chatto (2003). The most abundant species over all surveys for the Port McArthur site are, in order of abundance, Black-tailed Godwit, Great Knot, Red-necked Stint, Curlew Sandpiper and Bar-tailed Godwit (Figure 5). With the exception of the Curlew Sandpiper, all these species regularly occur on the list of the five most abundant shorebirds at sites around the NT coast.

These species percentage abundance figures, used in conjunction with total site counts, give an indication of peak numbers for each species. However, the NT has a great deal of inward and outward movement of shorebirds (probably more so than much of southern Australia) and consequently, using a total site count of all shorebirds at one time of the year in conjunction with what is effectively a yearly average percentage abundance for each species, will not always yield an accurate estimate. For greater rigour, a series (for example monthly figures) of percentage abundances is needed so the most appropriate one can be used for whatever time of the year the total count is done. The data exist for monthly percentage abundances to be calculated for many sites, but this has not yet been done.

Sites can also be significant for having the greatest number of birds in a single flock counted anywhere and at any time throughout the survey period. The Port McArthur site was significant for having the greatest number of birds in a single flock for the following species: Greenshank (500), Grey-tailed Tattler (1,000), Asian Dowitcher (70) and Curlew Sandpiper (1,000). I emphasise that these figures refer only to a single flock and do not represent the total number of that species in that site area.

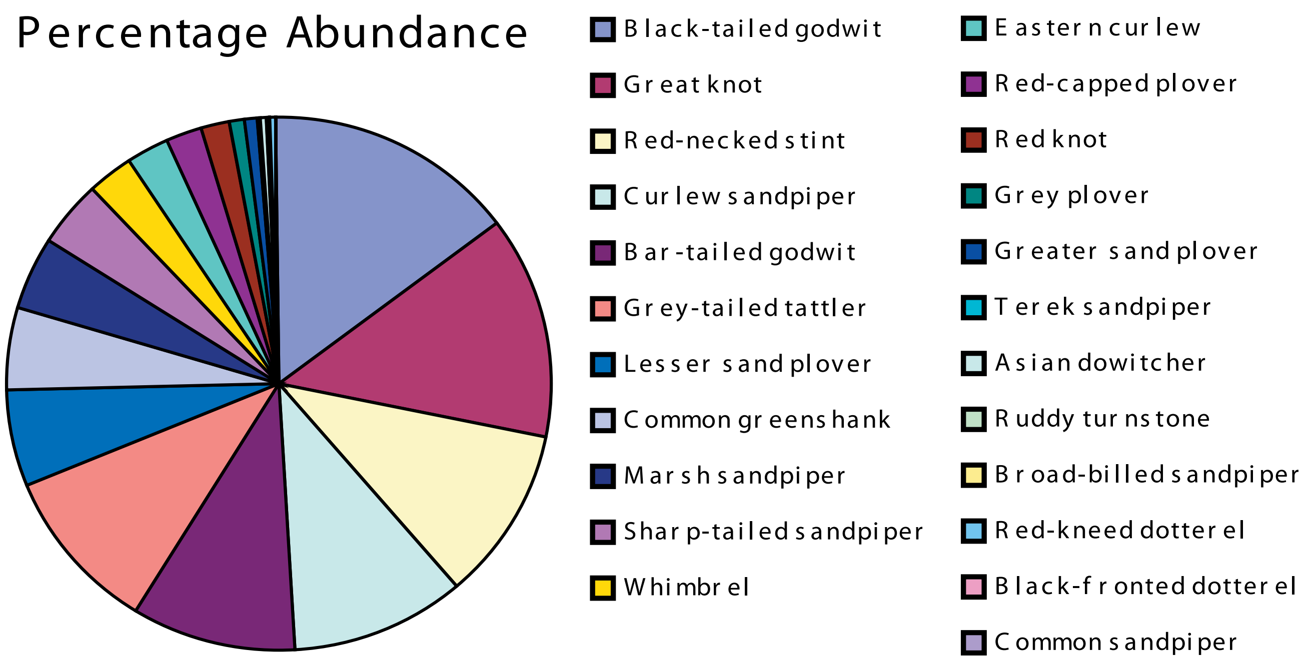

Figure 5. Average percentage abundance of each species of shorebird over all surveys within the Port McArthur area.

Site 2: Castlereagh and Boucaut Bays.

This site is in the central part of the northern coast of the NT. It includes Castlereagh and Boucaut Bays, which extend for about 100 km of coastline, and a number of islands in the Millingimbi area between the two bays.

Here again, counts in excess of 20,000 shorebirds in each of these bays would qualify them both for EAASN listing. At this site, 13 species have single flock counts in excess of the 1% Australian totals, and eight of these are also higher than the 1% international totals.

At Castlereagh and Boucaut Bays the most abundant species were: Great Knot, Bar-tailed Godwit, Greater Sand Plover, Black-tailed Godwit and Red-necked Stint.

A pie chart of percentage abundance of species at this site (Figure 6) differs from that of the first site where the most abundant species were fairly evenly represented.

At Castlereagh /Boucaut Bay there was a much greater dominance of one species, the Great Knot. This particular species is the most abundant shorebird in the Top End and dominated abundance figures in a number of areas around the coast.

The Castlereagh and Boucaut Bay site had the highest single flock counts for Bar-tailed Godwit (4,300), Ruddy Turnstone (305) and Pied Oystercatcher (320). An additional 200 Pied Oystercatchers observed within the general area made up a quite amazing total of 500+ Pied Oystercatchers at this location within the site area.

Another very interesting aspect of this site is the consistency of counts throughout the year at one island roost; between 12,000 and 14,000 shorebirds were surveyed there in each of the months of March, July, November and December. It is possible that birds from another roost could have been present in the July count, but these figures suggest that similar numbers of birds are present at this roost in both the breeding and non-breeding seasons.

This is an interesting observation, but more surveys are needed; these may be conducted in the second phase of this long term project after specific monitoring programs are set up at selected sites.

The consistency in those four monthly counts supports a theory I have held for many years. I suspect that in any given year, a significant number of migratory shorebirds do not migrate from the Top End, and these overwintering birds may include many that have flown to the Top End from southern parts of Australia. My hunch is supported by observations I have made at other sites. Such a phenomenon is more likely to occur at the northern edge of the continent where the birds have run out of land on which to make short test flights while gauging their ability to accomplish the long migratory flight across the ocean. Perhaps a proportion of birds that depart Victoria with the migratory flocks for some reason abort their migration when they reach the Top End.

Without full coverage of a wide range of sites in a big area around this roost, these four counts cannot be considered conclusive evidence on their own. However data on individual species counted throughout the entire project area may provide further evidence that this overwintering is happening. One such species is the Eastern Curlew - a species for which I have over 350 winter records over 14 years, spread across the Top End (Figure 7).

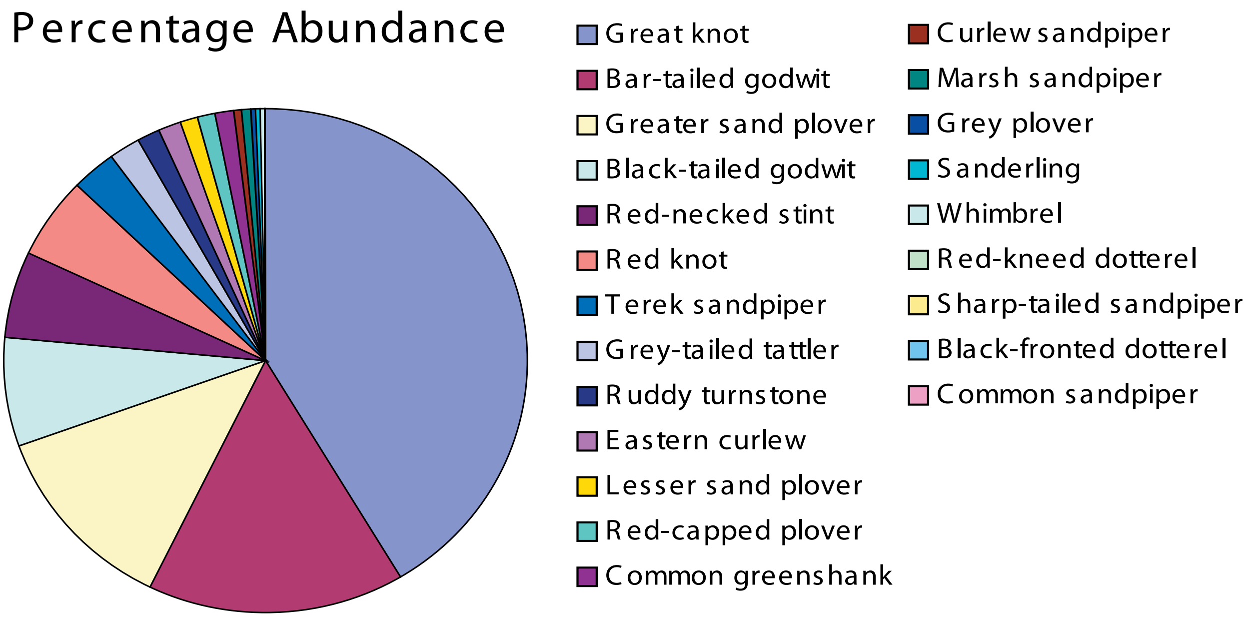

Figure 6. Average percentage abundance of each species of shorebird over all surveys within the Castlereagh/Boucaut Bay areas.

There are three ways in which shorebird records can be used to examine changes in the average monthly numbers of each species over the entire period of the surveys. Two of these are represented in Figures 8 and 9. Many factors and biases need to be considered for each species in relation to these graphs. These are discussed in more detail in the reports being written for each species group.

Figure 8 shows the average number of birds per record for each month over all surveys in simple terms. The higher the average number of birds per record, the bigger the flocks and hence liklihood of more birds being present. Other explanations are, however, possible. For example, if lower numbers of shorebirds are present in the non-breeding season, they might congregate in fewer roosting flocks or move to feed in a smaller number of superior feeding areas (once the fittest birds have migrated). This might result in fewer groups to divide into the total numbers, leading to higher numbers per record.

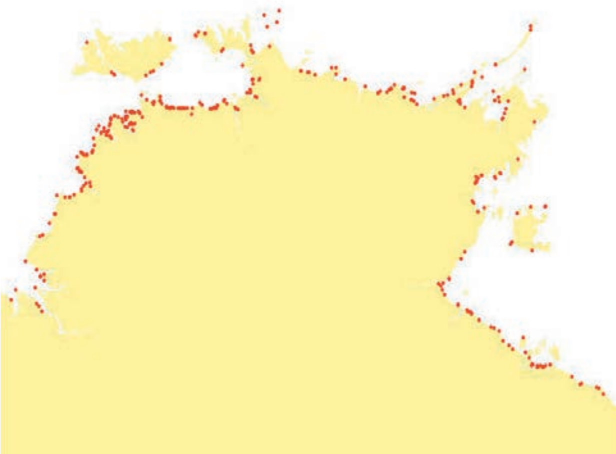

Figure 7. Distribution of Eastern Curlew records throughout all surveys.

Figure 9 shows the number of Eastern Curlew as a percentage of all migratory shorebirds. Any sudden local immigration or emigration will lead to a change in this percentage. Changes in the numbers of other species will also lead to changes, so these percentages should be treated with caution.

Accepting these uncertainties, it appears that there are higher numbers in June/July. An hypothesis is given below of a possible explanation of this possible situation of higher numbers when breeding adults are absent. The numbers used are hypothetical, and are not based on real counts.

The Northern Territory has an overwintering population of 4,000 Eastern Curlew and three-quarters of them migrate. To maintain a viable species, most birds will migrate to breed each year. This would leave 1,000 individuals in the NT and a decrease in the total June and July figures, not an increase. The NT, as the final departure point, may also receive 20,000 Eastern Curlew from more southerly parts of Australia. Let us say that 15,000 continue their migration and 5,000 stay. This would result in more Eastern Curlew present, at least for a short period, than in the pre-migration period. Hopefully future surveys will test this hypothesis.

Site 3: Chambers and Finke Bays

Chambers and Finke Bays area lie along the southern coast of the Arafura Sea, east of Darwin (Plate 2). This occupies around a 90 km section of coast. Behind this coastline are the large floodplains associated with several rivers including the Adelaide, Mary, Wildman and South Alligator.

The highest site count for this coastal stretch was 24,500 shorebirds in the September 1994 survey. Ten species

Plate 2. Chambers Bay, east of Darwin.

were recorded at least once in a single flock larger than the Australian 1% figure. Hence these bays would also qualify for EAASN listing.

The highest single flock counts for the area of Whimbrel (1,000), Eastern Curlew (500) and Common Redshank (30) were made at this site.

Although this presentation has dealt primarily with coastal shorebirds we will detour inland here to look at two other species of shorebird for which the large inland floodplains are of major importance - Sharp-tailed Sandpiper and Little Curlew.

Figures 10 and 11 illustrate overall monthly number changes for Sharp-tailed Sandpipers and Little Curlews. These are entirely different from the corresponding figures for Eastern Curlew. Sharp-tailed Sandpiper (Figure 10) appear to congregate in the Top End prior to their northward migration but not following their return migration, nor indeed for much of the rest of the year. Little Curlew (Figure 11) show the opposite behaviour. They arrive in the Top End in huge flocks of many thousands in October/ November, but disperse inland and southwards when the wet season rains come. They are not seen again, at least in large numbers, for the remainder of the year.

The seasonal graphs we have looked at so far imply different movement patterns for each of the three species. There are other seasonal patterns and the Red Knot provides a final example. Figure 12 shows the distribution of all of the Red Knot records. By indicating records of large and small flocks by large and small dots we see that the two main areas for larger flocks of this species are the NE and NW of the Top End. The interesting thing about these records is that the NE records (but not the NW ones) were around March and represented birds on the northward migration. Conversely, the NW records (but not the NE ones) fell around September; these will be birds migrating south by a totally different route. This inward migration route is further supported by the only other large flock (near the Roper River in the SE of the Top End) being recorded in October. It suggests that the September flocks in the NW move across the Top End through this area on their way south.

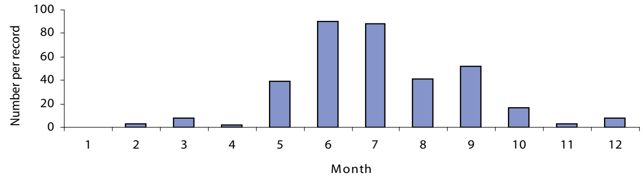

Figure 8. Average number of birds per record for Eastern Curlew on a monthly basis throughout all surveys.

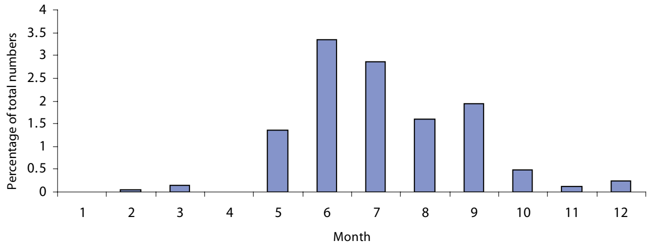

Figure 9. The number of Eastern Curlews as a percentage of all shorebirds on a monthly basis over all surveys.

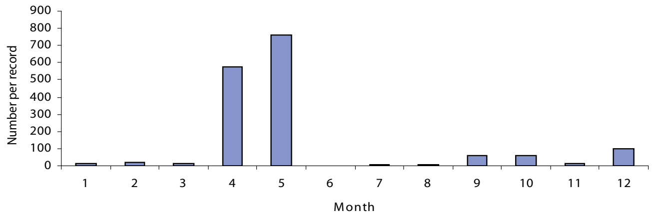

Figure 10. Average number of birds per record for Sharp-tailed Sandpiper on a monthly basis throughout all surveys.

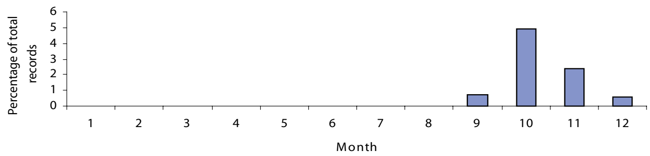

Figure 11. The number of Little Curlew records as a percentage of all shorebird records on a monthly basis over all surveys.

Site 4: Fog Bay

Fog Bay is situated south west of Darwin (Plate 3). This bay has very large number of shorebirds, particularly Great Knot. The highest count for this site, including some of the adjacent inland splashes, was over 40,000 shorebirds. Twelve species had at least one count of a single flock that was in excess of 1% of the Australian population. Both total site counts and individual species counts also qualify this site, for the EAASN.

The most abundant species at this site were Great Knot, Bar-tailed Godwit, Greater Sand Plover, Lesser Sand Plover, and Red-necked Stint. Highest single flock counts for this project were recorded here for Great Knot (5,000) and Greater Sand Plover (1,800). The latter count was based on a sample of 200 within a flock of 2,000 sand plovers; the figure could have been biased toward Greater Sand Plovers if they happened to be dominant in that part of the flock that was sampled.

Unlike most of the Top End coast, this site is at some risk of human disturbance. A housing development in the area (Dundee Beach) has created some disturbance to the shorebirds from people, vehicles and quad-bikes on the beach. Threats to Top End shorebirds are an issue I have not covered here today because of time restraints and because it has not been a major part of my project to date. All the threats or potential threats that are listed for shorebirds and shorebird habitats in other parts of Australia also apply in the Top End, but to a much less extent. This is no reason to be complacent and we should anticipate and learn from the threats that apply in other parts of Australia. As an example, we have just banned dogs from one of Darwin's beaches because it holds significant numbers of waders.

Figure 12. Distribution of Red Knot records.

Site 5: The south-west section of the Joseph Bonaparte Gulf

The final site considered is part of the Joseph Bonaparte Gulf in the far south west of the Top End (Plate 4). This site has yet to yield a count of 20,000 waders, the highest to date being 10,000, but considering the extent of suitable shorebird habitat, it would not be surprising if more than 20,000 shorebirds occurred at some stage of the year. It would, however, qualify for EAASN on the basis of five single species counts being greater than the Australian 1% criterion.

The most abundant species recorded here were the Terek Sandpiper, Greater Sand Plover, Bar-tailed Godwit, Red-necked Stint, and Great Knot. Highest single flock counts for the project were recorded for Terek Sandpiper (1,000) and Broad-billed Sandpiper (200).

One notable absentee from this site is the Black-tailed Godwit. This species is found in large numbers all around the remainder of the NT coast but in very small numbers here. This is one of the easiest species to identify from the air, both in breeding and non-breeding plumage, so it is unlikely that large numbers would have been missed. Just to the north of this site, Black-tailed Godwits are common and that appears to be the spot where they make landfall and from which they then move further north-eastwards along the coast towards Darwin.

Conclusion

This has been a very brief look at some examples of significant shorebird sites around the Northern Territory's Top End coast, which makes two main points. First, this remote and inaccessible part of northern Australia has finally been surveyed for wildlife. Secondly, I have located some sites which are amazingly important for wildlife, including shorebirds. Not only do we now know the location of these sites, but we are in a position to secure their conservation before the problems arise that have plagued so many other, more heavily populated parts of the Australian coastline.

Plate 3. Fog Bay, south-west of Darwin.

Plate 4. Joseph Bonaparte Gulf near the NT/WA border. Photo: R. Chatto.

Web site addresses for reports completed from series to the present time

Waterbird breeding colonies in the Top End of the Northern Territory. http://www.nt.gov.au/ipe/pwcnt/docs/colonial_breeding_waterbirds.pdf

The distribution and status of colonial breeding seabirds in the Northern Territory. http://www.nt.gov.au/ipe/pwcnt/docs/seabirds.pdf

The distribution and status of shorebirds around the coast and coastal wetlands of the Northern Territory. http://www.nt.gov.au/ipe/pwcnt/docs/shorebirds.pdf

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The Importance of Monitoring Shorebird Utilisation of the Coorong and Surrounding Wetlands in South Australia

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Abstract

The Coorong is ranked among the top 10 sites for waders in Australia and is also listed as a Wetland of International Importance under the Ramsar Convention. While it had a peak of almost 250,000 waders in the early 1980's it has shown dramatic declines to a low of 50,000 waders in 2001. The most numerous species are Red-necked Stint, Calidris ruficollis, *Curlew Sandpiper,* Calidris ferruginea, *Sharp-tailed Sandpiper,* Calidris acuminata, *and Banded Stilt,* Cladorhynchus leucocephalus.

The Coorong has been the subject of a number of changes to habitat, both man made and natural over the last 150 years which has influenced its use by all waterbirds. While wader counts were undertaken in the 1980's, it was not until 2000 that the site was revisited and a comprehensive count was performed. This paper describes a population monitoring program that has been carried out each summer since February 2000 and outlines the trends both in total numbers, their distribution within this large coastal estuarine system and its relevance to the East Asian-Australasian Flyway. This program is now one of the tools available to environment managers to make water management and land management decisions and review the outcomes. The methodology of counting this extensive system is described demonstrating what can be achieved by combining the resources of government, the AWSG and the community.

Introduction

The Coorong is a unique natural area with coastal lagoons protected by the narrow Young husband Peninsula forming a haven for aquatic flora and fauna, in particular, shorebirds. It was ranked by Watkins, 1993, as the seventh most important site for shorebirds in Australia and the second most important in South Australia having nine species recorded in numbers of International significance and ten species in numbers of National significance. However the Coorong has been the subject of significant habitat change resulting in a vast reduction in the number of waders utilising this area during the non-breeding season, that is the austral summer. With numbers declining from almost 250,000 in the early 1980's to around 70,000 in 2000, the South Australian Department for Environment and Heritage (DEH) invited the Australasian Wader Studies Group (AWSG) to undertake annual population monitoring counts of waders utilising the Coorong and adjacent wetlands. In addition to the AWSG Summer wader count, regular (bi-monthly/ monthly) waterbird counts are carried out by DEH (DEH-Dadds). Supplementing these are water quality and hydrodynamic monitoring, invertebrate, aquatic biological and key environmental features (freshwater soaks, threatened riparian habitat) monitoring that provides data giving long-term biological trends and short-term responses to management actions. DEH managers use the count information in conjunction with the hydrological and biological information to assist them in making water management decisions and monitoring their effectiveness eg Goolwa and Tauwitchere Barrage manipulation; regulated drainage flows from Upper South East Drainage Scheme.

The data gathered is not only important in managing the Coorong but provides additional data which can be integrated into the AWSG database as an aid to reviewing population numbers and trends within Australia and the Australasian East-Asian Flyway.

Description and Geography of the area

The Coorong derives its name from the long thin waterway known to the Aboriginal tribe as Karangh, meaning 'long neck'. The Murray Mouth is an important cultural and spiritual place for the Ngarrindjeri people. The Coorong is a system of lagoons, one to three metres deep, 2-4km wide confined by the coastal dunes of the Young husband and Sir Richard Peninsulas and stretches some 140 kilometres in a south-easterly direction from the mouth of the River Murray in South Australia. There are two main lagoons, Northern and Southern connected only by a narrow spit at Parnka Point. There are small salt and freshwater lakes in the vicinity of the Southern lagoon while the remnants of larger freshwater and semi-saline wetlands occur to the south-east (Tilley Swamp and Watervalley Wetlands etc). See Figure 1. The Coorong waters range from seasonally fresh water near the barrages during periods of high flow, to brackish and marine in the Murray Mouth area, to hypersaline in the southern lagoon. Changes in water level in the southern lagoon in late spring and summer expose mud flats and shallow sandbars which are habitat for a number of species of wader.

The water regime of the Coorong has been altered over a long period by reduced River Murray flows, drainage and habitat change. Historically, large volumes of water seasonally drained in a north-westerly direction and accumulated in the inter dunal flats of the Southeast of South Australia every winter. These have been steadily removed by extensive drainage schemes which date from 1863.(Wetlands Committee 1984). More recently surface water and ground water from agricultural areas is being drained into a wetland pondage basin at the headwaters

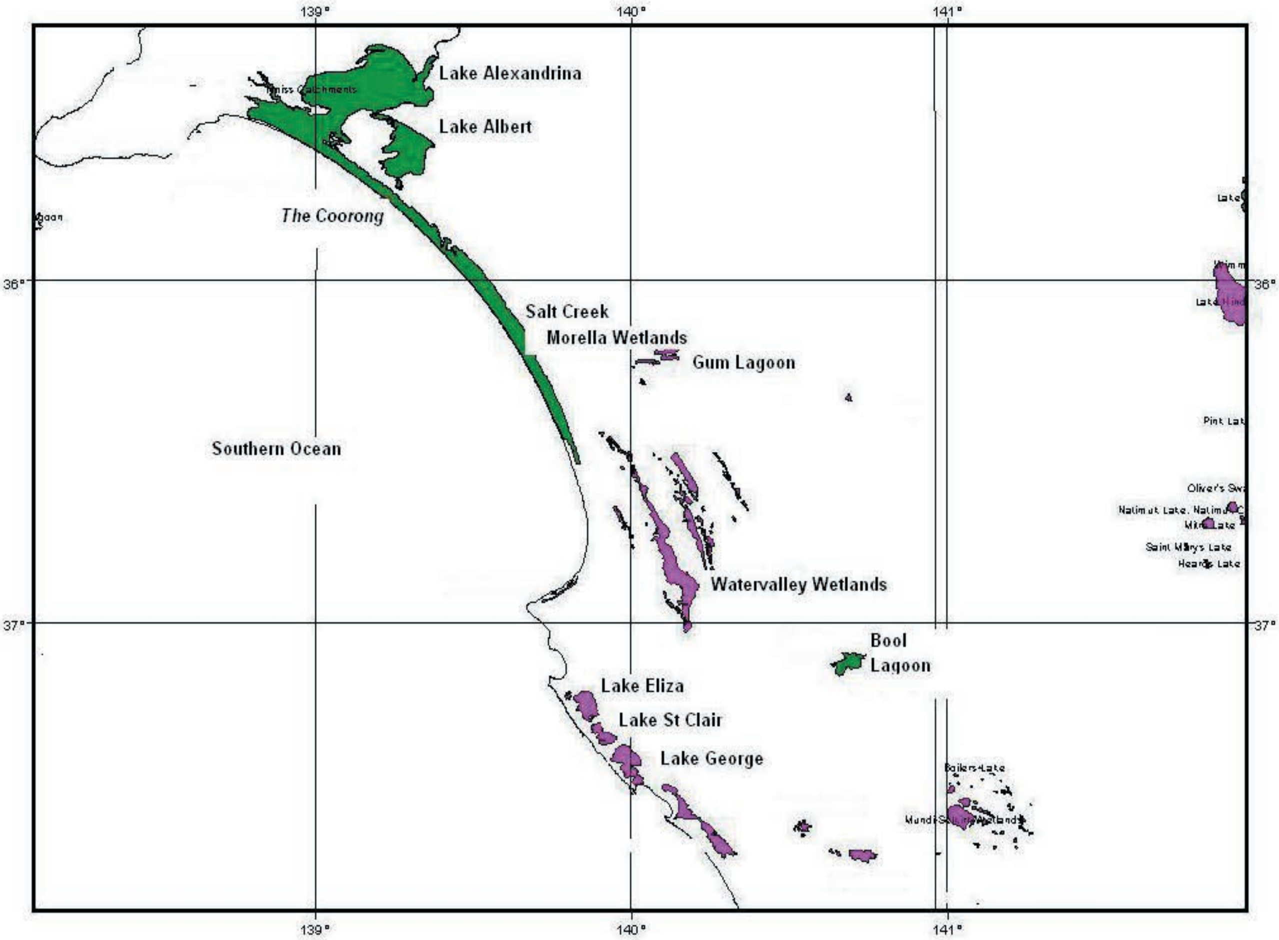

Figure 1. Map showing the Coorong and SE coastal lakes, South Australia.

of Salt Creek which is periodically allowed to flow into the southern lagoon as part of the Upper South East Dryland Salinity and Flood Management Plan (Boon 2000). In the 1930's barrages were constructed at the mouth of the River Murray to prevent salt water intrusion into Lakes Alexandrina and Albert in response to concerns from agricultural users upstream. This, combined with river regulation and water diversions have dramatically reduced river flows and flood frequency, with flows at the Mouth being less than 30% of the natural median flow (Murray-Darling Basin Commission Report 2002)..

Importance of the Coorong to Shorebirds

Some 85 species of waterbirds have been recorded in the region (Carpenter, 1985). This includes 20 species of migratory waders and 11 species of resident waders. The nine species which Watkins, 1993, records as being present in numbers of International Importance, are indicated in Table 2.

The Coorong is designated a Wetland of International Importance under the Ramsar Convention of 1985. A Ramsar Management Plan was prepared in 2000 by the South Australian Department for Environment and Heritage (DEH) in consultation with community groups (Department for Environment and Heritage, 2000). A community based Ramsar Implementation Taskforce oversees implementation of this plan which will be reviewed in 2005.

Current Significant Threats

The changes to the water regime of the Coorong outlined above have been exacerbated in recent years by the severe drought in South Eastern Australia. This has dramatically reduced the flows of the River Murray to the extent that no water was released over the barrages for a 20 month period in 2002/03. The consequence has been an accumulation of sediment at the Murray Mouth to the extent that it was completely blocked with sand in 2002. The implications of this on the health of the Coorong lagoons include decreasing water quality and increasing salinity, together with disturbance to the natural cycle of water level change. Both of these factors will lead to reductions in the quantity and quality of the estuarine habitats of the region. (Murray-Darling Basin Commission Report 2002). A dredging program was commenced in 2002 with the objective of keeping the Mouth open to the Goolwa Channel and Tauwitchere Channel but importantly providing conditions that maintained a tidal signature within the northern lagoon of the Coorong. Figure 2 indicates a small outlet was maintained at February 2003.

Table 1. DEH Waterbird Counts (Dadds) – 2001/2003

	Southern Lagoon			Northern Lagoon			Coorong Barrages			
Date	Waterfowl	Waders	Total – South Lagoon	Waterfowl	Waders	Total – North Lagoon	Waterfowl	Waders	Total – Coorong Barrages	Grand Total (Nth, Sth & Barrages)
March 2001	1646	1907	3553							
April 2001	6406	910	7316							
June 2001	26684	2862	29546							
August 2001	5591	2001	7592							
Oct 2001	2180	5059	7239							
Dec 2001	2750	2644	5394							
Feb 2002	4553	8094	12647							
April 2002	3227	2511	5738							
June 2002	9552	2964	12516							
August 2002	2454	220	2674							
Oct 2002	2428	2446	4874							
Dec 2002	2377	2115	4492							
Feb 2003	2705	3053	5758							
March 2003	2496	2848	5344							
April 2003	2098	1422	3520							
May 2003							6773	505	7278	
June 2003	1443	711	3597	4188	143	4331	6721	296	7017	14945
July 2003							5688	239	5927	
August 2003	1804	303	2107	972	18	990	3990	258	4248	7345
September 2003							2831	210	3041	
Oct 2003	1329	39	1368	3654	297	3951	2882	475	3357	8676
November 2003							7026	10646	17672	

Table 2. Total Counts in the Coorong in 1982,1982,1987,2000,2001,2002 and 2003

		1981	1982	1987	2000	2001	2002	2003	Imp.	Watkins 1993
Black-tailed Godwit	*Limosa limosa*	133	185	105	210	115	0	21		150
Bar-tailed Godwit	*Limosa lapponica*	15	0	3	8	0	0	20		25
Eastern Curlew	*Numenius Madagascarienis*	17	24	8	15	16	2	2		24
Marsh Sandpiper	*Tringa stagnatis*	0	2	30	0	0	68	1		30
Greenshank	*Tringa nebularia*	600	717	596	557	305	323	312	N	720
Terek Sandpiper	*Tringa terek*	0	0	0	0	0	1			
Common Sandpiper	*Actitis hypoleucos*	13	1	1	0	1		2		5
Ruddy Turnstone	*Arenaria interpres*	0	1	0	1	0				
Great Knot	*Calidris tenuirostris*	3	4	0	1	0				5
Red Knot	*Calidris canutus*	57	67	0	80	0	30			100
Sanderling	*Calidris alba*	113	929	308	512	53	10	120	I	930
Sharp-tailed Sandpiper	*Calidris acuminata*	24871	55739	22898	10697	5718	17067	6992	I	55700
Pectoral Sandpiper	*Calidris melanotos*	0	1	0	0	0	0			
Red-necked Stint	*Calidris ruficollis*	54743	63794	54710	30145	18368	44544	46067	I	63800
Curlew Sandpiper	*Calidris ferruginea*	39882	22614	22512	13124	4309	9177	13430	I	40000
Cox's Sandpiper	*Calidris paramelanotus*	0	0	1	0	0	0			
Pied Oystercatcher	*Haematopus longirostris*	108	297	84	92	9	208	149	I	630
Sooty Oystercatcher	*Haematopus fuliginosus*	0	0	3	3	3	24			18
Black-winged Stilt	*Himantopus himantopus*	238	991	291	340	183	712	282		600
Banded Stilt	*Cladorhynchus leucocephalus*	13782	77149	18692	11299	15611	24552	8602	I	77000
Red-necked Avocet	*Recurvirostra novaehollandiae*	1449	5401	3589	93	260	3856	4122	I	5400
Pacific Golden Plover	*Pluvialis fulva*	289	230	144	84	103	43	43		290
Grey Plover	*Pluvialis squatarola*	1	0	0	12	0	2	3		
Red-capped Plover	*Charadrius ruficapillus*	4677	5152	2533	1089	1288	968	2897	I	5700
Double-banded Plover	*Charadrius bicinctus*	0	0	1	0	0		1		150
Black-fronted Plover	*Charadrius melanops*	0	2	0	0	0		1		15
Lesser Sand Plover	*Charadius mongolus*	0	0	0	0	0	2			
Hooded Plover	*Charadrius rubricollis*	0	0	12	3	4	12	7		
Red-kneed Dotterel	*Erythrogonys cinctus*	14	17	0	0	0	1	3		10
Oriental Plover	*Charadrius veredus*	18	0	0	0	0				
Banded Lapwing	*Vanellus tricolor*	0	248	130	0	0				150
Ruff	*Philonachus pugnax*	0	0	0	1	0				
Masked Lapwing	*Vanellus miles*	591	978	765	233	355	337	423		800
Red-necked Phalarope	*Phalaropus lobatus*	0	0	3	0	0				
Unidentified small waders				3064		1724	1912	539		
TOTAL		141614	234543	130483	68599	48425	103851	84039		252252
	Banded Stilt & RN Avocet	15231	82550	22281	11392	15871	28408	12724		82400
	Total Less " " & " "	126383	151993	108202	57207	32554	75443	71315		169852

Figure 2. Aerial view of the Murray River mouth in February 2003.

The redirection of surplus surface water and ground water from agricultural areas in the Upper South East of South Australia is now being drained into the southern Coorong at Salt Creek as part of the Upper South East Dryland Salinity and Flood Management Plan (DEH 2000). This may change the currently hypersaline dominated ecosystem of the southern Coorong to a predominantly marine and estuarine system with a likely consequent impact on food resources. (Boon 2000 and Paton 2002).

In response to these threatening processes and as part of a strategic "Coorong Environmental Health Monitoring Program" the SA Department for Environment and Heritage (DEH) invited the AWSG to monitor the wader population of the region commencing in February 2000. Surveys have been carried out each year since then by the AWSG with the support of the Department (Wilson, J.R. 2000, Wilson, J. R. 2001, Gosbell et al 2002, Gosbell et al 2003).

Population Monitoring Methods

The extensive nature of the Coorong together with limitations of access has required the development of a methodology and processes that are both practical and reproducible. The area counted is between 7kms south of Salt Creek and northwards to the Goolwa Barrage, some 8kms north of the River Murray Mouth, a total distance of approximately 100kms This was divided into 31 sections by Jaensch & Barter (1988), see Figure 3. The ocean beach is also counted between Tea Tree Crossing and the Murray Mouth.

Waders in the Coorong are relatively mobile and water levels change locally depending on the direction and strength of the winds. The strong southeast winds which can be prevalent in the summer tend to push the water around resulting in the exposure and covering of feeding areas. This means that counters need to be aware of these influences if variance is to be minimized. An attempt at testing reproducibility was made in 2001 when both south and north lagoons were counted twice over a period of five days.(Wilson, J. R. 2001[a]). While the numbers recorded for several key species were very similar, it also showed that there will be discrepancies due to bird movements. Since 2001 the count has been carried out over two consecutive days. While counts have been made with teams of 5-10 people, experience over the past two years has shown that a team of 14 to 16 people are needed to ensure optimum coverage. Typically the southern lagoon is counted on the first day with four land based teams and two teams deployed in boats while on the second day the larger northern lagoon is counted with two land based teams and up to five boats. In addition to the two boats provided by DEH, the local fishers very generously provide up to four

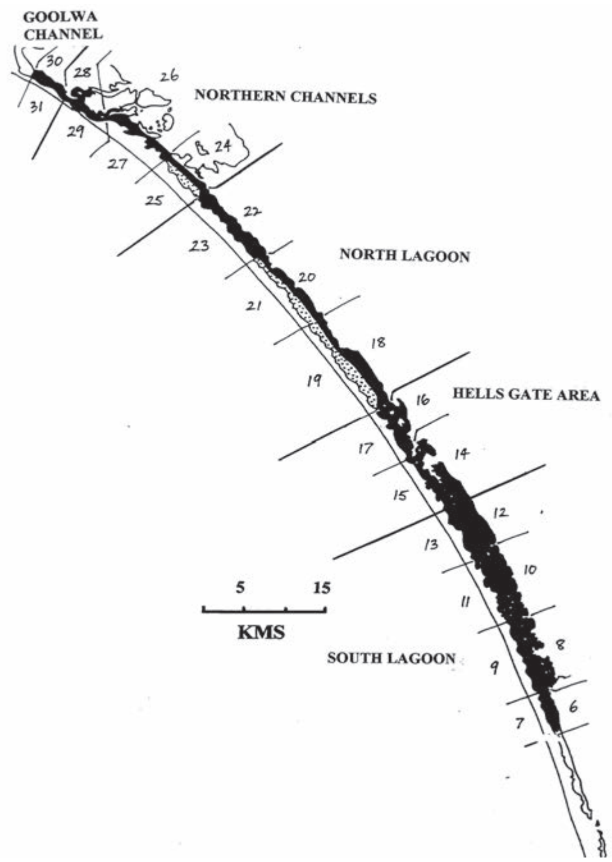

Figure 3. Map of Coorong showing the count sections used to subdivide the area for counts.

boats. The relatively shallow waters mean a lot of counting can only be done by walking the sand and mud banks. The teams are drawn from volunteers from both Victoria and South Australia ranging from experienced counters to interested members of the community keen to assist and learn more about this important region.

As the Coorong is part of a larger system of lakes, some of which are ephemeral, it is important to assess the significance of these adjacent areas as feeding or roosting areas for waders. For this reason surveys over the last 4 years have progressively included the Morella Basin, Watervalley Wetlands and many of the coastal lakes of South East as far as Lake George (Gosbell et al 2003). It has been shown that these can become important depending on the seasonal conditions.

In addition to the AWSG Summer wader count, bi-monthly/ monthly waterbird counts are carried out by DEH (DEH-Dadds).. These counts use a fixed point methodology where counts are taken in a radius around set survey points, therefore, relative numbers / species can be compared between counts, however, an overall wader population is not determined. These counts are undertaken every second month over winter (May- Sept) and monthly in summer (Oct - April) with some trend indications of a decline in wader numbers in the Southern Lagoon between 2001 and 2003. See Table 1.

Results of Population Monitoring in the Coorong

The total counts for 1981, 1982, 1987, 2000, 2001, 2002 and 2003 in the Coorong and on the Ocean Beach are shown in Tables 2 and 3, together with population estimates from Watkins 1993. Figure 4 shows these counts including and excluding the ephemeral species of Banded Stilt and Red-necked Avocet. This indicates a gradual decline in wader numbers in the Coorong from 234,543 in 1982 to a low in 2001 of 48,000 with an upturn in 2002 to 103,000. While the total count in 2003 was down by 19% from 2002, this is reduced to 5% when Banded Stilt and Red-necked Avocet are ignored. Essentially the number of migrant waders have remained static over the last year although well below (50% less) the peak numbers of 1982.

Figure 5 shows the change in the relative distribution of all waders in the Coorong for the years counted. Although total numbers have varied significantly and have declined in the Coorong overall, the proportional distribution of all species combined has only shown small changes up to 2001. However there has been a definite movement to the Northern channels over the last two years. The proportion of waders found to be utilizing the Northern Channels in 2003 follows the trend noted in 2002 and has increased to 62% of the total number using this area with a consequent reduction in the Parnka Point area to 19%. It is noted that in February 2003 the water level was very low for this time of the year. The reasons for this are complex but include such factors as the severe drought in southern Australia, the effective closure of the Murray Mouth in 2002 combined with virtually zero river flow, no water being released from the Morella holding basin and high evaporation rates. Although there were relatively high water levels in winter/ spring 2002 these were rapidly lowered in early summer. This in turn would have the effect of raising the salinity of the lower reaches of the Coorong both north and south of Parnka Point. Salinity levels in the vicinity of Parnka Point and into the southern portion of the Northern Lagoon were at record highs between December 2002 and May 2003. It also had the obvious effect of creating extensive areas of saline mudflats in the southern lagoons. Some of the potential implications for the Coorong as a result of closure or restricted flow at the Murray Mouth are discussed in Murray-Darling Basin Commission Report, 2002.

In 2003 the largest concentration of waders was on the Young husband Peninsula side opposite Pelican Point and in the southwest bays opposite Tauwitchere Island almost up to the Murray Mouth. Several of these bays had in excess of 15,000 waders feeding in them. The prevailing south-easterly winds moving waters northwards and uncovering good feeding areas may also have been a contributing factor to this movement.

Selected Species Accounts

The following outlines the trends in some of the important species found in the Coorong.

Sharp-tailed Sandpiper

Sharp-tailed Sandpiper numbers ranged from approximately 22,000 to 55,000 in the 1980's (24,871 in 1981, 55,739 in 1982 and 22,898 in 1987). In 2000 the numbers had declined to 10,697 and in 2001 there was a further decline to 5,718. However while in 2002 there was an increase of three-fold over the previous year with 17,067 being recorded, in 2003 the number dropped to 6992. See Figure 6(a). It is known that Sharp-tailed Sandpiper use ephemeral wetlands more than other C*alidrine* wader species, and it is possible that they may be utilizing other areas.

Table 3 Counts of the Ocean Beach in 1981, 1982, 2000, 2001, 2002 and 2003

	Kingston to Middleton ***	Kingston to Waitpinga ***	Tea Tree to Murray Mouth	Tea Tree to Murray Mouth	Tea Tree to Mrray Mouth	Tea Tree to Murray Mouth
	1981	1982	2000	2001	2002	2003
Bar-tailed Godwit				1		
Common Sandpiper		2				
Sanderling	311	**	15	161	24	110
Red-necked Stint	68	10	23			17
Pied Oystercatcher	568	334	526	432	331	502
Sooty Oystercatcher	18	5	13	2	1	2
Banded Stilt				5		
Grey Plover	5					
Red-capped Plover	902	529	48	52	6	168
Hooded Plover	102	130	25	49	18	5
Oriental Plover		6				
Masked Lapwing	159	337			n/c	11
Total	2133	1353	650	702	380	815

**865 Sanderling were recorded inside the Murray Mouth in 1982 (Table 1).
***Note that a much longer section was counted in 1981 and 1982
compared with 2000, 2001 and 2002.

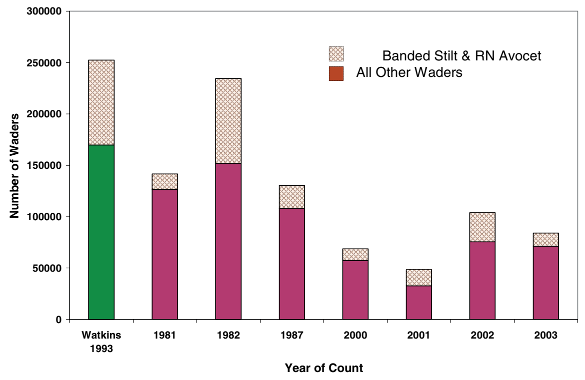

Figure 4 The total number of waders counted in the Coorong from 1981 to 2003.

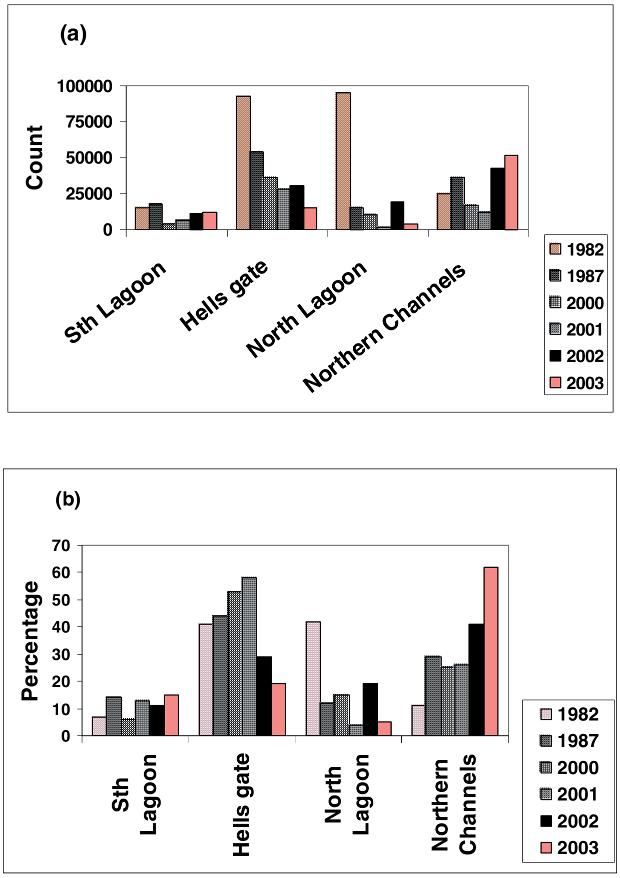

Figure 5. Variation in the distribution of waders along the length of the Coorong 1982 – 2003.
(a) Count distribution. (b) Distribution by percentage of total count.

The distribution of Sharp-tailed Sandpiper in the Coorong has also changed with the majority of this species in 2003 found in the Northern Channels (86%) whereas counts up to 2001 had recorded the majority in the Parnka Point (Hells Gate) and North Lagoon areas. Whether this is due to prevailing wind conditions or other environmental factors related to the closure of the Murray Mouth is not known.

Red-necked Stint

There were 50,000-60,000 Red-necked Stint in the Coorong in the 1980's (54,743 in 1981, 63,794 in 1982 and 54,710 in 1987). In 2000 the numbers had declined to 30,145 and in 2001 there was a further decline to a low of 18,368. In 2002 the numbers recorded more than doubled the previous year with a count of 44,544. This trend was repeated in 2003 with 46,067 being recorded. Figure 6(c) graphically shows the recovery in the numbers over the past two years.
The distribution within the Coorong was broadly similar in all years although in common with several other species there was a shift in concentration to the northern areas with 55% being found in the Northern channels.

Curlew Sandpiper

There were 22,000 to 40,000 Curlew Sandpiper in the Coorong in the 1980s (39,882 in 1981, 22,614 in 1982 and 22,512 in 1987). In 2000 the numbers had declined to 13,124 and in 2001 there was a further decline to 4,309 while in 2002 there was an increase to 9177. In 2003 the numbers increased again to 13,430. See Figure 6(b).

The distribution within the Coorong in 2003 reinforced the 2003 trend with 93% of the birds being observed in the Northern Channels. This compares with 35% to 41% being recorded in this area in 1987, 2000 and 2001.

Banded Stilt

The number of Banded Stilt in 2003 was 8,602. This is the lowest number ever recorded in the Coorong. See Figure 6(d). In addition, relatively small numbers were found on the Morella Basin and Lake George, sites where it is not uncommon to record flocks of up to 8,000 and 60,000 respectively. Due to the ephemeral nature of this species enquiries were made from Western Victoria to Gulf St Vincent without any indication of large flocks, the location of which remains a mystery. It was suggested that in 2000 when numbers were the lowest recorded, birds had moved to Lake Eyre to breed (Wilson 2000 and 2001[a]) where potentially 30 000 chicks hatched in July 2000 (Minton 2000). No such breeding event was reported in 2003.

The distribution along the Coorong also changed in 2003 with almost two thirds of the birds being observed in the Northern Channels again reinforcing the trend noted in 2002.

Red-necked Avocet

Numbers in 2003 (4,122) are similar to 2002 (3,856) and 1987 (3,572) and lower than 1982 (5,391). Low counts in the Coorong in 2000 and 2001 support the possibility (Wilson 2001[a]) that Red-necked Avocet had relocated to ephemeral wetlands in northern New South Wales and southern Queensland which were in prime condition for waders during those years.

Most Red-necked Avocet occur in the Parnka Point Area. In 1982 and 1987 and again in 2002 and 2003 high numbers were also recorded in the South Lagoon.

Red-capped Plover

The numbers in 2003 (2,897) are a large increase over 2000 to 2002 (968 to 1,319) and of a similar order to 1987 (2,793). The numbers recorded in 2003 are considered to be conservative due to the difficulty of counting in areas with low rocky outcrops. Interestingly, the declining trend on the Ocean Beach since the 1980s has again been recorded.

The distribution within the Coorong indicated a concentration in the Southern lagoon area in 2003 rather more than that of previous years. This is most likely due to the low level of these lagoons this year exposing extensive areas of saline mudflats, a factor also contributing to the higher numbers.

Discussion

Trends in counts for major Coorong species compared to other areas of SE Australia

In order to make an assessment of the significance of the population trends described for the Coorong and their relevance to local issues, it is useful to review trends for these species in the wider context of population movements in south-eastern Australia. Counts from Victoria and southeast Tasmania have been used for this purpose as it is considered that the coverage in these areas has been the most consistent and comprehensive over at least the last 20 years. Six sites have been counted in Victoria since 1981 and several sites in SE Tasmania have been counted since the late 1960's. The data sources are the Summer and Winter counts published in *The Stilt* or from the AWSG database.

Sharp-tailed Sandpiper

Figure 7 indicates that, taken across six sites in Victoria, there has been an overall decline in numbers since the late 1980's although not to the extent observed in the Coorong where numbers are around 20% of those found in 1982. There is little evidence to indicate any increase in numbers of this species in southern Australia despite observations by Minton (pers. com.) that 2 of the last 3 years have been above average breeding seasons.

The Coorong was identified by Watkins, 1993, as the most important site for Sharp-tailed Sandpiper in Australia.

Red-necked Stint

Figure 8 shows that in Victoria, Red-necked Stint were at their highest recorded numbers in 2003 following on from two record years in 2000 and 2001. These increases are thought to be due to 3 of the last 4 years being above average breeding seasons (2 at record levels) (Minton et al, 2002). While the numbers of Red-necked Stint in the Coorong have increased in the last two years they are of the order of 25% lower than the 1980's levels that might have been expected if the Victorian trend had been followed. This may be an indication that local factors within the Coorong are having an influence on the use of this area by this species. This is a matter of concern as the Coorong is the most important site in Australia for this species (Watkins 1993). Figure 9 shows counts for the Derwent River Region of SE Tasmania from 1973. The large decline at this site since the 1980's has some similarity with the Coorong. Reid and Park, 2003 indicate that this site has been subject to habitat degradation and human disturbance in recent years.

Curlew Sandpiper

Figure 10 shows that in Victoria Curlew Sandpiper have shown a steady decline since the mid 1980's with the lowest numbers being recorded over the last 3 years. This is also reflected in the Derwent Region of SE Tasmania (Figure 9). Minton et al, 2002, have observed that Curlew Sandpiper appear to have fared much less well than Red-necked Stint as far as breeding success is concerned during the last decade (6 of the 9 years in the 92/93 to 00/01 period were below average breeding success). This overall decline in Curlew Sandpiper in SE Australia is also evident in the Coorong. Although there has been an increasing trend in the Coorong since 2001, the numbers are still only one

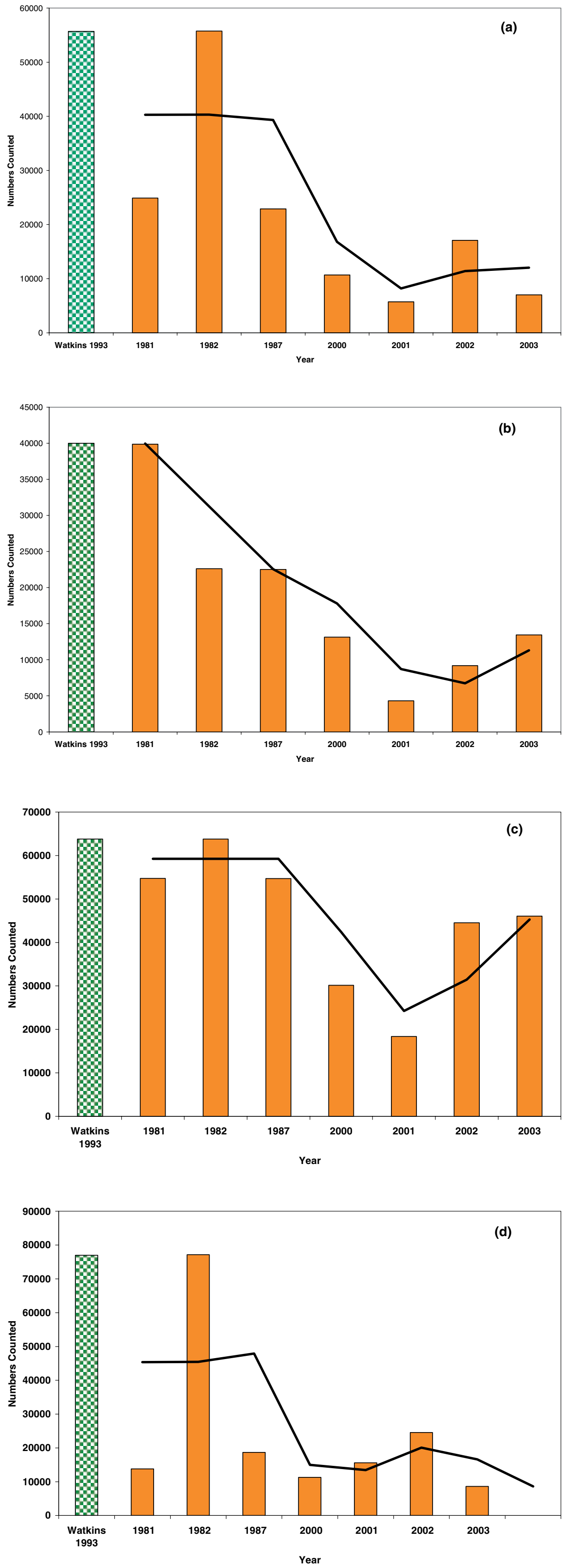

Figure 6. Changes in numbers of key species in the Coorong from 1981 – 2003.
(a) Sharp-tailed Sandpipers, (b) Curlew Sandpipers,
(c) Red-necked Stint, (d) Banded Stilt.

third of those in the early 1980's, that is, a massive 70% decline over 20 years.

The distribution of waders in the Coorong

The distribution of total waders shown in Figure 5 indicates that there has been a significant shift to the Northern Channels for most species; in 2003 this increase was dramatic with consequent reductions in the numbers of birds found in the Parnka Point and Northern lagoons. This may be a continuing indication of changing feeding regimes in the lower reaches of the Coorong and the subsequent concentration of the birds into the Northern Channels where environmental conditions may have suffered the least change. There has been a long-term trend to extremely high salinity levels in the southern lagoon, with consequent impact on food resources there. Paton, 2000 found that the distribution patterns of all macro-invertebrates that were found in the sediments around the Murray estuary largely matched the distribution of waders . Paton et al, 2000 and Geddes, 2003, also note the dearth of aquatic vegetation, invertebrates and fish in the southern lagoons compared to similar surveys undertaken in the 1980's.

Of course this puts more pressure on the food resources of the northern areas with unknown future impacts. The species mix utilizing these Northern Channels has also changed with Red-necked Stint, Sharp-tailed Sandpiper and Curlew Sandpiper making far more use of these areas in 2002 and 2003. On the other hand the numbers and proportion of Red-capped Plover found in the drying southern lagoon increased markedly in 2003.

Other possible influences on wader populations in the Coorong

It has been suggested that the wader numbers within the Coorong might be strongly influenced by drought/ flood conditions within inland Australia (Wilson, 2001). The use of the Coorong as a refuge has been used to explain the very high numbers in 1982 when there was a drought over much of southern Australia (Jaensch & Barter 1988). This may have relevance to those migratory species that commonly occur on inland wetlands such as Red-necked Stint, Sharp-tailed Sandpiper and to a lesser extent Curlew Sandpiper and to the resident waders that utilize inland waters to breed such as Banded Stilt, Black-winged Stilt and Red-necked Avocet. However, despite southern and eastern Australia suffering extensive drought conditions for between two and six years, there is little evidence at this stage to support this hypothesis to any great degree. As an example, there were wet conditions in southeast Queensland and northern New South Wales in 2000 while in 2003 these areas were suffering extremely dry conditions. Figure 6(a) shows that for Sharp-tailed Sandpiper, a species that could be expected to utilize inland wetlands, the numbers in the Coorong in 2000 and 2001 are similar to that recorded in 2003, a very dry year. Similarly, Banded Stilt numbers were the lowest recorded in the Coorong in 2003.

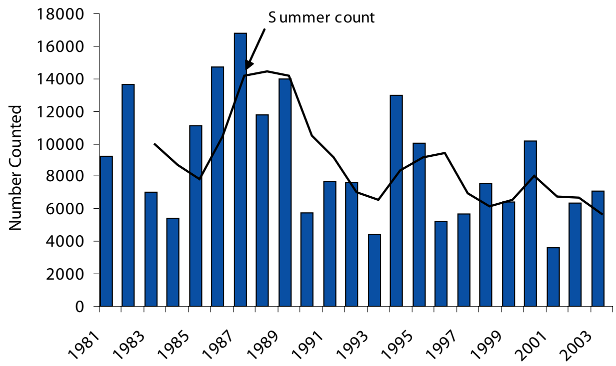

Figure 7. Sharp-tailed Sandpiper summer counts at six sites in Victoria.

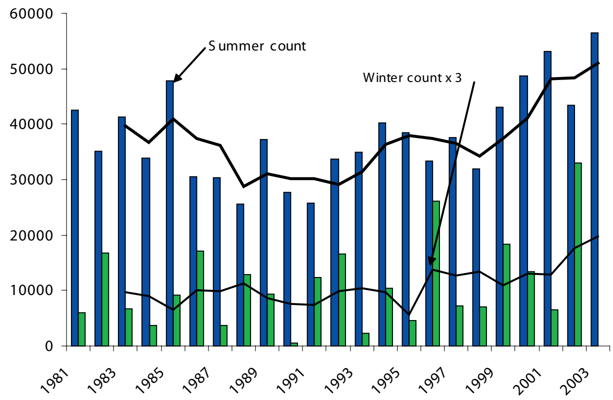

Figure 8. Red-necked Stint summer counts at six sites in Victoria

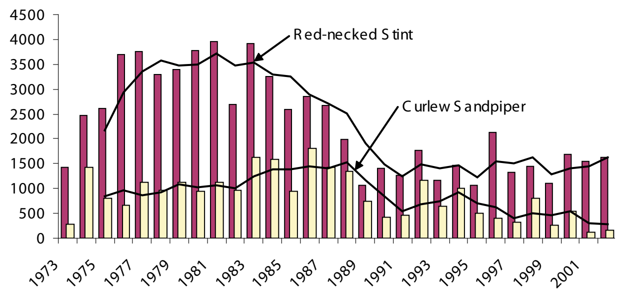

Figure 9. Red-necked Stint and Curlew Sandpipers counted in the Derwent Region of Tasmania 1973 – 2002.

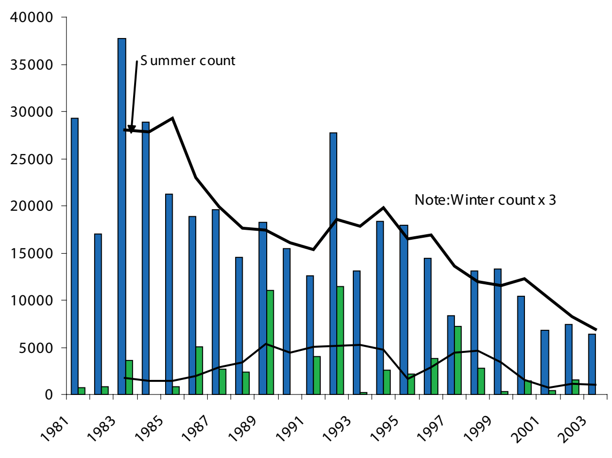

Figure 10. Curlew Sandpiper summer counts at six sites in Victoria.

Tabe 4. Summer counts of waders on Lake George in 1981, 1982, 1984, 1986, 1987, 2002 and 2003

Year	1981	1982	1984	1985	1986	1987	2002	2003
Common Greenshank	87	36	144	101	11	7	10	39
Ruddy Turnstone					2	1		
Red Knot		86						
Red-Necked Stint	2570	6101	4805	2710	5977	4200	9000	3885
Sharp-tailed Sandpiper		694	11	915	1758	4500	1270	156
Curlew Sandpiper	450	292	502	31	2	2100	1200	312
Banded Stilt	2	8	20	>50000	1967	5000	>60000	3095
Red-necked Avocet	6	160			325	35	21	578
Pacific Golden Plover						6		
Grey Plover		1						
Red-capped Plover	570	261	174	14	47	6	4	20
Double-Banded Plover	2		2					
Lesser Sand Plover			2					
Black-Fronted Dotterel				3				
Hooded Plover			21					
Red-Kneed Dotterel				15				
Masked Lapwing		147	31		2	9		31
Unidentified Small							500	
TOTAL	**3687**	**7786**	**5712**	**53789**	**10091**	**15864**	**72005**	**8116**

It is of interest to compare the use of Lake George with that of the Coorong in this regard. Lake George is the largest of the South East Coastal lakes; the lake is approximately 13km long and 8km wide at its extremities and in a dry year the southern basin is hypersaline or dries to a saltpan. See Figure 1 for location. Table 4 shows the counts of waders at this lake during February for the same years as the Coorong counts. It can be seen that apart from Banded Stilt, the general utilization of the lake by waders has been reasonably consistent regardless of inland conditions. In fact in 2003 the lowest number of Sharp-tailed Sandpiper were recorded since 1984. In contrast to this, Banded Stilt do tend to use this lake as a refuge; in 2002 some 60,000 were seen in the hypersaline basin. However there were only 3,095 in 2003. This species is particularly ephemeral and behaves differently to other waders in this regard.

The link between the use of coastal wetlands by migratory and resident waders and rainfall patterns is still to be studied in detail. Long term records of wader numbers and inland seasonal conditions are needed to determine to what extent, if at all, the Coorong and other coastal wetlands serve as a refuge in times of drought.

Regular monitoring aids land managers

The regular counting of the Coorong is important in assisting land managers from DEH to make water management (and to a lesser extent land management) decisions by combining these results with all the hydrological, biological and climate data available. The combined story provides indicators as to the long-term health of the Coorong including the various habitats bordering the lagoons. It also provides feedback on the short term impact of water and visitor management decisions such as the release of water from Morella Basin and the banning of water skiing or personal watercraft in certain locations on bird behavior and movements. The most important use of the summer count data is as an indicator of the biological impacts of the hydrological conditions and their management in the Coorong.

Counts alone cannot show all the environmental factors that may be influencing the distribution and declines in populations within the Coorong . They need to be supplemented with longitudinal studies of the availability and location of the various food resources for waders and other waterbirds and their relationship to the changing salinity and water level regimes.

Conclusion

The Coorong and the surrounding wetlands have seen major changes in the utilization by migratory shorebirds in the non-breeding season over the past 20 years. The population levels of several species have declined to a greater extent than has been recorded in other non-breeding areas of south-eastern Australia. The continuing impacts from habitat change including low river flows, changes to water levels in the lagoons and changes in salinity levels are having an effect on the abundance and variety of food resulting in a rapidly changing distribution of use by waders. The annual summer count which is undertaken by AWSG in conjunction with DEH and volunteers provides an important tool, in conjunction with other studies, for the land managers to monitor the health of the Coorong. In the short-term, the combined results will be used to manipulate low-volume flows from the Upper South East Drainage Scheme and from the River Murray Barrages to achieve temporary improvement in wader habitat. In the long-term, this information will be used to determine whether and how flows from the Upper South East Drainage Scheme impact upon overall habitat condition, options for best-practice barrage manipulation and long-term environmental outcomes from sand-pumping at the Murray Mouth. It is important that this continue and be incorporated into the AWSG Population Monitoring Program to enable its ongoing use in evaluating the population trends within the flyway.

Acknowledgements

The survey since 2001 has been supported with funds from the Department for Environment and Heritage, Mt. Gambier office. Enormous thanks to the team of volunteers who have so willingly contributed time and considerable effort to undertake these counts. Jim Wilson, past Chair of the AWSG is particularly thanked for his initial drive to undertake these surveys and for contributing to a great extent to developing the methodology.

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Assessing breeding success

Measuring Recruitment of Shorebirds with Telescopes: A Pilot Study of Age Proportions on Australian Non-breeding Grounds

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Abstract

The breeding success of migratory shorebirds differs from year to year; it is affected by factors such as lemming cycles and the time of snow-melt on the breeding grounds. Fluctuations in breeding success can be detected in Australia because they affect age proportions in the non-breeding flocks of shorebirds that we observe here. Documenting these age proportions can provide valuable information; it can help to interpret population trends revealed by shorebird counts; it improves our understanding of why breeding success varies from year to year, and as breeding success varies geographically, it may provide insights about where our shorebirds breed. In the future it may play a large role in understanding the effects of global warming on shorebird populations. Australian shorebird banders, especially in Victoria, put a great deal of effort into catching and ageing large numbers of shorebirds in summer so that age proportions can be estimated. Some nice results are coming out of this work. However, huge efforts and large banding teams required are required to collect these data, so few sites can be tackled.

In the right circumstances, many species of shorebird can be aged objectively in the field with a telescope. Age proportion data obtained in this manner are presented from a pilot study at the Western Treatment Plant, near Melbourne, during the austral springs and summers of 2001 to 2003. The ageing methods used are described for Red-necked Stint, Curlew Sandpiper and Sharp-tailed Sandpiper. We found that the great majority of juveniles had arrived before post-juvenile moult became too advanced for telescope ageing. Local distribution of immature birds was not homogenous; they tended to cluster in small groups and spent more time foraging at high tide than did adults. Implications of these findings for assessment of age proportions by cannon-netting are discussed (in particular the sample sizes required for representative data), and we compare our overall age proportions with those obtained through cannon-netting at the same site in the same years. We conclude that both cannon-netting and telescope observations can provide solid data on age proportions.

Although we are confident that age proportions can be estimated adequately at non-breeding sites, the approach does not give a direct measure of recruitment rates. Age proportions can vary geographically, both on small and large scales. If we are to develop realistic estimates of recruitment rates it would therefore be desirable to measure age proportions at many sites. This may be the greatest advantage of telescope observations, as they can be made by a single observer. They may also be valuable as a measure of age proportions at sites where cannon-netting is not practical, or on species that are difficult to catch.

Introduction

Migratory shorebirds pose difficult conservation problems as their continued survival depends on intact habitat throughout their range: not only the breeding areas, but staging and non-breeding sites which are often threatened by human population growth and related habitat loss. A recent worldwide analysis of available data on population trends has demonstrated that 51% of the species of short-distance migrants, and 47% of the species of long-distance migrants, are in decline (Zöckler *et al.* 2003). A range of international agreements are in place to encourage governments to conserve shorebirds and their habitats, and a great deal of effort, both professional and voluntary, goes into monitoring shorebird populations.

In order to arrest the decline of migratory shorebirds, it is important not only to monitor their populations, but to understand the causes of any changes. Declines in shorebirds are caused by reduced survival of adults, or by reduced recruitment of young birds into the adult population, or both. Survival estimates for adults can be derived from banding studies, and although these have not yet been used widely on shorebirds, a sophisticated range of methods of analysing such mark-recapture data is now available (Sandercock 2003). In contrast, relatively little work has been done on measurement of recruitment rates of shorebirds.

Shorebird breeding success varies from year to year, especially on arctic breeding grounds where a link has been demonstrated between lemming cycles, the frequency of nest predation, and the number of young birds subsequently reaching the non-breeding grounds (Summers and Underhill 1987). Given that the number of young shorebirds that reach the non-breeding grounds is related to breeding success, measurement of age proportions on the non-breeding grounds can be a valuable tool for interpreting population changes. For example, Boyd and Piersma (2001) demonstrated that a decline in the number of Red Knots (*Calidris canutus islandica)* spending the non-breeding season in Britain was linked to reduced breeding success. Studies by the Victorian Wader Group (VWSG) in southern Australia have demonstrated that a decline in non-breeding Curlew Sandpiper *(Calidris ferruginea)* numbers coincided with a series of years of low breeding success, while over the same period Red-necked Stints *(Calidris ruficollis)* experienced a series of successful breeding seasons and their non-breeding populations increased (Minton *et al*. 2002, Minton 2003).

In the studies cited above, age proportions on the non-breeding grounds were assessed by mist-net or cannon-net captures of shorebirds in the middle of the non-breeding season. This approach has many advantages (Minton 2003), notably that birds can be aged on objective characters (usually primary moult condition) at a time of year when all adults and first-year birds are thought to be on the non-breeding grounds. There is however a practical limitation. Safe capture and accurate processing of large numbers of non-breeding shorebirds can only be accomplished by large, dedicated and skilled teams of banders. The resources for such studies are only available for a small proportion of the shorebird non-breeding sites in the world, and this situation is unlikely to change in the foreseeable future.

A much less labour-intensive approach for measurement of age proportions of shorebirds is to age them directly in the field. A similar approach has been used to assess breeding success of several species of migratory geese in Western Europe (e.g. Summers and Underhill 1987; Fox *et al*. 1989; Fox and Gitay 1991; Ebbinge 1992). In most species of shorebird, the juvenile plumage (i.e. the first complete pennaceous plumage) of young birds differs in appearance from all subsequent plumages. Tripod-mounted telescopes with high-quality optics are now standard equipment for most shorebird enthusiasts, so it is possible to examine shorebird plumages in the field in considerable detail. Furthermore, shorebirds have received a great deal of attention from twitchers and others with an interest in resolving subtle field identification problems. As a result there is a wealth of literature that includes excellent illustrations or photographs of their juvenile plumages (e.g. Hayman *et al*. 1987; Paulson 1993; Rosair and Cottridge 1995, Higgins and Davies 1996). In principle then, ageing shorebirds in the field would appear to be a potential alternative for measuring age proportions.

In practice, measuring age proportions with a telescope is not so straightforward. Juvenile plumage of shorebirds fades with wear, becoming less distinctive than the fresh juvenile plumage illustrated in most field guides. Furthermore, juveniles typically begin body-moult to a non-breeding plumage soon after arriving on the non-breeding grounds (e.g. Higgins & Davies 1996), and the juvenile arrival period is probably rather protracted. It is possible that the first-arrived juveniles will have become difficult or impossible to age on body-plumage characters before the latest juveniles arrive. There is therefore a potential risk that age proportions measured with a telescope could be underestimates of the true age proportion.

This paper describes a pilot study of age proportions in Red-necked Stints, Curlew Sandpipers and Sharp-tailed Sandpipers *(Calidris acuminata)* at a non-breeding site near Melbourne, Australia. The study had several objectives. First, we wanted to compare age proportions estimated by telescope observations with age proportions obtained by cannon-netting at the same site. Secondly, we wanted to identify the time periods in which field separation of first-year and older birds was feasible. Finally, the use of telescope observations allowed us to assign ages to large numbers of birds in short periods, so we could sample more widely than a banding team. We therefore took the opportunity to assess the relative spatial distribution of young shorebirds to that of adults, as it has previously been suggested that age-segregation within or between shorebird flocks could bias age proportion results (Weston 1992).

Methods

The study was carried out at the Western Treatment Plant (WTP; formerly known to the bird-watching community as Werribee Sewage Farm), south-west of Melbourne, Australia (Figure 1). It is a large region (about 18 km x 3 km) of coastline and settling ponds, and contains a number of sub-sites (Figure 1) at which shorebirds may feed or roost. The VWSG has used cannon-net catches of roosting shorebirds between the 15th of November and the end of February to measure age proportions in the WTP annually since 1980 (C.D.T. Minton, pers. comm.). They have caught at many different sites within the WTP as local roosting distribution of shorebirds has varied over time.

Ages of Red-necked Stints, Sharp-tailed Sandpipers and Curlew Sandpipers were recorded through telescopes on 13 visits in the spring and summer of 2001/2, on 6 visits in 2002/3, and on 5 visits in the spring of 2003. We made initial visits to the WTP together to ensure that we were using the same ageing approaches; when we were satisfied that different observers were consistent, visits to the site were made by single observers, as this allowed us to sample on a larger number of days. At all sites in the WTP, it was possible to approach birds closely enough to record age proportions. We attempted to obtain age proportion data from a number of different sites on each sampling day. Coastal sites were scanned at low tide, and inland sites were scanned at high tide. Beyond this, the selection of sites was influenced mainly by the presence of birds to sample.

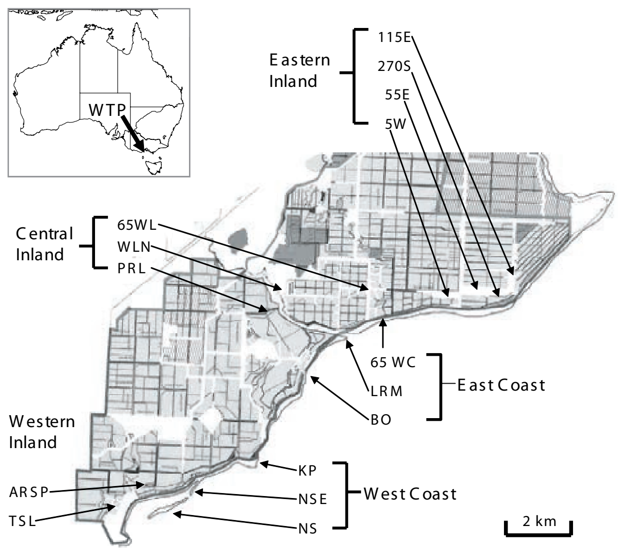


Figure 1. Map of the Western Treatment Plant, showing sites where shorebird age proportion data were collected, and the districts into which these were classified.

The objective when sampling was to count the number of birds in their first year: i.e. birds in juvenile plumage, moulting to the first non-breeding plumage, or in their first non-breeding plumage. These plumages are collectively referred to as "immature" in the remainder of this paper. We also counted the number of birds in adult breeding or adult non-breeding plumage. These birds are collectively referred to as "adult" in this paper, though in fact they would have included some second-year birds which had not yet bred. The first visits were made early in September to mid-October, before all juveniles were thought to have arrived, in order to familiarise ourselves with juvenile plumage at a time when it was easily recognised. Visits continued until we had reason (in December) to believe that we could no longer tell all immature birds from adults. In 2001/2, we also recorded age proportions of Red-necked Stints and Curlew Sandpipers in March, when adults were moulting into breeding plumage while immature birds were not.

Observations were made through a Kowa TSN-3 telescope (DIR), a Kowa TSN-821 telescope (KGR) or a Leica (MAB); standard eyepieces (25-32X) provided sufficient magnification for our purposes. Telescopes were tripod-mounted, except in situations where it was easiest to get close to birds by approaching them in a car, in which case we used a window-mount. Throughout the study we documented plumage variation with a small digital camera (Kodak DC4800). We focussed on individuals of interest with a telescope, then handheld the camera to the telescope eyepiece, taking photographs after using the preview screen to ensure the bird was in picture and that the focus was sharp. This technique, known as "digiscoping" to the bird-watching community (Ingraham 2001), allows observers to photograph what they can see through a telescope. Although the approach does not produce such high-resolution images as traditional photography, digiscoping has the advantage of allowing photographs to be taken at considerable distances and in poor light conditions with affordable, easily carried equipment. In addition, there are no film processing costs. Photographs were saved as jpeg files and were circulated between co-authors and used to refresh our memories of ageing methods before each fieldtrip.

We recorded the following details when performing age scans: (1) Date and time of observation; (2) precise site; (3) observer name; (4) number of birds in the flock; (5) number of adults counted; (6) number of immature birds counted; (7) whether or not the birds scanned might have been included in a previous age-scan; (8) behavior of the scanned flock (foraging, roosting). It proved to be convenient to age foraging and roosting birds in separate scans, even when foraging and roosting birds were mixed together. Data were initially recorded in notebooks, but we subsequently realised that use of a datasheet was needed to ensure consistent data recording conventions.

Often we found ourselves performing several age scans on the same flock: a quick one on arriving at the site and more thorough age scans if the birds were undisturbed and allowed us to get closer views. In cases when we had scanned the same flock, or part of the same flock, on several occasions during the same observation session, we used only one of the scans in subsequent analyses; unless notes were made in the field that a particular scan was considered most accurate, we simply used the one in which sample size was largest.

Age scans were made starting at the left of the flock and moving right (or vice versa) to prevent double-counting of the same individuals. If only a single observer was present, the convention was to maintain a mental count of the number of immature birds seen during a scan, while clicking once on a handheld counter each time an adult was seen. When two observers were present, one would scan while the other would record. This latter approach (or transcription of dictated tape-recordings of scans) resulted in a written sequence of ages (e.g. "ad, ad, imm, ad, imm, imm, imm, ad, ad, ad, ad…"). We later entered these sequences into speadsheet, for analysis of the spatial distribution of immature birds within flocks.

Statistical analyses were carried out in Systat 10 (SPSS 2000) except where stated. Daily estimates of immature proportion were made by dividing the number of immature birds aged over all independent scans by the total number of birds aged in these scans. Independent scans were required to ensure that no birds were included more than once in the calculation. Standard errors of daily immature proportions (r) were estimated by applying the Binomial Theorem:

Standard Error $\{r\} = \{r.(1 - r)/n\}^{1/2}$.

Combining daily population estimates to obtain a population age proportion for the season is less straightforward. It is tempting to use the same approach as that for calculating daily age proportions (see above). This would give a good central estimate, but would seriously underestimate its standard error, for two reasons. First, the estimated daily proportions are not independent as it is likely that some individual birds will occur in scans made on different days. Secondly, immatures often had bunched spatial distributions (see results) and we found significant differences between daily proportions. However each daily proportion is an estimate of the population age proportions and the spread in daily proportions indicates how closely the estimates get to some central value. In other words, the standard deviation of the daily scans can be interpreted as the standard error of the seasonal population estimate. In calculating the two parameters, we have weighted the daily age proportions by the number of aged birds contributing to them. Details of the calculation are given below.

Denoting I_i and A_i as the numbers of immature birds and adults aged in the i'th daily scan, and Ni as the total number of birds aged in the scan, we calculate the daily immature proportion, D_i, as:

$D_i = \sum (I_i) / N_i$ where $N_i = I_i + A_i$

The population immature proportion, PP, is given by: PP $= \sum(N_i.D_i) / \sum N_i$

The standard error of PR is given by:

$S.E.\{PP\} = \{(\sum(N_i.D_i\hat{}2) - PP\hat{}2.\sum N_i) / (\sum N_i - 1)\}^{1/2}$

Results

Ageing methods

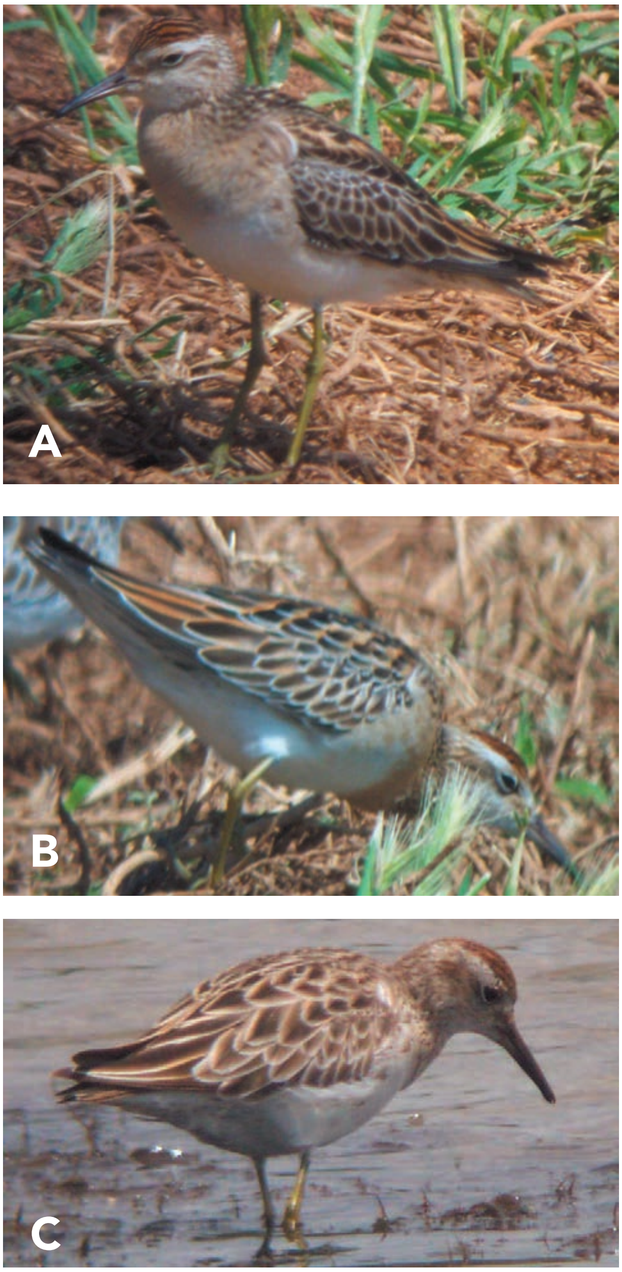
We began each field season when juvenile plumages of the focal species were fresh and therefore easy to identify. Our sampling began before the VWSG had begun its catching program at the WTP for the summer. The VWSG has been placing orange leg-flags on all captured migratory shorebirds in Victoria since 1992, and this provided us with another useful ageing guide, as we could be confident that all orange-flagged birds seen were adult. Examining such birds provided us with an overview of adult plumage variation which was helpful, though not essential.

Juvenile plumages of *Calidris* sandpipers and most other shorebirds have distinctive structural characters which are useful for ageing purposes (Figure 2). All juvenile feathers are grown at the same time (on the breeding grounds) so they show uniform wear. All subsequent body plumages of shorebirds are attained in more gradual moults, so close examination of the body feathers, especially in the non-breeding season, will usually show some body feathers and wing coverts to be more worn than others on the same bird. The scapulars of juvenile shorebirds (five parallel rows of large feathers inside the base of the wing, which cover most other feathers of the upperparts) are slightly smaller than those of adults; it is typical for them to lie in neat orderly rows. The posture of the scapulars is under voluntary control, and in juveniles the scapulars are often raised to expose the uniformly worn wing-coverts below. In contrast the larger scapulars of adults are not usually so neatly ordered, and they are typically drooped to conceal the wing-coverts.

While these ageing characters may appear to be relatively subtle features, they can be assessed objectively with experience. Our general experience is that in ageing juvenile shorebirds in the field, it is important to pay attention to structural plumage characters and the patterns of the dark centres of upperpart feathers. This may not appear an intuitively obvious course of action early in the season, when there are striking colour differences between juveniles and adults. However, the bright colours of fresh juveniles typically fade before post-juvenile body moult begins. In contrast the generic features of the juvenile plumage of shorebirds remain after any obvious rufous or buff tinges to the fringes of feathers have faded or worn away.

Some juvenile Red-necked Stints had already arrived by the time of the earliest surveys on 23rd September, and their fresh plumage made them easy to age through late September and all October. The most striking feature of fresh juveniles were neat, bright rufous fringes to the feathers of the mantle and the upper rows of scapulars, contrasting strongly with dark to blackish brown feather centres. Some adults were still moulting out of breeding plumage at this time, and could therefore retain a few rufous-edged scapulars, but these breeding feathers were isolated and large with bold black centres; they were not readily confused with juvenile plumage. Juvenile Red-necked Stints varied individually, and a few lacked rufous fringes of the scapulars and mantle even when fresh; in addition the rufous fringes of even the most boldly marked juveniles faded and were eventually lost with wear. Ageing of worn juveniles (through the first three or four weeks of November) remained straightforward, as the dark centres of their upperpart feathers remained and produced the appearance of mainly blackish brown upperparts, quite different to the predominantly grey upperpart of non-breeding adults in November. Post-juvenile body moult began between mid-November and the first week of December. The inner scapulars were among the last body feathers to be moulted, and the retained juvenile scapulars formed broad dark lines that contrasted strongly with the surrounding grey incoming non-breeding plumage. Immature birds at this moult stage also differed from non-breeding adults in having a warm brown ground colour

Figure 2. Age characters in Sharp-tailed Sandpipers (STS) and Red-necked Stints (RNS): A. Juvenile STS (24 Oct.) with wing-coverts exposed. B. Juvenile STS (24 Oct.) with scapulars drooped over wing-coverts. C. Adult STS (1 Dec.); note larger scapulars and less even wear of feathers. D. Fresh juvenile RNS (17 Oct.). E Adult RNS (17 Oct); note uneven plumage wear and narrower dark centres of retained old upper-part feathers. F. Worn juvenile RNS (9 Nov.); coverts worn but wear is uniform; retained juvenile plumage makes mantle appear rather uniformly dark. G. Red-necked Stint in post-juvenile moult (1 Dec.), retained juvenile upper scapulars forming dark strip along upperparts.



Significance level	Totals	Number of birds in scan					
		<10	11 - 25	26 - 50	51-100	100-150	>150
>99%	6	0	0	1	2	2	1
95-99%	10	1	0	1	4	2	2
90-95%	14	1	0	3	4	4	2
<90%	52	6	8	10	14	7	7

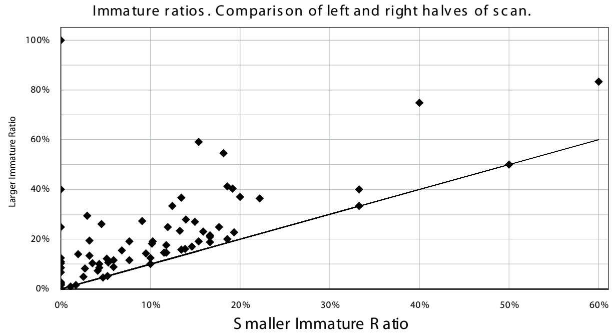


Figure. 3. Comparisons of immature proportions in the left and right side of scanned flocks of waders in the summer of 2001 to 2002.

to the crown. The first immature birds of the season to be seen with no remaining juvenile scapulars or crown feathers were noted in the first week of December. These individuals were aged on their relatively fresh outer primaries; outer primaries of adults in early December are worn, so they have a browner tinge and frayed tips. This character could be seen in the field given very close views, but obtaining suitable views proved so time-consuming that we stopped recording age proportions in Red-necked Stints after the first week of December. Another ageing "window" became available in late March and early April; on visits made on 17th March and 1st April, all adult Red-necked Stints appeared to show some moult into breeding plumage while immature Red-necked Stints remained in a non-breeding plumage.

Curlew Sandpiper juveniles probably start to arrive slightly earlier than Red-necked Stints; some were already present by the first field trips of the season in 2001 and 2003 (both on 23rd September). In fresh juvenile plumage they were the most easily aged of our three focal species, as they had bold pale buff to white fringes to all upperparts feathers, contrasting vividly with the dark oily brown subterminal markings of the feathers. Adults appeared quite different; remaining rufous traces of breeding plumage were conspicuous when present, and in non-breeding plumage their pale grey upperparts were very different to those of fresh juveniles. Juvenile plumage of Curlew Sandpipers changed rapidly with wear. By mid- to late October the buff fringes to upperparts feathers were lost, and the dark subterminal areas of the upperparts feathers could be quite faded, making ageing considerably more difficult. In good light conditions, ageing remained possible through detection of brownish subterminal feather markings on the upperparts, a character more easily seen from a vantage point above the birds than from side on. In addition the wing-coverts (uniform in age, and retaining clear buff to white fringes) remained a fairly obvious plumage character, albeit one that could be concealed by the scapulars if the bird was only viewed briefly. We were unable to establish when ageing of Curlew Sandpipers on the basis of retained juvenile feathers in the upperparts or wing-coverts became unreliable, though it could still be done on 23rd November. In late March and early April all adult Curlew Sandpipers observed had some obvious incoming breeding plumage while all immature birds observed had none.

Juvenile Sharp-tailed Sandpipers arrived at the study site slightly later than the other focal species, the earliest observations being made on 4th Oct. Their fresh juvenile plumage was striking, with a vivid chestnut cap and a bold apricot band across the breast. Some retained these characters well into December. However, after the start of November, ageing of Sharp-tailed Sandpipers simply on "brightness" of plumage should be done

cautiously, because some adults had completed moult to non-breeding plumage by this time and their fresh non-breeding plumage could be surprisingly brightly coloured. The colour of the cap could be similar to that of juveniles and the pale brown ground colour of the breast in fresh non-breeding plumage could be as bright as the faded breast of worn juveniles. From early November to mid-December we found it valuable to examine details of feather pattern in two tracts: (1) On the longer scapulars, the black feather centres of juveniles typically had a rounded end while those of adults had a pointed end. (2) The rufous fringes to the tertials of adults were narrower than in juveniles, tapering at both the tip and base of the feather where they usually graded to whitish; in contrast juveniles had rufous fringes to the tertials that were uniform in width and colour along the length of the feather. The timing of post-juvenile moult in Sharp-tailed Sandpipers varied. We first noted post-juvenile moult of the scapulars by in mid-November, but most individuals started later, many retaining apparently complete juvenile plumage until the first week of December; some immature birds (in post-juvenile moult) could still be aged by mid-December. Unlike Red-necked Stints and Curlew Sandpipers, Sharp-tailed Sandpipers could not be aged in March and April because both adults and immature birds moulted into a brightly coloured breeding plumage.

Consistency between observers

Qualitative comparisons suggested that we were ageing birds consistently; on several days when we all went in the field together and watched the same flocks, we did not disagree about the ageing of any individuals and picked out the same birds as juveniles. However we did not make any quantitative comparisons of age proportions measured by different observers at the same site on the same day. This oversight would be worth correcting in the future. In this paper we have combined the observations of different observers.

Bunching

Early in the fieldwork we developed a perception that immature birds tended to group together within flocks, in small loose groups that we subsequently refer to as "bunches". To test whether immature distribution within a flock of adults was random, we carried out Wald-Wolfowitz Runs tests (SPSS 2000) separately for all flocks for which we had recorded the sequence of ages. In 57 of the 64 flocks examined, immature birds were not distributed randomly ($P<0.05$) – i.e. there appeared to be some kind of pattern to their distribution. This conclusion was supported by a separate analysis, in which we split the data for each flock in half and compared the left half of the flock with the right half of the flock. If distribution of immature birds (or of small subgroups of immature birds) was random, we would expect the immature proportions to be similar on both sides of the flock. However in 36% of comparisons made, there was a significant difference in age proportion between the two halves of the flocks (Figure 3). It therefore appears that bunching of immature birds can occur on a reasonably large scale within a flock, or possibly there is bunching of bunches, with small clusters of immature birds occurring more on one side of a flock than on the other.
The distribution of immature birds within flocks is explored further in Figure 4, which shows the frequency distribution of the number of adults between immature birds. We obtained a good fit to these data with the empirical non-linear model for frequency F:

$$F = 0.192e^{-0.683(\text{n of intervening adults})} + 0.063e^{-0.108(\text{n of intervening adults})}$$

($R^2 = 0.9698$, df = 37).

We suggest that the first exponential term of the model is related to the size of small immature bunches, while the second exponential term is more closely related to the spacing of these small bunches. A model based on the sum of two logistic functions gave an almost identical result.

Influence of flock size

Immature proportions are plotted against flock size in Figure 5. Separate lines represent immature proportion for flocks smaller than or equal to the flock size shown on the X axis, and for flocks greater than this size. The lines diverge widely when flocks are small. Although there is a great deal of scatter in the data, the plot does seem consistent with our field impression that small shorebird flocks tended to contain a higher proportion of immature birds (but see Rogers *et al*. 2005) . The effect is sufficiently strong for us to regard age proportions from flocks of fewer than 50 birds as unreliable indicators of age proportions in the population as a whole, and we discarded small flocks from several subsequent analyses. In theory, if age proportions of small flocks are unrepresentative of overall age proportions, age proportions in large flocks must be unrepresentative too. In practice, this is not too great a problem. Unless there are very many small flocks, the bias on the population juvenile estimate based only on large flocks will be very small. Our subjective impression was that the majority of individuals of the focal species at the WTP occurred in large flocks (also see Figure 5).

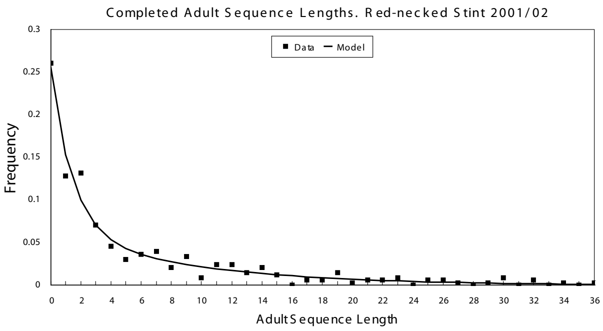


Figure 4. Frequency distribution of the spacing of immature Red-necked Stints within flocks, represented by the number of intervening adults (on the X axis). The line represents a statistical model (see text).

Site comparisons

Coastal sites are suspected to be superior feeding areas to inland sites within the WTP (Loyn *et al*. 2003), but age proportions within the two habitats appeared to be similar (Figure 6a). However, this finding might have been influenced by the fact that we sampled most coastal sites at low tide, and inland sites at high tide, when many shorebirds at the WTP move from coastal feeding sites to inland roosting sites. At the inland sites of the WTP, there were often situations where some shorebirds were roosting and others were foraging. The immature proportion within foraging birds was usually higher than it was in adjacent roosting birds (Figure 6b). Some shorebirds remain on the inland feeding sites

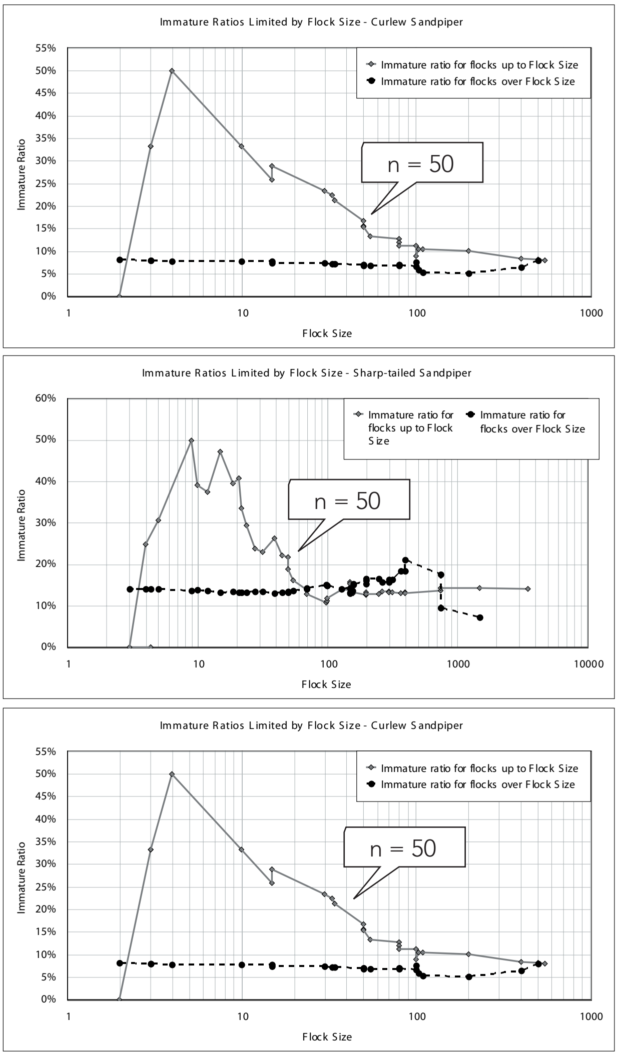


Figure 5. Immature proportion in the season 2001/2, plotted against flock size, for Red-necked Stint (Top), Sharp-tailed Sandpiper (Centre) and Curlew Sandpiper (Bottom). The dotted black line depicts age proportion in flocks greater than the flock size on the X axis; the grey line depicts age proportion in flocks smaller than or equal to the flock size on the X-axis.

of the WTP at low tide (Loyn *et al*. 2003) but the age composition of these remaining flocks has yet to be investigated.

There are many different shorebird sites within the WTP. Could site-to-site differences have played a large role in explaining the scatter we found in age proportions in different scans? In Figure 6c we plot age proportions obtained from each site from October to mid-December for Sharp-tailed Sandpiper. This was the species which we sampled at most sites; similar trends (from a smaller number of sites) were found in Red-necked Stint. Observed age proportions apparently varied substantially from site to site, with sites sampled on the same day showing very different age proportions. This finding may simply be due to the difficulties in obtaining representative samples of age proportions, especially in the presence of immature bunching. Alternatively it might reflect site-to-site differences of age proportions in the WTP, but if present these differences occur on rather small scales. When we combined data from nearby sites within the WTP there was no particularly obvious regional trend to age proportions (Figure 6d). Over the past twenty years, the Victorian Wader Study Group has captured and aged shorebirds at many different sites within the WTP. We have no reason to believe that the age proportions they obtained would have been systematically biased by the need to catch in different sites in different years.

Arrival dates, ageing windows and comparisons with cannon-netting data

In Figure 7, age proportions are plotted against date for Red-necked Stints and Sharp-tailed Sandpipers in the non-breeding seasons of 2001/2 and 2003/4. These were the only seasons in which over 500 birds were aged by both telescope observations and cannon-netting (these sample sizes were not reached in Curlew Sandpipers). We have combined sites in these graphs, and excluded age proportions obtained from samples of 50 birds or fewer. For both species, immature proportions were low early in the season when we presume that not all juveniles had arrived. In Red-necked Stints no differences could be found between age proportions obtained in late spring (November and early December) and those obtained in March 2002 when all juveniles had presumably arrived.

We suspect that arrival time of juveniles differed slightly in the two seasons. In 2001, no obvious trend for an increase in immature proportions could be discerned after the beginning of November. This does not necessarily mean that no such increase occurred, but by November any increase in the real immature proportion was smaller than the scatter in age proportions obtained with our sampling methods. In 2003, it is possible that there was an influx of juvenile Red-necked Stints after the middle of November. Other commitments prevented us from testing this in the field in late November or early December, and at the time of writing (February 2004) the second ageing window for Red-necked Stints has yet to begin.

Age proportions obtained by the VWSG through cannon-netting are also summarised in Figure 7. As with age proportions obtained through telescope observations, there is considerable variation between samples. Bearing this in mind, we consider the results obtained by the two methods to be reasonably similar. Although the overall age proportions obtained through telescope observations and cannon-netting are not identical, the estimates of overall age proportion are not very precise, so we doubt that the differences are of any causal significance (except perhaps in Red-necked Stints in 2003/4, a season for which data collection was incomplete at the time of writing has not yet been completed). Annual variation in age proportions of shorebirds is substantial; in the long-running study of (cannon-netted) age proportions by the VWSG, annual estimates of age proportions in Victoria ranged from less than 1% to over 30% in both Red-necked Stints and Curlew Sandpipers (Minton 2003). Detection of variation of this magnitude should therefore be possible through either telescope or cannon-net sampling.

Figure 6. Spatial variation in distribution of immature birds (for a map showing the localities indicated, see Figure 1): (a). Comparison of Sharp-tailed Sandpiper age proportions at coastal and inland sites in the summer of 2001/02; (b). Age-proportions of foraging vs roosting birds at inland sites; (c). Comparison of Sharp-tailed Sandpiper age proportions at individual sites in the summer of 2001/02; (d) Comparison of Sharp-tailed Sandpiper age proportions in different regions of the WTP in the summer of 2001/02.

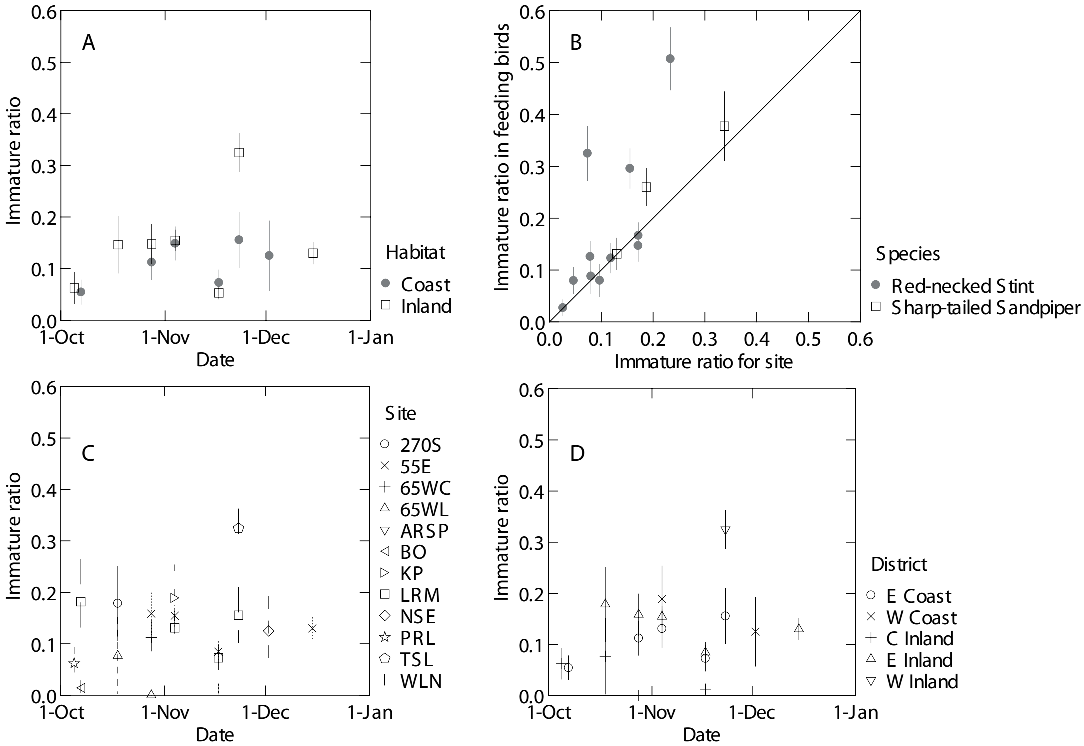
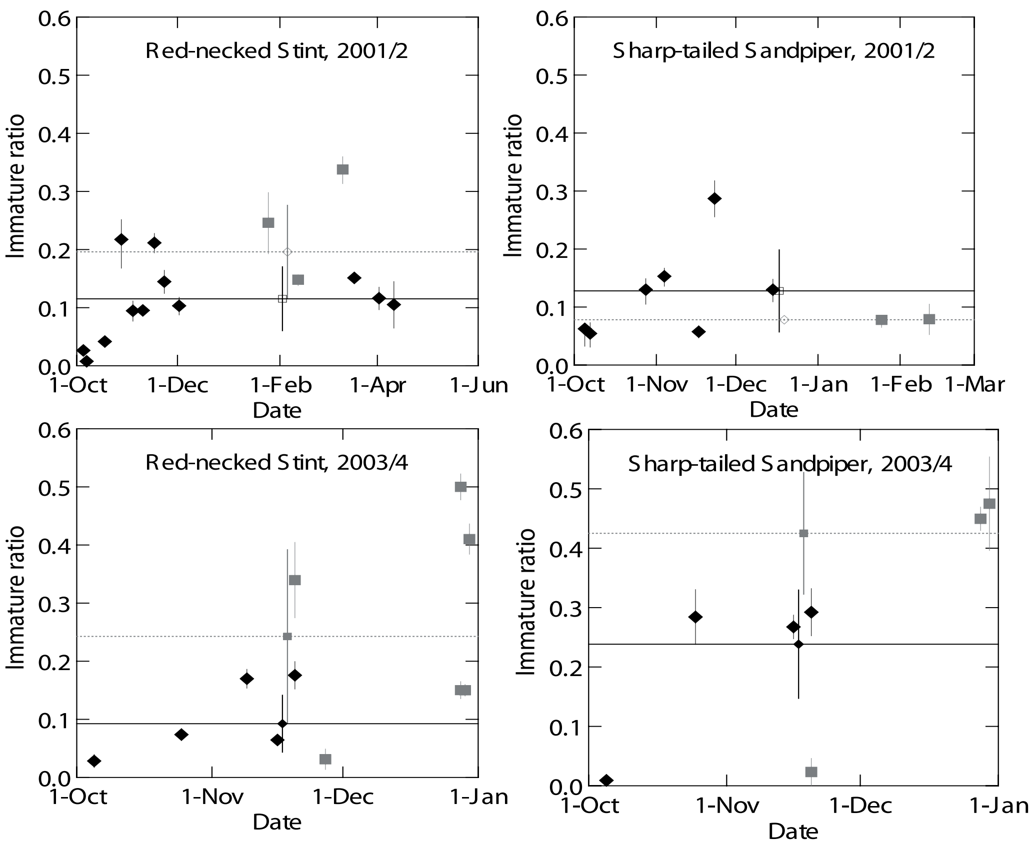


Figure 7. Age-proportions of Red-necked Stints and Sharp-tailed Sandpipers at the WTP in the summers of 2001/2 (top row) and 2002/3 (bottom row). Symbols represent overall proportions on particular days of sampling; the lines depict age proportion for the period from 15 November until departure. Results from cannon-net catches are shown by grey squares and dotted grey lines; results from telescope observations are shown by black diamonds and continuous black lines.



Discussion

A criticism that has been made of obtaining age proportions through telescope observations is that it becomes impossible to age birds in the field before all the immature birds have arrived (Minton 2003). We question this perception, for ageing of individuals could be based on objective characters for a longer part of the year than we expected. Immature Red-necked Stints and Sharp-tailed Sandpipers, in either juvenile plumage or post-juvenile moult, could be reliably distinguished from adults from their arrival in September or October until the first week of December. Curlew Sandpipers arrive slightly earlier and begin post-juvenile body moult slightly earlier, so it is possible that they cannot be aged after the fourth week of November. We were unable to sample enough Curlew Sandpipers to test this. Age proportions obtained from Red-necked Stints and Curlew Sandpipers in March 2002 (when adults were moulting into breeding plumage while immature birds were not) were similar to those obtained from sampling done in late November 2001, suggesting that there are two ageing "windows" for these species in which ageing can be done with a telescope.

Cannon-netting teams have traditionally regarded the 15th of November as the arbitrary date after which immature proportions are likely to be representative of the mid-summer non-breeding population. We consider this reasonable; by late November to early December the majority of immature birds had arrived in the study area in 2001. Annual variation in arrival dates of migratory shorebirds in southern Australia has not been investigated thoroughly, and there may be no sharply defined final date, with small numbers of immature birds continuing to arrive through the middle of summer. Sufficient cannon-netting data may have been collected to test this, but a detailed analysis has yet to be published.

If the objective of recording age proportions was only to come up with a precise measure of the non-breeding immature proportion, it would be important to do the sampling at a time of year when all immature birds had arrived and no adults had set off on northwards migration. However if the intention of recording age proportions is to monitor breeding success from year to year, there is a broader range of dates on which sampling is worthwhile. Provided sampling is done in consistent fashion from year to year, we think that telescope-ageing can be used to assess whether breeding success has been relatively high, relatively low, or intermediate. There is the caveat that this assumes that juveniles migrate south at the same time from year to year. While perhaps a generally reasonable assumption (especially for strictly coastal species), our data from 2003 suggest that there was a late influx of immature Red-necked Stints to the WTP. Perhaps this occurred because 2003 was a relatively wet year, resulting in arriving immature birds encountering more suitable inland Australian wetlands than arriving immature birds in the severe drought of 2001 and 2002. With telescope ageing, we would have struggled to detect an influx that had occurred any later than the end of November. For this reason we think it is helpful to also record age proportions in March to April for those species in which there is a second ageing window.

We have only considered the three most common shorebird species of the Western Treatment Plant in this paper. However, the ageing principles we used should be suitable for most species of migratory shorebirds, so telescope ageing could be extended to species which are difficult to catch in large numbers. A crucial part of obtaining age proportions through telescope observations is identification of the times of year when the onset of post-juvenile body moult begins, and at which it is so far advanced that ageing in the field becomes impractical. Shorebird banders could play a large role in identifying these periods if they were to make systematic records of the amount of juvenile body plumage retained in birds captured on the non-breeding areas between September and December. Collection of such data could be done rapidly using the principles by which many banding groups already record the amount of breeding plumage, but it would require familiarity with juvenile plumage patterns.

While ageing of young shorebirds proved to be reasonably straightforward, sampling flocks so that we obtained representative age proportions was undoubtedly difficult. This was because immature shorebirds did not have a random distribution within flocks. Bunching occurred both on small scales (immature birds tended to gather in small bunches of a few birds) and on larger scales (often one side of the flock would have more juveniles than the other). Although we found no broad regional differences in age proportion through the WTP, on a smaller scale there was probably a tendency for some sites to have higher immature proportions than others. At high tide on inland lagoons, foraging flocks had higher immature proportions than roosting flocks. Finally, there may have been a tendency for immature proportions to be higher in small shorebird flocks than in large shorebird flocks.

Other workers have also found that shorebird flocks are not necessarily random groupings of birds; colour-banded non-breeding shorebirds have been shown to have bunched distributions within flocks (e.g. Furness and Galbraith 1980; Harrington and Leddy 1982), and there is also evidence that birds of different mass may use slightly different sites (e.g. Rogers *et al.* 1996). The causes of such bunching are poorly known; different foraging requirements or some kind of social structure to the flocks may be involved. Whatever the causes of bunching, it poses analytical problems when estimating age proportions. It introduces a good deal of scatter to estimates of age proportion for different flocks, and makes it risky to extrapolate age proportion from a small sample to a large flock. At this stage it is not possible to make a general rule about the minimum sample size needed for an adequate estimate of age proportion; this will vary from site to site, in relation to such variables as the overall population size at the site, the proportion of juveniles in the population, and the local nature of "bunching" behavior. As a general rule of thumb though, we suggest that when population sizes are large, sample sizes of over 500 are desirable; samples from 100 to 500 may prove acceptable though they should be examined critically, while samples of 50 or fewer birds are too small for any realistic estimate of age proportion. Smaller samples would be acceptable in estimating age proportions within smaller populations in which a reasonable proportion of the birds present are aged. These conside proportions apply whether birds are aged through a telescope or in the hand.

Despite the sampling difficulties, we are confident that adequate age proportion data can be collected on the non-breeding grounds through either cannon-netting or through telescope observations. Provided the chosen methodology is used consistently, it should be possible to make robust comparisons between different years. It should also be possible to make comparisons between different sites. Few studies of age proportions in different parts of the non-breeding range have been carried out, but existing data suggest that geographical variation in age proportions of non-breeding waders can occur on large scales. For example, in Victoria, immature proportions of Red-necked Stints are consistently lower at the Western Treatment Plant than at other sites, such as Anderson's Inlet about 200 km to the east (CD.T. Minton, pers. comm.). On a still larger scale, the immature proportions of Western Sandpipers show a U-shaped distribution, with high immature proportions occurring in the north and south of the non-breeding range, with lower immature proportions in the intervening non-breeding areas of southern Mexico and Central America (Nebel *et al*. 2002). With geographical variation occurring on such large scales, it would obviously be desirable to measure age proportions at many different non-breeding sites.

Telescope observations could play a valuable role in increasing the geographical range over which age proportion data are collected. The fieldwork is not intensive. Now that we are familiar with the ageing methods and surveying times appropriate for the WTP, we think that a single observer could obtain representative age proportions there in only 2-4 strategically timed days of rather enjoyable fieldwork. Many other shorebirds sites could probably be monitored with a smaller investment of time, for the WTP is a relatively complex site containing many different feeding and roosting areas. If age proportion data were collected and reported from just a small proportion of the sites where shorebird observers regularly carry out counts or other observations, we would have a valuable tool for monitoring the breeding success and understanding the population dynamics of migratory shorebirds.

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Monitoring Shorebird Breeding Productivity by The Percentage of First Year Birds in Populations in S.E. Australian Non-breeding Areas

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Abstract

Reproductive success is one of the two key variables governing population levels. Direct measurement on a long-term basis at breeding locations is not practicable for most migratory shorebirds. Currently the best monitoring method seems to be the measurement of the proportion of young (first year) birds in samples caught for banding in the non-breeding season. This gives an index of breeding success for the previous breeding season. Twenty-six years of data collected by the Victorian Wader Study Group in S.E. Australia show that year to year variations in each species are quite marked and that there is limited synchrony between species except for the occasional very good or very bad breeding year. Red-necked Stint / Curlew Sandpiper and Ruddy Turnstone / Sanderling were the species pairs that showed the best correlations between changes in breeding success in successive years. Only the Red-necked Stint shows a noticeable three-year cycle of breeding success, but that broke down for a period in the 1990s. The proportion of first-year Red-necked Stint and Curlew Sandpiper was correlated with counts in the subsequent austral winter, but no correlations were found in any species between proportion of first-year birds and counts made in the same summer. Mortality rate data will be needed to assess how much the apparently low overall percentage first year breeding success figures have contributed to the major population declines observed in most species. It is important to continue the "percentage first year" breeding success data collection on a long-term basis if population trends determined from counts are to be understood.

Introduction

Breeding success and survival rates are the two key parameters controlling wader populations. Knowledge of both, particularly over a long period of time, is essential to understanding changes in population levels (Boyd and Piersma 2001, Minton 2003, Sandercock 2003, Atkinson et al 2003). Changes may range from short-term and annual variations caused by weather and predation conditions on the arctic breeding grounds to long-term trends associated, for example, with climatic change or habitat changes at migratory stopover sites.

There are several methods of obtaining an estimate or index of reproduction rates of long distance migrant shorebirds, all having certain advantages, but also limitations (Soloviev and Tomkovich 2000, Minton et al. 2000, Yosef 2002, Minton 2003, Rogers et al. 2004). This paper uses the percentage of first year birds in banding catches and an index of breeding success for migratory shorebirds in S.E. Australia. It brings together the percentage first year data collected over a 26-year period in S.E. Australia (Minton et al 2000, 2001, 2002a, b, 2003a, b, 2004, Minton 2003). It also carries out an initial comparison of this with population count data. More detailed examinations of the data for each species and its relation to factors such as the date of annual snow melt, June/July arctic temperatures, predator population levels, special weather events such as flooding, the breeding area of each species and the individual breeding habitat are planned. An initial draft paper covering some of these aspects has already been submitted for publication (Soloviev et al. 2006).

Methods

Sampling

All data were collected by the Victorian Wader Study Group (VWSG). The sampling process was standardised as far as practicable to minimise potential biases in the data and to make year to year comparisons as realistic as possible (Minton et al 2000, 2001). All catches included in the analysis were made by cannon netting, at high tide roosts. Mist netting generally gives higher proportions of juveniles than in cannon net catches at the same location (Pienkowski and Dick 1976, Goss-Custard et al 1981, personal obs.). Data from the two catching methods should therefore not be amalgamated. As the majority of Australian wader catches have been made by cannon netting, data obtained by this method were preferred for this analysis.

Only catches made in the period mid-November to mid-March were utilised, this being the period in Australia when migrant wader populations are relatively stable. However for Curlew Sandpipers, *Calidris ferruginea*, and Sharp-tailed Sandpipers, *Calidris acuminata*, only catches up to the end of February were included as northward migration of adult birds of these species from S.E. Australia commences in early March (VWSG unpubl.). Most catches were made at coastal sites in Victoria but some data over the last ten years came from the southeast coast of South Australia.

For each species attempts were made to catch at as many different locations as possible to broaden the sampling base. However some of the species studied occurred in only a few locations (e.g. Sanderling, *Calidris alba*, Ruddy Turnstone, *Arenaria interpres*, Red Knot, *Calidris canutus*, and Bar-tailed Godwit, *Limosa lapponica*). The timing of annual visits to each location was also standardised as far as possible to minimise any potential temporal variations.

All catches made during the sampling period were included in the analysis regardless of size and catching circumstances. Young birds are known to be non-uniformly distributed on both a macro scale (region, location) and a micro scale (different habitats at a location, within roosting flocks) (VWSG and AWSG unpubl. Rogers et al. 2004). Inclusion of all samples recognises and to some extent compensates for this situation. The amount of 'twinkling' (disturbing birds to get them into the catching area) before a catch can on occasions affect the proportion of young birds in a catch (pers. obs.). Twinkling effort is difficult to quantify and no attempt to correct for it has been made in this paper.

All species covered in this paper could be aged in the hand throughout the Nov.-Mar. period. The three main methods of identifying juvenile/first year birds were (a) plumage criteria; especially retained juvenile inner median wing coverts, (b) primary wear; little initially on juveniles, but late more than in freshly moulted adults, (c) primary moult; either none at all in juveniles or alternatively initiated much later than in adults and often partial only, starting mid-wing.

Estimating breeding success

"Breeding success" is expressed as the percentage of first year birds in the total number of birds caught. This was only calculated for years where the total catch of a species exceeded 30 birds. Atkinson *et al*. (2003) used a similar minimum sample size when calculating individual juvenile/adult proportions. The "percentage first-year" figure is technically the recruitment rate into the population of young birds which have survived their first southward migration from the breeding grounds. Adjustments would have to be made, if the actual reproduction rates were required, to recognise not only that some birds would not have survived their first southward migration but that only part of the "adult" population had contributed to the annual production of young. This is because in most wader species which visit Australia breeding does not commence until birds are two or more years old. However evaluation of the effects of such an adjustment showed (Minton 2004) that calculated reproduction rates were only slightly higher than recruitment rates, and that the ranking of years was not greatly affected. For this reason, and also because recruitment into the total population is the key parameter which needs to offset mortality of that population for long-term population stability, unadjusted juvenile/first year percentages are used throughout this paper.

Population data against which recruitment rates are compared were derived from the Australasian Wader Studies Group Population Monitoring Count Programme. This biannual census has been carried out at key wader locations around Australia since 1981, with a count each January/February (summer) and June/July (winter). Only the count data from Victoria were used in this analysis for comparability with the percentage first year data.

The tables in this paper express the proportion of first years in two ways; we refer to one as the "first-year percentage". This was calculated as follows:

If we have N birds comprising A adults and J first year birds. Then:

Juvenile Percentage = $P = J / N \times 100$
and its standard error = $SE\{P\} = \sqrt{(P.(1-P)/N)}$

Annual correlations of first year percentages were tested with the Spearman Rank Correlation Coefficient (R_s).

Results

Sample sizes

Victorian Wader Study Group catch data for S.E. Australia used in this analysis goes back to late 1978 when cannon netting was first introduced. Mist netting had been in progress since late 1975, but this early data and other mist-netting data generated since then have not been used. All cannon-netting data up to 30 June 2004 have been included.

Useable samples have been obtained each austral summer since 1978-79 for Red-necked Stints, *Calidris ruficollis*, (26 years) and since 1979-80 for Curlew Sandpiper (25 years). The Sharp-tailed Sandpiper data is almost as comprehensive with only three years having insufficient data over the same 26-year period. There are more gaps in the data for Red Knot (13 years of useable data) and Bar-tailed Godwit (15 years of useable data) as the South-eastern Australian populations are difficult to catch.

Locations for catching satisfactory numbers of Ruddy Turnstone and Sanderling were not developed until later in the study. However since useable samples of the former were first caught in late 1989 and of the latter in early 1991 there has been only one year for each species without sufficient data, giving data sets of 14 and 13 years respectively.

Table 1 shows the catching results for a typical year, in this case, the 2002/03 austral summer. The number of large (>50) and small (<50) catches are shown together with the total number of birds caught and the number and proportion aged as first year. In this particular year one of the seven species monitored each year in S.E. Australia was not sampled in sufficient numbers to give a meaningful percentage first year figure. These catches follow the 2002 arctic breeding season and are therefore a measure of the breeding success in 2002.

Red-necked Stint and Curlew Sandpiper

Catch data and the percentage of first year birds over a 26-year period for Red-necked Stint and 25-year period for Curlew Sandpiper are shown in Table 2. The last 16 years of the data are used in the analysis below (Figure 1).

Consistently high catches of Red-necked Stint (range 1804 to 6351) were made each year giving a total of 67408 birds. Curlew Sandpiper annual catches (233 to 2232) were also sufficient to give a satisfactory measure of annual breeding success though sample sizes declined over this 16-year period as the overall Curlew Sandpiper population

Table 1. Percentage of first year birds in cannon net catches of shorebirds in S.E. Australia in 2002/2003. All catches in period 28 Nov 2002 to 27 Feb 2003 except for Sanderling, Ruddy Turnstone and Red-necked Stint where catches up to 12 Mar 2003 are included.

Species	No. of catches		Total	First year birds		
	Large >50	Small <50	Caught	No.	Percent (%)	SE (%)
Ruddy Turnstone	-	4	89	15	16.9	3.97
Red-necked Stint	7	10	3357	438	13.0	0.58
Sanderling	2	5	459	196	42.7	2.31
Curlew Sandpiper	3	8	402	60	14.9	1.78
Sharp-tailed Sandpiper	2	5	270	54	20.0	2.43
Red Knot	-	3	12	11	91.7	7.98
Bar-tailed Godwit	1	2	164	27	16.5	2.90

Table 2. Cannon net catches of Red-necked Stint and Curlew Sandpiper in S.E. Australia between 1978/79 and 2003/04. All catches in the period late November to end February except for a few Red-necked Stint catches up to 20th March in some years

Year	Red-necked Stint						Curlew Sandpiper						
	No. of catches		Total	First year birds			No. of catches		Total	First year birds			
	Large >50	Small <50	Caught	No.	Percent (%)	SE{P} (% Pts)	Large >50	Small <50	Caught	No.	Percent (%)	SE{P} (% Pts)	% Curlew Sandpipers in Catches
78/79	4	4	871	148	17.0	1.27	-	-	-	-	-	-	-
79/80	9	6	3229	207	6.4	0.43	5	6	1922	132	6.9	0.58	35
80/81	7	6	2205	123	5.6	0.49	2	7	279	28	10.0	1.80	11
81/82	7	3	2542	407	16.0	0.73	3	5	210	20	9.5	2.03	7.6
82/83	9	3	1518	121	8.0	0.70	3	4	842	126	15.0	1.23	36
83/84	4	2	1515	98	6.5	0.63	4	2	730	54	7.4	0.97	32
84/85	8	-	3640	655	18.0	0.64	4	4	1175	54	4.6	0.61	24
85/86	8	1	2280	410	18.0	0.80	3	6	832	74	8.9	0.99	27
86/87	9	-	2795	190	6.8	0.48	5	3	1333	65	4.9	0.59	32
87/88	10	2	4896	1028	21.0	0.58	6	7	942	160	17.0	1.22	16
88/89	8	1	5436	750	13.8	0.47	7	3	879	282	32.1	1.57	14
89/90	4	1	2314	17	0.7	0.18	4	1	889	3	0.3	0.19	28
90/91	7	-	3824	545	14.3	0.57	2	5	963	102	10.6	0.99	20
91/92	8	4	1994	580	29.1	1.02	4	3	437	198	45.3	2.38	23
92/93	15	-	4340	163	3.8	0.29	6	6	2232	6	0.3	0.11	34
93/94	10	3	6015	892	14.8	0.46	6	4	1239	215	17.4	1.08	17
94/95	7	8	3191	594	18.6	0.69	3	9	954	92	9.6	0.96	23
95/96	8	3	1804	452	25.1	1.02	4	5	506	30	5.9	1.05	22
96/97	10	7	3526	421	11.9	0.55	5	13	636	56	8.8	1.12	15
97/98	11	8	4232	331	7.8	0.41	5	10	934	196	21.0	1.33	18
98/99	9	6	4854	1572	32.4	0.67	5	5	737	30	4.1	0.73	13
99/00	19	6	4885	1108	22.7	0.60	6	4	1016	206	20.3	1.26	17
00/01	11	14	5815	770	13.2	0.44	2	11	381	26	6.8	1.29	6.1
01/02	15	8	6351	2188	34.5	0.60	3	5	419	115	27.4	2.18	6.2
02/03	7	10	3357	438	13.0	0.58	3	8	402	60	14.9	1.78	11
03/04	12	7	5470	1259	23.0	0.57	2	6	233	34	14.6	2.31	4.1
All	236	113	92899	15467	16.6	0.12	102	142	21122	2364	11.2	0.22	18.5
Median					14.5						9.6		

decreased. The mean percentage of first year Red-necked Stint was 18% and the mean for Curlew Sandpiper was 13%. In both species there was marked annual variation. In some years the percentage first-years of the two species were dissimilar (e.g. 1995/96, 1998/99). However in 1989/90 and 1992/93 both species had record low percentage first year figures and in 1991/92 both had extremely high percentage first year figures.

The mid-1990s seems to have been a period when both species had a higher than average proportion of poor breeding years. In the Red-necked Stint four out of the six years between 1992/93 and 1997/98 showed percentage first year figures below average. For Curlew Sandpiper six of the nine years between 1992/93 and 2000/01 were below average. In contrast, four of the years from 1998/99 to 2003/04 had above average outcomes for the Red-necked Stint, with two of those years having the percentage of first year birds at record levels. The situation has also improved recently for Curlew Sandpiper with all three years since 2001/02 having an above average percentage of first year birds.

A three-year cycle of breeding success has been reported in Curlew Sandpipers spending the non-breeding season in South Africa (Summers and Underhill 1987). There was no clear evidence for such a pattern in Curlew Sandpipers or Red-necked Stints in S.E. Australia. In Curlew Sandpiper in S.E. Australia the period between good breeding years in the 25-year period since 1979/80 has varied between two years (most frequent) and five years, with only one clear three-year interval (both 1988 and 1991 had good breeding outcomes). Red-necked Stint showed quite a noticeable three-year cycle in the early years (1978, 1981, 1984, and 1987 were higher than adjacent years). After that the pattern broke down for a period. It was restored with 1995, 1998, and 2001 showing better breeding performance than adjacent years.

In the non-breeding areas, such as S.E. Australia, Red-necked Stints and Curlew Sandpipers usually occur together in mixed flocks at high tide roosts. It is thus normal to catch both species at the same time when cannon netting. Whilst Red-necked Stints have always outnumbered Curlew Sandpipers at all S.E. Australian locations, the proportion of Curlew Sandpipers in flocks has gradually decreased over recent years (AWSG count data, and see later in this paper). This change can be seen in Table 2: the proportion of Curlew Sandpipers decreased from typically 25-35% in the period 1979/80 to 1986/87 to typically 20-28% in the period between 1987/88 and 1995/96 to less than 10% in three of the last four years (average 7% from 2000/01 to 2003/04). In fact the magnitude of this change was probably greater than these figures imply, as more effort went into catching Curlew Sandpipers in later years when it became difficult to meet the season quota.

The percentage of first-year Red-necked Stint and Curlew Sandpiper is plotted against summer and winter population counts in Victoria in Figures 2 and 3. In these figures the counts are shown opposite the years in which they were made. However the percentage first year figures plotted against each year relate to the breeding success of the preceding year's arctic summer. Thus for example the

Figure 1 - Percentage First Year Red-necked Stint and Curlew Sandpiper in Wader Catches in SE Australia 1988/89 to 2003/04

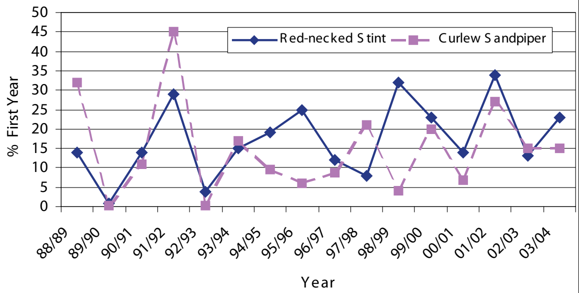


Figure 2 - Red-necked Stint Summer & Winter counts compared with % First year birds in catches in SE Australia

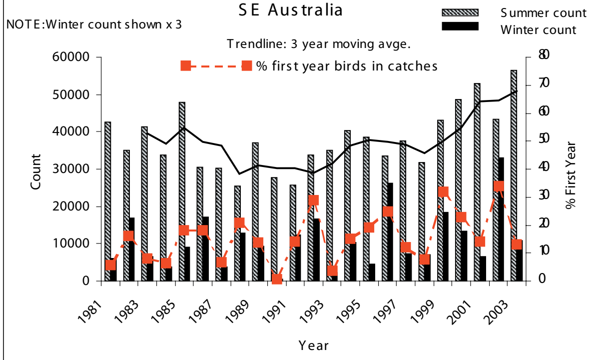


Figure 3 - Curlew Sandpiper Summer & Winter counts compared with % First year birds in catches in SE Australia

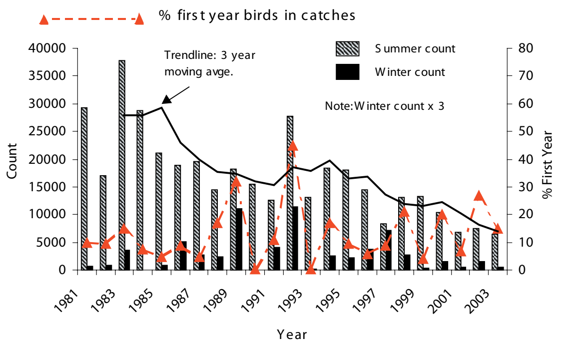
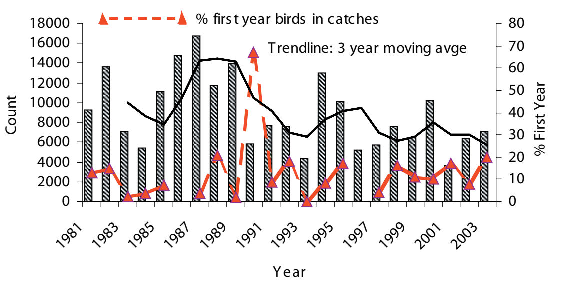


Figure 4 - Summer Count of Sharp-tailed Sandpipers compared with % First year birds in catches in SE Australia



counts in summer and winter 2003 have plotted against them the percentage first year birds recorded in the 2002/03 "season" (i.e. mid November 2002 to end February 2003) which were a measure of breeding success in 2002 (13.0% for Red-necked Stint and 14.9% for Curlew Sandpiper). The three-year moving averages of the summer population are also shown.

In Red-necked Stint the number of birds present in the austral winter population very closely mirrors the breeding success in the preceding arctic summer (Figure 2). This correlation is highly significant (R_s = 0.852, $p < 0.001$, Figure 7). The overall austral summer population of Red-necked Stints has varied significantly from year to year. The three-year moving average clearly shows, however, a marked increase in population level since 1999, of the order of 40%. The winter counts of Curlew Sandpipers also correspond reasonably well with annual breeding success measurements up until 1995 (Figure 3). However since then the correlation is rather less good as wintering populations in Victoria have almost disappeared. Nevertheless the correlation is still significant over the full 22-year period (R_s = 0.554, p = 0.007, Figure 8). The three-year trend-line of the summer population shows an almost continuous decline since the mid-1980s with the average population decreasing from around 28,000 to around 14,000 (50%).

Sharp-tailed Sandpiper

Catch data and the percentage of first year birds back to 1979/80 for Sharp-tailed Sandpiper are shown in Table 3. The percentage of first year birds is plotted against summer count data in Figure 4; there is no significant correlation between the two (R_s = 0.005, p = 0.98). This may reflect the quality of the count data (see discussion).

Table 3. Percentage of first year Sharp-tailed Sandpiper in catches in S.E. Australia between 1979/80 and 2003/04. All birds caught in cannon nets between mid November and end February.

Year	No. of catches		Total	First year birds		
	Large >50	Small <50	Caught	No.	Percent (%)	SE (%)
79/80	1	7	226	2	0.9	0.62
80/81	1	5	180	24	13.3	2.53
81/82	-	9	88	13	14.8	3.78
82/83	3	4	367	8	2.2	0.76
83/84	-	5	57	2	3.5	2.44
84/85	1	5	451	34	7.5	1.24
85/86	-	3	9	0	-	-
86/87	1	6	160	6	3.8	1.50
87/88	2	10	689	147	21.3	1.56
88/89	1	4	101	2	2.0	1.39
89/90	1	2	66	44	66.7	5.80
90/91	-	3	56	5	8.9	3.81
91/92	2	6	358	65	18.2	2.04
92/93	1	6	119	0	-	-
93/94	-	7	36	3	8.3	4.61
94/95	2	6	214	36	16.8	2.56
95/96	-	6	23	2	8.7	5.88
96/97	1	11	146	6	4.1	1.64
97/98	2	16	341	53	15.5	1.96
98/99	1	5	308	33	10.7	1.76
99/00	2	7	244	25	10.2	1.94
00/01	-	7	32	5	15.6	6.42
01/02	2	4	535	42	7.9	1.16
02/03	2	3	270	54	20.0	2.43
03/04	3	7	989	388	39.2	1.55
All	29	154	6065	999	16.5	0.48
Median					10.2	

Sharp-tailed Sandpiper appear to have a rather more variable breeding outcome between years than Red-necked Stint and Curlew Sandpiper. Whilst the mean percentage first year is 16.5%, the median is 10.2%. In 11 of the 23 years for which data are available the percentage first year birds was less than 9%. At the other end of the scale two years had phenomenal breeding success with 66.7% first year birds in 1989/90 and 39.2% in 2003/04. There is no sign of any three-year cycle.

Summer populations of Sharp-tailed Sandpipers show more marked variation from year to year than Red-necked Stints and Curlew Sandpipers. The three-year moving average reflects this but still indicates that, as in Curlew Sandpiper, there has been a marked decline in recent years. An average population of around 14,000 in the late 1980s has now decreased to an average of around 6,000.

In winter almost no Sharp-tailed Sandpipers remain in Victoria. Thus it is not possible to compare breeding outcomes with the population in the subsequent austral winter.

Red Knot

Red Knot catch data and the percentage of first year birds back to 1978/79 are shown in Table 4. This species occurs at relatively few locations in Victoria and overall is more difficult to catch than the smaller shorebirds. Furthermore in some years (years following poor breeding seasons) the species is almost totally absent from certain locations, especially ones where catches are more easily made. Thus over a 26-year period no samples were obtained at all in two of the years and inadequate samples (treated as <30 birds) in a further 11 years.

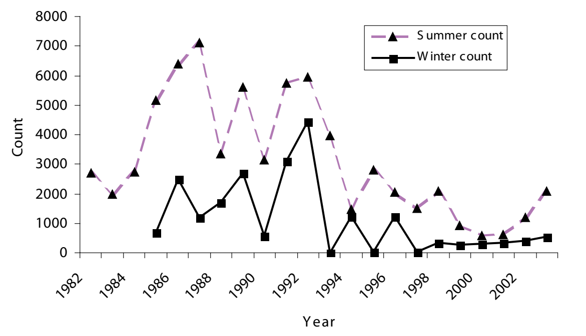
Table 4. Percentage of first year Red Knot in catches in S.E. Australia between 1978/79 and 2003/04. All birds caught in cannon nets between mid November and mid March.

Year	No. of catches		Total	First year birds		
	Large >50	Small <50	Caught	No.	Percent (%)	SE (%)
78/79	-	3	12	6	-	-
79/80	-	6	37	13	35.1	7.85
80/81	-	-	-	-	-	-
81/82	-	2	40	11	27.5	7.06
82/83	-	4	49	49	100.0	0.00
83/84	-	3	5	3	-	-
84/85	1	1	63	9	14.3	4.41
85/86	1	3	91	38	41.8	5.17
86/87	-	3	50	17	34.0	6.70
87/88	-	-	-	-	-	-
88/89	-	2	6	4	-	-
89/90	-	3	18	3	-	-
90/91	2	1	173	166	96.0	1.50
91/92	-	1	1	1	-	-
92/93	-	3	33	8	24.2	7.46
93/94	-	2	2	1	-	-
94/95	-	1	1	1	-	-
95/96	-	3	58	38	65.5	6.24
96/97	-	1	1	1	-	-
97/98	-	3	40	25	62.5	7.65
98/99	-	4	25	7	-	-
99/00	1	2	320	121	37.8	2.71
00/01	1	-	119	62	52.1	4.58
01/02	3	1	363	249	68.6	2.44
02/03	3	-	12	11	-	-
03/04	-	1	22	19	-	-
All	**12**	**53**	**1541**	**863**	**56.0**	**1.26**
Median					41.8	

In the 13 years in which larger samples were available it is immediately apparent that the percentages of first year birds were consistently very much higher than in any other species. The mean percentage of first years was 56.0% and the median 41.8%. Only two years were below 30% (14.3% and 27.5%), and figures range up to 96% and even 100%.

The summer and winter population count data for Red Knot are plotted in Figure 5. Breeding success data is not plotted on the graph because of the absence of figures for half the years. The count data plotted, which in this case is confined to the main Red Knot area in Victoria at Nooramunga National Park in Corner Inlet, shows that both the summer and winter populations have declined over recent years. Although marked yearly fluctuations are apparent, the average summer count of around 5,000 in the period 1985 to 1993 has decreased to an average of around 1,000 over the four summers since 2000, an 80% decline. Winter counts seem to have fallen to a plateau of around 200 to 500 over the last six years, whereas winter populations of 1,000 to 3,000 (once 4,500) were more typical in the period from 1986 to 1992.

Figure 5 - Summer & Winter Counts of Red Knot in Nooramunga NP, Corner Inlet



Bar-tailed Godwit

Yearly catch samples were also somewhat variable in the Bar-tailed Godwit (Table 5). However, in 15 years out of the 25-year period samples of over 30 birds were obtained. Age proportions in these samples varied markedly, as in the Sharp-tailed Sandpiper, with the mean annual percentage of first year birds being 12.2% and the median 13.3%. There were six breeding years with a percentage first year figure of 3.6% or less. Three of these poor breeding outcomes occurred in the last four years. In contrast there were two excellent years with 41.4% and 60.5% first year birds.

Summer and winter count data from Nooramunga National Park in Corner Inlet are plotted in Figure 5. Again, percentage first year data is not included in the graph because of the number of gaps in the data and because it would not be expected to have any close correlation with the winter population count (because the winter population is composed at least three different age cohorts – VWSG and AWSG data).

The population decrease of Bar-tailed Godwit from its high point in the late 1980s is not as marked as in the Red Knot and other species. The average population of around 11,000 in 1986 to 1991 period has fallen to an average of

Table 5. Percentage of first year Bar-tailed Godwit in catches in S.E. Australia between 1979/80 and 2003/04. All birds caught in cannon nets between mid November and mid March.

Year	No. of catches		Total caught	No. first year	% first year
	Large >50	Small <50			
79-80	1	-	181	1	0.6
80-81	-	-	-	-	-
81-82	-	2	38	23	60.5
82-83	-	-	-	-	-
83-84	-	1	12	-	-
84-85	-	1	45	12	26.7
85-86	1	2	90	3	3.3
86-87	-	1	8	5	-
87-88	-	1	1	1	-
88-89	-	-	-	-	-
89-90	-	3	89	11	12.4
90-91	1	2	94	25	26.6
91-92	1	-	180	4	2.2
92-93	-	3	49	7	14.3
93-94	-	-	-	-	-
94-95	-	-	-	-	-
95-96	1	1	166	22	13.3
96-97	-	3	13	7	-
97-98	-	1	16	-	-
98-99	1	3	99	41	41.4
99-00	-	2	36	7	19.4
00-01	1	-	83	3	3.6
01-02	2	-	282	4	1.4
02-03	1	2	164	27	16.5
03-04	-	1	43	1	2.3
TOTAL	**10**	**29**	**1689**	**204**	
Mean					12.1
Median					13.3

about 7,000 during the last five years, a decline of around 35%. The winter population count has followed a rather irregular course with a peak of 4,000 in the 2000 winter but less than 500 during some winters.

Ruddy Turnstone and Sanderling

Satisfactory data have only been gathered on Ruddy Turnstone since the 1989/90 summer and on Sanderling since 1990/91. Non-breeding populations of both these species in Victoria are quite small (500 and 570 respectively, Watkins 1993) and it was only when the VWSG started making visits to western Victoria and, more particularly, the significantly larger populations on the south-east coast of South Australia (1500 and 2000 respectively – Watkins 1993) that worthwhile catches were able to be made.

Data for 14 years for Ruddy Turnstone and 13 years for Sanderling are given in Tables 6 and 7. No satisfactory count data is available for comparison because much of the population of these two species inhabits sections of the coast which are not part of the population count monitoring project.

Both species show a pattern of a wide variation in percentage of first year birds. In the Ruddy Turnstone the mean is 18.8% first year birds and the median is 9.3%. 1989/90 was the poorest season with no first year birds found in a catch of 109 birds. In six years the percentage first year birds was less than 7%. In contrast excellent breeding success in three years was reflected in percentage first year figures of 29.4%, 40.2%, and 80.3%.

Table 6. Percentage of first year Ruddy Turnstone in catches in S.E. Australia between 1989/90 and 2003/04. All birds caught in cannon nets between mid November and mid March.

Year	No. of catches		Total caught	No. first year	% first year
	Large >50	Small <50			
89-90	1	-	109	0	0
90-91	1	2	140	16	11.4
91-92	1	3	152	122	80.3
92-93	-	3	78	2	2.6
93-94	-	2	14	1	-
94-95	2	5	185	11	6.0
95-96	-	6	108	10	9.3
96-97	1	5	197	12	6.1
97-98	4	7	331	133	40.2
98-99	1	4	177	11	6.2
99-00	-	5	51	15	29.4
00-01	-	6	181	19	10.5
01-02	1	4	118	11	9.3
02-03	-	4	89	15	16.9
03-04	-	9	122	8	6.7
TOTAL	**12**	**65**	**2052**	**386**	
Mean					18.8
Median					9.3

Table 7. Percentage of first year Sanderling in catches in S.E. Australia between 1990/91 and 2003/04. All birds caught in cannon nets between mid November and mid March.

Year	No. of catches		Total caught	No. first year	% first year
	Large >50	Small <50			
90-91	1	-	208	29	13.9
91-92	-	-	-	-	-
92-93	-	1	35	6	17.1
93-94	1	1	161	23	14.3
94-95	-	2	49	6	12.2
95-96	1	1	192	6	3.1
96-97	2	-	404	6	1.5
97-98	1	4	271	82	30.2
98-99	1	1	110	11	10.0
99-00	1	-	462	58	12.6
00-01	2	-	243	7	2.9
01-02	4	2	483	49	10.1
02-03	2	5	459	196	42.7
03-04	-	4	74	2	2.7
TOTAL	**16**	**21**	**3151**	**481**	
Mean					15.3
Median					12.2

The mean percentage first year birds in Sanderling were 15.3% and the median was 12.2%. These figures are not markedly different from those for Ruddy Turnstone. Poor breeding outcomes only occurred in four years (1.5% to 3.1%, cf. > 10% in all other years). In only two years were the percentage first year figures higher than 18% (30.2% and 42.7%).

Comparison between species in each year

Based on the data presented earlier for the seven species monitored, the breeding outcome for each species in each year has been categorised. Classifications of very poor, poor, moderate, good, or very good were based on defined ranges for each species derived by consideration of the mean and median percentages of first year birds. Ranges were chosen arbitrarily, but centred on the mean percentage first year figure, to give approximately a third of the years in each of the three broader categories. Where performance was exceptionally good or poor, then "very" was used to signify this. The results of categorisation are given in Table 8.

Table 8. Breeding success based on the percentage of first year birds in cannon-net catches in S.E. Australia. Classification based on mean % of first year figures.

Season	Red-necked Stint	Curlew Sandpiper	Sharp-tailed Sandpiper	Red Knot	Bar-tailed Godwit	Ruddy Turnstone	Sanderling
78/79	M						
79/80	P	P	VP	M	VP		
80/81	P	M	M				
81/82	M	M	G	P	VG		
82/83	P	G	VP	VG			
83/84	P	M	P				
84/85	G	P	P	VP	G		
85/86	G	M		M	P		
86/87	P	P	P	P			
87/88	G	G	G				
88/89	M	VG	VP				
89/90	VP	VP	VG		M	VP	
90/91	M	M	M	VG	G	M	M
91/92	VG	VG	G		P	VG	
92/93	VP	VP	VP	P	M	VP	G
93/94	M	G	M				M
94/95	G	M	G			P	M
95/96	G	P		G	M	M	P
96/97	M	M	P			P	VP
97/98	P	G	G	G		VG	VG
98/99	VG	M	M		VG	P	M
99/00	G	G	M	M	G	G	M
00/01	M	P	G	G	P	M	VP
01/02	VG	VG	P	G	VP	M	M
02/03	M	G	G		G	G	VG
03/04	G	G	VG		P	P	VP
Years of data	26	25	23	13	15	14	13
Mean % first year	16.6%	11.2%	16.5%	56.0%	12.1%	18.8%	15.3%
Median % first year	14.5%	9.6%	10.2%	41.8%	13.3%	9.3%	12.2%
Very Poor (VP)	<5%(2)	<3%(2)	<3%(4)	<20%(1)	<2%(2)	<3%(2)	<3%(3)
Poor (P)	<11% (6)	<7% (6)	<7% (3)	<35% (3)	<5% (4)	<7% (4)	<10% (1)
Moderate (M)	11-20% (11)	7-15% (10)	7-16% (9)	35-65% (5)	5-17% (4)	7-12% (4)	10-15% (6)
Good (G)	>20% (4)	>15% (4)	>16% (5)	>65% (2)	<17% (3)	>12% (2)	>15% (1)
Very Good (VG)	>28%(3)	>25%(3)	>25%(2)	>90%(2)	>30%(2)	>30%(2)	>25%(2)

Some of the more obvious observations from this table are:

a) The 1991 arctic breeding season, as reflected in the 1991/92 percentage first year figures, was an exceptionally successful one. Three of the five species for which data was available came in the "very good" classification. However note that one species, Bar-tailed Godwit, was classed as "poor".
No other year had quite the same high level of breeding success, but 2002 (reflected in the 2002/03 figures) came close with one species being classed as "very good" and another four as "good". 1997 was also similar with two species being classed as "very good" and three as "good". Note that this year occurred in the middle of a run of generally poor breeding seasons.

(b The 1992 arctic breeding season, as shown by the 1992/93 percentage first year figures, was particularly poor. Four of the seven species were categorised as "very poor" and another as "poor".
The 1989 breeding season was also extremely bad with three of the five species monitored being in the "very poor" category. 1979/80 was the only other year in which two "very poor" categorisations occurred, but another two species of the five species monitored were classified as "poor". This suggests that 1979 was also a generally poor breeding year in the arctic.

(c) In some years one or more species had apparent breeding outcomes markedly different from other species. For example in the very poor 1989 breeding season Sharp-tailed Sandpipers had an excellent outcome with a categorisation of "very good" and their highest ever percentage first year figure (66.7%). Similarly the best-ever outcome for Bar-tailed Godwit (60.5% first year) occurred following the 1981 breeding season when most other species only had "moderate" breeding success.
Red Knot quite often deviated from the general pattern with particularly good outcomes in the 1982 and 1990 breeding seasons, when most other species had "moderate" to "poor" breeding success.

Discussion

It needs to be borne in mind that the data considered in this paper for determination of breeding success is based on catch samples made on average some six months after juvenile birds fledged. Annual variations in mortality during this period could have contributed to the year to year fluctuations in the proportion of first year birds. However such variations are considered likely to be small in relation to the well-known propensity of arctic-breeding birds to exhibit wide variations in breeding success from year to year. It is therefore assumed, in the discussion below, that annual variations in the percentage of first year birds primarily relate to breeding outcomes.

Mean and median levels of percentage first year birds

Both mean and median percentage first year figures are shown for each species in the principal tables of results. This is because the occasional atypical very high or very low breeding success year can markedly affect the mean. In such cases the median may give a better indication of the typical level of breeding success over the years. Therefore both the mean and median are considered when assessing breeding outcomes.

The mean and median level of percentage first year birds showed no clear pattern (e.g. size-related) with means between 11.2% and 18.8%, and medians between 9.3% and 14.5%, for six of the seven species. The Red Knot is the exception with a mean of 56.0% and a median of 41.8%. Excepting Red Knot, the Red-necked Stint, the smallest of the species, shows the highest median percentage first year figure over the whole period (14.5%) and the second highest mean (16.6%). Furthermore, the largest of the seven species, the Bar-tailed Godwit, showed the second lowest mean percentage first year birds (12.1%). Ruddy Turnstone surprisingly showed the highest mean percentage first year birds (18.8%), but had the lowest median (9.3%). The high mean was caused by two extraordinarily successful years, with 40.2% and 80.3% first year birds in catch samples.

A notable feature of the data is the low mean and median figures for Curlew Sandpipers (11.2%, and 9.6% respectively) even though it is the equal (with Sanderling) second smallest species monitored. These are the lowest and second lowest mean and median figures, respectively, of the seven species studied. This may be significant therefore in explaining why the population of Curlew Sandpiper has declined so markedly over a prolonged period (see later).

The Red Knot figures are markedly different from all other species, with a mean percentage first year birds of 56.0% and a median of 41.8%. There are two reasons for the Red Knot figures being much higher than for other species. Banding and flagging (VWSG unpubl, Riegen *et al.* 2004) has shown that many young Red Knot remain in Australia throughout their first year and then move to New Zealand, subsequently becoming part of the second year and adult population which spends the non-breeding season there. Therefore S.E. Australia holds a high proportion of the first year Red Knot population, far above that related to the adult non-breeding population in that area. Apparent breeding success is therefore greatly magnified.

Figure 6. Correlation between % first year and winter count figures for Red-necked Stint (Rs = 0.85, P<0.001, n = 22).

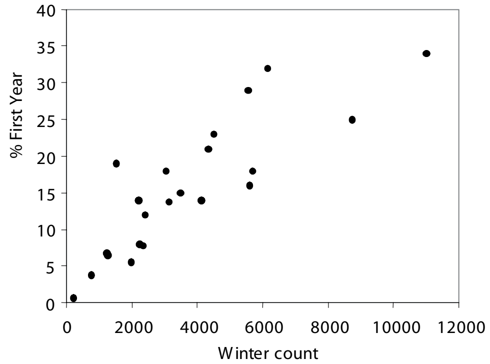


Figure 7. Correlation between % First Year and winter count figures for Curlew Sandpiper (Rs = 0.55, P = 0.007, n = 22).

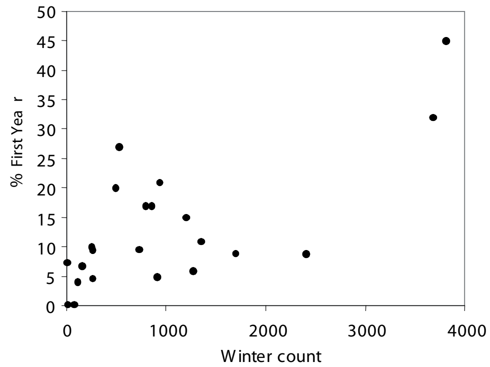


Figure 8. Correlation between Red-necked Stint and Curlew Sandpiper year to year changes in % first year figures (Rs = 0.43, P=0.04, n = 24), i.e. the difference between the percentage first year figures in successive years.

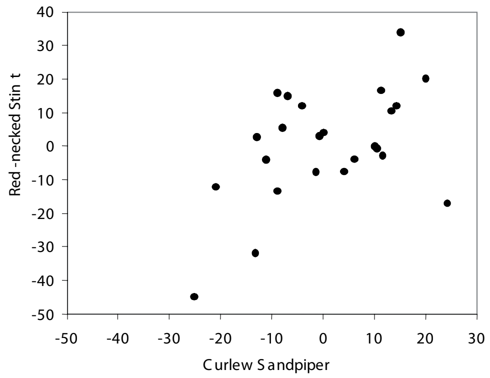
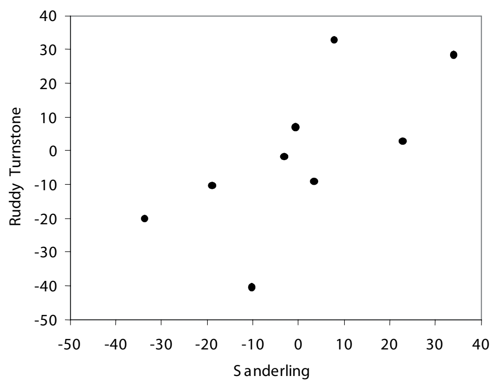


Figure 9. Correlation between Ruddy Turnstone and Sanderling year to year changes in % first year figures (Rs = 0.80, P = 0.01, n = 9), i.e. the difference between the percentage first year figures in successive years.



The distribution of these first year Red Knots in S.E. Australia also contributes to the distortion of the figures. Young birds tend to segregate into separate flocks and these often occur at locations away from the two main Red Knot non-breeding flocks in Swan Bay/Mud Islands and in Corner Inlet. The flocks of first year birds are generally easier to catch at such locations than birds in the main non-breeding locations. This therefore further magnifies the apparent proportion of young birds in the population, especially following good breeding years.

This segregation behavior of young birds may have been partly responsible for our failure to obtain adequate samples in 13 of the 26 years of the study. Whilst a few of the gaps in the data have been due to failed catching attempts (e.g. weather or unusual tide conditions) in many cases the lack of data is probably an indicator of a poor breeding year because there were no first year Red Knot at the best catching locations. This may be why there was only one year where an adequate catch was obtained but a relatively poor breeding performance (14.3%) was recorded. Many of the years without data were therefore probably years of low breeding success.

It is significant that the percentage of first year birds in Red Knot populations in New Zealand is always very low (<5%, Adrian Riegen, pers. comm.). Also, Red Knot spending the non-breeding season in N.W. Australia do not show these exceptionally high percentage first year figures (AWSG data, Minton *et al*. 2004). They are mainly from a different sub-species (*piersmai*) to the Red Knot which form the majority of the population in eastern Australia and New Zealand (*rogersii*).

Variations between species and years

The relationship between breeding success of arctic birds and the population levels of avian and terrestrial predators, controlled in turn by lemming abundance, was demonstrated by Summers (1986) and Summers and Underhill (1987). Data from Western Europe and South Africa suggested that a wide range of species (shorebirds and geese) often had similar breeding outcomes because each were subjected to the same predator pressure on the arctic breeding grounds. Three-year cycles of breeding success, coinciding with the typical lemming population cycle, were noted as occurring over a prolonged period.

The data from S.E. Australia show that there are quite frequently marked deviations from a uniform cyclic pattern for all species. There is little sign of a regular three-year cycle. This is not surprising considering that the birds coming to S.E. Australia mostly breed over different areas and a wider range of the arctic than the wader and wildfowl populations from which percentage first year data in the U.K. and South African non-breeding areas was examined. However Curlew Sandpipers from S.E. Australia have been recorded breeding as far west as the northwest Taimyr (90° east) and there is some overlap with the breeding range of South African birds (Minton *et al*. in press). The Red Knot in S.E. Australia are thought to come from Siberian breeding areas around 180° east, and the Bar-tailed Godwit which visit S.E. Australia breed in Alaska as far as 150° west. Thus shorebirds coming to Australia breed across a longitudinal range of 110°. Data is now collected systematically on lemming abundance and predator populations across a wide spectrum of arctic locations (Tomkovich and Soloviev 2003). It is now clear that there can be marked geographical variation in any particular year. Complete synchrony in breeding success across the seven species monitored in this study would therefore not be expected.

Nevertheless there were good correlations between certain species. For example Curlew Sandpiper and Red-necked Stint show a remarkably similar pattern of breeding success variation over the 16 years of data examined in detail in Table 2, and Figure 1. Only in three years were there markedly different outcomes, with Red-necked Stint breeding successfully and Curlew Sandpipers faring poorly in two such breeding years (1995 and 1998) and vice-versa in the third year (1997). There were three years (1988, 1991, and 2001) in which particularly good breeding success coincided and two years (1989 and 1992) when both had extremely poor breeding success. If the full 25-year data set is considered, the correlation between the percentage of first year Red-necked Stint and Curlew Sandpiper is not quite statistically significant ($R_s = 0.36$, $P = 0.08$). However if year-to-year changes (i.e. the *difference* between the percentage first year figures in successive years) in both species are compared then there is a significant correlation ($R_s = 0.43$, $P = 0.046$, n = 24, Figure 8). This means that generally both species have synchronous increases or reductions in breeding success between years. Both species have been shown by banding recoveries and flag-sightings to breed across virtually the same span of the arctic (Minton 1996, 1998). Some correlation could therefore be expected even though there are some differences in breeding area and habitat. Red-necked Stint tend to nest on higher ground and in areas slightly less far north than the high Arctic breeding Curlew Sandpiper.

Sharp-tailed Sandpipers from S.E. Australia appear to breed in a rather narrower range of longitude than the previous two species but, more importantly, have a markedly different nesting habitat. They prefer to nest on lower ground in extensive marshy and delta areas. They will thus be more prone to the effects of massive spring flooding which sometimes occurs in their breeding region, though their rather later commencement of breeding may obviate this (P. Tomkovich, pers. comm.). This potentially leads to lower breeding success when other species breeding on higher ground may be successful. A more likely explanation may be that their wet tundra habitat is less affected by the lemming/predator phenomenon, as lemmings are burrowing animals that avoid flooded ground. This could be why in two years (1989 and 2003) they had exceptionally good breeding success compared with other species. There is no correlation between the percentage of first year Sharp-tailed Sandpipers and Red-necked Stints ($R_s = 0.32$, $P = 0.14$), or Curlew Sandpipers ($R_s = 0.17$, $P = 0.44$), even when year-on-year changes are considered (STS and RNS: $R_s = -0.07$, $P = 0.78$, n = 20, and STS and CS $R_s = -0.10$, $P = 0.66$, n = 20).

There is some synchrony in the annual breeding outcomes for Ruddy Turnstone and Sanderling, but the correlation is not statistically significant ($R_s = 0.41$, $P = 0.18$). Although the absolute levels of percentage first year birds in the populations of each species were different, the direction of change between one year and the next was the same for both species in 7 of the 9 years where comparable data is available. For example both species clearly had excellent breeding success in 1997 and both species fared poorly in 1995 and 2003. Unfortunately data for only one species was available for the very poor breeding year of 1989 and for the very good breeding year of 1991. In the widespread poor breeding year of 1992 (Ganter and Boyd 2000). Sanderling was the only species that had a reasonably successful breeding outcome. There are nine year-on-year changes in the percentage of first year birds for both species and these are very significant (R_s = 0.80, P = 0.01, Figure. 10). Sanderling and Ruddy Turnstone both breed in the high arctic but there is little recovery/flag-sighting information from the breeding grounds to indicate how much the breeding areas of birds which visit S.E. Australia coincide geographically. Clearly however they are often subject to the same factors governing breeding success.

Bar-tailed Godwits are often different in their breeding outcome from the other six species. This is not surprising given their quite separate breeding area, in Alaska. Climatic conditions, as well as lemming/predator situations, can be markedly different in Alaska from those in northern Siberia in any particular year (R. Gill and P. Tomkovich, pers. comm., Arctic Birds Newsletters and http://www.arcticbirds.ru).

1991 was a year of widespread good breeding success across the Russian arctic (Ryabitsev 1998) and 1992 was a disastrous breeding season all around the arctic, a phenomenon attributed in part to an inclement summer caused by the Mount Pinatubo volcanic eruption (Ganter and Boyd 2000). These patterns were very clearly shown in the S.E. Australian data. The causes of other particularly good (1997, 2002) and bad (1979, 1989) breeding years have not yet been examined in detail.

Population trends

Winter population counts show a good relationship with percentage first year bird data in some species but not in others. Summer populations do not closely mirror percentage first year data, presumably partly because first year birds only form a small part of the total population and perhaps because the summer counts are imprecise. However longer term trends in summer populations are more likely to reflect any similar changes in breeding success measures.

The best correlation is shown in Red-necked Stints. The summer population remained fairly constant until 1999, with no apparent trend in the fluctuating percentage first year data either. However with the average mean percentage first year Red-necked Stint being 23% over the last six years, compared with 17% over the full 26-year period, it is not surprising that the higher breeding success level has led to a significant population increase in recent years.

There is also an excellent correlation between the annual breeding success and the winter population of Red-necked Stint the following year. Banding data has shown that these are all first year birds and that none of these migrate out of Australia at the end of their first year, with many remaining at their previous summer's non-breeding area (VWSG data). The correlation is so strong that in all but one of the 23 years for which breeding outcome and winter population count data is available the change between one year and the next was in a similar direction. In this species therefore in S.E. Australia the winter population count is a good indication of the previous year's breeding success.

There is also quite a strong correlation between the winter population count of Curlew Sandpiper and the apparent breeding success in the previous arctic summer. Only in three of the 23 years for which comparable data is available was there not a good correlation between the two. This correlation is still shown even in recent years when winter populations have fallen to an extremely low level. It is not quite as good as in Red-necked Stint, probably because a substantial proportion of one-year old Curlew Sandpipers move away from their summer non-breeding areas to spend the winter elsewhere in Australia, particularly in northern Australia. At some locations in Victoria, Curlew Sandpipers may be totally absent in winter even though the summer population may number a thousand or more.

There does not appear to be any close correlation between the annual breeding success levels of Curlew Sandpiper over the years and the annual summer population counts (R_s = -0.03, P = 0.90). The only exception to this was in 1992 when a large peak in the summer population occurred following the exceptional breeding success in 1991. Overall the Curlew Sandpiper summer population in Victoria has decreased by 50% over the last 20 years even though the breeding success level of Curlew Sandpiper has been, on average, fairly constant. However, as mentioned earlier, both mean and median annual breeding success levels have been lower over this period than on any of the other six study species. It could well be that this sustained low level of breeding productivity is the prime cause of the almost steady decline in population. It will be interesting to see if the higher breeding success in the last three years (average of 19% compared with the long-term average of 11%) eventually causes a levelling-out or upturn in population.

The proportion of first year birds in summer populations of Sharp-tailed Sandpipers has shown marked fluctuations from year to year but no apparent long term trend. In contrast the summer population appeared to peak in the late 1980s and has since decreased by nearly 60%. The mean level of breeding success (16.5%) looks satisfactory in comparison with other species but the median of only 10.2% may indicate that frequent low breeding success is a cause of the decline in population.

Some caution has to be exercised however in looking at summer population levels in this species. When conditions in inland Australia are suitable many Sharp-tailed Sandpipers will stop-off at ephemeral wetlands and do not penetrate into Victorian coastal areas if these habitats are sustained throughout the summer. Population counts in coastal regions of southern Australia may therefore be quite markedly affected by factors other the real Sharp-tailed Sandpiper population level. However, even taking into account the more marked annual variation in summer population in this species it does appear that there has been a genuine significant population decrease over the last 15 years. Again, it will be interesting to see what effect the excellent 2003 breeding outcome for the Sharp-tailed Sandpiper has on the future population.

It is not possible to compare winter populations of Sharp-tailed Sandpipers with breeding outcomes of the previous year because almost no birds of this species remain in S.E. Australia during winter. Most leave Australia completely in their first winter, but it is not known if they migrate all the way back to their breeding grounds. However data from S.E. Taimyr in 2003 suggests that they do, as many adults showed two generations of primaries, typical of first year birds (P. Tomkovich, pers. comm.).

Summer populations of Red Knot in the prime location of S.E. Australia, Corner Inlet, have shown a marked decline (80%), particularly over the last 10 years. Winter populations have also declined. The percentage of first year Red Knot does not appear to have changed over the 26 years monitored, but there may be too many gaps in the data to be certain of this. Winter count data is also of limited value in monitoring breeding success of this species because cohorts from at least two years remain in the non-breeding areas (i.e. Red Knot do not usually breed until age three). Also many of those remaining in Australia move northwards for the winter or at least move away from their summer area (VWSG and AWSG data). The small population upturn recorded in the last two summers does not seem to relate to recent measured breeding outcomes. This species is in decline worldwide, with suggestions being made that its genetic make-up may make it more vulnerable to changes in its environment (Baker *et al*. 2001, 2004).

It is also difficult to relate breeding success data to the summer population count pattern for Bar-tailed Godwit, again because of gaps in the data. The steady decline, totalling 35%, in summer population over the last 15 years cannot be explained by any apparent marked change in the percentage first year measurements during this period. However it is interesting that the proportions of first year birds in three of the last four years have been particularly low. The summer breeding population does not seem to have been markedly affected by this yet but the winter population, composed of one- to three-year old birds, has fallen to a very low level (even lower, 0, in 2004 - recent count data). Visual data collected in Alaska by field observations of the number of juveniles in pre-migratory flocks has also shown very low levels of juveniles in recent years (Bob Gill and Brian McCaffery, pers. comm.). The Bar-tailed Godwit badly needs a very good breeding season.

There is inadequate population data on Sanderling and Ruddy Turnstone for correlates with breeding success to be examined at the present time. However more systematic counting has been introduced recently in the main Sanderling and Ruddy Turnstone areas in the prime habitat along the south-eastern coast of South Australia and hopefully this will provide suitable data for comparisons in the future.

Conclusions

The data presented show the potential of the percentage first year measurements in banding catches to give a meaningful index of the annual breeding success of shorebirds which breed in the arctic and spend the non-breeding season in Australia. It also shows that although there are correlations at times between breeding outcomes for different species and years there are also marked deviations of some species from the norm on occasions.

Winter population count data also correlate well with breeding success patterns in a number of species, indicating the expected link between the two. However in some there is no clear synergy, although gaps in the catch and count data prevent a full comparison. There is no clear link yet apparent between percentage first year data and summer population levels, even though these have changed markedly in some species over the last 20 years.

A caveat. The percentage first year figures presented in this paper are rates of recruitment of young birds into the population measured in the middle of the non-breeding season. They are not true measures breeding success rates. Adjustments would be needed to obtain these. To determine the level of young produced to the fledging stage allowance would need to be made for those which had died in the 4-7 months between fledging and catch sampling. As only a proportion of the "adult" population produced these young (the true adults, not the second year birds which did not breed at the end of the first year in most species), this needs to be allowed for if the data is to be converted to breeding success in terms of young fledged per breeding pair.

This data set was recognised at the Workshop on Arctic Breeding Success held in Denmark in December 2003 as the best long-term information currently available concerning breeding success of arctic shorebirds. Data collection will be continued in an identical way in the future to extend this data set. It will be particularly valuable in helping to assess whether there are any long-term changes in breeding success caused either by changes in climatic conditions on the breeding grounds (global warming) or by loss or deterioration of habitat at migration stop-over locations in Asia preventing birds reaching their breeding grounds at the optimum time or the optimum condition for breeding.

Methods of improving the banding sampling will also be sought. At the same time other methods of measuring breeding success will be explored further. It is also desirable that similar age-proportion studies be commenced elsewhere in Australia and the East Asian – Australasian Flyway. Initial work on ageing birds in feeding or roosting flocks with the aid of a telescope has also produced encouraging results but has some limitations (Danny Rogers and Mark Barter, pers. comm.), and this technique should be further tested and developed.

Australia, situated at the terminus of migration, is the best location in the East-Asian Australasian Flyway for generating this important population dynamics data on these long-distance migratory shorebirds. It is critical that extension of the existing data set into the foreseeable future continues.

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Recognising threats to shorebird habitats

Shorebird Habitat Management in Australia – the Threat of Mangroves

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Abstract

Most shorebirds require an open area of mudflats or shallow water, including tidal estuarine flats, saltmarsh or the margins of non-tidal wetlands, for foraging. They also seek a secure site with an open aspect, on which to roost and preen. It would appear that shorebirds avoid locations that do not provide a clear view of potential predators - either mammalian or avian. Few species associate with habitat close to, or within, mangroves or areas boxed in by tall structures or trees. It is therefore of concern that large areas of tidal mudflats, as well as saltmarsh habitat are being colonised by mangroves at an unprecedented rate. Areas under particular threat from encroachment by mangroves are those estuaries where there has already been a reduction in shorebird habitat due to landfill and development. It would appear that colonisation of saltmarsh by mangroves is a result of rising sea levels, while a seaward invasion is likely due to excessive sedimentation caused by poor catchment management. In the short term, the only feasible management of important habitat within saltmarsh at the high end of the tidal range and tidal mudflats and the low end of the tidal range, appears to be "weeding" of colonising mangroves. In the longer term appropriate catchment management and the reinstatement of saltmarsh lost to development would appear to be the only options.

Introduction

Most migratory shorebirds require open mudflats on which to feed and tend to avoid areas closed in by tall vegetation or structures that prevent a clear view of potential predators. During high tide, when their feeding areas are covered, shorebirds tend to congregate at communal roost sites to rest and to wait for the tide to recede. Again, an open aspect is chosen by preference when roosting, such as a sand spit, beach or area of low vegetation such as a saltmarsh. Many of these habitats have been lost or reduced in size due to coastal development, especially in areas of high-density human population such as Sydney, Newcastle and Tweed Heads. In recent years attention has been drawn to the expansion of the range of mangroves over previously open mudflats and saltmarsh and the effect on shorebirds and their habitats.

Habitat requirements

A strong preference for open areas of undisturbed mudflats is exhibited by most shorebird species when feeding, and open sandspits, beaches or other secure locations are used as roosts during high tide (Marchant & Higgins 1993, Higgins & Davies 1996, del Hoyo *et al* 1996, Lawler 1996). When preferred habitats are not available, sub-optimal locations are used, but in the latter habitats, birds tend to remain alert to the potential approach of predators and spend less time feeding or resting, to their detriment (Lawler 1996, Paton *et al.* 2000).

Lawler (1996) surveyed 63 tidal flats in nine New South Wales estuaries on the east coast of Australia and determined the features in the feeding habitat of six species of shorebirds, that were related to their abundance. Bar-tailed Godwit selected large, low-lying tidal flats; Whimbrel favoured mangrove-lined tidal flats in high sediment regimes; Eastern Curlew and Pacific Golden Plover favoured large complexes of tidal flats. Common Greenshank frequented feeding areas of any size, provided they were wet, nutrient rich and mangrove fringed. Grey-tailed Tattler were more likely to feed adjacent to mangroves and on tidal flats with some ground cover.

When tidal flats were submerged during high tide, shorebirds required roosting sites such as undisturbed beaches, sand spits, saltmarshes, and structures such as infrequently used jetties, barges, rock walls and oyster platforms. A few species such as Grey-tailed Tattler and Whimbrel frequently roosted on exposed branches of mangrove trees.

One of the most significant findings of Lawler was the extent to which most shorebirds avoided trees while roosting. In a study of 134 sites used by roosting shorebirds in 18 estuaries in New South Wales, Lawler (1996) described the roosting habitat of five species in the above categories with respect to a range of variables. Of the ground roosts (of which there were 93), only two were within 10m of vegetation over five metres tall, and 83% were at least 30m distant from 5m tall trees. Ninety percent of ground roosting sites were further than 10m from 2m high trees and bushes. Beaches accounted for 55% of roost sites, saltmarshes for 15%, mangrove trees for 19% and artificial structures for 11%.

Expansion of mangroves

Estuaries have been modified in such a way that the proliferation of mangroves has occurred, resulting in the loss of tidal mudflats. This has to a large extent been caused by increased silt loads and nutrient levels associated with the development of catchments, that result in new and highly fertile mangrove environments. In Sydney, McLoughlin (2000) reported an overall increase in mangrove area in the Parramatta River-Port Jackson system since European colonisation. There have been few studies to document loss of intertidal shorebird habitat in other estuaries. Unfortunately, there are few data describing the distribution of estuarine macrophytes prior to the use of aerial photography.

In a review of 29 photogrammetric surveys covering over 20 estuaries in Queensland, New South Wales, Victoria and South Australia, Saintilan and Williams (1999) described an increase in the area of mangroves, and a corresponding decrease in saltmarsh habitat (see Table 1). In 70% of estuaries surveyed, saltmarsh losses to mangrove incursion exceeded 30%, and in some situations losses approached 100%. These impacts have placed heightened pressure on saltmarsh already impacted by agricultural and urban developments (Kratochvil *et al*. 1972, Saenger *et al*. 1977, Zann 1997, Finlayson and Rea 1999).

Wilton (2002) demonstrated that while saltmarsh losses in recent decades have been greatest in urbanised estuaries, the component of loss due to mangrove encroachment is relatively constant between estuaries, at a median figure of 30%. The overall sea-level rise in the period 1940-2000 (70 mm at the Fort Dennison datum in Sydney Harbour) represents approximately 30% of the vertical range of the saltmarsh. The consistency of the trend between estuaries, the approximation of the degree of loss with the degree of sea-level rise, and the pattern of encroachment along drainage lines (Saintilan and Williams 1999) all suggest that at least some component of saltmarsh loss is related to sea-level trends. The prognosis for NSW coastal wetlands in the context of further increases in sea-level is continued mangrove expansion landward ... and seaward, if sedimentation rates remain high (Stolper 2002).

The Ecological Significance of Saltmarsh for Shorebirds and Fisheries

In many estuaries along the eastern and south-eastern coasts of Australia, saltmarsh provides important habitat for shorebirds for both feeding and roosting, especially during spring high tides when tidal flats and most sandspits are covered by the tide. It has long been known that saltmarsh is used as roosting habitat in the Hunter River estuary - especially at night when most diurnal roost sites are abandoned in favour of flooded saltmarsh (Clarke & van Gessel 1983, Straw 2000a).

The mangrove communities replacing saltmarsh often consist of trees less than 20 metres apart, which according to the observations of Lawler (1996); make these environments unsuitable as roosting habitat for most species of migratory shorebirds. These birds prefer flooded saltmarsh as a night-time roost because of the safety the open vegetation structure provides from predators, and the presence of pools which make ambush difficult (Straw 1996).

While mangroves play an important role in tropical fisheries (Robertson and Blaber 1992, Twilley *et al*. 1996, Blaber 1997), their contribution to temperate fish productivity is equivocal. Clynick and Chapman (2002) found fish concentrations to be similar between mangrove and bare mudflat during winter high-tide cycles within the Parramatta and Lane Cover Rivers. Subtropical saltmarshes may also support a diverse fish assemblage, including species of commercial importance, during spring tides (Morton *et al*. 1988, Thomas and Connolly 2001). Mazumder *et al*. (2005) have found concentrations of juvenile and other small fish to be similar between temperate mangrove and saltmarsh environments at Towra Point, Botany Bay, during spring tides. In addition, saltmarsh was found to be a highly productive source of crab larvae, predominantly sourced from the genus *Paragrapsus*, which occupies mud to upper-intertidal situations (Mazumder *et al*. in prep.).

Management Issues

(i) preservation and conservation

The contribution of mangroves to estuarine ecosystems was the principal reason for enacting NSW State legislation including SEPP14 (State Environmental and Planning Policy 14-coastal wetlands) and the Fisheries Management Act (1994) in NSW. Under the latter, removal of mangrove below mean high water is prohibited, with fines of $55 000 for individuals and $100 000 applying for corporations (Diver 2002). Permits for mangrove removal may be obtained, though a 2:1 compensation proportion is applied to replanting (NSW Fisheries 1999, Diver 2002). Saltmarshes are not protected under the Fisheries Management Act (1994) because they occur primarily above mean high water. SEPP14 does not apply in the Sydney metropolitan area, therefore protection is not afforded where development and population pressures are greatest.

(ii) rehabilitation of saltmarsh

There is an encouraging trend toward the rehabilitation of degraded saltmarsh areas in the Parramatta River estuary (Burchett *et al*. 1999a, b) and in Botany Bay where local councils have been convinced to include saltmarsh restoration as part of bushland regeneration and parklands management (Sainty pers comm.). More research is required concerning successful saltmarsh regeneration and rehabilitation, particularly in relation to the control of mosquitos, and the control of mangroves. The topographic profile of the saltmarsh may be a significant factor in the control of mangrove encroachment, with encroachment rates lower in the upper intertidal environment (inundated by spring tides only). The control of water through entrance points at which mangrove propagules are excluded, warrants further consideration and testing. To our knowledge there is only one NSW project in place to assess the hydrodynamics and efficiency of such devices (Straw 2002a). More data are also needed to test the efficacy of rehabilitated saltmarsh as migratory shorebird roosting habitat, and moves are under way to develop such a program on Kooragang Island.

(iii) revision of mangrove policy

Prior to the implementation of SEPP 14, coastal wetlands were routinely replaced by real estate and other inappropriate developments. However, if the expansion of mangroves at the expense of other habitats is the result of anthropogenic modifications of an estuary, then the issue

Location	Mangrove increase (percent)	Period	Source
Johnstone River, Qld.	14.8	1943-1991	Duke 1995
Hinchinbrook Channel	5.8	1943-1991	Duke 1995
Coolangatta to Caloundra	-8.4	1974-1987	Hyland and Butler 1988
Oyster Point	119	1944-1983	McTainsh et al 1988
Morton Bay	10	1944-1983	Morton 1994
Tweed River	86	1930-1994	Saintilan 1998
Hunter estuary (overall)	31	1954-1994	Williams et al. 1999
-Kooragang Isld	20	1954-1994	Williams et al. 1999
-Tomago/Fullerton/Stockton	46	1954-1994	Williams et al. 1999
- South Bank	41	1954-1994	Williams et al. 1999
-Throsby Creek	-91	1954-1994	Williams et al. 1999
Couranga Point, Hawkesbury	30	1954-1994	Saintilan & Hashimoto
Berowra Creek, Hawkebury	30	1941-1994	Williams & Watford
Careel Bay	551	1940-1996	Wilton 2001
Homebush Bay	65	1930-2000	Rogers & Saintilan 2001
Port Jackson/Parramatta R.	-19	1930-1985	Thorogood 1985
Kurnell Peninsula	33	1956-1996	Evans & Williams 2001
Towra Point	36	1942-1997	Mitchell & Adam 1989
Minnamurra estuary	69.6	1938-1997	Chafer 1998
Currambene Creek	32	1949-1993	Saintilan & Wilton 2000
Cararma Inlet	15	1949-1993	Saintilan & Wilton 2000
Moruya River	43.4	1949-1999	Phillips 2001
Merimbula	122	1948-1994	Meehan 1997
Pambula	84	1948-1994	Meehan 1997
Kooweerup, Westernport	60	1940-1999	Rogers & Saintilan 2001
Rhyll, Westernport	20	1939-1999	Rogers & Saintilan 2001
French Isd. Westernport	2	1967-1999	Rogers & Saintilan 2001
Quaill Isd. Westernport	32	1973-1999	Rogers & Saintilan 2001
North Arm Creek, S.A.	19.6	1979-1993	Coleman 1998
Swan Alley S.A.	189	1935-1979	Burton 1982
River Light, S.A.	117	1949-1979	Burton 1982

Table I: Increases in mangroves in SE Australian estuaries

must be addressed within the overall framework of estuary management. Clearly the protection of mangrove has had the unintended consequence of aiding the invasion of saltmarsh. In ecological terms, the significance of such habitat change is unknown.

Active management of estuarine shorebird habitats

The reversal of shorebird habitat loss as a result of landfill operations or mangrove incursion, has been attempted in recent years. Such cases include the re-establishment of the main diurnal shorebird roost site in the Hunter estuary at Newcastle and the remediation and construction of feeding habitat and roost sites round Botany Bay, Sydney.

Roost sites

The loss of many roost sites and large areas of feeding habitat in the Hunter estuary has occurred since European settlement as a result of dredging and infilling of tidal flats, saltmarsh and sand bars. During this process a peninsula of dredged sand and shell grit was formed at the approach of Stockton Bridge during its construction in 1970/71. This site soon attracted large flocks of shorebirds in excess of 5 000 birds due to its open nature. However silts accumulating around the peninsula provided ideal habitat for the establishment of a fringe of mangrove. The sandy surface also became overgrown with dense vegetation including the introduced rush *Juncus acutus*, and the site became less and less attractive to shorebirds for roosting.

In 1995 the site was cleared of dense tall weeds and a tidal lagoon, with an island in the middle, was constructed. Despite these works comparatively few shorebirds were attracted to the site. In 2003 permission was obtained from NSW Fisheries to clear the foreshore of all mangroves, greatly opening up the aspect of the site. The effect of this was spectacular and within days of the work being completed large flocks of shorebirds returned to the site during high tide.

It is likely that the establishment of the fringing mangroves on one side of the peninsula and the existence of the bridge on the other had resulted in the site being boxed in as far as the shorebirds were concerned. The presence of dense tall weeds was without doubt a contributing factor but the removal of them alone was not sufficient to attract the birds to the site.

Other former roost sites in the Hunter estuary lost through the invasion of mangroves, are in the process of being managed in a similar way to the Stockton roost, to provide alternative roost sites. These are immediately adjacent to the main feeding habitat for the majority of shorebirds in the Hunter at Fullerton Cove, at Sandy Island, and at a previously popular beach site on the eastern shore of the Cove.

Feeding habitat

In Australia, many estuarine shorebird feeding areas are under threat of invasion by mangroves. The most obvious are those areas that have already been reduced in size due to landfill and development. Few attempts have been made to restore or construct shorebird feeding habitats in Australia although artificial feeding areas created incidental to other land uses exist; examples include Port Headland saltworks in the NW of Australia, Tullakool Evaporation Ponds in NSW, and Werribee Sewage Treatment Works in Victoria. A small area of tidal mudflats at the end of a narrow tidal channel in Rockdale known as Eve Street Wetlands, was restored by the Sydney Water Board in 1990/91. This project was initially successful in attracting migratory shorebirds which foraged and roosted at the site during the relevant seasons. However the site has suffered from lack of management in recent years resulting in the invasion of the tidal flats by mangroves and common reed *Phragmites australis*. The site has also been impacted on by the construction of a freeway across one side, as well as by a pre-existing sewer viaduct and tall trees on the other side and now rarely attracts any shorebirds.

As a result of the impact of the freeway on Eve Street Wetlands, an alternative site had to be found to provide compensatory habitat. This project included the creation of about three hectares of shorebird feeding habitat round the shores of a disused flooded sand quarry on the southern side of Botany Bay. The 10m deep brackish lake was widened and partially filled to create tidal flats after opening the lake to tidal waters from a nearby drainage channel. A major issue here would be the exclusion of mangrove seeds floating into the lake from nearby mangrove forests. Without some form of structure to exclude the seeds, the newly created tidal flats would rapidly become invaded by mangroves unless 'weeded' on a regular basis. A large reverse siphon/weir has been put in place and is being periodically adjusted and modified to exclude floating debris, including mangrove seeds.

The future

We suggest that a policy be developed to approve other such applications where the area to be cleared of mangrove is small enough to be maintained, where the habitat value of the saltmarsh or estuarine beach being protected is quantifiable, or where mangroves can be demonstrated as having newly colonised the area.

Another way to address these issues is within the estuary management plans currently being prepared by coastal councils in New South Wales. These plans are meant to provide a blueprint for ongoing management priorities as powers of estuary management are divulged to local councils by state agencies. We have seen little in these plans about migratory shorebirds and nothing in relation to the management of expanding estuarine vegetation, particularly in regards to shorebird habitat. The inclusion of the issue in the agenda of local estuary management would provide a more balanced approach to vegetation management. Estuary-by-estuary plans for vegetation management would, we believe, be able to accommodate local imperatives more readily than the proscriptive approach currently taken.

The spread of mangroves into saltmarsh and other shorebird habitats is by no means restricted to Australia. Mangroves are perceived to be a major threat to shorebirds in New Zealand (Woodley 2003), Hong Kong (Straw 2000b), Taiwan (Straw pers. obs.). Loss of other habitats, such as Melaleuca forests, has been documented in Queensland and the Northern Territory (Saintilan pers. comm.).

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Threats to Shorebirds: Managing Mangrove Expansion in The Firth of Thames, New Zealand

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Introduction

The Firth of Thames (37° 13'S, 175° 23'E) east of Auckland, New Zealand, is an internationally significant site for migratory shorebirds. It is a major wintering area for arctic-breeding species, in particular Bar-tailed Godwit (*Limosa lapponica baueri*), and Red Knot (*Calidris canutus*). It is also an important wintering area for New Zealand breeding waders including South Island Pied Oystercatcher (*Haematopus ostralegus finschi*), Banded Dotterel (*Charadrius bicinctus*) and Wrybill (*Anarhynchus frontalis.*) Up to 40% of the entire population of Wrybill winter on the Firth of Thames.

A shallow arm of the Hauraki Gulf, the Firth of Thames lies between the Coromandel and Hunua Ranges and is bordered on the southern edge by the Hauraki Plains. Two major rivers, other streams and artificial drainage canals flow into the Firth, draining an area of approximately 3,600 sq. km. An estimated 8,500 ha of intertidal mudflats provide rich feeding for waders. Extensive shell banks, particularly at Miranda, on the south west corner of the Firth, and at the Waihou River mouth, on the south eastern corner, provide secure roosting areas during high water. The major roosts on the Firth are now threatened by the expansion of the native mangrove, *Avicennia marina var. austalasica.*

Mangrove Expansion

Only one species of mangrove *Avicennia marina var. austalasica* occurs in New Zealand. The species has been present for at least 9,800 years and the Firth of Thames is close to its southern limit. As *A. marina* is the most cold tolerant of all mangrove species it is capable of establishing in areas where temperatures may drop below their normal tolerance limits. As there are no other native plants in New Zealand which prefer muddy, intertidal, brackish water habitat, mangroves face no competition. Moreover there are no devastating pests or diseases that place regular stress upon them.

When James Cook sailed into the Firth of Thames in 1769, he reported mangroves growing at the mouth of the Waihou River. Aerial photographs from 1944 and 1952 indicate that mangroves were present at the mouths of the Waihou and Piako Rivers. By 1963 there were small incursions into the Waitakaruru River and elsewhere along the southern margins of the Firth of Thames. Subsequent aerial photographs from 1978, 1983, 1992, 1993 and 1996 document extremely rapid expansion of mangroves on the entire south-western and southern coast.

Mangroves on the southern shores of the Firth of Thames have advanced into the open waters from isolated strands in 1961 to a nearly continuous fringe up to 300 m wide since 1977. Experience of local residents suggests mangrove expansion has accelerated since 1980. At some places mangrove forests now extend up to 550 m wide. Prior to this period, significant flocks of waders were associated with the area. Currently there are no areas that are suitable for a wader roost along that section of coast, and census results show that there has been no substantial use of the area by waders since 1990.

From the late 1970s to the mid 1990s the main shell spit along the Miranda coast enclosed an embayed area of open mudflat. Except on the higher tides when birds roosted on the shell spit itself, most birds preferred to roost on the embayed mudflat. Indeed, until the late 1990s this area was the most significant high tide roost for wading birds on the Firth of Thames. Since 1995 there has been a steady expansion of mangroves southwards along the embayment. Today the entire area is covered in mangroves or mangrove seedlings, and is now unavailable to roosting waders. An area known as the Stilt Pools, south of Miranda Shorebird Centre and 100m from the shoreline, has since become a critical roosting site. This area too is now subject to mangrove incursion.

The expansion of mangroves into the Firth of Thames is related to the changing sediment structure of the Firth's substrate. Agricultural and drainage activities in the catchment over the last 50 or more years have lead to increasing levels of sedimentation, conditions that suit mangroves. In addition, once initially established the mangroves can help create suitable conditions for their further establishment.

Impacts on Waders

Census data for Bar-tailed Godwit and Red Knot, the two most numerous arctic-breeding species wintering on the Firth, shows a gradual decline in numbers. (Veitch and Habraken 1999.) This decline is more evident for godwit than knot. Reasons for this trend are not understood, although it is suggested there is some drift of waders from the Firth of Thames to the Manukau Harbour. It seems likely that mangrove expansion may be a contributing factor to the loss of value of wader habitat on the Firth. More study is needed to determine if

1. Mangrove encroachment is degrading roosting habitat
2. Mangrove expansion is creating a net loss of intertidal areas available for feeding.

Proposal to Create Artificial Wader Roosts

While further study of these issues is needed, observations of roost sites over the last ten years suggest negative impacts on wader habitat of mangrove expansion can be predicted. The Miranda Naturalists' Trust (MNT) believes the scale and speed of mangrove expansion poses a significant threat to biodiversity on the Firth of Thames. The issues of controlling mangrove growth and/or clearing mangroves from certain areas are likely to be quite problematic, certainly in the short term. The MNT believes that a pre-emptive approach to meeting this expanding threat is desirable. We propose to create secure artificial roosting conditions for shorebirds.

In 2002 when a block of 11ha of dairy pasture south of the Miranda Shorebird Centre came on the market, the MNT set about raising funds to purchase it. A consortium of funding agencies expressed interest in the project and the land was purchased in November 2002.

The block currently consists of dairy pasture with several rows of exotic shelter belt trees, overlying old shell bank ridges. We propose to create a platform of earth and shell adjoining areas of shallow water. Ongoing maintenance of such roosts will need to be carefully considered. For instance, controlling vegetation to low levels suitable for small waders, as well as maintaining a shallow water regime will present challenges.

The MNT is now engaged upon an information gathering exercise before proceeding. There appears to be a range of overseas experience in creating artificial shorebird roosts as well as enhancing existing roosts. We are confident that suitable conditions can be created at Miranda to sustain the long term viability of its shorebird populations.

Acknowledgements

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Roost Management in South-East Queensland: Building Partnerships to Replace Lost Habitat

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Summary

A roost that was destroyed to make way for a residential development on Bribie Island was replaced with artificially-constructed habitat after a partnership was formed between the developer and a community group, and assistance was provided by both local and state government.

Introduction

Moreton Bay Marine Park, Ramsar Site 41, is the aquatic playground of residents and visitors in Brisbane, the Gold Coast and the Sunshine Coast. One of the fastest-growing urban areas of Australia, its increasing population is placing stress on shorebirds as their options for roosting sites decrease. At times during summer, there can be more than 100,000 migratory shorebirds and terns in Moreton Bay. Shorelines that were formerly occupied by migratory shorebirds at high tide, have been transformed into residential canal estates and grassed open spaces for community recreation. Mangroves are also invading former roosts.

The Queensland Wader Study Group (QWSG) has organised or participated in the construction of several artificial roosts in the area in recent years. Roosts were lost at Raby Bay, Cabbage Tree Creek, Manly Boat Harbour, Fisherman Islands and Dux Creek but new roosts have been constructed at Empire Point, Dynah Island, Manly Boat Harbour, Port of Brisbane and Kakadu Beach and these have had varying success. A roost extension at Toorbul (opposite Bribie Island) is currently in the planning stage.

Dux Creek Case Study

Background

A roost at Dux Creek, Bribie Island, was accidentally created when a developer with approval to construct a residential canal community and marina, cleared the shoreline of its dense mangrove forest, dredged the creek and dumped the dredge spoil upon the cleared land. The purpose was to raise the ground level prior to construction but the developer went into receivership and the site lay untouched for some years. Shorebirds increasingly roosted on the vacant site, which provided sanctuary, above all tide levels, from the public and their domestic animals. A new developer (Hegira Pty Ltd) took up the project and, as an early attempt to deal with a local dust problem, engineered a simple system to allow flooding of the site on very high tides. This encouraged shorebirds in greater numbers, with more than 1000 Eastern Curlews *Numenius madagascariensis* on some occasions, as well as thousands of other migratory shorebirds.

In 1999 the developer, in preparation for the next stage of the development, submitted to Caboolture Shire Council an environmental impact assessment asserting that upon the destruction of the Dux Creek roost, birds would find sanctuary at other roosts within the local area. The QWSG claimed that the developer had not demonstrated that the birds would all relocate, and it was unsafe to proceed until the needs of the birds had been assured. Faced with the prospect of costly time and/or legal delays, and directed by Council to consult with the QWSG, the developer agreed to lead a process that aimed to identify suitable alternative roosting sites within the immediate area, and to look into roost construction possibilities. At the same time the QWSG agreed not to pursue the retention of the roost within the new development. This was a contentious issue among environmentalists, but it was decided that the existing roost might not function well in the middle of an upmarket marina development. Returning the site to public ownership was out of the question because of the cost of compensation.

Process

Stakeholders who participated in the process were Hegira Pty Ltd, QWSG, Qld Environmental Protection Agency, Qld Parks & Wildlife Service, Qld Dept Primary Industries (Fisheries), Qld Dept Natural Resources, Caboolture Shire Council and Bribie Island Environmental Protection Association. It was decided to include all parties from the outset, so that "ownership" of the project would develop, and the issue of permits, when required, would be facilitated. This proved to be an insightful strategy.

A series of field trips followed, during which the QWSG acquainted Hegira's environmental consultant, Peter Scott (HLA Envirosciences Pty Ltd) with the finer details of shorebird needs in the area. As a requirement of Council, Scott wrote a Management Plan for Wader High Tide Roosts in the Central-Southern Pumicestone Passage. At the same time that Hegira was refining its residential development plans, a site within the proposed development (Kakadu Beach Wader Roost) was identified as suitable for a shorebird roost. This would, however, place shorebirds immediately adjacent to housing. Aided by the QWSG, Hegira produced a plan for a combined roost and residential development, which was lodged with Council. There followed much consultation with community groups to explain the plan and enlist support, and lobbying of councillors. Although Hegira had previously been held in low esteem by the local environmental community, united with QWSG it now approached Council, , to seek approval for the plan, which was backed by considerable support from the general community. Approval was granted after some minor changes.

As a preliminary action, a prototype roost was constructed in an unlikely location within the site, to gain experience in managing soils and water levels. Although this roost did not attract waders, it served its purpose, and will later be modified into a landscaped place for waterbirds.

Award

Before the artificial roost was built, the unusual partnership of Hegira and QWSG was recognised with the Prime Minister's Award for Excellence in Community Business Partnerships for Queensland, 2001.

Construction

The Kakadu Beach roost, costing Hegira over a million dollars, was constructed in the first three months of 2002. It consists of a sandy beachfront on the Pumicestone Passage, backed by a long and narrow tidal lagoon that acts as a water barrier to isolate the public from the birds. Two bird hides with car parks are located at the either end of the lagoon. An open-sided interpretive shelter displays posters that explain the basics of bird-watching, and the daily and annual habits of shorebirds, as well as providing identification features and photos of each species.

Degree of success

The roost was completed during the autumn northward migration, and immediately attracted up to 400 migrating birds. The following summer (2002/03), it attracted birds in flocks numbering up to 2000. During the current summer (2003/04) it has attracted more than 2500 birds on the highest tides. Although Eastern Curlew have used the roost on some occasions, they continue to frequent the remains of the old roost site, which is a now building site with active earth-moving vehicles. Records show that whilst the new roost is attractive to birds, it is not attracting flocks of the size previously seen on the old roost (see *Figure. 1*). It was not possible to replicate the characteristics of the old roost, which was considerably larger and had a lower gradient, a different (muddy) substrate and less disturbance because it was on private land.

Commercial and community benefits

Hegira found that responsible environmental behavior translates into good public relations, and resultant high income from favourable land sales. Favourable news stories covered the Prime Minister's Awards. The opening of the roost by the Hon. Dean Wells, Queensland Minister for the Environment, attracted more good publicity. Hegira, by now widely known as Pacific Harbour (the name of its development) took great advantage of the success to create its own well-deserved publicity. The QWSG was represented at Pacific Harbour's community events, addressing the public on aspects of shorebirds. Local schools sought, and continue to seek, shorebird education sessions. Education of the new residents of Pacific Harbour has begun, and will continue as more houses are built and residents move in. The hope is that the residents will become the overseers of the roost in the future.

Roost Maintenance

Once constructed, roosts must be maintained regularly to keep them clear of vegetation regrowth, so that they remain attractive to shorebirds. The stakeholders of the roost-building process produced a manual to guide Council's future maintenance workers. Funded by Pacific Harbour, the manual covers roost and landscaping matters, as well as lagoon maintenance. It specifies at what times of the year particular tasks should be undertaken, and under what tidal conditions. QWSG has committed to conducting annual inspections of the work, and intends to continue education of the workers as the need arises. A new residents' committee will take some responsibility for ongoing monitoring.

Managing for the future

Whilst Pacific Harbour is obliged to maintain the foreshore until March, 2004, most of its obligations ceased with completion of the construction of the new roost. The company's planners have moved on to the next stage of the development. It is clear, however, that the success of the project has brought a newfound pride to the company, which continues to participate with other parties in planning future shorebird management in the Pumicestone Passage. There is general agreement within the group that the increasing human population means that pro-active shorebird habitat management must occur in the future. The group has extended its scope beyond

	DX max	KB max		DX max	KB max
Black-tailed Godwit	90	5	Broad-billed Sandpiper	5	1
Bar-tailed Godwit	3500	2500	Pied Oystercatcher	58	21
Whimbrel	88	5	Sooty Oystercatcher	6	4
Eastern Curlew	1050	52	Black-winged Stilt	45	32
Marsh Sandpiper	2		Pacific Golden Plover	54	
Common Greenshank	47		Grey Plover	2	1
Terek Sandpiper	10	2	Red-capped Plover	160	55
Common Sandpiper	2		Double-banded Plover	36	21
Grey-tailed Tattler	29	3	Lesser Sandplover	240	150
Ruddy Turnstone	5	1	Greater Sandplover	32	8
Great Knot	550	250	Silver Gull	210	132
Red Knot	20	5	Gull-billed Tern	112	123
Red-necked Stint	225	178	Caspian Tern	54	15
Sharp-tailed Sandpiper	150	24	Crested Tern	195	8
Curlew Sandpiper	125	52	Little Tern	60	36

Figure. 1 Comparisons of Species Diversity and Maximum Abundance Dux Ck (DX) 1997-2002 and Kakadu Beach (KB) 2002-2003 *courtesy of Trevor Ford*

the Kakadu Beach roost to the encompass the entire Pumicestone Passage, and now calls itself the Pumicestone Shorebird Management Group. Caloundra City Council has joined the group, and begun talks about active management for shorebirds in the northern section of the Passage it administers, where more than 40,000 migratory terns occur at times during the summer. Plans have been drawn up for a modification of the existing roost at Toorbul, to allow the birds to remain roosting on higher tides than is currently possible. Toorbul is about 4km from the Kakadu Beach roost, and adjacent to some of the richest feeding mudflats in the area.

Lessons learned – roost building

- Building artificial roosts is a very costly exercise, requiring considerable contributions of time and skill, and an understanding of the complexities of government requirements for permits.
- It is better to retain existing roosts if possible. In the case of Dux Creek, it was not feasible.

Lessons learned – partnerships

- Whilst environmentalists and developers are not natural bedfellows, they can work well together when each party recognises the benefit of the liaison.
- It takes time to build up trust and respect.
- Negotiation requires compromise from each side.
- Two parties in a partnership can achieve more together than each party can achieve alone.
- Each partner should ensure the other receives ongoing benefits to ensure there is incentive to remain in the partnership – don't take each other for granted.
- Don't expect to turn developers into environmentalists – just give them a good, sound business reason to engage.

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Threats from Marine Farming in New Zealand to Waders on the East Asia-Australasian Flyway

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Abstract

The majority of the 166,000 international wading birds on the East-Asia/Australasian flyway that reach New Zealand, are found on the seven largest coastal wetlands and Lake Wairarapa. These wetlands appear to be particularly important as staging points during the spring and late summer migrations, as birds congregate at these wetlands on arrival and departure. These coastal wetlands have also been identified by the marine farming industry as important areas for the expansion of marine farming and commercial shellfish gathering. A recent change to New Zealand's Resource Management Act has opened up opportunities for a significant expansion of marine farming throughout New Zealand and in these key coastal wetlands favoured by waders. A case study of the potential impact of the marine farming expansion in the Auckland Region, where implementation of planning for marine farming is most advanced, illustrates the potential for significant impacts on wading bird populations in New Zealand and the East-Asia/Australasian flyway.

Introduction

Most of the 166,000 international wading birds on the East-Asia/Australasian flyway that reach New Zealand are found on the seven largest coastal wetlands and Lake Wairarapa (Figure 1) (Sagar *et al*. 1999). This information has been compiled from biannual wader counts that have been conducted regularly on more than 60 of New Zealand's wetlands for the past 20 years. These coastal wetlands appear to be particularly important as staging points during the spring and late summer migrations, as birds congregate at these wetlands on arrival and departure (Bellingham & Davis 1984).

We assess the potential impacts from the on-going expansion of shellfish aquaculture in New Zealand on the tidal areas that are important for waders. We include two case studies, at the Firth of Thames and Kaipara Harbour in the Auckland Region of northern New Zealand, where proposed and existing aquaculture sites are known. Both harbours are internationally important for wading birds and initial investigations in the Firth of Thames indicate potential impacts on the tidal flat and inshore ecosystems from aquaculture.

Shellfish aquaculture in New Zealand

Aquaculture is one of the fastest growing areas of the New Zealand seafood industry, making up around 20% of the total fisheries value. Aquaculture production has risen exponentially over the past decade and further dramatic increases are predicted before 2010, when the industry predicts that annual returns will be more than $NZ300 million. Greenshell mussels and Pacific oysters continue to be the mainstay of New Zealand's shellfish aquaculture industry, with exports totalling $NZ150 million (Statistics NZ 2002). Improvements in technology have seen a significant expansion of the industry and demand for new marine farm sites has spread beyond the main aquaculture areas at Stewart Island, Marlborough Sounds, Coromandel and Northland, to include most estuaries and offshore structures for mussel and fish farms.

Changes to New Zealand aquaculture legislation and planning system

In the past five years there has been significant pressure on coastal space for aquaculture at various locations around the country, and the New Zealand government responded by amending the Resource Management Act 1991 (the coastal planning legislation). The key purpose of the amendment was to ensure aquaculture is managed appropriately within designated Aquaculture Management Areas (AMAs) where aquaculture can be undertaken with a coastal permit. Outside AMAs, aquaculture activities will be prohibited (Harris & Sutherland 2004). The AMAs and aquaculture consents need to be consistent with three statutory documents:

1. **New Zealand Coastal Policy Statement** – This contains policies regarding the preservation of the natural character of the coastal environment, protection of the coastal environment from inappropriate use and development, maintenance and enhancement of public access to, and along, the coastal marine area, and the protection of characteristics of the coastal environment of special value to tangata whenua (traditional Maori landowners).
2. **Regional Policy Statements** – These contain policies to implement the national coastal policies within the regional context.
3. **Regional Coastal Plans**: – These plans implement the national and regional coastal policies, with use and protection zones and rules.

There is a limited amount of information available on the adverse effects, including cumulative effects, of aquaculture in the coastal marine area. The provisions in the new aquaculture variations to regional plans are required to adopt a precautionary approach for new development of aquaculture within Aquaculture Management Areas. In the Auckland Region the regional council have adopted an adaptive management technique to stage the development of aquaculture activities within the Kaipara Harbour, as aquaculture does not currently exist there. Further development of aquaculture in the Kaipara Harbour is dependent on the results of environmental monitoring demonstrating that aquaculture activities from the first stage of development are not causing any actual or potentially adverse cumulative effects. If monitoring shows development is causing an adverse effect then actions will need to be taken to avoid, remedy or mitigate those adverse effects. This could be achieved by reviewing consent conditions, not allowing the next stage of development to occur, or reducing the area zoned for the activity through a plan change.

Threats to wading bird habitat from aquaculture

There are potentially a number of adverse effects of aquaculture on wading birds affecting feeding areas and roost sites. We consider that the effects are greatest on feeding areas and in this paper we address the three main potential impacts:

- Shellfish aquaculture structures on or near wader feeding areas on tidal flats;
- Shore-based operations near feeding areas and roosts; and
- Food chain effects on wading birds from aquaculture.

Shellfish aquaculture on or near wader feeding areas on tidal flats

Oysters are farmed on raised racks or in small baskets on wires, suspended by pole structures. In New Zealand a typical oyster farm occupies at least 5-10ha, but recent changes to farming practices have seen new farms in sub-tidal channels, with proposals for hundreds of hectares.

Shore-based operations near feeding areas and roosts

Shorebirds can be affected also by the operation and maintenance of marine farms, both at the farm site and shore-based facilities. The highest impact appears to be from the operation and maintenance of oyster farms. In our experience from Northland and Auckland over the past 25 years, waders in particular seldom come within 50-100m of marine farms on the tidal flats when people are present. New proposals for oyster farms are in tidal channels where oysters are in suspended baskets, between pole and line structures.

Food chain effects on wading birds from aquaculture

Biologically, phytoplankton is the key element in the marine food chain, providing food for the shellfish in marine farms and for invertebrates that are the prey for wading birds. In inshore waters its productivity is governed by light and nutrients, particularly nitrogen (James and Ross 1996). Studies have shown that the effect of phytoplankton depletion varies depending on the size of the farms, local hydrodynamics, sizes of phytoplankton, and seasonal or annual variability.

It is not merely a conceptual possibility that mussel farms may cause substantial local depletion of plankton. It has been possible to detect depletion within operating farms (Grange & Cole 1997; Ogilvie *et al*. 2000). Ogilvie et al. (2000) found that mussel farms in Beatrix Bay (Marlborough Sounds) caused significant reductions in phytoplankton levels. Depletion of phytoplankton by mussel farms show strong seasonal patterns with the summer months (Nov. - Feb.) showing lowest phytoplankton biomass and winter the highest (Gall et al. 2000). Maximum depletion rates were found in the inner-bay farms (James op. cit.). Detailed studies at Forsyth Bay (Marlborough Sounds) have estimated that the average mussel farm can extract about 9.3% of phytoplankton available (Butler 2001).

The National Institute of Water and Atmospheric Research is currently researching mussel farm sustainability and carrying capacity (James and Ross 1996; Ross et al. 1998; Gall *et al*. 2000; Hayden *et al*. 2000). There is also anecdotal evidence that critical levels of plankton depletion are occurring in the Marlborough Sounds. Reports by marine farmers state that mussels in the Sounds are currently growing much more slowly than in the 1970s when few farms were present (Schemcel 2002). As early as 1983, mussel farmers in the Marlborough Sounds were expressing concerns that overstocking was resulting in poorer mussel condition (Hickman *et al*. 1991). A preliminary analysis of the effects of sustainability of aquaculture on the Firth of Thames (Broekhuizen et al. 2002) identified potential risks for plankton reaching wader-feeding areas in the upper Firth of Thames. This report identified that production and ecosystem carrying capacity within the Firth of Thames were influenced by ENSO-related variations in the composition, biomass and community structure of the planktonic community. Whilst the majority of nutrients entering the greater Hauraki Gulf stem from the ocean, approximately 30% stem from riverine inputs and these are more important towards the south of the Firth where the wader feeding habitat is located.

Threats from marine farming: Auckland Region Case Study

Marine farming is presently limited to the east coast of the region, but the Auckland Regional Council's proposed Aquaculture Management Areas includes 1000ha of mussel farming and 400ha of oyster farming areas in the Kaipara Harbour, and the Waikato regional Council propose a 1000ha expansion of the mussel farming in the outer Firth of Thames (Auckland Regional Council 2002).

Firth of Thames

The Firth of Thames has extensive wader feeding areas in the southern Firth, from Miranda to Thames. It is a designated Ramsar site and recognised for its wading bird population. It is New Zealand's fourth most important site for waders (Sagar *et al.* 1999) and it is notable for the high numbers of overseas migrant waders, particularly Eastern Bar-tailed Godwit and Lesser Knot. But it is equally important for New Zealand migratory waders and a third of the threatened endemic Wrybill over winter at the Firth. The largest roosts are in the southern Firth at Miranda and near Thames, close to the extensive mud flats where they feed.

Aquaculture is located in the outer Firth of Thames and nearby Hauraki Gulf Islands and a further 1000ha is proposed in the outer Firth. This is almost entirely long-line mussel farming. Some preliminary estimates of a mussel farm's ecological footprint in the Firth of Thames, predict the highest impacts will be in the 100-1000m around these farms. But effects can be expected under calm conditions and in the shallow (1-3 m) sites in the southern Firth of Thames that have slow residual currents, correspondingly long flushing times and slower recovery (Broekhuizen *et al.* 2002). Zeldis & Smith (1999) have calculated a flushing time of approximately 56 days for the Hauraki Gulf as a whole (incl. the Firth of Thames) and this is likely to be much longer for the upper Firth of Thames during summer when river inflow is minimal.

Broekhuizen *et al.* (2002) predict that downstream phytoplankton depletion will be observed if the Firth farms have similar characteristics (size, line density etc.) to those of the Marlborough Sounds. Furthermore, unless line densities, or mussel densities per line are correspondingly reduced within the very large farms proposed for the Firth of Thames, it is likely that, depletion will be more extreme downstream of the very large farms (in comparison with those within the Marlborough Sounds). The Firth of Thames and Hauraki Gulf is a net consumer of organic material (animals consume more organic material than phytoplankton produce). Furthermore, average phytoplankton concentrations are probably insufficient to support maximal growth rates amongst the herbivorous filter-feeding community (Broekhuizen *et al.* 2002). These two observations imply that even small reductions in phytoplankton abundance could increase any food limitation, which other trophic groups suffer.

For wading birds in the Firth of Thames, the critical time when potential food limitation could occur is in late summer, when both overseas and New Zealand migrants, and resident waders, are at their highest numbers. This can coincide with low phytoplankton in the Firth and the nutrient supply coming mainly from the Hauraki Gulf (Broekhuizen et al. 2002). If mussel farms intercept the plankton and nutrient supply to the southern tidal flats further up the Firth, then it could lead to a reduction in wader food supply when overseas migrants are getting ready for their northern migration.

Kaipara Harbour

The Kaipara Harbour has extensive and varied tidal habitat for shorebirds. It is New Zealand's third-most important site for waders and these birds are spread over seven major roosts and more than 15 other roosts, located near the major tidal flats. The regional council's proposed AMAs are located close to the main wader feeding areas in the middle of the Kaipara Harbour. There has been no impact assessment of the potential adverse effects of aquaculture on the Kaipara marine ecosystem or on wading birds. Aquaculture is likely to have similar potential impacts on the marine ecosystem of the Firth of Thames, with mussel and oyster farming intercepting the plankton supply in the central part of the harbour, where the main wader feeding areas are located. Also, proposed oyster farm operations could deter birds from feeding on several hundred hectares of tidal flats around this area.

Conclusions

The recent proposals for significant expansion of aquaculture in New Zealand have the potential to affect wading bird feeding areas if the scale and intensity of shellfish aquaculture intercepts significant proportions of plankton before it reaches tidal flats where waders feed. This problem is being investigated in the Kaipara Harbour and the Firth of Thames in the Auckland region, where 30% of New Zealand's waders on the East Asia-Australasian flyway over-summer. Potential effects appear to be greatest in late summer, when nutrients in the food chain are low and wader numbers area high. It has the potential to affect wading birds in the large Northland and northern South Island estuaries and tidal flats where another 30-40% of the overseas migrant waders over-summer and aquaculture proposals of a similar scale are proposed.

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Community involvement

The Role of Wetland Centres in Shorebird Conservation.

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Abstract

The idea of building centres to raise awareness of the importance of wetlands and their wildlife, probably began with the opening of the centre at Slimbridge (U.K.) in 1946 by Sir Peter Scott. Since then, a network of similar centres has been built around the world and wetland education has become one of the key tools in the conservation of wetlands and their wildlife. However, these centres do not just focus on wetland education and public awareness. They are often carefully located on the edge of an important wetland, so that the Centre may also play an important role in management of the wetland, conducting monitoring and research, and working with local communities and lobbying government for the long-term protection of the site.

Over the past decade, wetland centres around the world have been working together more closely through the Wetland Link International (WLI) initiative, in order to share resources and ideas for programs, and to carry out co-operative projects. This has been particularly true in Asia, where a number of older wetland centres have played important roles in providing support for the establishment of new protected wetland sites and associated centres in other countries. Similarly in Australia, established wetland centres have been networked under the coordination of The Wetlands Centre Australia, to build capacity among wetland educators. Education programs, such as the Sister Schools Program, have also brought together children from different countries that share the same migratory flyway, allowing them to learn more about wetlands and the migratory waterbirds that depend on them.

This presentation will provide a brief overview of the wetland centres along the East Asian – Australasian Flyway and the work that they carry out in promoting the conservation of migratory shorebirds and other wetland wildlife.

The role of wetland centres and wetland nature reserves

Efforts to conserve and raise awareness about the importance of wetlands date back as far the mid-1990s, when Sir Peter Scott (one of the founders of WWF), opened probably the world's first wetland education centre at Slimbridge, United Kingdoms in 1946. This centre is now internationally known and the concept of wetland centres has spread around the world, with similar centres having opened on almost every continent.

Underpinning the development of wetlands wentres around the world is a belief in the power of education to support conservation of wetlands. In many instances this has been accompanied by an interest in and a commitment to community involvement as a valuable resource for the on-going management of wetlands.

What wetland wentres can deliver for shorebird conservation is dependent on their location, their focus and programs. While some wetlands centres may not be located close to habitat used by shorebirds, there are other ways they can contribute. These include organising special visits and events for students and the public to raise their awareness about the value of wetlands and the need for their conservation; involvement in the daily management and conservation of the adjacent wetland; conducting monitoring and research of the wetland, and working with local communities and the government to ensure the 'wise-use' of the wetland and its long-term protection.

Education and awareness

One of the advantages of having an education centre built adjacent to a wetland, is that the wetland can be used as an educational tool where students and other visitors can be guided and shown first-hand, the variety of wildlife that can be found inside the wetland and the ecological stories that they hold.

To facilitate visitors' appreciation and understanding of the wetland, facilities such as exhibition room, nature trails, notice boards, bird watching hides and boardwalks are often available. Educational material and resources such as books and leaflets are usually produced to explain the various aspects of the ecology of the wetland and its wildlife. A range of special (e.g. guided) education and public awareness programmes are also often offered, targeting the general public (including the disabled), students, decision makers and others. There may also be programmes for volunteers to help with the daily management of the reserve and centre.

Conserve and manage habitats for wetland wildlife, including shorebirds

Wetland Centres may, or may not also be responsible for the management of the adjacent wetland. If so, then the work will involve maintaining the ecological value of the site. This may include providing habitat for the variety of wildlife for which the wetland is important, and to balance the need to conserve the site whilst maximising opportunities for visitors to enter and learn about, and value the importance of the site.

Monitoring and research

In order to manage the wetland in a scientific manner that can maximise its ecological value, regular baseline ecological monitoring needs to be conducted. This will allow any adverse changes to be quickly detected and action taken to resolve the problem. Such monitoring may include the quality of water in the site, changes in the diversity and abundance of waterbirds for which the site is important.

Research projects may be carried out by site staff or else, co-operative links may be established with local colleges or universities and projects conducted by students or academic staff. Examples of such projects may include investigating the optimal means of managing certain habitats in the reserve in order to maximise its value for key wildlife species.

It is important that the data and reports from such monitoring and research projects are published, and made available to the reserve staff who can then take appropriate management action.

Training

Provide facilities to train overseas site managers and decision makers on 1), habitat management 2), shorebird identification and survey techniques 3), catching and banding 4) environment education techniques. Can be done by inviting participants to the Centre, Centre staff visiting overseas sites, remotely via e-mail (such as the Sister Schools Programme), or by twinning sites

Wetland centres in Australia

There are now approximately 40 wetland centres in Australia, many of which are well located to support the conservation of shorebirds and their habitats. Shortland Wetland Centre, now trading as The Wetlands Centre Australia, provides a good example. Shortland was the first dedicated wetland centre in Australia and its development was actively supported by Slimbridge and the Wildfowl and Wetlands Trust in the United Kingdoms.

The Wetlands Centre is located in the Hunter Estuary in New South Wales, and was initiated in 1986 as a restoration project and an education facility. The Hunter Estuary provides significant shorebird habitat and is home to four major wetland restoration projects and a wealth of wetland interest groups that provide invaluable support for the restoration projects.

The Wetlands Centre can be viewed as a mature wetland restoration initiative that has involved the community at a high level. It still remains a community-owned facility and raises all of its own funds. Partnering with local organisations such as Hunter Bird Observers Club and the Australian Plants Society is critical to its operations.

The Wetlands Centre's overriding aim is the promotion of wetland values through communication, education and public awareness, a key objective of the Ramsar Convention. To meet this aim The Wetlands Centre delivers a broad range of education programs that cover the spectrum from public awareness to capacity-building and training. The Wetlands Centre also provides a storehouse for wetland information.

Now in its 20th year, The Wetlands Centre has had opportunities to be involved nationally and internationally. The Wetlands Centre

- Is a foundation member of the National Communication Education and Public Awareness Task Force recommended by the Ramsar Convention.
- Is a foundation member of the reference group of the Australian Wetlands Alliance (AWA), an umbrella network of non-government wetland interest groups and until recently was the host organisation for the AWA.
- Is the coordinator of Wetland Link International Australia, a network of Wetlands Centres in the Oceania region
- Is the coordinator of Shorebird Education Australia, a program involving educators along the East Asian-Australasian Flyway.

The last two initiatives have special relevance for Shorebird Conservation. The two projects were delivered during the same period with assistance from the Australian Government's Wetlands Program. The Wetlands Centre work in establishing a regional network of wetlands centres and initiating the shorebird education program with other flyway educators offered many synergies. Both programs provided opportunities for interaction among educators working in wetland education. Both programs allowed educators to learn more about other wetland sites and the education programs in place in those locations. Both programs have resulted in products that have applications for shorebird conservation.

Under the Wetland Link International Australia program, wetland educators collaborated on a National Communication Strategy which was the first of its kind. More recently 15 wetland centres have collaborated on a joint promotional brochure that promotes wetlands and wetland centres. It provides information on the location, facilities and programs for 15 wetland centres around the country The brochure is targeting the tourism market and will be distributed through major international tourist entry points. While this brochure may already include some of the centres located near shorebird habitat, a similar product could be produced that targets the bird-watching community and could be directly focused on centres where information on shorebirds is available.

Shorebird Education Australia

The Shorebird Education Australia project followed a similar direction in aiming to develop stronger links between educators and centres along the flyway to support the development of customised education products. This supported the development of the Shorebird Postcard Project in 2001-02, a project where students from shorebird sites in different countries exchanged postcards that they designed.

The Shorebird Education Australia initiative benefited greatly from valuable advice and assistance from the United States Fish and Wildlife Service's (FWS) Sister Shorebird Schools Program Coordinators. The Sister

Shorebird Schools program is delivered by the FWS and is well established and successful. Many schools along the East Asian-Australasian Flyway are regular participants.

One of the joint conclusions to come out of the Shorebird Education Australia program was the need for a Sister Shorebird Schools Program designed to meet the needs and characteristics of the East Asian-Australasian Flyway (EAAF). Many shorebird educators and advisors were canvassed to comment on this concept, including FWS Sister Shorebird Schools Program Coordinators. Overall there was strong consensus that a mirror program for the EAAF that could develop in tandem the FWS program would be a step in the right direction. The title 'Feathers Flyways and Friends' was agreed to during this consultation process.

At the time of writing a web page to launch the program has been developed to a preliminary stage and is undergoing a peer review. The web page can be located at www.wetlands.org.au/shoredirds

Sister Wetlands Agreements

Sister Wetlands Agreements are an initiative of the Ramsar Convention. These are co-operative regional arrangements between wetlands in different countries. Australia's first Sister Wetland Agreement was initiated in 1994 between the Kushiro Region in , Hokkaido, Japan and the Kooragang Wetlands in the Hunter Estuary. A Second Agreement was established in 1996 between Narashino, Japan and Brisbane, Australia at the time of the 6th Ramsar Conference in the city of Brisbane in Queensland.

Sister Wetland Agreements have great potential to deliver integrated Shorebird Education. There are several new Sister Wetland Agreements between countries along out flyway under consideration at this time. November 2004 will mark 10 years from the signing of the first Sister Wetland Agreement and it is hoped that a commemorative event will be held in Australia at that time.

Thus there are many opportunities to be realised through the greater involvement of wetland centres in Shorebird Education, through improved links between shorebird educators nationally and internationally and through integration of objectives and initiatives under the Ramsar Convention

Wetland centres in Asia

The development of wetland centres in Asia originally lagged behind that in 'western' countries but since the early 1980s, interest in providing such centres has gained momentum. This is especially so in those Asian countries whose economies have been growing more rapidly in recent decades. The following section provides a brief history of a few of these centres in Asia, their importance for shorebirds, and the work to conserve these birds through education programs and management of the wetland habitats associated with these centres.

Wetland Centres around Deep Bay, P.R. China

Mai Po Marshes Wildlife Education Centre and Nature Reserve, Hong Kong

The Mai Po Marshes forms part of the complex of wetlands around Deep Bay in the north-western corner of Hong Kong, and has been well known as a site for wetland wildlife since the end of the 1800s. Presently, some 54,000 waterbirds winter in these wetlands and an additional 20,000 – 30,000 shorebirds pass through during spring and autumn migration. Due primarily to its importance for migratory waterbirds, the Hong Kong Government designated a 1,500 ha area of the wetlands around Deep Bay in 1995 as a Wetland of International Importance under the Convention on Wetlands. This 'Ramsar Site' includes the Deep Bay mudflats, the MPNR, and an area of commercial fishponds on the landward part of the site.

WWF Hong Kong began management of the 380 ha Mai Po Marshes Wildlife Education Centre and Nature Reserve (MPNR) for promoting education and conservation in 1984 in collaboration with the Hong Kong Government.

Altogether, over 50 species of shorebirds have been recorded with 17 being of importance because they are threatened or occur in significant numbers (>1%) for the Flyway (Table 1).

The MPNR is made up of 24 traditionally operated shrimp ponds (locally called *gei wai*), each of about 10 ha in size and supporting a mixture of mangroves, reedbeds, and areas of open water. Shorebirds feed on the inter-tidal mudflat but at high tide, fly into the Reserve and roost in a number of specially managed *gei wai* that provide areas of shallow water during spring or autumn passage, or over the winter period. In summer however, the water level in these ponds is kept high to prevent reed encroachment from the edges of the pond into the open area of water. The height of vegetation around the roost sites is also kept low so as not to obstruct the flight lines of the shorebirds as well as allowing the shorebirds to see the approach of aerial predators (Lawler 1995).

Table 1. Shorebird species for which Deep Bay is important (Carey & Young 1999; Carey et al 2001)

Species	Scientific name	Peak no.	Significance
Black-winged Stilt	*Himantopus himantopus*	336	>1%
Pied Avocet	*Recurvirostra avosetta*	1069	>1%
Kentish Plover	*Charadrius alexandrinus*	2600	>1%
Greater Sand Plover	*Charadrius leschenaultii*	1000	>1%
Grey Plover	*Pluvialis squatarola*	616	>1%
Grey-headed Lapwing	*Vanellus cinereus*		NT
Curlew Sandpiper	*Calidris ferruginea*	11,400	>1%
Dunlin	*Calidris alpina*	3336	>1%
Spoon-billed Sandpiper	*Eurynorhynchus pygmeus*		V
Asian Dowitcher	*Limnodromus semipalmatus*	304	>1%
Black-tailed Godwit	*Limosa limosa*	1809	>1%
Eurasian Curlew	*Numenius arquata*	800	>1%
Spotted Redshank	*Tringa erythropus*	3500	>1%
Marsh Sandpiper	*Tringa stagnatilis*	1980	>1%
Common Greenshank	*Tringa nebularia*	3127	>1%
Spotted Greenshank	*Tringa guttifer*	38	>1%
Terek Sandpiper	*Xenus cinereus*	443	>1%

(Key: V = Vulnerable, NT = Near-threatened, >1% = occurs in numbers greater than 1% of the estimated flyway population)

MPNR staff also carries out limited management of the shorebirds' mudflat feeding area. This is because the mangroves that fringe the mudflat are slowly advancing out over the mudflats and each autumn, an area of mangrove seedlings approximately 30 ha in front of the bird watching hides on the edge of the mudflat are removed manually. This not only keeps the view from the hides open but also maintains an open area of mudflat for feeding shorebirds and other waterbirds.

Through a series of specially guided visit programmes to the Reserve, students and the public can get a first hand understanding of the importance of wetlands and shorebirds, and the need for their conservation. However, due to the Reserve's small size, visitor numbers have to be controlled so as to minimise disturbance to the wildlife. As a result, only around 40,000 people visit MPNR each year but this includes 400 groups of primary and secondary schools students on specially guided programs sponsored by the government's Education Department. Teams of volunteers also help with reserve management work at various times of year.

Wetland Park, Hong Kong

In 1987, reclamation work began on a 300 ha area of fishponds in the south-western corner of the Deep Bay wetlands for construction of a new town called Tin Shui Wai that would eventually house some 135,000 people. However, with increasing awareness of the importance of wetlands, the Government proposed in 1995 to set aside a 64 ha area of the development area as mitigation for the loss of wetlands due to the construction of the new town. This area would also act as a buffer between the new town and the Mai Po Inner Deep Bay Ramsar Site.

After further discussions, the Government decided in 1999 to expand the ecological mitigation area into a Wetland Park for both local residents and overseas visitors. This was partly in response to satisfy the demand by visitors to see, and have greater understanding of the Deep Bay wetlands but could not due to the lack of space on the guided tours at MPNR. The facility will have a modern wetland education centre as well as a range of demonstration wetland habitats, including a high tide roosting site for shorebirds and other waterbirds. Work began on the Tin Shui Wai Wetland Park in 2000 and the final phase is planned to open in 2005 and will be managed by the Hong Kong Government.

Being less ecologically sensitive than MPNR, this new Wetland Centre will have a capacity for up to 400,000 visitors per year. It will therefore be able to bring the message of the importance of the Deep Bay wetlands and shorebirds to a wider and larger audience.

Futian National Nature Reserve, Shenzhen SEZ

A range of wetlands, such as mudflats, mangroves, shrimp ponds and fishponds are also found along the northern, Mainland China side of Deep Bay. In 1984, protection of these wetlands began and in 1988, the area was upgraded as a national nature reserve. The boundaries of the Futian National Nature Reserve (NNR) were confirmed in 1998, enclosing an area of 304 ha and managed by the Department of Agriculture and Forestry, Shenzhen SEZ.

Many of the shorebirds that uses Deep Bay feed on the mudflats on both the Hong Kong and Shenzhen sides of the Bay. However, at high tide, the majority of these birds will fly and roost on the shallow water ponds within MPNR due to the lack of high tide roosts at Futian NNR.

In the late 1990s, the reserve began to develop a range of visitor facilities, such as a floating boardwalk and tower bird watching hide that overlook the mudflat and the waterbirds that use it. In December 2003, the reserve launched their education program by opening a wetland education centre and working with local schoolteachers to promote environmental education in Shenzhen's schools. This will be a good opportunity to spread the message of the importance of the Deep Bay wetlands to the community on the Shenzhen side of the Bay and hopefully, lead to co-ordinated conservation management of the whole Deep Bay catchment.

Cotai Wetlands, Macau SAR

The Macau Special Administration Region (SAR) is situated on the western bank of the Pearl River Estuary in Guangdong Province, southern China. It is made up of the peninsular of Macau, and the islands of Taipa and Coloane. In 1968, a causeway was built linking these two islands and due to the hydrology of the area, sediment began to slowly build up on the western side of the causeway. By 1989, this process of siltation had produced a 1,020 ha of new wetlands, mostly inter-tidal mudflats. However, in the 1990s, reclamation of this wetland for development began and only some 65 ha now remains.

Despite the decline in the area of the Cotai wetlands, important number of waterbirds can still be found there. This includes up to 46 Black-faced Spoonbills in winter, a figure that represents some 5% of the world's estimated population of this endangered species. In November 2003, a Black-faced Spoonbill was seen at the Cotai wetlands that had previously been caught and marked with colour leg-rings at Mai Po Nature Reserve in December 2002.

During spring and autumn passage, some 3,000 individuals of 38 species of shorebirds pass through the Cotai wetlands, with the main species being Red-necked Stint and Greenshank.

Of particular interest, is the fact that colour-flagged shorebirds have recently been recorded in the Cotai wetlands during northward migration. One of these birds, a Red-necked Stint seen in April 2002, had previously been caught in Victoria, Southeast Australia whilst another, a Curlew Sandpiper seen in April 2003, had previously been caught in Northwest Australia.

With the agreement by the Macau SAR Government to designate the 65 ha Cotai wetlands as a protected area and to manage it for conservation and education, this could be the start of wetland and shorebird conservation on the western part of the Pearl River Estuary.

Guandu Nature Park, Taipei.

The coastal wetlands at Guandu in northern Taiwan have always been an important site for bird watching, so in 1986, the Taipei government agreed to establish the Guandu Nature Park and a committee was formed to investigate the ecology of the site and plan its management. In 1988, the committee published its report and the government began acquiring the land for management. Finally in 1993, the government announced that the area would be set aside for the Guandu Nature Park. By 1996, a 57 ha area had been taken over for management and the land granted Wild Bird Society of Taipei (WBST) to manage.

Some 23 species of shorebirds have been recorded at the site with the commonest being Pacific Golden Plover, Common Greenshank, Wood Sandpiper, and Common Snipe. Three species of shorebirds have also been recorded at the Nature Park, being Painted Snipe, Black-winged Stilt and Little Ringed Plover.

Peak numbers of shorebirds are presently around 500 but prior to 1997, there used to be more than 2,000 Kentish Plover and Dunlin alone. The decline in shorebird numbers is suspected to be due to the decline in the area of mudflat adjacent to the Nature Park due to encroachment by mangroves. However, with the recent creation of a high tide roost site within Guandu Nature Park by the WBST, a group of 60 Dunlin were recorded in November 2003 again in the Nature Park.

The Nature Park has an active wetland education program attended by some 120,000 visitors annually. These include;

- Special activities for school students led by teachers on themes selected by the teachers themselves. These activities are mainly for primary students.
- During weekend and holidays, a variety of activities are offered for the public and for family groups. Depending on the season, these activities may include 'courses' on wetland ecology such as studying the local birds, water plants, and frogs. There may also be educational activities to further increase wetland awareness, such as folding paper waterbirds and dragonflies, and flower pressing. Other topics may also be offered, such as watching the stars at night!
- Teachers may also help to lead volunteers into the Nature Park to carry out a range of work that would not only promote greater appreciation amongst the volunteers of how to maintain the ecological value of wetlands, but also, help to improve the environment of the Nature Park.
- Special annual events are also organised such as an annual International Bird Fair in November.

Sungei Buloh Wetland Reserve, Singapore.

This coastal wetland dominated by mangroves is located on the northern shore of Singapore. Historically however, local fishermen had impounded the area for shrimp farming using inter-tidal ponds but in 1989, an 87 ha area was designated as a Nature Park that was later opened to the public in 1993. In 2001, its status was upgraded to a Nature Reserve as well as being listed as a Shorebird Network Site. Its size was expanded to 130 ha in 2002.

Some 35 species of shorebirds have been recorded at Sungei Buloh, with peak numbers of between 1,500 to 2,500 birds being recorded at any one time. These shorebirds feed mainly on the mudflat but roost inside the reserve.

One of the problems that the Reserve faces is from mangrove encroachment both over the mudflat and around the shorebird roosting sites within the Reserve. In response to these problems, the mangrove seedlings on the mudflat are removed on an annual basis, and there is also a program to control mangroves inside the reserve.

There is an active shorebird banding program with some 500 shorebirds being banded each year, with recoveries from as far as Russian Yakutia. A colour-flagging program has begun in 2003.

The Sungei Buloh Wetland Reserve has an active wetland education program that it promotes to the 100,000 local and overseas visitors it receives annually.

With assistance from HSBC, a Sungei Buloh Education Fund was established in 1997 to support a series of nature outreach programs at the reserve. These programs range from self-guided walks to specialised thematic trails such as 'Heron Watch' and 'Prawn Watch'. For walk-in visitors, volunteer guides are available on Saturdays at specific time to explain the ecology of the reserve. For organised groups, a 'Nature Hunt' series has been developed to allow these visitors to explore and learn more about the reserve.

In 1999, the reserve began a program with local schools whereby the school can adopt a particular part of the reserve, and take care of its maintenance.

Discussion

From the early 1980's, there has been a growing awareness in Asia of the importance of wetland conservation and the need to communicate this message to the public through the establishment of wetland education centres. These wetland centres now play a very important role in promoting wetland education and public awareness and in many cases, their staff are also involved in the active management and conservation of the wetland of which they are part.

With growing economic affluence in many Asian countries, an increasing number of education centres are continuing to be built, many of which for the first time in those countries. As a result, the message of wetland conservation will continue to spread across the continent. This is especially rewarding as many of these centres are beginning to network amongst themselves to share resources and experience so as to make their work more effective.

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Linking scientific knowledge on shorebirds with multiple sectors of local community through education and public awareness – Lessons learnt from the Kashima Model in Japan and its adaptive application to the Yellow Sea Ecoregion in China and Korea.

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Key words: education and public awareness, local pride, community-based management, Kashima Model, Yellow Sea Ecoregion

Sufficient scientific knowledge on shorebird population and ecology are fundamental to conservation of shorebirds and their habitat. However, this knowledge has been communicated only between narrow circles of government departments responsible for wildlife conservation and conservation NGOs in Japan previously. The Kashima-Shingomori site in Kashima City in Japan was chosen as a model case because it is an internationally important site for a number of shorebird species, including Whimbrel in particular. However, because the area around the site is actively used for fisheries and agriculture, the local community around the resisted the designation of legally protected area in the past.

WWF-Japan started developing an environmental education programme in 2000 on this site with the participation of the local government, the local education board, a local primary school as a model school, and local environmental NGOs. Local community groups that were involved in education and public awareness activities not only recognised the importance of the Kashima-shingomori site, but they became motivated to continue the education and public awareness activities. After creating a precedence of working with the local community on education and pubic awareness, WWF proposed a voluntary conservation option to the local government, which was to nominate to the East Asia-Australasia Shorebird Site Network. The local government consulted extensively with different sectors in the local community, and finally the local community agreed to nomination. The Kashima-shingomori site was formally designated as the network site in 2002.

The lessons learnt from the Kashima Model were that communication, education and public awareness activities that are based on scientific knowledge and that are targeted at multiple local sectors can create wider acceptance of and voluntary support for internationally important sites. This has happened because these local sectors, which had no direct wildlife conservation interests previously, were surprised by the scientific fact that the local site was internationally important and later they have developed a sense of local pride about their local site. Some of these groups also found new potential benefits such as opportunities for promoting regional development, nature-base tourism, community studies in formal education, better custodianship of an local area. These various local groups are continuing to develop their initiatives to better manage the site. The key to motivating multiple sectors in this case was that based on scientific knowledge, a site in the local community was given a accreditation as internationally important site.

Since 2002, in partnerships with WWF-China in China and the Korea Ocean Research and Development Institute (KORDI) in South Korea, WWF-Japan started the Yellow Sea Ecoregion Planning Programme and it has incorporated lessons from the Kashima Model into the design of the Yellow Sea Ecoregion programme. The programme has designated Chongming Dongtan in Shanghai City, China and the Geum estuary in Gunsan City, South Korea as community-based management model sites. The project is currently working with local communities on formal education at the initial stage, and plans to develop community-based management with multiple local sectors.

“A Year on the Wing” An Online Documentary

Nell White

Outline of 20 minute talk for
Shorebirds Conference December 2003

Just over Ten years ago I was crouched down in the sand dunes on the shores of Roebuck Bay, in the blazing sun. Holding my breath in anticipation, we were waiting for the tide to come in. I had no idea of what was to come next.

It was my first ever experience at bird watching and I wondered what I was in for. With military precision, Clive Minton then gave the word. The nets went off, as did the people around me. There was a great flurry of activity as everyone ran down the beach to greet the birds in the nets.

It proved to be a day I will never forget. There in the nets, were hundreds of birds which had just returned from Siberia. And amongst them was an Eastern Curlew.

For the past 12 months I had been raising money for an arts project which was to focus on the story of the Eastern Curlew and its amazing migration. Despite all the reading and talking I had never seen one of these birds Being able to see and hold an Eastern Curlew, was extraordinary. That bird has managed to inspire and motivate me for over 10 years.

That day I also saw a group of very skilled and incredibly passionate people as they worked to measure and record the details of hundreds of birds. I have since met many of these people, and I know that the birds inspire them in a similar way.

I am here today speaking on behalf of a team of people who come from an arts background, and we see our role as taking the knowledge, experience and passion that you have and finding ways to capture the hearts of others, just as you captured ours.

I am here to talk about an online documentary project and how it might be example of undertaking community education and raising awareness for particular issues. In other words how an internet project can be a tool for capturing the hearts and minds of others!

Background to the Project

The project ìA Year on the Wingî had its genesis in the performing arts project ìWaderbirds Odyssey of the Wetlandsî, which was completed in 1993. Many of you will remember that project, having been cajoled into participating by our persuasive team. Since then the story has been retold my Meme McDonald thru her children’s book ìThe Way of the Birdsî and through Sarah Watts award winning animated film based on the book.

A Year on the Wing was one of 4 projects in an ABC / Australian Film Commission initiative to experiment with interactive documentaries for the internet. Environment Australia also contributed to funding.

So from the start, this project was experimental. Taking storytelling and filmmaking and putting on the internet.

Brief Outline of project

“A Year On The Wing” is a multimedia documentary project designed for viewing via the Internet. It takes us on an astounding journey with over two million wading birds as they attempt their annual migration from the Southern Pacific to Siberia and back.

Our guide for the journey is the largest of all migratory wading birds, the Eastern Curlew. We travel with Dr Clive Minton, world renowned ornithologist, and Sarah Watt, multi-award-winning animator and artist, both of whom have travelled the migratory path of the birds in their own way.

With their help we are able to visit communities, discover the wetlands and meet the people in locations from Aotearoa/New Zealand locations across Australia and throughout South East Asia. Artists, storytellers, and bird enthusiasts are just some of the interesting people we meet to see and hear how people across the world have for centuries been inspired by these shy and powerful creatures.

Initially released in June 2002, “A Year On The Wing” was designed to tell the story of the birds’ journey as it unfolded in real time. Beginning with the breeding of wading birds in Siberia, each month, paralleling the progress of the birds’ southern migration and their return north, a further leg of the documentary became available on-line, over 12 months.

The project was supported by the Australian Film Commission, ABC and Environment Australia. An interactive component with the facility for the contribution of stories, information, observations, art-work and argument, is an integral part of this on-line documentary.

Key aims of the project have been to develop a new media project which brings together the concepts of storytelling through documentaries together with the interactivity of the internet; Create a popular and innovative means to raise awareness of the amazing flight of migratory wading birds and in particular the Eastern Curlew; Raise greater awareness of the vital importance of preserving our environment, particularly wetland sites throughout the East-Asian Australasian Flyway; and Build understanding and develop links between people throughout the East-Asian Australasian Flyway so as to facilitate active involvement in conservation activities.

Viewers can follow the journey of migratory Waders as they journey from Siberia through Japan and south to Australia and New Zealand and then back again, over the course of a year.

Response to the project

The project received an average of 3500 hits per week over the course of the first year, which was by far the most frequently visited of the online documentaries.

The response to the project was fantastic, and the AFC has used it as a key example of the sort of internet storytelling that they want to encourage, showcasing it both around Australia and internationally.

Unfortunately we have no detailed information about which aspects of the site were most popular, and in future this would be a great advantage to being able to design and build even better sites such as this.

Our license agreement with the ABC gave the ABC exclusive hosting rights for the first 12 months. The project will remain in an archived state on the ABC site for another 4 years. So it is possible to see the site, but it is not being updated.

What lessons have we learnt?

Although the site has been very successful and has gained great reviews here in Australia and overseas, there are a number of lessons which can be learnt, particularly in terms of how this medium might best be used in future for ongoing environmental education.

Both the medium (i.e. the internet) and the technology (i.e. the programs) for these types of projects are new and constantly changing. This means that sites can be ìout of dateî only months after being finished.

It also means that the audience is still learning how to use the medium, both technically and in other ways. Eg:- people have particular expectations which are still being tested and expanded by the medium. It takes a long time for people, schools and groups to learn and adapt to new technologies and opportunities.

So, as one of the first sites which aimed to incorporate storytelling, as well as information and the potential for interaction, we felt that there were many issues and questions for which we had no answers. Looking back on the site 12 months later, there are some things which we might approach differently if we were starting again today, but on the whole we think that it stands the test of time very well.

There is no doubt in our minds that as the technology continues to develop and the expertise of the audience grows the demands on these types of sites will grow enormously. It was very clear to us that we were able to reach an audience who were otherwise not linked into many of the specific ìbirding ìsites. They were coming to the subject matter from a very different point of view, perhaps the arts, perhaps the communities, perhaps the idea of travel.

The birding communities were very supportive and excited as we developed the site and provided a huge amount of support to our team, without which it would have been very difficult to achieve.

We were keen not to duplicate the work of existing organizations and their sites.
There is already a lot of very good sites on the net, which include a lot of informationÖ we didn't want to duplicate those. We were also aware that there are a small number of people who maintain and support many of these sites and we did not want to overload there already full work schedules.

So there are a number of technical lessons which continue to be learnt as the technology and the medium develop. I think that the key to using this medium however, is in harnessing its power as both a medium for storytelling as well as for interaction and participation. It is these factors together which make the medium so exciting. If done well the storytelling can inspire people, and the potential for participation allows us all to become involved. The combination of these factors is what is new and it is this which we need to encourage and foster.

See the site at www.abc.net.au/wing.

Shorebird Conservation In Australia – Community Conservation Action

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Abstract

As the human population continues to increase, overlap between human activities and habitats for shorebirds will intensify. Threats to shorebirds and their habitats, both direct and indirect, include loss of wetlands, altered water regimes, pollution, introduced predators, invasive weeds, a lack of public education and related human disturbance, inappropriate planning schemes and climate change.

To date, Australia's efforts to conserve shorebirds have been directed through international agreements (eg. CAMBA and JAMBA), site protection tools (eg. Ramsar, Conservation Estate, EPBC Act) and the promotion of the East Asian-Australasian Shorebird Site Network to facilitate recognition and improved management of important sites. Also, Commonwealth programs have supported community-based action through initiatives such as Coastcare, Envirofund, the Australasian Wader Studies Group banding and monitoring program, and more recently the Shorebird Conservation Project.

The Shorebird Conservation Project, which focuses on encouraging and enabling communities to engage in shorebird conservation, has found that, at a community-level, the general lack of awareness and on-ground action reflects the limited information, resources and incentives available to local communities and decision-makers (eg. landholders and managers, user and interest groups and local government). There are many opportunities to be gained by building community capacity, and efforts in the future must recognise and address the needs of local communities and the contribution they can make towards the conservation of shorebirds in Australia.

Introduction

A total of 75 species of shorebird can be found in Australia, comprising 18 resident, 36 migratory and 21 vagrant species (Priest *et al* 2002). Many of the migratory shorebirds breed in northern China, Mongolia, Siberia and Alaska during the northern hemisphere summer, returning to Australia in September of each year, to feed and rest during the southern hemisphere summer.

As the human population continues to increase, overlap between human activities and habitats for shorebirds (feeding, roosting and breeding) is likely to intensify. The loss or degradation of critical habitat is a major problem, both within Australia and abroad. Threats to shorebirds and their habitat, direct and indirect, include the reclamation and pollution of wetlands, alteration of wetland hydrology, introduced pests, a lack of public education and related human disturbance, inappropriate planning schemes and climate change.

Historically, the investment in conservation effort to mitigate threats has focused on identifying and raising the recognition of important shorebird sites, and where possible, applying site protection tools. However, of the 201 important shorebird sites identified in Australia, there is a large proportion of sites where there is still no recognition of conservation values. Many of these sites can be found on public and private land, managed primarily by Local Government, and landholders and managers respectively. Information on important sites does not appear to be disseminated at a local level. There are significant gains to be made by engaging local communities to undertake a range of conservation actions.

This paper provides an outline of conservation efforts in Australia to protect shorebirds and their habitats. The role of the community in achieving conservation outcomes is examined and the Shorebird Conservation Project is presented as a model for building community capacity to engage in shorebird conservation. Successes in community engagement are outlined as are options for overcoming challenges to engagement.

Conservation Efforts in Australia

Australia's conservation efforts have been directed at several scales -international, national and local - to protect migratory shorebirds, resident shorebirds with conservation status, and sites that are recognised as nationally and internationally important for shorebirds.

At an international scale, Australia has developed bilateral agreements such as the Japan-Australia and China-Australia Migratory Bird Agreements for the conservation of migratory birds. Also, the East Asian-Australasian Shorebird Site Network seeks to facilitate recognition and improved management of a network of important shorebird sites. The network now includes 31 sites across the flyway, encompassing ten countries, with eleven sites in Australia.

To date, protection of important sites within Australia has been pursued through the Ramsar Convention on Wetlands, the Environment Protection and Biodiversity Conservation Act and inclusion of sites within the Conservation Estate. The introduction of a Wildlife Conservation Plan will further add to the selection of site protection tools available within Australia.

Commonwealth programs through the Department of Environment and Heritage (DEH) have also sought to encourage at a local level community action to conserve shorebirds and their wetland habitats. Initiatives to facilitate community involvement include community grant programs such as Coastcare and now Envirofund, the Australasian Wader Studies Group banding and monitoring programs, and more recently the Shorebird Conservation Project.

In Australia there has been considerable effort to identify important shorebird sites. The long-term census and monitoring of shorebirds by the Australasian Wader Studies Group, a special interest group of Birds Australia, enabled the preparation of a 'National Plan for the Conservation of Shorebirds in Australia (Watkins 1993). Since the release of this plan that identified 201 areas of international and national importance for shorebirds, many sites have been the focus of concerted conservation efforts.

Historically, the investment in conservation effort to mitigate threats has focused on identifying and raising the recognition of important shorebird sites, and where possible, applying site protection tools. However, an analysis of the 201 important shorebird sites identified in Australia reveals that at a majority of sites there is still no recognition of their conservation values or they fall only partly within some form of protected area. Also, many sites that are now afforded protection face increasing pressure from a range of threats with few or no resources allocated for their management.

Many of the important sites can be found on public and private land, managed primarily by Local Government, and local landholders and managers respectively. At these sites, there is little awareness of conservation values. This lack of awareness and little emphasis on managing and protecting important sites would appear to partly reflect the lack of information, resources and incentives available at a local scale.

The role of the community in shorebird conservation

Community in this paper is defined broadly as the general public and includes landholders and management groups and user and interest groups. The focus of community involvement in shorebird conservation in Australia has historically taken the form of surveys and regular monitoring and more recently educational projects. This involvement has been invaluable in identifying important shorebird sites and monitoring changes in populations over time.

Many of our important shorebird sites are found on land managed by Local Government and local landholders and managers, who still appear unaware of the significant conservation values of these areas.

There is an urgent need to encourage community involvement in it's historical form to evolve into effective on-ground threat management, the management and protection of sites on private land, and advocacy to ensure appropriate planning within local government, who in many cases, may decide the fate of many of our important shorebird sites. The shorebird community within Australia also needs to support and facilitate this evolution in community involvement.

The Shorebird Conservation Project is a relatively recent initiative of the Commonwealth Government to increase awareness, understanding and involvement of communities in conservation of shorebird habitat, and where possible enable communities to conserve and wisely manage important shorebird sites. Given the significance of sites managed by Local Governments and local landholders and managers, there is clearly a need to engage more at a local level if there are to be effective conservation outcomes for shorebirds in Australia.

The Shorebird Conservation Project – enabling communities to act

The Shorebird Conservation Project (SCP), funded by the Natural Heritage Trust and co-ordinated by WWF Australia, occupies a very specific niche within Australia's efforts to conserve shorebird habitat. The SCP is positioned to build community capacity and facilitate community-based conservation action at important shorebird sites.

The approach taken to developing the project has focussed on delivering a model for enabling communities to engage in conservation. This model will now be discussed in terms of how the SCP facilitates community engagement with respect to site selection and planning, communications and capacity-building and monitoring and reporting. In doing so, the successes and challenges to enabling communities to engage in conservation will also be examined.

Site Selection

Priority shorebird sites are selected for a range of community-driven shorebird conservation projects. Currently there are seven sites including Western Port Bay (VIC), Mackay and the Great Sandy Strait (QLD), Roebuck Bay (WA), Northern Gulf St Vincent (SA), Clarence Estuary (NSW) and Boullanger Bay/Robbins Passage(TAS).

The selection process for determining these priority sites involved assessing sites of national significance, identified in the National Plan for Shorebird Conservation in Australia (Watkins 1993), against criteria agreed at the first meeting of the National Shorebird Taskforce in September 2001. Information in relation to the criteria was compiled in consultation with key stakeholders in each Australian State.

To assist with assessment of shorebird sites, each site is visited to meet with local stakeholders and discuss management concerns, and a survey is distributed widely to further assess the management needs of shorebirds. The survey provides an overview of the site's importance for shorebirds and levels of conservation management (taken and proposed) and asks a series of questions to identify local perceptions of threats to habitat, stakeholders, target audiences and actions needed to address threats. A site assessment is then compiled for each site.

A site action plan is prepared based on the site assessment and input from the National Shorebird Taskforce. Action Plans outline objectives, prioritised actions, lead stakeholders and performance indicators to monitor and evaluate project success. A site communication plan is also prepared that identifies specific management issues, target audiences and opportunities for reaching audiences. Site action plans are then presented to local stakeholders and those groups who are capable and interested in co-ordinating a project submit project plans.

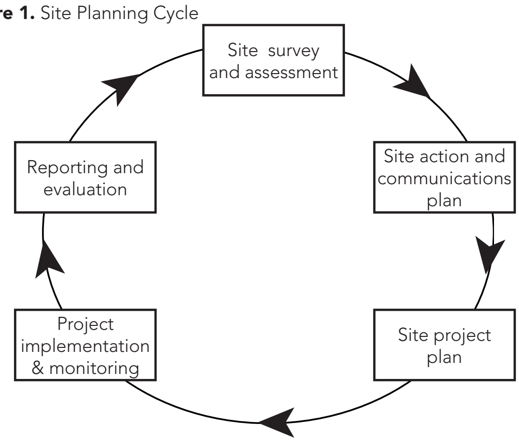
Table 1. Criteria agreed by the Shorebird Taskforce, September 2001

Prioritisation levels	Categories	Criteria
Level 1	1. shorebird importance 2. widely dispersed beach nesting shorebirds	- Sites must be of national importance for shorebirds - Species diversity & abundance - conservation status (national/international)
Level 2	3. threats and degree of threat	- list types of threats
	4. probability of success	- likelihood of mitigating threats - what needs to be done (i.e. capacity to act - access to management tools; profile of threat)
Level 3	5. proximity of support	- potential for community involvement - number of townships within close proximity to site
	6. cost effectiveness	- logistics (accessibility; hazards)
	7. focal site for action	- opportunities to test 'new'/ 'different' types of approaches to conservation
	8. potential as demonstration site	- opportunities to be identified as an 'icon' site
	9. degree of conservation action	- level of current management (existing conservation efforts)
	10. land tenure	- classification of use (does tenure match use?)
Level 4	11. widely dispersed shorebirds of inland Australia that have severe threats	- conservation status (State & Commonwealth) - 'National Plan for Shorebird Conservation'

Site Planning

The planning cycle for sites includes a site survey and assessment, site action and communication plan, project plan and reporting (monitoring and evaluation).

Figure 1. Site Planning Cycle



Communication and Capacity-building

In general, there is a poor level of awareness about shorebirds and their habitat needs throughout the wider Australian community. The objectives of the communication and capacity-building plan of the SCP are:

- to raise awareness and understanding about shorebirds, their habitat needs and conservation requirements, at priority project sites and then throughout the wider Australian community.
- to build on the existing capacity of stakeholders to actively participate in shorebird conservation at priority project sites and then throughout the wider Australian community
- to enable key target audiences to design and implement more effective shorebird conservation initiatives

To fulfil these objectives, the SCP is developing communication products and activities in collaboration with existing networks to allow the effective dissemination of information and resources to communities.

The Shorebird Conservation Toolkit is an evolving component of the SCP that will provide tools to build capacity among stakeholders, community groups in particular, to undertake conservation action. The toolkit will comprise: a website, a booklet 'Shorebird Conservation in Australia' (supplement to Wingspan) and Case-Studies (target-audience and issues-based and site-based). Other products that are available to complement this toolkit include: A Year on the Wing, Feathers Flyways and Fastfood, and a series of guides and fact sheets on the EPBC Act that relate to shorebirds, migratory species, Ramsar sites and planning for local government and natural resource management committees.

Monitoring and Reporting

A number of project indicators measure both conservation and social performance of the SCP against its stated objectives and desired outcomes on a national scale and at the site level. These indicators measure performance, impact and outcome. Performance Indicators aim to measure the amount of work achieved by the project, for example, the number of projects initiated and project outputs. Impact Indicators aim to measure how the target audiences responded, for example, the number of people attending project events, the number of media stories published, the number of threats removed or responses received to project surveys. Outcome Indicators aim to measure how the conservation status of shorebirds and their habitats changes. These are difficult to measure due to the cost, and consequently the project aims to have shorebird conservation outcome indicators included in State of the Environment reporting, regional NRM reporting or other reporting processes. An example of a social outcome indicator at a site might be the number of people skilled at monitoring shorebirds and site conditions.

Site Transition Strategy

To facilitate the long-term management of a site, a transition strategy has been prepared that considers the project's form of involvement, how responsibility will be devolved and which local groups could be taking the initiative to continue community engagement in conservation in the area. Several principles of community engagement have been adopted, these include:

- initiating activities only at sites where some local capacity exists (or can be developed) to continue the conservation action
- advocacy at all stages to set up support mechanisms, funded by government or other, that will maintain conservation action (e.g. Envirofund, NRM plans, local government environment grants)
- empowerment of communities as local managers (identifying when local communities have the capacity themselves to manage sites and keep initiatives going)
- initiating activities through already established local institutions rather than entering into agreements with communities directly

Table 2. Shorebird Projects

Project	Co-ordinating group	Activities
Roebuck Bay Shorebird Project (WA)	Rubibi Land Heritage and Development Group	• Shorebird Viewing and Cultural Tours • Installation of interpretive signs • Preparation of a tourist brochure
Port Gawler Shorebird Project (SA)	Two Wells and Districts Tourism and Trade Association	• Installation of an interpretive Shorebirds Shelter • Fencing
Thompson Beach Shorebird Project (SA)	Thompson Beach Ratepayers Association / Friends of Thompson Beach	• Installation of 2 Shorebird Interpretive Trails • Preparation of a trail brochure
Shorebird Logo Project (SA)	DC Mallala	• Creation of a shorebird logo for street signs within the district of Mallala
Phillip Island Shorebird Project (VIC)	Phillip Island Nature Park PINP	• Installation of interpretive signs (including the preparation of trail notes) to complement the Rhyll Inlet Walking Trail • Production of shorebird postcards for display at PINP Visitor Centre
Conservation Agreements, Yallock Ck Project (VIC)	Birds Australia	• Exploring opportunities for conservation agreements with landholders at Yallock Ck, Western Port Bay
Mackay Shorebird Project (QLD)	Queensland Wader Study Group	• Surveying and mapping shorebird habitat in the Mackay area • Field identification sessions • Slide nights
Far NW Tasmania Shorebird Project (TAS)	Robbins Passage Coast and Landcare Group and Birds Tasmania	• Mapping important ecological, social, economic and cultural values of the wetlands

Community Shorebird Projects

The SCP has been welcomed with enthusiasm by individuals and groups at project sites, who are keen to learn more about shorebirds, and actively participate in national and international efforts to conserve shorebirds. There are eight shorebird projects across five of the seven priority shorebird sites. Table 2 outlines the projects and groups co-ordinating each project. Two shorebird projects have recently been completed – the Conservation Agreements, Yallock Ck Project and Mackay Shorebird Project.

The projects outline a range of activities that are supporting efforts to manage threats (interpretive trails and fencing), protect sites on private land, map important habitat and evaluate threats, guide management planning as well as activities to educate both locals and visitors to sites.

The SCP is working closely with community groups, government and non-government organisations to develop and implement these shorebird projects. Project partners include Birds Australia, The Australasian Wader Studies Group, Wetlands International-Oceania, Wetland Care Australia, Conservation Volunteers Australia and State-based Conservation Councils including the Tasmanian Conservation Trust and the Conservation Council of WA.

Successes and Overcoming challenges in engaging communities in shorebird conservation

Successes in community engagement

Across Australia there are many examples of successes in protecting shorebirds and managing important shorebird habitat that began with and rely upon community involvement.

Community groups are involved in research to survey and monitor shorebirds, shorebird habitat and threats. This information provides the basis for guiding management and on-ground conservation action at important shorebird sites. Also, there are examples of groups actively engaged in threat management, working on-ground to address issues such as loss or degradation of habitat, introduced pests, invasive weeds and human disturbance. For example, the South Coast Shorebird Recovery Program (NSW), Mornington Peninsula Hooded Plover Recovery Program (VIC), Robbins Passage Wetlands Water Quality Monitoring and Rice Grass Control Projects (TAS), Milang Wetland Project (SA), Attadale Foreshore Dog Control Project (WA) and the Mackay Shorebird Project (QLD). Elsewhere community groups are involved in management planning and working tirelessly to raise awareness of shorebird management issues with respect to coastal development and human disturbance issues.

The benefits to local communities can been observed through the development and promotion of nature-based tourism industries, financial and technical assistance for landholders, and through establishing links to a national and international community and access to information and resources attached to this wider community.

Overcoming challenges to community engagement

While there are many successes to be enjoyed by engaging the community in shorebird conservation, there are also challenges to be overcome if there is to be effectiveconservation outcomes for shorebirds in Australia.

Perceptions of community involvement in conservation

There appears to be a perception that the role of the community in shorebird conservation is limited to research (surveys and monitoring) and education. However, there are examples of communities actively engaging in threat management, management planning and advocacy to ensure information is incorporated into local government planning schemes and development approvals. This perception of a limited role of the community in conservation under-values the contribution communities can make and represents lost opportunities for the conservation of shorebirds in Australia. Perceptions on the role of communities to achieving conservation need to be broadened to encompass research, education, threat management, management planning, advocacy and site protection.

Limited resources and vague management plans

Although there are a range of tools available to pursue the protection of shorebirds and their habitats, and there is emphasis on developing management plans, there are few resources allocated to the implementation of actions on-ground. Also, management plans can often be vague, referring to broad management strategies and motherhood statements to address issues at sites, with limited instructions on how strategies are to be implemented. Management plans need to be more specific if the community is to be engaged in supporting the implementation of actions at sites.

Lack of information within local government

Local Governments whose jurisdictions encompass sites already protected are often not familiar with the various forms of protection, the boundary of the protected areas and the obligations to manage these areas to maintain the high conservation values. Similarly, many planning officer don't appear to have information on the location of important sites (roost, breeding, feeding habitat), even when this information is available, and this is reflected in poorly informed local government planning schemes and inappropriate development activities. To address this issue, information and resources must be disseminated to relevant officers within local government, preferably with important sites mapped so they can be easily incorporated into local government databases. Also, the development of a guide to help inform planning officers of the impacts of particular activities on shorebird habitat would be useful.

Lack of information in the general public

The general public at sites visited as part of the SCP are often not aware of the importance of their area to shorebirds. There appears to be limited infiltration of information into the wider community. This communication problem may be addressed with information targeting local media and by allocating funds to ensure resources such as A Year on the Wing and Feathers, Flyways and Fastfood are incorporated into school curriculums, and the latter circulated to schools in areas where important sites have been identified.

Lack of support to protect sites on private land

Many important sites are located on private leasehold or freehold land. A range of protection and management options are provided through conservation agreements, which can vary in form from State to State, ranging from non-binding agreements to binding covenants attached to land title. Conservation agreements have potential to help conserve many important shorebirds sites, however, more support is needed to encourage landholders to enter into agreements. Also, some sectors within the shorebird community need to recognise the contribution agreements can make to conserving shorebird habitat and offer more support to efforts already underway to protect sites on private land.

Conclusion

Australia's investment in conservation efforts to protect shorebirds and their habitats can be commended, there are a range of options to facilitate conservation on both public and private land. Long-term census and monitoring by the Australasian Wader Studies Group has provided a lengthy list of important sites, located on a mix tenures, with many sites managed by local government and landholders and managers. Historically, the community has been under-valued in terms of the contribution it can make towards shorebird conservation in Australia. Where there has been an investment in community action through grants, the focus has been on projects more so than an interest in building the capacity of people to engage in conservation. The direction of conservation efforts in the future needs to address the capacity of individuals and groups to undertake action as well as the lack of information, resources and incentives available at a local level, as the community represents the front line of shorebird conservation in Australia.

Acknowledgements

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Shorebird studies

What have we learned from banding and flagging waders in Australia?

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Abstract

More than a quarter of a million waders have been banded in Australia over the last 45 years, 95% being migratory species. Around 126,000 of these have also been colour leg-flagged since this process was introduced in 1990. There have so far been 534 recoveries and 3903 sightings of leg-flagged birds overseas, as well as 150 recoveries and 225 leg-flag sightings in Australia of waders marked overseas. Overseas recovery rates for species varied widely, between 0.03% for Red-necked Stints banded in NW Australia and 1.1% for Red Knot from SE Australia. The average recovery rates for migratory waders banded in these two regions were 0.32% and 0.12% respectively, and 0.21% for Australia as a whole. Overseas flag-sighting rates were on average 30 times higher for birds marked in SE Australia and 5.6 times higher for NW Australia than banding recoveries. Flag-sightings have now been reported from 16 different countries in the Flyway. There is a strong preponderance of flag-sightings in Asia, of birds on northward migration over birds on southward migration. Maps of recoveries and flag-sightings show the marked differences in migration routes and destinations between different species, and even between different populations of the same species. Other knowledge gained from banding activities is briefly outlined, and future priorities discussed.

Introduction

Waders comprise nine percent of the Australian avifauna. Of the 73 species recorded in Australia, 37 are migrants (36 being from the Northern Hemisphere), 17 are vagrants (again, all from the Northern Hemisphere), and 19 are residents (nine being endemic to Australia).

As in many parts of the world intensive studies of waders have lagged behind studies of other groups of birds, especially land birds, seabirds and waterfowl. Systematic widespread population censuses of wader populations in Australia only commenced in 1981. The chicks of some resident species of waders have been banded ever since the inception of bird-banding in Australia in 1953. However large-scale banding of adult waders, especially of the migratory species, only commenced in the 1970s, when mist-nets and cannon-nets were first employed to catch the birds.

This paper concentrates on information that has come out of banding and colour leg-flagging activities via recoveries and re-sightings of colour-marked birds in the last 25 years. Other knowledge (such as biometric and moult data, age data, survival and reproduction rate information) gained during catching and banding operations is only briefly covered.

History

In comparison with many other banding activities, wader banding is very much a team operation. This is partly because of the logistics of handling heavy and bulky catching equipment, often in difficult terrain, but also because, in both mist- and cannon-netting, quite large numbers of birds may be caught at once. To process these birds quickly and collect the maximum amount of data, a large team is needed.

Wader banding activities around Australia have resulted largely from the efforts of a few experienced and enthusiastic individuals who gathered teams together to carry out the fieldwork. These teams have operated at different periods in time and at different locations over the last 45 years. Some programs operated for just a few years whilst others have been sustained over more than 25 years.

The main programs are summarised below:

a) Dom Serventy and Lexie Nichols caught waders on the Swan Estuary, Perth, from 1958 to at least 1961, using walk-in style traps (Serventy *et al. 1962).*

b) Jim Lane continued wader studies on the Swan River using mist-nets from 1972 to 1978. In 1979 the WA Wader Study Group (WAWSG) took over responsibility for wader banding in the Swan River Estuary, later introducing cannon-nets. This activity is continuing under the guidance of Mike Bamford,

c) Fred van Gessell, assisted by others including Bill Lane, commenced cannon-netting and mist-netting waders in New South Wales in 1970, mainly on the Hunter Estuary near Newcastle. These activities have continued intermittently up to the present time. The NSW Wader Study Group was also active in cannon-netting waders from 1991-97, under the leadership of Phil Straw.

d) Wader mist-netting was commenced by David Robertson and others at Werribee Sewage Farm in Victoria in late 1975. These efforts were augmented in late 1978 when Clive Minton introduced large-scale cannon-netting, as developed in Europe. The Victorian Wader Study Group (VWSG) was formally constituted at this time. These activities have been consistently maintained over a 26-year period.

e) The Australasian Wader Studies Group (AWSG) held the first of its expeditions to Northwest Australia (NWA) in 1981. These visits have become almost annual, covering Roebuck Bay (Broome), 80-Mile Beach, and Port Hedland Saltworks. Since the formation of Broome Bird Observatory (BBO) in 1988, BBO staff and other local enthusiasts have maintained wader banding operations between expeditions and in recent years these have been led by Chris Hassell.

f) Wader banding in the Hobart region, Tasmania, took place for about six years from 1979 to the mid-1980s, mainly employing cannon-nets. Mark Fletcher was the main co-ordinator.

g) Regular small-scale wader banding was commenced by Vic Smith in Albany, southern Western Australia, in 1985 and is continuing. Mist-nets were initially used and were later complemented with cannon-nets.

h) Extensive wader banding activities were carried out by the Queensland Wader Study Group (QWSG) in Moreton Bay, near Brisbane, between 1989 and 1999. Most birds were caught with cannon-nets. These activities terminated when the licensed cannon-netter, Peter Driscoll, became unavailable, then moved away from the area.

i) Attempts over the years to start regular wader banding in the Adelaide area, South Australia, have been unsuccessful. Max Waterman made a couple of good cannon-net catches of Red Knot in the Spencer Gulf in 1981-82, but activities then ceased. However since 1993 the VWSG has made annual visits to the southeast coast of South Australia, mainly to catch Sanderling and Ruddy Turnstone (see Tables 1 and 2 for scientific names). This is continuing, and is now supplemented by cannon-netting carried out by Maureen Christie, who lives in the area.

j) Some wader banding has taken place over the years in the Darwin region, Northern Territory. Occasional mist-netting by a number of people (Tony Hertog, Fred van Gessell) over the years has been augmented by short periods of cannon-netting, organised by Ray Chatto and assisted by visits of experienced people from elsewhere in Australia.

k) The WA Department of Conservation and Land Management carried out a major banding exercise on chicks at a Banded Stilt colony at Lake Ballard in 1995, with Grant Pearson the principal person involved.

Methods

Total numbers of individuals of each species banded in Australia were obtained directly from the groups and individuals (or their publications) involved in wader-banding activities over the last 45 years. This was necessary because some of the banding data submitted to the Australian Bird and Bat Banding Scheme (ABBBS) Office prior to the introduction of computerisation in 1984, have not yet been incorporated into its database. Also, several years of the most recent banding data are not yet incorporated into the database. I estimate that I have gathered at least 98% of the banding data on migratory waders but a smaller proportion of the banding data for resident waders, mainly because many of the latter were marked as chicks by very many individual banders over many years. Where the ABBBS figure for a species exceeds the total obtained from my direct approach to known major wader-banders, the ABBBS total has been used.

All recoveries have been provided by the ABBBS. A recovery is any report of a banded bird that can be identified individually, either by the number on the metal band, by unique colour-markings (e.g. multiple colour bands / leg flags), or by alphanumerically engraved leg flags. Recoveries may be of dead or injured birds, birds recaptured alive by banders away from the site of banding, or birds sighted as colour-marked individuals. Recoveries up to 29 November 2003 are included in this analysis.

The placing of a coloured PVC leg-flag on waders began, in Victoria, in December 1990. Leg-flagging in NW Australia began in August 1992 and leg-flagging has subsequently been introduced in other areas. To co-ordinate the introduction of flagging throughout the East Asian – Australasian Flyway, a Protocol was developed in the late 1990s under the auspices of Wetlands International and the ABBBS. The number of birds flagged each year in Australia, up to the end of 2003, has been collected from each wader-banding group or individual.

Flag-sightings have been gathered from a variety of sources, especially the groups and individuals responsible for the flagging. Since 2001 the AWSG has operated a centralised leg-flagging database on behalf of the ABBBS, with the financial support of the Federal Department of Environment and Heritage (previously Environment Australia). The numbers of birds flagged are provided up to the end of 2003. Flag-sightings (all of which relate to live birds) are provided up to 1 December 2003.

A recovery is a unique event (though very occasionally birds may be recovered more than once) but the number of flag-sighting reports doesn't necessarily equal the number of different flagged birds that have been seen, because a bird carrying a flag cannot be individually identified. For example, at regularly monitored migration stop-over locations, such as Mai-Po Marshes in Hong Kong, an individual bird may be re-sighted and recorded on a number of different days during its stop-over. Also, when a bird permanently changes its non-breeding area, for example from Victoria to an interstate location such as Moreton Bay or Roebuck Bay, it may be sighted several times over a period of months, or even years. Each sighting on a different day is added to the database as a new record. This potential multiplicity of records for a flagged bird needs to be considered when interpreting sightings data.

There is also potential for duplication of records when several flagged birds are present at a particular locality on the same day, often in the same flock. Many regular observers of flagged birds are skilled at determining the number of individual flagged birds present by using criteria such as the proportion of breeding plumage on the bird, its sex (determined by plumage or size), the position of the metal band, and the position of the flag(s). Duplication of records is more likely when two independent observers see a flagged bird on the same day at the same location. Follow-up discussion with the observers can often resolve this situation.

Results

Banding

The number of waders banded in Australia is shown in Tables 1 and 2. Overall, at least 254,953 migratory waders of 41 species have been banded. I consider that fewer than 2-4,000 banding records of migratory waders (around 1-2%) have been missed from this table. Around 10,698 resident waders, of 14 different species, have been banded. If the higher ABBBS database figures are used, then the minimum number of resident waders banded in Australia is at least 12,422, of 16 species. This figure will also be understated, perhaps by 1-2,000 (8-16%).

The banders and their main banding locations are also detailed in Tables 1 and 2. The VWSG, with 143,931 migratory waders banded, is the largest contributor (56% of the total). The AWSG, through its activities in NW Australia, has marked the greatest diversity - 36 species in a total of 80,381 migratory waders banded (32%). The VWSG has banded 32% of the resident waders, as recorded in Table 2, and is tied with the AWSG on diversity with 10 species.

Recoveries

A total of 534 waders banded in Australia have been recovered overseas (Table 3). A further 150 waders banded overseas have been recovered in Australia (Table 4).

Great Knot (143) have the most recoveries, followed by Bar-tailed Godwit (80), Red Knot (76), Curlew Sandpiper (66), and Red-necked Stint (53). Recoveries encompass 20 different species and have occurred in 16 different countries. By far the greatest proportion were in China (239) but a most valuable 111 recoveries have occurred in Russia (where most species breed), followed by 78 in New Zealand.

Almost half (73) of the overseas-banded birds subsequently recovered in Australia originated in New Zealand. This was an outcome of the intensive co-operative study of the Double-banded Plover (which migrates between these two countries) that was carried out by the VWSG and a range of New Zealand banders over a 10-year period from 1979 to 1988 (Pierce 1999). Sixty-six of the recoveries relate to this species alone.

Recovery rates

There have been 172 recoveries overseas of 11 species of migratory waders banded in SE Australia (Table 5). There have also been 59 controls in SE Australia of waders banded overseas, involving seven species.

Recovery rates ranged from 0.04% for Red-necked Stint to 1.12% for Red Knot. Overall the recovery rates averaged 0.12%, i.e. only one recovery overseas for every 800 birds banded.

No recoveries overseas have yet been reported for the 474 Common Greenshank, 347 Latham's Snipe, 236 Pacific Golden Plover, or 144 Grey Plover banded to the end of 2003 in SE Australia.

There have been 257 overseas recoveries, involving 12 species, of waders banded in NW Australia (Table 6). There have also been 49 controls there, relating to eight species, of waders banded overseas. The average recovery rate is 0.32%, ranging from 0.03% for Red-necked Stint to 0.80% for Great Knot.

No recoveries have yet occurred from the 1,244 Little Curlew, 1,089 Sharp-tailed Sandpiper, 649 Sanderling, 623 Black-tailed Godwit, 409 Lesser Sand Plover, 323 Oriental Plover, 278 Grey Plover, and 174 Common Greenshank banded in NW Australia up to the end of 2003.

Table 7 shows the overseas recovery rates on migratory waders from SEA and NWA in comparison with the rate for Australia as a whole (0.21%), and the rates for the Wash Wader Ringing Group (1.06%) which is the major wader-banding operation in the U.K. A comparison is also shown for Curlew Sandpiper banded in Australia (0.19%) and South Africa (0.13%), and with a similar sized species, the Dunlin (*Calidris alpina*), banded in the U.K (0.65%).

Leg-flagging

Numbers

The numbers of waders colour leg-flagged at the six locations in Australia where this procedure has been employed, appear in Table 8. Altogether 126,221 waders, of 50 different species, have been flagged up to the end of 2003. The largest numbers were flagged in Victoria (64,492), and in NWA (54,461). There is a good species spread, with more than a thousand having been flagged for each of 11 species. The largest total was for Red-necked Stint (just over 51,661), followed by 15,026 Curlew Sandpiper, 11,537 Great Knot, and 10,392 Bar-tailed Godwit.

Sightings

Up until 8 November 2003, there have been 3,569 sightings overseas of waders flagged in Australia (Table 9). Red Knot headed the list with 1,058 flag sightings, followed by Bar-tailed Godwit with 763, and Curlew Sandpiper with 528. So far there have been overseas sightings of 20 different species.

These sightings have occurred in 16 different countries (Tables 9 and 10). The growth in the number of overseas sightings reported annually can be clearly seen and reached a record 841 in 2003. A total of 1,642 sightings (42% of the total) came from New Zealand. Hong Kong produced 893 sightings, followed by Japan with 487 and Korea with 329.

A total of 225 waders flagged overseas have been reported in Australia (Table 11). This included 14 different species, with Grey-tailed Tattler (120 sightings) comprising more than half the total. Japan (143) was the main source of these overseas-flagged waders.

There have also been 1,588 sightings of waders within Australia away from their flagging location (Table 12). Sightings are spread widely through the different regions of Australia but Victoria predominates, with 1,242 flagged birds seen away from their flagging locations.

Table 13 details sightings of Australian-flagged waders in Asia during the migration period. Almost four times as many birds have been sighted during the northward migration (1,572) compared with the southward migration (451). This pattern is repeated in all of the countries where significant numbers of flagged birds have been seen, except for Japan (177 northward, 293 southward).

Sighting rates

The overseas sighting rates for birds from SEA have ranged from 0.38% for Sharp-tailed Sandpiper to 68.8% for Greater Sand Plover (Table 14). The overall average is 3.6%. No overseas sightings have yet resulted from 395 Common Greenshank and 278 Latham's Snipe leg-flagged in SEA.

Overseas sighting rates for birds from NWA are given in Table 15. Rates range from 0.7% for Sharp-tailed Sandpiper and Common Greenshank, to 50% for Common Redshank. The overall average is 1.8%. No overseas sightings have yet been reported from 890 Little Curlew, 256 Whimbrel and 238 Oriental Plover leg-flagged in NWA.

Valuable sightings, both within Australia and overseas, have occurred even when comparatively small numbers of a species have been flagged. Table 16 gives details of these, both for birds flagged in SEA and NWA. The prime example is Greater Sand Plover from SEA with 24 sightings (11 overseas and 13 in Australia), from only 16 individuals flagged. There have been four sightings of Black-tailed Godwit (two overseas and two in Australia), from only three individuals flagged in SEA. Also, the only Pectoral Sandpiper flagged in SEA was seen the next year in New South Wales.

Comparison of recovery and flag-sighting rates:

A comparison of overseas recovery rates and overseas flag-sighting rates for birds from SEA and NWA is shown in Tables 17 and 18. In both regions, and on all species, the flag-sighting rate is higher than the recovery rate.

In SEA overseas flag-sighting rates were on average 30 times higher than the overseas band recovery rate. The difference for individual species ranged from 1.5 times for Double-banded Plover to 371 times for Bar-tailed Godwit.

For NWA the overall proportion was 5.6 times, with a range from 2.4 for the Great Knot to 30 for the Red-necked Stint.

Selected recovery and flag-sighting information:

Tables and maps of recoveries and flag-sightings for a selected range of species are given below to illustrate some of the key migration information derived from banding and flagging activities.

Eastern Curlew

This species, the largest wader in Australia (and the world), has only been banded in modest numbers (1,267) in Australia, because of its extreme wariness and the consequent difficulty in making catches. There have been ten overseas recoveries (Figure 1), and 48 overseas flag-sightings (Figure 2).

Bar-tailed Godwit

Some 16,507 Bar-tailed Godwit have been banded in Australia, with 9,734 in NWA and the majority of the remainder in eastern Australia (Victoria, Queensland, and New South Wales). There have been 80 overseas recoveries and 763 overseas flag-sightings.

Table 19 shows the recoveries which have occurred in Asia during the migration period. Forty-six of these recoveries were of birds banded in NWA. The majority of recoveries were reported during the March-May northward migration season. Only three occurred in the August-September southward migration season, all being of birds from NWA.

Table 20 shows the corresponding data for leg-flag sightings in Asia during the migration periods. Again, reports during the northward migration period (278) dominate, with only 31 in the southward migration period. Furthermore, 30 of the latter relate to yellow-flagged birds from NWA.

All overseas recoveries of Bar-tailed Godwit banded in Australia are plotted on a map (Figure 3). Flag-sightings at Asian migratory stopover locations are also mapped (Figure 4). Flag-sightings on the breeding grounds, or at staging locations close to these, are shown in Figure 5.

Curlew Sandpiper

Figure 6 shows all the breeding location information deriving from catching, banding, and flagging Curlew Sandpiper in Australia (Minton *et al*. 2005a, in press). Also included is similar information from Curlew Sandpiper marked elsewhere in the world, in different flyways. This includes birds marked in, or reported from, India, South Africa, Western Europe, and Arctic Siberia. Of the 27 breeding grounds records, 11 relate to birds from Australia.

Other species

Figures 7 to 12 show maps of recoveries and flag-sightings for a further six species. In this case, recoveries and flag-sightings are plotted on the same map and a line links the origin location with the location of subsequent reports. The species covered are Red-necked Stint, Great Knot, Grey-tailed Tattler, Terek Sandpiper, Sanderling, and Double-banded Plover.

Photographs of flagged birds

With the recent explosion in the use of digital cameras, in conjunction with telescopes (digiscoping) many overseas flag-sighting reports are now accompanied by a photograph of the bird observed. A selection of these appears in Figure 13.

Discussion

Banding:

A striking feature emerging from the banding analysis is the low rate of overseas recoveries. This has resulted in a slow elucidation of migration patterns. The rate is particularly low for the smaller waders (Red-necked Stint, Curlew Sandpiper, Sharp-tailed Sandpiper, and Sanderling) which together account for two-thirds of the migratory waders banded in Australia. A greater proportion of the waders banded in NWA are of medium and large size, and this is the main reason for the overseas recovery rate of birds from there (0.32%) being almost three times higher than for birds from SEA (0.12%). However, even on the larger species of waders, recovery rates are not high, with Eastern Curlew for example only showing a 0.5% overseas recovery rate (of birds banded in SEA), and 0.68% for birds from NWA. Bar-tailed Godwit from NWA have a similar recovery rate (0.67%), but Bar-tailed Godwit from Victoria have an extremely low overseas recovery rate -only 0.07%. The recovery rate of SEA Red Knot (1.12%) is higher than that of NWA Red Knot (0.35%) and this may be a pointer to one reason for the overseas recovery rates of Australian-banded waders being so low. The principal reasons for the low recovery rate are considered to be:

a) It is a much greater distance from banding locations in Australia to "overseas" than for many other countries around the world. For example, it is a minimum of 700km from NWA to the nearest part of Indonesia, and 2,200km to New Zealand, or 3,000km to Papua New Guinea / Irian Jaya, from SEA. It is only 35km from England to France, and the shorter distance to an overseas country is one of the reasons why the Wash Wader Ringing Group has an overseas recovery rate five times higher than Australia.
b) Most of the countries which the waders visit in Asia on northward and southward migration use different languages and different scripts. Many bands may therefore go unreported because the inscriptions on the Australian bands cannot be understood.
c) Many of the habitats visited by waders on migration in Asia or utilised for breeding in Russia, are sparsely settled by humans (e.g. muddy/mangrove estuaries and shores). Preferences for habitats where humans are scarce are also probably the reason why the recovery rate of Sharp-tailed Sandpipers is so low, and why the 1,244 Little Curlew banded in NWA have so far not produced a single overseas recovery (or even a flag-sighting).
d) Dead birds decay rapidly in the warm tropical environment that many waders occupy in Australia and during their migration through Asia. This is in marked contrast to, for example, waders that spend their non-breeding season in the cooler parts of the Northern Hemisphere; there their remains may be preserved for a considerably longer period of time, resulting in many more being washed up and distributed in the debris along shorelines. It is also possible that there are more ground and avian predators and scavengers active along shorelines in the East Asian-Australasian Flyway, further reducing the chances of a banded bird being found by someone.

Overall, the low recovery rate means that the direct return on the investment of time and effort by wader banders is low if measured purely on the number of recoveries. It is interesting that the overseas recovery rate of Curlew Sandpiper banded in South Africa (0.13%) is even lower than that from Australia (0.19%), with almost all of the above possible reasons for low recovery rates being applicable to banded birds from that country too. It is not surprising, therefore, that the advent of colour leg-flagging was enthusiastically seized-upon by wader-banders in Australia, because of the huge increase in the rate of generation of information on movements (see later).

The high number of Great Knot recoveries overseas (143) is mainly the result of the intense hunting pressure in the Yangtze Estuary, near Shanghai, during the 1980s and the first-half of the 1990s. Bar-tailed Godwit were also intensively hunted in the same area, accounting for a significant proportion of the NWA recoveries. Local wader ornithologists were able to collect many of these bands from the hunters and reported them. The ban on hunting waders in China is now more effectively policed and hunting has almost completely ceased. Some of the Chongming Dao hunters are now even employed at migration times to catch waders for Chinese bird-banders on the Yangtze Estuary.

The 76 Red Knot recoveries overseas result largely from banding efforts in New Zealand, through which most of the 43 recoveries there have come. Similarly, almost all the 30 Double-banded Plover recoveries overseas have been live recaptures by banders in New Zealand, where intensive studies on this species were carried out over a long period of time.

The Curlew Sandpiper (66) and Red-necked Stint (53) recoveries were widespread in time and location and have resulted mainly from the large numbers of both species banded regularly each year in Australia over the last 25-30 years.

One of the most valuable features of the 534 overseas recoveries is that 111 of them came from Russia. This is the breeding location for most of the migratory waders that come to Australia and is the ultimate destination of their long migration. Hunting is still carried out widely across Siberia during the short period (late May to July), that waders are present there each year. Many Russian ornithologists have been instrumental in obtaining and reporting some of the bands from hunted birds. As a consequence, there is relatively more information on breeding areas of many species of waders than might be expected from the overall low recovery rates.

China naturally features strongly in the recovery locations (239 out of 534). Almost all wader species spending the non-breeding season in Australia pass through China on northward migration, and many do so also on southward migration. New Zealand features strongly too (78 recoveries) but, as already mentioned, this is mainly the result of the active wader-banding operations in that country, with most recoveries there being live recaptures of just two species.

Most of the 150 overseas-banded waders recovered in Australia are live recaptures by Australian banders. The special co-operative study between Australia and New Zealand on Double-banded Plover was responsible for 66 of these. Otherwise, the countries and species involved are widely spread. The paucity of wader-banding in China (until very recently) is reflected in only one Chinese-banded wader having ever been recovered in Australia.

Flagging:

The much higher reporting rate of colour leg-flagged birds, compared with banding recoveries, became apparent very quickly after flagging was introduced in Australia in 1990. It is interesting that the overseas flag-sighting rate for waders marked in SE Australia (3.6%) is higher than the rate for birds marked in NW Australia (1.8%). The explanation is possibly that many of the smaller waders (which form the bulk of birds flagged in SEA), when on migration through Asia probably occupy habitats more easily observed by ornithologists. The larger waders, such as the Bar-tailed Godwit and Great Knot which form a higher proportion of the birds flagged in NWA, tend to occupy large open tidal mud-flats where they are less easily approached and viewed.

Flag-sighting rates of birds from SEA are also greatly influenced by the large number of sightings of Red Knot and Bar-tailed Godwit that have moved to New Zealand. It is clear from both recoveries and flag-sightings that there is a major interchange between the populations of both these species on the east coast of Australia and in New Zealand. This particularly results from young birds spending their first austral summer and austral winter in Australia and then moving to New Zealand and adopting it as their principal non-breeding area. With the large, highly skilled and enthusiastic band of wader-watchers in New Zealand (originally located mainly in the Auckland area of North Island but now all over the country including South Island); it is not surprising that so many sightings of leg-flagged birds occur. As many as 25 different Red Knot flagged in Australia have been seen at the one time in a flock in New Zealand. Because the majority of Red Knot that occur in NWA are from a different subspecies (*piersmii* - Tomkovich 2001) to the subspecies (*rogersi*) that forms the main population in eastern Australian and New Zealand, the flag-sighting rate for Red Knot from NWA (3.2%) is an order of magnitude less than that of Red Knot from SEA (36.2%). A similar situation exists, for the same reason, for Bar-tailed Godwit (2.4% menzbieri NWA, versus 26.0% *baueri* SEA).

Sanderling and Grey Plover are two species for which almost all current information on their movements has been derived from flag-sightings (191 and 22 respectively) rather than recoveries (4 and 0). In both species a high proportion of flag-sightings have occurred in Japan. Unusually, in comparison with other species, most Sanderling flag-sightings have been of birds on southward migration, when the Japanese coasts are clearly used extensively as a major stopover location.

Hong Kong has a high profile as a flag-sighting location for birds from both NWA and SEA. Although Curlew Sandpiper and Red-necked Stint flag-sightings predominate (480 and 133 respectively, of a total of 827), a wide variety of species (13) has been seen. The Mai-Po Marshes are intensively watched and, as in New Zealand, a large proportion of the flagged birds that visit them are probably observed. Japan and Korea have produced far more flag-sightings (481 and 329 respectively) than China (111), even though a greater proportion of waders that visit Australia probably use China as their major stopover. The low sighting rate in China probably results from the relative lack of skilled observers, and even suitable optical equipment, compared with Japan and Korea. However, this situation is changing, with active wader studies now occurring at a number of sites along the Chinese coast. Furthermore, there has been a drop-off in sightings reported from Japan and Korea in recent years, partly due to administrative overload in their banding offices. There was also a temporary lull in reports from China in 2003, but this was due to restrictions on the travel of ornithologists because of the SARS epidemic.

Japan has been flagging waders for longer, and in larger numbers, than any country in the Flyway outside Australia. This in part explains why 143 of the 225 overseas-flagged waders seen in Australia have come from Japan. However, another reason for this predominance of Japanese-flagged birds seen in Australia is that many Grey-tailed Tattler have been flagged in Japan and a high proportion of these birds seem to spend their non-breeding season in Queensland. The Moreton Bay area is particularly well covered by skilled wader-watchers and the Grey-tailed Tattlers there tend to occupy habitats and high-tide roosts that facilitate the sighting of flags on birds' legs. A total of 116 of the 143 Japanese birds seen in Australia were Grey-tailed Tattlers. Only four other overseas-flagged Grey-tailed Tattlers have been reported in Australia, all being from Taiwan.

It is interesting that comparatively few New Zealand-flagged Red Knot and Bar-tailed Godwit have been seen in Australia, compared with the huge numbers of both species flagged in Australia that have subsequently been seen in New Zealand. This suggests that only moderate numbers of adults of these species pass through Australia on their migration to/from non-breeding areas in New Zealand. However the discrepancy may result from many New Zealand-bound migrants using remoter areas, such as the Gulf of Carpentaria, as migration stopover sites in Australia. At such locations flagged birds are unlikely to be observed.

The preponderance of overseas flag-sightings on northward migration compared with southward migration, evident in most species and for most countries, mirrors the pattern for banding recoveries. The migratory strategy of most species - to make a long (3-6,000km) non-stop flight for the initial leg of their migration – is the principal reason for this. On northward migration, most depart the northern shores of Australia and make their next landfall on the coasts of China, Taiwan, Korea, and Japan. Bird-observers, wader researchers, and hunters tend to concentrate on these coastal areas during the April-May migration period thus maximising the chance of a flagged bird being observed. On southward migration, adult waders are not so concentrated on these coastal areas. Some probably take off from inland locations, and others depart from the more remote coastal areas in eastern Siberia, for their long overseas flight to Australia. Few seem to stop at intermediate islands/countries. Consequently, the chances of a flagged bird being observed during southward migration are greatly reduced. The exception to this is the Sanderling, for which the coasts of Japan seem to be a more important stopover region on southward migration than on northward migration. With a good coverage of these areas by Japanese wader-watchers, a higher sighting rate for Sanderling on southward migration has resulted. The extreme example illustrating the overall pattern is that there have been 880 sightings of Australian-flagged waders on northward migration through Hong Kong but only 9 sightings reported there during the southward migration period. In contrast, in Japan the figures are 177 on northward migration, and 293 on southward migration.

Flag-sightings within Australia, but away from the flagging location, have provided a valuable insight into migration routes and strategies used by different species of waders at the commencement of their northward migration and during the latter stages of their southward migration. Nearly 90% of the sightings within Australia are of Victorian- or South Australian-flagged birds. This is because many birds which spend their non-breeding season in southern Australia make stopovers along the north coast of Australia on northward and/or southward migration. Also, on southward migration, quite a number of birds seem to trickle down the east coast rather than making non-stop movements directly across inland areas of the continent. The wide spread of different states in which Victorian- and South Australian-flagged birds have subsequently been seen, indicates that a range of routes are used by different species or even by different individuals of the same species. Many of the birds flagged in Northwest Australia and Queensland that have subsequently been seen elsewhere in Australia, were probably individuals that were flagged while still on migration.

A small number of flag-sightings of a range of species clearly show that some individuals may change their non-breeding areas in Australia from one year to the next. Almost all adult birds are resident at their non-breeding locations in the period between early November and the end of February. Sightings in this period away from southern flagging-locations in Australia are therefore almost certainly of individuals that are not planning to return to their previous non-breeding area. Some individuals appear to have changed their non-breeding location by up to 3,000km.

When leg-flagging was first introduced, consideration was given to flagging only those species that were caught in large numbers. It is now apparent that valuable sightings and information can derive from relatively small numbers of a species being flagged at any particular location. The strongest example relates to Black-tailed Godwit from SE Australia. Four sightings occurred when only two Black-tailed Godwit had been flagged there. The first sighting was on southward migration in Korea on 15 August 2000. The next was just over a month later, on 26 September, in Roebuck Bay, Broome. The following year, an orange-flagged Black-tailed Godwit was seen on northward migration, in late April in the northwest part of the Yellow Sea in China. By 20 September the flagged bird was back again in Broome. It seems likely that this bird had changed its non-breeding area to this region, which has a population of several thousand Black-tailed Godwit, rather than returning to Victoria where the summer non-breeding population is usually not more than 10-20. It is possible that all four sightings were of just one bird.

Comparison of recovery rates and flag-sighting rates:

As explained earlier, recoveries usually relate to a simple report of an individual bird but flag-sighting records will include a number of re-sightings of the same individual. This accounts for some of the difference between overseas flag-sighting and recovery rates, but it is only likely be a small factor. The main cause of the difference is the greater chance of a flagged bird being seen alive in the field than of a banded bird being found dead, killed, or re-captured by another bander.

The most extreme example, of Bar-tailed Godwit banded and flagged in SE Australia, results from two factors. Firstly, the overseas recovery rate, at 0.07%, is atypically low for such a large bird. There is no obvious reason for the overseas recovery rate of Bar-tailed Godwit from SE Australia being an order of magnitude lower than that of Bar-tailed Godwit from NW Australia (0.67%). The other factor is that the large movement of Bar-tailed Godwit from eastern Australia across the Tasman Sea to the well-watched areas of New Zealand results in a flag-sighting rate of 26.0%, exceptionally high even for a species of this size. The flag-sighting rate of Bar-tailed Godwit from NW Australia, few of which move to New Zealand, is only 2.4%. Red Knot show a similar "New Zealand effect" but, in this case, both the recovery rate (due to live re-captures) and the flag-sighting rate are equally affected. Nevertheless, the proportion of the overseas flag-sighting rate to recovery rate for Red Knot from SE Australia is 32.3. For Red Knot from NW Australia, which have only a small link with New Zealand, the proportion is 9.1.

The greatest benefits of leg-flagging (as a means of gathering information on migration routes, stopover sites, and destinations) are realised with the smallest species of waders, whose banding recovery rates are especially low. For Red-necked Stint, the proportion of overseas flag-sighting rates to recovery rates is 18.0 (for birds from SE Australia) and 30.0 (birds from NW Australia). For Curlew Sandpiper the corresponding figures are 21.1 and 22.9. Sanderling from SE Australia show a massive 42.7 proportion. It is not possible to calculate the proportion for NW Australia because there have been no banding recoveries of Sanderling from there, but the overseas flag-sighting rate of 3.8% suggests that a high proportion would be present.

Of the smaller waders, only Sharp-tailed Sandpiper fail to yield a particularly large benefit from flagging, with a proportion of 5.4. The overseas flag-sighting rate of birds from SE Australia is only 0.4% (and 0.7% for birds flagged in NW Australia). The latter is the lowest overseas flag-sighting rate for any species flagged in NW Australia. These low rates are probably because Sharp-tailed Sandpiper tend to inhabit inland marshy areas rather than coastal areas, and in such habitats flagged birds are rather less likely to be observed.

Selected recovery and flag-sighting information:

It is not the intention of this paper to detail for each species the knowledge gained about their migration from banding and flagging, but selected data are presented to illustrate some of the range of migration patterns that have become apparent for waders that visit Australia.

Eastern Curlew visiting Australia appear to breed in a limited area in south-eastern Siberia. Their migration path also appears to be narrow, with their main stopover locations being in south-western Japan and the Korean and Chinese coasts of the Yellow Sea. However some birds take a more westerly path, passing through Taiwan.

Flag-sightings and recoveries of Bar-tailed Godwit have revealed an almost complete dichotomy of birds spending the non-breeding season in NW Australia and eastern Australia. The birds from NW Australia (the *menzbieri* subspecies), migrate to the northern Yakutia region of Siberia to breed and their main stopover region on northward and southward migration is the coast of the Yellow Sea. The *baueri* subspecies from eastern Australia (and New Zealand) go to Alaska to breed. On northward migration they also use the Yellow Sea, and Japan, as stopover locations but on southward migration very few adult *baueri* occur in Asia, with most making a trans-Pacific migration from Alaska directly back to Australia and New Zealand. This is a distance of 10-11,000km and is the longest known non-stop migration of any species in the world. Banding recoveries, and especially leg-flag sightings, have also shown that there is a large interchange of Bar-tailed Godwit populations between eastern Australia and New Zealand.

In most migratory bird species, the populations that spend the non-breeding season in different areas usually migrate back to different breeding areas. This is well-documented in wildfowl, particularly geese (Boyd 2004). Where sufficient data exist for waders (e.g. Red Knot –Piersma and Davidson 1992, Eurasian Oystercatcher – Sitters 2002) the same pattern is apparent, i.e. discrete breeding areas are associated with discrete non-breeding areas.

Curlew Sandpiper do not seem to show such a strong segregation pattern (Underhill 1995). They have widely separated non-breeding populations in Western Africa, South Africa, India, and Australia but banding recoveries and flag-sightings in the breeding areas show a significant overlap in the breeding range of Curlew Sandpiper from these four main non-breeding areas. There is a tendency for those populations that breed furthest west to spend the non-breeding season furthest west, and similarly for eastern breeding/non-breeding area birds, but there is no complete segregation of these populations on the breeding grounds. As a result, no subspecies have been identified for Curlew Sandpiper and there is no marked clinal variation in biometric measurements. In spite of the overlap of breeding areas, so far there have so far been no definite interchanges of Curlew Sandpiper between one flyway and another. A Curlew Sandpiper banded in Victoria on 20 November 1976 and recaptured in southeast India on 29 August 1980, may possibly have changed flyways, but it could have been on its way back to its previous non-breeding area, albeit by a rather circuitous migration route.

The six maps on which all recoveries and flag-sightings for six different species are shown, illustrate the variety of paths taken by different species between Australia and their breeding grounds. The Red-necked Stint passes through Asia on a broad front and also uses stopover locations widely spaced around the Australian coast. The Great Knot migration is more focused on the Yellow Sea, with another important stopover in the southern part of the Sea of Okhotsk in eastern Siberia on southward migration. All the evidence suggests that Great Knot make an 8,000km non-stop flight back to Australia from there.

As mentioned previously, Grey-tailed Tattler spending their non-breeding season in eastern Australia, particularly Queensland, have a particularly strong link with migration stopover locations in Japan. Some Grey-tailed Tattler from NW Australia non-breeding areas also visit Japan, but some also occur further west along the whole length of the Chinese coast, and in Taiwan. Terek Sandpiper, on the other hand, seem to concentrate more on the coasts of the Yellow Sea when on migration, though there are also a number of records linking Australian birds with Japan. The dominance of Japan as a migratory stopover location for Sanderling from all around Australia is very clear. Also apparent from recoveries and flag-sightings, is the tendency for this species to change its non-breeding area quite widely around the coasts of the southern half of Australia.

The Double-banded Plover shows a recovery pattern totally different from all other migratory species of wader in Australia. It is a trans-Tasman migrant, moving between breeding areas in the centre of South Island, New Zealand, and the coasts of eastern and southern Australia (Pierce 1999). It is particularly interesting that only this segment of the Double-banded Plover population breeding in New Zealand makes this migration. Those that breed on lower ground around the coasts of South Island, and those that breed in North Island, remain in New Zealand for the winter.

The movements data presented and discussed in this paper so far may give a falsely optimistic impression of the extent of current knowledge. Huge gaps still exist. There has still not been a single recovery or flag-sighting on, or close to, the breeding grounds of a Red Knot marked in Australia (or New Zealand). The exact breeding areas of Curlew Sandpipers that occur in NW Australia have not been defined as a result of no recoveries of birds from the breeding region (in contrast to 11 from eastern Australia). None of the many Ruddy Turnstone marked in SE Australia have been reported from breeding areas. Only one Sanderling (from NW Australia) has been found in the high arctic. Neither of the Sand Plovers – Greater or Lesser – have had any marked birds reported from the expected breeding locations. Grey Plovers also have only produced flag-sightings at stopover locations in Asia, and there has not yet been a recovery anywhere.

The initial and primary objective of wader-banding in Australia was to develop an understanding of migration patterns; this objective was subsequently supplemented and greatly enhanced by the introduction of colour leg-flagging. Recoveries and flag-sightings of marked birds are the most tangible results of these activities and the ones most easily comprehended by the general public and non-specialists in the wader field. Many other benefits have derived from the additional data collected from birds in the hand and from re-traps of marked birds and much of these data have been published over the last 20 years, with much further analysis and papers in hand. Some key results in these ancillary areas are mentioned briefly below:

a) Measurements of bill length, total head length, wing length, and weight have been gathered on some 65,000 of the birds caught in Victoria, 50,000 of those from NW Australia, and many others from elsewhere. These data have enabled the biometric ranges for each age group and each sex of many species to be defined.
It has also revealed very unequal sex proportionns in some species. This is sometimes associated with the different timing of migration between the sexes. However, in some species, the unequal representation of sexes has occurred throughout the non-breeding season. The extreme example is the Grey Plover where close to 100% of the birds present in Australia are female (VWSG and AWSG data).
b) Weight data have shown that weights vary geographically and temporally during the non-breeding season. The most valuable data on weights relate to accumulation of fat prior to the northward migration departure (Barter and Minton 1998). The strategy of nearly all waders departing Australia seems to be to accumulate enough fat to fuel them for a non-stop journey of 3-6,000km to the Asian mainland coast, or to adjacent areas such as Taiwan and Japan.
c) Data collected on the primary moult have shown when this occurs in the annual cycle. Most species carry out a complete wing-moult at their main non-breeding location. Many first-year birds coming to Australia also carry out a partial, or sometimes a complete, wing-moult in their first year. The pattern and timing of moult in all age groups, particularly immature birds, differs among regions in Australia. Knowledge of the moult for each species is of considerable assistance in accurately aging birds in the hand.
d) Information on the age structure of wader flocks has revealed which age groups do not return to the Northern Hemisphere breeding grounds in the boreal summer. In almost all species, all one-year-old birds remain in Australia. Some then go north to breed for the first time at age two, but others, especially amongst the larger waders, do not go north to breed until they are three, four, or even five years old.
e) Measuring the proportion of first-year birds in banding catches is the best method available for obtaining an index of annual reproduction rates of a wide range of migrant species (see separate paper in this publication – Minton *et al. 2005b).* The reproductive rate is a very important parameter in any long-term study of waders for identifying their conservation problems and needs.
f) Measuring survival rate (or the converse, mortality rate) is important in understanding changes, particularly long-term, in the size of wader populations. To measure survival, birds have to be individually identified, either by the metal band number or by unique colour- or alphanumeric-marking combinations. The latter have only recently been introduced into the Australian wader-banding program and so currently, calculation of survival rates is dependent on the analysis of re-trapped birds. Only one analysis has so far been published on migrant waders in Australia (Double-banded Plover, Barter 1989). However, the volume of re-trap data now available on a number of species is sufficient for comprehensive survival rate analyses to be undertaken. These require quite sophisticated expertise and computer-modelling knowledge but they are the most pressing area for analysis in the voluminous data which have been accumulated on Australian waders.

Conclusions

Much knowledge has been gained during 45 years of wader-banding and 14 years of wader leg-flagging in Australia, and this includes data from the wide variety of studies associated with these activities,. Many preliminary analyses have been undertaken and a wide range of publications have ensued, particularly over the past 20 years. However much more comprehensive data are now available for analysis and an increased effort to produce major publications is now required.

There is also a need for carefully planned, further fieldwork. A key element of this is annual catches of sufficient size, on a range of species and at a variety of locations, to enable ongoing monitoring of reproduction rates (through the percentage of first-year birds), and survival rates. The latter could be calculated through re-traps, or preferably, by recording birds individually identifiable in the field by colour band/flag combinations or alphanumerically-engraved flags. There is also a need for more waders to be caught, banded, and flagged in regions of Australia that have not been adequately covered in the past, e.g. northern Queensland (especially the Gulf of Carpentaria), the Northern Territory, and South Australia. Furthermore, for many of the less numerous or harder to catch species, there is still little known about migration routes and stopover locations; for these species, further catches are necessary.

It is important to fully utilise new tools and techniques which have been developed overseas and which have application to wader studies in Australia. Satellite transmitters have already been used on the large Eastern Curlew (Driscoll and Ueta 2002) and as smaller and lighter versions are developed, it will be possible to use them on other, smaller species of waders. DNA techniques can assist in a variety of ways including sexing (thus aiding interpretation of biometric data) and identifying subspecies (thereby helping movements studies). Stable isotope analyses, using feather or blood samples taken from individuals, have the potential to give a much more detailed insight into the migrations of wader populations than is currently obtainable through banding and flagging. All three techniques have been applied, but need to be further exploited in the future.

Finally, banders need to continue to assist veterinary researchers who are examining the potential for avian-borne diseases entering Australia on migratory birds arriving from overseas. Blood and cloacal samples collected over the last 20 years have shown waders to be relatively 'clean', but with new viruses appearing, monitoring has been increased.

The knowledge already gained through banding and flagging waders in Australia has been a strong foundation for conservation initiatives throughout the Flyway. It is vital that this information base continues to grow, and especially that the monitoring element of fieldwork programs continues and, preferably, is expanded. With 44% of the wader populations in the world showing major declines (Anon. 2003) it is more vital than ever that banding studies continue to generate information that assists the determination of conservation needs and actions.

Acknowledgements

The information presented in this paper is the result of the efforts of many thousands of people who have participated in wader-banding in Australia over the years. Countless hours have been expended in fieldwork, with a cannon-netting session typically involving six to twelve hours and mist-netting often involving an all-night session. Considerable physical effort is often required, for example for carrying cannon-netting equipment to remote locations or wading around in deep water and mud when mist-netting. Fieldworkers also have to cope with the vagaries of weather and tide. All participants, whatever their level of skill, have contributed to the success of fieldwork operations and all are gratefully thanked for their efforts.

The Australian Bird and Bat Banding Scheme is thanked for providing bands, permits, and records of banding recoveries. Wildlife authorities in the various states and territories kindly provided permits to wader-banders around Australia. The Federal Department of Environment and Heritage has helped since 2001, by funding, the establishment and operation of a leg-flag sighting database. All individuals and groups who have provided wader-banding and flagging figures are greatly thanked, and all those in Australia and throughout the Flyway who have reported flag-sightings and banding recoveries have also made a major contribution. Those who provided photographs of flagged birds seen in the Flyway are also thanked. Jacquie Clarke (BTO - U.K.), Les Underhill (South Africa) and Phil Ireland (Wash Wader Ringing Group – U.K.) kindly supplied recovery rate data. Ken Gosbell helped by preparing the maps used in Figures 1-6. Finally Johannes Wahl, Wetlands International, is thanked for plotting and providing the maps used in Figures 7-12.

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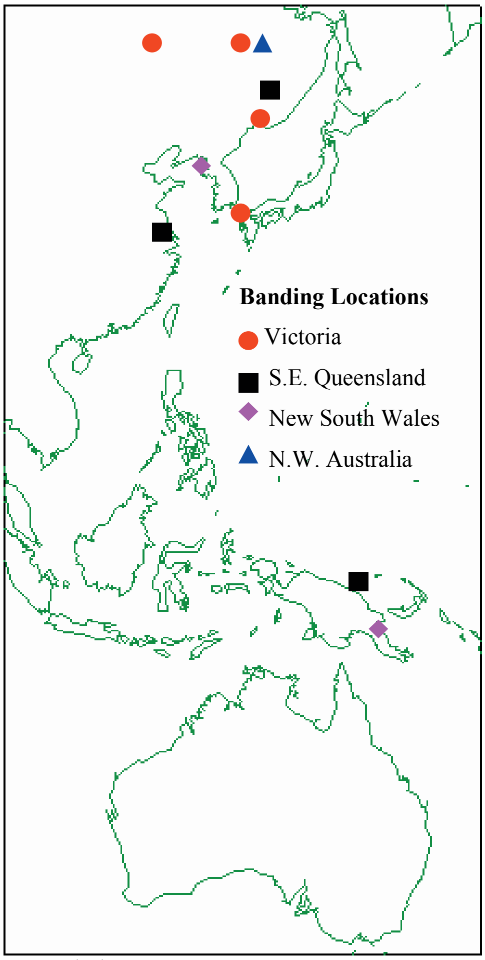


Figure 1. Overseas Recoveries of Eastern Curlew Banded in Australia

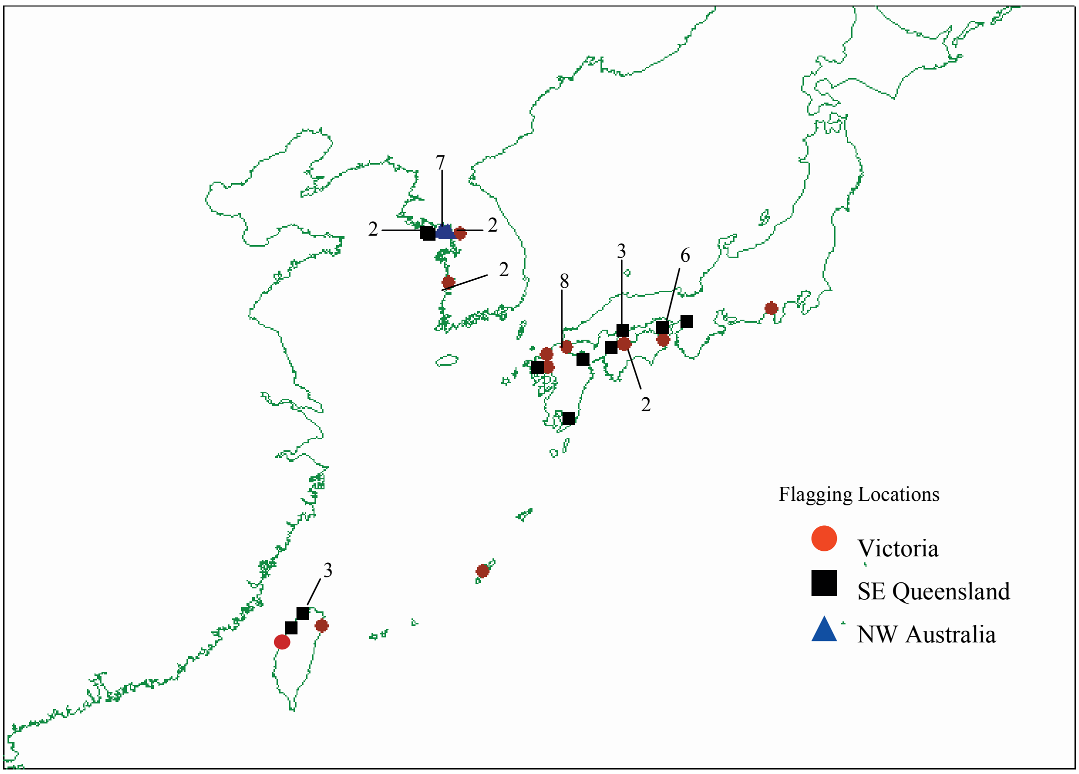


Figure 2. Overseas Sightings of Eastern Curlew Flagged in Australia

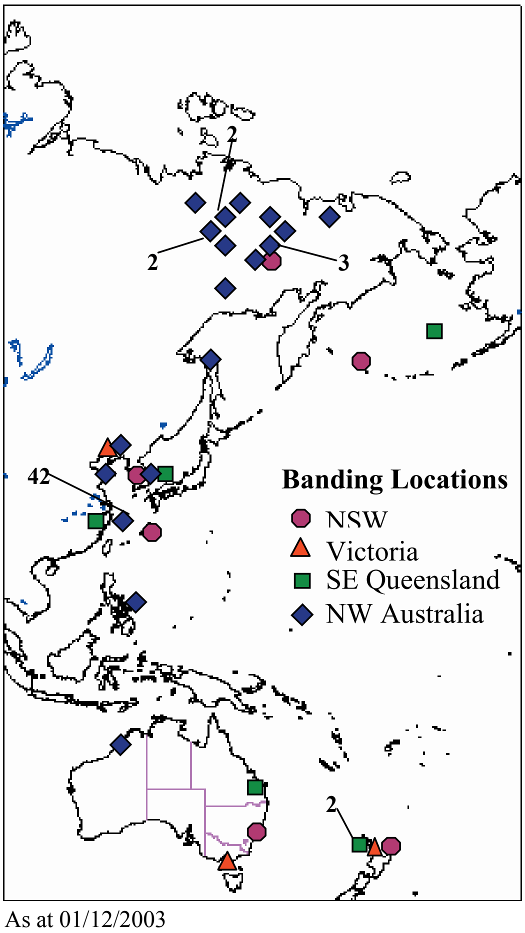


Figure 3. Overseas Recoveries of Bar-tailed Godwit Banded in Australia

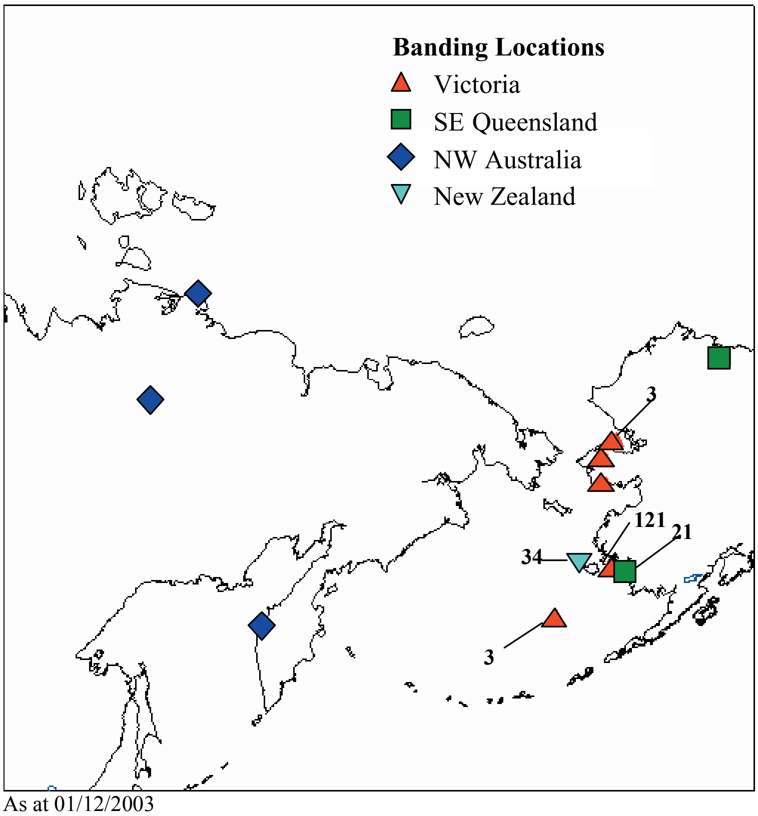
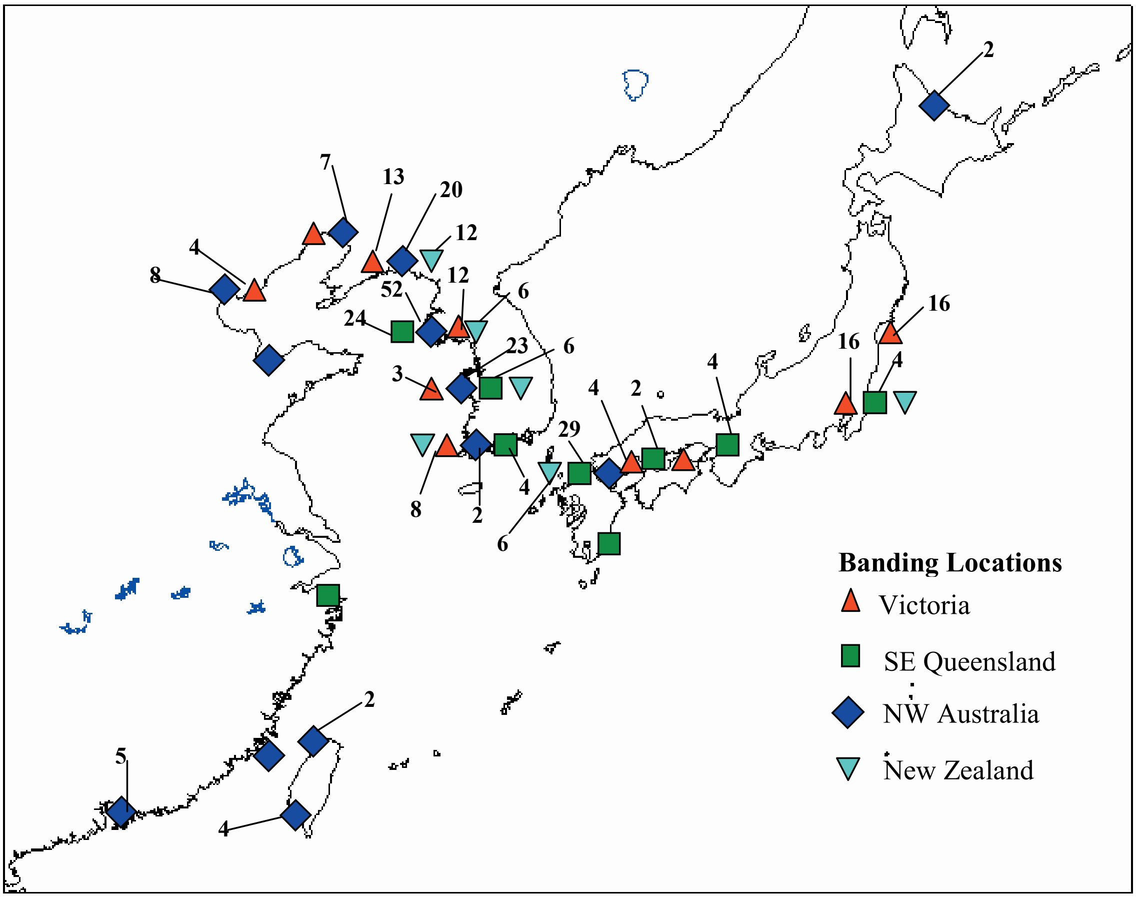
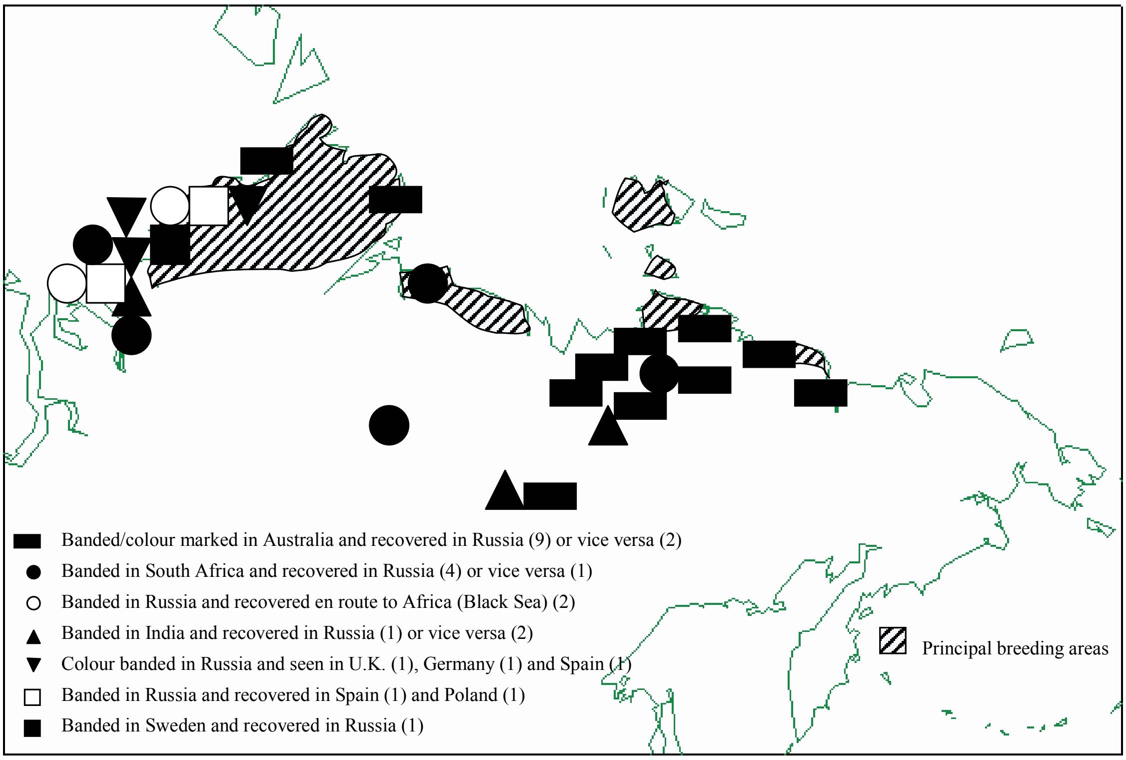


Figure 4. Sightings in Siberia and Alaska of Bar-tailed Godwit Flagged in Australia and New Zealand



As at 01/12/2003

Figure 5. Sightings in Asia of Bar-tailed Godwit Flagged in Australia and New Zealand



As at 01/12/2003

Figure 6. The Recovery/Banding/Colour-marking/Leg-flag Sighting Locations of Curlew Sandpipers which indicate the Breeding Areas of Birds from the different Flyways

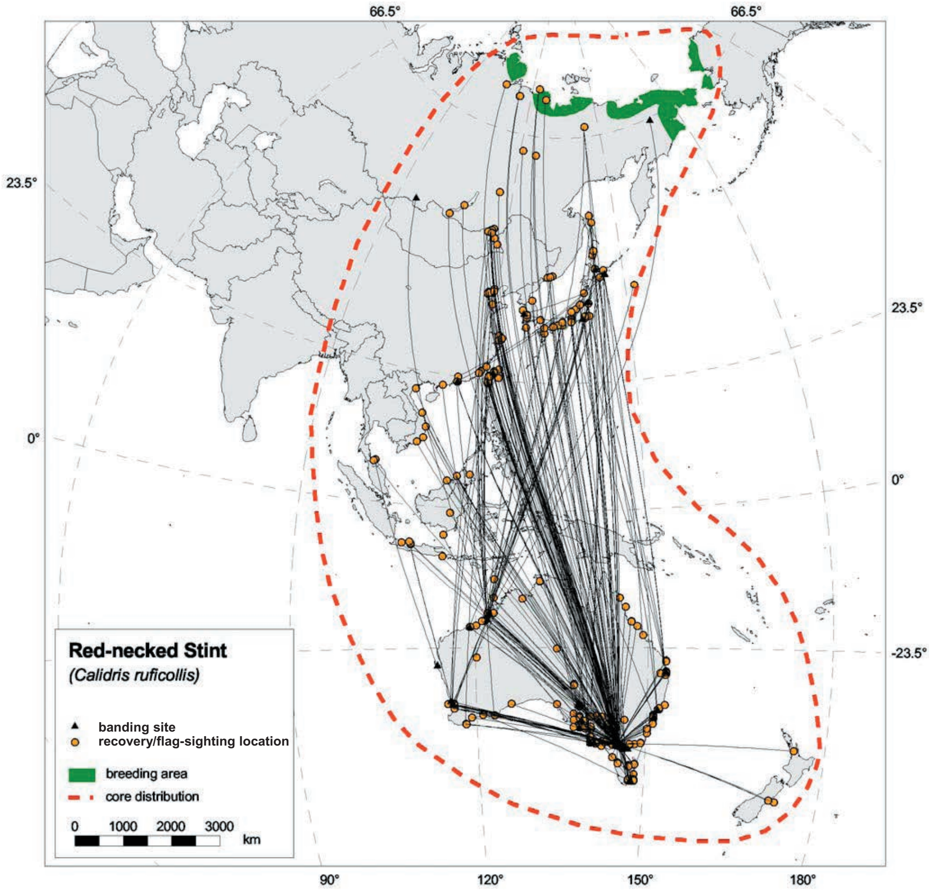


Figure 7. Recoveries and Flag-sightings of Red-necked Stint marked in Australia (to Dec. 2002)

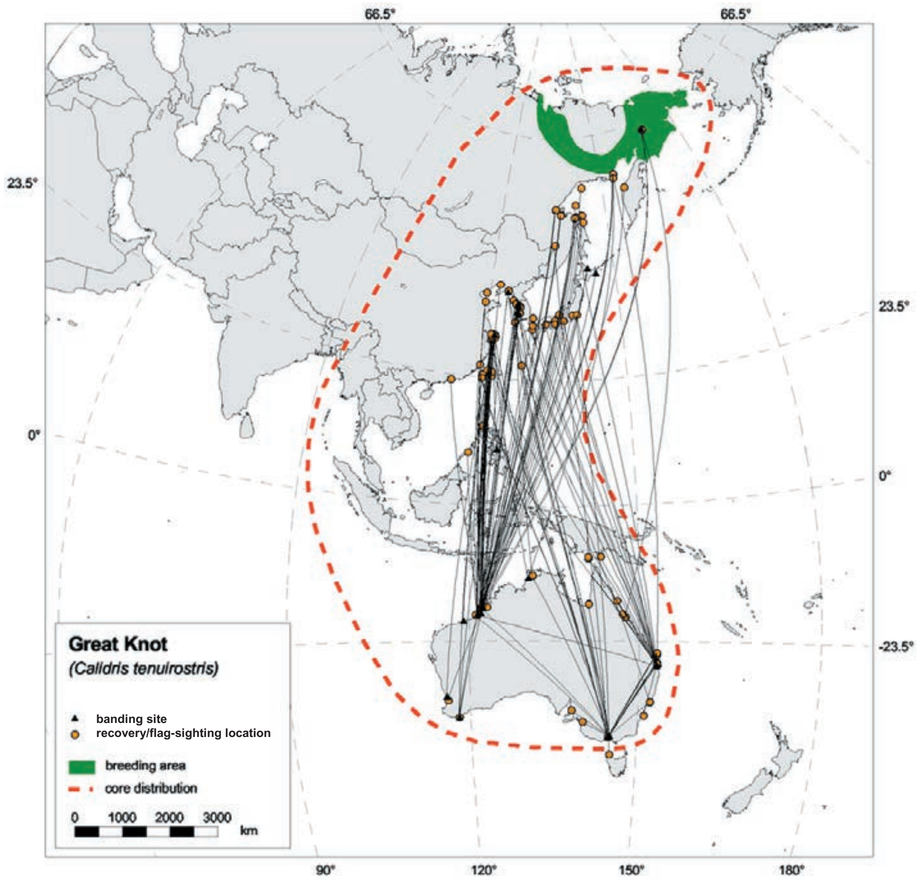


Figure 8. Recoveries and Flag-sightings of GreatKnot marked in Australia (to Dec. 2002)

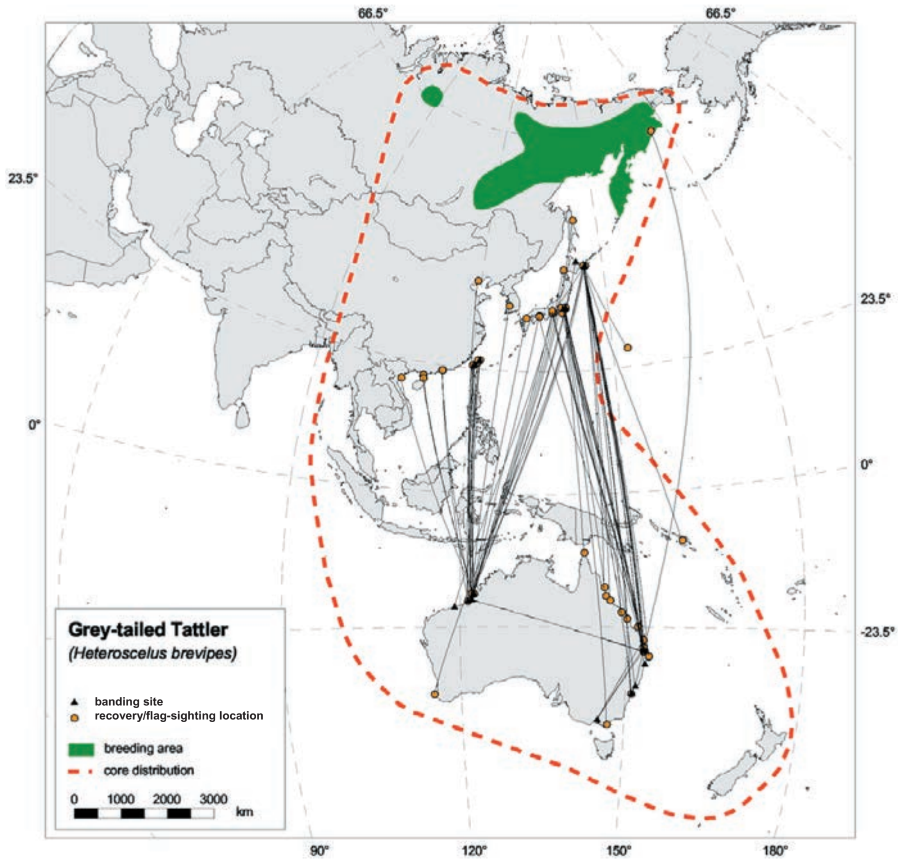


Figure 9. Recoveries and Flag-sightings of Grey-tailed Tattler marked in Australia (to Dec. 2002)

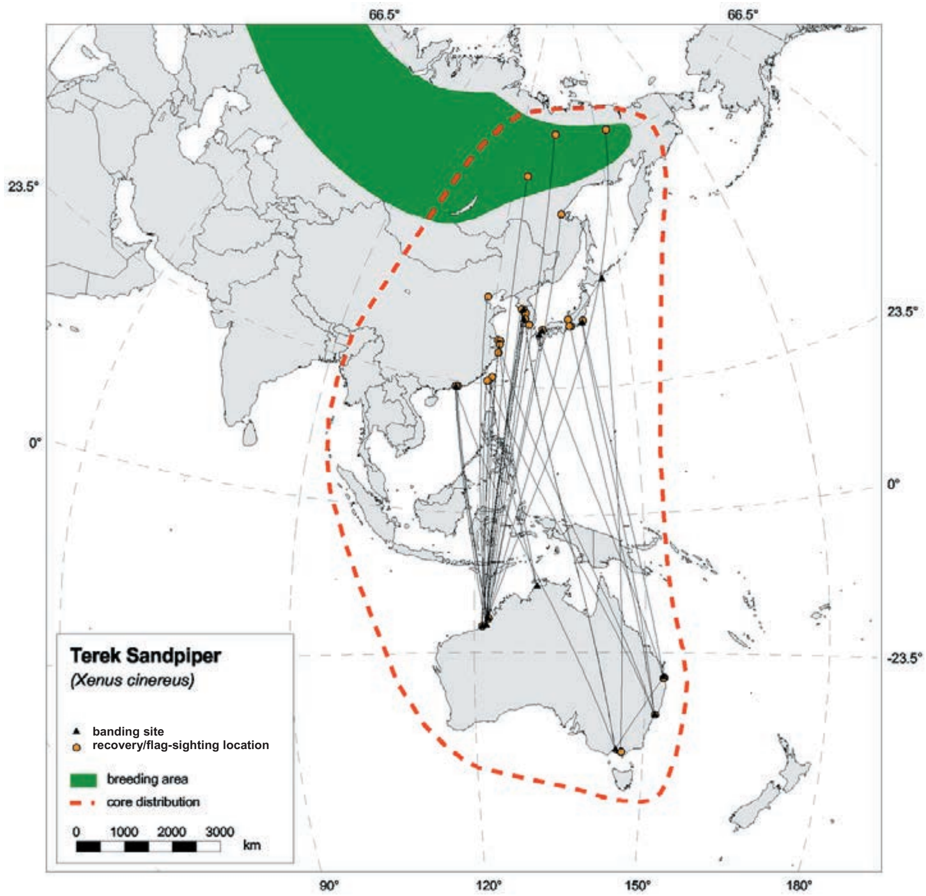


Figure 10. Recoveries and Flag-sightings of TerekSandpiper marked in Australia (to Dec. 2002)

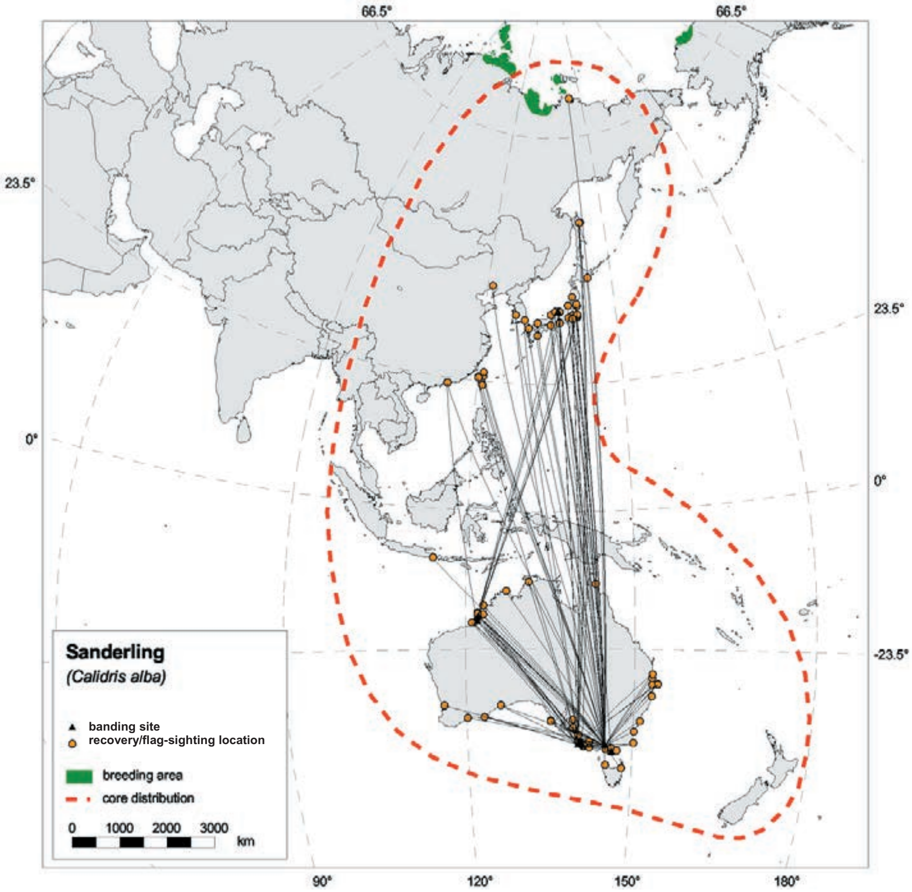


Figure 11. Recoveries and Flag-sightings ofSanderling marked in Australia (to Dec. 2002)

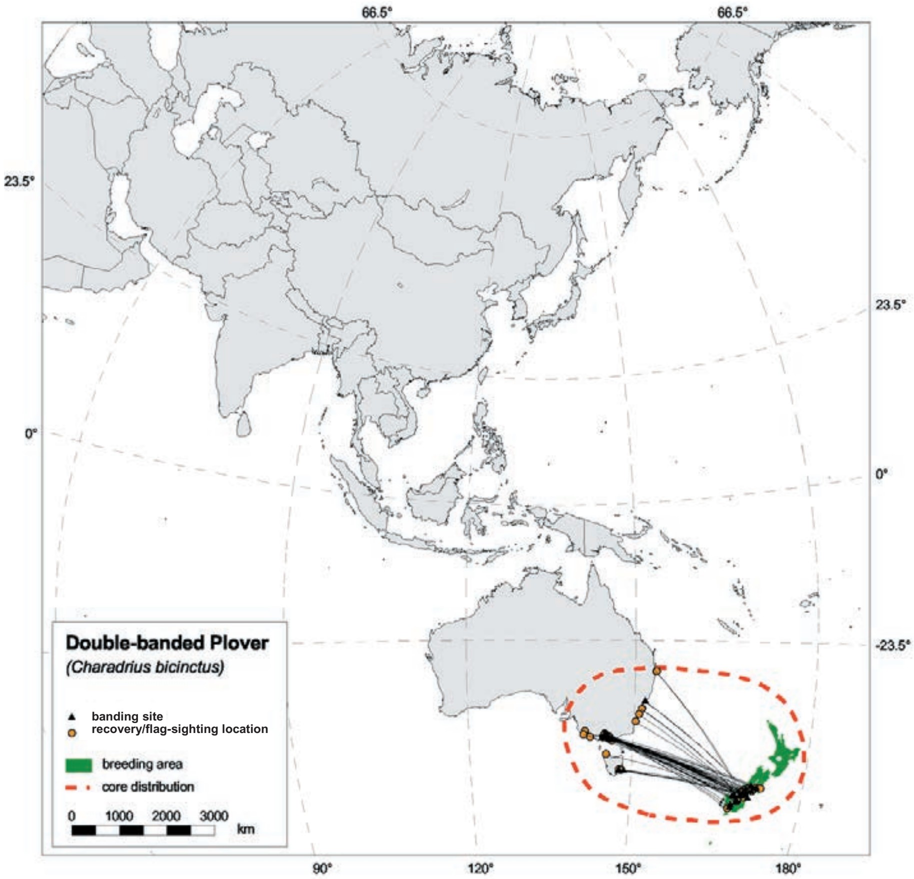


Figure 12. Trans-Tasman Recoveries and Flag-sightings of Double-banded Plover marked inAustralia and New Zealand (to Dec. 2002)

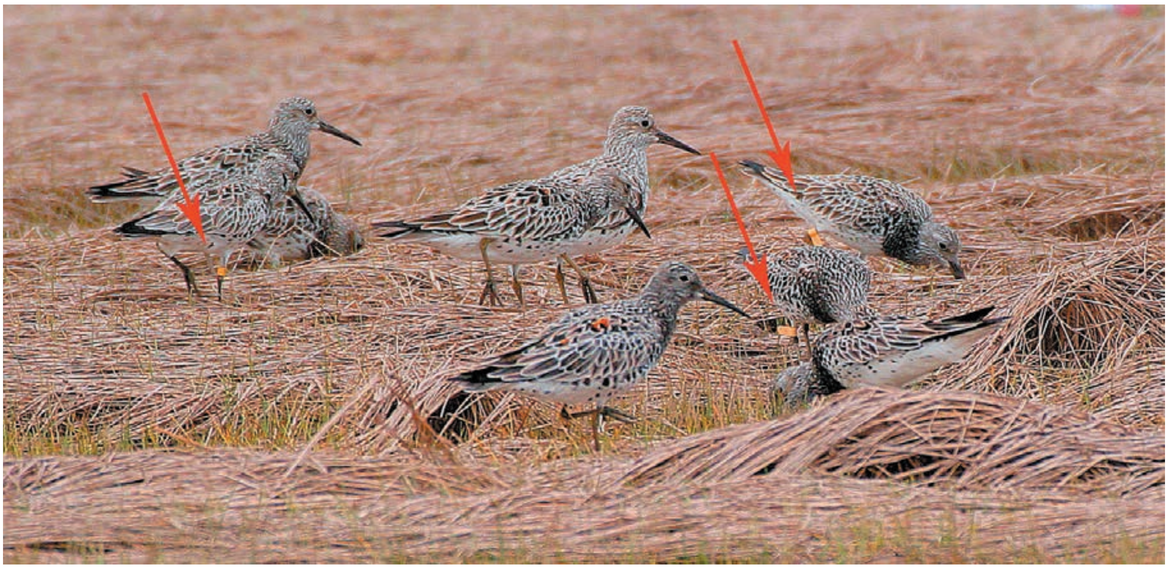


Figure 13a. Australian-flagged Waders sighted on Migration through Asia. These are Yellow flagged Great Knot at Chongming Dongtang, China - 31/03/2004 - Photo by Yuan Xiao

Figure 13b. Orange flagged Red-necked Stint at Hanbou, Changhua County, Taiwan - 17/05/2002 - Photo by Chung-Yu Chiang

Figure 13c. Orange flagged Eastern Curlew at Kao-Mei, Taichung County, Taiwan - 09/03/2003 - Photo by Mr. Pan, Chih-Yuan

Figure 13d. Yellow flagged Black-tailed Godwit at Geum River Estuary, Chungham Province, Korea - 11/05/2002 - Photo by Hansoo Lee

Table 1. Migratory Waders Banded in Australia

	STATE	VIC*	WA					NSW		TAS	QLD	NT			SA	TOTAL
	Region		NWA	Perth	Perth	Albany	Perth									
	Bander/s Period**	VWSG 1975-	AWSG/BBO/ NWWSG1981-	WAWSG 1979-	Jim Lane 1972-78	Vic Smith 1985-	Serventy & Nichols 1958-60	Fred van Gessell 1970-	NSWWSG 1991-1997	BOAT 1979-1988	QWSG 1989-99	Ray Chatto 1995-96	Tony Hertog 1978-85	Fred van Gessell 1983-86	Max Waterman 1981-82	
Species	Scientific name															
Red-necked Stint	Calidris ruficollis	94196	12876	2256	1163	812	732	1044	66	4270	184	60	83			117742
Curlew Sandpiper	Calidris ferruginea	23854	9014	452	365	81	106	1454	273	1263	280		42			37184
Great Knot	Calidris tenuirostris	593	15678	74	43	219	1	27	2		1028	392	1			18058
Bar-tailed Godwit	Limosa lapponica	3019	9734	10	38	19		933	728	34	1991	1				16507
Greater Sand Plover	Charadrius leschenaultii	31	8848	2		27	374	10	2		81	113	14			10863
Red Knot	Calidris canutus	3928	4919	66	31	114		188	29	8	320	271			900	10774
Sharp-tailed Sandpiper	Calidris acuminata	7476	1089	14		32	2	1582	83	11	35		184			9147
Terek Sandpiper	Xenus cinereus	33	5402	1		3		659	112	1	4	29	11			6255
Grey-tailed Tattler	Heteroscelus brevipes	38	5379	2				248	31	1	288	4	7			5998
Ruddy Turnstone	Arenaria interpres	2418	1428	1	1	1	1	83	8	8	78	16	3			4046
Double-banded Plover	Charadrius bicinctus	3516						150	35	89	74					3864
Sanderling	Calidris alba	2671	649	12								4				3336
Eastern Curlew	Numenius madagascariensis	796	147					47	33	1	243					1309
Little Curlew	Numenius minutus		1244										5			1267
Broad-billed Sandpiper	Limicola falcinellus	5	1229					67					8			1249
Common Greenshank	Tringa nebularia	474	174	4				183	205	4	1					1139
Black-tailed Godwit	Limosa limosa	3	623			16		250	204		55					1057
Lesser Sand Plover	Charadrius mongolus	115	409			2		328	56		113	12	12			1047
Latham's Snipe	Gallinago hardwickii	347				11	6	71	34							841
Oriental Plover	Charadrius veredus		323							3			1			807
Grey Plover	Pluvialis squatarola	144	278	18							4					566
Pacific Golden Plover	Pluvialis fulva	236	23		12	24	1	285	205	14	57		4			463
Marsh Sandpiper	Tringa stagnatilis	2	157					314	315				19			452
Whimbrel	Numenius phaeopus	24	273	2				26	121		100		4			329
Oriental Pratincole	Glareola maldivarum		162													162
Common Redshank	Tringa totanus		6													109
Swinhoe's Snipe	Gallinago megala		6										47	56		101
Common Sandpiper	Actitis hypoleucos		48	2				6					18			74
Asian Dowitcher	Limnodromus semipalmatus		101													62
Long-toed Stint	Calidris subminuta	1	61													57
Australian Pratincole	Stiltia isabella		15										5	6		26
Wood Sandpiper	Tringa glareola		57													23
Little Stint	Calidris minuta	7	1				1	1		1						13
Pectoral Sandpiper	Calidris melanotos	2	2					7		1						10
Red-necked Phalarope	Phalaropus lobatus		23													6
Little Ringed Plover	Charadrius dubius		1													3
Ruff	Philomachus pugnax		1					1					1			2
Cox's Sandpiper	Calidris paramelanotos	1						1								2
Pin-tailed Snipe	Gallinago stenura		1											1		1
Short-billed Dowitcher	Limnodromus scolopaceus	1														1
Buff-breasted Sandpiper	Tryngites subruficollis							1								1
TOTAL		**143931**	**80381**	**2916**	**1653**	**1361**	**1224**	**7966**	**2542**	**5709**	**4936**	**902**	**469**	**63**	**900**	**254953**
Species		**27**	**36**	**15**	**7**	**13**	**9**	**26**	**19**	**15**	**18**	**10**	**19**	**3**	**1**	**41**

As at Dec. 2003   * Includes c. 7000 banded in S.E. of South Australia   ** Where no end date is given, banding is still taking place

Table 2. Resident Waders Banded in Australia

	STATE	VIC	WA					NSW		TAS	QLD	NT		TOTAL	ABBBS
	Region		NWA	Lake Ballard	Perth	Perth	Albany								**Totals**
	Bander/s	VWSG	AWSG/BBO/ NWWSG	CALM	WAWSG	Serventy & Nichols	Vic Smith	Fred van Gessell	NSWWSG	BOAT	QWSG	Ray Chatto	Tony Hertog		
	Period	1975-	1981-	1995	1979-	1958-60	1985-	1970-	1991-97	1980-87	1989-99	1995-96	1978-85		
Species	*Scientific name*														
Pied Oystercatcher	*Haematopus longirostris*	2081	205		6					451	164		1	2908	2250
Red-capped Plover	*Charadrius ruficapillus*	631	884		546	108	47	188	86	245	12		7	2754	3124
Banded Stilt	*Cladorhynchus leucocephalus*	151	92	850	23		4							1120	265
Red-necked Avocet	*Recurvirostra novaehollandiae*	312	232		36			287	252					1119	704
Black-winged Stilt	*Himantopus himantopus*	24	409		51			218	205		6		28	941	601
Sooty Oystercatcher	*Haematopus fuliginosus*	638	50							14				702	484
Red-kneed Dotterel	*Erythrogonys cinctus*	135	192		2	1		84	3				9	426	615
Masked Lapwing	*Vanellus miles*	160	99					10	6	62	2		4	343	868
Black-fronted Plover	*Elseyornis melanops*	56	109		6			76	2	44			7	300	283
Hooded Plover	*Thinornis rubricollis*	26			10					24				60	439
Banded Lapwing	*Vanellus tricolor*							3	1	12				16	96
Painted Snipe	*Rostratula benghalensis*		6											6	4
Beach Stone-curlew	*Esacus neglectus*								1			1		2	15
Bush Stone-curlew	*Burhinus grallarius*												1	1	20
Comb-crested Jacana	*Irediparra gallinacea*														136
Inland Dotterel	*Charadrius australis*														13
TOTAL		**4214**	**2278**	**850**	**680**	**109**	**51**	**866**	**556**	**852**	**184**	**1**	**57**	**10698**	**12422***
Species		**10**	**10**	**1**	**8**	**2**	**2**	**7**	**8**	**7**	**4**	**1**	**7**	**14**	**16**
As at Dec. 2003															

ABBBS totals are ex their data bank as at Sept. 2003
* Summation using the higher figure for each species in the two “totals” columns

Table 3. Overseas Recoveries of Waders Banded in Australia

Species	China	Russia	New Zealand	Hong Kong	Japan	Taiwan	Vietnam	Indonesia	Philippines	Korea	Papua New Guinea	Thailand	Alaska	Vanuatu	India	Mongolia	TOTAL
Great Knot	102	34							4	1	2						**143**
Bar-tailed Godwit	46	21	5		1				1	3			2	1			**80**
Red Knot	19	12	43	1						1							**76**
Curlew Sandpiper	29	10		14		2	4	4				2			1		**66**
Red-necked Stint	21	13		1	2	4	5	5				1				1	**53**
Double-banded Plover			30														**30**
Grey-tailed Tattler	2	2		1	8	4						1					**18**
Terek Sandpiper	4	4		1	1	2				2							**14**
Sharp-tailed Sandpiper	6	3				1		1	1								**12**
Eastern Curlew	2	4			1					1	2						**10**
Ruddy Turnstone	2	3			1	1			1		1						**9**
Greater Sand Plover	2						4										**6**
Sanderling	2				2												**4**
Whimbrel		3															**3**
Swinhoe's Snipe									2								**2**
Broad-billed Sandpiper		1				1											**2**
Pacific Golden Plover	1													1			**2**
Lesser Sand Plover	1								1								**2**
Latham's Snipe					1												**1**
Marsh Sandpiper		1															**1**
TOTAL	**239**	**111**	**78**	**18**	**17**	**15**	**13**	**10**	**10**	**8**	**5**	**4**	**2**	**2**	**1**	**1**	**534**

As at 29/11/2003

Table 4. Recoveries in Australia of Waders Banded Overseas

Species	New Zealand	Japan	Hong Kong	Russia	Taiwan	Korea	Alaska	China	Singapore	Thailand	Vietnam	TOTAL
Double-banded Plover	66											**66**
Curlew Sandpiper	1		7	2	7				1	1	1	**20**
Red Knot	5	1	5	5		1						**17**
Great Knot				5		5		1				**11**
Red-necked Stint		4	2	2	1							**9**
Terek Sandpiper		3	3			2						**8**
Grey-tailed Tattler		4			3							**7**
Latham's Snipe		5										**5**
Bar-tailed Godwit			1				1					**2**
Ruddy Turnstone	1	1										**2**
Sanderling		1										**1**
Pacific Golden Plover							1					**1**
Greater Sand Plover					1							**1**
TOTAL	**73**	**19**	**18**	**14**	**12**	**8**	**2**	**1**	**1**	**1**	**1**	**150**

As at 29/11/2003

Table 5. Recoveries and Controls relating to Waders in S.E. Australia

Species	Number Banded in S.E. Australia*	Number Recovered overseas**	Overseas Recovery Rate %	Controlled in S.E. Australia, banded overseas†**
Red Knot	3928	44	1.12	3
Curlew Sandpiper	23854	42	0.18	9
Red-necked Stint	94196	36	0.04	2
Double-banded Plover	3516	25	0.71	43
Great Knot	593	5	0.84	
Sharp-tailed Sandpiper	7476	5	0.07	
Ruddy Turnstone	2418	4	0.17	1
Eastern Curlew	796	4	0.50	
Sanderling	2671	4	0.15	1
Bar-tailed Godwit	3019	2	0.07	
Lesser Sand Plover	115	1	0.87	
Other species (migratory only)	1349			
TOTAL	**143931**	**172**	**0.12**	**59**

* to end 2003
** to 29/11/2003
† plus one Grey-tailed Tattler
(S.E. Australia includes Victoria and the southeast of South Australia)

Table 6. Overseas Recoveries and Controls relating to Waders in N.W. Australia

Species	Number Banded in N.W. Australia*	Number Recovered Overseas**	Overseas Recovery Rate %	Controlled in N.W. Australia, banded overseas**
Great Knot	15678	125	0.80	9
Bar-tailed Godwit	9734	65	0.67	1
Red Knot	4919	17	0.35	10
Curlew Sandpiper	9014	13	0.14	9
Grey-tailed Tattler	5379	11	0.20	3
Terek Sandpiper	5402	9	0.17	6
Greater Sand Plover	8848	6	0.07	1
Red-necked Stint	12876	4	0.03	4
Ruddy Turnstone	1428	3	0.21	
Broad-billed Sandpiper	1229	2	0.16	
Whimbrel	273	1	0.37	
Eastern Curlew	147	1	0.68	
Other species (migratory only)	5454			
TOTAL	**80381**	**257**	**0.32**	**43**

* to end 2003
** to 29/11/2003

Table 7. Comparison of Overseas Recovery Rates

a)

Region/group	**Migrant Waders Banded**	**Recovered Overseas**	**Overseas Recovery Rate %**
N.W. Australia	80,381	257	0.32
S.E. Australia	143,931	172	0.12
Australia (total)	c. 255,000	534	0.21
Wash Wader Ringing Group (U.K.)	239,319	2532*	1.06

b)

Species	**Country Banded**	**Overseas Recovery Rate %**
Curlew Sandpiper	Australia	0.19
Curlew Sandpiper	South Africa	0.13
Dunlin	U.K.	0.65

N.W. Australia, S.E. Australia to end Dec. 2003, WWRG to Dec. 1998
* Plus 1532 captures of birds banded overseas

Table 8. Numbers of Waders Flagged in Australia

State (region): Bander/s: **Flag colour/s:**	**VIC** VWSG **Orange**	**WA (northwest)** AWSG **Yellow**	**QLD** QWSG **Green**	**SA** VWSG **Orange/Yellow**	**WA (southwest)** WAWSG Vic Smith **Yellow/Orange**	**NSW** NSWWSG **Orange/Green**	**TOTAL**
Species							
Latham's Snipe	278			4			282
Pin-tailed Snipe		1					1
Swinhoe's Snipe		5					5
Black-tailed Godwit	3	558					561
Bar-tailed Godwit	1753	6989	1647	3			10392
Little Curlew		890					890
Whimbrel	21	256	94				371
Eastern Curlew	524	137	206				867
Common Redshank		4					4
Marsh Sandpiper	2	95					97
Common Greenshank	395	135					530
Wood Sandpiper		41					41
Terek Sandpiper	10	3739					3749
Common Sandpiper		45					45
Grey-tailed Tattler	5	3703	189	1			3898
Ruddy Turnstone	1454	804	76	802			3136
Asian Dowitcher		95					95
Great Knot	290	10372	874		1		11537
Red Knot	2733	2884	258		1		5876
Sanderling	1488	640		1128			3256
Little Stint	5	1					6
Red-necked Stint	42078	8336		1013	230	4	51661
Long-toed Stint		45					45
Pectoral Sandpiper	1	1					2
Cox's Sandpiper	1						1
Sharp-tailed Sandpiper	3373	599		36			4008
Curlew Sandpiper	9241	5300	247	238			15026
Broad-billed Sandpiper	3	484					487
Ruff		1					1
Red-necked Phalarope		22					22
Painted Snipe		6					6
Pied Oystercatcher		192	79				271
Sooty Oystercatcher		45					45
Black-winged Stilt	6	253					259
Banded Stilt	151						151
Red-necked Avocet	84	133					217
Pacific Golden Plover	64	19		3			86
Grey Plover	75	237			2		314
Little Ringed Plover		1					1
Red-capped Plover	81	514		13			608
Double-banded Plover	282			10			292
Lesser Sand Plover	55	230	72				357
Greater Sand Plover	16	6113	33		1		6163
Oriental Plover		238					238
Black-fronted Dotterel	1	66		3			70
Hooded Plover				1			1
Red-kneed Dotterel	2	74					76
Masked Lapwing	17	72		4			93
Oriental Pratincole		75					75
Australian Pratincole		11					11
TOTAL	**64492**	**54461**	**3775**	**3254**	**235**	**4**	**126221**

Data to end of 2003
VIC total also includes some Sanderling and Ruddy Turnstone flagged orange (only) in S.E. of South Australia prior to April 1999

Table 9. Overseas Sightings of Waders Flagged in Australia

Species	**New Zealand**	**Hong Kong**	**Japan**	**Korea**	**Taiwan**	**Alaska**	**China**	**Russia**	**Mongolia**	**Vietnam**	**Indonesia**	**Brunei**	**Malaysia**	**Thailand**	**Singapore**	**Papua New Guinea**	**TOTAL**
Red Knot	1034	11	1	1	9		2										**1058**
Bar-tailed Godwit	300	5	89	150	7	150	59	3									**763**
Curlew Sandpiper		480	2		34		8	2		1			1				**528**
Red-necked Stint	29	133	54	10	65		12	35	19	2	3	4	3	1			**370**
Great Knot		70	24	107	15		18	2								1	**237**
Sanderling		10	156	6	6		3	7			1						**189**
Grey-tailed Tattler		3	81	3	28		1										**116**
Greater Sand Plover		51			7					2							**60**
Ruddy Turnstone	15	4	18	3	13												**53**
Terek Sandpiper		38	1	9	3		1										**52**
Eastern Curlew			29	13	6												**48**
Black-tailed Godwit				14	7		2										**23**
Grey Plover			19	2			1										**22**
Broad-billed Sandpiper		15		1	1		1										**18**
Sharp-tailed Sandpiper		4		7	3		1				1						**16**
Lesser Sand Plover		3	5		1												**9**
Double-banded Plover	3																**3**
Whimbrel			2														**2**
Common Sandpiper															1		**1**
Asian Dowitcher					1												**1**
TOTAL	**1381**	**827**	**481**	**326**	**206**	**150**	**109**	**49**	**19**	**5**	**5**	**4**	**4**	**1**	**1**	**1**	**3569**

As at 08/11/2003

Table 10. Sightings of Australian flagged waders reported from each country

Year	**Country**																**TOTAL**
	New Zealand	Hong Kong	Japan	Korea	Taiwan	Alaska	China	Russia	Mongolia	Vietnam	Indonesia	Malaysia	Brunei	Thailand	Singapore	Papua New Guinea	
1990	1	4															5
1991	10	1	1														12
1992	26	2	12		1						1		1				43
1993	22	89	9		2						1			1			124
1994	22	38	10	4	2		1	3		2							82
1995	25	10	29		4		1	1		1		1					72
1996	43	20	57	7	1		3	12		1							144
1997	46	45	81	61	12	1	4	2			2						254
1998	68	159	51	77	1		6	1									363
1999	90	142	83	57	27	24	14	15	1								453
2000	112	105	73	36	33	2	14	7	17	1	1	1			1		403
2001	202	111	71	36	26	21	20	2	1							1	491
2002	380	75	3	39	45	27	42	2					3				616
2003	595	92	1	12	52	76	6	5	0	0	0	2	0	0	0	0	841
TOTAL	**1642**	**893**	**481**	**329**	**206**	**151**	**111**	**50**	**19**	**5**	**5**	**4**	**4**	**1**	**1**	**1**	**3903**

Table 11. Origin of Overseas-flagged Waders seen in Australia

Species	Japan	New Zealand	Korea	China	Taiwan	Hong Kong	TOTAL
Grey-tailed Tattler	116				4		120
Great Knot	6		22	1			29
Bar-tailed Godwit		7	6	11			24
Red Knot	1	23					24
Red-necked Stint	8						8
Ruddy Turnstone	4		2				6
Black-tailed Godwit	4						4
Curlew Sandpiper	1					2	3
Greater Sand Plover					2		2
Lesser Sand Plover	1						1
Double-banded Plover		1					1
Terek Sandpiper	1						1
Sharp-tailed Sandpiper					1		1
Broad-billed Sandpiper	1						1
TOTAL	143	31	30	12	7	2	225

As at 01/12/2003

Table 12. Flag-sightings within Australia away from the Flagging Location

Flagging Location	TOTAL Sighting Location							
	WA	SA	QLD	NSW	VIC	TAS	NT	**TOTAL**
VIC	285	290	290	187	91	80	19	**1242**
SA	54	31	1	7	98	1	5	**197**
NWA	30	16	5	22	40	2		**115**
QLD			6	24	2			**32**
SW WA	1	1						**2**
TOTAL	**370**	**338**	**302**	**240**	**231**	**83**	**24**	**1588**

As at 01/12/2003

Table 13. Overseas Sightings of Australian-flagged Waders on Northward and Southward Migration through Asia

Country	Migration Season	
	Northward	**Southward**
Hong Kong	880	9
Korea	228	90
Japan	177	293
Taiwan	154	47
China	106	2
Mongolia	17	2
Vietnam	5	0
Malaysia	3	1
Indonesia	1	4
Brunei	1	3
TOTAL	**1572**	**451**

As at 01/12/2003

Table 14. Overseas Sightings of Waders Leg-flagged in S.E. Australia

Species	Number Flagged in S.E. Australia*	No. Flag Sightings Overseas**	Overseas Flag-sighting Rate %
Red Knot	2733	989	36.2
Bar-tailed Godwit	1756	457	26.0
Curlew Sandpiper	9479	357	3.8
Red-necked Stint	43091	311	0.7
Sanderling	2616	167	6.4
Ruddy Turnstone	2256	34	1.5
Eastern Curlew	524	21	4.0
Grey Plover	75	19	25.3
Great Knot	290	14	4.8
Sharp-tailed Sandpiper	3409	13	0.4
Greater Sand Plover	16	11	68.8
Terek Sandpiper	10	4	40.0
Double-banded Plover	292	3	1.3
Black-tailed Godwit	3	2	66.7
Lesser Sand Plover	55	1	1.8
Other species (migratory only)	783		
TOTAL	**67388**	**2403**	**3.6**

*to end 2003
**to 01/12/2003
S.E. Australia includes Victoria and the southeast of South Australia

Table 15. Overseas Sightings of Waders Leg-flagged in N.W. Australia

Species	Number Flagged in N.W. Australia*	No. Flag Sightings Overseas**	Overseas Flag-sighting Rate %
Great Knot	10372	197	1.9
Curlew Sandpiper	5300	172	3.2
Bar-tailed Godwit	6989	167	2.4
Red Knot	2884	91	3.2
Red-necked Stint	8336	72	0.9
Greater Sand Plover	6113	53	0.9
Terek Sandpiper	3739	52	1.4
Grey-tailed Tattler	3703	51	1.4
Sanderling	640	24	3.8
Black-tailed Godwit	558	19	3.4
Broad-billed Sandpiper	484	17	3.5
Eastern Curlew	137	7	5.1
Ruddy Turnstone	804	7	0.9
Sharp-tailed Sandpiper	599	4	0.7
Grey Plover	237	3	1.3
Lesser Sand Plover	230	2	0.9
Common Redshank	4	2	50.0
Asian Dowitcher	95	1	1.1
Common Greenshank	135	1	0.7
Other species (migratory only)	1736		
TOTAL	**53095**	**942**	**1.8**

*to end 2003
**to 01/12/2003

Table 16. Sightings of Species where few have been Flagged

Victoria	No. Flagged	No. Resighted	Locations of Sightings (No. of re-sightings)
Red-necked Avocet	84	7	NSW (2), elsewhere in VIC (5)
Grey Plover	75	20	Japan (18), Korea (1), elsewhere in VIC (1)
Lesser Sand Plover	55	11	Hong Kong (1), QLD (9), NSW (1)
Greater Sand Plover	16	24	Hong Kong (9), Vietnam (1), Taiwan (1), QLD (12), NSW (1)
Terek Sandpiper	10	5	Korea (3), Hong Kong (1), QLD (1)
Grey-tailed Tattler	5	4	QLD (4)
Broad-billed Sandpiper	3	2	Taiwan (1), elsewhere in VIC (1)
Black-tailed Godwit	3	4	Korea (1), China (1), WA (2)
Pectoral Sandpiper	1	1	NSW (1)
Northwest Australia	**No. Flagged**	**No. Resighted**	**Locations of Sightings (No. of re-sightings)**
Black-winged Stilt	253	1	Perth – 2000km away (1)
Eastern Curlew	137	6	Korea (6)
Common Greenshank	135	1	Hong Kong (1)
Asian Dowitcher	95	1	Taiwan (1)
Common Sandpiper	45	1	Singapore (1)
Common Redshank	4	2	Hong Kong (2)

Data to Dec. 2003

Table 17. Overseas Recovery Rates vs. Flag-sighting Rates for S.E. Australia-marked Waders

Species	Overseas Recovery Rate %	Overseas Flag-sighting Rate %	Proportion (flag-sighting/ band recovery)
Bar-tailed Godwit	0.07	26.0	371.0
Sanderling	0.15	6.4	42.7
Red Knot	1.12	36.2	32.5
Curlew Sandpiper	0.18	3.8	21.1
Red-necked Stint	0.04	0.7	18.0
Ruddy Turnstone	0.17	1.5	8.8
Eastern Curlew	0.50	4.0	8.0
Great Knot	0.84	4.8	5.7
Sharp-tailed Sandpiper	0.07	0.4	5.4
Lesser Sand Plover	0.87	1.8	2.1
Double-banded Plover	0.71	1.0	1.5
Greater Sand Plover		68.8	
Black-tailed Godwit		66.7	
Terek Sandpiper		40.0	
Grey Plover		25.3	
Average of all birds	**0.12**	**3.6**	**30.0**

Data to end of 2003
S.E. Australia includes Victoria and the southeast of South Australia

Table 18. Overseas Recovery Rates vs. Flag-sighting Rates for N.E. Australia-marked Waders

Species	Overseas Recovery Rate %	Overseas Flag-sighting Rate %	Proportion (flag-sighting/band recovery)
Red-necked Stint	0.03	0.9	30.0
Curlew Sandpiper	0.14	3.2	22.9
Broad-billed Sandpiper	0.16	3.5	21.9
Greater Sand Plover	0.07	0.9	12.9
Red Knot	0.35	3.2	9.1
Terek Sandpiper	0.17	1.4	8.2
Eastern Curlew	0.68	5.1	7.5
Grey-tailed Tattler	0.20	1.4	7.0
Ruddy Turnstone	0.21	0.9	4.3
Bar-tailed Godwit	0.67	2.4	3.6
Great Knot	0.80	1.9	2.4
Common Redshank		50.0	
Sanderling		3.8	
Black-tailed Godwit		3.4	
Grey Plover		1.3	
Asian Dowitcher		1.1	
Lesser Sand Plover		0.9	
Sharp-tailed Sandpiper		0.7	
Common Greenshank		0.7	
Whimbrel	0.37		
Average of all birds	**0.32**	**1.8**	**5.6**

Data to end of 2003

Table 19. Timing of Recoveries in Asia of Bar-tailed Godwits Banded in Australia

Banding Location	**Month of Sighting**						**TOTAL**
	March	**April**	**May**	**August**	**September**	**Not Known**	
WA	1	37	4	2	1	1	46
QLD		2					2
NSW		1	1				2
VIC		1					1
TOTAL	**1**	**41**	**5**	**2**	**1**	**1**	**51**

As at 01/12/2003

Table 20. Timing and Location of Sightings in Asia of Bar-tailed Godwits Flagged in Australia and New Zealand

Orange Leg Flags (Victoria)

	April	May	August	TOTAL
Japan	12	25		**37**
Korea	15	8		**23**
China	14	3	1	**18**
TOTAL	**41**	**36**	**1**	**78**

Green Leg Flags (Queensland)

	April	May	TOTAL
Japan	29	11	**40**
Korea	26	8	**34**
China	1		**1**
TOTAL	**56**	**19**	**75**

Yellow Leg Flags (North-west Australia)

	April	May	July	August	September	TOTAL
Korea	25	25	1	17	9	**77**
China	20	16				**36**
Taiwan	7					**7**
Hong Kong	5					**5**
Japan	1			2		**3**
Russia				1		**1**
TOTAL	**58**	**41**	**1**	**20**	**9**	**129**

White Leg Flags (New Zealand)

	April	May	TOTAL
China	10	2	**12**
Korea	6	2	**8**
Japan	5	2	**7**
TOTAL	**21**	**6**	**27**

Summary

	Yellow	Orange	Green	White	TOTAL
North	99	77	75	27	**278**
South	30	1			**31**
TOTAL	**129**	**78**	**75**	**27**	**309**

As at 01/12/2003
example. Ostrich 66: 41-45.

Shorebird Studies in Taiwan

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Abstract

Migratory shorebirds have special conservation needs because of their annual migration which passes through many different areas and countries, a distance of several thousand kilometres. Taiwan, which is located at the midpoint of the major route on the East Asian-Australasian Flyway, is an important stopover and wintering area. The important wetlands of Taiwan, including tidal mudflats, mangrove swamps and salt marshes, are primarily located along the west coast.

Birders, local wild bird societies and academic units in several important wetlands have carried out regular shorebird counts for many years. Several academic units have also carried out research related to shorebirds and wetlands. Recently, several coastal wetland reserves have started their management works, ex. Fu-bou Ecological Park, Kuan-tu Nature Park, Szutsao Wildlife Refuge.

TWSG (Taiwan Wader Study Group) is an informal but sole shorebird study group in Taiwan and the members are mainly lab colleagues in the Department of Environmental Science in Tunghai University. We have focused on shorebird studies for over 10 years at coastal areas of Changhua county. The studies were various, including feeding and breeding ecology, habitat utilisation, migration strategy and population management of some target species. We also counted and banded shorebirds at Changhua coastal area at least once a month. A metal ring and two flags (white over blue were put on each bird we banded and we also built and maintained a database of all waterbird banding and recovery data for Taiwan. We also built a flag reporting system for local birders who found flags in the field. In recent years and in the near future, studies of the migration strategy and status of the three dominant species, Dunlin, Kentish Plover and Greater Sand Plover, are the focus of our interest.

Introduction

Taiwan, which is located at the midpoint of the major route on the East Asian-Australasian Flyway, is an important stopover and wintering area for migratory shorebirds (Figure 1). Many shorebird species pass through Taiwan and a large proportion of them roost at Changhua, Tainan and Ilan (Figure 2). It is important to know more about their status, ecology and migration patterns so we have a good basis on which to carry out shorebird conservation and wetland management works.

The dominant species of shorebirds are different in the four seasons here. In winter, the most abundant species are Dunlin and Kentish Plover, and the numbers of Ruddy Turnstone, Eurasian Curlew, Grey Plover, Golden Plover, Greenshank and Red-necked Stint are also high. In spring, Dunlins remain dominant, and the numbers of Ruddy Turnstones, Greater Sand Plovers, Curlew Sandpipers, Red-necked Stints, Grey-tailed Tattlers, Lesser Sand Plovers, Sharp-tailed Sandpipers and Wood Sandpipers etc. also increase. Kentish Plovers, Black-winged Stilt, Oriental Pratincoles, Little Terns, Little Ringed Plovers and Painted Snipes breed here in summer. In autumn, large number of Greater Sand Plovers arrive very early, almost all by early July, and Kentish Plovers and other shorebirds increase later. But there are fewer shorebirds in autumn than in spring.

TWSG (Taiwan Wader Study Group) is the sole shorebird study group in Taiwan. The members are mainly lab colleagues in the Department of Environmental Science in Tunghai University. We have focused on shorebird studies for over 10 years at coastal areas of Changhua county and the studies were various, including feeding and breeding ecology (Tsai 1994, Chang 1998, Liu 2001), habitat utilization (Chiang 1997), activity pattern (Liu 2001), migration strategy (Li 2001, Chiang et al. 2003) and population management of some target species (Liu 2001, Chen 2003). We conduction shorebird counts and banding in the Changhua coastal area at least once a month. We also helped collect and report observations of flagged birds since 2000 and the results are shown in Figure 3.

Because some species, eg. Dunlin and Kentish Plover, are dominant, more studies have been focused on them. I have selected some of these topics to present here

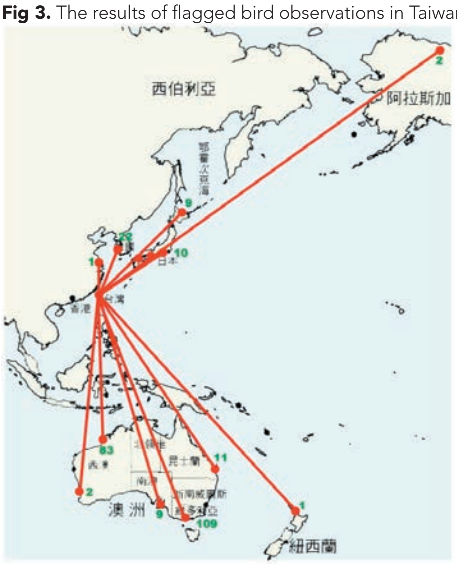
1. Dunlin

Dunlin are the most numerous shorebirds on the East Asian-Australasian Flyway, breeding from Alaska to Russia and migrating to East Asia during the non-breeding season. Dunlin are also one of the most common shorebirds on the western coast of Taiwan from winter to spring. Tsai (1994) used exclosure experiments to understand the relationship between Dunlin and their main prey (amphipods). Li (2002) recorded the fat loads of the Dunlin populations in autumn, winter and spring at Ta-tu Estuary by measuring total body electric conductivity (TOBEC) during 2000-2002. The results showed that a possible migratory strategy of autumn populations was energy selected while that of spring populations was time selected. Now we are investigating the habitat use of Dunlin and trying to understand the difference in their distribution and habitat selection between day and night.

Fig 1. The location of Taiwan in the East Asian-Australasian Flyway

Fig 2. The relative location of Changhua, Tainan and Ilan area in Taiwan.

Fig 3. The results of flagged bird observations in Taiwan



2. Kentish Plover

Kentish Plover is one of the most abundant shorebird species in Taiwan and also one of the few shorebird species that breed here. The wintering population was estimated at 65,000 and the breeding population was about 5,000. During 2002-2003, recoveries of the colour-ringed breeding population showed that at least some of the breeding pairs were residents. Several species of crabs on the tidal flat are the main prey of the wintering birds. Chen (1999) studied the foraging behavior of Kentish Plovers on three species of crabs, both in exclosure and in the field, and explained the diet choice, foraging behavior and net energy intake of wintering population based on the principle of optimal diet theory. The breeding population was concentrated in the western coastal area of Taiwan, mainly in Changhua and Tainan. Kentish Plovers preferred nesting with Little Terns and Oriental Pratincoles on the wide, open coastal gravel zones, which were newly reclaimed for industrial use. Liu (2002) studied the habitat selection and breeding success of the population bred in Changhua Coastal Industrial Park and provided suggestions for future management. Another ongoing Kentish Plover project is the study of activity pattern of the breeding pairs by colour-ringing and radio-tracking. We are now interested in the geographical variation, population structure and breeding origin of the East Asia populations. The morphological difference between the breeding and wintering populations in Taiwan has been determined. The next step is to undertake some genetic studies and compare the results with what was shown by morphology.

3. Other Shorebirds

Some species were abundant in local areas, for example Pied Avocets at Sz-tsao, and Eurasian Curlews on the Changhua coast. There were many fishponds at Sz-tsao area, but Avocets roosted in just a few of them. Chiang (1997) tried to find the factors of habitat selection in Avocets at Sz-tsao area and the results showed the water depth might be the key factor. The biggest population of Eurasian Curlew roosted at the Ta-tu Estuary. The counting data showed a decrease from 4,000 to less than 1,000 birds between1993 and1999, due to the increase in reclamation and human disturbance. Conservation management for this population is necessary and urgent. Liu (2002) recorded the daytime activity pattern of Eurasian Curlew and its relation with abiotic factors from 2000-2001. The results showed that rest was the predominant behavior during daytime. According to the low proportion of feeding during daytime, Eurasian Curlews may feed there at night. There were also some studies in feeding ecology of Painted Snipe (Cheng 2002, Li & Chiang 2003) by a lab of National Changhua University.

4. Shorebird Populations Monitoring and Investigation

Birds are relatively easier to count than most other wildlife and ornithologists have a distinct contribution to make to biodiversity conservation. Sometimes they also use birds as a monitor or index of environmental quality. Long-term monitoring data are used to derive population estimates and to study trends in abundance and distribution of bird populations (Kirby et al. 1995). We had counted birds at Changhua coastal area at least once a month since 1994. The waterfowl population has decreased dramatically due to habitat loss there. Birders, local wild bird societies and some academic units have also conducted some similar investigations at other wetlands in Taiwan (Lin 1993, Lu 1997, Pan 1997, Chih 2000),

5. Migration Pattern (by Body Fat Load)

Body composition is an important aspect of migration in birds (Burger 1997). Population declines in migratory species may be attributed to changes on their breeding grounds or refuelling sites, because they could not deposit enough fat during migration to cross large ecological barriers (Lyons and Haig 1995). It is important to know more about the migration patterns or strategies by shorebirds, so we can develop appropriate policies for shorebird conservation. Walsberg (1988) showed the TOBEC (total body electrical conductivity) methodology was a promising and non-lethal way to determine fat stores in wild animals. We used this method to collect fat data of shorebirds from 2000, then analysed the fat load data and tried to estimate the migration patterns and flight range of the birds (Li 2001). Chiang et al. (2003) estimated the flight distance of Greater Sand Plover in different age categories and showed that the body fat proportion of both adult and juvenile birds was as high as 50%, indicating that Greater Sand Plovers could fly directly from Taiwan to Australia in autumn. We have collected good samples on Dunlin and Greater Sand plover, and we will make more effort to collect data on other long-distance migration species in the next few years.

6. Habitat Management

Management works in several wetlands have recently been commenced by local government, companies, academic units, conservation groups like wild bird societies, and local communities. Fu-bou Ecological Park in Changhua, Kuan-tu Nature Park in Taipei, Szutsao Wildlife Refuge and Guantian Jacana Reserve in Tainan have all achieved great success in increasing habitat diversity, protecting waterbird populations or endangered species, and raising public awareness.

7. Other Research

A lab in the National Taiwan University studied the temporal and spatial variation of wetland bird communities and the effect of landscape changes in several important coastal wetlands, by using long-term counting data and GIS techniques (Lin 1994, Lin 1995, Pan 1998, Chih 2000, Lin 2001).

The Animal Health Research Institute focused on avian influenza studies (Cheng *et al.* 2003, Cheng 2003). They have surveyed the highly pathogenic avian influenza viruses in wild bird since 1998, and some samples were taken by banders when they caught birds in the field. In Taiwan in 2002, a total of 2,722 faecal samples, were collected from wild birds (including 72.7% (1,980) from ducks and 21.7 % (592) from shorebirds) for virus isolations (Cheng et al. 2003). Results showed that most disease viruses were found on waterfowl in winter (Cheng *et al.* 2003, Cheng 2003).

Conclusions

There are over 500 species of wild birds recorded in Taiwan and among them, 15 endemic species and 69 endemic subspecies. Research that concentrated on shorebird biology and ecology studies declined in recent years and the situation was the same in shorebird banding work. However we have had some good results in shorebird research in the past two years, and by participating in international shorebird conferences, workshops and expeditions, and by the preparation of English publications, we hope we will have more opportunities to communicate and co-operate with other researchers and banders in the flyway.

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Key wetlands in the Flyway

Population Estimates and Important Sites for Shorebirds in the East Asian-Australasian Flyway

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Background and Approach

This project was undertaken by Wetlands International Oceania, through funding by Environment Australia, in response to needs identified in the Asia-Pacific Migratory Shorebird Action Plan. The two major aims of the project were:

- Revise population estimates for shorebirds in the East Asian-Australasian (EAA) Flyway;
- Use the 1% criterion of the convention on Wetlands (Ramsar) to identify sites of international importance or shorebirds in the region.

The aim of this paper is to present an overview of the project, explaining how it was carried out and presenting some examples of the results.

The project involved a review of count data (where available) from 22 countries in the EAA Flyway, and considered 54 species of migratory shorebirds. Major sources of data were the AWSG count database and the Asian Waterfowl Census, but many other sources were accessed. These data were entered into a database that was then used for the calculation of Minimum Population Estimates (MPEs). The MPEs were the basis for calculating values for the application of the 1% Ramsar criterion to identify important sites for each species.

The database contains over 100,000 records but these records came from different sites, were made at different times of the year and coverage was not the same each year. Some species were considered to be covered fairly well in at least some years in some countries, whereas other species were considered to be grossly under-sampled in all years. The calculation of Flyway MPEs for each species from this database required a process that could be understood, even if not everyone may agree with the outcome. This process had the following steps and assumptions:

1. The study considered only migratory species or races that make regular seasonal movements between countries in the EAA Flyway.
2. Count data from the non-breeding season (December to February inclusive) were used as birds can be expected to move around least at that time.
3. With this assumption, it was possible to divide counts by country or by regions within large countries, and then find the maximum count for each species in each region. These maximum counts were taken from any year after 1984. The use of data from different years was essential given the nature of the available data.
4. The maximum regional count for each species was assumed to be the minimum number of that species present in that region on a regular basis, although this was subject to interpretation based on personal experience and feedback from country representatives (see below).
5. By assuming that regional maximum counts are independent, they can be combined to provide a pooled maximum count for each country. In theory, these country pooled counts can be combined to give a Flyway count, but that assumes that each species has been thoroughly surveyed in every region in at least one year. That is highly unlikely. Therefore….
6. Count data were manipulated at a regional or country level for most species. This manipulation involved estimating the level of coverage in a region or country for each species, and adjusting the count accordingly. This usually involved increasing the estimate by a factor of 25% or 50%, although in some cases it was considered that maximum counts were due to exceptional circumstances and the estimate was reduced.
7. Manipulated count data from each country were then combined to provide a Flyway MPE for each species. Unfortunately, however, this process failed for 18 species that were badly under-sampled. These were largely shorebirds of freshwater wetlands that do not form flocks and are therefore hard to count. For some of these, there were so few count data that it was not possible to calculate country estimates. For others, pooled count data were less than a third of pooled country estimates and previous minimum estimates, which suggests a low level of confidence. For these 18 species, population ranges, proposed by Rose and Scott (1997) and Delaney and Scott (2002), were compared with the results of what count data were available, and the population ranges were retained or adjusted as appropriate.
8. For species with a calculated Flyway MPE, this value was used as the basis for the 1% criterion. For species for which an MPE could not be calculated, the minimum value of the population range was used as the basis for the 1% criterion. The 1% criterion for each species was run against the database to identify sites that met the 1% criterion for a species at any time of the year. In addition, the staging criterion (0.25%) was cautiously applied to counts from migration periods only.

Tables 1 and 2 illustrate the process involved in calculating MPE values. Table 1 illustrates the calculation of the country estimate for the Common Redshank in Malaysia on the basis of regional count data. From the pooled count of about 6,000, a country estimate of 8,000 was proposed. Table 2 illustrates the calculation of the EAA Flyway MPE for the Red-necked Stint from country counts and country estimates. In the case of the Red-necked Stint, the importance of interpretation of count data is well-indicated with the treatment of records from the regions in Australia. Australia was the only country where regional data were treated at this level of detail, and this was important because of the reliance upon non-breeding season data. In southern Western Australia, the maximum count is considered to represent the regional estimate because coverage has been very good, whereas in other areas the count has been adjusted. In parts of northern Australia, high counts are considered to represent migrating birds that are likely to be included in counts in southern Australia, and therefore the regional estimate is less than the count. In Victoria and South Australia, however, local advice was that counts are not complete and therefore the regional estimate is greater than the count.

Table 1. Example of the use of regional count data to calculate a country estimate: the Common Redshank in Malaysia.

Region	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Maximum
Johore	-	-	120	-	117	164	248	**270**	-	108	-	-	-	270
Kedah	-	-	**450**	-	-	8	27	43	-	25	15	-	-	450
Melaka	-	-	81	-	28	**105**	30	90	-	-	-	-	-	105
Pahang	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Perak	-	-	700	-	-	**1005**	750	750	-	-	-	-	-	1005
Sabah	-	100	-	-	-	-	-	**120**	-	-	-	-	-	120
Sarawak	-	**2698**	-	-	-	-	-	-	-	-	-	120	40	2698
Selangor	250	290	236	20	280	383	600	600	-	1500	1301	-	-	1500
TOTAL														**6149**

Table 2. Red-necked Stint: maximum country counts and country estimates used for the calculation of the EAA Flyway MPE for the species. Counts and estimates are for the non-breeding season (December to February). Regional data are presented for Australia as this was the only country in which counts were manipulated to estimates on a regional basis.

Country	Count	Estimate
Australia	220 068	260 000
southern Western Australia	15 252	15 000
mid Western Australia	8 312	15 000
north Western Australia	60 000	25 000
Northern Territory	150	15 000
Queensland	41 063	20 000
New South Wales	800	800
Victoria	23 675	70 000
Tasmania	7 016	10 000
South Australia	63 800	80 000
Bangladesh	0	0
Brunei	72	100
Cambodia	6	50
China	2871	10 000
India	0	0
Indonesia	1 695	5 000
Japan	1 308	1 500
Laos	0	0
Malaysia	2 794	6 000
Myanmar	NA	0?
New Zealand	231	250
North Korea	NA	0?
Papua New Guinea	716	4 000
Philippines	7 747	12 000
Singapore	140	150
South Korea	10	50
Taiwan	1 670	2 000
Thailand	2 670	4 000
Vietnam	759	2 000

Overview of revised Minimum Population Estimates for the EAA Flyway

Table 3 presents the pooled count, country estimate, Flyway MPE and 1% criterion for each species in the EAA Flyway. The sum of maximum counts for all species came to 2,700,000 and the sum of country estimates came to just over 4 million. Pooled Flyway MPEs, using the minimum values for species with a population range, came to just over 5 million; about 1.5 million more than previously.

Some proposed MPEs for the EAA Flyway are similar to the minimum values published by Rose and Scott (1997), but there are many exceptions. For example, both the Eurasian and Eastern Curlews and the Terek Sandpiper are more numerous than the previous minimum values suggest, while the difference for the Dunlin is extreme (25,000 compared with 950,000). In the case of the Dunlin, count data suggested a population of over 150,000, but estimates from the breeding grounds suggest a population of nearly 1,000,000. The difference for the Grey Plover (minimum of 25,000 compared with an MPE of 125,000) is also considerable. In contrast, species such as the Red-necked Stint and Curlew Sandpiper appear to be less abundant.

Overview of shorebird species and countries in the EAA Flyway

It is estimated that there are about 5,000,000 migratory shorebirds in the EAA Flyway, while 455 important sites were identified. For each species, the report presents:

- Pooled maximum count and population estimate (where available) for each country in the non-breeding season;
- EAA Flyway MPE;
- Details of counts and important sites throughout the EAA Flyway;
- Discussion on the proposed and previous population estimates;
- Discussion on the distribution of important sites in the EAA Flyway.

For each country, the report presents:

- Number of sites important for each species in each season;
- Details on all important sites, such as the species for which each site is important;
- Discussion on the role of that country in supporting migratory shorebirds in the EAA Flyway.

Table 3. The pooled count, country estimate, Flyway MPE and 1% criterion for each species in the EAA Flyway. NA indicates where country estimates could not be calculated or where values were not given. Also presented is the minimum value of the population ranges proposed by Rose and Scott (1997).

English Name	Sum of country counts	Sum of country estimates	Flyway MPE	1% criterion	Minimum estimate for EAA Flyway (Rose and Scott 1997)
Common Snipe	11 734	78 300	100 000- 1 000 000	1 000	100 000
Japanese Snipe	762	NA	36 000	360	36 000
Swinhoe's Snipe	582	NA	25 000-100 000	250	25 000
Solitary Snipe	375	NA	10 000-100 000	100	NA
Pintail Snipe	6 845	25 710	25 000-1 000 000	250	25 000
Eurasian Woodcock	775	NA	25 000-100 000	250	NA
Black-tailed Godwit	126 821	158 720	160 000	1 600	162 000
Bar-tailed Godwit	227 077	321 580	325 000	3 250	330 000
Little Curlew	242 017	180 970	180 000	1 800	200 000
Whimbrel	18 271	54 270	55 000	550	40 000
Eurasian Curlew	22 859	33 200	35 000	350	10 000
Far Eastern Curlew	18 594	38 880	38 000	380	21 000
Spotted Redshank	21 331	37 410	25 000-100 000	250	10 000
Common Redshank	31 659	64 360	65 000	650	NA
Marsh Sandpiper	28 777	66 970	100 000-1 000 000	1 000	90 000
Common Greenshank	23 603	57 120	55 000	550	40 000
Spotted Greenshank	300	640	1 000	10	1 000
Green Sandpiper	2 082	21 510	25 000-100 000	250	25 000
Wood Sandpiper	8 302	42 400	100 000	1 000	100 000
Terek Sandpiper	24 748	52 660	50 000	500	25 000
Common Sandpiper	8 921	30 360	30 000	300	25 000
Grey-tailed Tattler	21 984	43 720	40 000	400	25 000
Ruddy Turnstone	20 704	31 210	31 000	310	25 000
Asian Dowitcher	9 008	23 280	23 000	230	15 000
Great Knot	316 080	379 125	380 000	3 800	319 000
Red Knot	256 131	218 970	220 000	2 200	255 000
Sanderling	9 913	21 420	22 000	220	10 000
Red-necked Stint	242 757	309 110	315 000	3 150	471 000
Long-toed Stint	4 941	24 200	25 000	250	25 000
Temminck's Stint	2 987	9 230	10 000-100 000	100	10 000
Sharp-tailed Sandpiper	120 369	155 420	160 000	1 600	166 000
Dunlin	152 035	497 700	950 000-2 750 000	9 500	25 000
Curlew Sandpiper	215 230	178 750	180 000	1 800	250 000
Spoon-billed Sandpiper	370	3 620	4 000	40	4 000
Broad-billed Sandpiper	13 114	25 140	25 000	250	10 000
Red-necked Phalarope	942	NA	100 000-1 000 000	1 000	NA
Asian Painted Snipe	982	1 440	10 000-100 000	100	1 500
Pheasant-tailed Jacana	2 165	14 210	25 000-100 000	250	NA
Eurasian Oystercatcher	3 774	9 560	25 000	250	<10 000
Black-winged Stilt	9 041	20 460	25 000-100 000	250	10 000
Pied Avocet	14 509	32 630	25 000-100 000	250	10 000
Pacific Golden Plover	27 189	49 230	100 000-1 000 000	1 000	100 000
Grey Plover	29 412	46 120	125 000	1 250	25 000
Little Ringed Plover	8 328	24 350	25 000	250	25 000
Kentish Plover	83 744	100 210	100 000	1 000	25 000
Double-banded Plover	7 005	50 000	50 000	500	30 700
Lesser Sand Plover	76 453	130 670	130 000	1 300	>100 000
Greater Sand Plover	55 573	103 430	100 000	1 000	99 000
Long-billed Plover	194	2 510	<10 000	100	10 000
Eastern Sand Plover	31 719	70 100	70 000	700	44 000
Grey-headed Lapwing	3 639	8 620	10 000	100	10 000
Northern Lapwing	29 751	62 270	100 000-1 000 000	1 000	25 000
Oriental Pratincole	76 105	73 030	75 000	750	67 000
Australian Pratincole	32 022	60 300	60 000	600	60 000
	2 704 605	**4 045 095**	**4 990 000**		**3 537 200**

Table 4 presents a summary of the number of important sites (for any species) in each country, and the number of species for which each country has important sites. To a great extent, this reflects the nature of the available data, with a lot of information from Australia and Japan that are well surveyed. There is also a lot of information from the non-breeding season, which also favours Australia.

The report is still in draft form and available for comment at <wetlands international – oceania>. As examples of the sort of information presented, the Red-necked Stint and Australia are discussed below.

Table 4. Number of important sites in each country and the number of species for which important sites were recognised in each country.

Country	N important sites	N species with important sites
Alaska	6	4
Russia	25	41
Cambodia	3	4
Vietnam	8	20
Laos	0	0
Myanmar	6	5
Bangladesh	19	7
India	4	3
Thailand	9	21
Malaysia	19	22
Brunei	3	3
Indonesia	9	19
East Timor	0	0
North Korea	1	1
South Korea	22	24
Taiwan	11	10
Philippines	9	18
China	28	49
Singapore	1	4
Papua New Guinea	2	6
New Zealand	16	4
Japan	117	22
Australia	137	28

Case study: Red-necked Stint

The EAA Flyway population estimate for the Red-necked Stint is 315,000, considerably less than the previous estimate of 471 000. This great difference is largely due to what are believed to have been unusually large numbers of Red-necked Stints recorded in parts of southern and south-eastern Australia during the early 1980s. The previous estimate was based on these counts. Such variations in population size may be cyclical and natural, but the population at the lowest point in the cycle is considered to be the best basis for the recognition of important sites.

Over 80% of the population of the Red-necked Stint occurs in Australia during the non-breeding season and all important sites were in Australia during this period. Of the 64 important sites recognised for the species, 32 were in Australia.

Numbers of important sites (those meeting the 1% criterion at any time of the year, or the staging criterion during migration periods) for the Red-necked Stint in each country were as follows:

Australia	32
South Korea	9
Russia	7
Japan	6
China	5
Philippines	2
Indonesia	1
Malaysia	1
Thailand	1

The recognition of important sites at different times of the year reveals something about patterns of migration in the species. More sites were important during southward than northward migration in Australia, but the reverse was the case throughout Asia. One interpretation of this is that Red-necked Stints move rapidly through Asia on southward migration but tend to aggregate upon arrival in Australia, whereas their departure from Australia on northward migration may be more dispersed and they may rely more heavily on Asian sites during this period.

Sites in Russia are important during both migration periods. The estuary of the Moroshechnaya River was the single most important site in the EAA Flyway for the Red-necked Stint, with an estimate of 300,000 birds passing through on southward migration compared with 100,000 on northward migration. The birds made greater use of Daursky Nature Reserve, also in Russia, on northward than southward migration, suggesting different seasonal patterns of site usage in Russia.

The only sites recognised during the breeding season were in Australia. This indicates that large numbers of non-breeding birds remain in Australia during this period.

Numbers of important sites recognised by season in major geographical regions were as follows:

	SM	NB	NM	B
Russia	5		4	
South Korea and Japan	4		12	
Eastern China and south-eastern Asia	4		7	
Australia	9	28	3	4

(SM – southward migration; NB – non-breeding season; NM – northward migration; B – breeding season)

Table 5. Shorebirds in Australia – number of important sites by season.

Species	Total sites	Number of sites each season			
		SM	NB	NM	B
Japanese Snipe	2		2		
Black-tailed Godwit	18	4	6	5	2
Bar-tailed Godwit	12	3	8	5	
Little Curlew	9	3	7		
Whimbrel	8	2	6	1	1
Far Eastern Curlew	20	9	13	3	4
Marsh Sandpiper	4	1	1	1	
Common Greenshank	11	4	8		
Terek Sandpiper	11	3	6	1	2
Common Sandpiper	2		2		
Grey-tailed Tattler	17	7	8	5	3
Ruddy Turnstone	20	7	15	3	
Asian Dowitcher	1			1	
Great Knot	11	3	9	2	
Red Knot	10	3	9	1	
Sanderling	19	7	14	4	3
Red-necked Stint	33	9	29	3	5
Sharp-tailed Sandpiper	39	6	27	7	4
Curlew Sandpiper	25	8	23	3	4
Broad-billed Sandpiper	1		1		
Pacific Golden Plover	1		1	1	
Grey Plover	5	2	4		
Double-banded Plover	10		10		
Lesser Sand Plover	7	3	5	2	
Greater Sand Plover	8	5	4	1	1
Eastern Sand Plover	6	2	3	1	
Oriental Pratincole	10		9		1
Australian Pratincole	9	2	2	2	3

Note that no dates were available for some counts, so these sites could not be assigned a season. Therefore, the number of sites by season may add up to less than the total number of sites.

Case study: Australia

Australia has 137 important sites for 28 shorebird species. This is a much smaller number of important sites than previously recognised because of the amalgamation of some clusters of sites. The definition of what constitutes a "site" for a shorebird is very difficult as it is a question of scale. The birds may use one beach to roost but an entire bay to forage, and larger areas (management units, often a gazetted reserve or park) were recognised in this study. Future investigations will focus on the composition of important locations within such areas.

Australia supports >5% of the populations of 28 species in the non-breeding season, and over 75% of the populations of Bar-tailed Godwit (*L. l. menzbieri*), Little Curlew, Grey-tailed Tattler, Great Knot, Red-necked Stint, Sharp-tailed Sandpiper, Eastern Sand (Oriental) Plover and Australian Pratincole. During migration, it supports over 75% of the populations of the Bar-tailed Godwit (*L. l. anadyrensis*), Red Knot and Ruddy Turnstone for which New Zealand is important during the non-breeding season.

Important sites in Australia were identified throughout the year, but with more (99) recognised during the non-breeding season, and more during southward (44) than northward (32) migration (see Table 4). 26 sites were important during the breeding season. These patterns indicate that birds concentrate more upon arrival on southward migration than during departure on northward migration, and that large numbers of some species remain in Australia through the breeding season. Only 4 sites were important for 10 or more species (Roebuck Bay, Eighty-Mile Beach, South-East Gulf of Carpentaria and Moreton Bay), while 80 sites were important for single species.

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Are Populations of Migratory Shorebirds in The East Asian Australasian Flyway at Risk of Decline ?

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Abtract

Populations of shorebirds throughout the East Asian-Australasian Flyway are under increasing risk of population collapse due to losses of feeding and roosting habitat and dramatic declines in habitat quality in the Yellow Sea region. We undertake a population viability analysis of the potential impact on the population size of four species of shorebird that use the Yellow Sea on migration. We used data from banding studies undertaken by the Australasian Wader Studies Group and Victorian Wader Study Group to estimate population trends of each species under four scenarios that may mimic the effects of habitat loss in the Yellow Sea. Simple matrix modelling was used to project the populations of Bar-tailed Godwit, Great Knot, Curlew Sandpiper and Red-necked Stint from current Flyway population size estimates. The models predict that all species would decline under the scenarios where adult survival is reduced. However, there was high variation in the predicted population estimates, such that for some species we could not be confident of detecting a decline in adult survival of 10% per year, even after 10 years. Our analyses suggest that we will not be able to detect a decline of less than 20% per year within five years. These results suggest that in order to detect short-term (< 10 yrs) declines in shorebird populations from the effects of the large Saemangeum reclamation project in South Korea, we need a multiple pronged approach. This would involve monitoring changes in adult survival rates, population size estimates and habitat use of key species. The AWSG is well placed to undertake these studies through their on-going mark-recapture studies (banding) and extensive population monitoring of the non-breeding grounds in Australia. Studies of shorebird feeding habitat carrying capacity would be best undertaken on the migration staging grounds in the Yellow Sea by competent local scientists.

Introduction

Migratory shorebirds in the East Asian Australasian Flyway (EAAF) are coming under increasing threat from habitat degradation and loss. This is particularly important during migration, where critical regions such as the Yellow Sea are degrading from damming of the Yellow River and being reclaimed at a great rate (Barter 2002).The huge Saemangeum reclamation project on the west coast of Korea will threaten up to 16 species of shorebird that occur there in internationally-significant numbers. The site supports over 30% of the Flyway population of Great Knots during northward migration (Barter 2002).

Milton (2003) showed that 20% of the shorebird species (19 spp) that regularly use the East Asian Australasian Flyway have been officially classified as globally threatened with substantial population decline. Of these, only four species of migratory shorebird were identified to be at risk (Birdlife International 2000). However, a recent International Wader Study Group conference in Cadiz, Spain in September 2003 found that 48% of migratory shorebird populations with sufficient data are in decline. One example cited was the recent rapid decline of Western Hemisphere populations of Red Knot because of a reduction in food available at the major migration site in Delaware Bay from competing fisheries. This has led to reduced adult Red Knot survival and subsequent decline in breeding success (Baker et al. 2004).

Given the rapid loss and degradation of intertidal habitats in the Yellow Sea, many species of migratory shorebird in the EAAF could potentially show similar declines. However, it is difficult to monitor shorebird populations on the non-breeding grounds to identify species in decline (Wilson 2001). In the EAAF, this has only been possible for most species on the non-breeding grounds in Australia or New Zealand. Even then, it will take several years before sufficient data are available to identify population trends with statistical confidence. That timeframe may be too long for many species, especially if changes are rapid.

Another approach is to model populations under a range of potential scenarios with matrix models. These models use estimates of reproductive contribution (new recruits) and survival rate to predict the impacts of external changes on the population (Caswell 2001). They project population estimates forward under the constraints identified in each scenario. By incorporating environmental and demographic stochasticity (for example, annual variation in survival rates between age classes), these models can generate a measure of the expected confidence in model predictions (Akcakaya et al. 1999).

The aim of this study is to assess the potential effect on migratory shorebird populations of four scenarios that cover the range of potential impacts from habitat loss in the Yellow Sea. The four scenarios examined are (1) a 10% reduction in fledgling production because of poorer breeding; (2) 10% reduction in adult survival because of poor conditions during migration; (3) 10% reduction in the whole population because of poor condition during southward migration and (4) a 20% reduction in the whole population.

Methods

Data on the fertility and survival of four species of migratory shorebird were obtained from banding studies undertaken by the Victorian Wader Study Group (VWSG) and the Australasian Wader Studies Group (AWSG). Data on two species, Bar-tailed Godwit (*Limosa lapponica*) and Great Knot (*Calidris tenuirostris*), were collected in north-western Australia from 1982 – 2003. In this region, the AWSG has conducted regular expeditions since 1981. Birds are caught by cannon-netting and banded with a metal ring and yellow leg flag (since 1990). The other two species, Curlew Sandpiper (*Calidris ferruginea*) and Red-necked Stint (*Calidris ruficollis*), were caught in Victoria with similar methods to those used in north western Australia. Birds are caught at the same range of sites each summer non-breeding season with cannon nets.

In this analysis, we examine data from birds caught between1975 and 2000. All birds were aged at first capture based on plumages and classified as Age 1 birds (young of the year), Age 2 birds (birds in their second year), or Age 2+ birds (adults i.e. birds in their second year or older). Following moult in their second year, second year Red-necked Stints and Curlew Sandpipers cannot be distinguished from adults. Until this time, a couple of months or so, full adults will be in their third year or older (Age 3+). In the other species, Age 2, 2+ and 3+ birds were not distinguished consistently. Consequently these three age classes were grouped together for analysis. By convention, the wader year in Australia starts on August 1 so, for example, Age 1 birds automatically become Age 2 birds on August 1 in the year after they fledged and migrated to Australia.

Recoveries of banded first year birds were tracked between successive samples (years or expeditions) as each annual cohort aged. This enabled us to obtain a series of annual estimates of survival rates for each age class. These estimates of survival rate assume that all birds return to the same region each year and are equally catchable. Shorebird fertility was estimated from the number of Age 1birds caught, relative to the number of adults (Age 2+) caught the previous year. These birds were all assumed to have contributed to breeding in the previous year and that none had delayed maturity (which is known to occur (Akcakaya et al. 1999). As banding effort and the number of birds caught of each species varied considerably between years, particularly in north western Australia, we attempted to standardise effort to improve precision. This was done by adjusting the numbers of each age class caught by the proportion of the total captures for that year to the mean of all years. This assumes the probability of capture remained constant between years.

The matrix population modelling was undertaken with RAMAS Ecolab 2.0 (Akcakaya et al. 1999). This software allows up to seven life stages, each with an estimate of mean annual survival rate and standard deviation. In our analysis, we estimated mean annual fertility across all adult age classes (Age 2+) and assumed all contributed similarly to population productivity. Most age classes had few birds in many years and so many annual recapture rate (survival) estimates are based on few birds (< 5). However, across the large number of years the birds had been sampled, we expect that the mean recapture rate to be indicative of the true local survival rate. The variances of these survival rates are probably over-estimated by the inclusion of the data from years where recaptures were low.

The RAMAS software uses standard deviation of the recapture rate estimates of each life stage to generate stochastic demographic variation. We assumed a net emigration rate of 15% for all species, based on the studies of Ken Rogers on Red-necked Stint and Curlew Sandpiper (unpubl. data). Incorporating emigration in the models is necessary as our recapture rate estimates are not true survival, but an approximation of "local" survival that is a product of true survival and emigration. We also assumed there would be contest density-dependence in these species, particularly at current population levels. This would be expected to occur if feeding habitat became limiting as coastal habitats are degraded or lost.

Four scenarios were examined: (1) annual removal of 10% of Age 1 birds if the reduction in feeding habitat reduced adult breeding success; (2) annual removal of 10% of adult (age 3 – 7+ birds) if adult survival is reduced during northward migration, (3) annual removal of 10% of all birds due to increased losses during southern migration and (4) annual removal of 20% of all birds if the effect in (3) is more severe. Initial population estimates were based on the recent revised estimates of migratory shorebirds by Bamford and Watkins (2004). These population estimates have to be broken down among the age classes. In our analysis, we initially estimated the mean proportion of first year birds from the banding data and removed those from the population estimate. The remainder were then assigned to the adult age classes by their proportion of all birds of each species of known age that had been banded during the study. Each scenario was run for 10 years for 1000 iterations with demographic stochasticity within the bounds of the matrix of standard deviations of each parameter. The mean and 95% confidence limits (CL) at each time are calculated by RAMAS. The probability of getting at least one population estimate above or below the initial population estimate was also calculated by the RAMAS package.

Results

Bar-tailed Godwit

A total of 9,410 Bar-tailed Godwit were banded by AWSG in north western Australia from 1982 to 2003. Of these, 974 were recaptured during the same period, giving an overall recapture rate of 10.4% across all ages. First year birds represented 23% of all captures and this varied greatly between years. The oldest bird recaptured was first caught as an Age 3+ bird in 1984. Over 58% of recaptures were within four years of banding with recaptures within one or two years most common.

Adult fertility was low and variable, with each pair producing an average 0.98 ± 0.11 (N = 9) fledglings per year that survive to be Age 1 birds in Australia. Mean annual survival rates of these Age 1 birds to their second year were quite low and variable (0.447 ± 0.118, ranging between 1 and 55%). The survival of adult Bar-tailed Godwits was higher in most years (0.808 ± 0.12) with a similar variance to that of juveniles.

The model projections (Figure. 1) show that reductions of adult survival of 10% lead to large reductions in the overall population more so than reductions in the survival of Age 1 birds. However, the variability in the estimates is so large, that the effect is not detectable until about 10 years later. At this time, the mean population estimate is less than half that at the start. A reduction in survival of 20% led to a mean estimated population of about 15% of the original number after 10 years (Figure. 1).

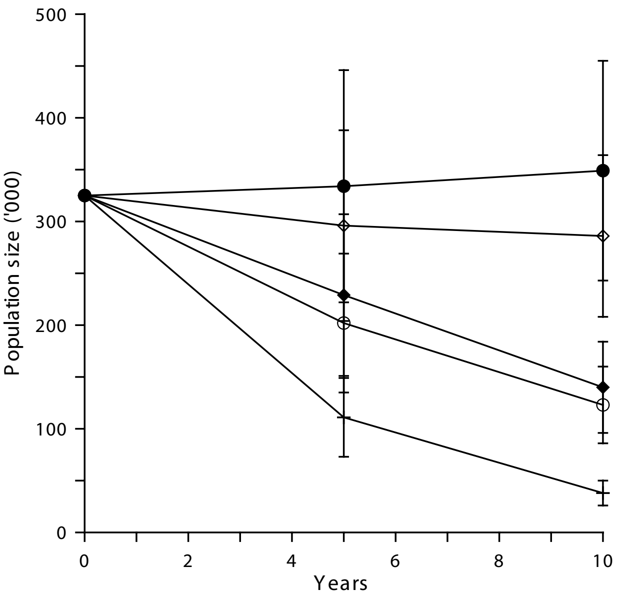

Figure 1. The mean survival ± 95% CL of Bar-tailed Godwit after 5 and 10 years under five potential scenarios (a) no change in current survival rates (closed circles) (b) 10% reduction in annual fledgling survival (open diamond), (c) 10% reduction in adult survival closed diamond), (d) 10% reduction in survival of all ages (open circle) and 20% reduction in survival of all ages (cross).

Great Knot

From 1982 to early 2003, 15,243 Great Knot were banded in north western Australia. Of these, 22 % (3379) were identified as Age 1 birds. Of the birds banded, 1,829 were recaptured at least once (12%). This recapture rate was lower than for Bar-tailed Godwits in the same region. The modal age was similar to the Godwits and 72% of the recaptures were within four years. The oldest bird was banded as a 2+ year-old in 1985.

Great Knot fertility was slightly lower than for Bar-tailed Godwits with each pair producing 0.90 ± 0.11 (N = 13) fledglings that survive to be Age 1 birds in Australia. This appears to be partly compensated by the slightly higher estimated mean annual survival rate of Age 1 birds (0.55 ± 0.07) and adults (0.82 ± 0.13). The consequence of these higher survival and lower reproductive rates is that under average conditions, the population will increase slightly (Figure. 2). However, the mean estimate is more variable than in Bar-tailed Godwit, increasing the difficulty in detecting when changes in reproductive productivity or adult survival have occurred. This can be seen in the predicted population size estimates when survival of Age 1 birds is reduced by 10% (Figure. 2). The mean population size is predicted to remain stable for 5 years and only decreases slightly 10 years after it starts to occur. The model predicts that all scenarios where survival is reduced by 10% will have statistically similar mean population estimates. It requires a reduction in overall survival of at least 20% before the effect is detected (Figure. 2). However, the mean population size is predicted to be less than 50% of the original estimate after 5 years.

These data suggest that Great Knot populations probably have much greater natural fluctuations than Bar-tailed Godwits. This makes detecting trends in population size after losses of feeding habitat more difficult. The Saemangeum reclamation project in Korea will impact a large percentage of the Great Knot population during migration. If this impact leads to a reduction in adult or juvenile annual survival, the model predicts it will not be detectable after ten years unless the reduction is at least 20%.

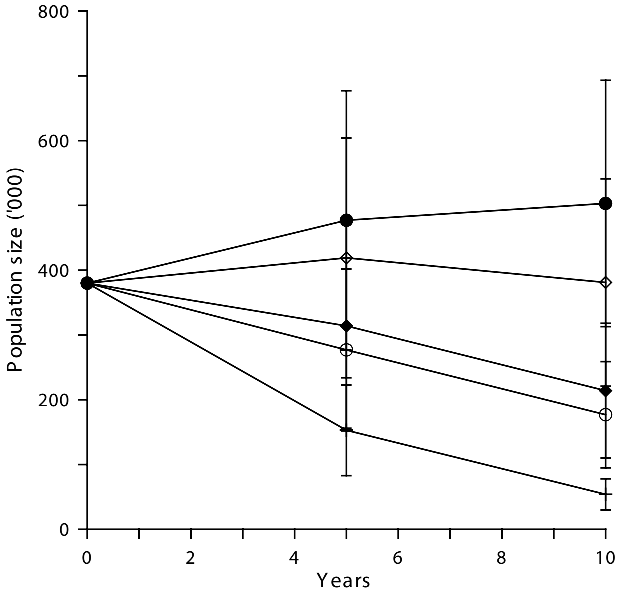

Figure 2. The mean survival ± 95% CL of Great Knot after 5 and 10 years under five potential scenarios (a) no change in current survival rates (closed circles) (b) 10% reduction in annual fledgling survival (open diamond), (c) 10% reduction in adult survival closed diamond), (d) 10% reduction in survival of all ages (open circle) and 20% reduction in survival of all ages (cross).

Curlew Sandpiper

The population size predictions for Curlew Sandpiper show similar patterns to those of Great Knot, except that the estimates have even larger variances (Figure. 3). This was because the estimated mean number of Age 1 birds produced per adult pair was lower than in the two previous species (0.64 ± 0.08) and the mean annual adult survival was higher and less variable (0.69 ± 0.04). This was based on 11,780 birds of known age caught in Victoria between 1978 and 2000. Of these, 3,833 (33%) were 1-year olds and this was a higher percentage than in the two previous species.

The model predicts that there is no detectable difference in the mean estimated Curlew Sandpiper population between no change and 10% reduction in survival of Age 1 birds. Mean population estimates were predicted to be higher after 5 years under both scenarios. The models predict that it will take 10 years for even a 20% reduction in survival to be statistically detectable; such is the high

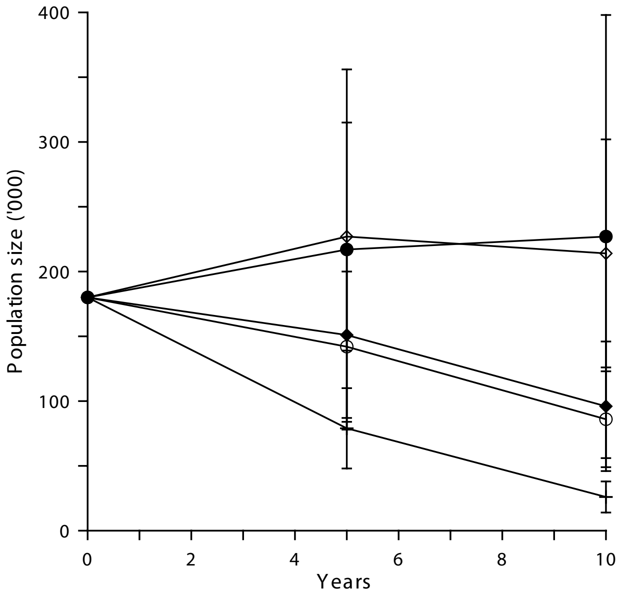

Figure 3. The mean survival ± 95% CL of Curlew Sandpiper after 5 and 10 years under five potential scenarios (a) no change in current survival rates (closed circles) (b) 10% reduction in annual fledgling survival (open diamond), (c) 10% reduction in adult survival closed diamond), (d) 10% reduction in survival of all ages (open circle) and 20% reduction in survival of all ages (cross).

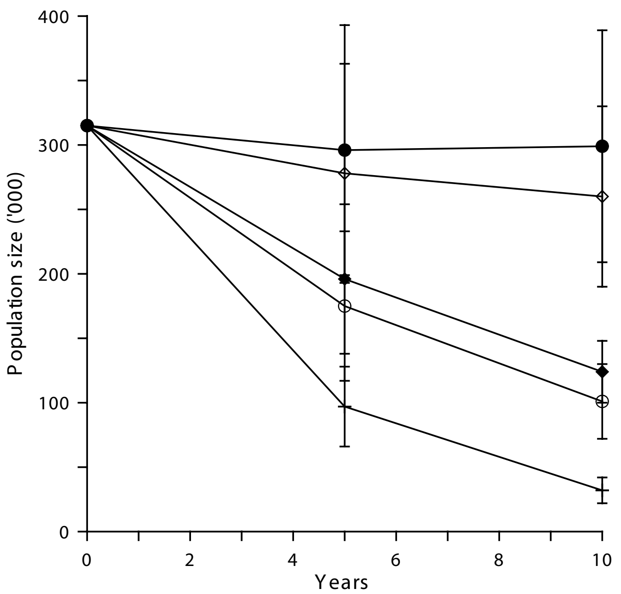

Figure 4. The mean survival ± 95% CL of Red-necked Stint after 5 and 10 years under five potential scenarios (a) no change in current survival rates (closed circles) (b) 10% reduction in annual fledgling survival (open diamond), (c) 10% reduction in adult survival closed diamond), (d) 10% reduction in survival of all ages (open circle) and 20% reduction in survival of all ages (cross).

natural level of variation. By this time, the predicted mean population size is only 14% of the original population size (Figure. 3).

Red-necked Stint

Red-necked Stints were the most abundant species caught in this study, with 78,096 known age birds caught between 1975 and 2000. Of these, only 21% (16,315) were Age 1 birds. Of these birds, 5,213 or 33% were recaptured at least once and their mean estimated annual survival rate to Age 2 was 0.42 ± 0.08. This compared with an estimated mean adult survival of 0.65± 0.06.yr-1. These values were lower than those found in the three larger species. Reproductive productivity was also lower and less variable (0.55 ± 0.03 Age 1 birds per pair) in Red-necked Stint compared with other species.

The pattern of predictions for Red-necked Stints was similar to those predicted for Bar-tailed Godwit. Statistically detectable differences could be identified after 10 years for the scenarios where adult survival declined by at least 10%. If overall survival declines by 20%, the model predicts that populations will be about 10% of initial estimates after 10 years (Figure. 4).

Discussion

The matrix population modelling has been widely used in population viability analyses when limited demographic data are available (Caswell 2001). While the approach we have adopted is relatively simplistic, it does give some indicators of the important demographic parameters that need to be monitored (Russell 1999). The results clearly indicate that maintaining adult survival is critical for long-term viability of wader populations. This is hardly surprising, given the life history of waders. They are long-lived, take at least two years to mature and have low and variable annual productivity. Population viability analyses of other wader species (Hitchcock and Grotto-Trevor 1997; Larson et al. 2002) and species with similar life histories, such as seabirds and large sharks, have all found similar patterns (Russell 1999; Otway et al. 2004). Elasticity values are highest in the oldest age classes, indicating that the survival of these birds has the greatest contribution to population viability.

Russell (1999) argues that declines in population size are difficult to detect by monitoring in species with long generation times and low or variable offspring survival. A population may continue to decline for several years after an adverse event has occurred (Croxall and Rothery 1991; Baker et al. 2004). Thus, an ability to identify changes in adult survival should be a better early indicator of potential threats to wader populations. Unfortunately, there have been no published studies of wader survival rates in the East Asian-Australasian Flyway. These data are available from extensive banding studies since 1975 by the Australasian Wader Studies Group (AWS) and the Victorian Wader Study Group (VWSG). However, to date only Red-necked Stint and Curlew Sandpiper has been examined in any detail (Ken Rogers unpubl. data). This indicates that one of the pressing priorities for the AWSG and VWSG should be to undertake similar analyses and obtain survival rate estimates for other species, especially those most impacted by habitat loss in the Yellow Sea (eg. Great Knot and Bar-tailed Godwit).

Our estimates of the survival of Bar-tailed Godwit, Great Knot, Curlew Sandpiper and Red-necked Stint are probably biased due to our assumption of constant probability of recapture. Banding effort in north-western Australia has not been constant and the timing of visits and the level of effort has varied considerably between trips. We have not accounted for these differences in effort in our survival rate estimates and thus are probably under-estimating survival. Studies of similar-sized species in other Flyways have estimated higher survival rates for most species (Sandercock 2003).

Estimates of population size after 5 and 10 years showed wide variances due to the high variation in survival rate estimates, especially for Great Knot and Curlew Sandpiper. This suggests that either our ability to detect biologically significant trends in population sizes of these species may be poor or that better estimates of survival are required that take into account interannual differences in catchability. More elaborate estimation procedures that account for interannual variation in probability of capture need to be undertaken. Statistical applications like the program MARK are better suited for these types of analyses and are likely to produce higher and more precise survival rate estimates Thus, our models predict the worst case scenario from two perspectives. Firstly, any population reductions from lost feeding habitat in the Yellow Sea are unlikely to continue at the same rate for many years. Population losses should stabilise at a new carrying capacity. Secondly, our use of recapture rates as a proxy for survival have underestimated the true survival by not directly accounting for juvenile dispersal or survivors from previous years. Sensitivity analyses could be undertaken to identify which parameters have the greatest effect on population growth (Ø).

However, it is still worth noting some of the important outcomes of our analyses. In most of the scenarios examined, the models predict that we require at least 10 years of data to be confident of a 20% reduction in annual survival. By this time, the estimated mean population size of all species had dropped to less than 20% of the current estimate. This suggests that in order to predict if such a decline in adult survival could occur following the Saemangeum reclamation, we need a better understanding of the relationship between wader density and the extent and quality of feeding habitat. We could then more rapidly predict and respond to habitat losses on the staging and non-breeding grounds without waiting for several years of data. Studies to predict the carrying capacity of intertidal wetlands in the East Asian-Australasian Flyway are urgently required if we hope to reduce the impacts of the loss and damage to critical coastal habitats for wader populations.

Acknowledgements

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Yellow Sea-driven Priorities for Australian Shorebird Researchers

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Abstract

If one single fact should provide focus for the activities of Australian shorebird researchers it is that more than 1/3rd of the world's human population lives within the East Asian – Australasian Flyway - although it is only one of eight shorebird flyways around the globe. The great majority of these people live in very fast developing East Asian economies which are consuming and degrading shorebird habitats at an extremely rapid rate. The Yellow Sea, located between China and the Korean Peninsular, is the most important staging region during northward migration for shorebirds spending the non-breeding season in Australia. The information, or lack of it, gained from this region in recent years provides guidance on crucial research activities aimed at collecting the key data necessary to underpin effective conservation action. Twenty of the 60 migratory shorebird species in the Flyway occur in Australia in numbers exceeding 30% of their estimated Flyway populations. Of these, it is believed that >90% of the breeding populations of three species pass through the Yellow Sea on northward migration (Great Knot, Eastern Curlew and Bar-tailed Godwit), whilst the Yellow Sea supports in excess of 30% of the breeding numbers of an additional eight species at this time (Red-necked Stint, Red Knot, Whimbrel, Terek Sandpiper, Black-tailed Godwit, Broad-billed Sandpiper, Lesser Sand Plover and Common Greenshank). Suggested opportunities for Australian shorebird workers include: further survey work and co-operative migration studies within the Yellow Sea, and monitoring, within Australia, those species which are most threatened by habitat loss in the Yellow Sea and marking populations and species not currently well covered.

Introduction

Although the East Asian-Australasian Flyway is only one of eight recognised shorebird flyways encircling the globe, it supports more than 1/3rd of the world's human population who live in the fastest developing economies. The resulting economic and social pressures are posing major threats to wetlands, with more than 80% of the significant wetlands in east and south-east Asia being classified as threatened in some way; 51% of these are under serious threat (Scott and Poole 1989).

Recent surveys in the Yellow Sea (Figure 1) have shown that this region is the single most important area for migratory shorebirds during the northward migration period (Barter 2002), with an estimated minimum number of 2 000 000 birds, i.e. 40% of the flyway total, passing through at this time. Around 1 000 000 shorebirds stage through the Yellow Sea on southward migration. To date, 36 out of the flyway's 60 migratory shorebird species have been found to occur in internationally important numbers at one or more site in the Yellow Sea; 27 sites have been identified which support at least one species in internationally important numbers.

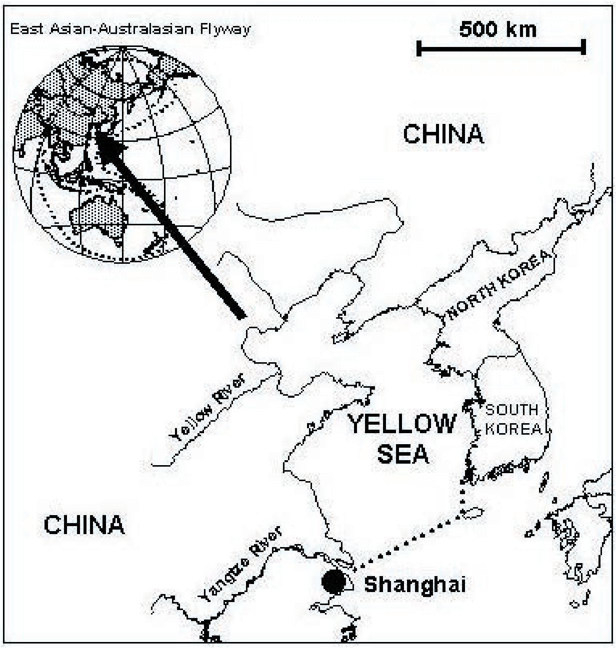

Figure 1. The Yellow Sea: location, littoral countries and major rivers

Unfortunately, the Yellow Sea is suffering serious loss and degradation of coastal wetland habitats.

Approximately 37% of the intertidal areas existing in the Chinese portion of the Yellow Sea in 1950 and 43% of those in the South Korean part in 1917 have been reclaimed to date. China has plans to reclaim a further 45% of its current mudflats and South Korea an additional 34%. The two largest rivers flowing into the Yellow Sea, the Yellow and Yangtze Rivers, are undergoing significant changes that will greatly reduce the amount of sediment input and it is predicted that future loss of intertidal areas will occur at an increasing rate due to the combined effects of reclamation and reduced accretion.

Human disturbance, by affecting feeding and roosting birds, and competition, through unsustainable harvesting of benthic fauna, may also have a serious impact on shorebirds. The declining river flows and high levels of pollution are leading to reduced benthic productivity and, thus, a decline in food supplies for shorebirds. It is predicted that global warming will result in a sea level rise of 0.5-0.6m in the Yellow Sea by the end of this century – one of the highest in the world. With sea walls encircling the Yellow Sea this can only result in a significant reduction in the extent of shorebird feeding areas.

The adverse effects of the various threats being encountered by shorebirds in the Yellow Sea are most significant during northward migration when shorebirds are preparing for their final long flight into the breeding grounds.

It can be predicted that the loss and degradation of coastal habitats in the Yellow Sea will lead to a decline in the populations of those species which use the Yellow Sea in large numbers. Indeed it may already be having such an effect (Wilson 2001).

The connection between Australia and the Yellow Sea

I have used two criteria to identify important "Australian" shorebird species which are highly dependent on the Yellow Sea during northward migration:

Criterion 1: 30%, or more, of the species' estimated flyway population occurs in Australia.

Criterion 2: 30%, or more, of the species' breeding population passes through the Yellow Sea.

These criteria are arbitrary but seem a reasonable starting point.

Twenty species meet the first criterion, these being:

Grey-tailed Tattler	Red Knot
Oriental Plover	Bar-tailed Godwit
Little Curlew	Ruddy Turnstone
Great Knot	Whimbrel
Oriental Pratincole	Sanderling
Sharp-tailed Sandpiper	Terek Sandpiper
Red-necked Stint	Black-tailed Godwit
Eastern Curlew	Broad-billed Sandpiper
Greater Sand Plover	Lesser Sand Plover
Curlew Sandpiper	Common Greenshank

The species are listed in percentage order, i.e. 100% of Grey-tailed Tattler spend the non-breeding season in Australia, whilst only 30% of Common Greenshank do.

Application of the second criterion to the twenty species meeting Criterion 1, identifies 11 species for which the Yellow Sea supports 30%, or more, of their breeding populations during northward migration, namely:

	% of breeding population
Great Knot	>90
Eastern Curlew	>90
Bar-tailed Godwit	>90
Whimbrel	70
Lesser Sand Plover	65
Red Knot	40
Red-necked Stint	35
Terek Sandpiper	35
Broad-billed Sandpiper	35
Common Greenshank	35
Black-tailed Godwit	30

Three species are at the >90% level and for these the Yellow Sea can be classified as critically important. However, any region that supports 30%, or more, of the breeding population is of great importance for that species.

It is believed that a further five species probably meet the second criterion, these being:

Little Curlew	Sharp-tailed Sandpiper
Curlew Sandpiper	Ruddy Turnstone
Sanderling	

However, further survey work is needed to establish whether they do or not.

The Red Knot is an obligatory coastal species. So far only 40% of the estimated breeding population has been found in the Yellow Sea, but it seems probable that the great majority, if not all, of this species must be staging somewhere in the region; possibly in North Korea.

Four species which occur in large numbers in Australia occur only in small numbers in the Yellow Sea region. These are:

Grey-tailed Tattler	Oriental Pratincole
Oriental Plover	Greater Sand Plover

Therefore, the Yellow Sea is of considerable importance for 11 of the 20 important "Australian" shorebird species, and probably for another five.

What Can Australian Researchers Do?

The evident threats to an important part of our avifauna should provide a strong impetus for Australians to collect the key data necessary to underpin effective conservation action throughout the flyway.

Australians have a particularly important role to play. We have by far the greatest numbers of skilled counters and banders of any country in the flyway; skills that have been developed over 25 years of intensive studies within Australia. Additionally, unlike the inhabitants of the majority of countries within our region, we have, individually and as a nation, substantial financial resources and discretionary time available. If we don't take up the challenge, it's difficult to see who will.

Some important areas for investigation are listed below.

Within Australia

Monitoring of the 11 species which meet the 30%/30% criteria. This will require a statistically robust integrated counting and banding (for survival and recruitment rates) programme.

Marking of species and populations not currently adequately covered or sufficiently known, e.g.:

- Black-tailed Godwit, Eastern Curlew, Whimbrel, Great Knot and Red Knot in the Gulf of Carpentaria and Northern Territory; establishing the distributions of the different races in species such as Bar-tailed Godwit, Lesser Sand Plover and Red Knot.

In the Yellow Sea

Continuing survey work, especially in China, to:

- identify additional key sites;
- obtain more information on the "missing" species, e.g. Red Knot, Little Curlew, Sharp-tailed Sandpiper, Curlew Sandpiper, Ruddy Turnstone and Sanderling.

Cooperative migration studies to:

- determine the provenance of the main species and populations passing through the Yellow Sea;
- study migration phenology and energetics; This is very important complementary work to that already done in Australia, where there is a very large body of data available on migratory departure schedules and weights.
- understand how different races use the Yellow Sea. E.G., Bar-tailed Godwit (*menzbieri* and *baueri*), Red Knot (*piersmai* and *rogersi*), Great Knot (NW and NE Australia populations) and Lesser Sand Plover (*mongolus* and *stegmanni*).

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The Penzhina River Estuary, Kamchatka, Russia – a very important shorebird site during southward migration

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Summary

Daily observations of the southward migration of shorebirds at the Penzhina River estuary, Kamchatka, were carried out over 61 days between July 12-August 10 2002 and August 11-September 10 2003. Two main methods were used to count shorebirds on a daily basis: a 5-6 hour count on mudflats along a fixed 10 km shoreline length and a count of birds flying past the study area. Observations have shown that shorebirds generally remain in the Penzhina River estuary no more than one day, as this region does not have suitable roosting places for species such as Dunlin and Red-necked Stint. There are no beaches, and only grasslands remain uncovered by water during high tide. During southward migration, large numbers of shorebirds fly over the mudflats without stopping and the total daily count of migrating birds therefore includes the counts of birds using the mudflats and in passing flocks. This survey has confirmed the great importance of the Penzhina River estuary for shorebirds during southward migration. In total almost 450 000 shorebirds of 30 species were counted. Most numerous were Dunlin (370 000), Red-necked Stint (63 000) and Red-necked Phalarope (11 000).

Introduction

Kamchatka is a large north-south oriented peninsula in Far East Russia, with a length of 1200 km. The peninsula is located on the migration routes of many shorebird species which breed in the Russian Far East and Alaska, and spend the non-breeding season from East Asia through South-east Asia to Australia and New Zealand. Active research on shorebird migration in Kamchatka commenced in the middle 1970s, becoming more intensive from 1989 onwards.
Observations of visible migration have been the main study method used during northward migration and involved daily counts of shorebirds passing the study area. In 1990-2003 we made nine such counts at eight different places in Kamchatka. Each of these counts was carried out over a 15-30 day period. The same type of counts were used during southward migration, but were combined with daily counts of feeding and resting shorebirds on mudflats, sand beaches and tundra. Places at which migration studies on Kamchatka have been conducted in recent years are shown in Figure 1.

The results of these observations have allowed the determination of migration routes, identification of the main staging areas and an estimation to be made of the numbers of the main migrants (Table 1; Gerasimov & Gerasimov in press.). These studies have formed the basis for a series of papers (Gerasimov 1991, 1998, 1999a, 1999b, 2001; Gerasimov & Gerasimov 1998, 2000; Gerasimov & Kalyagina, 1996; Gerasimov et al. 1998). However, there is still much to be found out, especially concerning southward migration.

The studies in 2002 and 2003 are part of the implementation of the Action Plan for the Conservation of Migratory Shorebirds in the East Asian-Australasian Flyway: 2001-2005 (Shorebird Working Group of Wetlands International. 2001).

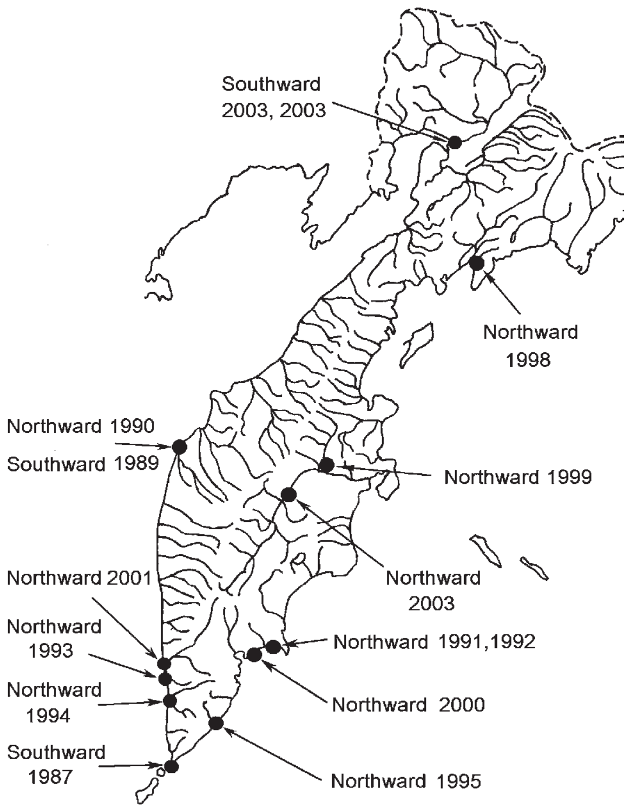

Figure 1. Main places of shorebird migration studies on Kamchatka. (Observations on Lopatka Cape were conducted by E. Lobkov (2003); other observations were carried out by the author).

Study area and methods

The Penzhina River is 713 km long and has a catchment area of 73,500 km^2; the Talovka River has a length 458 km and a catchment area of 24,100 sq. km. The rivers

Table 1. Approximate numbers of the main shorebird species arriving on Kamchatka and passing through the Peninsula during northward migration.

Species	West coast flyway	Central flyway	East coast flyway	All Kamchatka
Grey Plover	1000	–	1000	2000
Pacific Golden Plover	1000	500	500	2000
Lesser Sand Plover	2000	1000	2000	5000
Ruddy Turnstone	1000	–	2000	3000
Eurasian Oystercatcher	500	–	–	500
Wood Sandpiper	10000	10000	5000	25000
Common Greenshank	5000	5000	2000	12000
Red-necked Stint	100000	10000	10000	120000
Dunlin	150000	20000	30000	200000
Great Knot	40000	500	2000	42500
Red Knot	3000	–	–	3000
Eastern Curlew	1000	500	500	2000
Whimbrel	10000	–	2000	12000
Black-Tailed Godwit	5000	5000	1000	11000
Bar-tailed Godwit	5000	–	1000	6000

are covered in ice for about 200 days of the year (Surface Water Resources of the USSR 1973). The estuaries of the Penzhina and Talovka Rivers, as well as all the northern part of the Penzhina Gulf, have a very high tidal range (second greatest in the world). The maximum range is 14 m, with an average of 9 m. The high tidal range leads to vast mudflats at low tide.

The average annual temperature in Manily is -5.1° to -8.3°C. The minimum temperature measured is -2.4°C; and the maximum temperature is +28.1°C. Snow cover occurs between October 2-November 9. Snow melt occurs between May 3 and 31 (The Climate Directory of the USSR 1970, 1971).

Daily observations of the southward migration of shorebirds at the Penzhina River estuary, Kamchatka (Figure 2) were carried out over 61 days between July 12-August 10 2002 and August 11-September 10 2003.

We used two methods to study southward migration. On a daily basis, we carried out a five–six hour count of shorebirds on mudflats along a fixed ten km shoreline length (Figure 3). Additionally, we counted shorebirds flying past the study area. At night, estimates of migrating shorebird numbers were made based on the calls of birds flying past. The total daily estimate of migrating shorebirds includes the counts of birds on mudflats and those counted flying past.

We do not think that gross errors will occur due to summing the daily counts as observations showed that shorebirds generally remain at the Penzhina River estuary no more than one day, as suitable roosting places for species such as Dunlin and Red-necked Stint are absent during high tide. There are no beaches, and only areas of grassland remain uncovered by water during high tide. Furthermore, during migration large numbers of shorebirds fly over the mudflats without stopping and are not included in the mudflat count.

Sunny weather prevailed during our stay at the Penzhina River estuary. Most rain occurred on July 18–19, July 29 – August 1, August 21–22 and August 28–29. A very strong NE wind blew on August 24–25. The daily maximum temperature fluctuated from +11 to +23°C. The first night frost occurred on August 14. Smoke from a large fire on Chukotka affected visibility on August 11-20.

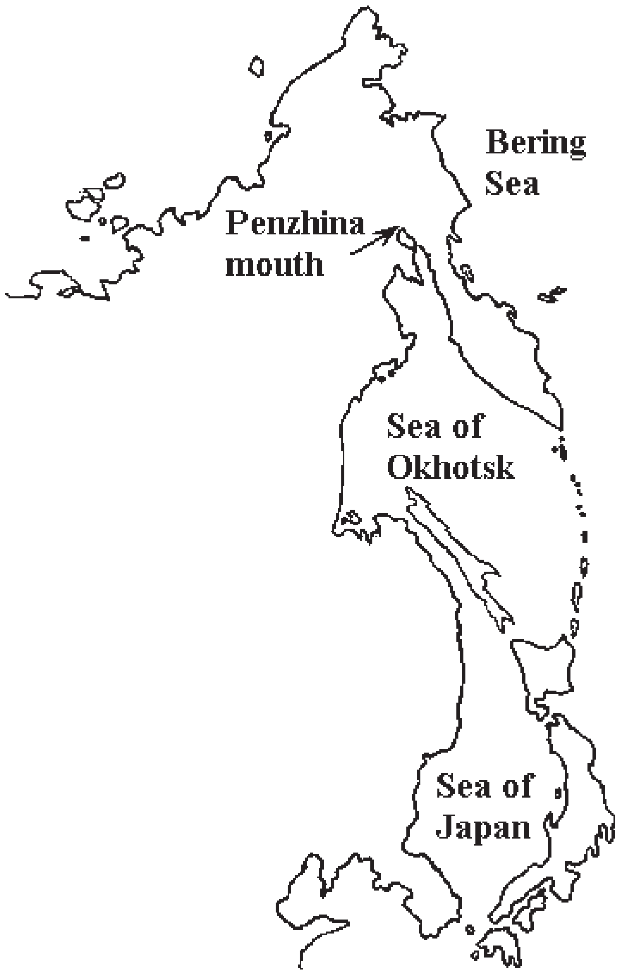

Figure 2. Location of survey area on a map of Far East Russia.

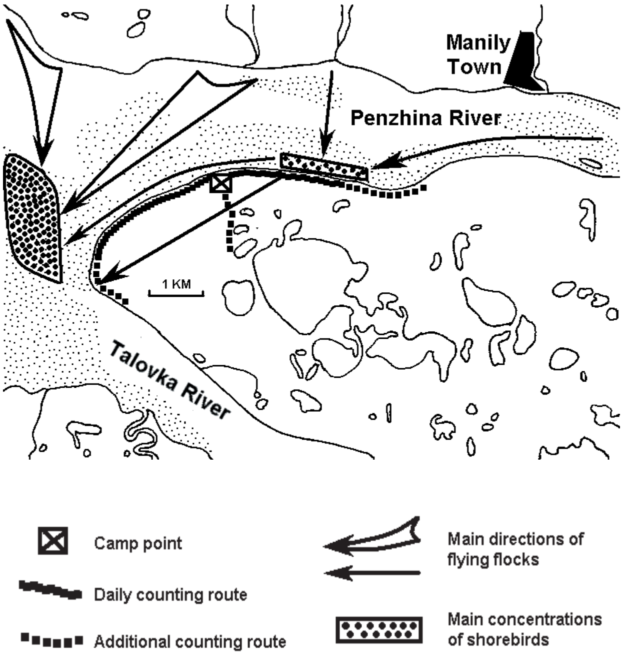

Figure 3. Map of the estuaries of the Penzhina and Talovka Rivers.

Results and discussion

A total of 447,438 shorebirds of 30 different species was observed during the two month survey in 2002 and 2003. The three most numerous species were Dunlin, Red-necked Stint and Red-necked Phalarope and they represented more than 99% of all shorebirds counted. The numbers counted of the different species in 2002 and 2003, together with their overall totals, are given in the Table 2.

Conservatively, it is believed that the total number of shorebirds migrating through the Penzhina region is between 500,000 and 1,000,000 individuals.

Our studies have shown the high importance of the Penzhina River estuary for shorebirds during southward migration. However, the number of Great Knots and Bar-tailed Godwits was unexpectedly low.

From August 29 – September 1, during a survey on one incoming tide on the opposite side of the Penzhina Gulf, between the Tylkhoy and Kuyul estuaries (62°23'N; 163°20'E – 100 km west of the Penzhina River estuary), about 60,000 small shorebirds (presumably Dunlin) were counted. Many flocks of other species were seen.

Notes on the individual species are given below.

Grey Plover *Pluvialis squatarola* is a late migrating species. The first bird appeared on July 20. During late July and August we saw only a few single birds and small flocks. Main migration began on September 6 and continued to the end of the study period (Figure 4). We saw single Grey Plovers and small flocks of up to five individuals. All closely observed individuals were either juveniles or adults which had completed body moult, in comparison to birds migrating at the end of July 2002 which still had breeding plumage. Migration of Grey Plovers almost certainly continued after we left, as in southern Kamchatka this species occurs until November.

Table 2. Summary of shorebird numbers counted in 2002 and 2003 at the Penzhina River estuary.

	Species	Number		
		2002	2003	TOTAL
1	Pacific Golden Plover	123	352	475
2	Grey Plover	13	72	85
3	Common Ringed Plover	45	10	55
4	Lesser Sand Plover	43	5	48
5	Eurasian Oystercatcher	1	–	1
6	Red-necked Phalarope	8,918	1,858	10,776
7	Grey Phalarope	2	–	2
8	Ruddy Turnstone	1	1	2
9	Dunlin	67,316	302,820	370,136
10	Long-toed Stint	15	3	18
11	Temminck's Stint	92	17	109
12	Red-necked Stint	60,964	1,810	62,774
13	Sharp-tailed Sandpiper	–	5	5
14	Sanderling	27	3	30
15	Red Knot	51	–	51
16	Great Knot	12	–	12
17	Spoon-billed Sandpiper	1	–	1
18	Ruff	10	12	22
19	Wood Sandpiper	1,131	129	1,260
20	Spotted Redshank	1	320	321
21	Common Greenshank	34	14	48
22	Grey-tailed Tattler	25	170	195
23	Wandering Tattler	1	–	1
24	Common Sandpiper	44	32	76
25	Terek Sandpiper	382	1	383
26	Long-billed Dowitcher	166	44	210
27	Bar-tailed Godwit	140	5	145
28	Eastern Curlew	8	11	19
29	Whimbrel	58	67	125
30	Common Snipe	3	50	53
	TOTALS	139,627	307,811	447,438

Pacific Golden Plover *Pluvialis fulva*. The first birds were recorded on July 23. Rather intensive migration took place from August 17 to September 7, except for two days with a very strong wind (August 24 and 25) when migration of all birds species ceased (Figure 5). Pacific Golden Plovers migrated as single birds or in small flocks of up to eight individuals. All closely observed birds were juveniles or adults which had completed body moult. The Pacific Golden Plover is a late migrant, similar to the Grey Plover. The last sighting on Karaginsky Island (370 km to the south) was October 22 (1970) (flock of 10 individuals); and for Petropavlovsk-Kamchatsky was November 13 (1965) and November 18 (1993) (unpubl. data).

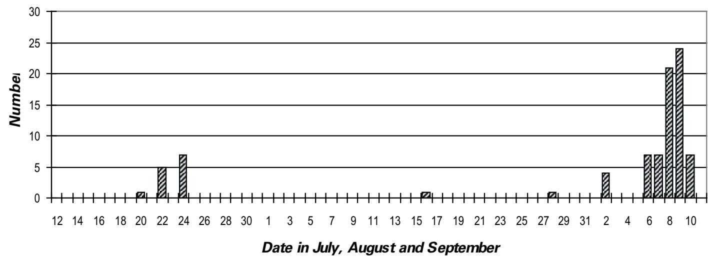

Figure 4. Combined daily counts in 2002 and 2003 of Grey Plover at the Penzhina River estuary

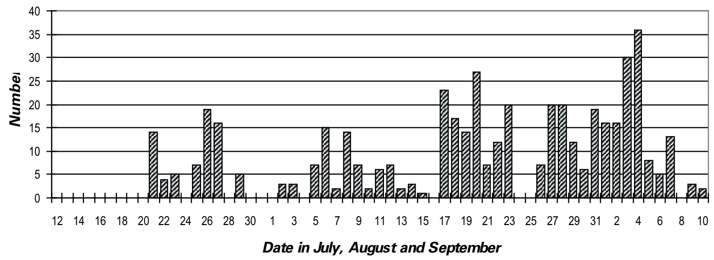

Figure 5. Combined daily counts in 2002 and 2003 of Pacific Golden Plover at the Penzhina River estuary.

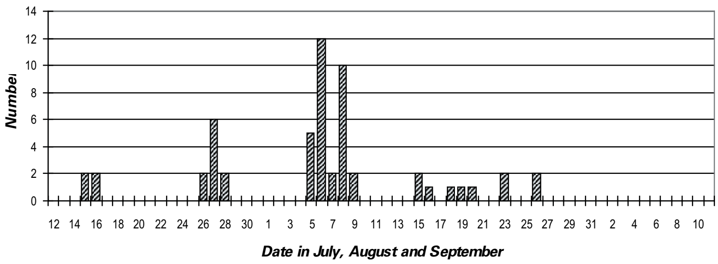

Figure 6. Combined daily counts in 2002 and 2003 of Common Ringed Plover at the Penzhina River estuary.

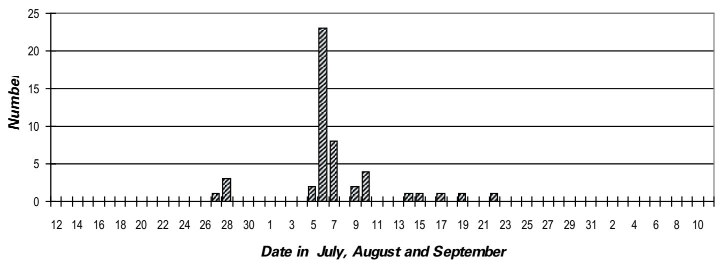

Figure 7. Combined daily counts in 2002 and 2003 of Lesser Sand Plover at the Penzhina River estuary.

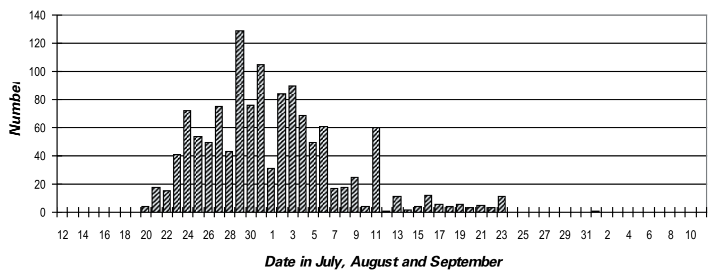

Figure 8. Combined daily counts in 2002 and 2003 of Wood Sandpiper at the Penzhina River estuary.

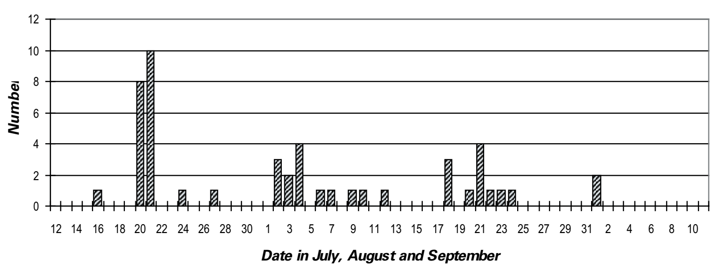

Figure 9. Combined daily counts in 2002 and 2003 of Common Greenshank at the Penzhina River estuary.

Common Ringed Plover *Charadrius hiaticula*. The first birds were seen on July 15, and the most migration took place from August 5-9 (Figure 6).

Lesser Sand Plover *Charadrius mongolus*. Migration started on July 27 (Figure 7). Most birds were observed feeding on the mudflats, often with Dunlin and Red-necked Stint.

Ruddy Turnstone *Arenaria interpres* was a rare species, with single birds seen on July 8 and August 20.

Eurasian Oystercatcher *Haematopus ostralegus* was rare. We saw one bird passing over the river to the southwest on July 28.

Wood Sandpiper *Tringa glareola* was common. This species migrates on a wide front and the total number passing through the Penzhina River estuary region is probably much higher than we recorded. Migration started on July 20 and finished by August 23, although a single bird was seen on September 1 (Figure 8).

Common Greenshank *Tringa nebularia*. Numbers were low and irregular (Figure 9). We saw mainly single flying birds and all passed without stopping.

Spotted Redshank *Tringa erythropus*. One single bird was seen on July 25, but it could have been a local breeder. The first migrating birds were seen on August 21. Active migration started on August 21 with a peak on August 23 (Figure 10). Some passing flocks (5, 3, 26, 84, 5 individuals) were seen in the morning. Following this we observed about 130 Spotted Redshanks on a 2 km long lake located about 2.5 km inland from the river. Some of these birds were feeding actively on mudflats amongst the *Phragmites australis (P.communis)*, but most were resting – obviously after migrating a long distance. We counted 35 birds on the same lake on August 26 after two days of very windy weather. After this we saw very few birds, with the final sighting being on September 3.

Grey-tailed Tattler *Tringa brevipes*. A total of 170 birds were counted. Migration started on July 20 and was more or less active from August 18 to September 4 (Figure 11). Some birds passed the study area at night, probably without stopping. Other birds stopped and fed on the shore edge. We saw single birds and small flocks up to five individuals.

Wandering Tattler *Heteroscelus incanus* was rare. We saw only one bird, on July 20.

Common Sandpiper *Actitis hypoleucos.* Migration took place from July 25 to August 23; peak numbers were counted on the last two days (Figure 12). Most birds was seen along the river shore between the camp and the river estuary. Common Sandpipers preferred to feed and rest at the border between wetlands and mudflats.

Terek Sandpiper *Xenus cinereus* was common. Migration took place from July 13 to August 10 and one single bird passed during the night of August 20 (Figure 13). Migration occurs on a broad front, similar to Wood Sandpiper, and the total number passing through the Penzhina River estuary region is probably at least 1000.

Grey Phalarope *Phalaropus fulicarius* was rare. We observed two adult birds in breeding plumage on the first day of our studies (July 12).

Red-necked Phalarope *Phalaropus lobatus* was numerous. Migration took place during almost the whole study period (Figure14). We believe that the number of Red-necked Phalaropes passing through the area was significantly higher than that counted, as we could not identify many small shorebirds on the 3 km distant mudflats located between the Penzhina and Talovka estuaries.

Ruff *Philomachus pugnax* mostly occurred as single birds, in some cases with Spotted Redshank.

Red-necked Stint *Calidris ruficollis* was numerous. We estimate that at least 100,000 Red-necked Stints migrated southward through the study area. This species breeds close to the Penzhina River. As flocks of non-breeding birds remain on the mudflats during the breeding season, it is difficult to determine when southward migration starts. Most active migration took place on July 24–28 (Figure 15). The last birds were seen on August 31.

Long-toed Stint *Calidris subminuta.* The number passing through the area is probably much higher as this species migrates during the night.

Temminck's Stint *Calidris temminckii.* The first bird was seen on July 21. Active migration took place from August 4-9 (Figure 16). The last birds were recorded on August 31. We saw single birds and flocks of up to ten individuals. Temminck's Stints fed on the mudflats but usually separately from other species, as they prefer the muddy slopes of creeks running into the river.

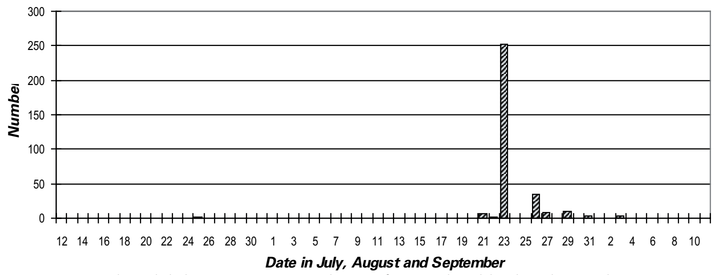

Figure 10. Combined daily counts in 2002 and 2003 of Spotted Redshank at the Penzhina River estuary

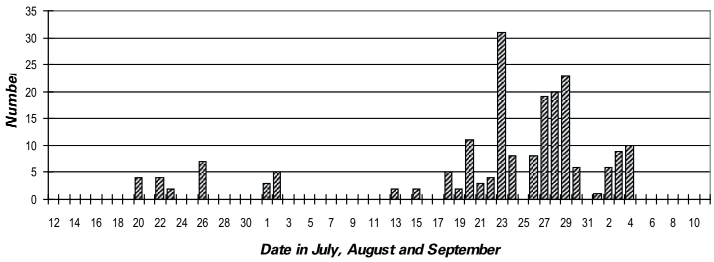

Figure 11. Combined daily counts in 2002 and 2003 of Grey-tailed Tattler at the Penzhina River estuary.

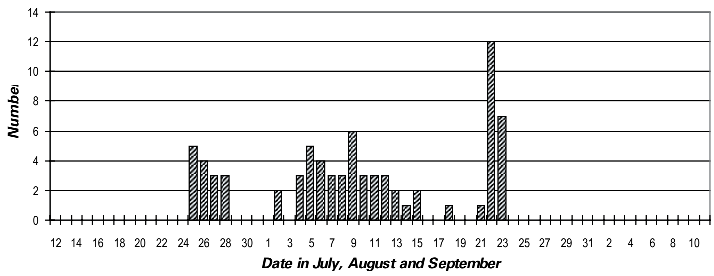

Figure 12. Combined daily counts in 2002 and 2003 of Common Sandpiper at the Penzhina River estuary.

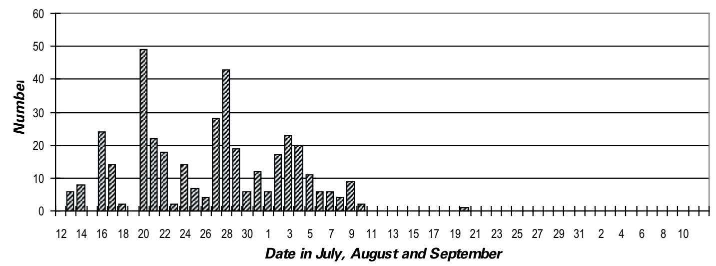

Figure 13. Combined daily counts in 2002 and 2003 of Terek Sandpiper at the Penzhina River estuary.

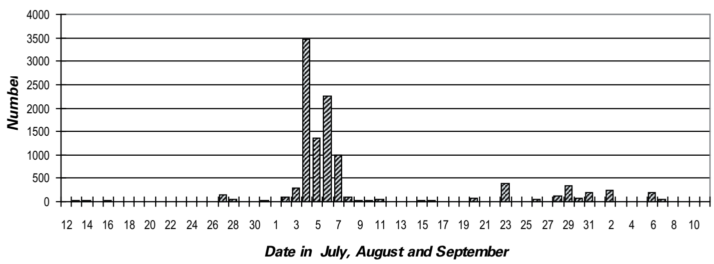

Figure 14. Combined daily counts in 2002 and 2003 of Red-necked Phalarope at the Penzhina River estuary.

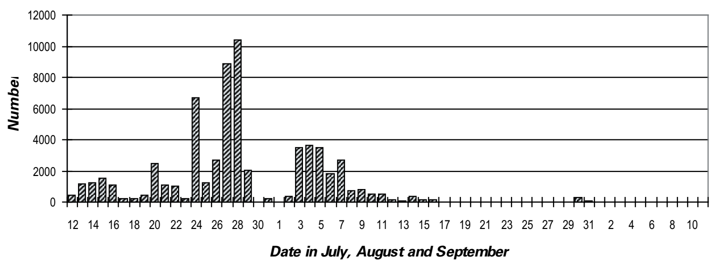

Figure 15. Combined daily counts in 2002 and 2003 of Red-necked Stint at the Penzhina River estuary.

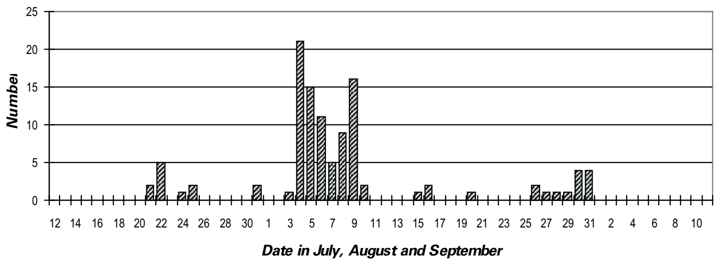

Figure 16. Combined daily counts in 2002 and 2003 of Temminck's Stint at the Penzhina River estuary.

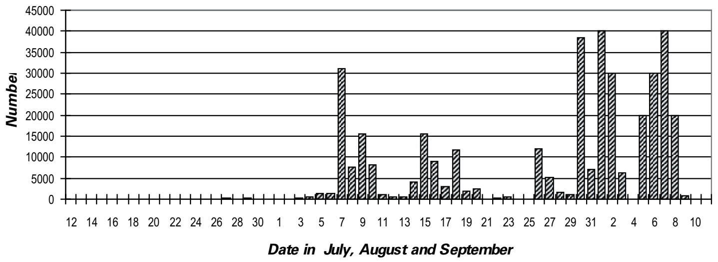

Figure 17. Combined daily counts in 2002 and 2003 of Dunlin at the Penzhina River estuary.

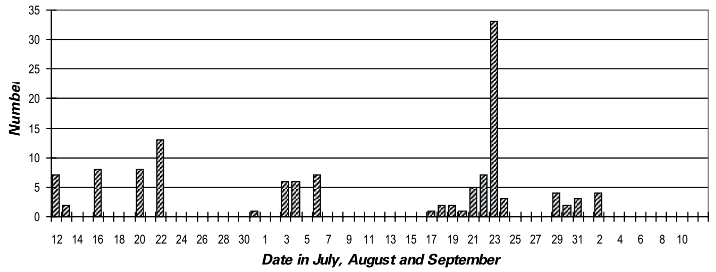

Figure 18. Combined daily counts in 2002 and 2003 of Whimbrel at the Penzhina River estuary.

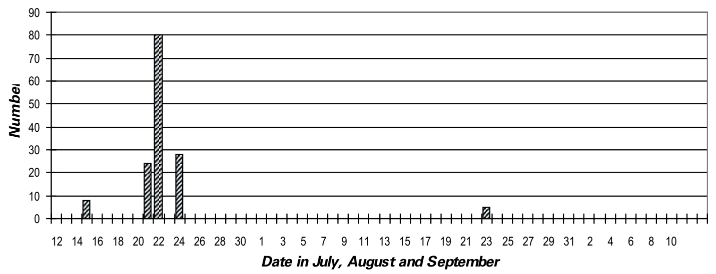

Figure 19. Combined daily counts in 2002 and 2003 of Bar-tailed Godwit at the Penzhina River estuary.

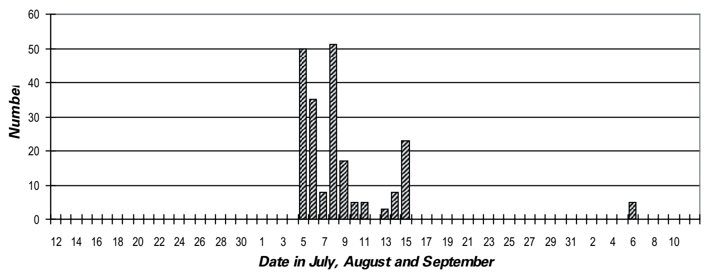

Figure 20. Combined daily counts in 2002 and 2003 of Long-billed Dowitchers at the Penzhina River estuary.

Dunlin *Calidris alpina* was the most numerous species. Dunlin migration was very small until August 4, increased from August 5–6 and then sharply on August 7. Four main migration waves took place: August 7-10, August 14-20, August 30-September 3 and September 5-8, with peak numbers on some days of up to 40,000 individuals (Figure 17). We believe that most birds arrived from the north and northeast directly over the mountains.

Great Knot *Calidris tenuirostris*. We counted many less birds than we expected as this region contains the closest mudflats to much of the breeding range of this species.

Red Knot *Calidris canutus*. The first birds were seen, in breeding plumage, on July 24. On August 3 we saw 3 flying birds in non-breeding plumage.

Sharp-tailed Sandpiper *Calidris acuminata* was rare. A late migrating species, with five birds counted between September 4 and 6.

Sanderling *Calidris alba*. Migration took place only at night.

Common Snipe *Gallinago gallinago*. We only counted a small number of birds, but believe that many more migrated through the area. We recorded Common Snipe at night (mainly 20.00-22.00). The periods of more active migration were August 20 to 23, 26 to 28, and September 2 to 6. We did not record Common Snipe after September 6.

Eastern Curlew *Numenius madagascariensis*. Migration took place from July 13 to August 23, with a maximum of seven birds on August 23. Even this small number was higher than expected, as we do not know of a breeding area to the north of the Penzhina Gulf.

Whimbrel *Numenius phaeopus*. Despite advice from the local people that migration finished by the end of July, we recorded Whimbrel until September 2, with a peak of 33 individuals on August 23 (Figure 18). Whimbrel migrated as single birds and in small flocks of up to five individuals.

Bar-tailed Godwit *Limosa lapponica*. We saw a passing flock of 8 individuals on July 15 and observed feeding Bar-tailed Godwit on mudflats at the Penzhina-Talovka confluence on August 21-24, with a maximum of 80 birds at one time (Figure 19). We also saw five birds on August 23 after an absence of 29 days.

Long-billed Dowitcher *Limnodromus scolopaceus*. This species was completely absent from the study area until it suddenly appeared in rather large numbers on August 5 (Figure 20). They were migrating from west to east, instead of to the south and west as with other species. Most migration had finished by August 15, but a flock of five birds was seen on September 6 after an absence of 21 days.

Shorebird predators

During our studies we frequently saw Parasitic Jaegers (Arctic Skua) *Stercorarius parasiticus* pursuing small shorebirds, mainly Wood Sandpipers. It seems that they have difficulty in catching Dunlin, but capture Wood Sandpipers more easily. Wood Sandpipers usually dived into long grass to avoid capture. Long-tailed Jaegers were rarer and departed the study area in early August. We did not see them attack shorebirds. During passerine migration, Merlin *Falco columbarius* are common; sometimes they try to catch small shorebirds unsuccessfully. We recorded Peregrine Falcon *Falco peregrinus* repeatedly, but always at high altitude and newer saw them attack shorebirds. However, this species, as well as the Gyrfalcon *Falco rusticolis* which breeds in North Kamchatka, could attack larger shorebirds.

In 2003, we saw hunting Short-eared Owls *Asio flammeus* every day. This species can only predate chicks and non-flying juvenile shorebirds. Also some mammalian predators in this region could catch juvenile shorebirds before they fly: Brown Bear *Ursus arctos*; Polar Wolf *Canus lupus*, Red Fox *Vulpes vulpes*, Wolverine *Gulo gulo*, Least weasel *Mustela nivalis*, Ermine *Mustela erminea* and Mink *Mustela vison*.

Threats

There are no significant threats to shorebirds in the study area. Except for Whimbrel, shorebirds in Kamchatka are traditionally not popular targets for hunters; even Whimbrel are not commonly taken, as ducks and geese are quite numerous.

Habitat loss and pollution problems are low because of the small human population, lack of industrial development and absence of oil drilling and exploration.

Acknowledgements

We are very grateful to the Australian Department of Environment and Heritage for providing the funding for the surveys. Our special thanks go to the Koryak Autonomous Area Hunting Management Service which helped us greatly with our work in northern Kamchatka. Particular thanks go to V.L. Krapivyansky and V.L. Borovskoy.

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The need to identify critical sites in the Flyway

The Spoon-billed Sandpiper on The Edge: A Review of Breeding Distribution, Population Estimates and Plans for Conservation Research in Russia.

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Abstract

The Spoon-billed Sandpiper is one of the rarest waders in the world. This stenochoric species, endemic of East Asia, has always attracted ornithologists' attention due to its charismatic appearance. However, no special efforts have been ever made specifically for its preservation. The species biology has been almost unknown, except for the set of studies at the breeding sites by A. Ya. Kondratyev (1974, 1982) and P. S. Tomkovich (Tomkovich, 1991; 1994, 1995) and some occasional observations in non-breeding grounds. Until the end of the 20th century the species was considered rare, but with a stable population (BirdLife International, 2001).

The studies started by the expedition of the Institute of Ecology and Evolution of Russian Academy of Sciences in 2000, showed, as early as the first season, that Spoon-billed Sandpiper populations were in decline. It turned out that the species breeds much more sporadically than it had been realised. Most populations with enough data to serve as a basis for monitoring have demonstrated a negative trend (Tomkovich et al., 2002). Taking that into account we started a special long-term project to investigate the present status of the Spoon-billed Sandpiper in its breeding areas. The project was continued in 2001 - 2003 and is planned to continue in the future. These studies revealed population decreases in many sites, but important new breeding areas of the species were also found (Syroechkovski, Jr. et al., in prep).

In this paper we present a review of the new data obtained in the breeding areas in 2000 - 2003, analyse the gaps in our knowledge on the species in its breeding areas, and discuss perspectives of the efforts aimed at preservation of the species in general.

Methods

Field studies were carried out at various areas of the breeding range within Chukotka Autonomous Region boundaries in 2000 - 2003 (Figure. 1). In the areas where breeding was known before, we thoroughly surveyed the sites of the former findings during the incubation or brood raising period. In localities potentially suitable for species breeding, we surveyed landscapes similar to those that are used by the species for breeding in other areas. The methods are described in more detail in our publications (Tomkovich et al., 2002; Syroechkovski, Jr. et al., in press).

Large-scale aerial surveys of the Chukotka coasts were also performed in late July 2002. They covered about 40% of the potential breeding range of the species (Figure. 1). While flying in a light airplane (An-3) at 50 m altitude, with the help of GPS we recorded all areas visually suitable for breeding, familiar to us from land observations.

Our estimation of the probable number of breeding pairs in different areas of the breeding range was based on:
1) the sum of our knowledge of the breeding habitats used by this stenochoric species (they are: certain types of spits near lagoons, some parts of the deltas of small rivers and streams in the southern sector of the range, and areas of moraine massifs adjacent to the spits, etc.);
2) known breeding densities of the species for different sectors of the range;
3) our assessment of the area of potential habitats for the species in different parts of its range, based on aerial observations and topographic maps at 1:100 000 scale.

In the present publication we divided the entire potential breeding range into segments and made educated estimate of breeding pair numbers within each segment. Also, the extent of ornithological knowledge of the breeding range segments was evaluated (Figure. 2). We selected the segments considering similarity of the landscapes used by Spoon-billed Sandpipers and the extent of ornithological knowledge on the coasts. The sizes of selected coast segments do not exceed 300 km of the coast line. The exception comprises the poorest known portion of the breeding range, on Kamchatka. There the areas suitable for breeding interspersed with predominantly rocky coasts so the total length of the coast line included in that particular segment is greater. We excluded the coast portions totally unsuitable for Spoon-billed Sandpipers from our estimates.

Results

The Spoon-billed Sandpiper's breeding range comprises, according to our estimation, a discontinuous 4500-km line stretching along the coasts of the Chukchy and Bering Seas. Birds breed in the tundra adjacent to maritime lagoons; maritime spits are the traditional habitat for the species. These habitats are described in more detail elsewhere (Tomkovich et al., 2002; Tomkovich, 1994). We found a new type of Spoon-billed Sandpiper breeding habitat during our studies in the southern portion of its range.

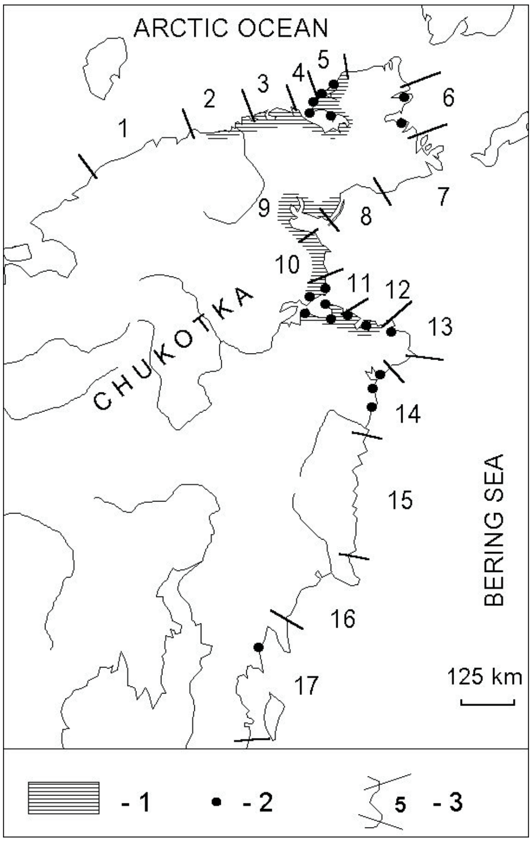

Figure 1. 1 - area covered by aerial surveys
2 - our study sites on land
3 - segment numbers and range

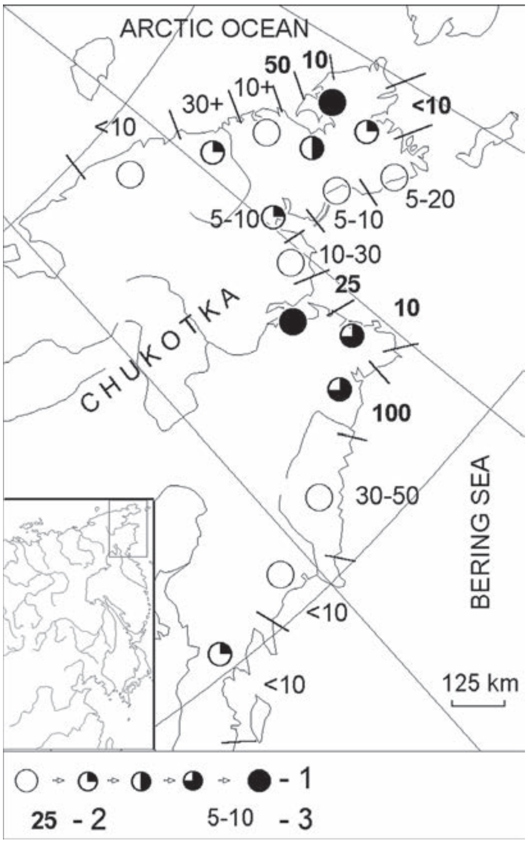

Figure 2. 1 - coverage of segments by land surveys in late 20th century: from 0 (open circle) to 100% (black circle)
2 - numbers of breeding pairs confirmed in 2000-03
3 - estimate of breeding pairs for each segment

New type of the Spoon-billed Sandpiper breeding habitat.

During surveys of the hilly tundra sites adjacent to spits, we found Spoon-billed Sandpiper broods and later also their nests, located in landscapes that earlier were not considered suitable breeding habitats for the species (Tomkovich, 1994; BirdLife International, 2001). These were slopes and inter-ridge depressions of the large massifs of lateral moraine planes, up to 100 m high, subsequently flattened by marine transgressions. Such landscapes are quite widespread in the coastal areas adjacent to the Koryak Mountains, as remains left after the glaciations 12-24 thousand years ago. We found nests as far as five to seven km from the sea coasts and saline lagoons. The majority of nests of this species were previously found at 100 - 500 m distance from the sea coast (Tomkovich, 1994), however, one record was known at a distance of 5-6 km from the sea in the lower Khatyrka valley (Kistchinski 1980). Spoon-billed Sandpipers use such landscapes around Kaynupilgen Lagoon (63°24'N; 178 °54'E), where three broods were found in 2000 (Tomkovich et al., 2002), and in several moraine massifs near Meinopilgeno village, where a total of 6 nests, 3 broods and also 4 territorial pairs were found. More detailed analysis, with the help of satellite images, of the use of such habitats will be the theme of a separate publication.

The present state of the breeding range inventory.

We performed and published in part the inventory of all known breeding records of the Spoon-billed Sandpiper for the two key portions of the northern and southern Chukotka coasts (Tomkovich et al., 2002; Syroechkovski, Jr. et al., in prep). However, these portions cover only 35-45% of the potential breeding range of the species.

In describing the records of breeding sites within different segments, we avoided repetition of our data published previously in a detailed inventory of the species breeding areas on southern Chukotka (Tomkovich et al., 2002) and in Koluchin Bay surroundings (Syroechkovski, Jr. et al., in prep). Detailed references are given only for the new findings and also for some records not listed in the above mentioned publications.

Segment 1.

Lagoons near Billings up to Shmidt Cape. It is the northernmost area of a potential range, where breeding Spoon-billed Sandpipers have never been found. However, considering very poor ornithological knowledge of the area, and the presence of landscapes potentially suitable for Spoon-billed Sandpiper breeding, we include this segment in the potential range. An estimation of the population is 0 – 10 pairs.

Segment 2.

From Cape Shmidt to Amguema River mouth (Ekvyvatap River delta, Tynkyrgynpilkhen Lagoon). The main part of the area has hardly ever been surveyed by ornithologists. At least 3 territorial pairs were found in the western corner of this area in late June 1990 (Stishov, Maryukhnich, 1992). An aerial survey in 2002 covered 80% of the area and revealed a diversity of promising sites for Spoon-billed Sandpiper breeding at the outer spit of Tynkyrgynpilkhen Lagoon, especially in its north-western sector. Some portions of deltas of the rivers flowing into the lagoon are possibly also used by Spoonbills for breeding. An estimation of the population is 30 - 40 pairs.

Segment 3.

Portion of Vankarem lowland, between Ukouge and Penopilgyn Lagoons (western outskirts of Kolyuchin Bay). The ornithological survey of the area was fragmentary, and no ornithological studies on land had been conducted there since 1970. Spoon-billed Sandpiper breeding in low densities was known at three different spits (Kistchinski, 1988). Aerial counts in 2002 covered 100% of the area and revealed promising sites on the coasts of most lagoons. An estimation of the population is 20 - 30 pairs.

Segment 4.

Kolyuchin Bay. It was considered to be the most promising area for Spoon-billed Sandpiper breeding before our survey in 2002. In 2002 Spoon-billed numbers were 22-24 pairs in the most favourable sites for the species, at Belyaka Spit and Yuzhny Island, and had decreased by 60% in comparison with numbers in 1986-1988 (Tomkovich, Soloviev, 2000). Having surveyed about 40% of the bay coasts we counted only 4 Spoon-billed Sandpiper nests and potential territories. Considering possible losses to predators and the necessity of a more thorough survey, we estimate the species population presently inhabiting the bay coasts as 50 pairs or less.

Segment 5.

Lagoons from Cape Dzhenretlen to Enurmino village. Prior to our study, they had been surveyed by ornithologists incompletely and sporadically. Spoon-billed Sandpiper breeding in the vicinity of Enurmino had been repeatedly confirmed before (Syroechkovski, Jr. et al., in prep). A quite thorough ground survey of 80% of the area in 2002 revealed only 8 pairs, so we estimate the total numbers there as 10 - 15 pairs.

Steep slopes, unsuitable for the species, prevail along the lengthy portion of the coast from Cape Serdtse-Kamen to Lavrentiya Bay. Breeding Spoon-billed Sandpipers were not found at well-surveyed lagoons near Inchoun and Uelen (Tomkovich and Sorokin, 1983).

Segment 6.

Maritime lowlands of Mechigmenskaya Bay and southwards to Yanrakynnot. In 2000 a team from our expedition surveyed a part of Mechigmenskaya Bay coast and found one Spoon-billed Sandpiper brood. One nest was earlier found at Getlyangen Lagoon (Konyukhov and Zubakin, 1988). More than half of the suitable habitats have never been surveyed by ornithologists. Since the total number of suitable sites is not high, we estimate the total number of Spoon-billed Sandpipers in this area as not above 10 pairs.

Segment 7.

Coasts from Senyavina Strait to Bering Cape. These are rocky coasts with numerous small lagoons, spits and deltas. Small breeding groups of Spoon-billed Sandpipers have been found there since the late 19th century (Portenko, 1972). Breeding is confirmed for the three sites: Kivak Lagoon, Provideniya Bay and Plover Spit (Tomkovich and Sorokin, 1983; Portenko, 1972), in the latter site also in 1993 (Dorogoi, 1997). An estimation of the population is 15 - 20 breeding pairs.

Segment 8.

Flat coasts from Bering Cape to the western edge of Meechkyn Spit. The area has hardly ever been surveyed by ornithologists, and breeding of the species has not been recorded there, but the existence of suitable spits allows the possibility of 5 – 10 Spoon-billed Sandpiper pairs breeding there.

Segment 9.

Kresta Bay coasts. There are few suitable breeding sites for the species on the rocky coasts. However, 4 nests were found at one bay during the survey in the early 1970s (Kistchinski, 1988). Since then the species numbers in this area have declined (Dorogoi, 1997). Other parts of the coast have not been surveyed. An estimation of the present population is 15 - 20 pairs.

Segment 10.

Vast lagoons in Uelkal vicinities, near the entrance to Kresta Bay. Aerial surveys there in 2002 showed the existence of quite promising sites for the species, visually very similar with those at Kolyuchin Bay spits. An estimation of the population is 20 - 30 pairs.

Segment 11.

The coast of Anadyr Lagoon. One of the best known portions of the breeding range. We thoroughly surveyed it in 2000, when our inventory revealed 18 breeding pairs (Tomkovich et al., 2002). We cannot rule out the possibility that 3 - 5 pairs of the species could remain unrecorded in the low reaches of small rivers on the northern coast of the lagoon and in the vicinity of the Avtotkuul River mouth. An estimation of the population is 27 – 32 pairs.

Segment 12.

Tymna, Kaynupilgen, Yuzhnaya Lagoons. About a half of the potential habitats of the species were covered by ground surveys in 2000. 4 broods were recorded (Tomkovich et al., 2002). All lagoons hold non-surveyed sites potentially suitable for Spoon-billed Sandpipers, revealed during the aerial survey in 2002. An estimation of the population is 10 - 15 pairs.

Segment 13.

Lagoons in the north-eastern corner of the Koryak Highlands up to Navarin Cape to the south. Lakhtina Lagoon was well surveyed; no birds were seen there in July 2000 (Tomkovich et al., 2002) and 2 Spoon-billed Sandpiper pairs were found by us in 2001. We did not find Spoon-billed Sandpipers at the spit at Gavriila Bay. Several more small lagoons remain unsurveyed. Probably 5 – 10 pairs inhabit the area.

Segment 14.

Meinopilgeno lakes and rivers network and Khatyrka Lagoon. The largest of the presently known breeding grounds of the species. In 2003, 68 pairs were recorded in surveyed areas of Meinopilgeno spits, and 3 more pairs at Kaypilgen Lake in 2001 (observations by A.V. Kondratyev). Considering possible gaps in counts and non-surveyed massifs of moraine hills, we estimate the numbers on these breeding grounds as 100 - 120 pairs.

Segment 15.

The coasts from Mellen Lagoon to Olyutorskiy Cape. From there and further south, Spoon-billed Sandpipers inhabit Koryak Autonomous Region, but ornithological ground surveys have never been carried out there. An estimation of the numbers is based on map inventory of 21 potential breeding sites with small areas in river mouths and not less than 10 adjacent moraine massifs. An estimation of the population is 80 - 100 or more pairs.

Segment 16.

Olyutorskiy Bay coasts, from Olyutorskiy Cape to Goven Cape. There Spoon-billed Sandpiper breeding has been recorded only once before (Kistchinski, 1980). However, there have been few ornithological surveys, so some pairs could still be around. There are few potentially suitable breeding sites, habitats are probably unfavourable and small in area. Possibly, 0 - 10 pairs of the species inhabit this segment.

Segment 17.

The coastal lagoons at the Kamchatka Peninsula, including the coasts of Korf Bay and the northern part of Karaginskiy Bay, southwards up to 58° 40' N. Breeding of the species southwards on the Kamchatka coast is unlikely. At about that location, the spring flocks of migrating Spoon-billed Sandpipers cross the Kamchatka Peninsula from the Sea of Okhotsk, travelling from west to east. (Ju. Gerasimov, personal communication). In general, that is the edge of the breeding range, where only two breeding sites are known: Korf Lagoon and Kayum Lagoon (Kistchinski, 1988; Gerasimov and Vyatkin, 1973). In the vicinity of Korf no Spoon-billed Sandpipers were found in 2002 (Gerasimov 2003). An estimate of the possible numbers in this area is most difficult. Potential breeding sites are quite numerous there (19), since the coast abounds in lagoons and spits. Besides that, most of them have never been visited by ornithologists with the aim of finding breeding Spoon-billed Sandpipers. So it is impossible to assess how completely they might be inhabited by the species on the edge of its range. Possible numbers of Spoon-billed Sandpiper breeding pairs in the area can be estimated at 5 - 50.

An attempt to estimate the total numbers of the species.

Detailed studies of the breeding population at Belyaka Spit (Koluchin Bay) showed that even during a stationary nest search, conducted by counting displaying males in spring, at least 20% of nests remained unfound. They were found later during spring counts, mapping of nests and extra broods and records of previously colour-marked birds. Spring counts in pre-breeding period (checking of suitable habitat for birds) can reveal most birds with the least effort. However, comparisons of figures showed that spring counts underestimate the real population at 14-28%, mean 22% (Tomkovich and Soloviev, 2000). Most of our surveys in 2000 - 2002 were thorough but short-term, so the likelihood of gaps in our counts was higher than on stationary studies at Belyaka Spit. According to different data, egg losses due to various causes, by the end of the incubation period may comprise 49-82% (Tomkovich, 1995; our data). Taking that into account, our brood counts in July were also not complete, since we obviously missed a considerable number of pairs that started breeding but lost their clutches to predators. In estimating the total numbers of pairs in the areas that our expedition surveyed in 2000 -2003, we consider the systematic error to be 30%, and we have included this factor in our counts on land. Summarising our estimates for different segments of the breeding range provides an overall total for the species within the breeding range of 402 - 572 pairs, or 804 - 1144 birds. Taking into account the non-breeding portion of birds and multiplying it by a factor 1.5, (as it is suggested in Wetlands International, 2002), we get a total Spoon-billed Sandpiper population estimate of 1206 – 1716 birds.

Possible threats to the Spoon-billed Sandpiper in its breeding areas.

The reasons for the decline of the population of this species are still unknown. It is highly probable that activities threaten them outside the limits of the breeding range, at stopovers in East Asia and on wintering grounds on the coasts between Hindustan and South China. This is supported by the numerous data on development projects affecting about 50% of the inter-tidal zone of the Yellow Sea (Barter, 2002), high anthropogenic pressure on remaining mudflats, and continued hunting of all wader species in various countries of South East Asia. Although we need to conduct further investigations for a more informed discussion on threatening processes in the non-breeding range of the Spoon-billed Sandpiper, we do have some data on threatening processes at the breeding areas.

In our publication (Tomkovich, et al., 2002) we briefly mentioned possible factors affecting the population decline in the breeding areas. At first we did pay much attention to possible human effect (Tomkovich, et al., 2002) but with the collection of new data, we gradually revised our attitude to this problem. Though the human population of Chukotka is small, almost 90% of it (about 100 000 people), is concentrated on the seacoast. 75% of the populated sites (20 settlements and over 50 summer fishing camps) are located within the potential breeding range of the Spoon-billed Sandpiper. Most of them are situated on spits, in close proximity to potential Spoon-billed Sandpiper breeding sites. Considering the species is stenochoric, a constant human presence at Spoon-billed Sandpiper breeding sites is a common factor on seemingly uninhabited Chukotka. Taking into account our observations in the recent years, we list the following main negative anthropogenic factors:

1) Habitat degradation: construction of buildings and roads on spits and pollution of breeding sites;
   Potential impacts on Spoon-billed Sandpipers near settlements are from local activities such as hunting, fishing and recreational activities and by children when eggs and nests could be trampled. However, a more serious impact may be from frequent disturbance by people resulting in birds deserting their nests or young as well as an increased incidence of predation of unprotected nests.

3) The effect of unleashed dogs kept in settlements. In summer these dogs feed only on what they get by themselves, including clutches of eggs and young birds. In summer from 20 to 50 dogs search for food in the vicinities of almost every Chukotka settlement or fishing camp.

In the four years of our study we witnessed at least one case of mortality of a Spoon-billed Sandpiper nest or brood due to each of above-mentioned reasons, but quantitative data of this kind has been accumulating over a long time. The observation in Meinopilgeno clearly demonstrated the effect of a settlement on the breeding success of Spoon-billed Sandpipers in the vicinity. In summer 2003, of 6 depredated and deserted nests, 4 were within 2 km of the village or along a busy road constantly used by people and dogs, whereas the mortality of clutches in areas remote from human habitation was considerably lower. The high human pressure is also obvious in the surroundings of Beringovskiy, Egvekinot, Neshkan, at the 10th moorage of Anadyr city, hydro-station Russkaya Koshka, and some others.

Increasing Arctic Fox predation could become a factor affecting the survival of nests in the northern portion of the range. The increase of Arctic Fox numbers in the mid-1990s might be linked to people. From the middle of the 20th century until to the mid-1990s, the seacoast populations of the Arctic Fox were under high pressure from trapping by indigenous hunters.

In the Chukotka, Provideniye, Iultin, and Shmidt districts (the main areas where the breeding range of Spoon-billed Sandpipers and the summer range of the Arctic Fox overlap) the hunting bag for Arctic Foxes comprised, (including illegal hunting), 2200 to 8100 animals per year for the period from 1933 to 1988 (the data from the Chukotka Autonomous District State Archive, provided by K. B. Klokov). After "perestroyka" the price for Arctic Fox furs sharply decreased and Arctic Fox hunting became unprofitable. At present only 100 - 300 Arctic Foxes per year are hunted throughout the same area. The main pressure of Arctic Fox trapping was always concentrated on the seacoasts, where up to 80% of animals were trapped. Maritime spits of the Chukotka Peninsula were divided into hunting territories. Thus, local Arctic Fox populations inhabiting maritime plains of Chukotka, existed under high hunting pressure, and then, within 4 - 5 years, this pressure decreased almost to zero. Though no special investigation was conducted, it is quite possible that local Arctic Fox populations sharply increased, which could have resulted in increasing predation pressure on birds, and so contribute to the decline of the species population. It would be possible to clarify this with targeted studies.

Discussion.

Confidence of the numbers estimate.

Wintering grounds and key stopovers of Spoon-billed Sandpipers are still known only in a very general way. For the past 15 years neither a methodical inventory nor monitoring of the previously known concentrations has been conducted. Breeding grounds are the only areas that allow estimation of the total numbers of the species. The facts that the species is stenochoric, and it has a restricted range and high breeding site fidelity is very helpful for estimating breeding populations (Tomkovich, 1995).

The estimates of numbers we present in the present paper are approximate and do not pretend to be highly accurate. However, they are based on knowledge obtained on the biology of the species and its distribution, and our extensive field experience. A more accurate estimate of the total numbers of the species is possible only with a complete survey of all potentially suitable breeding areas within a quite extensive range. That will take not less than 5 years of active studies. The data of our extrapolation can be made more precise with decoding of satellite Landsat and Aster images. This work is already in progress but it will also take much time. Considering all above mentioned, we think we can use our estimate as a basis for the estimate of the species population at the present stage of our knowledge on the Spoon-billed Sandpiper.

Limiting factors.

Low breeding success of the species (on average 0.31-0.95 fledged young per 1 breeding pair) from all eggs laid (Tomkovich, 1998) on Belyaka Spit for 3 study years suggests, that even a small decrease in juvenile survival can result in gradual negative trend in the population. Young birds are the most vulnerable at the breeding sites, where about 50% of young die before fledging. If the mortality of clutches and pre-fledged broods of Spoon-billed Sandpipers in the Arctic has increased for the past 10 - 15 years for the reasons mentioned above and others still unknown, then one of the key reasons for a decrease of the Spoon-billed Sandpiper population becomes clear. However, it can be confirmed only by long-term studies; for the time being we do not have enough data. A general population decline can be also related to increased mortality of adult birds. According to our observations, the mortality of adult birds in the breeding areas is very low. However, it can increase in non-breeding areas, in relation to the disappearance of key habitats on migration in China or Korea, or high pressure from local hunters along the migratory routes. Investigations on wintering grounds will help to verify this. Monitoring of individually marked (by colour flags) birds can yield the best evidence, but in the breeding areas, not on migratory routes or wintering grounds. High breeding site fidelity of the Spoon-billed Sandpiper suggests that all or almost all birds usually return to their last-year breeding sites, and the data obtained during the studies in late 1980s can be taken as the starting point for comparison of the adult survival dynamics.

To answer these questions we consider that it is necessary to do the following research during the coming years:

1) To continue monitoring individually marked populations in the key breeding areas of Spoon-billed Sandpiper on Chukotka for 3 - 4 years. The best way to carry out such studies is to conduct monitoring of the northern and southern sub-populations at the same time.
2) To continue the inventory within the limits of the species breeding range, defining the total numbers of the species and revealing key areas for preservation.
3) To conduct genetic population studies for revealing the extent of genetic difference between breeding populations.
4) To carry out investigations on the population dynamics of the Arctic Fox and other predators in the northern portion of the Spoon-billed Sandpiper's breeding range.
5) To arrange an effective public awareness campaign on the species' preservation in its breeding areas and to establish the measures providing real protection to the species' breeding habitats.

6) To start the investigation of the possible reasons for population decline of the species on wintering grounds and at stopover sites.

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Movements of Red Knot between Australia and New Zealand

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Abstract

We review banding and leg-flag records of movements of Red Knot between Australia and New Zealand. Most of the 42 band recoveries and 406 leg-flag sightings made in New Zealand are of birds caught in Victoria. The age-proportion at capture (42% juveniles in Victoria, 5% in New Zealand) indicates that most first-year birds settle in southeast Australia. Over half the birds recaptured in New Zealand were banded as 1 or 2-year olds, indicating that after spending the first year in Australia these young birds cross the Tasman Sea to New Zealand. Some adults also pass through Victoria en route to New Zealand. Leg-flag records and recaptures of five birds reveal movement from Western Australia to New Zealand. Two of these were sub-adult birds caught in August in northwest Australia and the following January in New Zealand. Once the sub-adult birds settle in New Zealand they are thought to return directly to New Zealand after breeding. This probably represents the largest age-related population shift in the waders of the East Asian-Australasian Flyway.

Introduction

Red Knot (*Calidris canutus*) breed in the high Arctic of North America, Asia and Greenland and migrate to coasts of Europe, the southern USA and southern hemisphere landmasses (Piersma & Davidson 1992). Worldwide six subspecies of Red Knot are recognized: *canutus, rogersi, roselaari*, *islandica*, *rufa* and *piersmai*. (Tomkovich 1992, 2001). Two subspecies are now thought to breed and migrate within the East Asian-Australasian Flyway (EAAF). *Piersmai* is a newly described subspecies (Tomkovich 2001) that breeds on the New Siberian Islands and parts of Yakutia; *rogersi* breeds on the Chukotka Peninsula, but the precise geographical distribution of the breeding grounds is yet to be determined. During the non-breeding season these two subspecies are exclusively coastal, and found mainly in Australasia. *Rogersi* is believed to be the dominant subspecies in east Australia and New Zealand and *piersmai* is believed to occur in northwest Australia (NWA). It is possible that small numbers of *C. c. piersmai* also reach southeast Australia and New Zealand, as birds flagged in NWA have been seen in both regions.

Banding of Red Knot has been undertaken in Australasia since the mid-1970s with thousands of birds banded in Australia (primarily Victoria, northwest Australia and Queensland, with small numbers at other sites) and New Zealand. Since 1990, coloured leg-flags have been fitted to many birds. The use of these highly visible leg flags has greatly increased the international 'recovery' rate of waders banded along the EAAF. For Red Knots, however, movements along the flyway are still relatively poorly known (Riegen 1999). An interesting phenomenon that has become increasingly apparent with the advent of leg flagging is extensive movement of knots from Australia to New Zealand.

In this paper we aim to:
(1) Summarise evidence from banding and leg flagging for movement of knots from Australia to New Zealand
(2) Summarise evidence from banding and leg flagging for movement of knots from New Zealand to Australia

We have used all band and leg flag records we are aware of (obtained from Wader Study Group databases) up to the time of writing (unless stated otherwise). New flag sightings continue to come in daily but could not be incorporated.

Methods

Birds are caught in daylight using cannon nets at high tide roost sites and mist nets at night, generally erected over mudflats close to night-time roost sites. All birds have a single metal leg band attached stamped with a unique number/letter code and most birds also have one or two colour leg flags attached. These are made of DARVIC (uPVC) and are shaped like a band but with the addition of a small protruding tag. The flag/s enables the origin of an individual bird to be determined without the need to catch it. A colour flag protocol has been established on the EAAF with colour combinations allocated to different countries or regions. To date Red Knot have been flagged at the following locations

North Island New Zealand	White
Victoria	Orange
Southeast Queensland	Green
Northwest Australia	Yellow
Southwest Australia	Yellow/Orange
Chongming Dao – China	White/Black
South Korea	White/Orange
Hokkaido – Japan Blue	Blue

Birds are aged as Juvenile (juv) - used for birds with identifiable juv body plumage or wing coverts and fresh primaries. Applicable from first arrivals in Sept/Oct until end Nov.

1 - a bird in its first year (until July 31st). Identifiable by remaining juv wing coverts, newish primaries at the start of the period and worn primaries at the end, partial or sometimes complete primary moult but much later than in adults, always some secondaries or tail feathers retained un-moulted, and little or no breeding plumage on the under parts in the 1st winter. Used from December to July 31st.

2 - Second year. Generally only identifiable in the August to October period at the beginning of the 2nd year. Identified by presence of either very good primaries (changed in the 1st year), or very old primaries (juv feathers not changed in the 1st year), or both. Some retained very old juv secondaries or tail feathers usually present. In the 2nd year many, perhaps most, 2s remain in the non-breeding areas in winter. Most gain large amounts of breeding plumage. Their feathers show slight wear, much more so than on a 1 at this time. All secondaries and tail feathers are also new.

2+ - "Adults ". Birds which are in their second year or older, precise age not known. This terminology is often incorrectly thought to mean "more than 2 years old". Birds are definitely not juvs or 1s. They may however be 2s. Used for adults whenever 2s cannot be identified with certainty -usually from October onwards.

3 - Third year. Not often identifiable, Can be used on some birds early in the 3rd year (August to October) where primary wear and body plumage differ from those of returning adults.

3+ - True adults. Birds in their third year or older. In early part of year are moulting out of breeding plumage and just commencing conventional wing moult. Go back into breeding plumage in Feb/April following year after completing primary moult. However at that time are not always definitely separable from 2s and therefore 2+ generally used then. So 3+ use is mainly confined to Aug/Oct period.

Results

Movements from Australia to New Zealand

Band recoveries

Table 1 shows the total number of Red Knot banded and flagged in Australia and New Zealand to 31 December 2003. Since 1979, when wader banding began in New Zealand, 42 Red Knot banded in Australia have been recovered in New Zealand (detailed in Appendix 1). The New Zealand Wader Study Group (NZWSG) recaptured 39 and three were recovered dead in the Auckland region. They were banded in the following locations, and are discussed below.

Victoria (VIC)	30
Southeast Queensland (SQLD)	5
Southwest Australia (SWA)	3
Northwest Australia (NWA)	2
Northern Territory (NT)	1
New South Wales (NSW)	1

From Victoria

The greatest movement of Red Knot across the Tasman has been those from Victoria. Twenty-seven individuals have been recaptured and three recovered dead.

From southeast Queensland

Five birds banded at Moreton Bay in southeast Queensland have been recaptured in New Zealand; all but one was banded during southward migration. 051-91407 was recaptured in New Zealand 49 days after banding in Moreton Bay. 051-31296 and 051-56717 were banded on the same date in October 1990 and were recaptured together in March 1993. These had presumably been part of a flock movement. 051-56741 was a juvenile when banded and was recaptured in New Zealand one year and eight months later, indicating it had not returned to the arctic breeding grounds prior to arriving in New Zealand. Moreton Bay is a known area for Red Knot and is on a direct flight path between the Gulf of Carpentaria, another major Red Knot staging site (Watkins 1993), and New Zealand.

From southwest Western Australia

Of the knot banded in southwest Australia there have been two birds recaptured and one bird recovered dead in New Zealand. 051-28849 and 051-28862 were recaptured 16 months after banding in July (breeding season), indicating they probably moved from southwest Australia to New Zealand without having returned to the arctic breeding grounds. The route taken is unclear but likely to be via southern Australia and Victoria. One southwest Australian bird has been recaptured in Victoria.

From northwest Western Australia

Two individuals have been recovered from catches in northwest Australia. Both were part of an over wintering flock at 80-Mile Beach in August 1998. This flock was known to have departed before new birds from the Arctic arrived that season (Minton unpubl. data). Both were caught in New Zealand five months later. Recent evidence indicates that some Red Knot, Curlew Sandpiper and Red-necked Stints make a partial northward migration within Australia in their first year, even moving 3,000km from SEA to NWA. Therefore quite a lot of the birds in NWA in the winter (May-August) may not be birds which were in that location during the preceding summer.

Table 1. Total number of Red Knot banded and flagged in Australia and New Zealand to 31 December 2003

Banding/flagging location	Banded	Flagged
North Island NZ	5470	1751
NWA	4919	2884
VIC	3928	2733
SA	900	0
QLD	320	258
NT	271	0
NSW	217	0
Other WA	213	1
TAS	8	0

We now have recent evidence to support the view that even immature NZ Red Knot can go as far as Broome for the winter (5000 km), with an Albany (SWA)-banded bird, seen in NI NZ in March 2004, subsequently turning up in Broome in July 2004. There is also an earlier July sighting of a white-flagged Red Knot in Broome.

It is possible that the principal source of birds flagged in NWA and subsequently seen in New Zealand relate to birds of the eastern Australia and New Zealand race, which have passed through NWA (the western extremity of their migration path) on southward migration. A secondary reason could be that some immature birds from the east go as far as NWA on a partial migration for the winter and then get caught in NWA before they return to the east.

From Northern Territory

Only one catch of Red Knot has been made in the Northern Territory, during southward migration in September 1995. One recovery resulted from this: 051-80879 was recovered in New Zealand in October 1996. As this is the sole Northern Territory recapture, it is difficult to say whether this is a regular migration route for New Zealand bound birds.

From New South Wales

There has been just one bird recovered from New South Wales, in 1991. However, only small numbers of Red Knot have been banded there and none for several years.

Ages of birds recovered in New Zealand

Around half of the knots recovered in New Zealand were banded as first or second-year birds in Australia (Table 2). Of particular interest are three first-year birds, 052-22581, 052-22584 and 052-03937. These were all banded at Corner Inlet on 25.06.01 and were still together 13 months later when recaptured at Miranda, Firth of Thames on 14.07.02. This predominance of young birds moving to New Zealand from Australia, especially from Victoria, reflects the age-structure in southeast Australia. Table 3 compares the age at capture of all knots caught in Victoria and New Zealand, and shows clearly that the majority of young knots stop in Australia rather than continuing to New Zealand. Seven Victorian birds were recaptured in New Zealand within 12 months of banding.

Flag re-sightings

By 31 December 2003 there had been at least 624 Red Knot flag sighting reports in New Zealand (including New Zealand-flagged birds) (Table 4), and more arrive daily! Birds have been seen in all months, though most records are from the southern summer (the non-breeding season). Of the overseas flagged birds, more than 75% were Victorian, which have been recorded at 40 sites around New Zealand, from the Far North (Parengarenga Harbour) to the southernmost parts of the South Island (Awarua Bay, Southland) and even as far east as the Chatham Islands (850 km east of Christchurch) (Figure 1). The 40 sites include most sites at which the species regularly occurs. Combining the sites that are close together reduces that number to 24 general locations. By comparison, white flags (New Zealand-flagged birds) have been recorded at just 24 sites (13 general locations). Only six of these sites (and 24 records) were away from the banding regions.

Table 2. Age when banded of Australian birds recovered in New Zealand.

Age (years)	Number	Percent of total
1	18	42.8
1+	5	11.9
2	4	9.5
2+	7	16.7
3	1	2.4
3+	7	16.7

Table 3. Ages of Red Knot caught in Victoria (VIC) and New Zealand (NZ), and percentage of 1 year birds caught at each site. Also percentage 1 & 2 years combined. Data to Dec 2003. Note: many banded as 2s are done so just at the beginning of their 2nd year. The large number of unaged 1+ in New Zealand is due to 'ringing and flinging' in large catches; most of these birds were 3+. All 1-year birds were fully processed in these catches.

Age >>		1	1+	2	2+	3	3+	Total	% of 1 years	% 1 & 2 years
Overall	VIC	2150	94	580	784	0	758	4366	49.2%	62.5%
Totals	**NZ**	**273**	**1452**	**718**	**24**	**28**	**2975**	**5470**	**4.9%**	**18.1%**

Table 4. Summary of the total number of flag sightings of Red Knots made in New Zealand and Victoria, Australia.

		Number of sightings	
Flagging location	Flag colour	New Zealand	Victoria
NZ	white	178	1
Vic	orange	340	
SE Qld	green	25	3
NWA	yellow	69	
N Japan	blue	5	
China[1]	white/black	3	
S Korea	white/orange	4	
Total		**624**	**4**

[1]Chongming Dao, Yangtze River

Table 5. Flag sightings within Australia to April 2003.

	Sighting location							
Flagging location	QLD	NSW	NT	WA	SA	VIC	TAS	TOTAL
VIC	87	10	2	23	15	1	1	139
QLD		2						2
NWA	2	14		2		5	2	25
NZ	16	1		1		1		19
TOTAL	**105**	**27**	**2**	**26**	**15**	**7**	**3**	**185**

Movements from New Zealand to Australia

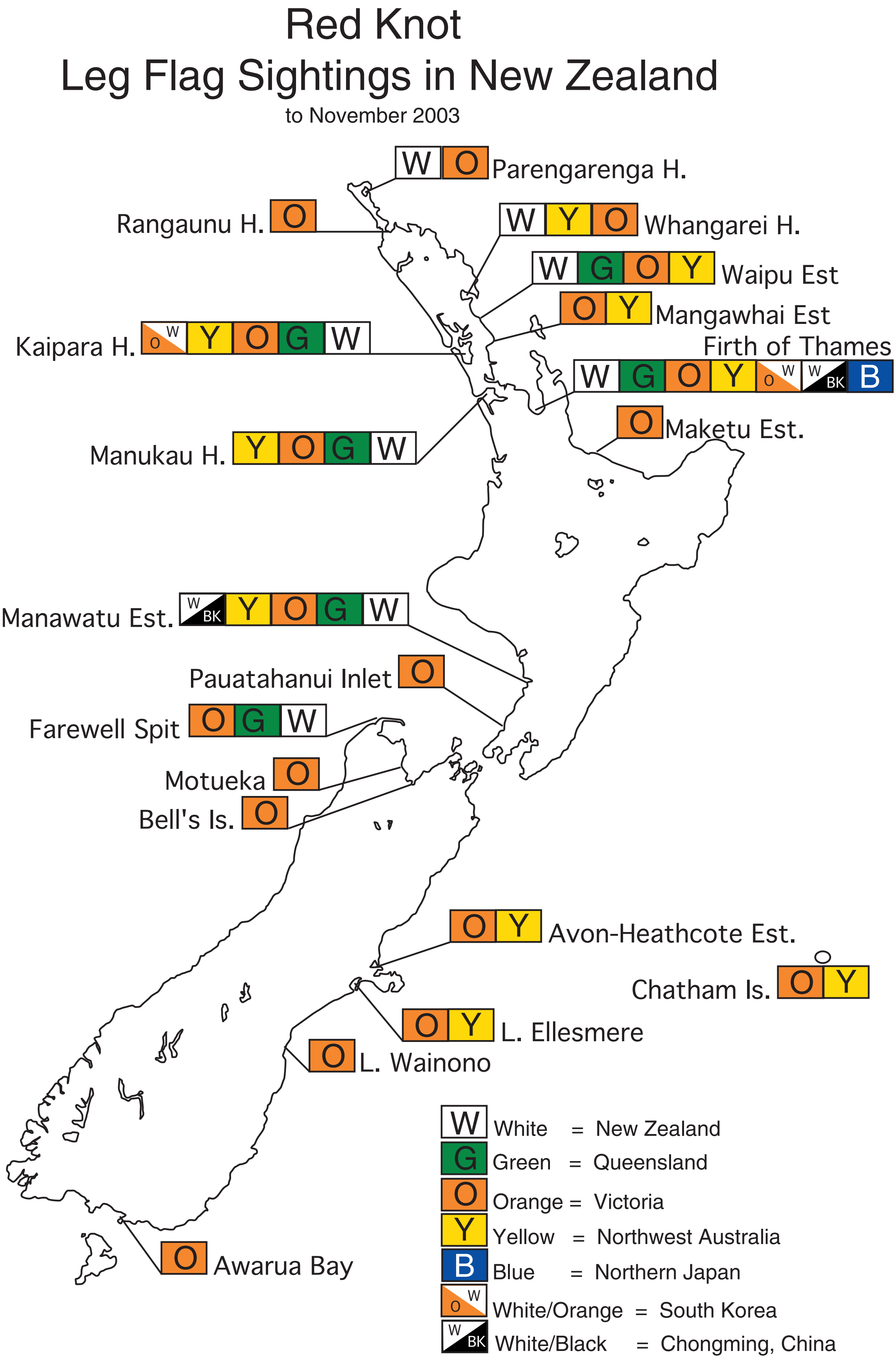
Band records

In contrast to the large number of Australian-banded Red Knot being recovered in New Zealand there are only five recoveries of New Zealand-banded knots in Australia (Appendix 2). Of these five recoveries, four have been during southward migration, two in Victoria and two in Queensland, and these individuals may well have continued to New Zealand. There has been only one recovery of a bird on northward migration, an individual found dead near Maryborough in Queensland on 31.03.81.

Flag records

An even larger disparity exists in the flag sightings between New Zealand and Australia. Only 19 sightings of New Zealand-flagged knots have been made in Australia and there is just a single sighting in Victoria (Tables 4 and 5). Thirteen of these sightings were from southeast Queensland and all occurred between September 1st and October 7th during the peak southward migration period. The other Australian sightings include one in September from NSW, one from Victoria in October, one from northwest Australia in July and three sightings, one of which was of four birds near Karumba in the Gulf of Carpentaria, in April. The

Figure 1


Red Knot
Leg Flag Sightings in New Zealand
to November 2003
W O Parengarenga H.
Rangaunu H. O
W Y O Whangarei H.
W G O Y Waipu Est
O Y Mangawhai Est
Kaipara H. O W Y O G W
Firth of Thames
W G O Y O W W BK B
O Maketu Est.
Manukau H. Y O G W
Manawatu Est. W BK Y O G W
Pauatahanui Inlet O
Farewell Spit O G W
Motueka O
Bell's Is. O
O Y Avon-Heathcote Est.
Chatham Is. O Y
O Y L. Ellesmere
O L. Wainono
O Awarua Bay
W White = New Zealand
G Green = Queensland
O Orange = Victoria
Y Yellow = Northwest Australia
B Blue = Northern Japan
O W White/Orange = South Korea
W BK White/Black = Chongming, China

Gulf of Carpentaria holds thousands of Red Knots during northward migration in March and April (Driscoll 2001) and the region is probably an important staging site for New Zealand Red Knots.

Discussion

Movements from Australia to New Zealand

Substantial evidence from both band recoveries and flag sightings indicates that many Red Knots do not settle immediately in New Zealand, but spend their first year or more in Australia. In addition to the 42 band recoveries or recaptures, there are at least 434 (and counting) flag re-sightings of Australian-flagged knots in New Zealand. Most of these records relate to Victorian birds, which is expected given the State's proximity to New Zealand and the large amount of wader catching that has gone on there over the years. The data presented here also show that there is some movement between the west coast of Australia and New Zealand (even as far as the Chatham Islands to the east of New Zealand), a link not recognised or suspected prior to 1991 when leg-flagging first commenced. Quantifying the frequency of these movements will be difficult.

A comparison of the age-proportion at banding of knots caught in Victoria and New Zealand (Table 3) reveals a disproportionately high juvenile component in the Victorian population. This indicates that most first-year knots at the eastern edge of the EAAF stop in southeast Australia rather than crossing the Tasman. Many knots, predominantly those banded as young birds in Australia (Table 2), subsequently make this shift to New Zealand. This movement of young birds to New Zealand is clearly not a random event but a significant aspect of the Red Knot life cycle. This shift in the population between non-breeding sites is almost certainly the biggest of any wader species on the East Asian-Australasian Flyway.

Victoria also appears to be a regular staging area for adult Red Knots on southward migration to New Zealand. Seven adult birds (aged 3+) banded in Victoria, have been recaptured in New Zealand. All of these birds were banded during southward migration (Oct/Nov) and six of them were recaptured in New Zealand within four months. These seven birds are the only recoveries in New Zealand of birds banded in Australia as adults. The low number of New Zealand-banded knots recaptured in Victoria indicates however, that it is not a major migration route, and it appears that generally once young birds have reached New Zealand the majority return in subsequent years directly to New Zealand, probably by way of the Gulf of Carpentaria and Moreton Bay in Queensland.

While band records provide the 'hardest' data on movements between sites (with individual identity allowing maximum travel times), detailed flag records can provide supplementary information. For example, flag sightings in the Auckland region may help determine the possible travel time of the birds 051-90657 and 051-90907 from northwest Australia to New Zealand. The last yellow-flag sighting at Miranda in the 1997-98 summer was on 19.10.97 (although one was seen 50 km away at Karaka, Manukau Harbour, until 28.02.98). The next sighting in New Zealand was at Miranda eight months later on 17.10.98 when a single yellow-flagged bird was seen, just two months after the 80-Mile Beach bandings. There were three sightings of a single bird on the Manukau Harbour during Nov/Dec 98. Assuming the bird seen on 17.10.98 was part of a flock movement of those 80 Mile Beach birds, which is highly likely given the small number of yellow flags seen in the Auckland region, then the travel time was a little under two months. The route used by Red Knot between from northwest Australia and New Zealand is not known.

Flags are also proving invaluable for getting a better picture of the relative size of the movements, but they can also be rather misleading, as individual birds will be reported numerous times at well-watched areas. For instance, while there have been 69 sighting records of yellow-flagged Red Knot in New Zealand, this does not mean 69 individual birds were present. Nevertheless, in 2001-2002, at least eight individual birds from northwest Australia could be identified. For Victorian birds the numbers in New Zealand are large in absolute terms. On one day in April 2003 at least 25 orange flags were seen in a flock of 1200 knot at Tapora, Kaipara Harbour, and in August 2003 22 orange-flagged Red Knot were seen in a non-breeding flock at Karaka, Manukau Harbour.

This raises the important question of how much an absence of flag records reflects effort rather than bird absence. The flagging programme does not record flag sighting effort. However, in New Zealand all colours are counted and recorded, including white even at the flagging sites. As white flags are likely to be seen at these sites on most visits, this at least gives some indication of the effort being made. Table 4 reveals a monumental difference in the number of flag sighting records in Victoria and New Zealand. Does this mean there are no Red Knot moving through Victoria from other banding sites or is it just that they don't occur in observable or accessible locations? Similarly the low number of flag sightings from the largely inaccessible Gulf of Carpentaria is due not to the lack of Red Knot but the lack of observers. For the flagging programme to be really meaningful, more effort must be made at major wader sites along the flyway. New Zealand is lucky in that it has many major wader roost sites readily accessible and close to large population centres, along with a band of active wader watchers and flagophiles. At least 1100 flag sighting reports of Bar-tailed Godwit (*Limosa lapponica*), Red Knot and Turnstone (*Arenaria interpres)* have been made in New Zealand, far more than any other country on the flyway. A good number of sightings in the Brisbane, Queensland, area is also due to a band of active observers working the roost sites in that region.

The number of flag sightings reported obviously also reflects the size of the pool of marked birds (Table 5). High numbers have been flagged in NWA, so if there were regular and sizeable movements to eastern Australia and New Zealand, higher numbers of sightings could be expected. The fact that they are not seen is strong evidence that the two populations generally do not mix. Because differences in morphology between *piersmai* and *rogersi* are small, it is not clear whether movements from Western Australia to New Zealand indicate that some *piersmai* move to the eastern part of Australasia, or that some *rogersi* drift westward on their first southward migration.

It is a curious result that more orange than white flags are seen in New Zealand, despite white being New Zealand's own code, and also that orange flags are seen much more widely around New Zealand (figure 1) than white flags are. There are two possible reasons why orange flags are seen at more New Zealand sites than white flags. Large numbers of Red Knots are banded in Victoria as 1-2 year olds. These birds are more likely to wander in their second year in search of a suitable non-breeding site, whereas adults caught around Auckland are likely to be more site-faithful. Secondly, orange flags are more visible against the white belly feathers than white flags and are therefore more likely to be seen.

Why so many young Red Knot cross the Tasman Sea to New Zealand from Victoria or why they fly first to Victoria instead of New Zealand is unknown. Distance may be a factor for young birds. If they are staging in the Gulf of Carpentaria on southward migration, then the flight to Victoria from the Gulf is approximately 2500 km whereas to northern New Zealand it is around 4000 km.

Acknowledgments

We are very grateful to the volunteers who make up the various wader study groups in Australia and New Zealand; without their considerable efforts, the early mornings and discomforts they suffer, none of this data would be available and we would know considerably less about these birds. A special thanks also to all those flagophiles who tirelessly search the flocks for flags, with particular thanks to Tony Habraken and Gwen Pulham who have submitted hundreds of flag sightings from New Zealand. Gillian Vaughan and Phil Battley's critical review and considerable assistance with the paper was invaluable.

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Appendix 1. Red Knot recaptures and recoveries in New Zealand to 31 December 2003

From Victoria

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
061-31435	Werribee, Aust	38 00S	144 30E	27.01.79	1	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	02.03.80		Miranda Banders	Caught/released	2613	1y 2m
051-02342	Queenscliff	38 15S	144 40E	31.10.82	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	23.02.89		Miranda Banders	Caught/released	2613	6y 4m
051-16176	Queenscliff	38 15S	144 40E	03.06.84	1	VWSG			
	S. Manukau Harbour	37 05S	174 50E	19.05.85		A. Riegen	Dead - Shot	2652	0y 11m
051-16166	Queenscliff	38 15S	144 40E	03.06.84	1	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	28.02.87		Miranda Banders	Caught/released	2613	2y 8m
051-18305	Queenscliff	38 15S	144 40E	19.10.85	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	28.02.87		Miranda Banders	Caught/released	2613	1y 4m
051-15386	Queenscliff	38 15S	144 40E	08.11.86	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	28.02.87		Miranda Banders	Caught/released	2613	0y 3m
051-15251	Queenscliff	38 15S	144 40E	08.11.86	Juv	VWSG			
C-45327	Jordan's-Kaipara	36 30S	174 20E	23.02.89		Miranda Banders	Caught/released	2613	2y 3m
	Miranda FoT	37 10S	175 10E	03.11.90		Miranda Banders	Caught/released	105	1y 9m
051-15556	Queenscliff	38 15S	144 40E	01.10.88	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	23.02.89		Miranda Banders	Caught/released	2613	0y 4m
051-42655	Yallock Creek	38 13S	145 28E	12.01.91	1	VWSG			
	Taramaire FoT	37 09S	175 20E	04.07.92		Miranda Banders	Caught/released	2617	1y 6m
051-42981	Stockyard Point	38 22S	145 32E	11.08.91	2	VWSG			
	Taramaire FoT	37 09S	175 20E	04.07.92		Miranda Banders	Caught/released	2610	1y 5m
051-53018	Stockyard Point	38 22S	145 32E	11.08.91	2	VWSG			
	Taramaire FoT	37 09S	175 20E	04.07.92		Miranda Banders	Caught/released	2610	1y 5m
051-15420	Queenscliff	38 15S	144 40E	01.10.88	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	23.02.89		NZWSG	Caught/released	2624	0y 4m
051-59681	Stockyard Point	38 22S	145 32E	04.07.92	1	VWSG			
	Taramaire FoT	37 09S	175 20E	18.12.93		NZWSG	Caught/released	2610	1y 5m
051-15348	Werribee, Aust	38 00S	144 30E	18.01.87	1	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	18.12.94		N75ZWSG	Caught/released	2613	7y 11m
051-42994	Stockyard Point	38 22S	145 32E	11.08.91	2	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	22.12.91		NZWSG	Caught/released	2547	0y 4m
051-08762	Stockyard Point	38 22S	145 32E	24.07.83	1	VWSG			
C-54301	Taramaire FoT	37 09S	175 20E	20.10.96		NZWSG	Caught/released	2610	13y 2m
051-08574	Queenscliff	38 15S	144 40E	05.04.81	1t	VWSG			
C-54303	Taramaire FoT	37 09S	175 20E	20.10.96		NZWSG	Caught/released	2687	15y 6m
051-60302	Queenscliff	38 15S	144 40E	18.10.97	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	29.11.97		NZWSG	Caught/released	2687	0y 1m
051-60350	Queenscliff	38 15S	144 40E	18.10.97	3+	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	29.11.97		NZWSG	Caught/released	2687	0y 1m
051-40690	Stockyard Point	38 22S	145 32E	14.01.96	1	VWSG			
	Jordan's-Kaipara	36 30S	174 20E	29.11.97		NZWSG	Caught/released	2610	1y10m
051-60579	Queenscliff	38 15S	144 40E	18.10.97	2+	VWSG			
	Taramaire FoT	37 09S	175 20E	06.01.99		NZWSG	Caught/released	2687	1y 2m
052-02888	Swan Is, Queenscliff	38 15S	144 40E	27.01.00	2+	VWSG			
	Karaka-Manukau	37 05S	174 50E	24.02.01	Ad	NZWSG	Caught/released	2650	1y 1m
052-02911	Swan Is, Queenscliff	38 15S	144 40E	27.01.00	1	VWSG			
	Kaiaua-FOT	37 07S	175 10E	00.03.01		Anon	Found dead	2687	1y 1m
051-94000	Corner Inlet VIC	38 42S	145 23E	14.07.98	1	VWSG			
	Auckland Airport	37 01S	174 48E	30.03.02		Airport Staff	Bird Strike	2490	3y 8m
052-22581	Corner Inlet VIC	38 42S	145 23E	25.06.01	1	VWSG			
	Taramaire FoT	37 09S	175 18E	14.07.02		NZWSG	Caught/released	2495	1y 1m
052-22584	Corner Inlet VIC	38 42S	145 23E	25.06.01	1	VWSG			
	Taramaire FoT	37 09S	175 18E	14.07.02		NZWSG	Caught/released	2495	1y 1m
052-03937	Corner Inlet VIC	38 42S	145 23E	24.06.01	1	VWSG			
	Taramaire FoT	37 09S	175 18E	14.07.02		NZWSG	Caught/released	2495	1y 1m
052-03943	Corner Inlet VIC	38 41S	146 50E	24.06.01	1	VWSG			
	Karaka-Manukau	37 05S	174 50E	01.02.03		NZWSG	Caught/released	2452	1y 7m
052-02982	Swan Is Queenscliff	38 15S	144 40E	27.01.00	1+	VWSG			
	Karaka-Manukau	37 05S	174 50E	01.02.03		NZWSG	Caught/released	2645	3y 0m
052-22908	Western Port Bay VIC	38 16S	145 18E	20.01.02	1	VWSG			
	Taramaire FoT	37 09S	175 18E	22.02.03		NZWSG	Caught/released	2632	1y 1m

From Southeast Queensland

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
051-56741	Moreton Bay QLD	27 22S	153 09E	17.11.90	Juv	P. Driscoll			
C-46153	Taramaire FoT	37 09S	175 20E	04.07.92		Miranda Banders	Caught/released	2342	1y 8m
	Access Bay FoT	37 10S	175 19E	20.10.96		NZWSG	Caught/released	0	4y 3m
051-31296	Brisbane River QLD	27 22S	153 10E	21.10.90	2+	QWSG			
	Jordan's-Kaipara	36 30S	174 20E	07.03.93		NZWSG	Caught/released	2245	2y 5m
051-56717	Brisbane River QLD	27 22S	153 10E	21.10.90	2+	QWSG			
	Jordan's-Kaipara	36 30S	174 20E	07.03.93		NZWSG	Caught/released	2245	2y 5m
051-56795	Nudgee Beach QLD	27 20S	153 05E	03.05.93	1+	QWSG			
C-54304	Taramaire FoT	37 09S	175 20E	20.10.96		NZWSG	Caught/released	2352	3y 5m
051-91407	Nudgee Beach QLD	27 20S	153 05E	01.09.96	1+	QWSG			
C-54302	Taramaire FoT	37 09S	175 20E	20.10.96	2	NZWSG	Caught/released	2352	0y 1m

From Southwest Australia

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
050-10307	Pelican Pt Perth	31 50S	115 40E	30.10.73	1+	B. Lane			
	Okaro B - Kaipara	36 30S	174 20E	20.03.76		B.S. Cooksay	Found Dead	5330	2y 5m
051-28849	Albany	35 05S	117 53E	16.03.91	2+	V. Smith			
	Taramaire FoT	37 09S	175 20E	04.07.92		Miranda Banders	Caught/released	5082	1y 4m
051-28862	Albany	35 05S	117 53E	16.03.91	2+	V. Smith			
	Taramaire FoT	37 09S	175 20E	04.07.92		Miranda Banders	Caught/released	5082	1y 4m

From Northwest Australia

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
051-90657	80 Mile Beach	19 00S	121 00E	09.08.98	3	AWSG			
	Taramaire FoT	37 09S	175 20E	06.01.99		NZWSG	Caught/released	5470	0y 5m
051-90907	80 Mile Beach	19 00S	121 00E	21.08.98	2	AWSG			
	Taramaire FoT	37 09S	175 20E	06.01.99		NZWSG	Caught/released	5470	0y 5m

From Northern Territory

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
051-80879	Finniss River	12 53S	13019E	14.09.95	2+	R.E. Chatto			
C-49980	Jordan's-Kaipara	36 30S	174 20E	26.10.96		NZWSG	Caught/released	5100	1y 1m

From New South Wales

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
051-48030	Kooragang Is NSW	32 52S	151 46E	04.12.88	1+	J.W. Hardy			
	Jordan's-Kaipara	36 30S	174 20E	22.12.91		NZWSG	Caught/released	2106	3y 0m

Appendix 2. Red Knot banded in New Zealand and recaptured or recovered in Australia

To Southeast Queensland

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
C-31629	Miranda, FoT	37 10S	175 20E	17.08.80	3+	Miranda Banders			
	Maryborough	25 30S	152 40E	31.03.81		Sutton	Hit Lighthouse	2491	0y 7m
C-45552	Miranda FoT	37 10S	175 20E	03.11.90	3+	Miranda Banders			
	Nudgee Bch, Brisbane	27 20S	153 05E	04.09.93		QWSG	Caught/released	2260	2y 10m
C-31444	Jordan's-Kaipara	36 30S	174 20E	23.02.89	3+	Miranda Banders			
	Bribie Is. QLD	27 03S	153 08E	17.10.93		QWSG	Cannon netted	2260	4y 8m

To Victoria

Band #	Banding Site	Lat	Long	Date	Age	Observer	Status	Distance	Time
C-54669	Jordan's-Kaipara	36 30S	174 20E	29.11.97	3+	NZWSG			
	Rhyll, Phillip Is, VIC	38 18S	144 45E	09.10.99	3+	VWSG	Caught/released	2680	1y 11m
C-49896	Miranda FoT	37 10S	175 20E	20.10.96	1+	NZWSG			
	Queenscliff	38 15S	144 40E	18.10.97		VWSG	Caught/released	2687	1y 0m

Keeping the Common Shorebirds Common: Action Planning to Save the Dunlin

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Abstract

Dunlin are the most numerous shorebirds within the East Asian-Australasian Flyway, breeding in Alaska and the Russian Far East and migrating to East Asia during the non-breeding season. Much of the habitat they use during the non-breeding and migration periods is under very serious threat from reclamation, degradation, pollution and human disturbance. The current state of knowledge of the Dunlin subspecies' population sizes and breeding ranges, their non-breeding distribution, important migration staging sites, and major threats to populations and habitats is summarised. Important gaps in our knowledge of the species are identified and potential actions to fill these, involving surveys, banding studies and population monitoring activities, are proposed, in order to provide information that can be used to develop an effective plan to keep the Dunlin common.

Introduction

The Dunlin Calidris alpina has a nearly circumpolar breeding distribution, with four of the nine generally recognised subspecies occurring within the East Asian - Australasian Flyway (EAAF). It occurs almost solely in the northern hemisphere, with very few birds migrating south of the equator (del Hoyo et al. 1996). They are the most numerous shorebirds within the EAAF, breeding in Alaska and the Russian Far East and migrating during the non-breeding season to East Asia (Bamford et al. in prep.).

The EAAF Action Plan (Shorebird Working Group 2001) calls for the implementation of a model ìFlyway Management Approachî project for the Dunlin Calidris alpina. This is the first project of its type and the Dunlin was chosen because it:

- has high potential to be an icon species (most numerous shorebird, wide distribution, easily observed and identified);
- connects a significant number of existing EAAF Shorebird Network sites;
- provides the opportunity to link USA and Russia (the countries containing the breeding ranges) with Japan, South Korea, Taiwan and China (the countries supporting the major non-breeding populations);
- appears to have a poor conservation status as it is dependent on habitats that are under increasing threat and at least one subspecies seems to be declining in abundance.

The objectives of this paper are to:

- provide a brief summary of knowledge about the subspecies' population sizes and their breeding ranges, and the species' non-breeding distribution and migration staging sites;
- describe the major threats to populations and their habitats;
- identify important gaps in our knowledge of the species;
- propose actions to fill information gaps so that an action plan can be prepared to support flyway management of the Dunlin.

What We Know And Don't Know About The Dunlin?

Population sizes

The estimated population sizes of the four subspecies occurring in the EAAF are given in Table 1.

Table 1. Estimated population sizes of the four Dunlin subspecies.

Subspecies	Estimated number	Source
arcticola	750 000	Brown, S. et al. 2001.
sakhalina	100 000 - 1 000 000	Bamford et al. in prep.
kistchinski	100 000 - 1 000 000	Bamford et al. in prep.
actites	600	Nechaev & Tomkovich 1987, 1988.

The population estimate for arcticola is based on extrapolation of known breeding ground densities, whilst the estimates for sakhalina and kistchinski are given as population ranges due to insufficient data.

On the basis of the data in Table 1, the minimum population estimate for Dunlin in the EAAF has been set at 950 000 allowing internationally important sites to be identified using the 1% criterion of 9 500 birds (Ramsar Convention Bureau 2000; Bamford *et al*. in prep.).

It is believed that arcticola numbers may be smaller than the figure published in the United States Shorebird Conservation Plan (Brown, S. et al. 2001). A more recent estimate by D. Troy (in litt.) gives a figure of 640 000; R.E. Gill (in litt.) also believes that 750 000 is too high and suggests that 200 000 - 300 000, based on data from Gill & Handel (1990), may be a more realistic figure.

The suggestion by P. Tomkovich (in litt.) that the individual population sizes of *sakhalina* and *kistchinski* may be similar to those of *arcticola* is based on limited data which indicate that *sakhalina* and *kistchinski* could have comparable breeding densities and similar breeding range areas to *arcticola*.

The *actites* population size is extremely small.

Given the uncertainty surrounding the *arcticola* population estimate, and assuming that the individual population sizes of *sakhalina* and *kistchinski* may be similar to those of *arcticola*, the total number of Dunlin in the EAAF may lie in the range 1.5 to 2 million.

Obtaining accurate population estimates is very important for conservation purposes as it allows:

- identification of internationally important sites, and
- measurement of population trends.

Important gaps in current knowledge

1. Accurate population estimates for the *arcticola, sakhalina* and *kistchinski* subspecies;
2. Subspecies' population trends.

Breeding ranges

The breeding ranges of the four subspecies (sakhalina, kistchinski and actites after Lappo & Tomkovich (1998) and arcticola after Warnock & Gill (1996)) are shown in Figure 1.

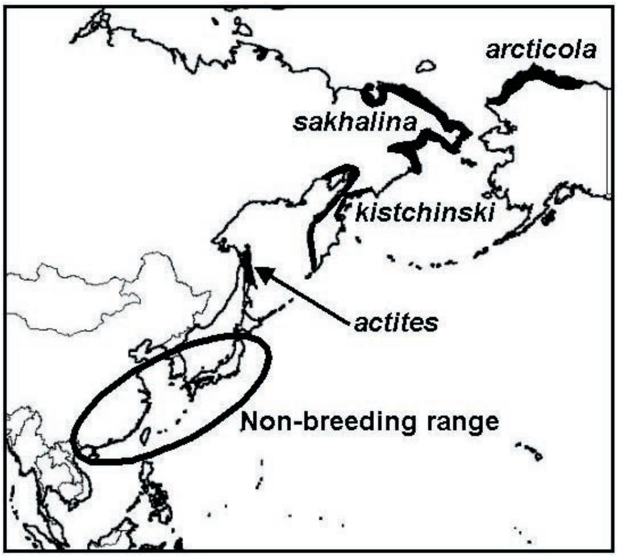

Figure 1. Breeding ranges of the four Dunlin subspecies (arcticola, sakhalina, kistchinski and actites) and their combined non-breeding range in the East Asian-Australasian Flyway.

Whilst the arcticola breeding range is generally well defined, the breeding ranges of *sakhalina* and *kistchinski* are less well known. Lappo and Tomkovich (1998) stress that identification of the core breeding areas is important for conservation purposes, as reproductive success is particularly dependent on these regions.

Important gaps in current knowledge

Need for improved information on the range and core breeding areas of sakhalina and kistchinski.

Non-breeding distribution

Non-breeding season count data from individual countries in the EAAF are detailed in Table 2 (Bamford *et al*. in prep).

It can be seen that Dunlin occur in significant numbers in East Asia as far south as southern China, but few are found in South East Asia. This information is reflected in the combined subspecies non-breeding distribution shown in Figure 1.

There is a large discrepancy between the estimated total

Table 2. Non-breeding season counts to March 2003.

Country	Count
China	260 000
Taiwan	63 000
Japan	41 000
South Korea	12 000
Hong Kong	4 500
Vietnam	2 100
Philippines	119
Indonesia	114
Malaysia	32
Thailand	6
TOTALS	**382 871**

population size (say 1.5 to 2 million) and the number of Dunlin counted in the non-breeding region (totalling approximately 380 000 birds). It is very important to find the remaining major non-breeding areas used by Dunlin, given that significant wetland habitat loss is occurring throughout East Asia (Melville 1997; BirdLife International 2003). It seems that habitat loss may already be having an effect on the arcticola population, as the US Shorebird Action Plan (Brown *et al*. 2001) identifies the need to halt the decline and then restore numbers of this subspecies to 1980 levels.

Japan, South Korea, Taiwan and Hong Kong have been well-surveyed during the non-breeding season and it seems likely that the ìmissingî Dunlin are located within the floodplain of the middle and lower reaches of the Yangtze River and along the south-east and south coasts of China (see Figure 2) (Barter & Lei 2003; Qian Fawen pers. comm.; G. Carey in litt.; WWF 2003).

Important gaps in current knowledge

1. Location of the ìmissingî 1 - 1 Ω million Dunlin.
2. Distributions and movements of the subspecies within the non-breeding range.

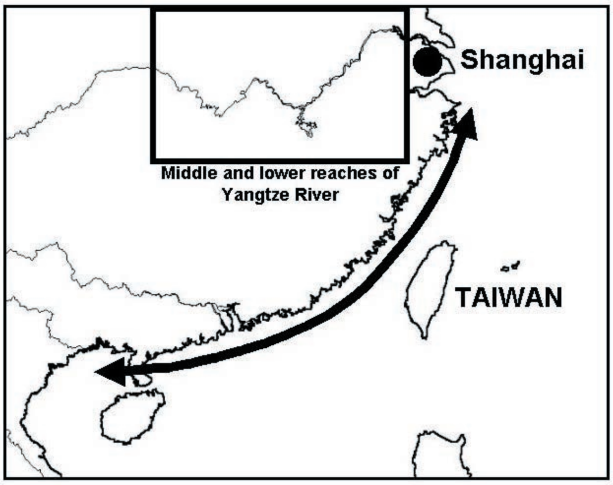

Figure 2. Prospective regions used by Dunlin during the non-breeding season.

Migration

During northward migration, peak numbers occur in the Yellow Sea from late April to mid-May (Barter 2002) and in Japan during mid-May (Brazil 1991). The most active migration through the Kamchatka Peninsular takes place during the middle of May (Gerasimov & Gerasimov 2001).

Arrival of arcticola on the breeding grounds occurs in late-May and early June and southward departure takes place in September and October (Warnock & Gill 1996). Peak southward passage through the Penzhina Gulf (N Kamchatka) occurs during the first-half of September (Gerasimov 2003; Y. Gerasimov in litt.), in Japan from mid-September to late October (Brazil 1991) and in South Korea during September (Barter 2002).

Twenty-one staging sites of international importance (Figure 3) have been identified to date (Bamford et al. in prep.), ten being important during both northward and southward migrations. Most sites are located in the Yellow Sea.

A further 27 staging sites have been identified that support in excess of 0.25% of the minimum estimated Dunlin population. Twelve of these are in Japan, with the remainder being in the Yellow Sea and Far East Russia (Bamford et al. in prep.; R. Gill in litt.).

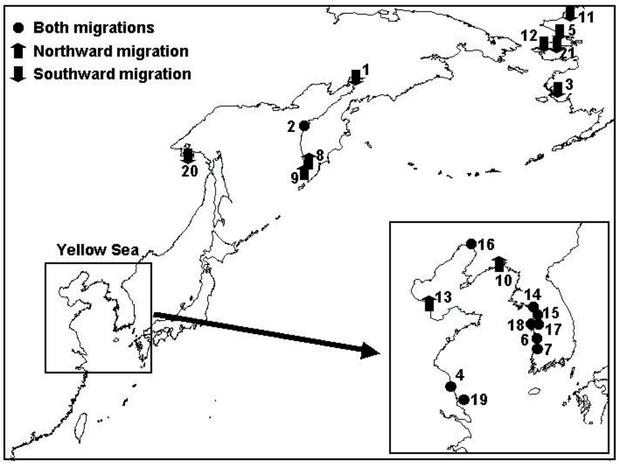

Figure 3. Staging sites supporting internationally important concentrations of Dunlin (i.e.1%, or more, of the estimated minimum EAAF population [9 500 birds]).

Barter (2002) estimates that 660 000 Dunlin are present in the Chinese and South Korean portions of the Yellow Sea during northward migration, when birds are preparing for the flight into the breeding grounds after a relatively short movement north from the non-breeding areas. There are almost certainly significant numbers of Dunlin present in North Korea during this period. It is possible that many Dunlin fly directly to the breeding grounds from the non-breeding areas in Taiwan and southern China.

Dunlin are less numerous in the Yellow Sea during southward migration (Barter 2002), and it is likely that birds are flying non-stop from more northerly staging sites to the non-breeding areas.

Dunlin have been banded (many leg-flagged) on the breeding grounds (Alaska and the Russian Far East), during migration and on the non-breeding grounds (Japan, South Korea, China, Hong Kong and Taiwan). As a result of these activities, there have been a number of band recoveries and flag sightings confirming movements from the breeding grounds to East Asia and within East Asia. It is important to compile a complete listing of these movements and produce an analysis of the results.

Important gaps in knowledge

1. Migration strategies of *arcticola*, *sakhalina* and *kistchinski*.
2. Role of Sea of Okhotsk during southward migration.
3. Lack of a comprehensive list, and analysis, of movements by banded and flagged Dunlin.

Threats

The major threats to Dunlin are occurring on the staging areas in the Yellow Sea and the non-breeding regions in southern China, South Korea, Taiwan and Japan. At this time, threats on the staging areas in Far East Russia (Gerasimov 2003; Antonov 2003) and on the breeding grounds (Warnock & Gill 1996; P. Tomkovich in litt.), and on the staging grounds in western Alaska (R.E. Gill in litt.; R. Lanctot in litt.) appear to be relatively minor.

Significant threats are:

Yellow Sea (Barter 2002)

- loss of 40% of the intertidal areas which existed in the Yellow Sea in the mid-1900s and plans to reclaim 43% of what remains;
- significant changes in the two largest rivers flowing into the Yellow Sea, the Yellow and Yangtze Rivers, which will greatly reduce the amount of sediment input. It is predicted that future loss of intertidal areas will occur at an increasing rate due to the combined effects of accelerating reclamation and reduced accretion;
- declining river flows and high levels of pollution leading to reduced benthic productivity and, thus, declining food supplies for shorebirds;
- human disturbance, by affecting feeding and roosting birds, and competition, through unsustainable harvesting of benthic fauna, is likely to have a serious impact on shorebirds.

The adverse effects of the various threats being encountered by shorebirds in the Yellow Sea are most significant during northward migration when shorebirds are not only preparing for their final long flight into the breeding grounds but also gaining additional reserves to sustain them during the period immediately after arrival, when feeding conditions may be poor.

Lower Yangtze River floodplain (BirdLife International 2003)

- The wetlands of the middle and lower reaches of the Yangtze River have been much reduced and degraded by economic activities, principally reclamation for agriculture. The total area of lakes is reported to have declined by 62% in c.30 years, from 17 200 km^2 in the 1950s to only 6 600 km^2 in the 1980s. Although the total area of wetlands is still large, their quality has been greatly affected by development, pollution, overfishing and human disturbance. The construction and operation of the Three Gorges Dam, which commenced filling in June 2003, will change the seasonal flows of water in the Yangtze River and could negatively affect the wetlands downstream.

Taiwan (W. Liu in litt.)
- 70% of the coastal wetlands in Taiwan have already been reclaimed.

Japan (S. Maekawa in litt.)
- 45% of tidal flats have been lost since 1945

Important gaps in knowledge

1. Location and rates of habitat loss along south east and south coasts of China;
2. Magnitude and effects of hunting on Dunlin populations in southern China.

Proposed actions to address gaps n knowledge
The following actions are designed to fill the identified important gaps in the information base for Dunlin (by subspecies when possible).

Surveys

Breeding ground surveys in the Russian Far East
Establish ranges and population sizes of the sakhalina and kistchinski subspecies.
Non-breeding area surveys
Determine the abundance and distribution of Dunlin in China (particularly the middle and lower reaches of the Yangtze River and the coasts of SE and S China, from Shanghai to the border with Vietnam);

Assess the type and level of threats to Dunlin and their habitats.
Southward migration surveys in the Sea of Okhotsk
Establish the importance and role of the Sea of Okhotsk during the southward migration period.

Banding studies

Delineation of the ranges of the four subspecies
Determine the non-breeding ranges and migration corridors of the four subspecies through the use of DNA and stable isotope techniques,. Samples obtained from the migration sites and throughout the non-breeding region can be compared with material from the breeding sites.

There is a need to develop protocols for obtaining genetic and stable isotope samples.
Analysis of existing band recoveries and flag sightings
Compile a complete listing of band recoveries and flag sightings, and an analysis of the results.
Identification of desirable new banding activities
E.g. to study:
- movements within the non-breeding region;
- migration energetics;

Population monitoring

Breeding grounds
Establish population-monitoring programmes for the four subspecies on the breeding grounds.

Non-breeding region
Establish population-monitoring programmes for Dunlin on the non-breeding grounds. In time, it should be possible to monitor the individual subspecies as their individual ranges are delineated.

Site Key (maximum count or estimate):

1	Penzhina River mouth	(370 000)
2	Moroshechnaya Estuary	(350 000)
3	Yukon-Kuskokwim delta	(250 000)
4	Yancheng NNR	(57 687)
5	Noatak River Delta	(50 000)
6	Mangyeung Estuary	(47 650)
7	Tongjin Estuary	(38 850)
8	Bolshaya Region	(32 666)
9	Opala River	(32 380)
10	Yalu Jiang NNR	(25 181)
11	Kasegaluk Lagoon	(25 000)F
12	Shishmaref Inlet	(25 000)
13	Huang He NNR	(24 106)
14	Ganghwa Island	(17 000)
15	Yeong Jong Island	(16 800)
16	Shuangtaizihekou NNR	(16 411)
17	Namyang Bay	(15 200)
18	Asan Bay	(14 000)
19	Dongsha	(13 081)
20	Turgurskiy Bay	(12 610)
21	Cape Espenberg	(10 000)

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Critical Habitat in the Yellow Sea from a Korean perspective

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Recent surveys in Yellow Sea region show that this region support approximately 40 % of shorebirds in the East Asian-Australasian Flyway. Extensive intertidal mudflat areas at west coast of Korea have been major stopover sites for the migratory shorebirds, including two globally threatened shorebird species ; Spoon-billed Sandpiper *Eurynorhynchus pygmeus* and Spotted Greenshank *Tringa guttifer*. During the last 10 years shorebird surveys in Korea, we found that more than 10% of shorebirds in the Flyway use Korean coastal habitats in their northward migration period. A total of 23 shorebird species exceeding 1% of their estimated flyway population occur in Korea and at least 12 species populations exceed 10% of estimated flyway populations.

Among the 22 sites that covered in Korea shorebird surveys, a total of 11 sites support more than 10,000 shorebirds. Among the sites, Dongjin Estuary (more than 140,000 birds), Mankyung Estuary (84,000 birds) and Asan Bay (79,000 birds) are the most important shorebird habitats in Korea. 19 sites support at least one shorebird species in internationally important number and 9 sites have been identified at which at least one globally threatened shorebird species occur in more than 1% of their estimated world populations.

The most threat that Korean coastal wetlands face is the habitat loss caused by the ongoing large-scale reclamation and development projects. During the last 10 years, large areas of intertidal mudflats in Yongjong Island and Namyang Bay have been lost by the new airport construction and local reclamation projects. And the estuarine habitats in Mankyung and Dongjin River are threatened by the large-scale development project.

Ministry of Environment, Korea is planning the countermeasure for the wetland loss and the serious biodiversity decrease, caused by past development-driven policy. And the two cooperated surveys (1999~2000, 2003) were conducted in Mankyung and Dongjin Estuary, to find out wise-use planning of the wetlands.

Major NGO activity for the conservation of shorebirds and their habitats is the "shorebird monitoring program" by the Korean Federation for Environmental Movement (KFEM). This program include the shorebird monitoring works, shorebird-guide training and the public education programs. Another relevant program is the "Yellow Sea Ecoregion Planning Programme" by Korea Ocean Research and Development Institute (KORDI) and WWF. Major purposes of this program are planning for the communication, environmental education and increase of public awareness in local communities and building a network of scientists in Korea, China and Japan. Gunsan City was selected as the first demonstration site of this project. In order to achieve this program's goals, several environment education programs have been conducted, focused on the importance of shorebird habitats in Mankyung Estuary and national workshop for the public awareness increasing was held in Gunsan City.

Frameworks for shorebird conservation

Shorebird Action Plan for the East Asian-Australasian Flyway – Lessons Learned

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Abstract

The Asia-Pacific Migratory Waterbird Conservation Strategy was launched in 1996 as an international cooperative framework for conservation action across networks of key wetland sites for migratory waterbirds in the East Asian-Australasian Flyway. It includes separate Action Plans for each of the three main migratory waterbird groups: shorebirds, cranes and Anatidae. The Shorebird Action Plan for the East Asian-Australasian Flyway includes 14 actions grouped across three themes: 1) developing a network of internationally important sites for shorebirds, 2) improved management of these sites and 3) enhancing the information needed to conserve migratory shorebirds. The Shorebird Action Plan is commencing a review of its second 5-year term (2001-2005).

There are currently 33 sites in 11 countries participating in the Shorebird Site Network, and a target has been set to have 100 (25%) of the known internationally important sites, and 20 countries, participating by December 2005. Developing the size of the network is considered crucial to success of the program, but increasing the number of participating sites has been limited in many countries. Constraints to nominating new sites have included low levels of awareness about shorebirds, limited capacity of site managers and governments to commence or complete the nomination process, and low level of priority given to recognising the international importance of sites to shorebirds.

A focus to date on basic shorebird skills training, especially in the critically important Yellow Sea region, has led to major improvements in the collection of scientific information for setting conservation priorities, as well as benefits in site management, education and awareness, and increased government support. Other activities within the network of sites and organisations have proved very effective at increasing awareness even beyond the site network. The program has moved into a new phase in countries such as China, where more ambitious initiatives and resources for shorebird conservation have recently begun to develop from within the country. Evaluation of the program to date has identified several areas of focus where the Shorebird Action Plan could strengthen conservation outcomes:

1. *Develop more effective means to enlarge the Shorebird Site Network, eg., working closely with governments to nominate groups of sites into the Network;*
2. *Work with site managers to enhance effectiveness of the site network as a mechanism for information exchange, capacity development, for example through sister-site relationships;*
3. *Enhance capacity in SE Asian countries through training programs in shorebird skills, management, education and awareness;*
4. *Attract the involvement of more training providers in shorebird research, education and awareness and site management;*
5. *Promote partnerships between site managers and local stakeholders, business and corporate sectors to develop wise use practices at key wetland sites and in catchments.*

Whilst expansion of the site network has been limited, the Shorebird Action Plan has met several other milestones in capacity development, education and awareness, identification of new sites, and improving knowledge on populations and migration patterns. The program is demonstrating an ability to influence and benefit additional sites and conservation programs beyond the existing network of participating sites. Challenges for the next 5-year plan will be to develop improved communication and exchange between sites and increased participation of site managers, local NGO's and governments. The immediate conservation priorities for migratory shorebirds also include participation of local stakeholders in the wise use and management of key waterbird habitats.

Introduction

The East Asian-Australasian Flyway extends from the breeding areas of the Russian Far East and Alaska southward to include Mongolia, China, North Korea, South Korea, Japan, the Philippines, Vietnam, Laos, Cambodia, Thailand, Myanmar, Bangladesh, Malaysia, Singapore, Brunei, Indonesia, East Timor, Papua New Guinea, Australia and New Zealand. Within the East Asian-Australasian Flyway it is estimated that there are over 5 million migratory shorebirds of at least 65 species (Watkins 1993).

Following the 1993 International Workshop on Migratory Waterbirds and Wetlands at Kushiro, Japan (Wells and Mundkur 1996), the Ministry of Environment Japan and the Australian Department of the Environment and Heritage funded Wetlands International to coordinate the development of a set of conservation initiatives for migratory waterbirds. The overall framework, known as the Asia-Pacific Migratory Waterbird Conservation Strategy: 1996-2000, was launched at the Ramsar Conference of Parties in Brisbane, 1996. The Asia-Pacific Migratory Waterbird Conservation Strategy includes separate

Action Plans for each of the three main waterbird groups: shorebirds, cranes and Anatidae. These initiatives were updated for the 2001-2005 period and are currently in a review phase to enable planning for post-2005.

The East Asian-Australian Flyway Shorebird Action Plan: 2001-2005 identifies 14 key actions, grouped around three themes: 1) developing the network of internationally important sites for shorebirds, 2) improved management of these sites and 3) enhancing the information needed to conserve shorebirds.

Results & Discussion

1. Development of the Shorebird Site Network

Work under the Action Plan has shown that there are over 420 sites of international importance for migratory shorebirds in the Flyway (Bamford et al. in prep). Broad recognition of the importance of these sites is seen as essential to maintaining shorebird populations. The Site Network is being developed as a mechanism to provide recognition of the importance of these sites at the local, national and Flyway level. The Site Network is a voluntary and cooperative program for conservation of shorebirds and their habitats. Sites must be nominated by the site management body and have the endorsement of an appropriate national government agency. In nominating their site to be part of the Network, site managers undertake to ensure that the site will be managed is such a way as to maintain its value to migratory shorebirds.

The Action Plan includes a target to build the Site Network to 100 by the end of 2005. It is considered that achieving recognition of 25% of the internationally important sites in the Flyway by 2005 will help to create a strong impetus for more sustained conservation efforts across the flyway. However progress in obtaining the nomination of new sites has been slow even where sites are managed by conservation agencies.

As at December 2003, only 33 of the target 100 sites of international importance for migratory shorebirds were participating in the Shorebird Site Network. This should not have been a difficult target to achieve given the national commitments made to sustainable development. Impediments to achieving the target include general lack of awareness of shorebirds and wetlands, limited capacity of staff at sites and in governments, and low level of priority given to recognising the international importance of sites to shorebirds. The site nomination process is simple, but for many sites has stalled. Site staff are usually willing and able to complete Site Information Sheets for site nomination, but government agency staff may face difficulties in obtaining agreement from higher levels for endorsement of the nomination. For some government agencies, the responsibility and process to endorse sites to join an international program presents challenges. We have learnt that government agencies are more relaxed about nominating new sites and participating in the Network if they understand the informal and cooperative nature of the Shorebird Site Network. Equally important for governments considering participating, this conservation framework was developed to be voluntary with no required financial contributions. We have also attracted greater interest in nominating sites by showing the range of benefits that have occurred for sites and governments through participation in the Network. These benefits include:

1. Using recognition of the international importance of sites to help attract greater support for sites;
2. Access for site managers and government agencies to other sources of expertise, training and information on shorebird and habitat management;
3. Sharing of new information and knowledge on shorebird science, conservation and education between sites;
4. Participation in additional international networks for education and scientific exchange activities;
5. Access to new developments and related conservation activities with partner organisations of the Asia Pacific Migratory Waterbird Conservation Strategy; and
6. Development of national networks of sites to improve national support for migratory waterbird conservation;

In several countries of the flyway, nominating sites to the Shorebird Site Network has remained difficult because of poor awareness of the importance of shorebirds and their habitats. Advances have resulted from making special presentations to government agencies and site managers, and holding national awareness-raising workshops that also include national and local NGO's. More sustainable changes have resulted following training workshops in basic shorebird skills, particularly if repeat workshops are delivered.

Working with governments to nominate blocks of sites has recently begun to show promise as a way to increase the pace of growth of the network. Governments and sites have been more convinced to join when the benefits of participation have been well articulated. This has been easier to do with the recent increases in the range of activities and achievements under the Shorebird Action Plan (above).

Financial support to implement the Shorebird Action Plan has primarily come from the Australian Department of the Environment and Heritage. This support has enabled a Flyway Officer to coordinate and facilitate implementation of the Action Plan, plus fund several high priority areas of work. This core support has proved crucial to the continuous functioning of an international-scale cooperative conservation program. Efforts to secure additional core funding have had limited success. Collaborative proposals for new implementation activities are recognised as a priority.

2. Management of Shorebird Network Sites

Whilst the Action Plan provides a framework for international recognition and networking for sites, it also encourages the local community and governments to assist site managers to maintain the values of these sites. Under the Action Plan priority has been given to assisting sites in the key staging areas of the Flyway, particularly around the Yellow Sea, where development pressures and impacts are also severe.

Activities for enhancing capacity have focused around shorebird surveys in the Chinese part of the Yellow Sea. Over 250 participants have been involved in a series of training activities to build the skills of site staff to assess shorebird use and the implications for site management. These activities have involved volunteer trainers from Australasian Wader Studies Group. Other training activities have been conducted at important shorebird sites in Russia, Mongolia, South Korea, Vietnam, Cambodia, Thailand, Philippines, Indonesia and Papua New Guinea.

In China, annual shorebird skills training workshops as well as education and awareness activities with governments, universities and schools, commenced in 1996. Many of the workshop trainees have become champions for shorebird and wetland conservation at key sites and Universities in China. In 2004 the 3rd Chinese Waterbird Workshop will be held. A national network of site managers and researchers has begun to lobby governments for increased commitment to shorebird research and conservation. The success of these repeated training activities in China contrasts with the relatively slow pace of change in South East Asian countries. The obvious lesson is that greater resources need to be focussed toward training workshops in those countries.

Increasing communication and information sharing amongst site managers, researchers, governments and NGO's throughout the flyway is another key element of the Action Plan. Activities to foster and support this have included:

- international meetings (eg., in South Korea, Japan, China, Mongolia, Malaysia, the Philippines, Singapore and Australia),
- distribution of a quarterly Flyway newsletter (The Tattler),
- production and distribution of awareness posters (in Korean, Japanese, Chinese, Vietnamese, Thai, Malay, Indonesian and English) and brochures,
- contributions to journals and special publications,
- contributions from shorebird experts into education and awareness programs in schools and interactive websites,
- email discussion groups and task force groups for addressing arising issues across the Flyway.

Education and awareness materials and websites have been used at almost every public activity associated with the Action Plan and the ongoing availability of these materials is very important. Production of these materials has required modest funding, and attracting these funds was helped by development of a detailed communications plan.

Dedication ceremonies for sites to commemorate joining the Shorebird Site Network have used strong media publicity to profile the international importance of the site and attract greater local, and sometimes national, support for sites to fund ongoing conservation and education activities. New network sites have been quick to use shorebird conservation activities to attract additional local media profiles.

Communication and distribution of information and resources for Site managers has grown more recently with increased use of email networks and listservers. As links between sites, researchers and conservation practitioners have increased and strengthened, new levels of communication have developed, leading to new initiatives that contribute to goals of the Action Plan. Nevertheless, if the Network is to create become a self-sustaining mechanism for new and increased levels of conservation action, even greater levels of networking are needed, and developing these linkages has still depended on facilitation by the Flyway Officer.

3. Improving the Information Base

Improving the information base on shorebirds in the Flyway has included: enhanced shorebird monitoring programs in Australia and Japan, surveys to identify important sites, increased knowledge of migration strategies and revision of population estimates.

Shorebird monitoring programs remain essential to establishing an understanding of population trends for the Flyway. Countries such as Australia and New Zealand are uniquely placed to contribute information on population changes because of the stability of shorebird numbers during the middle of the non-breeding season and because of the number of skilled volunteers available to take part in monitoring. The existing monitoring programs need to be enhanced and expanded to capture more statistically representative samples of populations. Monitoring programs in Taiwan, South Korea and Japan are also yielding good information on important shorebird sites and migration timing, although there is still need for integration of data collection.

Shorebird survey activity is limited in most countries in the Flyway. Baseline information is still required in many countries to identify important shorebird sites and to enable informed decisions to be made about changes in wetland management and land use. Bird watchers in Australia and New Zealand have extensive skills and experience and have assisted baseline surveys in other parts of the Flyway. The leading example of this work has been the series of training and survey activities implemented in China by members of the Australasian Wader studies Group working with Wetlands International – China (Barter 2002). These surveys, together with the population monitoring data, have assisted in reviewing population estimates, whilst building a reliable skills base in China. The Action Plan has recently begun to facilitate increased levels of training and survey work in South East Asian countries to help fill the large information gaps on shorebird populations in that part of the Flyway.

Under the Action Plan promotion of the colour flagging program for migration studies and modifications to colour marking protocols has had substantial impact on our understanding of shorebird migration. This information has helped to identify the specific wetlands and parts of the flyway that are crucial to conservation of each shorebird population. The last decade of colour flagging shorebirds has also greatly increased the level of networking across the flyway, and this network is being used to improve and standardise protocols.

4. Applying the lessons learned

Annual reviews of the Action Plan to date have enabled fine-tuning of priorities to optimise the use of our limited resources throughout the program to date. Now mid-way through the second 5-year plan, new strategies may be needed to help achieve the 2005 targets. These include:

1. Develop more effective means to enlarge the Shorebird Site Network, eg., working closely with governments to nominate groups of sites into the Network;
2. Work with site managers to enhance effectiveness of the site network as a mechanism for information exchange, capacity development, for example through sister-site relationships;
3. Enhance capacity in SE Asian countries through training programs in shorebird skills, management, education and awareness;
4. Attract the involvement of more training providers in shorebird research, education and awareness and site management;
5. Promote partnerships between site managers and local stakeholders, business and corporate sectors to develop wise use practices at key wetland sites and in catchments.

Results of the current review are also leading to development of the third 5-year Action Plan. Lessons from the program to date, and changes in socio-economic, environmental and technological circumstances in the flyway, could possibly lead to more substantial changes in direction or approach for the next Shorebird Action Plan: 2006-2010.

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Appendix 1

Actions of The East Asian-Australasian Shorebird Action Plan: 2001-2005

Action 1 Obtain the nomination of at least 25% of the sites of international importance for the Network (to give a total of 100 sites in the Network).
[Shorebird Flyway Officer, Site Management Bodies, Governments, Shorebird Working Group]

Action 2 Obtain the nomination of at least one site in all countries with sites of international importance for the Network. Remaining countries to be included are United States (Alaska), Bangladesh, Vietnam, Thailand, Mongolia, Malaysia, Singapore, Myanmar and the Democratic Peoples Republic of Korea.
[Shorebird Flyway Officer, Governments, Non-government organisations]

Action 3 Ensure adequate planning and fund raising for the development of the Network. Conduct annual reviews of the implementation of the Action Plan in the flyway and prepare an annual work plan.
[Wetlands International, Shorebird Working Group, Shorebird Flyway Officer, Non-government Organisations]

2.2 Appropriate management of Network sites

Supporting the implementation of appropriate habitat and species management (wise use of wetland resources as defined by the Ramsar Convention) at each Network site is the highest priority of the Action Plan. This will be achieved by improving site management skills, building community awareness and empowering local communities to be involved in site management.

Action 4 Provide access for site managers and staff to training in species monitoring, wetland management, management planning, public awareness and education programs and project management. The target will be for each site to have competence in these 4 themes by the end of 2005.
[Shorebird Flyway Officer, Site Management Bodies, Governments, Non-government organisations]

Action 5 Provide a range of tools and programs to promote public awareness and education activities on shorebirds. The target will be to have 50% of Network sites conducting awareness and education programs or involved in activities developed and promoted under the Action Plan.
[Shorebird Flyway Officer, Site Management Bodies, Non-government organisations]

Action 6 Conduct dedication ceremonies at new Network sites that involve the site management agency, Government and local community representatives.
[Site Management Bodies, Shorebird Flyway Officer, Non-government organisations]

Action 7 Provide management planning information to all Network sites to promote the development of management plans.
[Shorebird Flyway Officer, Site Management Bodies]

Action 8 Develop a special program of activities to address the ongoing loss and degradation of shorebird habitat in the Yellow Sea (including the Bohai Sea).
[Shorebird Flyway Officer, applicable Governments, Non-government organisations, Site Management Bodies]

Action 9 Implement a model "flyway management approach" project for Dunlin; a species for which a significant number of Network sites act as key staging and non-breeding areas.
[Shorebird Flyway Officer, Site Management Bodies]

Action 10 Enhance the exchange of information on shorebird conservation and habitat management between site managers, researchers and non-government organisations. This will include the use of existing publications (eg. The Stilt and Tattler), wetland newsletters, email and Web sites.
[Non-government Organisations, Site Management Bodies, Shorebird Flyway Officer]

2.3 Increasing the information base on migratory shorebirds

Ongoing survey, monitoring and research work on shorebirds and their habitats is needed to ensure that the Network is achieving conservation of migratory shorebirds in the East Asian-Australasian Flyway.

Action 11 Support implementation of statistically robust methodologies to monitor shorebird populations in priority countries (Australia, New Zealand and Japan).
[Non-government Organisations, Site Management Bodies, Governments, Shorebird Flyway Officer]

Action 12 Develop and implement projects to identify internationally important sites for:

- shorebirds in countries where knowledge is incomplete, notably the Russian Federation, Peoples Republic of China, Democratic Peoples Republic of Korea, Myanmar, Bangladesh and Papua New Guinea;
- endangered species (Spoon-billed Sandpiper and Nordmann's Greenshank)

[Non-government Organisations, Governments, Shorebird Flyway Officer]

Action 13 Support existing and initiate new projects on shorebird migration with a special focus on the use of colour leg flags. Seek to maximise community involvement in these projects through reporting and analysis of sightings of colour flagged birds.
[Non-government Organisations, Governments, Shorebird Flyway Officer]

Action 14 Develop a database to collate shorebird counts in the flyway. Compile and publish an up-date of the population estimates of shorebirds and inventory of internationally important sites in the East Asian-Australasian Flyway. Assess the adequacy of the Network to conserve species.
[Non-government Organisations, Shorebird Flyway Officer]

Poster Papers

Not Just Another Survey - Mackay Wader Surveys 2003

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The Queensland Wader Study Group (QWSG) has completed three surveys of the Mackay coastal region and a number of freshwater wetlands in 2003. This was supported with funding from the Natural Heritage Trust through the World Wide Fund for Nature (WWF) Shorebird Conservation Project. Previously, four sites in the region had been identified in Watkins (1993) as having internationally significant numbers of waders.

In 1996, Dr Peter Driscoll assessed waders along the Queensland coastline and he estimated the wader population for the central coast region (between 20° and 22° S) to be about 19,000 birds. He listed thirteen roost sites having over 300 waders each within the region covered by the current survey. However, this assessment was based on counts over several years and no single count had been made of the entire central coast of Queensland.

The QWSG, in partnership with the Queensland Parks and Wildlife Service, the Mackay Conservation Group and supported by the Mackay Bird Observers Club, undertook the surveys of the population of waders from Cape Palmerston to Proserpine. These comprehensive surveys have involved transportation of observers to about 40 significant high tide roosts

The first survey was conducted over two days in January 2003. Key regions surveyed included Armstrongs Beach, Ince Bay, Sandringham Bay, Sand Bay and New Beach. This survey recorded a count of 21,629 waders. The full population for the region is estimated to be in excess of 22,000 waders during the austral summer given that as many as 1,000 additional waders were noted during aerial surveys that were done in November and April at locations not counted in January.

Counts in April and October 2003 provided additional information on how the region is used during migration. Data collected during these two surveys indicated that the region is particularly important for Grey-tailed Tattler and Whimbrel during their northward migration, and Grey-tailed Tattler and Eastern Curlew during their southward migration. The region supports over 3% of the Flyway population of each species during these times. Nine species of waders occurred in internationally significant numbers in the region and they include Pied and Sooty Oystercatcher, Whimbrel, Eastern Curlew, Lesser Sand Plover, Greater Sand Plover, Grey-tailed Tattler, Great Knot and Bar-tailed Godwit.

The information obtained from these surveys will be useful to the QPWS in future surveys and for conservation planning. The Environmental Protection Agency and QPWS will also feed this information into the local governments in comments provided as part of the normal planning scheme preparation process. A copy of the final report has also been provided to local governments, providing them with knowledge of important wader roost sites within their jurisdiction.

Managing Habitats for Shorebirds – the Parramatta River Estuary

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There has been a past history of treating wetlands as wastelands and waterways as drains for carrying wastewater. Rapidly expanding development around the bays and foreshores has caused extensive loss of habitat and disturbance. Sydney Olympic Park Authority (SOPA) has the opportunity, through wise management, to manage parts of the wetlands for shorebirds, by providing both quality feeding habitats and safe roosting sites. The Parklands Plan of Management ensures that conservation and enhancement of biodiversity has been incorporated into planning, design and construction of the landscapes. For an urban area, it is a place of high biodiversity value.

Fifteen species of migratory shorebirds have been recorded in the Parramatta River estuary and most of these have been in decline over the past years, as in other parts of the region. The estuary was listed as a priority 3 site of importance for migratory shorebirds in 1991. Other species of shorebirds use the estuary regularly or as a refuge during drought.

In the coastal zone there are increasing pressures to shorebirds and their habitats. Local challenges include disturbance, pollution and run-off, excess nutrient levels leading to algal blooms and growth of mangrove seedlings and other invasive species in feeding areas. This is a highly modified environment.

SOPA Management continues to resource planning, training, monitoring and education. Substantial remediation, improvement of tidal exchange into the wetlands and ongoing research and monitoring all contribute to improving the environment. Appropriate management of the habitat is essential for the long-term protection of shorebirds.

Nocturnal and diurnal habitat use by Double-banded Plover *Charadrius bicinctus* in Botany Bay, New South Wales, Australia

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The aim of this study was to identify important feeding and roosting sites of Double-banded Plover *Charadrius bicinctus* in Botany Bay. Sites used during the day and at night were identified over a five-month period (May - September 2003), by making behavioural observations of 40 – 50 birds during the day and radio-tracking five birds at night. Opportunistic visual observations were also made of a night. Double-banded Plover used three habitats within two sites. Penrhyn Inlet, a small inlet with tidally exposed sand and mudflats on the northern side of Botany Bay subject to high levels of human disturbance, was used primarily as a diurnal roost. The other site, Sydney Airport, was used as a diurnal roost and nocturnal roost and feeding site. During the day the birds were observed in a loose flock loafing on a crushed concrete perimeter or the retaining wall of the southern tip of the runway 34R. During the night they dispersed as small groups or individually over both runways. The population utilised a much larger home range at night (617.5 ha) than they did during the day (51.5 ha). Precipitation (mm), air temperature (°C), relative humidity (%), wind speed (km/h) and wind direction (°) did not have a strong influence on diurnal site choice. However, the population was recorded at Penrhyn Inlet more often when night time and daytime air temperature was low (<15°C), relative humidity was high (>75%), and when there was little wind (wind speed < 19km/h). Time of day best described diurnal patterns of behaviour while tide, air temperature, wind speed, wind direction and relative humidity had little influence. Double-banded Plover spent the greatest proportion of daylight roosting than any other behaviour.

These results suggest that the Botany Bay population of Double-banded Plover use the parallel runways at the airport to forage on a night. Considering that there is approximately 50km of shoreline, Double-banded Plover showed a strong preference for only two sites within Botany Bay. Environmental variables appeared not to explain why such a preference exists.

Mission:

To sustain and restore wetlands, their resources and biodiversity for future generations through research, information exchange and conservation activities, worldwide.

The Australasian Wader Studies Group (AWSG) was formed in 1981 as a special interest group of the Royal Australasian Ornithologist's Union (Birds Australia). The group is a non-government organisation dedicated to studying waders (shorebirds) throughout the East Asian-Australasian Flyway.

The Australasian Shorebird Conference (ASC) series was initiated by the AWSG in 1996 at Brisbane, Queensland, and is now held biennially within Australia or New Zealand. From time to time the proceedings of the ASC are published and distributed to members and other shorebird specialists. These papers were presented at the Fourth Australasian Shorebird Conference held in Canberra, Australian Capital Territory, in December 2003. These papers cover a wide range of issues and to a large extent summarise what is known about the status and conservation of shorebirds in the East Asian-Australasian Flyway. Perhaps more importantly they highlight what we don't know about our shorebirds and the need for more extensive research within the whole of the Asia Pacific Region.

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