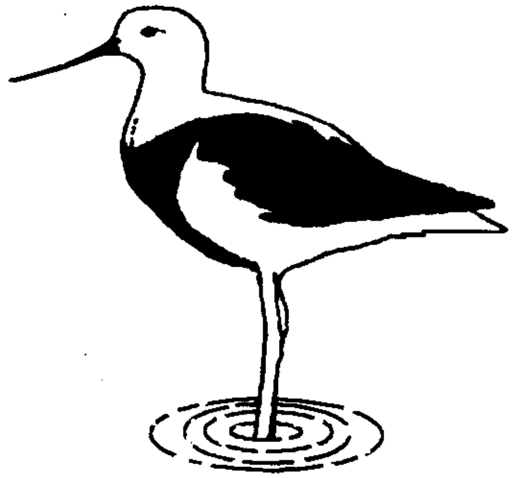
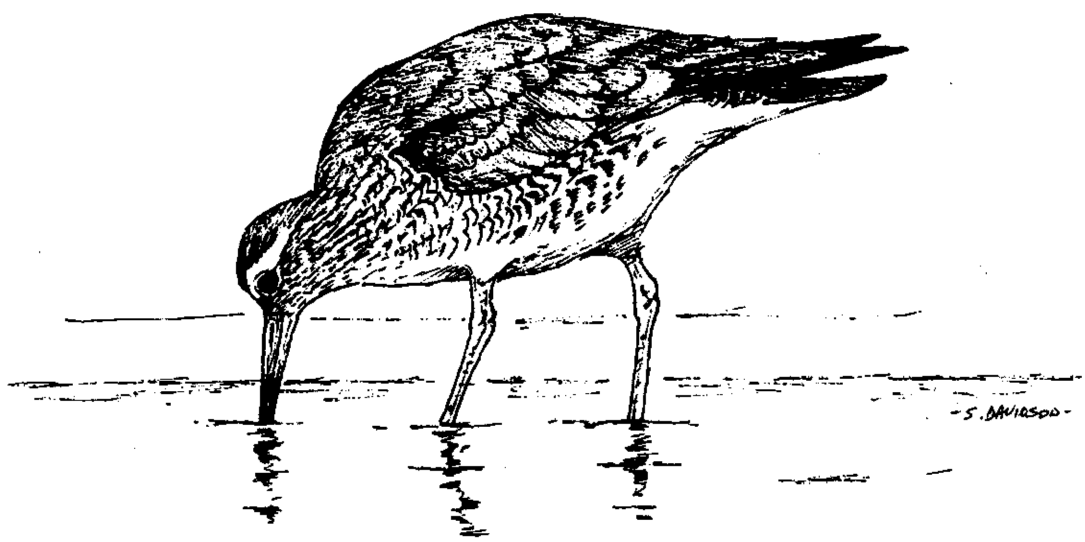
The Stilt



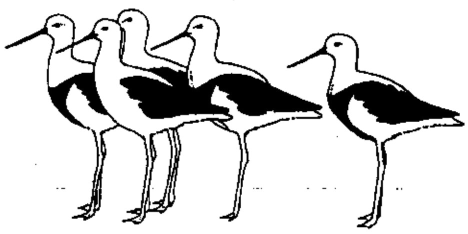
The Bulletin of the East Asian-Australasian Flyway



Australasian
Wader
Studies
Group

A special interest group of Birds Australia

Number 40
October 2001



The Stilt

ISSN 0726-1888

MISSION STATEMENT

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

OBJECTIVES

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

To encourage and promote the involvement of a large band of amateurs, as well as professionals, to achieve these objectives.

MEMBERSHIP OF THE AUSTRALASIAN WADER STUDIES GROUP

Membership of the AWSG is open to anyone interested in the conservation and research of waders (shorebirds) in the East Asian-Australasian Flyway. Members receive the twice yearly bulletin *The Stilt*, and the quarterly newsletter *The Tattler*. Please direct all membership enquiries to the Membership Manager at Birds Australia (RAOU) National Office, 415 Riversdale Rd, East Hawthorn, 3122. Vic., AUSTRALIA.
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Cover Illustration: Stephen Davidson

EDITORIAL

In this, the third issue in 2001, we see the first articles in *Stilt* from the extensive 20 year banding and flagging program of the VWSG and AWSG. The AWSG committee hope that the new scientific advisory committee of the AWSG will facilitate the analysis and publication of much more of these data. Non-government organizations such as the AWSG are coming under increasing scrutiny from other groups that feel activities such as cannon-netting and mist-netting cause the birds unjustifiable stress. They feel that the occasional deaths from using these methods of capture are completely unsupportable. These criticisms increase the pressure on AWSG members to make sure that all banding programs are well-planned, have clear, justifiable objectives and provide data that can be used to enhance the conservation of the birds. I hope that we continue to see a flow of good quality scientific output from the AWSG banding studies and the thousands of birds banded have not been needlessly stressed in vain.

Jim Wilson has shown the way with his timely reports on the results of two extensive wader surveys in the Coorong in South Australia and throughout Victoria in early 2001. The results of these surveys show an alarming trend of declining abundance of several species in both areas. Jim discusses the potential causes of these low abundances and hypothesizes that some are due to poor environmental conditions in southern Australia in early 2001. However, he has identified other species whose declines may be due to a shrinking Flyway population. These species need to be monitored carefully throughout Australia in order to ascertain if the declines are local or widespread phenomena. This is when data from an active and concerted Population Monitoring Project (see Jim's article in *Stilt* 39) has great value. It is the only data to provide a broad scale count of waders in Australia. Without this project, any estimates of abundance would not provide a meaningful index of the wader populations in Australia.

When this issue comes out, many of the AWSG committee will be in Broome in northwestern Australia, participating in the wader expedition. I plan to join the expedition for the first two weeks and get a better insight into the data being collected and its limitations. In this way, I hope we can maximize the benefits to the birds of these major expeditions and make gains in scientific understanding that will contribute to their conservation.

I hope readers enjoy this issue and plan to send in lots of articles for the next, to be published at the regular time in April 2002.

David Milton

LONG-TERM CHANGES IN NUMBERS OF VARIABLE OYSTERCATCHER (*HAEMATOPUS UNICOLOR*) AT TWO WINTERING SITES IN CANTERBURY, SOUTH ISLAND, NEW ZEALAND

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ABSTRACT
The total population of Variable Oystercatchers in New Zealand is believed to have doubled since the 1970's. Wintering numbers at two sites in the Canterbury Region of the South Island have been monitored since 1947 and 1985 respectively. Substantial increases in Variable Oystercatcher numbers are demonstrated from 1988 onwards.

INTRODUCTION

The Variable Oystercatcher *Haematopus unicolor* is endemic to New Zealand and is one of three oystercatcher species recognised from the region (Turbott 1990). It is almost exclusively a coastal wader, favouring sandy and rocky shorelines as well as estuaries and some shallow coastal lagoons.

Since the early 1970's, numbers of Variable Oystercatcher are thought to have doubled (Heather & Robertson 1996, Sagar *et al.* 1999). Credible total population estimates made over the last three decades have included c.2000 in 1970-71 (Baker 1973), c.2000 in 1979 (Baker 1985), 2000-3000 in the mid 1980's (Hayman *et al.* 1986), c.3900 in the late 1980's (Marchant & Higgins 1993), c.4000 in the mid 1990's (Heather & Robertson 1996) and 3413+ in 1999 (Sagar *et al.* 1999).

In the Canterbury Region on the east coast of the South Island, the Variable Oystercatcher has long been considered an uncommon species. Potts (1882) made the assessment that "*north, south and west, this wader is of common occurrence, yet in the Canterbury district it is rare.*" It is significant that neither Stead (1927) nor Hope (1927) included Variable Oystercatcher among comprehensive accounts of birdlife occurring in Canterbury over the period 1890's to 1920's. The local scarcity of this species was later reconfirmed, either implicitly or by inference by Falla (1939), Baker (1972, 1973), Bull *et al.* (1985), Harris & Crossland (1990) and Marchant & Higgins (1993). Potts'statement remained accurate for more than 100 years until a dramatic increase in numbers became evident from the late 1980's onwards.

During the post-breeding period (late December to February) and non-breeding season (March to early September) many Variable Oystercatchers move away from breeding areas and congregate at a small number of key wintering sites on the Canterbury coast (pers. obs.). From north to south, the most important sites (each supporting >10 birds) are Kaikoura Peninsula, Motonau Rivermouth, Ashley Estuary, Avon-Heathcote Estuary, Lyttelton Harbour, Okains Bay and Washdyke Lagoon (Fig. 1). Flocks at these wintering sites comprise adults as well as immatures and juveniles, although flocks between December and February tend to be dominated by immatures (pers. obs).

Two wintering sites, Avon-Heathcote Estuary and Lyttelton Harbour, are located close to Christchurch city and have been regularly visited by researchers and members of the Ornithological Society of New Zealand (OSNZ) for many years. In this paper, data from such observations are used to demonstrate the recent increase in Variable Oystercatcher numbers at these sites.

STUDY AREA AND METHODS

The Avon-Heathcote Estuary (43^{O} 33'S 172^{O} 45'E) is located on the eastern fringes of Christchurch city and supports the largest wintering flock of Variable Oystercatchers in the Canterbury Region with up to 75 birds. This site is a barrier-enclosed

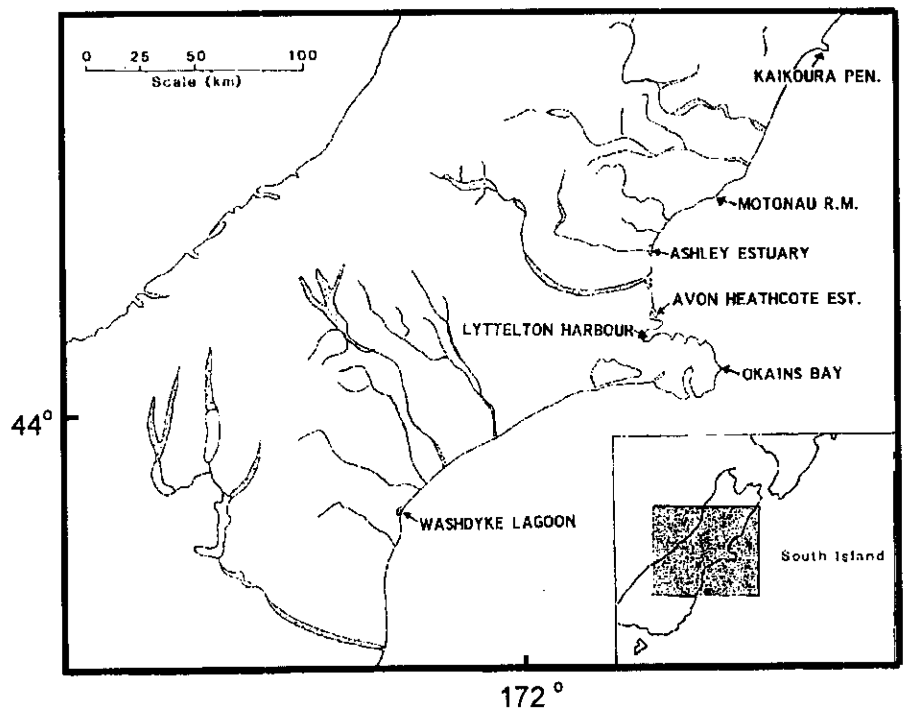

Figure 1. The Canterbury Region and location of Avon-Heathcote estuary and Lyttelton Harbour, South Island, New Zealand.

estuary containing approx. 650 ha of inter-tidal mudflats at low tide. The Avon-Heathcote Estuary supports up to 7000 waders, comprising mainly South Island Pied Oystercatcher *Haematopus finschi*, Bar-tailed Godwit *Limosa lapponica*, Pied Stilt *Himantopus himantopus*, Double-banded Plover *Charadrius bicinctus* and Masked Lapwing *Vanellus miles* (Crossland 1993). Variable Oystercatchers tend to congregate on the eastern, sandier side of the estuary and on adjacent sandy and rocky coastlines. During high tides they roost amongst large flocks of other waders (mainly South Island Pied Oystercatcher and Bar-tailed Godwit).

Lyttelton Harbour (43° 37'S 172° 45'E) is located on Banks Peninsula and occupies the partly submerged crater of an extinct volcano. This is another notable wintering site, but differs from the Avon-Heathcote Estuary in that Variable Oystercatchers have recently returned after being absent for many years. The inner harbour contains extensive inter-tidal mudflats which support up to 1200+ waders, dominated by South Island Pied Oystercatcher, Bar-tailed Godwit and Pied Stilt. Variable Oystercatchers however segregate themselves to the outer harbour, where they frequent wave-cut rock platforms, exposed reefs and sandy beaches. Interestingly, the high tide roost used currently, a reef adjacent to a small islet known as Ripapa Island, is the same site where Potts (1882) observed Variable Oystercatchers roosting and nesting in the 1850's to 1880's.

Where possible, the highest available count made between March and early September has been used, however, in some years (mainly prior to 1988) peak numbers sometimes coincided with a spring (September to November) or early summer (December) influx of non-breeders and immatures. In such cases, this count has been used.

RESULTS

Peak census data were available for 32 of the last 54 years on the Avon-Heathcote estuary (Fig. 2). Numbers were fairly stable at 1-4 birds over the first 40 years of monitoring (1947-1987), then increased steadily over the subsequent 13 years. Counts rose from 3 birds in 1987 to 75 in June 1999 (a 25-fold increase). The 70+ birds now wintering on the Avon-Heathcote estuary represents about half the total Canterbury regional population, estimated at 150+ birds in 1999 (Crossland in prep.). This estuary also now supports almost 2% of the World population of Variable Oystercatcher and therefore technically qualifies under Ramsar

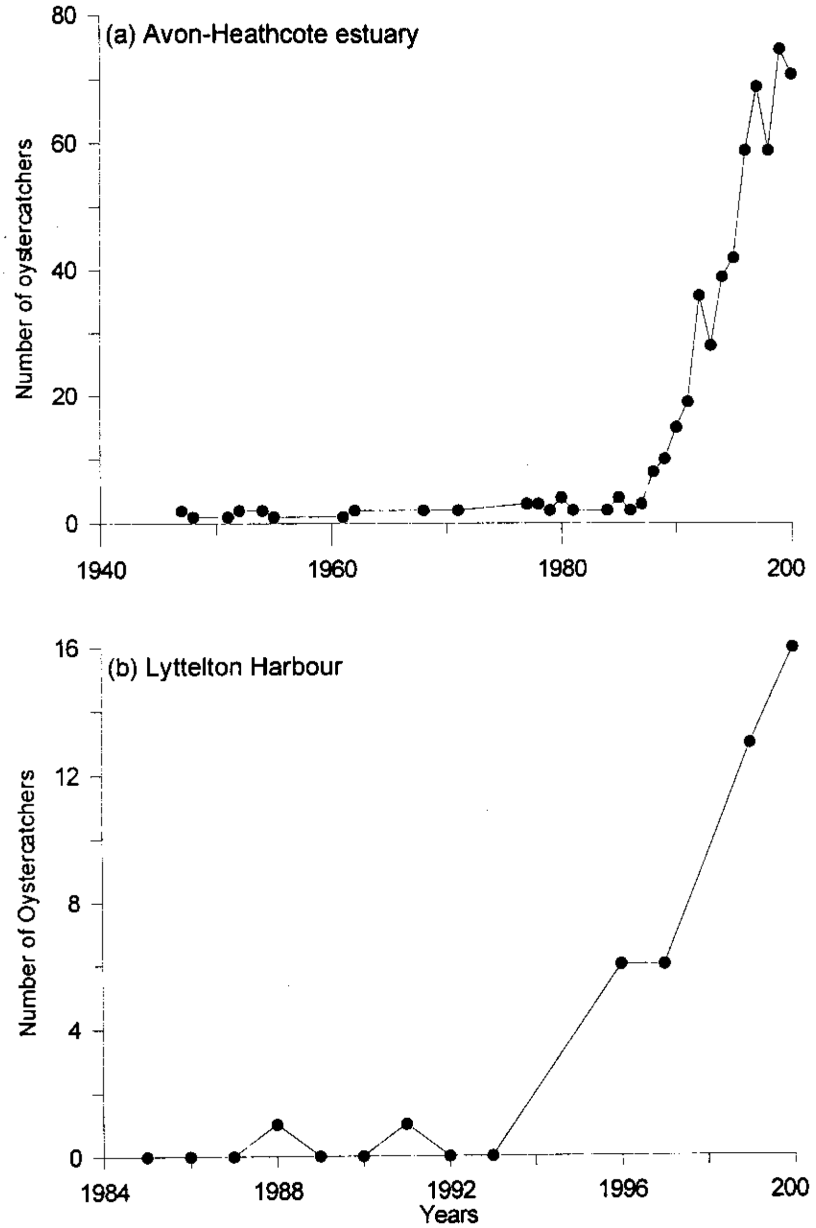

Figure 2. The changes in the number of Variable Oystercatchers at (a) Avon-Heathcote estuary from 1947 to 2000 and (b) Lyttelton Harbour from 1984 to 2000. Counts prior to 1984 were taken from Guy (1949), Bruce (1953), Rosenberg (1963), Baker (1969, 1972, 1973) and the records of Armstrong, Harrison, Howell and Turbott.

Convention criterion as an internationally important site for the species.

At Lyttleton Harbour, wintering numbers have been monitored only since 1985. Peak census data are available for 13 of the last 16 years (Fig. 2), and show a similar trend to the Avon-Heathcote Estuary except that numbers are lower and the increase started later. Variable Oystercatchers were absent or scarce on Lyttelton Harbour between 1985 and sometime between 1993 and 1996. No winter census was undertaken in either 1994 or 1995 so the precise date when the species reappeared is not known. Peak numbers increased 2.7-fold between 1996 (6 birds) and 2000 (16 birds). The latter total is probably the highest in decades as Variable Oystercatchers have been reportedly absent or very scarce on the harbour since at least the 1940's (Dawson & Cresswell 1949, CSN records).

The much later increase at Lyttelton Harbour (approximately eight years after numbers began to rise on the Avon-Heathcote estuary) is probably due to a 'spill-over' effect. As numbers built up on the Avon-Heathcote, more birds began to feed at low tide along the rocky coastline that separates the two sites. By 1996 when 59 birds wintered on the Avon-Heathcote estuary, six were present at Lyttelton Harbour. By this time, the Avon-Heathcote may have become substantially 'filled up' and the small decline from 75 in 1999 to 71 in 2000 may suggest that the carrying capacity of the Avon-Heathcote estuary is c.70 birds.

DISCUSSION

The observed increase in the size of wintering Variable Oystercatcher flocks at the two Canterbury study sites reflects the general increase in abundance of this species nationally over the last 20 years (Marchant & Higgins 1993, Heather & Robertson 1996, Sagar *et al.* 1999). Large increases have also been recorded at other wintering sites. For example; a 78% increase in Variable Oystercatcher numbers was reported for Wellington Harbour between 1975-77 and 1986-88 (Robertson 1992) and peak wintering numbers on the Motueka-Riwaka coastline in the Nelson Region increased four-fold in 13 years from 44 in 1987 to 175 in 1999 (Crossland in prep.).

Why the Variable Oystercatcher has increasing in abundance is not clear, particularly as populations of most other coastal-nesting waders in Australasia are either declining (eg. Hooded Plover *Thinornis rubricollis*, Pied Oystercatcher *Haematopus longirostris*, Sooty Oystercatcher *Haematopus fuliginosus*, Beach Stone-Curlew *Esacus magnirostris*) or have already become extinct in much of their historic range (eg. Shore Plover *Thinornis novaeseelandiae*, New Zealand Dotterel *Charadrius obscurus*) (Marchant & Higgins 1993).

The Variable Oystercatcher population appears to have increased without significant direct conservation management. In some localities Variable Oystercatchers have undoubtedly benefited from habitat enhancement and predator control programmes aimed at protecting other bird species (such as New Zealand Dotterel and breeding colonies of terns, penguins and seabirds), but to date these programmes have occurred in only a small number of sites and their effect at national population level has probably been negligible. Also, populations have increased in regions such as Canterbury which are remote from where potentially beneficial conservation management has taken place (mainly in the northern half of the North Island). At the same time, an increase in human recreational activity along sandy and rocky shorelines, particularly with the upsurge in popularity of four-wheel drives, trail-bikes and all-terrain vehicles, would seem to threaten Variable Oystercatcher breeding success. This would seem even more likely given that the breeding season (September to February) coincides with the busy New Zealand summer holiday period when disturbance levels in coastal nesting areas is greatest.

The possibility that behavioural changes may have played a role in the population increase of Variable Oystercatcher merits investigation. Baker (1969, 1972, 1973, 1974a, b) described the narrow niche occupied by the species in terms of habitat selection, breeding, food and social behaviour. Casual observation suggests that since the period of Baker's study (late 1960's to early 1970's), Variable Oystercatchers seem to have become less restricted to a narrow rocky/sandy shoreline environment and now appear to more commonly utilise estuarine, coastal pasture, parkland and river mouth environments. In addition, the species may have developed more effective behavioural responses to introduced mammalian predators and to disturbance by humans, animals, vehicles and watercraft.

With reference to Potts (1882), Variable Oystercatcher numbers at the two study sites and in the Canterbury Region generally may now be larger than what they were at any time since the early phase of European settlement in the mid-late 19th Century. European settlement in New Zealand brought with it the mixed onslaught of habitat destruction, increased hunting pressure, the introduction of mammalian predators and new avian diseases. The impact on native birdlife was catastrophic (Potts 1882, Hope 1927, Stead 1927). and many species, presumably including Variable Oystercatcher, suffered substantial population declines. The Variable Oystercatcher is one of a number of native coastal and wetland bird species that have begun to show population recoveries in Canterbury in recent years (Crossland 1999).

It seems remarkable that a wader species, limited by a very small base population (c.2000 birds in the early 1970's), occupying a narrow habitat niche and highly vulnerable to predation because it feeds, roosts and nests on the ground, should be increasing in numbers so rapidly without the assistance of substantial direct conservation management. Further research into why this is occurring will not only prove enlightening but may also assist in efforts to conserve and enhance populations of other waders elsewhere in Australasia.

ACKNOWLEDGEMENTS

Many thanks to a succession of oystercatcher counters in Canterbury over the last 54 years who have either published their records, or made their unpublished data available to me. Particular thanks to Kathleen Harrison, Sheila Petch, Barry Armstrong, Stu Moore, Graham Turbott and the late George Guy. Those once-in-a-while records have now all been put to good use and demonstrate the value of long-term population monitoring! Special thanks to Phil Battley, Scott Butcher, Kathleen Harrison and Sheila Petch for providing valuable comment on earlier drafts of the manuscript.

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THE BIOMETRICS AND MOULT OF SANDERLING *CALIDRIS ALBA* IN AUSTRALIA

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ABSTRACT

The Victorian Wader Study Group has caught a total of 2558 Sanderlings on the coast of Victoria and the south east coast of South Australia during the austral summers between 1979 and 2000. Size and mass have been compared with the 441 birds caught in northwest Australia (1985 to 1998). These data have also been compared with that reported for Sanderlings studied in other parts of the world. No significant differences were evident, although small geographic differences could have been masked by sexual dimorphism. The primary moult of adult Sanderling in S.E. Australia took around 110 days, commencing (on average) at the end of October and finishing in the second week of February. Almost all first year birds also appeared to go through a complete primary moult commencing around 6 weeks later than the adults and completing by early April. Many first year birds in S.E. Australia gain weight in March and April and probably move northwards for the austral winter. Adults gained around 50% in mass before migratory departure in April. The proportion of first year birds in the population varied markedly between years, showing a close correlation with Ruddy Turnstone data and therefore presumably being a reflection of breeding success in the Arctic. Based on the dimorphic bill length differences between the sexes, an analysis of the sex ratios in various individual catches showed considerable variability but with generally a preponderance of males except in early April. This suggests that males may depart for the breeding grounds first.

INTRODUCTION

Sanderling have a circumpolar breeding distribution, breeding at high latitudes in both the Nearctic and the Palearctic regions including the Canadian Arctic, Greenland and coastal regions of northern Siberia (Engelmoer & Roselaar 1998). They undertake one of the longest migrations in the world, with birds reaching close to the southern tips of Africa, South America and Australia during the non – breeding season. The birds found in Australia probably breed mainly in the eastern parts of the Siberian breeding range, the only direct evidence being a bird flagged in Victoria and seen breeding on the New Siberian Islands (Åke Lindstrøm, pers. comm.).

Watkins (1993) estimated 11000 birds in the East Asian - Australasian flyway, including a population of 8000 birds in Australia. Adult birds depart from the breeding grounds in northern Siberia from mid-July to mid-August followed by juveniles in early August (Higgins & Davies 1996). They arrive in northern Australia from August to October (Lane 1987) and some then cross the continent to southern Australia (VWSG/AWSG unpublished recovery, retrap and flag sighting data). Northward return movements are in late March and April.

The distribution of Sanderling around the coasts of Australia is uneven, with occasional flocks of several hundred birds at preferred locations and large stretches with virtually no birds at all (Watkins 1993). In northwest Australia, the main site is at Bush Point on Roebuck Bay (near Broome) where several hundred are regularly present and up to 2000 have been seen. In Victoria, flocks of up to 200 to 400 normally occur, both in the Sandy Point and Corner Inlet (Nooramunga National Park) areas and along the western coasts between Killarney Beach, Port Fairy, and Discovery Bay, Nelson. The southeast coast of South Australia is a particular stronghold with 500, occasionally nearer 1000, spread along the beaches of Canunda National Park (near Millicent) and between Brown Bay and Port MacDonnell.

Many wader species show subspecific or clinal variations in size but data so far reported on Sanderling suggests there is negligible variation between populations breeding or 'wintering' in different parts of the world. Biometrics of Sanderling in Australia have not been extensively studied. The only previous analysis was by Jessop (1992), but this was based on only one large catch. This study analyses the biometric and moult data collected from 2558 Sanderling caught in southeast Australia (SEA) and 441 in northwest Australia (NWA) by the Victorian and Australasian Wader Study groups respectively, during the period 1979 to 2000. The data are examined for regional, temporal, age and sex differences and are compared with similar data from Sanderling populations elsewhere in the world. The moult of the primaries is a critical activity that has to be fitted into a wader's annual cycle. Its timing and duration are examined for both adult and first year birds in SEA and NWA.

STUDY AREAS AND METHODS

The SEA birds were caught at high tide roosts with cannon-nets at a variety of sites in Victoria (838) and South Australia (1720) (Fig. 1). The main catches were made over the austral 'summer', between late October and early April (Table 1), which is the period when maximum numbers of Sanderling are present in southeast Australia.

Capture sites were generally sandy wave-washed beaches backed by dunes that are typical feeding areas for Sanderlings. However, one of the sites near Port MacDonnell where birds were captured was on a stony shore, used only for high tide roosting.

In NWA, most birds were caught in two cannon-net catches at Bush Point (419) on Roebuck Bay, near Broome, in early October and late April Table 1. Small numbers were also caught at 80 Mile Beach (22) in August/October and March/April.

Measurements were obtained using methods described in Rogers (1989). Wing length (WL) was measured as maximum chord (flattened straightened wing) and recorded to the nearest mm. Total headbill (HB) and bill lengths (exposed culmen) (CL) were recorded to the nearest 0.1 mm. Birds were weighed to the nearest gram with Pescola spring balances until September 1997, after

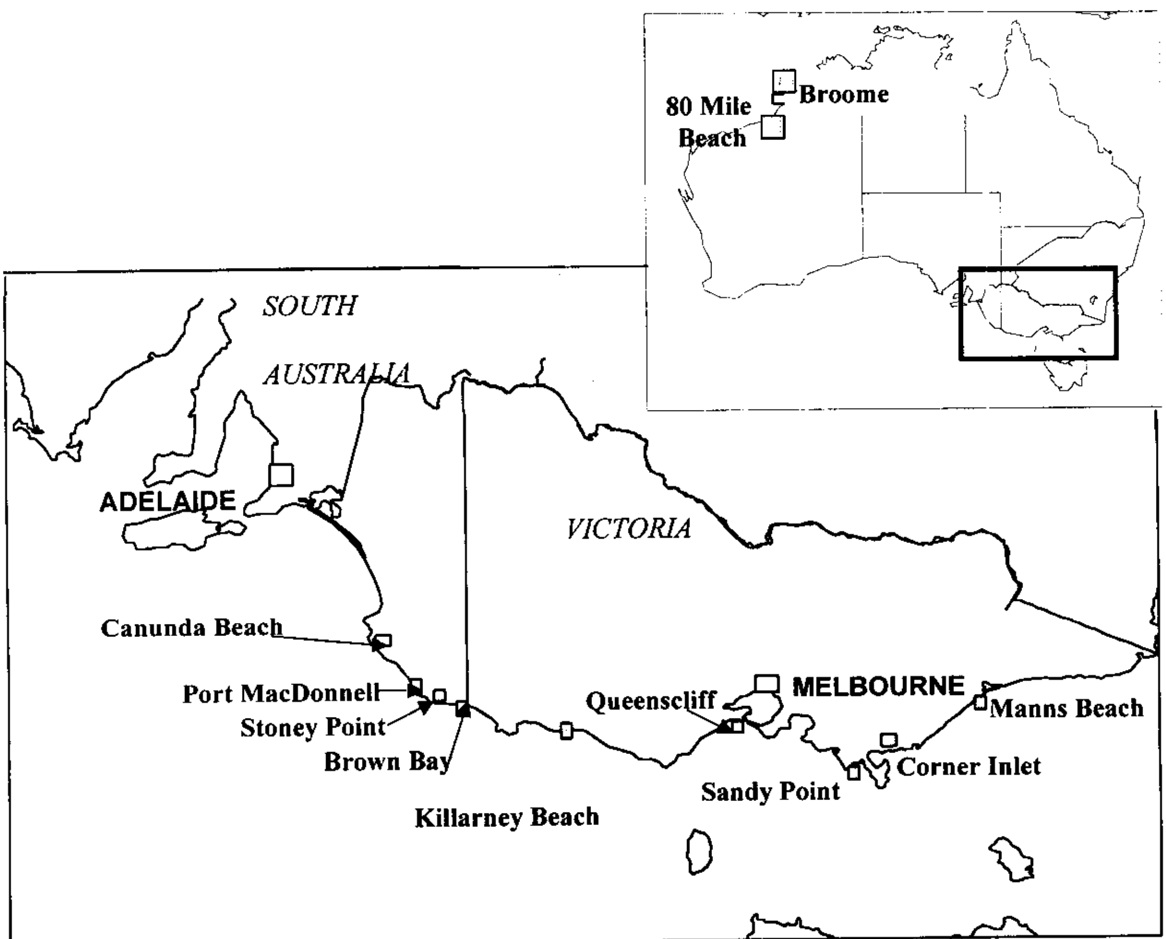

Figure 1. Sites where Sanderling have been caught in southeast Australia from 1979 - 2000. Note that Corner Inlet is the generic name for the area of the Nooramunga National Park including the offshore islands and sandbars off Mann's Beach near Port Albert.

Table 1. The age composition and the frequency of new and retrapped birds in Sanderling catches from southeast (SEA) and northwest Australia (NWA) between 1979 and 2000.

Region	Date	Location	New	Retp	Total	Age			
						1	1+	2	2+
SEA	28.12.79	Manns Beach Victoria	2	-	2	-	-	-	2
	2.1.82	Manns Beach Victoria	11	-	11	1	-	-	10
	19.10.85	Queenscliff Victoria	1	-	1	-	-	-	1
	4.11.89	Manns Beach Victoria	6	-	6	-	-	-	6
	2.3.91	Killarney Beach Vic.	208	-	208	25	29	-	154
	7.3.93	Manns Beach Victoria	35	-	35	6	-	-	29
	28.11.93	Canunda Beach SA	157	3	160	23	-	-	137
	22.1.94	Manns Beach Victoria	1	-	1	-	-	-	1
	6.2.95	Brown Bay SA	47	2	49	6	5	1	37
	18.1.96 - 19.1.96	Manns Beach Victoria	4	-	4	-	-	-	4
	10.2.96 - 11.2.96	Brown Bay SA	145	44	188	6	-	1	181
	8.11.96	Canunda Beach SA	175	61	236	5	-	4	227
	25.2.97	Stoney Point SA	99	68	168	1	1	-	166
	28.10.97	Sandy Point Victoria	47	1	48	8	-	4	36
	15.1 98	Brown Bay SA	26	5	31	24	-	2	5
	16.1.98	Canunda Beach SA	5	13	18	1	1	-	16
	19.1.98	Brown Bay SA	90	93	183	44	2	3	134
	23.2.98	Manns Beach Victoria	1	-	1	-	-	-	1
	24.2.98	Manns Beach Victoria	38	-	38	13	-	-	25
	7. 4. 98	Sandy Point Victoria	113	15	128	43	-	-	85
	22.11.98	Sandy Point Victoria	66	39	105	11	-	-	93
	24.2.99	Manns Beach Victoria	5	-	5	-	-	-	5
	4.4.99	Canunda Beach SA	63	20	83	3	-	1	79
	17.10.99	Sandy Point Victoria	4	5	9	-	-	-	9
	31.10.99	Sandy Point Victoria	38	38	76	6	-	-	70
	9.3.00	Brown Bay SA	340	122	462	58	-	-	404
	28.10.00	Sandy Point Victoria	39	20	59	-	-	6	53
	8.12.00	Canunda Beach SA	80	62	142	-	-	13	129
	14.12.00	Sandy point Victoria	57	44	101	7	-	7	87
TOTAL SEA			1903	655	2558	291	38	43	2186
NWA	4.4.85	80 Mile Beach	2	-	2	1	-	-	1
	5.4.85	80 Mile Beach	2	-	2	1	-	-	1
	26.9.92	80 Mile Beach	3	-	3	-	-	-	3
	13.10.92	80 Mile Beach	2	-	2	-	-	2	-
	21.3.94	80 Mile Beach	3	-	3	-	-	-	3
	20.4.96	Bush Point	43	-	43	12	-	-	31
	9.8.98	80 Mile Beach	4	-	4	-	-	4	-
	20.8.98	80 Mile Beach	3	-	3	-	-	3	-
	8.9.98	80 Mile Beach	1	2	3	-	-	-	3
	8.10.98	Bush Point	374	2	376	5	-	36	335
TOTAL NWA			437	4	441	19	-	45	377

which electronic balances were used.

Birds were aged according to the Australian Bird and Bat Banding Schemes code:

- 1 first year birds
- 1+ birds of unknown age which may be in their first year or older.
- 2 birds in second year
- 2+ adult birds in second year or older

Years are deemed to be from 1 August to 31 July.

The ageing technique used relied on the status and timing of the primary moult and plumage features. The following guidelines were adopted:

A. **First year birds (1).** The original set of primary feathers is retained from arrival (September / October) until the start of primary moult in December/January (around 6 weeks later than adult birds). Before moult, primary feathers of first year birds are in better condition than those of adults. Juvenile plumage is retained up to February - March and can be identified by cream-buff fringes with narrow dark

Table 2. Biometrics of Sanderling in southeast (SEA) and northwest Australia (NWA) (S.D. = Standard deviation; * = 'old primaries' - measured prior to 10 February; ** = 'new primaries' - measured after 10 February).

Measurements (mm)	Age	SEA Mean	S.D.	Range	N	NWA Mean	S.D.	Range	N	*t*	*P*
Bill length	1	25.2	1.5	21.7-28.9	214	25.8	1.7	23.5-29.6	18	1.61	>.05
	2+	25.1	1.5	20.9-29.7	1433	25.5	1.5	21.9-29.9	414	4.78	<.05
Total head length	1	50.4	1.8	46.5-55.6	205	50.4	2.3	47.0-56.3	18	0	>.05
	2+	50.5	1.8	45.0-57.6	1409	50.3	1.7	46.3-54.9	413	1.18	>.05
Wing length	1	124.4	3.6	116-136	151	124.6	3.5	117-139	17	0.22	>.05
	2+*	126.3	3.7	112-137	743	125.2	3.7	115-136	364	4.65	<.05
	2+**	128.9	3.2	120-139	413	129.5	2.8	123-136	31	1.01	>.05

terminal edges on median and secondary coverts and tertials. Lack of, or lateness in assuming, breeding plumage by March or April also indicates that a bird is in its first year, as do retained worn faded brownish coverts (with fringes now worn off).

B. **Adult birds (2+)** On arrival (September), adults have not commenced primary moult and have worn outer primaries (although there is considerable individual variation). Primary moult commences in October and is generally completed by late January. Some breeding plumage is usually still present in birds on arrival. Moult into breeding plumage does not commence until late February/March and this is far from complete in most birds when they depart in April.

C. **Second year birds (2)** These are not easy to distinguish because many birds carry out a complete primary moult in their first year and also assume at least a partial breeding plumage. However it is considered that some individuals can be aged, particularly early in their second year (August/September), on the basis of their relatively less worn primaries (compared with full adults) or if they have undergone only partial primary moult in the first year.

Moult was recorded for the primary feathers for one wing of each bird using the nomenclature described in the ABBBS Manual (Lowe 1989). In most birds, where checked, the primary moult was identical on both wings. The Primary Moult Score (PMS) is the sum of each of the individual primary feather scores recorded and is a measure of the relative stage of moult in a given bird. As waders have 10 main primaries, the PMS can range from 0 (moult not started) to 50 (moult completed).

In all the biometric and moult analyses, data from both newly banded birds and retraps are combined, assuming that each catch was an independent sample of the population. Adults (2+), first year (1) and birds aged simply as 1+ were analysed separately. Age 2 birds were grouped with adults for most purposes in this analysis. Statistical analyses were mainly carried out with Systat 5.0.

RESULTS AND DISCUSSION

Bill Length

There were no significant differences in bill length between age classes at either site (Table 2). For adults, mean bill length in SEA was slightly (1.6%) less than in NWA, but as samples were unsexed and the NWA sample was mainly from one catch in October, the difference could be due to different sex ratios.

In Table 3 bill length measurements for Sanderlings around the world are summarised. While not exhaustive, the samples cover the main Atlantic and Western Hemisphere flyways. Comparisons between the unsexed samples from South Africa, Delaware Bay, N. Taimyr, E. Greenland, Teesmouth and Mauritania and the samples from SEA, showed no differences (P<0.05), confirming that Sanderlings around the world have similar length bills. Birds from SW Iceland had shorter bills than those in SEA ($t = 4.6$ P<0.01), however, it is possible that the birds captured in May could have contained a high population of smaller males.

Table 3. Comparison of biometric measurements (in mm) and mass (in g) of Sanderlings from throughout their geographic range (THL = total head length).

Feature	Location	Age	N	Mean	S.D.	Range	Comment	Source
Bill length	Australia	Adult	7	24.8	1.43	23.3 - 27.0	Skins	(1)
		Immature	7	25.9	0.74	25 - 26.9	" "	
		All (male)	18	24.1	1.62	22.1 - 27.5	" "	
		All (female)	11	25.6	1.17	23.6 - 28.6	" "	
	N.Taimyr	Adult (male)	31	24.1	0.8	22.8 - 25.8	Live	(3)
	(Siberia)	Adult (female)	36	25.6	1.0	23.9 - 27.4	" "	
		Adult (unsexed)	105	24.9	1.2	22.4 - 27.4	" "	
	Netherlands	Adult (male)	38	24.4	1.36	21.7 - 27.3	Live	(2)
		Adult (female)	55	25.7	1.10	24.2 - 27.8	" "	
	South Africa	Adult (male)	53	24.9	1.1	24.6 - 25.2	Live	(4)
		Adult (female)	20	26.2	1.0	25.7 -26.7	"	
		Adult (unsexed) Oct	35	24.9	1.4	22.5 - 28.0	"	
		Age 1 Oct	10	25.0	0.8	24 - 26	"	
	E. Greenland	Adult (All)	38	24.8	1.5	20.6 - 27.0	Live	(5)
	SW Iceland	Adult (All)	224	24.6	1.5	20.1 - 29.9	Live	(5)
	S. Uist Scotland	Adult (All)	61	25.4	1.5	22 - 28	Live	(5)
	Teesmouth UK	Adult (male)	22	23.3	1.2	21 - 26	Live	(8)
		Adult (female)	20	25.5	1.4	24 - 28	Live	(8)
	Mauritania	Adult (All)	31	24.6	1.9	20.9 - 27.9	Live	(2)
	Delaware Bay (USA)	Adult (All)	311	25.3	1.7	20.8 - 29.4	Live	(6)
	N. Canada	Adult (male)	45	24.8	0.9		Skins	(7)
		Adult (female)	39	26.6	1.1		Skins	
	Alaska	Adult (male)	17	24.6	0.8		Skins	(7)
		Adult (female)	11	27.1	1.1		Skins	
THL	N. Taimyr	Adult (male)	18	49.4	0.9	48.0 - 51.2	Live	(3)
	(Siberia)	Adult (female)	29	51.1	1.2	49.3 - 53.1	"	
		Adult (unsexed)	82	50.5	1.5	46.9 - 55.5	"	
	Delaware Bay (USA)	Adult (unsexed)	310	51.3	2.2	42.5 - 59.7	"	(6)
Wing	Australia	Adult	6	125.5	2.74	122 - 128.6	Skins	(1)
		Immature	6	124.5	3.45	121 - 130	" "	
		All (male)	12	123.3	3.2	120 - 129	" "	
		All (female)	20	125.0	2.41	121 - 128	" "	
	N. Taimyr	Adult (male)	31	126	2.3	122 - 134	Live	(3)
	(Siberia)	Adult (female)	36	129.5	2.4	123.5 - 135	"	
		Adult (unsexed)	104	127.6	2.9	122 - 135	"	
	Netherlands	Adult (male)	17	124	1.99	122 - 128	Skins	(2)
		Adult (female)	28	129	1.89	126 - 132	" "	
	E. Greenland	Adult (All)	38	126.9	3.7	121 - 137	Live	(5)
	SW Iceland	Adult (All)	224	127.8	3.3	117 -135	Live	(5)
	S. Uist Scotland	Adult (All)	61	127.3	3.5	113 - 135	Live	(5)
	Teesmouth UK	Adult (male)	22	124.7	4.5	117 - 132	Live	(8)
		Adult (female)	20	130.6	2.6	123 - 134	Live	(8)
	Mauritania	Adult (All)	31	126.8	3.7	118 - 133	Live	(5)
	South Africa	Adult (All)	342	128.0	3.1	117 - 136		(5)
	Delaware Bay (USA)	Adult (All)	315	125.9	4.0	115 - 137	Live	(6)
	N. Canada	Adult (male)	45	125.6	2.7		Skins	(7)
		Adult (female)	39	129.1	2.9		Skins	
	Alaska	Adult (male)	17	125.3	2.9		Skins	(7)
		Adult (female)	11	127.5	2.6		Skins	
Mass	N. Taimyr	Adult(m) June-Aug	33	54.3	4.0	42.7 - 59.7	Live	(3)
	(Siberia)	Adult(f) June-Aug	34	62.3	6.3	48.6 - 70.5	"	
		Adult unsexed " "	103	57.9	6.6	42.7 - 70.5	"	
	Morocco	September	32	48.5	4.53	37 - 60	Live	(2)
	Mauritania	Sept - Nov	129	45.5	4.47	33 - 58	Live	(2)
	South Africa	Sept - Feb	527	54.4	4.29	43 - 69	Live	(9)
		Weeks1&2 Mar	42	55.9	4.7	44 - 75		
		Weeks3&4 Mar	295	64.0	8.0	46 - 83		
		Weeks 1&2 Apr	59	68.6	7.9	54 - 87		
		Weeks 3&4 Apr and Weeks1&2 May	110	82.8	9.85	59-102		
	Delaware Bay (USA)	Adult April/May	312	55.4	6.5	30 - 75	Live	(6)

(1) Higgins & Davies (1996), (2) Cramp & Simmonds (1983), (3) Soloviev & Tomkovich (1995), (4) Summers et al. (1987), (5) Gudmundsson & Lindstrøm (1995), (6) Allan Baker (pers. comm.), (7) Engelmoer & Roselaar (1998), (8) Wood (1987), (9) Summers & Waltner (1979)

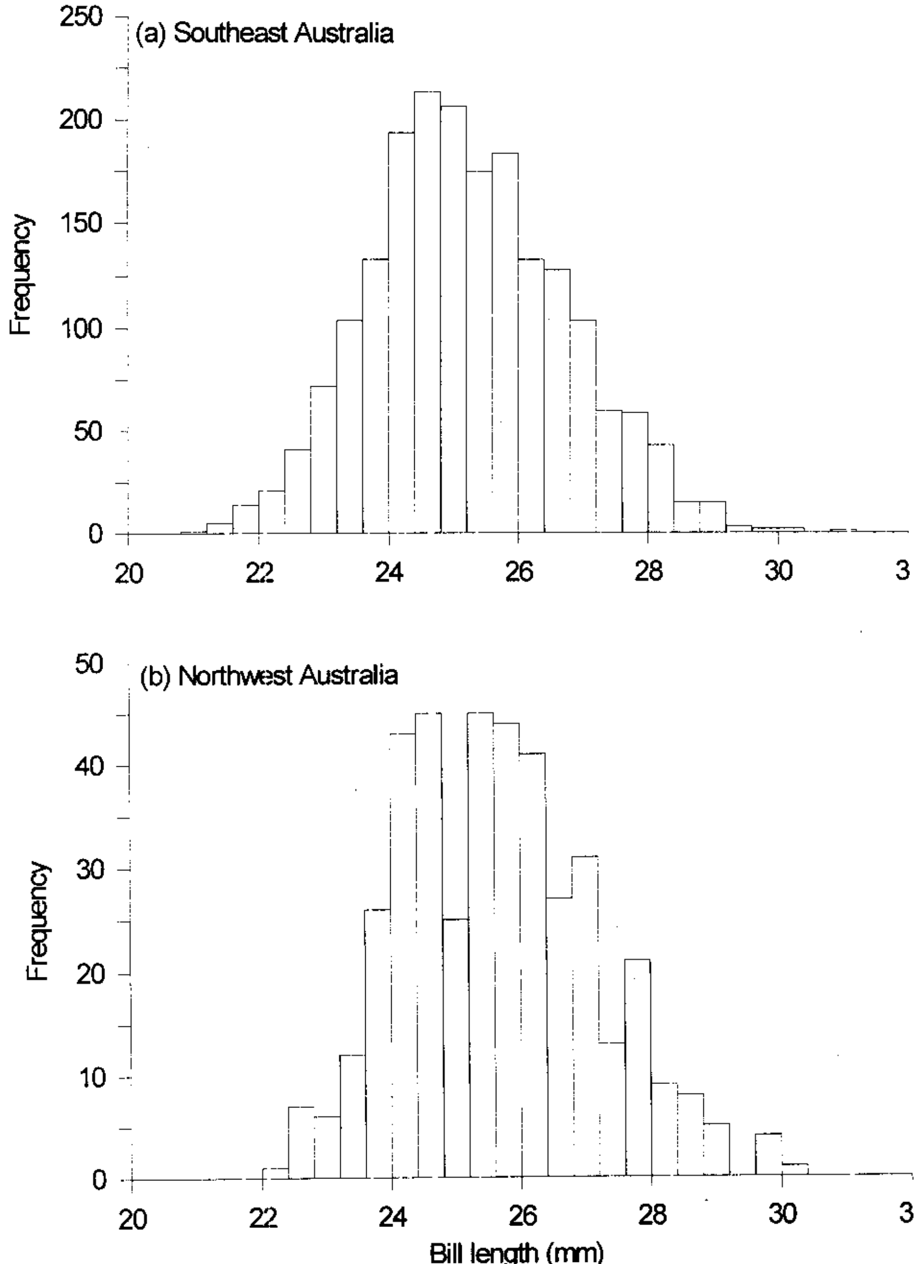

Figure 2. Frequency distribution of bill lengths for Adult (2+) Sanderlings (a) SEA (N = 1931), (b) NWA (N = 414).

Sexual differences in bill length have been shown by Summers et al. (1987) and Soloviev and Tomkovich (1995) (Table 3). This difference has been reported in Higgins & Davies (1996), Cramp & Simmonds (1983) and Engelmoer & Roselaar (1998) with females being on average larger than males in all samples. Females are typically 5-6% longer in the bill. The frequency distribution of bill lengths of Sanderling from SEA and NWA (Fig. 2) shows some indication of bimodality, was more evident in the NWA sample that was taken mainly from a single catch in October. The South African study also showed that there were seasonal variations in bill lengths, particularly in adult (1+) birds. There was no evidence for this in Australia (Table 4). Seasonal variation in bill lengths could well reflect the moult of feathers at the bill base rather than growth or changing populations.

Total Head Length

There were no significant differences in total head length between NWA and SEA (Table 2). However Delaware Bay birds were significantly longer (t =3.7, P<0.01). This measurement is subject to a similar influence of sexual difference as bill length and the results could therefore be dependent on the ratio of sexes within the sample. Overall, there does

Table 4. Monthly variation in mean bill length (mm) of adult and first year Sanderlings from southeast Australia (SEA) and northwest Australia (NWA) over the Austral summer (S.D. = standard deviation).

Month	Adult (2+)						First Year (1)					
	SEA			NWA			SEA			NWA		
	Mean	N	S.D.	Mean	N	S.D.	Mean	N	S.D.	Mean	N	S.D.
October	25.3	40	1.5	25.4	371	1.5	26.2	8	0.9	26.3	5	2.2
November	25.0	454	1.5	-	-	-	25.1	39	1.5	-	-	-
December	25.0	210	1.3	-	-	-	25.5	7	1.6	-	-	-
January	24.4	134	1.3	-	-	-	24.6	44	1.5	-	-	-
February	25.3	384	1.4	-	-	-	25.0	7	1.0	-	-	-
March	24.9	182	1.4	-	-	-	25.5	31	1.5	-	-	-
April	25.5	165	1.5	26.5	31	1.3	25.1	46	1.4	25.5	12	1.5

not appear to be any significant geographical variation.

Wing Length

The mean wing length of adult birds in SEA with 'old' feathers prior to the completion of moult (second week of February) was 126.3 mm and for NWA 125.2mm (t = 4.6, P<0.01). This difference is significant but may be related to the widely reported greater rate of wing feather wear in the tropics. The corresponding wing lengths following moult were 128.9 mm and 129.5 mm, this difference was not significant (t = 1.0, P>0.40). However, a comparison of wing lengths after moult with those reported in other parts of the world for unsexed birds (Table 3) shows variable levels of difference. The wing lengths of birds captured at Teesmouth over a 12 month period were similar to the SEA population (t = 2.57, P>0.01) while those reported from Delaware Bay, Northern Taimyr (Siberia), South Africa, Greenland and SW Iceland were significantly different (t = 11.2, 3.8, 3.9, 3.6 and 4.1, P<0.01 respectively). With mean wing lengths of all samples spanning only 3.5 mm and given the potential for differences in measurement technique and for variation in feather wear between samples, it seems likely that wing lengths of Sanderling worldwide are extremely similar.

The mean wing length for a small sample of first year birds prior to the completion of their first moult in SEA was 123.7 mm (SD = 3.6, N = 108) and 121.8 mm (SD = 3.4, N =5) for NWA. As found by Summers et al. (1987) wing lengths of first year birds before moult were shorter (123.7 mm) than those of adults after moult (127.3 mm).

Mass

The mean body mass of adult Sanderling in SEA showed substantial changes over the austral summer period (Table 5). Before migratory fuelling in February/March, monthly mean adult masses ranged from 52.3 to 56.1 g (mean 54.6g, individual range from 43 to 76 g). The October/ November means were probably biased upwards because of the presence of a small number of birds still

Table 5. Variation in mass of Sanderlings caught during the Austral summer in southeast Australia and northwest Australia.

Region	Month	Adult (2+)				First Year (1)			
		Mean	S.D.	Range	N	Mean	S.D.	Range	N
SEA	October	53.9	4.8	46 – 66	40	54.7	2.7	51 - 61	7
	November	54.6	4.7	43 - 76	459	55.2	5.8	41 - 64	39
	December	50.7	3.7	43 - 60	207	54.2	3.0	49 - 58	7
	January	52.3	3.6	44 - 61	165	51.6	3.3	44 - 58	70
	February Weeks 1 & 2	56.0	4.6	44 - 68	215	53.1	2.8	50 - 57	12
	February Weeks 3 & 4	56.3	4.4	45 - 67	196	50.8	4.3	44 - 57	13
	March Weeks 1 & 2	61.5	4.5	52 - 74	181	58.4	3.7	50 - 67	31
	April Weeks 1 & 2	67.6	5.6	53 - 83	164	56.1	4.3	45 - 66	45
NWA	Week 4 Sept (26/9/92)	50.3	-	47 - 55	3	-	-	-	-
	Week 2 Oct (8/10/98)	53.3	-	43 - 67	332	46.2	-	41 – 54	6
	Week 3 March (21/3/94)	73.0	-	69 - 78	3	-	-	-	-
	Week 1 Apr (4-5/4/85)	59.0	-	57 - 61	2	48.5	-	48 – 49	2
	Week 3 Apr (20/4/96)	70.0	-	57 - 80	31	48.0	-	41 – 58	12

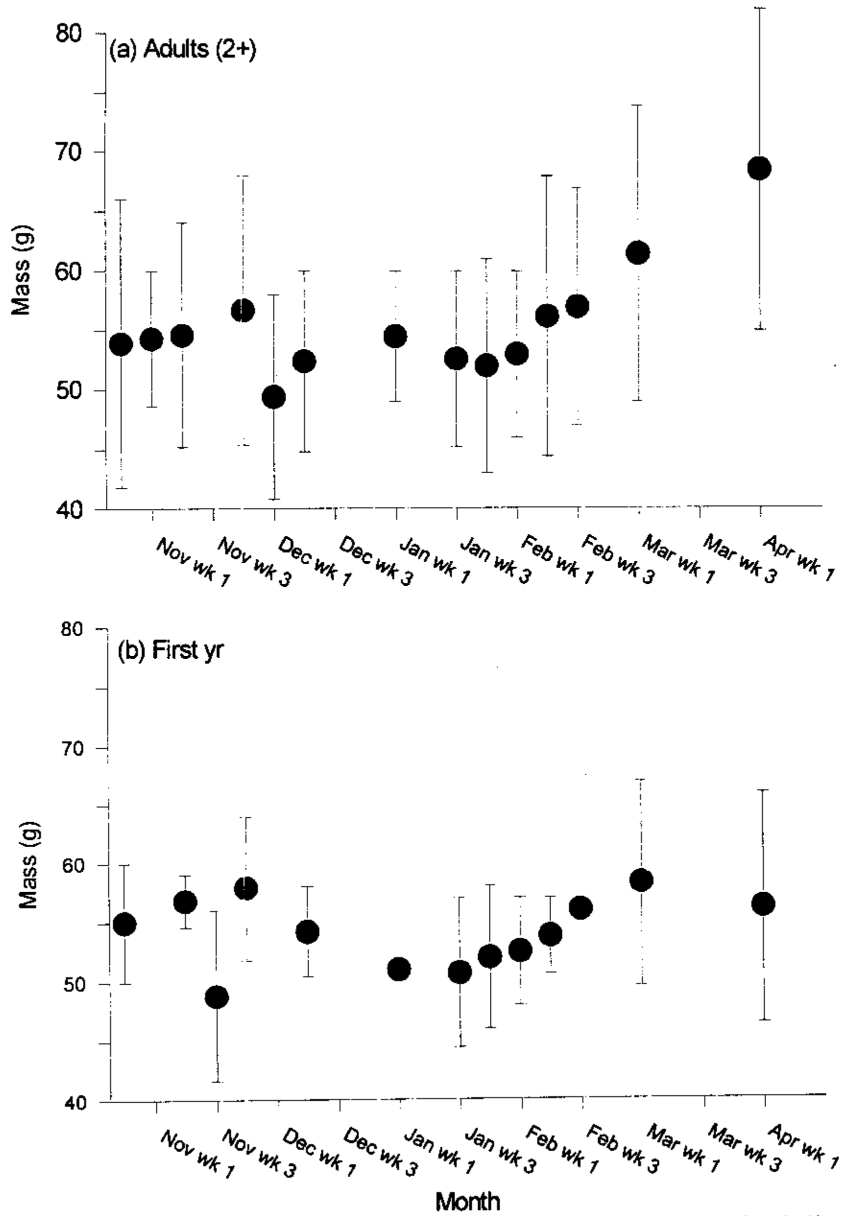

Figure 3. Mean and range in mass of (a) Adults (2+) and (b) First Year Sanderling over austral summer in SEA.

carrying migratory fat reserves. These could have been either birds still on migration to other non-breeding areas (eg. Tasmania) or birds that have arrived with surplus fat. The lower weights in many waders in Australia that are reached during December/ January could in fact be due to birds moulting their primaries (Fig. 4). Rogers et al. (1996) showed that for Red Necked Stints *Calidis ruficollis* in SEA, there was an apparent weight loss until the primary moult score reached about 30, which for Sanderling, occurs around this period (Fig. 5).

The weight increase prior to departure on northward migration clearly began in February (Fig. 3), after the primary moult had been completed. It continued through March, with the mean mass in SEA reaching 67.6 g (range 53 to 83 g) in the first week of April (latest catch was 7 April). This apparently low and slow increase (approx. 0.5 $g.d^{-1}$) in the mean mass of adults prior to departure on migration appears to be because there is a wide spread in the timing of weight gain between individuals. The population starts decreasing in late March but significant numbers can still be present until late April, suggesting a prolonged overall departure period. It is probable that birds reach weights in the range of 70 to 85 g before departure from SEA, an increase of around 45-50% from the January masses. This increase is

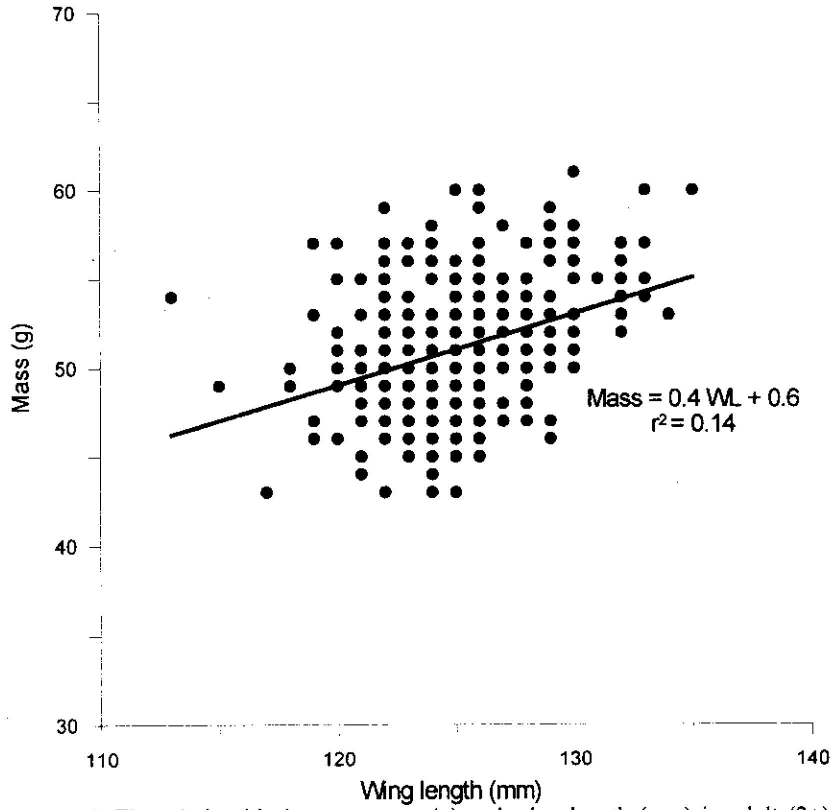

Figure 4. The relationship between mass (g) and wing length (mm) in adult (2+) Sanderling caught in SEA in December/January.

less than many other species departing from SE Australia and is significantly less than recorded in South Africa (see later), in the UK in May (CM, pers. obs.) and on Delaware Bay (mean of 85 g reached in late May/early June with individuals ranging in weight up to a phenomenal 110 g - CM, pers. obs.).

First year birds had a mean mass of 53.0 g for the period October to February, slightly lighter than that of adults. Mean weights are heavier in March and April, but not as heavy as adults and with no individuals heavier than 67 g. The fact that some, perhaps many, first year birds put on weight (and carry out a complete primary moult and assume at least partial breeding plumage) suggests they intended to make a partial northward migration. Such an exodus is also supported by winter counts, which are generally lower than numbers expected from the proportion of first year birds in the summer population samples.

Birds captured in NWA in October 1998 had a mean mass of 53.3 g (Table 5). The majority had already commenced wing moult and this, coupled with the fact that only a small proportion had increased in weight, suggests that the majority of adults on passage to southern Australia had already passed through. The mean mass in NWA prior to departure (late April) was 70.0 g, which compares with the mean of 67.6 g in SEA in the first week of April. Both means are depressed by several low weight individuals, which suggests that the mean weight of departing birds may be heavier.

Mean mass of first year birds in NWA in April was 48 g and is much less than that found in birds in SEA (56.1 g). There were no heavy individuals in NWA and presumably these birds remain in NWA over the winter.

Comparison with mass data from South Africa

These patterns of mass variation observed in SEA are similar to those detailed by Summers et al. (1987) for Southern Africa (Table 6). However, the South African adult birds have a mean mass prior to departure of 85.4 g; equivalent to the highest recorded mass of an individual from SEA. Therefore, the South African birds appear to accumulate more fuel prior to departure which also appears to be later than from SEA. These facts suggest that the initial migratory flight made by the South African birds is longer than that made by

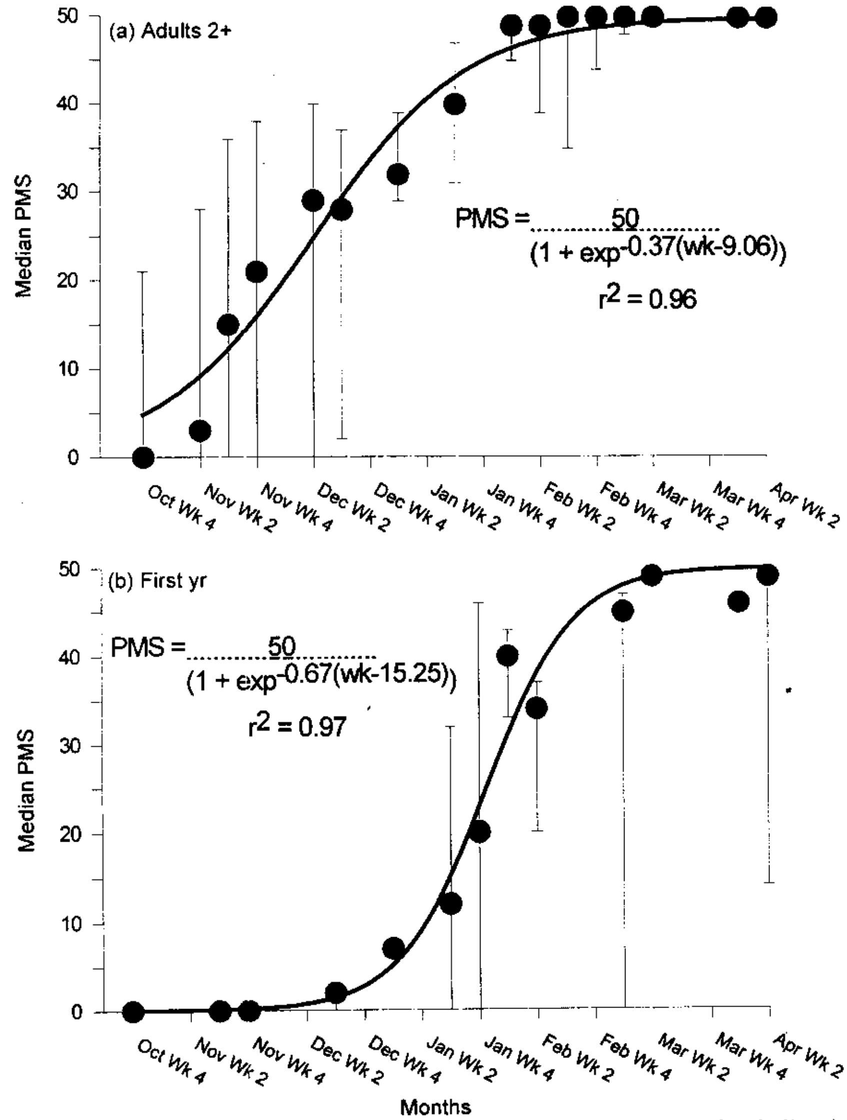

Figure 5. Plot of Median of (a) Adults (2+) and (b) First Year (1) Sanderling in SEA from October to April.

SEA birds. In contrast, first year birds from South Africa do not appear to gain weight in March/April (Table 6), suggesting that they do not make significant movements away from their non-breeding grounds in their first year.

Variation in mass with respect to size

Larger birds were heavier than smaller birds in December/January, when individuals are probably nearest their 'base masses' (Rogers et al. 1996) (Fig. 4). Part of this size variation is presumably sexual in origin (Soloviev & Tomkovich 1997). But

Table 6. Comparison of Sanderling mass (g) by month between South Africa and SEA. South African data are from Summers et al. (1987).

Month	Adult				First Year			
	S. Africa	N	SEA	N	S. Africa	N	SEA	N
October	54.0	176	53.9	40	48.2	10	54.7	7
November	54.6	96	54.6	459	52.3	27	55.2	39
December	53.9	98	50.6	207	52.1	61	54.2	7
January	54.0	170	52.3	165	53.1	77	51.6	70
February	55.8	318	56.1	411	51.7	58	53.0	25
March	60.6	462	61.5	181	53.0	31	58.4	31
April	77.2	203	67.6	164	51.9	34	56.1	45
May	85.4	34	-	-	55.6	7	-	-

Table 7. Percentage of first year Sanderlings and Ruddy Turnstones in catches in southeast Australia between late October and early April.

Year	SANDERLING		RUDDY TURNSTONE	
	N	First year birds (%)	N	First Year birds (%)
1981-82	11	10	-	-
1990-91	208	14	-	-
1992-93	35	21	-	-
1993-94	161	17	-	-
1994-95	49	14	-	-
1995-96	192	3	122	9
1996-97	404	2	247	5
1997-98	447	42	240	67
1998-99	193	8	192	9
1999-00	569	14	131	41

Sanderlings are not so sexually dimorphic to have non-overlapping size measurements in males and females. The significant relationship between mass and wing length (Fig. 4) could be used to correct premigratory body masses for differences in body size, especially if the sex ratio (and hence relative sizes) of the population studied is thought to vary during the fuelling period.

Breeding origins

Engelmoer & Roselaar (1998) found slight sexual and geographic differences for Sanderling, sexual differences being larger than geographic differences. While they propose that two morphometrically different populations can be recognized, (1) N. Canada and Alaska, and (2) Greenland and Siberia, the differentiation requires knowledge of the sex of the bird and at least 4 measurements (wing, culmen, tarsus and secondary lengths). We do not have sufficient data collected from our samples of live birds to make these comparisons. Based on the data available, the SEA and NWA birds are morphologically similar to Sanderling breeding in Siberia (Table 3). No further analysis is possible because of the inability to sex individual live birds.

Percentage of first year birds

There is a marked annual variation in the percentage of first year birds in our samples ranging from 1.5% to 42% but lacking any regular cycle (Table 7). As the samples in seven of these years constituted 10 – 30% of the population in the study areas, the figures should be indicative of the relative breeding success of Sanderling in the different years. On this basis 1990, 1993 and 1999 could probably be classed as good breeding years, 1997 as an exceptionally good breeding year, 1995 and 1998 as poor breeding years, with 1996 being exceptionally poor. There is a correlation with the apparent breeding success of Ruddy Turnstones, *Arenaria interpres*, another high arctic breeder, in the 1995 – 1999 period (VWSG data, Table 7; $r^2 = 0.90$, $P < 0.05$). The overall percentage of first year birds in the Sanderling population over the 20-year period is 14.6%.

Primary moult

By analysing the primary moult score of the captured birds over the austral summer it is possible to establish the timing and duration of moult (Ginn & Melville 1983). The data from all years were pooled; this assumes the same moult timing occurred each year.

The PMS of adults (2+) and first year birds (1) in catches in SEA suggest the average moult duration for adult birds in SEA is around 110 days (Table 8; Fig. 5), with the median start date being in the last week of October and the median finish date in the second week of February. First year birds commence moulting at least 6 weeks later than the adults, around mid to late December, and finish their complete moult by early April, a duration of around 105 days. The logistic regression of median moult score on time shows that the timing of primary moult is more protracted in adults than first year birds (Fig. 5).

Moult scores from 40 second year birds caught during the moulting period suggest some second year birds commenced moulting earlier than returning adults. For example, on 28 October the median PMS of 6 birds was 11 (range 3 - 17) compared to zero for adult birds. However, other

Table 8. Primary moult score of catches of Sanderling in SEA on different dates.

Date	Adult (2+)			First Year (1)		
	Median PMS	Range	N	Median PMS	Range	N
28 October 1997	0	0-21	36	-	-	-
28 October 2000	0	0 - 6	53	-	-	-
8 November 1996	3	0-28	225	-	-	-
22 November 1998	15	0-36	93	0	0	10
28 November 1993	21	0-38	131	0	0	21
8 December 2000	29	0 - 40	126	-	-	-
14 December 2000	28	2 - 37	83	2	0 - 3	7
28 December 1979	24	19-30	2	-	-	-
2 January 1982	32	29-39	10	7	7	1
15 January 1998	48	30-49	4	12	0 - 32	24
16 January 1998	40	31-47	12	28	28	1
18/19January 1996	35	14-35	3	-	-	-
19 January 1998	44	6-50	119	20	0 - 46	43
22 January 1994	36	36	1	-	-	-
6 February 1995	49	45-50	37	40	33 - 43	6
10/11February 1996	49	39-50	181	34	20 - 37	6
24 February 1999	50	35-50	5	-	-	-
25 February 1997	50	44-50	166	22	22	1
2 March 1991	50	48-50	151	45	0 - 47	25
7 March 1993	50	50	29	49	49	6
9 March 2000	50	43 - 50	404	40	25 – 50	52
4 April 1999	50	50	76	46	45 - 47	3
7 April 1998	50	50	85	49	14 - 50	43

December catches showed no difference; the median PMS for second year birds caught 8 and 14 December (N=13 and 7) is 25 which is similar to adult birds. This is not altogether surprising as many first year birds do a complete moult and make a migration in their first year. This contrasts with some other species whose primary moult in their second year is on average ahead of adult birds (VWSG/ AWSG unpubl. data)

Contrary to Higgins & Davies (1996), it is apparent that almost all (96%) first year birds in SEA undergo a complete moult during their first austral summer (Table 9). Of those that don't complete such a moult, most retained all their 'old' feathers (O^{10}). However, there were examples (also observed in their second year) of birds that left one or two of the outermost feathers unmoulted. In some cases the initial moult, that had been arrested, was resumed in the second year, completing the arrested moult in parallel with carrying out a 'conventional' complete moult starting (again) at the innermost primary. Thus, any bird with simultaneous moult at two places in the wing is likely to be a second year bird. This is confirmed by two retraps originally banded as first year birds on 9 March 2000 at Brown Bay and recaptured 8 December 2000 as 2nd year birds (moult of $5^{2}4^{1}1^{2}R^{4}O^{1}$ and $5^{5}2^{1}R^{3}2^{1}$ respectively, where R = replaced).

Of 12 first year birds caught on 20 April in NWA, ten had completed (or were completing) a full primary moult. The other two birds were undertaking only a partial moult of the outermost 7 and 4 primaries respectively.

Of all 291 first year birds caught in SEA, only two

Table 9. Proportion of first year birds undertaking a complete primary moult in southeast Australia.

Date	Number Caught	Number in Primary Moult	Percentage in Primary Moult
15-19.1.98	69	60	87
10-11.2.96	19	19	100
2.3.91	19	18	95
9.3.00	58	54	93
7.4.98	43	42	97

Table 10. Monthly changes in the percentage of birds with different amounts of breeding plumage in southeast Australia.

Month	N	Breeding Plumage (%)			
		Trace	10-25	25-50	>50
February Weeks 3 & 4	171	8.7	5.8	-	-
March Weeks 1 & 2	310	44.5	5.2	-	-
March Weeks 3 & 4	-	-	-	-	-
April Weeks 1 & 2	164	26.2	39.0	20.7	7.0

were undertaking a partial primary moult, commencing mid wing, as is found on many other first year waders in Australia (e.g. Curlew Sandpipers, *Calidris ferruginea*). This seems to be far less frequent than reported by Davies (1982) (also quoted in Higgins & Davies 1996), who reported two such birds in a small sample caught in early March in Perth. There may therefore be some variation in the moulting pattern of first year birds around Australia.

Also, in eight Sanderling caught in NWA in August 1998 at the beginning of their second year, six had completed a full moult. However the other two were in active moult ($5^2 4^1 3^1 R^6$ and $5^1 4^1 1^1 R^7$). These could have also replaced all their feathers in the first year and been then commencing a normal moult in their second year. But equally they could have replaced only the outer six or seven (respectively) feathers in the first year and then been in the process of replacing the inner, originally unmoulted, feathers.

In a catch at Sandy Point on 26 March 2001, we had difficult in identifying some retrapped first year birds (originally banded October and December 2000). Some first year birds were found to have completed the moult of all primaries, secondaries, wing coverts and tail feathers. Others were easier to identify as moult was still occurring in the wing and tail. It is increasingly difficult to age first year birds on plumage characteristics once the prebasic moult is complete, as they do not retain any diagnostic feathers. This leaves lighter weight and the reduced amount of breeding plumage as the only guide to first year birds.

Breeding Plumage

Birds caught in the period February to April in Victoria displayed breeding plumage to varying degrees (Table 10). In the samples caught at Sandy Point and Canunda Beach in the first week of April, almost all adult birds showed some form of breeding plumage. This varied from a 'trace' to 75% but with the majority being 25% to 50%, a somewhat lower proportion to that observed in other species during the same period. Most other species assume 75% breeding plumage before departure from SEA or NWA (VWSG & AWSG unpubl.). Sanderling must therefore either depart much later than other species or else complete the body moult during migration. In 1999, few birds were present by the end of the second week of April suggesting moult is completed elsewhere.

At Sandy Point and at Canunda, not only were almost all first year birds completing a total moult including all body, wing and tail feathers but there was also some evidence of partial breeding plumage on a significant number of these birds. Although some of these birds may have made a partial northward movement in late April/May it is unlikely, based on their plumage and their weights, that any reach the breeding grounds (as some first year birds do in other flyways, Cramp & Simmonds 1983).

Table 11. The estimated percentage males in samples of Sanderlings in southeast (SEA) and Northwest (NWA) Australia, the bill length (mm) of males and females and the SHEBA bill criteria (mm) used to estimate the sex ratios of the samples.

Region	Age group	Males (%)	N	95% confidence level				50% confidence level		
				Male		Female		Bill Criterion	Male (%)	Female (%)
				Bill	S.D.	Bill	S.D.			
SEA	All adults (2+)	67	1145	24.6	1.2	26.6	1.2	25.6	65	35
SEA	All first year (1)	60	151	24.2	0.9	26.7	0.9	25.4	59	41
NWA	All adults (2+ and 2)	66	414	24.8	1.1	26.9	1.2	25.9	64	36

Table 12. The estimated sex ratios (%) of catches of Sanderling obtained with SHEBA.

Region	Date	Location	N	SEX RATIOS	
				Male	Female
SEA	28.10.97	Sandy Point	39	41	59
	8.11.96	Canunda B.	223	75	25
	22.11.98	Sandy Point	89	73	27
	28.11.93	Canunda B.	135	48	52
	8.12.00	Canunda B.	138	60	40
	14.12.00	Sandy Point	100	75	25
	19.1.98	Brown Bay	131	58	42
	10.2.96 - 11.2.96	Brown Bay	179	69	31
	25.2.97	Stoney Point	151	70	30
	2-3-91	Killarney B.	153	62	38
	9.3.00	Brown Bay	126	75	25
	4.4.99	Canunda B.	79	32	62
	7.4.98	Sandy Point	84	33	67
NWA	8.10.98	Bush Point	371	67	33

Sex ratios

For breeding and non-breeding birds, there are no distinguishing plumage features to separate the sexes. Therefore unless the sex of a bird is determined genetically (Baker et al. 1999) or from dissection, the estimation of the proportion of each sex in samples depends on size dimorphism (Cramp & Simmonds 1983, Higgins & Davies 1996). If sexes differ sufficiently in size, frequency histograms of body measurements may appear bimodal. If so, then the SHEBA program (Rogers 1995) can be used in an attempt to discriminate between the sexes.

Using the data on the adult (2+) Sanderling referred to in Table 1, histograms were prepared for two variables: bill length and wing length. Bill length was more bimodal and therefore appeared to have more discriminating power in such an analysis. Analysing the sample of adult birds captured in SEA up to 4 April 1999 (excluding outliers) the estimated mean bill length of males was 24.6 mm and females 26.6 mm. The difference between male and female bill length of 8.1% is similar to the difference found by Engelmoer & Roselaar (1998) in museum specimens from N. Canada, Greenland and Siberia. Biometric studies of Sanderling breeding in N. Taimyr found a mean bill length for males of 24.1 mm (SD = 0.8 N = 31) and females 25.6 mm (SD = 1.0 N =36) (Soloviev & Tomkovich 1995).

The overlap of frequency distribution of the two sexes in SEA results in a poor level of confidence in the use of this criteria to sex individual birds. However, using a 50% confidence level the technique can be used to provide an indication of sex ratios. For the sample of adult birds up to 4/4/99 (N = 1145), the resulting sex ratio is 65% male and 35% female. A similar proportion was found for the Bush Point (NWA) catch (8 October 1998).

A similar analysis of the total sample of Age 1 birds, applying the 50% confidence level, found the sex ratio of first year birds is 59% male and 41% female, similar to the adult birds. Using the same rule (50% confidence level) on large catches within the data shows that for the period between November and March, the proportion of males in a sample varies from 48% to 75% (Table 12). In the two samples captured in April (Sandy Point and Canunda Beach) the proportion of males was smaller, 33% and 32%. The lower percentage of males present in these samples may be due to males departing for the breeding grounds prior to this date. The variation in sex ratios on the South Australian beaches (Canunda and Brown Bay) may mean that these beaches are used by birds travelling from and to the breeding grounds, although additional information is needed within a season to confirm this suggestion. The apparent high percentage of males (75%) observed in the retraps at Brown Bay (9 March 2000) also comprised 15% of birds banded in Victoria, indicating these birds could be moving northwest along the coast. In contrast, there were no Victorian birds among the 62 retraps of the catch of 142 at Canunda on 8 December 2000. This will be a matter for further study.

Summers et al. (1987) collected 78 Sanderling shot at Langebaan Lagoon, South Africa and were able to correlate biometric measurements with sex. They report a sex ratio in this sample of 71.8% male and 28.2% female. Wood (1987) used a discriminant analysis based on birds of known sex to establish sex ratios on birds captured at Teesmouth, UK. The ratio varied in catches between February and November from 29% male in February (N=34) to 50% male in March (N=18). He found that using both bill length and wing length in this analysis, the probability of misclassification was 14% but this was up to 25% when only one variable was used.

CONCLUSIONS AND RECOMMENDATIONS

This comprehensive study has revealed a great deal about the biometrics, moult cycle and sex ratios of Sanderling in SEA and NWA. The analyses of biometric data showed that there are no significant differences between SEA and NWA or with Sanderling populations in other parts of the world. While Sanderlings commence adding fuel from February, after they complete their primary moult, their departure weights from SEA are less than those recorded in South Africa. The primary moult of adult Sanderling is completed by the second week of February, shortly after which birds start to develop breeding plumage. Most birds commence northward migration before they have developed more than 50% of their breeding plumage. Almost all first year birds undertook a complete primary moult, commencing with the innermost primary, during their first summer. Many then develop partial breeding plumage, put on weight and move northwards in April. A theoretical analysis showed that the sex ratios varied between individual catches, with a strong male bias in most samples. There was a greater percentage of females in samples of birds caught in early April, leading to a conjecture that males may depart for the breeding grounds first.

In addition, the paper has highlighted several areas that require further study. These are:

More comprehensive data is required from NWA as almost all the data up to now have been collected in October and April. Data are particularly required during the moult period (October to February).

In SEA it would be desirable to obtain samples in September and early October to better ascertain the median start date for moult.

In addition, samples during the winter (from anywhere) to ascertain moult, weight, plumage of birds that stay behind at the end of the their first year as opposed to those which make at least a partial movement towards to the breeding grounds.

ACKNOWLEDGEMENTS

This paper was made possible by the considerable efforts of VWSG and AWSG members who spent many hours in the field catching and processing Sanderlings in all sorts of weather conditions. Particular thanks to Ren de Garis and Iain Stewart for their observations and for originally inviting us to South Australia in 1993 and for acting as our hosts there ever since. Paul Feast is also thanked for accommodation and beach access at Brown Bay. The ABBBS are thanked for providing bands and administrative support. The South Australian Parks and Wildlife Service and the Victorian Department of Natural Resources and Environment and Parks Victoria are thanked for permission to band, including on reserves. Thanks to Allan Baker and Larry Niles for permission to use some of their data collected at Delaware Bay, USA. Thanks also to Mark Barter and Jim Wilson for their encouragement and helpful comments during the preparation of this paper and to referee Phil Battley for constructive suggestions for improvement.

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NOCTURNAL ROOST USE BY MIGRATORY WADERS IN THE RICHMOND RIVER ESTUARY, NORTHERN NEW SOUTH WALES, AUSTRALIA

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ABSTRACT

Day and night roost use by migratory waders was studied in the Richmond River estuary, northern New South Wales. The survey was conducted in February and March 1995. The aim of the study was to determine if waders used the same high tide roosts at night as they did during the day. Roost use was assessed through direct observation during the day and night, and via radio-telemetry. Differences in roost use were recorded between a number of sites, and for several species. The differences recorded during the survey may be due to a range of factors, including avoidance of human activity, differences in the type of prey exploited between day and night, and differences in the foraging habitats exploited between day and night. Avoidance of nocturnal predators does not appear to influence nocturnal roost selection, although there is some evidence to suggest that avoidance of diurnal predators may contribute to the observed differences.

INTRODUCTION

Waders living in tidal environments congregate into large mixed species flocks at high tide, where they rest, preen and bath (Lane 1987). These sites are generally called high tide roosts. Different species of wader have different roost requirements, although the roosts used are often in close proximity to preferred feeding grounds. Typical roosting sites include sand spits and bars, ocean beaches, rock groynes, saltmarsh, rocky headlands, and mangroves.

A variety of factors may influence a birds choice of roosting site. Some of the primary factors include the height of high water (i.e. spring or neap tides), prevailing weather conditions, and disturbance by humans and raptors (Handel & Gill 1992). The use of high tide roosts can vary considerably between spring and neap tides. During spring tides the number of available roosts is limited and birds form larger flocks at sites above spring high water. During neap tides there are generally more roosting sites available and birds may utilise a variety of sites.

One factor that may have a considerable influence on roost selection but which has gained only limited attention is time of day. It is widely acknowledged that waders are active during both the day and night (Robert *et al.* 1989; Marchant & Higgins 1993; Higgins & Davies 1996). However, research on nocturnal roost use has been limited. Handel and Gill (1992) provide one of the few detailed studies on roost use. In their study, tide was the primary factor influencing roost use, although time of day also proved to be an important factor, and some roosts that were used intensively during the day were not used at night.

Changes in the use of high tide roosts between day and night have considerable implications for the management of wader habitat. Current management priorities are established from daytime assessments of habitat use. If waders utilise different roosts at night, daytime assessments may seriously underestimate the value of some sites, and it is possible that unidentified sites could be destroyed, to the detriment of the local wader population. The paper presents the results of general surveys aimed at comparing roost use by waders between day and night in the Richmond River estuary. The study was conducted as part of a more intensive survey into the use of low tide feeding habitat.

STUDY AREA

The study was conducted in the Richmond River estuary, northeastern NSW. The Richmond estuary is classified as a barrier estuary with a semi-diurnal tidal regime, with two high and two low tides occurring in every 25-hour period. The estuary includes three main areas, the lower Richmond River, North Creek and Mobbs Bay (Fig. 1).

METHODS

Radio-telemetry and direct observation were used to compare roost use by waders between day and night at eight high tide roosts. The eight roosts

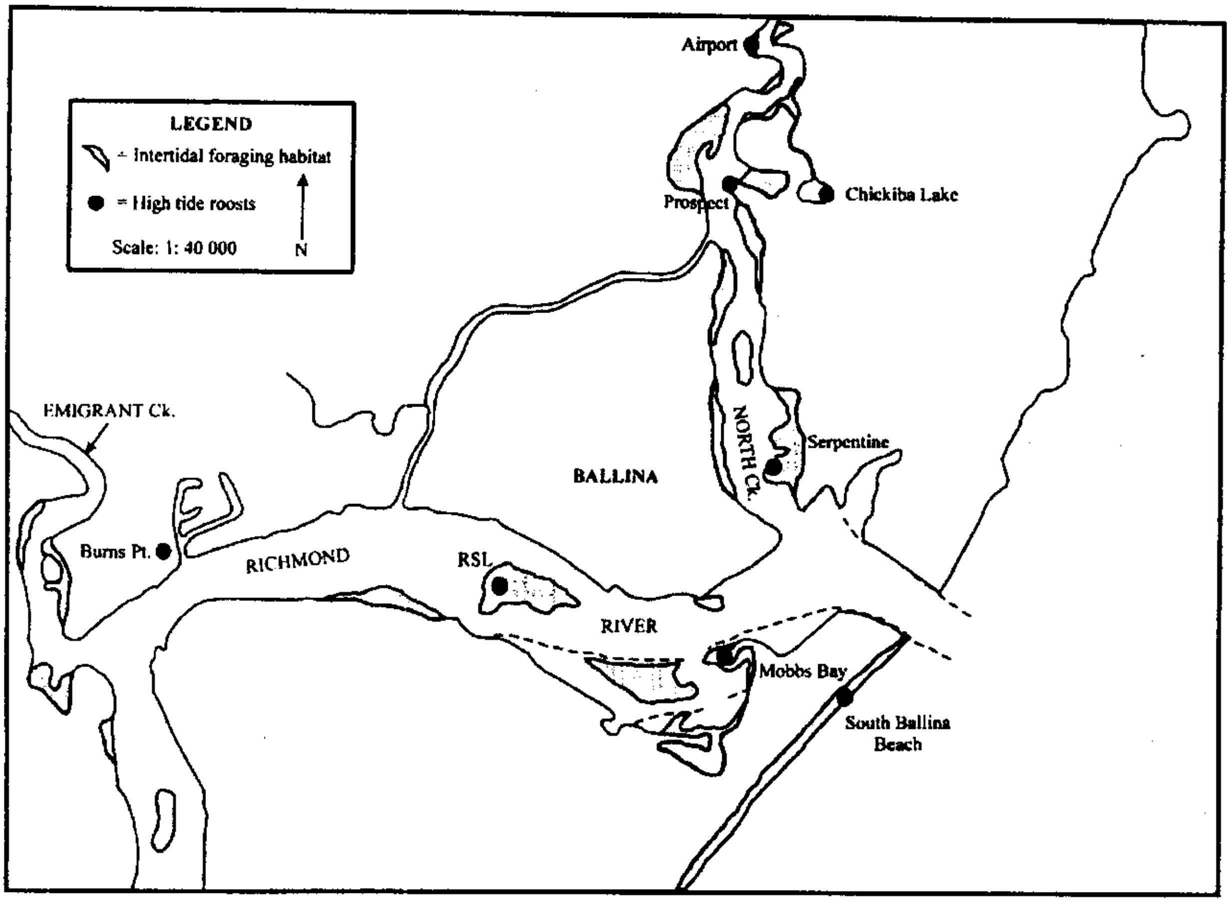

Figure 1: Location of survey sites within the Richmond River Estuary.

included a variety of different habitat types (Table 1). Observations were conducted during February and March 1995 and in June and July 1995 and 1997. Day and night observations were conducted during the same 24-hour period. Tide height varied between the sample periods, and between day and night (Table 2). Tides were higher during the day on the 28/2 and 1/3/95 but lower during the day on the 9/2 and 14/2/95. The difference in tide height between day and night did not exceed 0.3 m on any occasion.

As part of a study on the use of low-tide feeding habitat, the movements of 32 migratory waders were assessed by attaching single-stage radio-transmitters (Rohweder 1999). The presence of radio-tagged birds at high tide roosts was assessed on an occasional basis thereby providing some

Table 1. High tide roosts sampled to compare roost use between day and night.

Site	General features	Relative human disturbance level
Chickiba Lake	Saltmarsh with moat, constructed roost site.	Low
Serpentine	Sand island	High
Prospect	Sand bank, constructed roost site	High
Burns Point	Saltmarsh	Low
RSL	Sand island	Moderate
Mobbs Bay	Sand Spit with rock groins	Moderate
South Ballina Beach	Exposed ocean beach	Moderate
Airport	Narrow shoreline, with small areas of saltmarsh	Low

Table 2. The dates, and maximum tide heights recorded during day and night roost observations.

Date	Tide height - day	Tide height - night
9/2/95	1.1 m	1.4 m
14/2/95	1.7 m	1.4 m
28/2/95	1.8 m	1.5 m
1/3/95	1.8 m	1.6 m

comparative data on day and night roost use. Ten species of wader were studied during the radio-telemetry survey, however, information on high tide roost use was only gathered for six species.

Direct observations were conducted using a pair of 8 x 40 mm binoculars or a 20-60 x 80 mm spotting scope during the day, and a 100 watt spotlight with a red filter, and a pair of 8 x 40 mm binoculars at night. Birds were often startled by the spotlight resulting in frequent calling and in some cases brief flights around the roost. Alarm calls of the birds assisted in identifying the species present. Dodd and Colwell (1996) successfully used a filtered spotlight during studies on waders in North America. Data for the 10 most common species are included here.

The methods used to observe birds meant that it was impossible to obtain accurate counts. Consequently the data presented has been limited to a comparison of presence/absence between day and night. The methods used also decreased the likelihood of detecting inconspicuous species or species that occurred in low numbers. Only the most abundant and conspicuous species have been included in the assessment.

RESULTS

Comparison of the proportion of observations that waders were recorded at high tide roosts between day and night revealed some substantial differences (Table 3). The most distinct differences were recorded at Chickiba Lake. Ten species of wader were regularly recorded at Chickiba Lake during day observations. However, Eastern Curlew and Masked Lapwing were the only species recorded in a similar proportion of night observations. The reverse trend occurred at Serpentine where most species were recorded more frequently at night than during the day. A similar result was recorded at Prospect where birds were recorded more frequently at night. Birds were recorded in similar proportions during the day and night at Burns Point. Pacific Golden Plovers were not recorded at any of the survey sites at night, whilst sand plover spp. were recorded only at Serpentine at night.

Table 3. Proportion of observations of 10 species of migratory wader species that were recorded at high tide roosts during the day and night. N = 4 for all observations.

Species	Site							
	Chickiba Lake		Burns Point		Serpentine		Prospect	
	D	N	D	N	D	N	D	N
Bar-tailed Godwit	100	0	100	100	0	100	25	25
Whimbrel	100	25	100	100	0	75	25	50
Eastern Curlew	100	75	75	100	25	75	25	0
Greenshank	100	25	100	100	0	75	25	100
Grey-tailed Tattler	100	25	0	0	0	100	0	75
Curlew Sandpiper	100	25	75	100	0	0	0	0
Black-winged Stilt	75	0	100	100	0	0	25	25
Masked Lapwing	100	100	0	50	25	100	25	75
Pacific Golden Plover	100	0	0	0	0	0	0	0
Sand Plover sp.	100	0	0	0	25	100	0	0

Radio-telemetry identified distinct differences in roost use for some species (Table 4). Both Double-banded and Pacific Golden Plovers used different high-tide roosts at night. None of the three Pacific Golden Plovers radio-tracked could be located at night, although all three birds roosted at Chickiba Lake during the day. A similar result was recorded for Double-banded Plovers with all four radio-tagged birds using an unknown roost at night. Grey-tailed Tattlers also displayed some differences in roost use, with birds roosting at sites closer to feeding grounds at night.

The remaining three species displayed some overlap in roost use between day and night. Curlew Sandpipers used similar roosts during the day and night, with the roost used at night possibly dependent on that used during the day. Three of the four Curlew Sandpipers radio-tracked used Chickiba Lake on at least one high tide during the day but were not recorded at the site at night. Bar-tailed Godwits were recorded mainly at Serpentine during the night, but used either Chickiba Lake, RSL or South Ballina Beach during the day. No trends were obvious for Terek Sandpipers.

Table 4. Results of radio telemetry on six species of migratory wader radio-tracked at high tide in the Richmond River estuary. The number in parenthesis refers to the number of high tides that birds were recorded at a site. BN = bird number, CL = Chickiba Lake, S= Serpentine, P = Prospect, MB = Mobbs Bay, BP = Burns Point, SBB = South Ballina Beach, A = Airport, Unk = Unknown, D = day, N = night.

Species	BN	CL	S	P	RSL	MB	BP	SBB	A	Unk.
Bar-tailed Godwit	1	-	N (2)	-	D (1)	-	-	D (1)	-	-
	2	-	N (1)	-	D (1)	-	N (2)	D (2)	-	-
	3	D (1)	N (2)	-	-	D (1)	-	-	-	-
	4	D (1)	N (1)	-	-	-	-	-	-	-
Terek Sandpiper	1	D (1)	-	-	-	D (1)	-	-	-	D (1)
		-	-	-	-	N (2)	-	-	-	N (1)
	2	-	-	-	N (2)	D (2)	-	-	-	-
	3	-	-	-	-	D (2)	-	-	-	-
	4	D (1)	-	N (1)	-	-	-	-	-	-
Grey-tailed Tattler	1	D (2)	N (2)	-	-	-	-	-	-	-
	2	-	-	-	-	D (1)	-	-	-	-
	3	D (1)	N (1)	-	-	-	-	-	-	-
	4	D (1)	-	N (1)	-	-	-	-	-	-
Curlew Sandpiper	1	D (3)	-	-	D (1) N (1)	-	N (1)	-	D (1) N (1)	N (1)
	2	-	-	-	N (2)	-	N (2)	-	D (1) N (1)	-
	3	D (1)	-	-	-	-	D (2) N (5)	-	N (1)	-
	4	D (3)	-	-	-	-	-	-	-	N (2)
Pacific Golden Plover	1	D (5)	-	-	-	-	-	-	-	N (5)
	2	D (5)	-	-	-	-	-	-	-	N (5)
	3	D (5)	-	-	-	-	-	-	-	N (5)
Double-banded Plover	1	-	D (4)	-	-	-	-	-	-	N (4)
	2	-	D (4)	-	-	-	-	-	-	N (4)
	3	-	-	-	-	-	-	D (2)	-	N (2)
	4	-	-	-	-	-	-	D (2)	-	N (2)

DISCUSSION

The results of the present study have identified some obvious differences between day and night in the use of some high tide roosts in the Richmond River estuary. However, differences in roost use vary between sites, and species. The differences in roost use recorded during this survey may be due to a variety of reasons including, avoidance of human activity, day/night changes in the exploitation of prey, day/night changes in the use of low-tide habitats, and avoidance of diurnal predators. Seasonal changes in roost use and variable weather conditions may also influence roost use, although the present study was of insufficient duration to identify if such differences affect roost selection in the study area. Although variation in tide height affects roost use the variability in tide height incorporated into this survey minimises the likelihood that the observed result would be due to tide alone.

Avoidance of nocturnal predators, specifically foxes (*Vulpes* spp.) has been identified as a primary factor influencing roost use by waders in both North America and southern Africa (Hockey 1985; Handel & Gill 1992). Although foxes (*V. vulpes*) occur in the study area, the threat of fox predation is not regarded as a primary factor influencing roost use. Of the eight sites sampled the threat of fox predation is likely to be greatest at Prospect, Burns Point, South Ballina Beach and Airport. Direct observation showed that the occurrence of birds did not decrease at either Burns Point or Prospect at night, and radio-telemetry showed that some individuals utilised sites with a greater risk of fox predation at night. For example, some Curlew Sandpipers roosted at island habitats during the day but used saltmarsh at night.

The obvious differences between day and night roost use at Chickiba Lake and Serpentine may be due to human disturbance. Waders may avoid disturbance during the day by roosting at Chickiba Lake. However, at night when disturbance is minimal, birds roost at Serpentine, which is situated closer to feeding grounds. By roosting closer to feeding areas at night birds will expend less energy moving between roosts and feeding grounds. The pattern of roost use observed for Grey-tailed Tattler also suggest avoidance of human activity, with birds avoiding sites with high levels of human activity during the day but using these sites at night.

The risk of predation by raptors can influence a birds choice of roost site. Although the risk of predation in the Richmond River estuary is considered low, it is possible that birds may select roost sites that provide a greater level of protection from diurnal raptors. Saltmarsh habitat at Chickiba Lake may provide small waders with greater protection during the day than the exposed sand islands at Serpentine. Although at the same time, the habitat surrounding Chickiba Lake provides a better opportunity for raptors to remain concealed and mount a surprise attack on roosting waders. In comparison, roosting on the exposed sand islands at Serpentine would ensure rapid detection of approaching raptors. One of the few concerted attempts of raptor predation on waders in the Richmond estuary was recorded at Chickiba Lake (Rohweder 1997).

Significant differences between day and night use of low tide foraging habitat by migratory waders have been identified in the Richmond River estuary (Rohweder & Baverstock 1996). The differences in roost use recorded during this study, and in particular the differences recorded for Pacific Golden Plover and Curlew Sandpiper may be related to changes in the use of foraging habitats at night. Pacific Golden Plovers appear to leave the estuary at night to roost at an unknown site, possibly to exploit increases in prey availability (Rohweder 2000). Curlew sandpipers also roosted close to their nocturnal foraging sites, which in some cases differed from the sites used during the day.

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SEXING CRITERIA, AGE STRUCTURE, BIOMETRICS, AND MOULT OF THE PIED OYSTERCATCHER, *HAEMATOPUS LONGIROSTRIS* IN VICTORIA

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ABSTRACT
A total of 2239 Pied Oystercatchers, including 712 retraps, have been caught in Victoria, Australia, over the past twenty years by the Victorian Wader Study Group. This paper discusses the age structure, biometrics and moult of these birds. Sexing criteria are developed based on bill length (adult males mean 71.4 mm, females mean 79.8 mm). Of all the birds caught, 81.1 % were adults, 9.5 % first year and 9.4 % second year. Females are bigger then males in all measurements, and immature birds are generally smaller than same sex adults. Adult weights slightly increase before the breeding season. Immatures begin their moult at the start of October, and complete it within 150 days. Adults commence their moult approximately two months later, after the breeding season, but complete it within around 130 days.

INTRODUCTION

Pied Oystercatchers, *Haematopus longirostris*, mainly occur in Australia, with an estimated minimum of 10.000 birds in total, including 1400 birds in Victoria (Watkins 1993). Their status is classified as uncommon and is threatened by habitat destruction, human disturbance and native and non-native predators. Since they are ground nesters their eggs and chicks are particularly vulnerable to these problems (Marchant and Higgins 1993). Low breeding success is also caused by nest failure due to high tides and strong winds (Lauro and Nol 1993; Newman 1992). Another factor, which may influence their abundance, is food availability. They feed on molluscs, worms, crabs, and small fish, mainly on sandy mudflats (Lauro and Nol 1995a). Like other Oystercatcher species males and females do not show any plumage dimorphism, but they do show size dimorphism (Marchant and Higgins 1993; Zwarts *et al.* 1996a).

In order to get a better understanding of the Pied Oystercatcher movements, age structure, biometrics and moult patterns in Victoria, the Victorian Wader Study Group has conducted a long term catching program since 1979. Most data have been collected during the non-breeding season. This paper summarises the biometrics, moult and age-structure found over this period. Australian Pied Oystercatchers mainly feed on soft substrates. Thus, the wear of the bill is minimal, increasing the possibility of using this measurement to sex birds (Lauro and Nol 1995a; Zwarts *et al.* 1996a). Sexing criteria have therefore been developed based on bill-length differences between males and females, using a computerised maximum likelihood approach, described by Rogers (1995). These criteria are then applied to our data to determine differences in weight, wing, bill, and head-bill length between males and females. We also examine the sex ratio and age classes at different catching sites and calculate the timing and duration of primary moult.

MATERIAL AND METHODS

Pied Oystercatchers were caught and banded with standard metal bands at 18 different locations along the Victorian coast over 20 years (1979-1999). Birds were mostly caught by cannon netting at high tide roosts, although a few birds were mist-nested at night. After being caught, birds were held in holding cages, made out of strong cloth, and processed as soon as possible. Since 1989, all birds were individually colour banded. Prior to 1989, only a single location colour band was used with the normal metal band. Weight, age, moult of the primaries, wing, bill and head-bill length were recorded for most birds. Age classes were divided into 5 groups (1, 1+, 2, 2+ and 3+), based on bill, eye and leg colour (Prater *et al.* 1977). To simplify data analysis, birds were divided into 3 age classes (first year, second year, and adult birds). The few 1+ birds were removed from the data set, since their age was uncertain. All 2+ and 3+ birds were amalgamated into a single "adult" category. Wing lengths for second year and adult birds were divided into two categories, depending on whether the outer primary (p10) was old or new.

Moult of the 10 primary feathers were scored as follows: 0 = old feather, 1 = pin only, 2 = only small tip of new feather is visible, 3 = new feather has grown half way, 4 = new feather is ¾ grown, 5 = complete new feather. The moult score was then calculated by adding up the scores of the 10 feathers. To study the timing of moult and moult duration, median moult scores were calculated per week of all the years combined.

Sexing criteria were developed, using the computer package SHEBA (Rogers 1995), based on bill-length only. These criteria were then used to assign probabilities to each bird being a male or female. Subsequently the measurements of, for example, wing length were multiplied by the male and female probabilities, for each bird. By adding up these values for both males and females the mean wing length of males and females were calculated.

RESULTS

A total of 2239 birds were caught during the 20-year study, with 712 retraps. Of these, 81.1 % were adults (2+ and 3+), 9.5 % first year (1) and 9.4 % second year (2). There is a difference in the number of immatures (first and second year birds) caught in different years (Fig. 1) and at different sites (Fig. 2).

The histogram of the bill length clearly shows two modes, presumably representing females and males respectively (Fig. 3). This is not the case for most other biometric measurements (except for head-bill length). An example is given in figure 4 for the wing length of adult birds that had recently completed their moult. Therefore, we only use bill length develop sexing criteria. In Table 1, sexing criteria are presented at different confidence levels as calculated by the computer package SHEBA (Rogers 1995). Since bill length increases with age (Table 2), the criteria have been developed separately for the three different age classes.

Table 1 can be used as follows: adult birds with a bill length of 79.1 mm or above can be called female with 95 % certainty. At this confidence

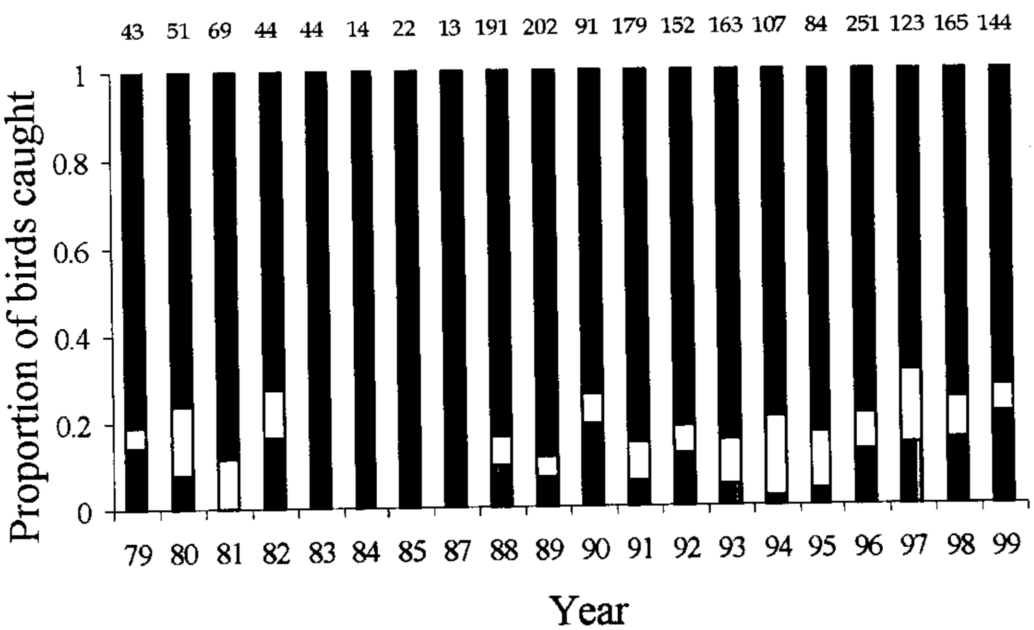

Figure 1. Proportion first year (grey), second year (white) and adult (black) Pied Oystercatchers caught in Victoria. Numbers at the top give total number of birds caught in each year.

Table 1. Univariate sexing criteria based on bill length of Pied Oystercatchers in Victoria. For example, if you use the 95 % confidence level, all first year birds with a bill length of 61.7 mm or less are identified as males, and all birds with a bill length > 84.1 mm are classified as females. With this criterion, there are 0.1 % of the birds that are sexed incorrectly, but 94.4 % that cannot be sexed (because they have bill lengths between 61.8 – 84.0 mm).

	First year					Second year					Adult				
Confidence interval	Upper limit males	Lower limit females	Percent sexed wrong	Don't know sex	Percent sexed right	Upper limit males	Lower limit females	Percent sexed wrong	Don't know sex	Percent sexed right	Upper limit males	Lower limit females	Percent sexed wrong	Don't know sex	Percent sexed right
95%	61.7	84.2	0.1	94.4	5.5	70.6	77.7	0.4	36.1	63.4	72.1	79.1	0.6	35.8	63.6
90%	65.9	81.6	0.6	81.8	17.6	71.6	76.8	1.0	24.8	74.2	73.0	78.3	1.3	25.8	72.9
80%	69.5	78.8	3.5	55.7	40.8	72.6	75.9	2.2	14.7	83.1	74.0	77.4	2.6	15.7	81.7
70%	71.6	77.1	8.2	34.4	57.4	73.2	75.3	3.4	9.1	87.5	74.7	76.7	4.2	9.0	86.8
60%	73.0	75.6	14.0	16.5	69.5	73.7	74.7	5.0	4.3	90.8	75.2	76.2	5.8	4.4	89.8
50%	74.3	74.4	21.2	0.6	78.2	74.2	74.3	6.6	0.4	93.0	75.7	75.8	7.5	0.4	92.1

level, adult birds with a bill length of 72.1 mm or less are males. With these 95 % confidence levels 63.6 % of all adult birds caught are sexed correctly. However, since the distributions of male and female bill lengths overlap 0.6 % will be sexed wrong and 35.8% of the birds are of unknown sex. At lower confidence levels, more birds can be assigned a sex, but the number sexed incorrectly will increase.

The biometric measurements clearly vary between different age classes and between sexes (Table 2). In all age classes, females have significantly longer bill and head-bill measurements than males. The mean bill length of adult males was 71.4 ± 3.6 mm, and for adult females 79.8 ± 4.1 mm. There was a similar marked difference in head-bill lengths (adult males 116 ± 4.3 mm and adult females 124.9 ± 4.6 mm). Although still significantly different (except between second year males and females), wing lengths showed fewer differences between males and females, with adult male wing length of 283.8 ± 8.0 mm and adult female wing length of 289.2 ± 8.2 mm, for birds with old feathers (pre-

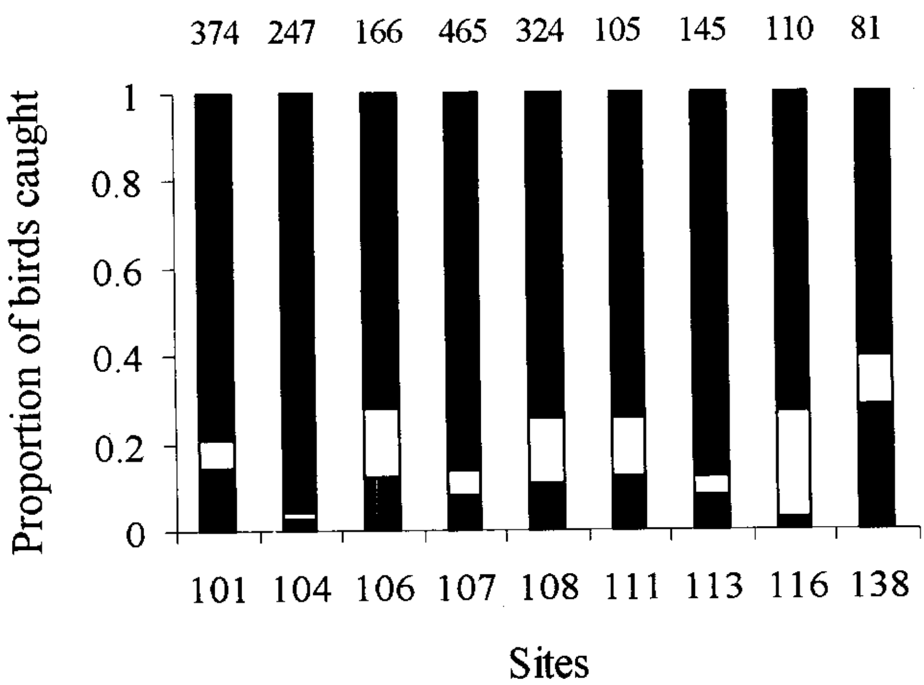

Figure 2. Proportion first year (grey), second year (white) and adult (black) Pied Oystercatchers caught at different locations in Victoria over the past 20 years. Numbers at the top give total number of birds caught at the different locations. Locations: 101, WerribeeSF; 104, Queenscliff; 106, Barry Beach; 107, off Manns Beach (Corner Inlet); 108, Stockyard Point (Westernport); 111, Rhyll; 113, Long Island (Hastings); 116, The Gurdies (Westernport); 138, Roussac Point near Foster (Corner Inlet).

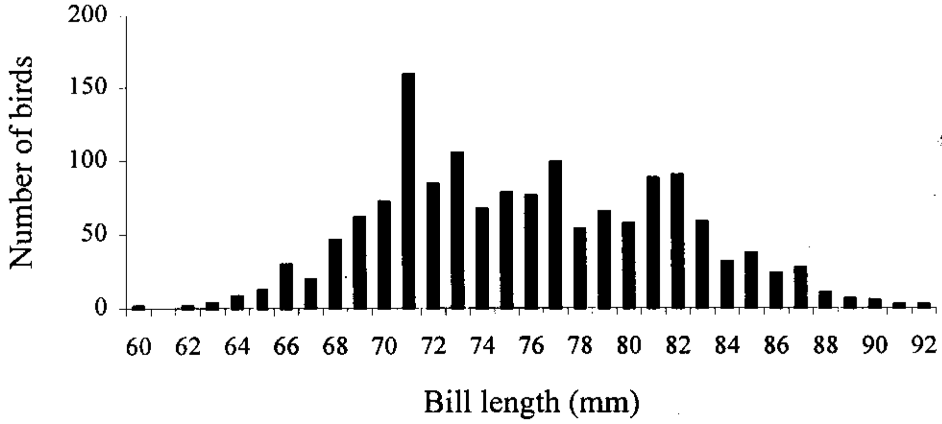

Figure 3. Histogram of the observed frequencies of bill length in adult Pied Oystercatchers caught in Victoria (n = 1099).

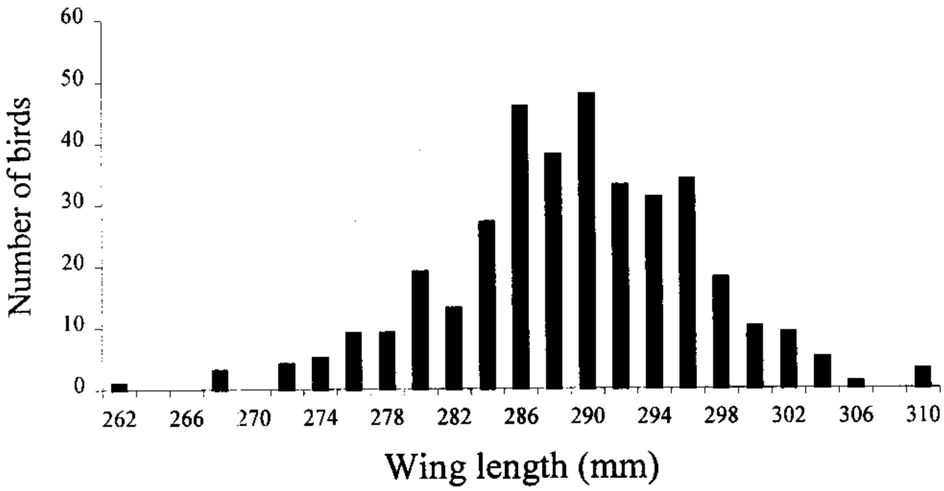

Figure 4. Histogram of the observed frequencies of wing length (with p10 new) in adult Pied Oystercatchers caught in Victoria (n = 367).

moult). Immediately after moult, adult males have a mean wing length of 287.1 ± 7.3 mm, and adult females is 290.7 ± 7.4 mm. The wing length is therefore shorter for old feathers compared to new feathers, and this difference is significant in both second year and adult males, but not in females. In most cases, adults are significantly larger than second year birds of the same sex and the measurements are even smaller for first year birds (Table 2). The exceptions are the wing length between first and second year females, and the bill and head-bill length of first, second and adult males.

The sex ratios of the samples are skewed towards males in first year and adult birds, and towards females in second year birds (Table 2). Generally 56 % of the adults are presumed to be males. About 45 % of second year birds are males, and of the first year birds 52 % are males.

Weight increases significantly with age, and females are generally around 30 grams heavier then males in all age classes, with mean adult males weighing 732.8 ± 56.1 g, and adult females 763.5 ± 58.4 g. The weight of first year birds gradually increases throughout the first year, though they are typically 60-70 g lighter than adults (Figs. 5 and 6). Second year birds seem to lose weight markedly when they first start moulting, from November till March. The weights of adult birds increase slightly from January until approximately July, after which their weight decreases. This increase in weight seems to become more rapid in adults that have

Table 2. Weight, wing, bill and head-bill length for males and females of three different age classes (1 = first year, 2 = second year, 2+ = adult birds) in Pied Oystercatchers in Victoria. Standard deviation (S.D.), number of birds used in the analysis (N) and the percentage of males, as determined by SHEBA, are given.

Measurement	Age	Male		Female		N	Percentage male	Z	P
		Mean	S.D.	Mean	S.D.				
Weight	1	668.4	57.4	692.7	59.5	212	52.9	3.02	<0.01
	2	689.3	55.5	729.3	58.7	192	46.6	4.85	<0.01
	2+	732.8	56.1	763.5	58.4	1749	56.1	11.10	<0.01
		Z	P	Z	P				
Z - test	1/2	2.62	<0.01	4.40	<0.01				
	2/2+	7.09	<0.01	5.54	<0.01				
	1/2+	11.28	<0.01	11.21	<0.01				
Wing	1	277.9	8.3	282.1	8.4	155	50.4	3.12	<0.01
	2 new	282.7	7.4	285.0	7.4	56	39.9	1.14	n.s.
	2+ new	287.1	7.3	290.7	7.4	367	52.8	4.69	<0.01
		Z	P	Z	P				
Z-test	1/2	2.64	<0.01	1.81	n.s.				
	2/2+	2.68	<0.01	4.08	<0.01				
	1/2+	8.55	<0.01	7.72	<0.01				
	2 old	275.0	8.1	282.7	8.4	76	50.4	4.07	<0.01
	2+ old	283.8	8.0	289.2	8.2	356	58.4	6.19	<0.01
		Z	P	Z	P				
Z - test	2 old/2+ old	6.17	<0.01	4.28	<0.01				
	2 new/2 old	3.78	<0.01	1.23	n.s.				
	2+ new/2+ old	4.32	<0.01	1.71	n.s.				
Bill	1	70.9	4.8	76.7	5.2	201	52.9	8.21	<0.01
	2	70.6	3.6	78.9	4.0	162	45.9	13.91	<0.01
	2+	71.4	3.7	79.8	4.1	1099	55.5	35.51	<0.01
		Z	P	Z	P				
Z - test	1/2	0.48	n.s.	3.22	<0.01				
	2/2+	1.81	n.s.	1.93	<0.05				
	1/2+	1.03	n.s.	5.51	<0.01				
Head-bill	1	116.1	5.0	121.6	5.3	180	51.7	7.14	<0.01
	2	115.2	4.3	123.2	4.6	137	47.5	10.48	<0.01
	2+	116.4	4.3	124.9	4.7	857	56.2	27.33	<0.01
		Z	P	Z	P				
Z - test	1/2	1.20	n.s.	2.04	<0.05				
	2/2+	2.10	<0.05	2.86	<0.01				
	1/2+	0.54	n.s.	5.36	<0.01				

finished moulting (May) (Figs. 5 and 6). The weights of second year males and females appear to increase rapidly from October to December (Figs. 5 and 6), but this could be an artefact of small sample sizes for November/December (n=6).

Adult birds start moult in early January and most birds have completed their moult at the end of May, and therefore have a moult duration of around 130 days (Fig. 7). Although sample sizes for second year birds are small, they appear to start moulting earlier then adults, in the beginning of October, and most birds have completed their moult at the end of March (Fig. 8). So the "typical" immature bird in the population has a moult duration of 150 days.

DISCUSSION

Several papers have been published on sexing oystercatchers using a discriminant analysis approach (Heppleson & Kerridge 1970; Hockey 1981; Zwarts *et al* 1996a). At least two variables are used to create a formula based on measurements of birds of known sex. This formula is then used to

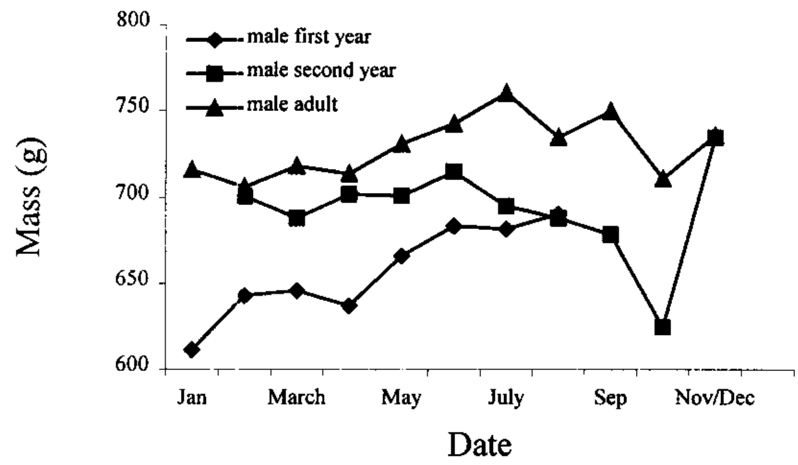

Figure 5. Mean monthly weights (g) of male Pied Oystercatchers in Victoria.

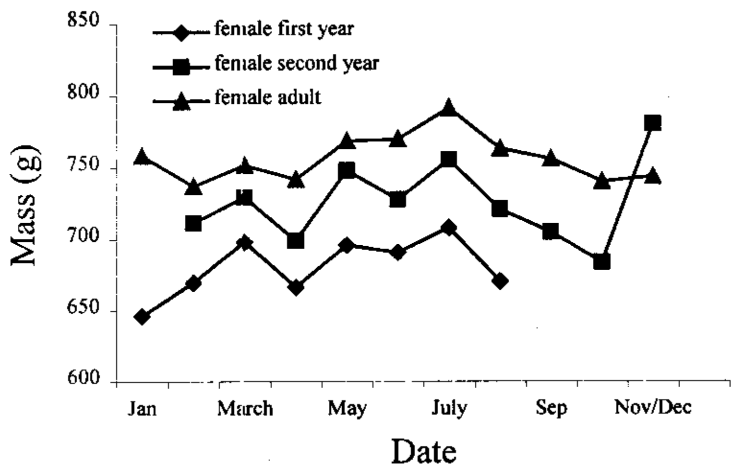

Figure 6. Mean monthly weights (g) of female Pied Oystercatchers in Victoria.

determine the sex of unknown birds. Two variables used frequently for sexing European Oystercatchers, *H. ostralegus*, are bill length and bill depth. We were not able to use this approach, since measurements on birds of known sex from Victoria are too scarce and because bill depth has never been measured on the birds. Zwarts *et al.* (1996a) showed that bill length is the most important variable for sexing European Oystercatchers, and enables birds to be sexed correctly with a confidence level of 83.5 %. Adding other variables did not increase the probability of sexing a bird correctly by much (up to 92.8 %).

The maximum likelihood approach we used to sex birds is a good alternative (Rogers 1995; Rogers & Rogers 1995). In our case, only bill length was clearly bimodal and useful for separating the sexes with SHEBA (Rogers 1995). Therefore birds were sexed using a univariate approach.

The age composition of the Pied Oystercatcher samples varied between years, but due to small sample sizes it is hard to tell whether this difference is due to different age compositions at catching sites, different timing of catches at those sites, or variation in breeding success between years. The number of birds caught at different catching sites also varies between years and is thus also influencing the interpretation of age composition data. Age composition appears to vary between sites, but again, since this is the combination of

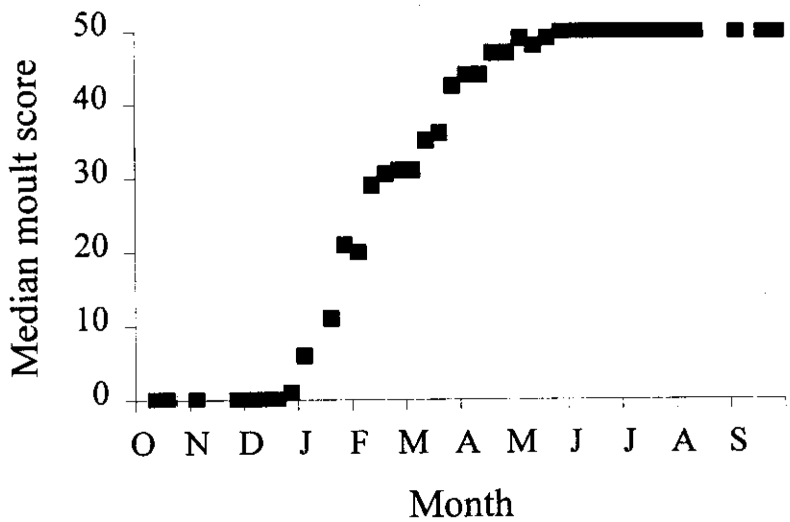

Figure 7. Median moult score versus date for adult Pied Oystercatchers in Victoria (number of birds in each week varies from 1 to 143).

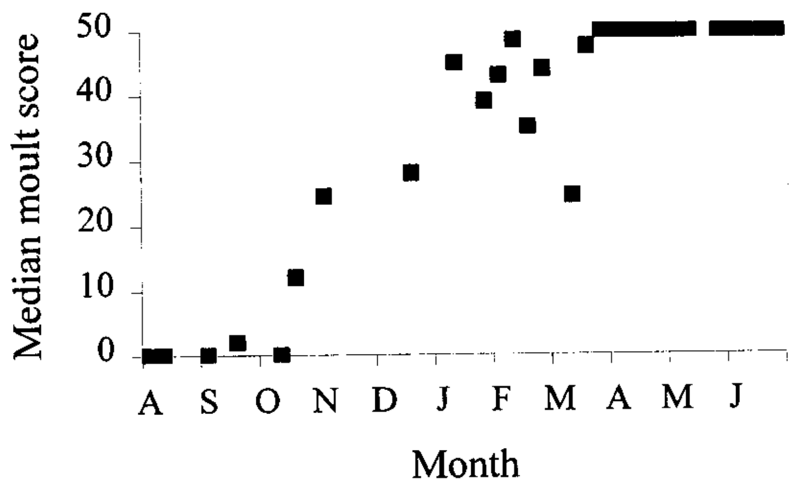

Figure 8. Median moult score versus date in second year Pied Oystercatchers in Victoria (number of birds in each week varies from 1 to 17).

twenty years data, it is impossible to tell whether this is due to the site or the difference in breeding success in different years.

This is the first comprehensive study of the biometrics of the Australian Pied Oystercatcher. Data can only be compared with a few measurements taken from skins (Marchant and Higgins 1993). Museum specimens of adult birds from southern Australia have a mean bill length of 71.5 and 79.6 mm for males and females respectively. We found birds with a bill length of 71.4 and 79.8 mm could be unambiguously assigned as adult males and females respectively. So our results are consistent with data on birds of known sex. The fact that females are bigger in all measurements is well known in oystercatchers (Hockey 1981; Zwarts *et al.* 1996a, b, c). Immature Pied Oystercatchers are smaller compared to same sex adults, with the wing length being 9 mm shorter in first year birds and 5 mm for second year birds. This is similar to the pattern found in European Oystercatchers, where first year birds have wing lengths which are 10 mm shorter than adults, and second year birds have wing lengths 3 mm shorter then adults (Zwarts *et al.* 1996a, c).

The sex ratio bias towards adult males is also observed in European Oystercatchers. Durell & Goss-Custard (1996) studied this bias by using a simple population model. They found that the difference in sex ratio is mainly explained by higher mortality rates in young adult females. Oystercatchers can live for at least 21 years (AWSG unpublished data; Newman 1992) and a slight difference in mortality rates between males and females could cause such a bias.

The monthly differences in Australian Pied Oystercatcher weight were small compared to those seen in oystercatcher populations that migrate longer distances from their breeding grounds to wintering grounds (Dare 1977). Still some seasonal trends in weight can be observed. Pied Oystercatchers lay their eggs during the period from September to December (Marchant & Higgins 1993; Newman 1992). Their nests often fail due to predation or high tides and strong winds, leading to re-nesting up to three times per breeding season (Lauro & Nol 1993; 1995b; Newman 1992). Since both male and female contribute to incubation and feeding the chicks, it is likely that during the breeding season, birds of both sexes experience high energy demands (Marchant & Higgins 1993). This is supported by our data, since adult weights (especially females) decrease from August till January/February, which coincides with the breeding season. The increase in weight of adult birds from January till July coincides with the end of the breeding season and the start of moult. As in the European Oystercatcher, this is the period where adult birds are gaining weight, probably building up fat reserves for the next breeding season. However, the European Oystercatcher is building these fat reserves to carry them through the winter (Zwarts *et al.* 1996c). The observed trend in adults is generally also true for first and second year birds, which do not breed (Newman 1992). This probably reflects food availability, which can differ during different times of the year (Dare 1977; Ens *et al.* 1996). Younger birds are always lighter than adults, probably partly due to smaller body size (Zwarts *et al.* 1996c).

Moult studies on European Oystercatchers have shown that adult birds start moulting after the breeding season, and that non-breeding adults can start their moult earlier in the season. Second year birds start their moult approximately two months earlier. On average the moulting period for both adults and immatures takes up to three and a half months (Dare & Mercer 1973, Hulscher 1977; Wilson & Morrison 1981). The same difference between immatures and adults is found in Australian Pied Oystercatchers. Breeders will start their moult at the end of the breeding period, whereas immatures start their moult about two months earlier. The moult duration is longer than in the European Oystercatcher (4 ½ months for adults and 5 months for immatures). This prolonged moult is one of the longest of any wader species, and is possible because, unlike long distance migrant waders, a greater period is available. Furthermore, unlike waders spending the non-breeding season in the northern hemisphere, moult can be continued into the winter months.

Our study has enhanced our knowledge on biometrics, moult and sex composition of Victorian Pied Oystercatchers. In order to further test our sexing criteria, blood samples need to be taken to carry out DNA testing, to sex the birds (Griffiths *et al.* 1998). It would also be worth taking some bill depth measurements, to see if this aids sex identification in the way it does on European Oystercatchers.

ACKNOWLEDGEMENTS

We would like to thank all the volunteers in the Victorian Wader Study Group who helped catch the birds, Ken Rogers for explaining the computer package SHEBA, and Ken Kraaijeveld and David Steward for valuable comments on the manuscript. The Australian Bird and Bat Banding Scheme is thanked for providing bands and the Department of Natural Resources in Victoria for providing permits. Parks Victoria kindly provided boat transport to access Pied Oystercatcher roosts in parts of Nooramunga National Park (Corner Inlet). Landowners are especially thanked for permission to access foreshores.

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WADER SURVEYS IN THE COORONG, SOUTH AUSTRALIA IN JANUARY AND FEBRUARY 2001

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ABSTRACT

Wader numbers in the Coorong have shown dramatic declines from peaks of 141,614 in 1981 and 234,543 in 1982 to 130,483 in 1987, 68,599 in 2000 and 48,425 in 2001. The declines were particularly marked in Sharp-tailed Sandpipers (from a peak of 55,739 in 1982 to 5,718 in 2001), Red-necked Stints (from 63,794 in 1982 to 18,368 in 2001), Curlew Sandpipers (from 39,882 in 1981 to 4,309 in 2001), Red-necked Avocets (from 5,401 in 1982 to 260 in 2001) and Red-capped Plovers (from 5,152 in 1982 to 1,288 in 2001). In some species, large declines have also been detected in Gulf St Vincent and Victoria and declines in the Coorong are assumed to reflect an overall decline in the population (Curlew Sandpipers), or movements to inland wetlands (Sharp-tailed Sandpipers, Red-necked Avocets and Red-capped Plovers). However, Red-necked Stints had peak populations in S.E. Australia in 2001 after two to three good breeding years. But this is not reflected in the Coorong counts. This suggests that environmental factors within the Coorong have also contributed to the declines. Yet, there have not been large changes in the distribution of waders within the Coorong, even though changes would be expected if different environmental factors were affecting wader numbers in different parts of the Coorong. This apparent inconsistency needs further investigation through more detailed study of wader distribution in the Coorong and further analysis of the Australian population counts.

INTRODUCTION

The waders in the Coorong have previously been counted in 1981, 1982, 1987 and 2000 (Jaensch & Barter 1988, Wilson 2000). In the 1980s the Coorong was the third most important wader site in Australia, after Eighty Mile Beach and Roebuck Bay in northwestern Australia. This is no longer the case. The counts showed a reduction in the total number of waders from 141,614 in 1981 and 234,543 in 1982 to 130,483 in 1987 and 68,599 in 2000. These massive declines are a cause for concern, and for that reason the Australasian Wader Studies Group (AWSG) counted the Coorong in 2001. The total number then was 48,425. This report gives the results of the 2001 count, compares the results with previous counts for each species, documents the wader distribution within the Coorong and compares the changes in populations in the Coorong with changes elsewhere in southeastern Australia.

THE COUNT PERIOD AND COVERAGE

The Coorong was counted twice between 31 January and 4 February 2001 by the AWSG, each survey taking two days. On the morning of 31 January one team counted the South Lagoon, while two teams counted the Magrath Flat/Hells Gate area. In the afternoon of 31 January, two teams counted from the Needles to Camp Noonameena. On 1 February two teams in two boats counted the area from Marks Point to just beyond the Murray mouth at Swan Point. On 2 February two vehicles covered the Ocean Beach from Tea Tree Crossing to the Murray Mouth. As the two vehicles followed each other there was essentially one team. On the morning of 3 February four teams counted the Malgrath Flat/Hells Gate area. On the afternoon of 3 February two teams counted the South Lagoon. On 4 February two teams in two boats counted from Pelican Point to Goolwa barrage. In addition, a team working independently of the main group, counted from Long Point to Mark Point on 3 February and from Long Point to Pelican Point on 4 February, from the road. The north end of the Morrella Basin behind Salt Creek, which is not part of the Coorong, was counted in the evening of 2 February. Birds using this area could have been attracted away from the Coorong (see discussion).

Ten counters were involved in the project, although never more than six were in the field at a time. The number of teams was restricted by lack of telescopes (3-4 on any count day). However, in the Coorong it is useful to have one observer with binoculars in a team to estimate total flock sizes, count the larger species and check for movements in and out of the area being counted.

The small number of teams available meant that the Coorong count took two days. As it is never likely that large numbers of people could be encouraged to count the Coorong on an annual basis, it was thought best to test out methods and accuracy of counting with the team sizes that are likely to be available in the future. This was in any case dictated in 2001 by the shortage of good volunteer counters. This is the first time that the Coorong has been counted twice in a period of five days.

THE COUNT SECTIONS

The count sections (Fig. 1) were the same as used in 1987 (Jaensch & Barter 1988) and 2000 Wilson (2000). In 2001, section 20 on the inland side of the Coorong and sections 7, 9, 11, 13, 19 and 21 on the Younghusband Peninsula side of the Coorong were not counted. However these sections are generally poor for waders.

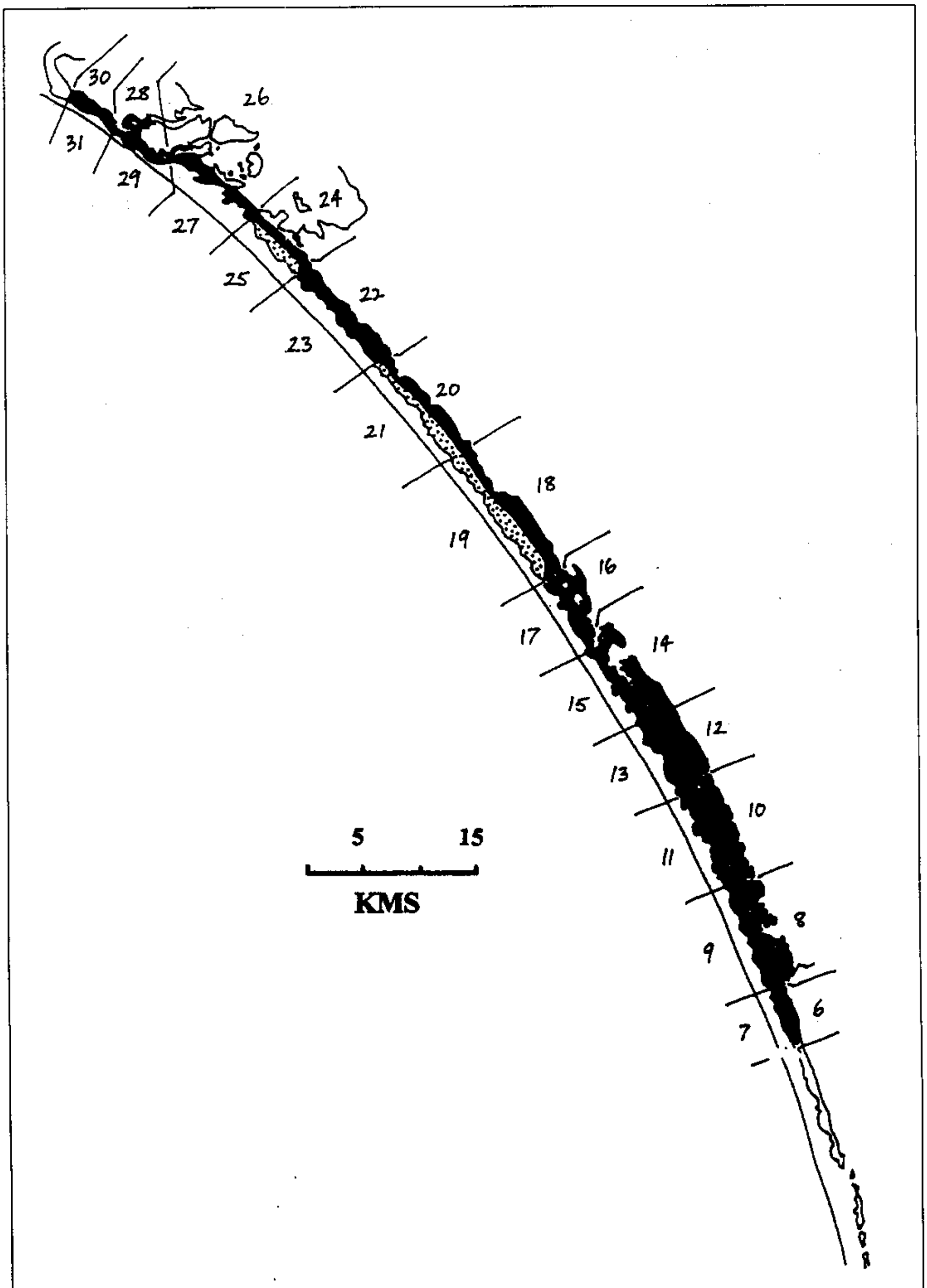

Figure 1. Map of the Coorong showing the sectors used to subdivide the area for surveying in 2000 and 2001.

RESULTS

Total counts for 1981, 1982, 1987, 2000, and 2001 in the Coorong and on the Ocean Beach in 1981, 1982, 2000 and 2001 are shown in Tables 1 and 2, together with population estimates from Watkins (1993). Note that a greater length of beach was counted in 1981 and 1982 than in 2000 and 2001. The Ocean Beach was not counted in 1987. The distribution and numbers of the waders in each section in 2001 are shown in Table 3 and in the four main areas in 1982, 1987, 2000 and 2001 in Table 4. Counts in the Morrella Basin made in 2001 are shown in Table 5.

Total numbers in the Coorong

The total numbers recorded in the Coorong was

Table 1. The total counts of each species of wader during the five surveys between 1981 and 2001. Summary counts from Watkins (1993) are also shown.

Common name	Scientific name	Years					Watkins
		1981	1982	1987	2000	2001	1993
Black-tailed Godwit	*Limosa limosa*	133	185	105	210	115	150
Bar-tailed Godwit	*Limosa lapponica*	15	0	3	8	0	25
Eastern Curlew	*Numenius madagascarienis*	17	24	8	15	16	24
Marsh Sandpiper	*Tringa stagnatis*	0	2	30	0	0	30
Greenshank	*Tringa nebularia*	600	717	596	557	305	650
Common Sandpiper	*Actitis hypoleucos*	13	1	1	0	1	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	100
Sanderling	*Calidris alba*	113	929	308	512	53	930
Sharp-tailed Sandpiper	*Calidris acuminata*	24871	55739	22898	10697	5718	35000
Pectoral Sandpiper	*Calidris melanotos*	0	1	0	0	0	-
Red-necked Stint	*Calidris ruficollis*	54743	63794	54710	30145	18368	60000
Curlew Sandpiper	*Calidris ferruginea*	39882	22614	22512	13124	4309	22000
Cox's Sandpiper	*Calidris paramelanotus*	0	0	1	0	0	-
Pied Oystercatcher	*Haematopus longirostris*	108	297	84	92	9	630
Sooty Oystercatcher	*Haematopus fuliginosus*	0	0	3	3	3	18
Black-winged Stilt	*Himantopus himantopus*	238	991	291	340	183	600
Banded Stilt	*Cladorhynchus leucocephalus*	13782	77149	18692	11299	15611	30000
Red-necked Avocet	*Recurvirostra novaehollandiae*	1449	5401	3589	93	260	4500
Pacific Golden Plover	*Pluvialis fulva*	289	230	144	84	103	290
Grey Plover	*Pluvialis squatarola*	1	0	0	12	0	-
Red-capped Plover	*Charadrius ruficapillus*	4677	5152	2533	1089	1288	4000
Double-banded Plover	*Charadrius bicinctus*	0	0	1	0	0	150
Black-fronted Plover	*Charadrius melanops*	0	2	0	0	0	15
Hooded Plover	*Charadrius rubricollis*	0	0	12	3	4	-
Red-kneed Dotterel	*Erythrogonys cinctus*	14	17	0	0	0	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	800
Red-necked Phalarope	*Phalaropus lobatus*	0	0	3	0	0	-
Unidentified		-	-	3064	-	1724	-
TOTAL		141614	234543	130483	68599	48425	160082

Table 2. The counts of waders on the ocean beach at the Coorong on four occasions between 1981 to 2001 (* = Kingston to Middleton, ** = Kingston to Waitpinga and includes 865 Sanderling recorded inside the Murray Mouth (Table 1)). Note that the length of beach covered in 1981-82 is much greater than in 2000-01.

Species	1981*	1982**	2000	2001
Bar-tailed Godwit	-	-	-	1
Common Sandpiper	-	2	-	-
Sanderling	311	**	15	161
Red-necked Stint	68	10	23	-
Pied Oystercatcher	568	334	526	432
Sooty Oystercatcher	18	5	13	2
Banded Stilt	-	-	-	5
Grey Plover	5	-	-	-
Red-capped Plover	902	529	48	52
Hooded Plover	102	130	25	49
Oriental Plover	-	6	-	-
Masked Lapwing	159	337	-	-
Total	2133	1353	650	702

141,614 in 1981, 234,543 in 1982, 130,483 in 1987, 68,599 in 2000 and 48,425 in 2001 (Table 1). Thus, apart from the peak year of 1982, there has been a steady decline in the wader numbers in the Coorong.

In 2000 the northern channels from Murray Mouth to Goolwa barrage and parts of the Younghusband Peninsula were not counted. In 2001, the northern channels were counted but the same sections missed on the Younghusband Peninsula in 2000 were also missed in 2001. Compared to 1987, and using 1987 figures, counting these sections would have theoretically added approximately 12,300 waders to the 2000 count, and 9,300 to the 2001 count. However, as wader numbers had declined generally by 46% between 1987 and 2000 and 62% between 1987 and 2001, the theoretical adjustments would be an addition of 6,600 waders to the 2000 count and 3,500 waders to the 2001 count.

The 1981 count was incomplete, as the South Lagoon was not counted. A maximum of 15,320 waders were counted there in 1982, 19,636 in 1987, 4,161 in 2000 and 5,554 in 2001. The mean proportional adjustment compared to the three years 1987, 2000 and 2001 would be an addition of 15,000 waders to the 1981 totals, assuming that the distribution of waders was similar (see below). Such theoretical adjustments are small compared to the changes in populations recorded across the five counts.

Population changes in individual species

Population changes of individual species are discussed under the species accounts below.

Population changes in Sharp-tailed Sandpipers, Red-necked Stints, Curlew Sandpipers, Red-necked Avocets and Red-capped Plovers at six monitored sites in Victoria for the years 1981-2000, and for four of the same six sites for 1981-2001 (counts are not yet available for the other two sites for 2001) are shown in figures 2-6. These are used to help interpret changes in the populations in the Coorong.

Total numbers on the ocean beach

Comparison of the counts on the ocean beach between 1981, 1982 and 2000, 2001 are difficult as only about 100 kms of beach were counted in 2000 and 2001 (Table 2). However, of particular note is the apparent reduction in the numbers of Red-capped and Hooded Plovers (see the species accounts).

The distribution in the Coorong

Table 3 shows the distribution in the Coorong in 2001 according to count section and date. Table 4 shows the distribution of the most numerous wader species within the Coorong in 1982, 1987, 2000 and 2001 in the four main count areas. The channel north of the Murray Mouth to Goolwa barrage is not included. The totals are the sum of the maximum recorded in the different zones on the different count days. These sometimes differ from the totals in Table 1 because these have taken account of suspected movements of birds between count areas, and include the Goolwa Channel.

Although total numbers of waders have dramatically declined in the Coorong, the proportion of all species combined in each region has only shown small changes (Table 4). Excluding 1982, when numbers in the North Lagoon were biased by the large numbers of Banded Stilts there, between 6 and 14% of the total of the most common waders have been recorded in the South Lagoon, 40-58% in the Hells Gate area, 4-15% in the North Lagoon and 25-29% in the Northern Channels. The sections for 1982 were unclear and some birds included in the North Lagoon were almost certainly in the south end of the Northern Channels as the count boundary in 1982 was the Tauwitchere Barrage (Pelican Point in other years). Few were recorded in the North Lagoon in 2001 (3%), because birds in a bay and on sandbanks in the northwest corner of that section have been included in the Northern Channels (they moved there on the second count).

The more marine species such as Eastern Curlew, Red Knot, and Sanderling only occurred in the Northern Channels, where there is a tidal influence. Salt loving species such as Banded Stilts mainly occurred from the Needles (Hells Gate area) southwards, whereas Black-winged Stilts avoided the saltiest areas. Considering that birds can easily move from one section to another during a count period, and counting the Coorong is difficult (see discussion), the distribution of most species was broadly similar from year to year, although for many species there have been large declines in the

Table 3. Counts of each species in each section of the Coorong in 2001.

Count area	South Lagoon		Hell's Gate area					North Lagoon				Northern Channels				
Count sector	6–13	6–13	14,15	14,15	16,17	16,17	18	22	22	24	24	25	25	26/27	26/27	28,29
Date	31.1	3.2	31.1	3.2	31.1	3.2	31	3.2	4.2	1.2	4.2	1.2	4.2	1.2	4.2	4.2
Black-tailed Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	15	115	-
Bar-tailed Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eastern Curlew	-	-	-	-	-	-	-	-	-	-	-	-	-	13	16	-
Marsh Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Greenshank	24	-	-	27	20	46	6	8	6	15	1	4	5	152	166	-
Common Sandpiper	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Ruddy Turnstone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Knot spp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sanderling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	53
Red-necked Stint	2684	-	5203	8150	952	1890	29	110	128	85	60	1760	2084	4780	5031	-
Sharp-tailed Sandpiper	122	20	21	1729	521	511	-	972	512	72	149	430	-	1719	259	-
Curlew Sandpiper	747	-	604	1068	21	120	-	600	230	-	-	290	338	1272	1410	-
Pied Oystercatcher	2	-	-	-	2	-	-	-	-	-	-	-	-	2	7	-
Sooty Oystercatcher	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Black-winged Stilt	-	-	-	-	30	22	-	4	2	4	3	24	2	58	143	-
Banded Stilt	1788	2370	14	11000	7341	2225	-	-	-	-	-	-	-	-	16	-
Red-necked Avocet	6	-	78	147	6	51	-	-	7	-	-	5	-	22	49	-
Pacific Golden Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	59	24	-
Grey Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-capped Plover	117	2	374	53	158	828	3	3	5	76	9	-	-	240	38	-
Double-banded Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-fronted Dotterel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hooded Plover	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-
Red-kneed Dotterel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Banded Lapwing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Masked Lapwing	38	14	38	24	41	25	11	14	14	66	2	3	-	206	20	-
Unidentified small	26	-	160	1500	-	188	-	-	-	-	-	-	-	-	-	-
TOTAL	5554	2406	6492	23701	9096	5908	49	1711	904	318	224	2516	2429	8538	7294	53

Table 3 cont. Counts of each species in each section of the Coorong in 2001, the adjustment for double counting and the revised total counts.

Count area	Goolwa Channel		South Lagoon Area		Hells Gate Area		Northern Channels							adjust double count	Revised total
Count sector	30,31	30,31	max	sum	sum	max		max	sum		max	max	Total	count	total
Date	1.2	4.2		31.1	2.2		18	2.2	1.2	4.2		30/31			
Black-tailed Godwit	-	-	0	0	0	0	-	0	15	115	115	0	115	-	115
Bar-tailed Godwit	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Eastern Curlew	-	-	0	0	0	0	-	0	13	16	16	0	16	-	16
Marsh Sandpiper	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Common Greenshank	9	22	24	20	73	73	6	8	171	172	172	22	305	-	305
Common Sandpiper	-	-	0	1	0	1	-	0	0	0	0	0	1	-	1
Ruddy Turnstone	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Great Knot	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Red Knot	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Knot spp	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Sanderling	-	-	0	0	0	0	-	0	0	53	53	0	53	-	53
Red-necked Stint	330	396	2684	6155	10040	10040	29	128	6625	7175	7175	396	20452	-2084	18368
Sharp-tailed Sandpiper	145	163	122	542	2240	2240	-	972	2221	408	2221	163	5718	-	5718
Curlew Sandpiper	26	-	747	625	1188	1188	-	600	1562	1748	1748	26	4309	-	4309
Pied Oystercatcher	-	-	2	2	0	2	-	0	2	7	7	0	11	-	11
Sooty Oystercatcher	-	-	0	0	3	3	-	0	0	0	0	0	3	-	3
Black-winged Stilt	-	1	0	30	22	30	-	4	86	148	148	1	183	-	183
Banded Stilt	-	-	2370	7355	13225	13225	-	0	0	16	16	0	15611	-	15611
Red-necked Avocet	-	-	6	84	198	198	-	7	27	49	49	0	260	-	260
Pacific Golden Plover	9	44	0	0	0	0	-	0	59	24	59	44	103	-	103
Grey Plover	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Red-capped Plover	45	36	117	532	881	881	3	5	316	47	316	45	1367	-	1367
Double-banded Plover	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Black-fronted Dotterel	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Hooded Plover	-	-	0	3	2	3	-	0	0	0	0	0	3	-	3
Red-kneed Dotterel	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Banded Lapwing	-	-	0	0	0	0	-	0	0	0	0	0	0	-	0
Masked Lapwing	2	18	38	79	49	79	11	14	275	22	275	18	435	-80	355
Unidentified small	-	10	26	160	1688	1688	-	0	0	0	0	10	1724	-	1724
TOTAL	566	690	6136	15588	29609	29651	49	1738	11372	10000	12370	725	50669		48505

total populations. For example, the distribution of Red-necked Stints has remained remarkably consistent, although total numbers have declined from a peak of 63,794 to18,368. The distributions are described in more detail under each individual species below.

The Morrella Basin

The Morrella Basin is a recently formed wetland, about 3 kms inland of the Coorong behind Salt Creek, the South Lagoon. It has been formed as part of the new scheme to channel more fresh water into the southern end of the Coorong. The area suitable for waders covered about 2 km^2 in 2001. This small area of wetland had more 1,549 waders (Table 5) that presumably would normally use the Coorong, including 565 Sharp-tailed Sandpipers (10% of the Coorong total) and 190 Black-winged Stilts (compared to 183 in the whole Coorong). There were also several thousand ducks. The Morrella Basin was probably in prime condition in 2001 as it had only recently been flooded. It remains to be seen if it can continue to sustain large numbers of waders.

Table 4. The count of each species in four regions of the Coorong during four surveys between 1982 and 2001 and the percentage of the total count of that species. Mean distribution refers to the total of each species seen across all surveys. (SL = South Lagoon, HG = Hell's Gate area, NL = North Lagoon, NC = North Channel).

Species	Year	Count					Percentage			
		SL	HG	NL	NC	Total	SL	HG	NL	NC
Black-tailed Godwit	1982	0	0	0	185	185	0	0	0	100
	1987	0	0	0	105	105	0	0	0	100
	2000	0	0	0	210	210	0	0	0	100
	2001	0	0	0	115	115	0	0	0	100
Mean distribution		0	0	0	615	615	0	0	0	100
Eastern Curlew	1982	0	0	2	15	17	0	0	12	88
	1987	0	0	1	7	8	0	0	13	88
	2000	0	0	0	15	15	0	0	0	100
	2001	0	0	0	16	16	0	0	0	100
Mean distribution		0	0	3	53	56	0	0	5	95
Common Greenshank	1982	39	75	193	360	667	6	11	29	54
	1987	177	62	96	182	517	34	12	19	35
	2000	20	49	131	357	557	4	9	24	64
	2001	24	73	8	172	277	9	26	3	62
Mean distribution		260	259	428	1071	2018	13	13	21	53
Red Knot	1982	0	0	27	8	35	0	0	77	23
	1987	0	0	0	0	0	0	0	0	0
	2000	0	0	0	80	80	0	0	0	100
Mean distribution		0	0	27	88	115	0	0	23	77
Sanderling	1982	0	0	0	865	865	0	0	0	100
	1987	0	0	0	304	304	0	0	0	100
	2000	0	0	0	512	512	0	0	0	100
	2001	0	0	0	53	53	0	0	0	100
Mean distribution		0	0	0	1734	1734	0	0	0	100
Sharp-tailed Sandpiper	1982	4200	18726	27185	4928	55039	8	34	49	9
	1987	1715	4378	11280	2414	19787	9	22	57	12
	2000	51	4817	2236	3593	10697	0	45	21	34
	2001	122	2240	972	2221	5555	2	40	17	40
Mean distribution		6088	30161	41673	13156	91078	7	33	46	14
Red-necked Stint	1982	5500	27852	13580	14358	61290	9	45	22	23
	1987	5223	22932	1371	24860	54386	10	42	3	46
	2000	3470	16149	3632	6894	30145	12	54	12	23
	2001	2684	10040	128	7175	20027	13	50	1	36
Mean distribution		16877	76973	18711	53287	165848	10	46	11	32
Curlew Sandpiper	1982	2550	10162	6816	3036	22564	11	45	30	13

Species	Year	Count					Percentage			
		SL	HG	NL	NC	Total	SL	HG	NL	NC
	1987	784	12642	1243	7839	22508	3	56	6	35
	2000	0	4028	3950	5146	13124	0	31	30	39
	2001	747	1188	600	1748	4283	17	28	14	41
Mean distribution		4081	28020	12609	17769	62479	7	45	20	28
Pied Oystercatcher	1982	12	36	69	170	287	4	13	24	59
	1987	42	17	0	25	84	50	20	0	30
	2000	2	30	19	41	92	2	33	21	45
	2001	2	2	0	7	11	18	18	0	64
Mean distribution		58	85	88	243	474	12	18	19	51
Black-winged Stilt	1982	1	11	560	319	891	0	1	63	36
	1987	4	49	179	50	282	1	17	63	18
	2000	0	18	66	256	340	0	5	19	75
	2001	0	30	4	148	182	0	16	2	81
Mean distribution		5	108	809	773	1695	0	6	48	46
Banded Stilt	1982	950	30206	44899	94	76149	1	40	59	0
	1987	7145	11160	387	0	18692	38	60	2	0
	2000	462	10821	16	0	11299	4	96	0	0
	2001	2370	13225	0	16	15611	15	85	0	0
Mean distribution		10927	65412	45302	110	121751	9	54	37	0
Red-necked Avocet	1982	830	3635	482	444	5391	15	67	9	8
	1987	1573	1988	7	4	3572	44	56	0	0
	2000	0	93	0	0	93	0	100	0	0
	2001	6	198	7	49	260	2	76	3	19
Mean distribution		2409	5914	496	497	9316	26	63	5	5
Pacific Golden Plover	1982	0	0	1	214	215	0	0	0	100
	1987	0	0	24	0	24	0	0	100	0
	2000	0	0	39	45	84	0	0	46	54
	2001	0	0	0	59	59	0	0	0	100
Mean distribution		0	0	64	318	382	0	0	17	83
Red-capped Plover	1982	1160	1886	1560	246	4852	24	39	32	5
	1987	820	1141	267	565	2793	29	41	10	20
	2000	140	586	287	76	1089	13	54	26	7
	2001	117	881	5	316	1319	9	67	0	24
Mean distribution		2237	4494	2119	1203	10053	22	45	21	12
Masked Lapwing	1982	78	68	435	282	863	9	8	50	33
	1987	265	48	335	62	710	37	7	47	9
	2000	16	20	102	95	233	7	9	44	41
	2001	38	79	14	275	406	9	19	3	68

Species	Year	Count					Percentage			
		SL	HG	NL	NC	Total	SL	HG	NL	NC
Mean distribution		397	215	886	714	2212	18	10	40	32
Total wader populations	1982	15320	92657	95809	25524	229310	7	40	42	11
	1987	17748	54417	15190	36417	123772	14	44	12	29
	2000	4161	36611	10478	17320	68570	6	53	15	25
	2001	6110	27956	1738	12370	48174	13	58	4	26
Mean distribution		43339	211641	123215	91631	469826	9	45	26	20

Selected species accounts

Black-tailed Godwit

Numbers have varied between a maximum of 185 in 1982, and a minimum of 105 in 187. There were 115 in 2001. They have only been recorded in the Northern Channels.

Eastern Curlew

Numbers have varied between a maximum of 22 in 1982 and a minimum of 8 in 1987. There were 16 in 2001, no different to the count in 1981 (17) or 2000 (15). Eastern Curlews have mainly been recorded in the Northern Channels.

Common Greenshank

Numbers have varied between a maximum of 671 in 1982 and a minimum of 305 in 2001. Prior to 2001, Greenshanks had not shown any significant declines in the Coorong. Twenty-eight birds were seen in the Morrella Basin on 2 February 2001. Presumably these would normally have been in the Coorong. Greenshanks were most numerous in the Northern Channels. In 1987 they were also particularly numerous in the South Lagoon, but not in other years.

Red Knot

Red Knots are not numerous in the Coorong. They only occur near the tidal influence in the North Lagoon or Northern Channels. Maximum numbers were 80 in 2000.

Sanderling

Numbers on the sandbanks in the Murray Mouth were the lowest recorded. This may have been because of strong northerly winds and blowing sand on 1 February made the sandbanks unattractive. Large numbers of people also heavily disturbed the area on Sunday 4 February. Sanderlings are known to roam along the South Australian beaches and the low numbers in 2001 is probably not of any significance. Some had obviously moved from the Murray Mouth to the adjacent ocean beach in 2001 (Table 2).

Sharp-tailed Sandpiper

Sharp-tailed Sandpiper numbers ranged from approximately 22,000 to 55,000 in the 1980s (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.

Close & McCrie (1986) estimated 12,500 Sharp-tailed Sandpipers at the Gulf St.Vincent saltfields and Clinton Conservation Park. In 2000, there were 3,874 (Wilson 2000) and in 2001 2,707 (David Close pers. com.). Counts from four sites in Victoria suggest that in 2001 populations were at the lowest levels in 20 years (Fig. 2). Also there were few Sharp-tailed Sandpipers throughout Victoria in January and February 2001 when the whole state was counted as part of a special survey (Wilson 2001). The Victorian inland was very dry

Table 5. Count of waders in Morrella Basin (36° 7' 27" S 139° 40' 2" E) on the 2 February 2001.

Species	Count
Common Greenshank	28
Red-necked Stint	151
Sharp-tailed Sandpiper	565
Curlew Sandpiper	2
Black-winged Stilt	190
Banded Stilt	337
Red-necked Avocet	3
Red-capped Plover	29
Red-kneed Dotterel	3
Banded Lapwing	9
Masked Lapwing	50
Unidentified small wader	182
Total	1549

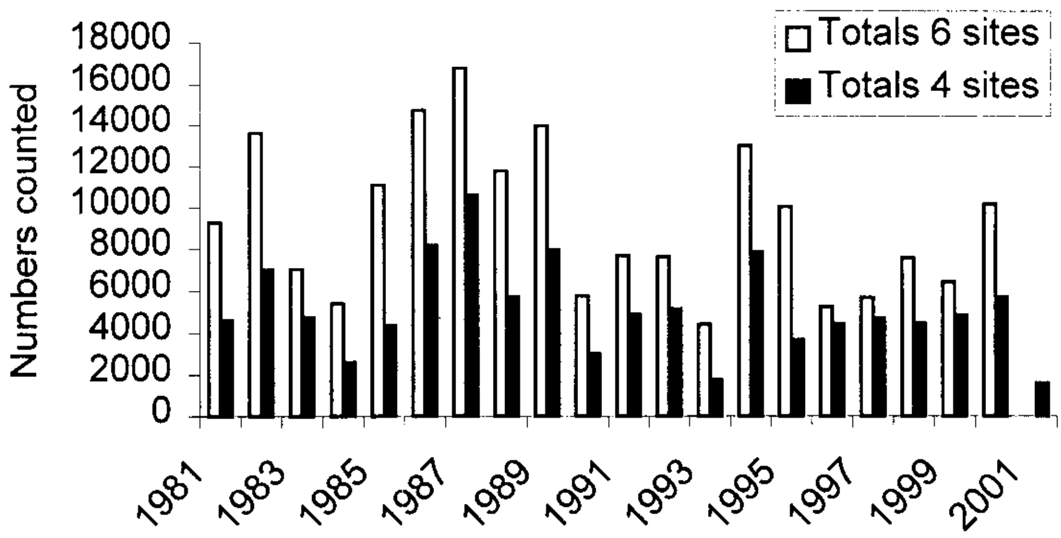

Figure 2. Changes in the number of Sharp-tailed Sandpipers at the six AWSG PMP sites in Victoria.

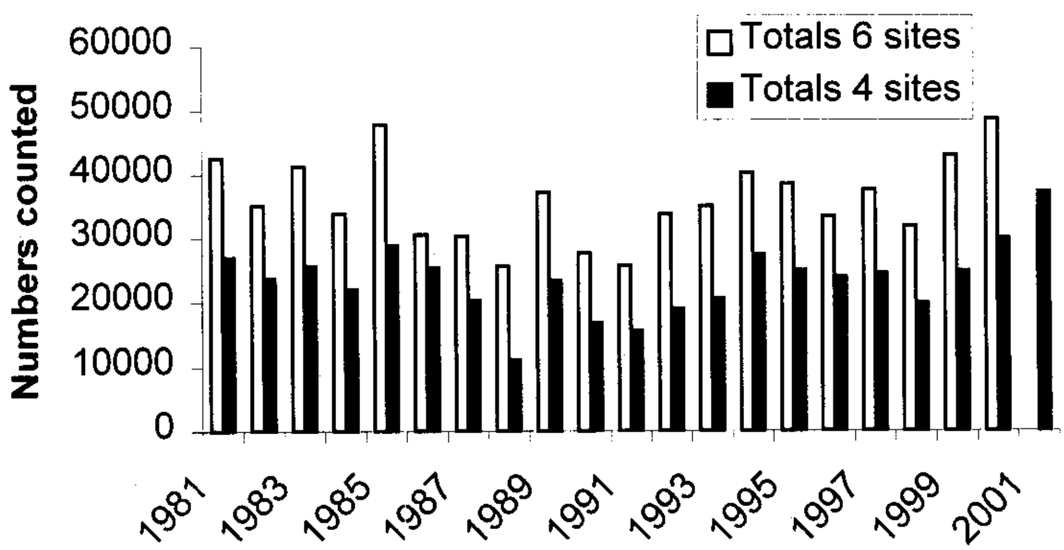

Figure 3. Changes in the number of Red-necked Stint at the six AWSG PMP sites in Victoria.

after a reported 5 years of almost drought and many of the known good sites for Sharp-tailed Sandpipers had dried out. Thus the marked decline in numbers in the Coorong was also evident throughout southeastern Australia. Sharp-tailed Sandpipers use ephemeral wetlands more than other *calidrine* wader species. As it was very wet in Queensland and northern New South Wales, it is possible that many of them stopped off during their migration in 2001 before they reached southern Australia. It is not known whether other factors might also have caused declines in the species (eg. breeding success). However, there is a correlation in numbers between the Coorong and Victoria The high numbers of 1982 in the Coorong was also reflected in high numbers in Victoria. But in 1987, there were even higher numbers in Victoria than in 1982, whereas in the Coorong numbers had declined by 50%.

The distribution of Sharp-tailed Sandpipers in the Coorong has changed (Table 4). In 1982 and 1987

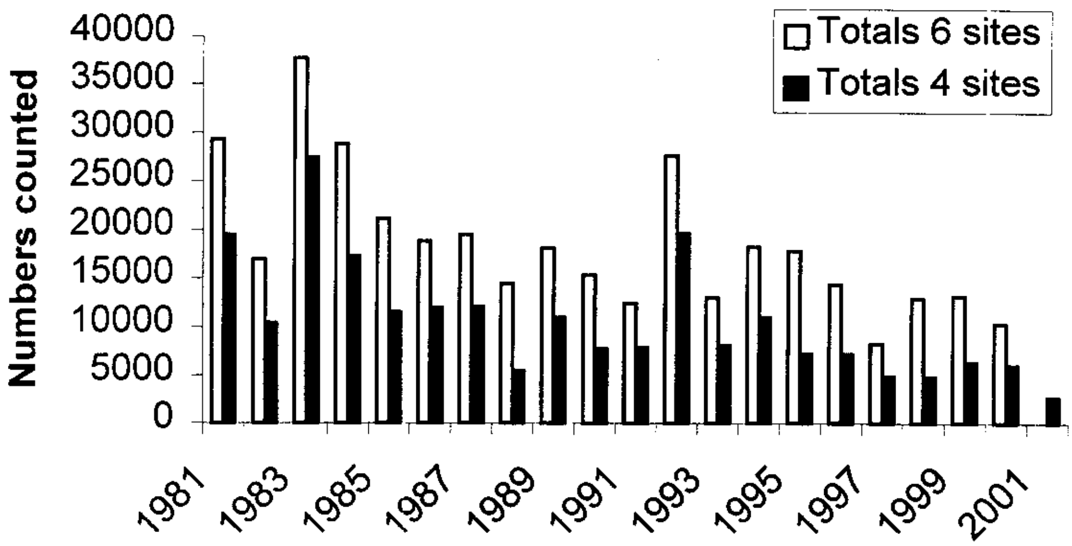

Figure 4. Changes in the number of Curlew Sandpipers at the six AWSG PMP sites in Victoria.

there were proportionally more in the South Lagoon and North Lagoon than in 2000 and 2001. In the latter two years there were proportionally more in the Hells Gate Area and the North Lagoon. The decline from the peak year in 1982 to 2001 was 97% in the South Lagoon, 88% in the Hells Gate Area, 96% in the North Lagoon compared with 55% in the Northern Channels. It is probable that the decline in the Northern Channels has been greater than this, since the count boundaries were uncertain in 1982. However, although there was a lower proportion of the total population in the Northern Channels compared with 2001 the number of birds were similar (2,414 and 2,221 respectively).

Red-necked Stint

There were about 50,000-60,000 Red-necked Stints in the Coorong in the 1980s (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 18,368.

Close & McCrie (1986) estimated 19,200 Red-necked Stints at the Gulf St.Vincent saltfields and Clinton Conservation Park. In 2000, there were estimated 7,000 (Wilson 2000) and in 2001 there were possibly 17,270 (counted 12,270 + 5,000 small waders which were probably Red-necked Stints (David Close pers. comm.). In Victoria, Red-necked Stint numbers were at their highest levels in 20 years in 2000 and 2001 (Fig. 3). It is believed that this was due to two and possibly three good breeding seasons in succession. As the Victorian totals were higher in 2000 and 2001 than in 1981, 1982 or 1987, one might expect that there would be record totals of over 60,000 Red-necked Stints in the Coorong. The continuing large declines in Red-necked Stint numbers is disturbing, as it is not matched in populations elsewhere. It is the only species for which it is not possible to show that there might be external factors causing declines.

The distribution within the Coorong was broadly similar in all years. The decline from 1982 to 2001 in the South Lagoon was 51%, in the Hell Gate Area 64%, in the North Lagoon 99% and in the Northern Channels 50%. It is probable that the decline in the Northern Channels has been greater than this, since the count boundaries were uncertain in 1982. Comparing 1987 with 2001 showed a decline of 71%.

Curlew Sandpiper

There were about 22,000 to 40,000 Curlew Sandpipers 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.

Curlew Sandpipers have shown a very widespread and large population decline in southern Australia since the 1980s. There were 6,300 counted in the Gulf St Vincent saltfields and Clinton Conservation Park in the early 1980s compared with 1,237 in 2000 (Wilson 2000) and 2,488 in 2001 (David Close pers.com.). In Victoria, there have also been very large declines since the 1980s with the lowest numbers in 20 years recorded in 2001 (Fig. 4). Note the high numbers in 1992 after a very good breeding season. The changes in the populations in the Coorong are matched by those in Victoria in each of the five years. There is anecdotal evidence that there have also been very large declines in southwestern Australia, Queensland and New South Wales (AWSG records). It would seem that Curlew Sandpipers are at their lowest level in 20 years in at least large areas of Australia with a decline of over 50%. The decline is so large and widespread that the main factors causing it probably lie outside Australia. There is evidence from the percentage of juveniles in birds caught for banding that at least part of the reason may have been a series of poor breeding years, although no other Arctic species have been affected in the same way in recent years.

The distribution within the Coorong was broadly similar in all years. The decline from 1982 to 2001 in the South Lagoon was 70%, in the Hell Gate Area 88%, in the North Lagoon 91% and in the Northern Channels 42%. It is probable that the decline in the Northern Channels has been more than this, since the count boundaries were uncertain in 1982. Comparing 1987 with 2001 showed a decline of 77%.

Pied Oystercatcher

Four hundred and thirty-two Pied Oystercatchers were counted on the ocean beach from Tea Tree crossing to the Murray Mouth in 2001, down from 526 in 2000. Surprisingly, there were only 16 immature birds, which might suggest that there had been a poor breeding season. Few were seen on the sandbanks in the Murray Mouth. On 1 February, these were very exposed to the northerly winds. On the second visit on Sunday 4 February, people heavily disturbed the area. This might explain much of the apparent decrease within the Coorong. Seven Pied Oystercatchers were seen on the ocean beach that had been colour banded in Victoria as part of a long term study there. Many of the Pied Oystercatchers recorded in the Coorong, especially those south of the Northern Channels, may have crossed over from the ocean beach to roost, rather than feed.

Black-winged Stilt

Maximum number recorded were 991 in 1982. Minimum numbers were 183 in 2001. However, this is not dissimilar to the 238 in 1981, 291 in 1987 and 340 in 2000. Also 190 were seen in the north end of the Morella Basin in 2001 that may have been using the Coorong in other years. Thus, some Black-winged Stilts may have moved out to adjacent wetlands in 2001. Black-winged Stilts were most numerous in the North Lagoon and Northern Channels in all years.

Banded Stilt

It was suggested that in 2000 numbers were the lowest recorded because birds had moved to Lake Eyre to breed (Wilson 2000). Although the first two breeding attempts there failed due to predation by Silver Gulls *Larus novaehollandiae*, potentially 30,000 chicks hatched in July 2000 (The Tattler July 2000). Numbers in 2001 (15,616) were higher than in 1981 (13,782), when the South Lagoon was not counted and in 2000 (11,299), and close to those in 1987 (18,692). It seems that by the end of January 2001, the Banded Stilts had returned to the non-breeding areas where over 70,000 were located through Victoria and westwards along the South Australian coastal strip to Port Augusta (AWSG unpubl. data). A few days prior to the Coorong survey, 11,000 Banded Stilts were recorded in Lake George (Maureen Christie pers. comm.). These possibly would have also used the Coorong in a dry year. There were also 30,800 Banded Stilts in the Gulf St Vincent saltfields in February 2001, compared with a total of 9,512 in 2000. Comparing the 2001 figures with 1987, suggests that there has not been a dramatic change in the numbers of Banded Stilts using the Coorong. The count for 1982 was exceptionally high. Another check of the field sheets suggests that the minimum figure in that year was 59,436 (if there had been movements during the count), still a very high total. In most years, the majority of Banded Stilts have been in the Hells Gate area.

Red-necked Avocet

Numbers in 2001 (260) increased from the low numbers in 2000 (93), but were still lower than the

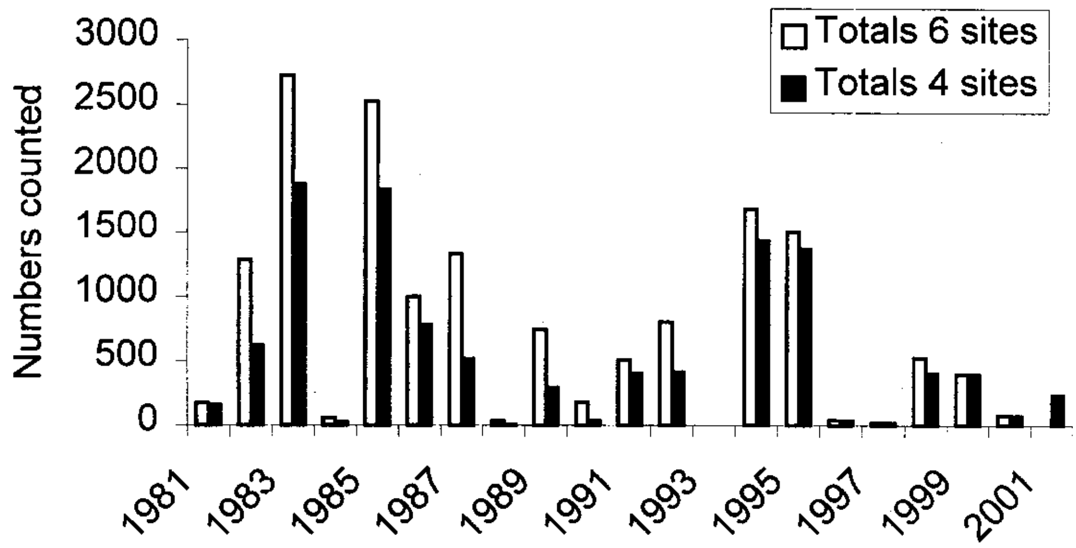

Figure 5. Changes in the number of Red-necked Avocets at the six AWSG PMP sites in Victoria.

1,449-5,083 recorded in the 1980s. It is possible that Red-necked Avocets had relocated to ephemeral wetlands in northern New South Wales and southern Queensland that were in prime condition for waders. In the 2000 report, I suggested that birds had moved inland (Wilson 2000). Close & McCrie (1986) estimated 1,100 in the Gulf St Vincent saltfields and Clinton Conservation Park in the early 1980s, compared with 38 in 2000 (Wilson 2000) and 98 in 2001(David Close pers.comm.). Counts from sites in Victoria over 20 years showed marked fluctuations with very low numbers in 1981, 1984, 1988, 1990, 1993 (none), 1996, 1997, 2000 and 2001 (Fig. 5). In contrast, 1982 and 1987 were good years for Avocets in Victoria, as in the Coorong. Most Red-necked Avocets occur in the Hells Gate Area. In 1982 and 1987, large numbers were also recorded in the South Lagoon, but there were none there in 2000 and only six in 2001.

Pacific Golden Plover

Numbers in 2001 (103) increased from 2000 (84). This possibly only reflects the fact that no count was made of the section from Murray Mouth to the Goolwa barrage in 2000. Numbers still remain below those recorded in the 1980s. This may reflect declines recorded in the larger population elsewhere in eastern and southeastern Australia from 1986 to 1994 (Harris 1994). Pacific Golden Plovers only occur in the North Lagoon and Northern Channels.

Red-capped Plover

Numbers in 2001 (1,367) were higher than in 2000 (1,089), but still below the 2,533-4,677 recorded in the 1980s. Interestingly there has also been a very large decline on the ocean beach since the 1980s. This suggests that declines might be due to wider population changes, rather than environmental factors within the Coorong.

Numbers of Red-capped Plovers at coastal sites monitored in Victoria have remained more or less stable for 20 years (Fig. 6). However, these birds may be drawn from different breeding populations to those in the Coorong. Birds in Gulf St. Vincent possibly belong to the same populations as those in the Coorong. At the Gulf St Vincent saltfields and Clinton Conservation Park, numbers declined from 2,305 in the early 1980s (Close & McCrie 1986) to 851 in 2000 (Wilson 2000). There were 1,273 counted there in 2001 (David Close pers.comm.) a decline of 45% since the 1980s.

The distribution within the Coorong was not similar in all years. The decline from 1982 to 2001 in the South Lagoon was 90%, in the Hell Gate Area 53%, in the North Lagoon 99%, but numbers actually increase in the Northern Channels by 28%. It is probable that the increase in the Northern

Channels has been less than this, since the count boundaries were uncertain in 1982. Comparing 1987 with 2001 showed a decline of 44% in the Northern Channels.

Hooded Plover

Forty-nine Hooded Plovers were seen on the ocean beach between Tea Tree crossing and the Murray Mouth. Six were single adults, there were 10 pairs without sign of chicks, 1 was a single immature, 1 was a single adult with a flying immature, 3 were adults in a flock and there were 5 pairs with chicks. Two pairs had one chick each about 1 week old, one pair had a chick about 10 days old, one pair had a fledged chick and 1 pair and 3 chicks about 1 week old. Although this was an increase from 2000 to 2001, the numbers are much lower than the early 1980s, although a longer stretch of beach was then counted.

DISCUSSION

The effect of wind and water levels on the distribution of waders in the Coorong

Overall, water levels during the 2001 count were higher than in the February 2000 AWSG count (Wilson 2000). However, there was significant variation caused by the wind, and in some places, water levels were lower than in 2000, particularly on 1 February when the Northern Channels was counted.

During the five day visit, the prevailing weather pattern was typical of that found on the Coorong in February. Calm mornings with little wind, changed to strong to very strong south-east sea breezes in the afternoons. This pattern was broken on the afternoon of the 1 February by strong northerlies. These winds persisted through 2 February when the ocean beach was counted. On the morning of 3 February, there were calm conditions again that deteriorated in the afternoon into very strong south-easterlies. This wind persisted through the whole day on 4 February.

The shift in wind direction had a profound effect on water levels in the Coorong. When we crossed Tea Tree Crossing to the ocean beach on the morning of 2 February it was dry. When we returned 6 hours later it was covered by 20 cms of water that had been pushed down the South Lagoon by the northerlies. On the 1 February there were several large dry sandbanks in the Northern Channel between south of Pelican Point to the Tauwitchere Barrage. There were few waders on the sandbanks. On the 4 February, the sandbanks were covered in a film of water. Water levels had probably risen 15-20 cms at that time. About 2,000 small waders were then feeding on these banks. Feeding areas used by waders on 1 February on the Younghusband Peninsula just south of Paddy Lookout and on the

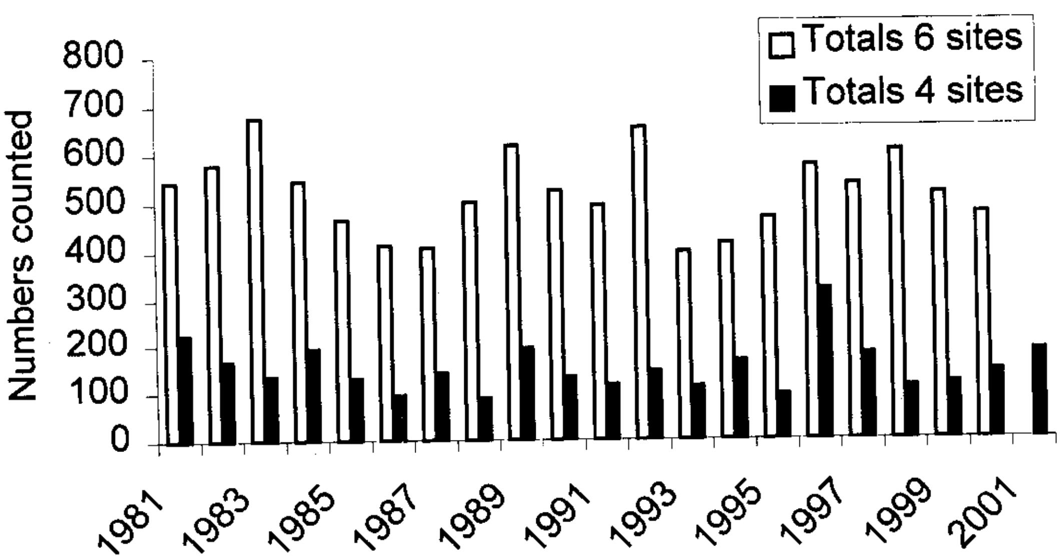

Figure 6. Changes in the number of Red-capped Plover at the six AWSG PMP sites in Victoria.

reefs on Tauwitchere Island and Ewe Island were partly or wholly covered by water on 4 February.

By far the largest concentration of waders in the Coorong in 2001 was along the shore near the Princes Highway in the bay enclosed by the Hack Point peninsula in the Malgrath Flat/Hells Gate area. Large numbers were seen feeding there in the mornings of 31 January, 3 February and 4 February, but these birds left the area about midday. In particular, it was noticeable that at the end of the count on 3 February the birds (about 13,000) left more or less en masse. On these days, there were strong south-easterly winds that developed at about mid-day. Birds possibly left because the shore became too exposed to the wind, or because the wind had pushed water over the wet feeding areas. In contrast on 1 February, when there were strong northerlies in the afternoon, waders remained on the area all day. This shore was then more sheltered and the wind would have exposed potential feeding areas. Few waders were seen along this shore in 2000.

Accuracy of counts

The size of the Coorong, movements of birds, heat haze and strong winds made counting difficult. Variability in skill among observers will also effect count results, but this was thought to be minimal compared to discrepancies caused by the short-term movements of birds. The Coorong was counted twice in 2001 to check on the accuracy of counts. The counters did not generally disturb birds to a great extent. All counts were done with telescopes, and where available, from higher view points (especially in the Malgrath Flat/Hells Gate area). Where possible, flocks were checked for movements and the time and direction of such movements recorded. The only case recorded of extensive double counting was in the bay south of Panmurung Point in the Northern Channels. Here about 1,000 Red-necked Stints were seen entering the bay at the start of the count. As 1,500 Red-necked Stints had been recorded on the sandbanks off Pelican Point only 30 minutes earlier, it was thought that the birds had probably come from there. Immediately after the count the boat was taken back to the sandbanks, and indeed all the Red-necked Stints had left.

Because of potential mass movements, it is important to count the areas where waders are most numerous quickly, rather than aim on counting every last bird. Preferably counts should be made in a large area in the space of 5-6 hours in the morning, before birds are effected by the sea breezes. This was done for the Malgrath Flat/Hells Gate area and the Northern Channels as far north as the Murray Mouth on the second count.

The total counts on two days in sections 24 to 31 in the Northern Channels were remarkably similar for several species, given the difficulties of counting (Table 3) This gives some confidence in the abilities of the counters involved. However, counts in the Malgrath Flat/Hells Gate showed large discrepancies. In section 14/15 there were 6,292 waders on 31 January and 23,701 on 3 February, and in section 16/17 9,096 waders on 31 January and 5,908 on 3 February. Obviously, some birds had moved from section 16/17 to 14/15, and possibly 3,600 small waders had moved into 14/15 from the South Lagoon as these were absent on 3 February. Despite their being recorded on 31 January. However, even allowing for such a movement, there is still a discrepancy between the two counts in the Malgrath Flat/Hells Gate area of 10,621 birds.

Half of this is due to Banded Stilts that increased from 7,355 on 31 January to 13,225 on 3 February. In the same period, Banded Stilt numbers in the South Lagoon increased from 1,788 to 2,370. Strong northerly winds had been blowing between the two count periods. Five Banded Stilts were also seen in the unusual habitat of the ocean beach at the same time. Thus, it is possible that the winds had triggered a movement of Stilts from the inland to the coast.

There were also large discrepancies between counts in the Hells Gate Area in 2000 when 33,263 waders were counted on 8 February compared with 17,166 on 12 February. Discrepancies were also noted in 1982 (Wilson 2000). The shore of the Younghusband Peninsula can be viewed from the inland shore and islands in the Malgrath/Hells Gate area from the bay up to 1 km north of the Needles to Hack Point. However, the shore around the islands south of Hack Point (Cow Island, Long Island, Round Island), and Long Bay, opposite this island were not counted in 2000 or 2001. If waders were using these areas this could be causing the discrepancies in counts. In future surveys these areas need to be checked by boat.

Possible causes for the decline in the number of waders in the Coorong

Migratory waders such as Greenshank, Red-necked Stint, Sharp-tailed Sandpiper and to a lesser extent Curlew Sandpiper, commonly occur on inland wetlands. Australian resident waders such as Banded Stilts, Black-winged Stilts, Red-necked Avocets, and Red-capped Plovers breed inland as well. The Coorong has been thought of as a refuge in times of drought (Jaensch & Barter 1988). Numbers could vary significantly depending on the drought/flood conditions of the inland. This has been used to explain the very high numbers in 1982 when there was a drought over much of southern Australia.

As the species of migratory and resident waders mentioned above make up approximately 98% of the wader populations in the Coorong, the state of inland wetlands could have a profound effect on the total numbers of waders using the Coorong in any one year.

In addition to the possible effects of the inland drought/flood conditions, the Flyway wader populations can change quite significantly over time. Declines recorded in the Coorong might only reflect declines in the larger populations. This seems to be the case in Curlew Sandpipers that have declined at monitored sites in Victoria by at least 50% in the last ten years, and in Pacific Golden Plovers.

Thus large changes in numbers have to be interpreted against the information available on the state of inland wetlands and populations elsewhere. Good rains in November 2000 flooded many of the coastal wetlands in South Australia between the Coorong and the Victorian border. For example, Lake George, which had very low water levels during the 2000 count, filled up and one week before the 2001 count there were 11,000 Banded Stilts there. Also there were 1,549 waders in the north end of the Morrella Basin, behind Salt Creek near the Coorong on 2 February 2001 (Table 5).

In a drier year, one might expect these birds and others from local wetlands, to use the Coorong. Further inland in South Australia, conditions were dry. AWSG wader surveys in inland Victoria in January and February 2001 showed that most wetlands there had dried up after five years of poor rainfall, and there were few waders. However, very good rains in Queensland and northern New South Wales in 2000 probably meant that many wetlands there were in prime condition for waders. It is not known to what extent migratory waders such as Red-necked Stints and Sharp-tailed Sandpipers might make a large shift in their non-breeding range if they encounter good conditions further north during the southward migration. Counts are needed over several years in the Coorong and these counts need to be linked with rainfall patterns before it can be shown to what extent the Coorong serves as a drought refuge.

It is possible to find factors operating in the larger populations that explain the declines in all but one of the most common wader species in the Coorong. Red-necked Stints are an exception to this pattern as populations in 2001 were at an all time high in Victoria. This is not reflected in the Coorong count, where this species has shown continuing declines.

The total numbers of waders in the Coorong have shown declines at every count since 1982. Counts themselves cannot show the environmental factors within the Coorong that might be causing declines. This would need much more detailed study than merely monitoring populations. It has been shown that around the Murray Mouth, the highest concentration of food items were generally found on finer sediments and the abundance of Sharp-tailed Sandpipers and Red-necked Stints were correlated with the abundance of the invertebrates in the sediments and in these two species and Curlew Sandpipers with the numbers of polychaetes, oligochaetes, chironomid larvae and/or bivalves (Paton *et al.* 2000). Decreases in the amount of silt brought down by the Murray after the barrages were built, coupled with increased water extraction upstream, may have caused the sediments on some of the flats at the Murray Mouth to become coarser and thus less suitable for waders (as sand has been carried in by the sea). Boring of cores may show the historic composition of these flats.

Further south, the Coorong is less influenced either by marine saline water, or fresh water flows from the Murray. As any periodic flushing effect from the Murray has diminished due to the reduced flows. Also, there is less local fresh water entering the Coorong in the southern end than formerly. Salination may have caused a deterioration in the Coorong in the South Lagoon and Malgrath Flat area. Certainly many of the flats there are very saline and not used extensively by birds. Recently more fresh water has been allowed to enter the South Lagoon via Salt Creek and a monitoring program has been set up to track any changes in wader populations there.

Although total populations for several species have declined quite markedly, there have not been any dramatic changes in the distributions. This suggests that if environmental factors within the Coorong are causing declines, or compounding declines already occurring in the larger populations, then such factors are affecting numbers throughout the Coorong, rather than only in part of it.

ACKOWLEDGEMENTS

The survey was supported with funds from the Department of Environment and Heritage, Mt. Gambier office. The Coorong National Park assisted with boats (2 days) and a vehicle on the ocean beach. Many thanks to Phil Hollow for arranging for this. Rangers, Bill Koolmatrie and Simon Oster piloted the boats and Eric de Smit drove up the ocean beach with part of the survey team. Permission to cross Aborigine land was given by George and Tom Trevorrow. Thanks also to Brenton Greare at the Mt. Gambier office for arranging funding and other support. The survey team consisted of David Close, Maureen Christie, David and Margret Dadd, David Edey, Jan Goode, Ken Gosbell, Vicki Natt, Ian Stuart, Johannes Wahl and Jim Wilson. John Eckert also surveyed independently the shore from Long Point to Pelican Point. Iane Mitchener kindly brought and piloted his own boat.

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THE JANUARY AND FEBRUARY 2001 VICTORIA WADER COUNT

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ABSTRACT
The Australasian Wader Studies Group 2001 wader count of Victoria has been published in a full report. The report is summarised in this paper. New wader population estimates for Victoria are calculated, and an account is given of each species. Large declines were detected in the counts of eight migratory wader species.

INTRODUCTION

In January and February 2001 the AWSG organised a wader count of Victoria. The main objective of the count was to obtain updated wader totals for Victoria to feed into the international and national wader population estimates. These were originally calculated in 1993 (Watkins 1993). The estimates for migratory species are currently being updated by Wetlands International. The Victoria count data will feed into that estimate. The count details have been published as a full report (Wilson 2001a). This paper gives a summary of the results published in that report. The sum of the summer AWSG Population Monitoring Project (PMP) counts from six sites in Victoria from 1981 to 2001 were used in the report to help interpret changes in populations, and to check that changes in 2001 were not a one off phenomena. Methods used in the surveys are given in the report.

RESULTS

Tables 1 and 2 show the summary of numbers counted on the coast and inland in 2001. Table 3 shows the new Victorian estimates and compares them with those in Watkins (!993). Specific details about the counts of each species that occurs in Victoria are given below.

Species Accounts

Latham's Snipe *Gallinago harwickii*

Only 150 Latham's Snipe were recorded. This species needs special survey methods that were not used in this survey. In the absence of other data, the population estimate of 11,000 given by Watkins (1993) has been maintained.

Black-tailed Godwit *Limosa limosa*

No Black-tailed Godwits were recorded. None were recorded in the PMP counts in 2000, but very low numbers occur in Victoria in most years, especially at Werribee.

Bar-tailed Godwit *Limosa lapponica*

Bar-tailed Godwits mainly at three sites at Victoria, Corner Inlet, Western Port and Swan Bay/Mud Island. They are most abundant at Corner Inlet. The PMP indicate that the total population increased during the first half of the 1980s, was stable in the late 1980s and early 1990s, and possibly declined slightly in the late 1990s. The higher numbers recorded in eastern Victoria compared with previous counts may be due to better coverage. The new estimate of 9,582 is similar to the old estimate of 9,931.

Whimbrel *Numenius phaeopus*

The mean count for the six monitored sites in the PMP was 16 in the years 1981-1986, compared with 79 for the years 1997-2001. There have been five years with totals ≥100 at the six sites combined (1987: 123; 1994: 216; 1995: 147; 2001: 100). The data suggests that Whimbrels were more numerous in the 1990s than in the 1980s, although numbers are still low. They mainly occur at two sites in Victoria: Corner Inlet and Western Port. The new estimate of 102 is an increase on the old estimate of 42 birds.

Eastern Curlew *Numenius madagascariensis*

Eastern Curlews mainly occur at three sites in Victoria: Corner Inlet, Western Port and Swan Bay/Mud Island. They are most abundant at Corner Inlet, followed by Western Port. The PMP indicates that the population has been fairly stable with some annual fluctuations. The new estimate of 3,385 is similar to the old one of 3,106.

Table 1. Summary of counts of waders from coastal Victoria during 2001 and the corresponding counts in Watkins (1993).

Species	This study								Watkins (1993)							
	East Gippsland coast	Gippsland Lakes & Coast	Corner and Shallow Inlet	Anderson Inlet	Westernport Bay	Port Phillip Bay	Torquay to Vic Border	Total count VIC coast	East Gippsland coast	Gippsland Lakes & Coast	Corner and Shallow Inlet	Anderson Inlet	Westernport Bay	Port Phillip Bay	Torquay to Vic Border	Total estimate VIC coast
Latham's Snipe				7		130	13	150			8		1	3		12
Black-tailed Godwit										4				40		44
Bar-tailed Godwit	115	22	8251	5	280	856	3	9532	50		9030		315	535	1	9931
Whimbrel	2		67		33			102			30		7	5		42
Eastern Curlew	40		2171	180	872	112		3375	20	1	1600	230	1000	255		3106
Marsh Sandpiper						234	4	238		1				105	5	111
Common Greenshank		88	192	99	149	762	17	1307		50	200	240	210	620	20	1340
Wood Sandpiper						1	2	3						5	1	6
Terek Sandpiper													5			5
Common Sandpiper						5	6	11					1	10	1	12
Grey-tailed Tattler	1	1			7	3		12			6		15	35	2	58
Ruddy Turnstone			26		282	100	239	647			95		70	115	220	500
Great Knot	1	21	100			45		167	1	2	430		2	375		810
Red Knot	2	1	1800		40	576		2419	3	1	3800		40	625	5	4474
Sanderling	6		100				412	518			135			10	425	570
Red-necked Stint	239	1642	24059	3679	6164	21290	728	57801	100	2125	14700	1940	3550	25180	975	48570
Pectoral Sandpiper						1		1								
Sharp-tailed Sandpiper		156	15	35	52	3451	24	3733	9	1090	160	660	360	12720	315	15314
Curlew Sandpiper		2	1276	52	1659	3773	2	6764		105	5300	350	3230	18500	1	27486
Bush Stone-curlew																
Pied Oystercatcher	105	20	854	25	347	116	130	1597	30	25	920	14	205	145	50	1389
Sooty Oystercatcher	55		422	56	32	1	3	569	4	1	270	16	10	10	5	316
Black-winged Stilt		270				1662	524	2456		30		15		860	85	990
Banded Stilt		23				2893	8	2924						3025	20	3045
Red-necked Avocet						437	6	443						1220	5	1225
Pacific Golden Plover	1	168	73	115	46	130	6	539	0		100	110	55	280	25	570
Grey Plover	1		171			29		201			600		1	200	20	821
Red-capped Plover	78	119	63	21	121	537	113	1052	70	110	40	30	65	490	215	1020
Double-banded Plover	7			13	29	8	10	67	15	250	730	550	500	1400	305	3750
Lesser Sand Plover		4				2		6			62		2	60		124
Greater Sand Plover			3					3			8		1	3		12
Oriental Plover										11	53					64
Black-fronted Dotterel	0			2		21	11	34	2	18				70	5	95
Hooded Plover	33	6	13	77		5	79	213	75	45	60	25	60	30	250	545
Red-kneed Dotterel						11	6	17		10				80	5	95
Banded Lapwing										1				10		11
Masked Lapwing	131	43	73	15	209	1518	395	2384								
Australian Pratincole																
Unidentified small		300					600	900						2		2
Unidentified medium							50	50								
Unidentified large																
Unidentified wader							5	5								
Total	817	2886	39729	4381	10322	38709	3396	100240	379	3880	38337	4180	9705	67023	2961	126465
Total less Double-banded Plover and Masked Lapwing								97789								122715

Table 2. Summary of the waders counted in inland Victoria during the 2001 survey and corresponding counts in Watkins (1993).

Species	This study							Watkins (1993)										
	Hamilton Area	Western District Lakes	Horsham Area	North-west Lakes/mallee	Kerang/ Swan Hill	Bendigo, and north VIC	Totals	Hamilton Area	Western District Lakes	Horsham Area	North-west Lakes/mallee	Mildura	Kerang/ Swan Hill	Bendigo area	Shepperton	Central Victoria	North-east Victoria	Totals
Latham's Snipe	N																	
Black-tailed Godwit	O											1	3					4
Bar-tailed Godwit	T																	
Whimbrel	C																	
Eastern Curlew	O																	
Marsh Sandpiper	U				23		23			15		25	70	1	1			112
Common Greenshank	N	2			29	5	36		10	15		40	15	10				90
Wood Sandpiper	T									1		1						
Terek Sandpiper	E																	
Common Sandpiper	D										2	1		1				4
Grey-tailed Tattler																		
Wandering Tattler																		
Tattler Spp																		
Ruddy Turnstone																		
Great Knot																		
Red Knot																		
Sanderling																		
Red-necked Stint		4668		7	220		4895		1450	330	15	110	980	15		20		2920
Pectoral Sandpiper																		
Sharp-tailed Sandpiper		1281			81	20	1382		1510	3035		330	2260	100	20	75		7330
Curlew Sandpiper		3064					3064		675	60		50	760	4		1		1550
Bush Stone-curlew																		
Pied Oystercatcher																		
Sooty Oystercatcher																		
Black-winged Stilt		205		79	597	382	1263		410	575	25	305	500	180	55	15		2065
Banded Stilt		15330		250	1406		16986		1835	1225	15	160	291		15			3541
Red-necked Avocet		31		16	317	12	376		65	735	560	735	400	85	40	10		2630
Pacific Golden Plover									5									5
Grey Plover																		
Red-capped Plover		651		4	494	37	1186		155	810	140	240	620	30	20	130		2145
Double-banded Plover		8					8		3700	20		5	40	10				3775
Lesser Sand Plover																		
Greater Sand Plover																		
Oriental Plover																		
Black-fronted Dotterel		12	18	7	14	9	60		5	105	65	40	5	55	10	50	45	380
Hooded Plover																		
Red-kneed Dotterel				4	36	9	49		5	190	5	125	50	85	30	20	5	515
Banded Lapwing					58		58	25			24	75						124
Masked Lapwing		779	37	122	300	282	1520											
Australian Pratincole					3		3			10		10	10					30
Unidentified small		1000					1000											
Unidentified medium																		
Unidentified large																		
Unidentified wader																		
Total		27031	55	489	3578	756	31909	25	9825	7126	851	2253	6004	576	191	321	50	27220
Total less Double-banded Plover and Masked Lapwing							30381											23445

Table 3. The estimated populations of each species of wader species in Victoria during 2001 and the corresponding estimate in Watkins (1993).

	This study					Watkins (1993)				
	Coast	Inland	Total	Unallocated	Total estimate	Coast	Inland	Total	Unallocated	Total estimate
Latham's Snipe	150		150	11000	11000	12		12	11000	11000
Black-tailed Godwit				30	30	44	4	48	30	78
Bar-tailed Godwit	9532		9532	50	9582	9931		9931		9931
Whimbrel	102		102		102	42		42		42
Eastern Curlew	3375		3375	10	3385	3106		3106		3106
Marsh Sandpiper	238	23	261	50	311	111	112	223	50	273
Common Greenshank	1307	36	1343	100	1443	1340	90	1430	100	1530
Wood Sandpiper	3		3		3	6	2	8		8
Terek Sandpiper						5		5		5
Common Sandpiper	11		11	50	61	12	4	16	50	66
Grey-tailed Tattler	12		12		12	58		58		58
Ruddy Turnstone	647		647		647	500		500		500
Great Knot	167		167		167	810		810		810
Red Knot	2419		2419		2419	4474		4474		4474
Sanderling	518		518		518	570		570		570
Red-necked Stint	57801	4895	62696	4100	66796	48570	2920	51490	1500	52990
Pectoral Sandpiper	1		1		1					
Sharp-tailed Sandpiper	3733	1382	5115	500	5615	15314	7330	22644	1000	23644
Curlew Sandpiper	6764	3064	9828	500	10328	27486	1550	29036	1000	30036
Bush Stone-curlew				500	500				500	500
Pied Oystercatcher	1597		1597	50	1647	1389		1389		1389
Sooty Oystercatcher	569		569	50	619	316		316		316
Black-winged Stilt	2456	1263	3719	1000	4719	990	2065	3055	1000	4055
Banded Stilt	2924	16986	19910		19910	3045	3541	6586	5000	11586
Red-necked Avocet	443	376	819	300	1119	1225	2630	3855	500	4355
Pacific Golden Plover	539		539		539	570	5	575		575
Grey Plover	201		201		201	821		821		821
Red-capped Plover	1052	1186	2238	500	2738	1020	2145	3165	500	3665
Double-banded Plover	67	8	75	8950	9025	3750	3775	7525	1500	9025
Lesser Sand Plover	6		6		6	124		124		124
Greater Sand Plover	3		3		3	12		12		12
Oriental Plover						64		64		64
Black-fronted Dotterel	34	60	94	1000	1094	95	380	475	1000	1475
Hooded Plover	213		213	203	416	545		545		545
Red-kneed Dotterel	17	49	66	500	566	95	515	610	500	1110
Banded Lapwing		58	58	3000	3058	11	124	135	3000	3135
Masked Lapwing	2384	1520	3904	26096	30000				30000	30000
Australian Pratincole		3	3	129	132	2	30	32	100	132
Unidentified small	900	1000	1900							
Unidentified medium	50		50							
Unidentified large										
Unidentified wader	5		5							
Total	100240	31909	132149	58668	188712	126465	27222	153687	58330	212005

Marsh Sandpiper ***Tringa stagnatilis***

Watkins (1993) recorded four sites of international or national importance for Marsh Sandpipers in Victoria. These were Third Marsh (Kerang), Reedy Lake (Moolap), Hospital Lake (Moolap) and Swan Hill Sewage Works. In the 2001 survey, only 23 Marsh Sandpipers were recorded at inland sites, and those were only in the Kerang/Swan Hill area. Only two were recorded at Reedy Lake, but there were 194 at Hospital Lake. The PMP shows that there was a peak in the population in the period 1995-1997, but in 1999-2001 the population returned to similar levels to that recorded in the 1980s and early 1990s. These estimates mainly come from the two sites at Moolap near west Port Phillip Bay. Fluctuating numbers there may be due to varying local conditions. The current population estimate (311) differs little from the earlier estimate of 273.

Common Greenshank ***Tringa nebularia***

Common Greenshanks are mainly coastal in Victoria. The PMP shows that numbers have fluctuated, and there are no real signs of any change. The new estimate of 1,430 is similar to the old estimate of 1,530.

Wood Sandpiper ***Tringa glareola***

Wood Sandpipers have always been uncommon or rare in Victoria and there has been no change in their status. Only three were recorded in 2001.

Terek Sandpiper ***Xenus cinereus***

Terek Sandpipers have always been uncommon or rare in Victoria. None were recorded in 2001.

Common Sandpiper ***Actitis hypoleucos***

The number counted in 2001 (9) was not much different from the previous count (16). Common Sandpipers often occur as solitary birds on rivers and creeks where they are easily overlooked and thus 50 have been included as an unallocated estimate in Table 3.

Grey-tailed Tattler ***Heteroscelus brevipes***

The Grey-tailed Tattler is a coastal species that has never been common in Victoria. The main concentrations have always been in the Swan Bay/Mud Island area, with additional birds in Corner Inlet and Western Port. The PMP counts show that Grey-tailed Tattlers have now almost disappeared from Victoria. It is most likely that this decline is due to factors affecting the larger population, than local environmental factors. The current estimate is 12, compared with 58 in Watkins (1993)

Ruddy Turrnstone ***Areneria interpres***

The current estimate of 647 is an increase on the earlier estimate of 500. This may be due to difficulties in counting the flock at Flinders that seems to cross to Phillip Island from the Mornington Peninsula when there is heavy disturbance. All, or part of, this flock may have been missed in earlier counts. Populations appear to be stable.

Great Knot ***Calidris tenuirostris***

Great Knots mainly occur at Corner Inlet and in the Swan Bay/Mud Island area. The PMP shows that the population has collapsed from the 1980s and early 1990s to the present low levels. The current estimate is 167, a reduction from the previous estimate of 810. As the decline has occurred on both the Great Knot sites, it is possible that it reflects declines in the larger population, rather than habitat changes in Victoria.

Red Knot ***Calidris canutus***

Like Great Knots, with which they associate, Red Knots mainly occur in Corner Inlet and in the Swan Bay/Mud Island area. Also like Great Knots, the population has shown a marked decline since the levels in the 1980s and 1990s, although the PMP suggest that the population may be merely returning to former lower levels (but note coverage was poorer at the beginning of the 1980s). The current estimate is 2,419 and a reduction from the previous estimate of 4,474. As in Great Knots declines may be a reflection of declines in the wider population.

Sanderling ***Calidris alba***

The current estimate of 518 is similar to the previous estimate of 570. The populations appear to be stable. Banding has shown large movement of birds between Victoria and South Australia. There is also no indication of any long term change in the populations in South Australia.

Red-necked Stint *Calidris ruficollis*

Numbers counted on the coast and inland were higher than in Watkins (1993). The new estimate is 66,796 compared with the previous estimate of 52,990. The PMP shows that in 2001, Red-necked Stint numbers in Victoria were at the highest on record. It is believed that this is due to two successive good breeding seasons (Clive Minton pers. comm.).

Pectoral Sandpiper *Caidris melanotus*

This is an uncommon bird in Victoria which can easily be overlooked. Only one was recorded in the 2001 survey.

Sharp-tailed Sandpiper *Calidris acuminata*

Population estimates of 5,615 in this survey are much lower than the previous estimate of 23,644. The PMP showed that 2001 was the worst year on record. The Sharp-tailed Sandpiper is a species that extensively uses the ephemeral wetlands, and it is thought that large numbers only come to the coast in time of drought. It is possible that many stopped off in inland Queensland and New South Wales in 2001, where there had been good rains, and that they did not reach Victoria. Record low numbers were also recorded in a survey of the Coorong in South Australia in 2001 (Wilson 2001b).

Curlew Sandpiper *Calidris ferruginea*

Population estimate in 2001 of 10,328 is much lower than the previous estimate of 30,036. The PMP shows that there has been an almost continuous decline in Curlew Sandpiper counts in Victoria, and the numbers in 2001 were the lowest on record. It is probable that this decline reflects declines in the overall population. Record low numbers were also recorded in a survey of the Coorong in South Australia (Wilson 2001b). The species is most numerous on the coast. The sighting of a flock of 3,000 at Lake Martin has been confirmed by the author. This is a new site of international importance for Curlew Sandpipers. The only previously recorded inland site of international importance in Victoria was at Lake Connerwarre (2,820 counted).

Bush Stone-curlew *Burhinus grallarius*

None were recorded in the 2001 survey, hardly surprising given their different habitat to other wader species and nocturnal behaviour. In the absence of recent data the previous estimate of 500 has been maintained.

Pied Oystercatcher *Haematopus longirostris*

More were recorded than the previous population estimates (1,597/1,389 respectively). Also a few Pied Oystercatchers will have been missed on areas not visited (estimated at 50). The new population estimate is therefore set at 1,647 compared with the previous 1,389, an increase of 19%. Most of the increase comes from the more remote beaches in the east and west. It is not known if the counts represent a real increase or better coverage.

Sooty Oystercatcher *Haematopus fuliginosus*

More were recorded during the 2001 survey than the previous population estimates (569/316 respectively). The increase is due to higher numbers in Corner Inlet, and to better coverage. For example there were 55 counted on the East Gippsland coast compared with the previous estimate of four. Many pairs of Sooty Oystercatchers do not flock after breeding, but remain on rocky coasts and islands that are not often visited. These were not well covered on this survey, but missed birds were estimated at 50, a figure which may be too low. The new population estimate is 619, and increase of 96% over the previous estimate. It has been estimated that there are 5,000 Sooty Oystercatchers in Australia. This figure is probably too low, as was also shown by the South Australia survey in 2000 (Wilson 2000).

Black-winged Stilt *Himantopus himantopus*

The numbers counted (3,719) were remarkably similar to the previous total (3,055). However, there seems to have been a marked switch from inland to coastal sites as twice as many were recorded on the coast, and only half as many inland. This possibly reflects the dry inland conditions in 2001. The 2001 estimates are set at 4,719, compared with the previous estimate of 4055.

Banded Stilt *Cladorhynchus leucocephalus*

Banded Stilts nested successfully on Lake Eyre in July 2000, and it was estimated that potentially

30,000 eggs hatched (Anon 2000). Banded Stilts are a mobile species that move from wetland to wetland as conditions change. A total of 19,910 were counted in 2001, compared with the previous estimate of 11,586. The 2001 count includes one flock of 12,000 at Lake Martin. This is 6% of the estimated Flyway population. Lake Martin is not specifically listed as a site of international importance by Watkins (1993), although it is an extension of Lake Corangamite, which is listed, with a maximum flock size of 6,000 Banded Stilts. There are 13 sites listed as of international importance for Banded Stilts in Victoria. Several of these were dry in 2001.

Red-necked Avocet *Recurvirostra novaehollandiae*

Population estimates at 1,119 are much lower than the previous estimate of 4,355. There were about equal numbers on the coast and inland. The PMP shows that numbers of Red-necked Avocets fluctuate widely. It is assumed that birds were away breeding somewhere in Queensland or New South Wales in 2001, after good rains there.

Pacific Golden Plover *Pluvialis fulva*

Population estimates at 539 are similar to the previous estimate of 575. However, the PMP shows that on the monitored sites there has been a decline since the 1980s. This decline has been detected throughout east and southern Australia (Harris 1994). Thus the apparent similarity in population estimates may be due to better coverage in 2001. The decline shown by the PMP is assumed to be a reflection of a decline in the overall population.

Grey Plover *Pluvialis squatarola*

Population estimates of 201 are lower than the previous estimate of 821. Grey Plovers mainly occur at two sites, Corner Inlet and Swan Bay/Mud Island. The PMP has shown a decline from the 1980s and early 1990s to a lower population in the mid to late 1990s. The pattern is broadly similar to that in Great Knots and Red Knots, and possibly reflects changes in the overall population.

Red-capped Plover *Charadrius ruficappillus*

Numbers on the coast were similar to those in Watkins (1993), but were lower inland, possibly because of the very dry conditions in 2001. The new estimate 2,738 is lower than the previous estimate of 3,665.

Double-banded Plover *Charadrius bicinctus*

Double-banded Plovers are winter migrants from New Zealand. Only the earliest of the returning migrants were recorded in the 2001 survey. In the absence of any new data the previous estimates of 9,025 has been maintained.

Lesser Sand Plover *Charadrius mongolus*

Lesser Sand Plovers are a coastal species that have never been numerous in Victoria. The main concentrations have always been in Corner Inlet and the Swan Bay/Mud Island area, with fewer birds in Western Port. The PMP counts show that Lesser Sand Plovers numbers peaked in 1981/1982 and again in 1992/1993. They have now almost disappeared from Victoria. It is more likely that this decline is due to factors affecting the overall population, than local environmental factors within the sites in Victoria. The current estimate is 6, compared with the previous estimate of 124.

Greater Sand Plover *Charadrius leschenaultii*

Greater Sand Plovers have always been uncommon in Victoria. The 2001 count produced 3 birds compared with the previous estimate of 12.

Oriental Plover *Charadrius veredus*

Oriental Plovers are rare in Victoria, but are perhaps also overlooked in the dry north-west where they are most likely to occur. In very hot weather some birds move out to the coast. None were recorded in 2001.

Black-fronted Dotterel *Elsevornis melanops*

The counts suggest there has been a large decline and the current estimate is 1,094, compared to the previous estimate of 1,475. However, it is probable that it is better to count this species in the winter, when they have gathered away from their breeding areas. The inland was very dry in 2001, and birds may have moved northwards to New South Wales and Queensland where there had been good rains.

Hooded Plover *Thinornis rubricollis*

The best estimate for Hooded Plover populations in Victoria come from the recent Hooded Plover survey in November 2000 organised by Mike Weston. From this survey, the Victorian population has been provisionally estimated, at the time of publication of the report, at 416. This compares with the previous estimate of 545 (Watkins 1993). During the 2001 wader count 213 were recorded. This would have included young birds from the 2000/2001 breeding season. However, not all the areas used by Hooded Plovers were covered by the 2001 count, as they often nest on long oceanic beaches that have few or no other waders, and so were not covered in the survey. The Hooded Plover surveys have shown that there has been a real decline in the Hooded Plover populations in Victoria. The present estimates suggest that decline has been about 25% since the 1980s.

Red-kneed Dotterel *Erythrogonys cinctus*

The counts suggested a large decline and the current estimate is 566 compared with the previous estimate of 1,110. However, it is probably better to count this species in the winter, when they have gathered away from their breeding areas. The inland was very dry in 2001, and birds may have moved northwards to New South Wales and Queensland where there had been good rains.

Banded Lapwing *Vanellus tricolor*

Banded Lapwings are usually seen when they move to inland wetlands and the coast, especially in hot weather. They are easily overlooked on the paddocks where they normally occur. In the absence of any new data the previous unallocated estimate of 3,000 has been retained.

Masked Lapwing *Vanellus miles*

Masked Lapwings are numerous and widespread in Victoria. 3,904 were counted in the 2001 survey. It is unlikely, however, that as much as 13% of the previously estimated population of 30,000 was counted. This estimate would give an average of one bird per 7.7 km^2. Although there are large areas of Victoria that are not suitable for Masked Lapwings, the previous estimate seems to be far too low. However, in the absence of other data the previous 30,000 estimate has been maintained.

Australian Pratincole *Stiltia isabella*

This is an uncommon species and only three were recorded during the 2001 survey. However, it is easily overlooked and may be more common in the north-west than the survey suggested. In the absence of new data the previous population estimate has been maintained.

Population declines

The survey has detected large declines in eight migratory species of wader. These are Grey-tailed Tattler, Great Knot, Red Knot, Sharp-tailed Sandpiper, Curlew Sandpiper, Pacific Golden Plover, Grey Plover and Lesser Sand Plover. For the six PMP sites combined the size of the declines expressed as a percentage of the peak in five year means for the years 1981-2000, and also as a percentage of the 1981-1985 mean are shown in Table 4.

Table 4. Estimated population declines in Victoria based on AWSG Population Monitoring Project counts at six sites. Counts of the species showing declines in the Coorong, South Australia (Wilson this issue) are included for comparison (* 2001 declines from 1981 count).

State	Species	Five year means					2001 decline
Victoria		1981-1985	1986-1990	1991-1995	1995-2000	2001	from peak (%)
	Grey-tailed Tattler	51	45	26	8	9	-82
	Great Knot	690	886	298	119	145	-84
	Red Knot	3504	5571	4518	1556	2416	-57
	Sharp-tailed Sandpiper	9277	12612	8545	6735	3501	-72
	Curlew Sandpiper	26807	17315	17948	11425	6801	-75
	Pacific Golden Plover	349	382	193	152	176	-54
	Grey Plover	494	883	933	406	200	-79
	Lesser Sand Plover	137	69	140	59	2	-99
Coorong		1981	1982	1987	2000	2001	
South Australia	Red-necked Stint	54743	63794	54710	30145	18368	-71
	Sharp-tailed Sandpiper	24871	55739	22898	10697	5718	-90
	Curlew Sandpiper	39882	22614	22512	13124	4309	-89

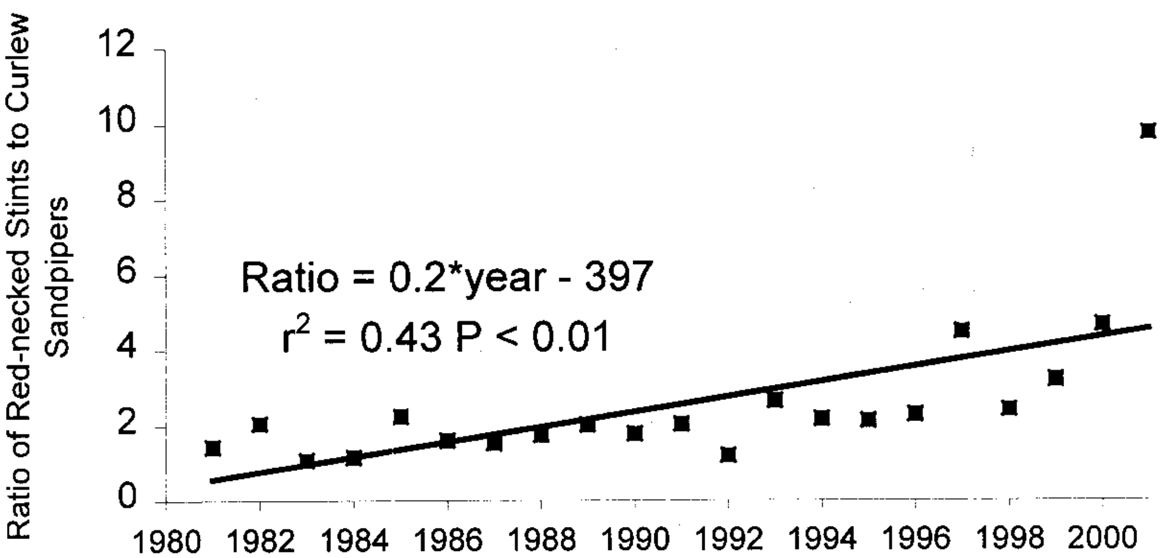

Figure 1. Ratio of Red-necked Stints to Curlew Sandpipers at six AWSG Population Monitoring Project sites in Victoria between 1980 and 2001.

The results of the PMP have been used uncritically in this study without checking on notes made on count sheets as to local factors that could have affected the counts, such as tide height or weather. Despite this, I think the coverage by counters has always been fairly consistent, apart from when Shallow Inlet was included in the Corner Inlet counts in the early 1980s. As well, the same counters have been involved for 20 years. As six species with populations of >100, such as Bar-tailed Godwit, Eastern Curlew, Marsh Sandpiper, Common Greenshank, Ruddy Turnstone and Sanderling seemed to have remained more or less stable and Red-necked Stints have increased in numbers it is probable that the declines are real and not an artifact of counting.

Also the ratio of Red-necked Stints to Curlew Sandpipers, two species that occur together in the same habitat, and therefore are counted at the same time, has changed steadily over the years as the Curlew Sandpiper population has decreased. As well, the Red-necked Stint population has increased in the last two years (Fig.1). Large declines in Sharp-tailed Sandpipers and Curlew Sandpipers have also been recorded in the Coorong, but there Red-necked Stints have also been declining in contrast to the increase in Victoria (Table 4).

Poor breeding success could have caused the declines, although as the species that have declined come from a wide breeding range, which overlaps with those that have not declined, this seems to be unlikely to be the cause in all species. It is also unlikely that the declines are due wholly to changes in local conditions, since some species have remained stable and Red-necked Stints have increased. Also some of the species that have declined occurred in very low numbers in the first place, and habitat destruction in Victoria has not taken place on the scale that would reduce their numbers. However, a careful assessment is needed at each of the main sites in Victoria, as there are also undoubtedly some factors that could affect numbers on a local site basis. This needs more intimate long term knowledge of the site than was available to this survey, and is best done by local observers.

The AWSG has been expecting declines in migratory wader populations for many years. These waders use the East Asian-Australasian Flyway and are known to be under threat from massive habitat reclamation and deterioration on their staging areas in Asia. Victoria is at, or near, the edge of the non-breeding range for migratory waders. As populations decline, one might expect this to be more noticeable at the edge of the range, than at the core of the range as populations retreat into the core as space becomes available. Are the declines in Victoria (and South Australia) then the first signs of a decline in Flyway populations due to habitat destruction in Asia?

ACKNOWLEDGEMENTS

Full acknowledgments are given in the report. Many thanks to all the counters involved. In particularly BOCA are thanked for the Western Port counts. The AWSG thanks the Natural Heritage Trust for financial support, without which the survey would not have been possible.

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Erratum to Stilt 38

During the editorial process the following errors occurred in the paper by Finn *et al.* Stilt 38, 9-17. The editor apologises for this omissions.

Errata:

1. Page 11, column 1, line 5: "r^2" should read "r".
2. Page 11, column 2, line 2: "$r^2 = 0.34$" should read "$r = 0.58$".

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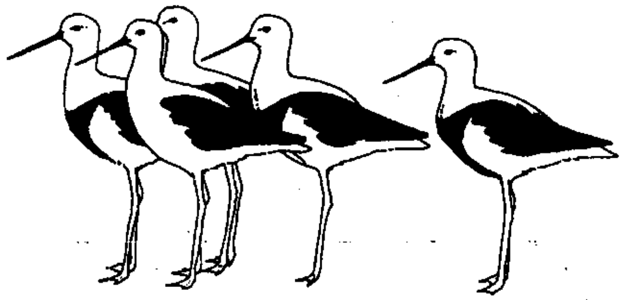
Deadlines:

The closing dates for submission of material have been revised. They are <u>**1 March**</u> and <u>**1 September**</u> for the April and October editions respectively. **Extensions to these dates must be discussed with the Editor.** Contributors are reminded that they will probably have some comments to consider, and possibly incorporate, at some time after submission. It would be appreciated if this could be done promptly.



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