# Shorebirds in New Zealand

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# SHOREBIRDS IN NEW ZEALAND

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New Zealand's coast supports up to 166,000 northern hemisphere breeding waders, including internationally important populations of Bar-tailed Godwit and Red Knot, during the austral summer. Some 163,000 local breeding waders occur on the coast during winter. Most taxa of endemic waders are threatened, the Black Stilt being critically endangered. Habitat loss and predation by introduced mammals are the greatest threats.

## INTRODUCTION

New Zealand, with a land area of 270,500 km$^2$, is situated at the southernmost point of the East Asian-Australasian Flyway, between 33$^o$ and 47$^o$S. The coastline is some 15,134 km long (Anon 2006); two-thirds of it is hard rocky shore, the remaining third being soft sand, silt and gravel (Taylor & Smith 1997). An introduction to coastal environments in New Zealand is given by Morton & Miller (1973) and Morton (2004).

Nationwide counts of waders co-ordinated by the Ornithological Society of New Zealand were made in summer and winter from 1983 to 1994. Endemic waders breed on coasts (Northern New Zealand Dotterel, Variable Oystercatcher), on braided river beds (Wrybill, Black Stilt), subalpine mountain tops (Southern New Zealand Dotterel) and densely vegetated subantarctic islands (snipe); population estimates of these species were derived from winter counts, whereas estimates for northern hemisphere breeders were made from summer counts. These counts showed that New Zealand's coast supported some 166,000 northern hemisphere breeding waders during the austral summer and about 163,000 New Zealand breeding waders in winter (Sagar *et al*. 1999).

The first human arrival, of Polynesians some 2000 years ago (Worthy & Holdaway 2002), is thought to have set in train the first wave of bird extinctions due to introduced mammalian predators (notably Pacific Rat [kiore] *Rattus exulans*). Subsequent introductions by European settlers caused further waves of extinction with impacts continuing to the present day (see below).

Habitat changes following human settlement also have had marked impacts on some wader species. The felling of forests and the opening of pasture lands opened the way for colonisation of power schemes and the spread of exotic plants in riverbeds has resulted in less breeding habitat for species such as Black-fronted Terns and Wrybills.

Mangroves *Avicennia resinifera* occur in the northern part of the North Island, south to about 38$^o$ (Wardle 1991) and currently cover some 22,500 ha (MAF 2006). In recent years encroachment of tidal areas by mangrove has increased, apparently due to increased sediment and nutrient runoff, and is becoming a topic of public debate (Green *et al*. 2003), with concern about the loss of high-tide wader roosts in the Firth of Thames (Woodley 2005).

## ENDEMIC WADERS

Eighteen taxa representing at least 13 species of wader breed in New Zealand, of which 10 are endemic. Population estimates are given in Table 1. Information on the distribution and movements of endemic waders in New Zealand has recently been summarised by Dowding & Moore (2006) and is not considered further here.

## ARCTIC-BREEDING MIGRANT WADERS

New Zealand lies at the South-eastern extremity of the East Asian-Australasian Flyway and receives relatively few migrant Arctic-breeding shorebirds, especially when compared with Australia. A total of 47 species has been recorded (Tables 2 and 3) but of these only three occur in internationally significant numbers – Bar-tailed Godwit, Red Knot and Ruddy Turnstone.

Coastal wader surveys have been conducted at some sites by members of the Ornithological Society of New Zealand (OSNZ) since the 1950s. A national wader census project between 1983 and 1994 resulted in coverage of all main wader sites throughout the country with winter (June/early July) and summer (November/early December) counts (Sagar *et al*. 1999). Wader counts continued, but on a less formal basis, between 1994 and 2003 (Southey in prep.), and since 2003 have been reinstated as an official OSNZ project, with support from the Department of Conservation (OSNZ unpubl.). Population estimates of the more regularly occurring species are given in Table 2; vagrant species are listed in Table 3. Note that the estimates based on Sagar *et al.* (1999) were derived from censuses from 1984-1994 and may be out of date; updated national estimates are not yet available.

Count data at a national level are too few to allow detailed analysis of national population trends. However, medium- to long-term data sets exist for certain major sites, particularly the Manukau Harbour and Firth of Thames (continuous since 1960/1961; Battley *et al*. 2007) and Farewell Spit (periodic since 1961, continuous since 1983; Schuckard 2002). These reveal that there have been substantial changes in numbers of Bar-tailed Godwits and Red Knots at these sites. Godwits showed two general population peaks in the Manukau Harbour and Firth of Thames – one in the mid-1960s and one in the early-mid 1990s. Over a shorter time scale, numbers of godwits at four

**Table 1**. Population estimates of waders breeding in New Zealand After Dowding and Moore (2006) if not otherwise indicated.

| Species | Population estimate | Comments |
|---|---|---|
| New Zealand Pied Oystercatcher *Haematopus finschi* | 130,000 | Population increasing |
| Variable Oystercatcher *Haematopus unicolor* | 4,500 | Population increasing |
| Chatham Island Oystercatcher *Haematopus chathamensis* | c. 170 mature individuals | Subject to ongoing management |
| Pied Stilt *Himantopus himantopus leucocephalus* | 30,000 | Population trend not known |
| Black Stilt *Himantopus novaezelandiae* | c. 50 | Population declining due to predation and interbreeding with Pied Stilt |
| Southern New Zealand Dotterel *Charadrius obscurus obscurus* | c. 250 | Increased from a low of 62 in 1992 due to intensive management |
| Northern New Zealand Dotterel *Charadrius obscurus aquilonius* | c. 1,700 | Population declining |
| Banded Dotterel *Charadrius bicinctus bicinctus* | 50,000 | Population declining |
| Auckland Island Banded Dotterel *Charadrius bicinctus exilis* | 730 | Population trend not known |
| Black-fronted Dotterel *Charadrius melanops* | 1,700 | Colonised in 1950s |
| Spur-winged Plover *Vanellus miles* | abundant | Colonised in 1930s |
| New Zealand Shore Plover *Thinornis novaeseelandiae* | c. 120 mature individuals | Largely confined to 2 islands in the Chathams group |
| Wrybill *Charadrius (Anarhynchus) frontalis* | 4,500-5,000 | Population declining |
| New Zealand Snipe *Coenocorypha aucklandica* | 20,000[2] | Population trend not known |
| Chatham Island Snipe *Coenocorypha pusilla* | At least 1,000 pairs | Confined to 4 islands in the Chathams group |
| Snares Island Snipe *Coenocorypha [aucklandica] huegeli* | 1,100[1] | Population trend not known |
| Antipodes Island Snipe *Coenocorypha [aucklandica] meinertzhagenae* | 8,000[1] | Population trend not known |
| Campbell Island Snipe *Coenocorypha* undescribed taxon | <50[2] | Population now expanding from Jacquemart Island to Campbell Island (Miskelly and Fraser 2006) |

**Notes**: [1]After Wetlands International (2006). [2]After Barker *et al.* (2005).

**Table 2**. Population estimates of arctic-breeding shorebirds occurring regularly in New Zealand after Sagar *et al*. (1999).

| Species | Population estimate |
|---|---|
| Greater Sand Plover *Charadrius leschenaultii* | <10 |
| Lesser Sand Plover *Charadrius mongolus* | <10 |
| Pacific Golden Plover *Pluvialis fulva* | 649 |
| Grey Plover *Pluvialis squatarola* | <10 |
| Ruddy Turnstone *Arenaria interpres* | 5,069 |
| Red Knot *Calidris canutus* | 58,637 |
| Sanderling *Calidris alba* | <10 |
| Curlew Sandpiper *Calidris ferruginea* | 86 |
| Sharp-tailed Sandpiper *Calidris acuminata* | 81 |
| Pectoral Sandpiper *Calidris melanotos* | <10 |
| Red-necked Stint *Calidris ruficollis* | 175 |
| Eastern Curlew *Numenius madagascariensis* | 34 |
| Whimbrel *Numenius phaeopus* | 117 |
| Bar-tailed Godwit *Limosa lapponica* | 101,698 |
| Black-tailed Godwit *Limosa limosa* | <10 |
| Hudsonian Godwit *Limosa haemastica* | <10 |
| Grey-tailed Tattler *Tringa brevipes* | <10 |
| Greenshank *Tringa nebularia* | <10 |
| Marsh Sandpiper *Tringa stagnatilis* | <10 |
| Terek Sandpiper *Tringa terek* | <10 |

of the most important sites in New Zealand (Kaipara and Manukau Harbours, Firth of Thames, Farewell Spit) declined substantially from the mid-1990s to mid-2000s, with a decrease of almost over 20,000 birds (Figure 1). The national population may currently be considerably lower than the 101,000 estimated by Sagar *et al*. (1999).

Red Knots increased in the Manukau Harbour from less than a thousand birds in the early 1960s to 10-20,000 birds in the 1980s (Battley *et al*. 2007). This increase overlapped with a long-term decline in knot numbers on Farewell Spit (from 27,000 in 1961 to 6800 in 2001; Schuckard 2002) but the timing of the changes do not mean there has been a simple redistribution of birds between these sites (the steepest decline on Farewell Spit was when numbers in the Manukau Harbour were fairly stable). It is evident that factors affecting Arctic shorebird populations in New Zealand are not constant among sites. Preliminary analyses of numbers of Arctic waders in the Manukau Harbour and

**Table 3.** Vagrant waders recorded in New Zealand after Sagar *et al*. (1999), Turbott (1990), Heather and Robertson (1996), Hill (2006), Petch *et al*. (2002).

| Species |
|---|
| Painted Snipe *Rostratula benghalensis* |
| Oriental Pratincole *Glareola maldivarum* |
| Red-capped Dotterel *Charadrius ruficapillus* |
| Ringed/Semipalmated Plover *Charadrius hiaticula/semipalmatus* |
| Red-kneed Dotterel *Erythrogonys cinctus* |
| Oriental Plover *Charadrius veredus* |
| Japanese Snipe *Gallinago hardwickii* |
| Great Knot *Calidris tenuirostris* |
| Dunlin *Calidris alpina* |
| Baird's Sandpiper *Calidris bairdii* |
| White-rumped Sandpiper *Calidris fusicollis* |
| Little Stint *Calidris minuta* |
| Western Sandpiper *Calidris mauri* |
| Long-toed Stint *Calidris subminuta* |
| Broad-billed Sandpiper *Limicola falcinellus* |
| Stilt Sandpiper *Micropalama himantopus* |
| Ruff *Philomachus pugnax* |
| Asiatic Dowitcher *Limnodromus semipalmatus* |
| Little Whimbrel *Numenius minutus* |
| Bristle-thighed Curlew *Numenius tahitiensis* |
| Upland Sandpiper *Bartramia longicauda* |
| Wandering Tattler *Tringa incana* |
| Common Sandpiper *Tringa hypoleucos* |
| Lesser Yellowlegs *Tringa flavipes* |
| Red-necked Phalarope *Phalaropus lobatus* |
| Grey Phalarope *Phalaropus fulicarius* |
| Wilson's Phalarope *Phalaropus tricolor* |

Firth of Thames indicate that while for some for species changes in productivity are at least partly behind their population changes (peaks in total numbers coincide with increases in overwintering immature birds), habitat changes have affected the distribution and numbers of other species at a local scale.

## WETLANDS OF INTERNATIONAL IMPORTANCE FOR WADERS

Cromarty & Scott (1996) reviewed wetlands throughout New Zealand and listed sites of international importance according to the Ramsar criteria then current. Among the 73 sites listed, there were 19 which were identified as having particular wader values.

The only population estimates for Northern Hemisphere waders in New Zealand currently available are those given by Sagar *et al*. (1999). The Ramsar criteria for identifying sites of 'international' importance based on waterbird numbers are:

> **Criterion 5.** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds
>
> **Criterion 6.** A wetland should be considered internationally important if it regularly supports 1% of the individuals of a population of one species or subspecies of a waterbird (based on Wetlands International 2006)

Taking the results of the 1983-1994 censuses (Sagar *et al*. 1999), and current total population figures (Wetlands International 2006) there are 15 sites which should be considered as internationally important for Arctic-breeding waders (Table 4).

Dowding & Moore (2006) list the 22 main sites of international importance for endemic waders (Table 5). It should be noted that due to the very small populations of species such as Chatham Island Oystercatcher and Black Stilt, sites regularly supporting one bird are considered to be internationally important under the Ramsar criteria; these sites are not listed in Table 5.

Four of the six listed Ramsar sites in New Zealand are of importance to waders (Table 6). None of these has a current management plan, although one for Farewell Spit is in preparation. The ecology of waders on Farewell Spit was studied by Battley (1996), and Battley *et al*. (2005a) detail the benthos of the Farewell Spit tidal flats. Rance & Cooper (1997). Thompson & Ryder (2003) provide information about Waituna Lagoon. Brownell (2004) provides information about the ecology of the Firth of Thames site and Battley & Brownell (2007) give more information on changes in numbers of waders and summarise relevant knowledge about wader foraging ecology. Information about the Manawatu estuary is available from the Ramsar Sites Information Service (http://www.wetlands.org/rsis/). A proposal to extend the Waituna Lagoon Ramsar Site to include Awarua Bay (Cromarty & Scott 1996) has yet to be implemented.

A review of rivers of national/international importance was undertaken by Chadderton *et al*. (2004); this includes a number of rivers with wader values.

## THREATS TO WADERS

The arrival of humans (initially Polynesians, later Europeans) in New Zealand together with their attendant camp followers and deliberately introduced species (especially rats *Rattus exulans*, *R. norvegicus*, *R. rattus*., cats *Felis catus*, mustelids *Mustela erminea*, *M. nivalis*, *M. furo*, and European Hedgehogs *Erinaceus europaeus*), have had a marked impact on many shorebird species in New Zealand and predation by introduced mammals continues to seriously threaten a number of species (Dowding & Murphy 2001). Population recovery once predators have been removed can be spectacular (Miskelly & Fraser 2006).

Three endemic taxa are known to have become extinct (Table 7) – snipe possibly having become extinct on the North and South Islands by the time of European arrival (Worthy & Holdaway 2002, but see Tennyson & Martinson 2006). Ranges of some species have become severely restricted – for example, Shore Plovers used to occur at inland sites in the South Island, and fossils of New Zealand Dotterel have been found at high altitude in northwest Nelson (Worthy & Holdaway 2002). Hybridisation with Pied Stilt remains a serious threat to the Black Stilt (Greene 1999). Four species are currently considered to be nationally critical/globally endangered (Table 8).

Human impacts on coastal environments are increasing with habitat loss due to infilling/reclamation, subdivision for urban development adjacent to shores (with associated

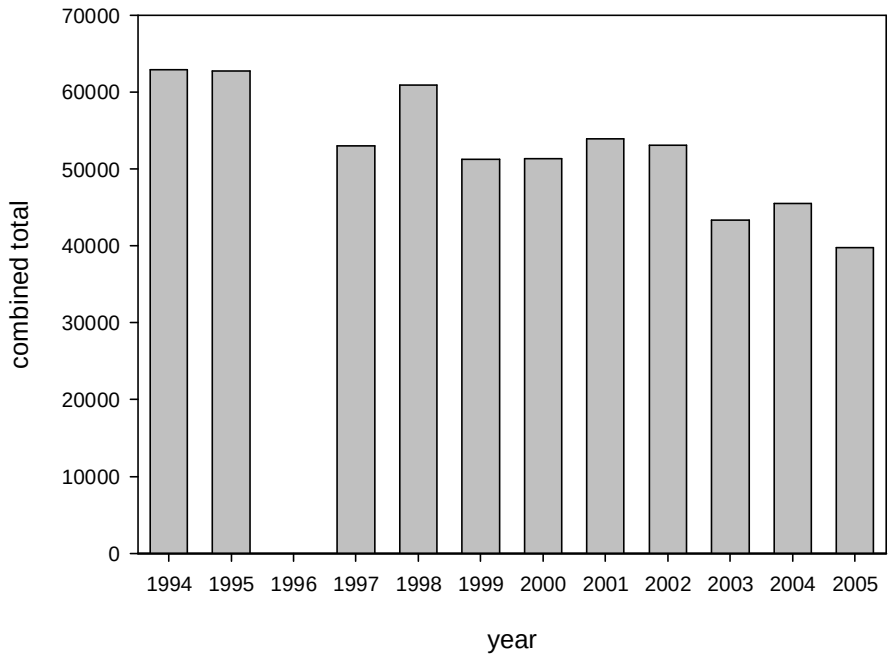


**Figure 1.** Decrease in numbers of Bar-tailed Godwits in the Kaipara and Manukau Harbours, Firth of Thames and Farewell Spit. Counts are from OSNZ censuses conducted in November/December (first three sites) or are the higher of censuses in November or February (Farewell Spit).

**Table 4.** Coastal wetlands in New Zealand of international importance for Arctic-breeding waders.

| Site | Criteria | | | |
|---|---|---|---|---|
| | 20,000 waterbirds | Bar-tailed Godwit | Red Knot | Ruddy Turnstone |
| Parengarenga, Far North | . | + | + | + |
| Houhora Harbour, Far North | . | . | + | . |
| Rangaunu Bay, Far North | . | + | + | . |
| Whangarei Harbour, Northland | . | + | + | . |
| Kaipara Harbour, North Auckland | + | + | + | . |
| Manukau Harbour, Auckland | + | + | + | . |
| Firth of Thames, South Auckland | + | + | + | . |
| Tauranga Harbour, Bay of Plenty | . | + | . | . |
| Ohope Spit, Ohiwa Harbour, Bay of Plenty | . | + | . | . |
| Kawhia Harbour, Waikato | . | + | . | . |
| Farewell Spit, Northwest Nelson | + | + | + | . |
| Motueka Estuary, Tasman Bay | . | + | . | . |
| Waimea Inlet, Tasman Bay | . | + | . | . |
| Avon-Heathcote Estuary, Canterbury | . | + | . | . |
| Invercargill Estuary, Southland | . | + | . | . |

disturbance and pet animals), mangrove encroachment in the northern harbours, shellfisheries, aquaculture and sea level rise. The introduction of exotic organisms, both deliberate, e.g. the cord-grass *Spartina* (Partridge 1987) and accidental, e.g. the oyster *Crassostrea gigas* (Dinamani 1971), has resulted in widespread impacts in many coastal areas. Green (2006) provides an introduction to current estuarine management issues.

Loss of shorebird nesting habitat in braided rivers is occurring as a result of encroachment by vegetation (mostly exotic), which often is exacerbated by changing flow regimes due to water abstraction for irrigation and hydroelectric schemes (O'Donnell 2004).

Recovery plans have been prepared by the New Zealand Department of Conservation for New Zealand Dotterel (Dowding 1993, Dowding & Davis 2007), Chatham Island Oystercatcher (Anon. 2001), Chatham Island Snipe (Aikman *et al.* 2001), and Black Stilt (Maloney & Murray 2002).

**Table 5.** Sites of international importance for endemic waders in New Zealand after Dowding and Moore (2006).

| Site | Pied Oyster-catcher | Variable Oyster-catcher | Pied Stilt | Black Stilt | New Zealand Dotterel | Banded Dotterel | Wrybill |
|---|---|---|---|---|---|---|---|
| **Sites of international importance for two or more taxa** | | | | | | | |
| Parengarenga Harbour, Far North | . | + | + | . | + | + | + |
| Houhora Harbour, Far North | . | + | + | . | + | + | + |
| Rangaunu Harbour, Far North | . | + | + | . | + | . | . |
| Whangarei Harbour, Northland | + | + | + | . | + | + | + |
| Mangawhai Estuary, Northland | . | + | . | . | + | . | . |
| Kaipara Harbour, North Auckland | + | ? | + | + | + | + | + |
| Manukau Harbour, Auckland | + | . | + | + | + | + | + |
| Firth of Thames, South Auckland | + | . | + | + | + | . | + |
| Aotea Harbour, Waikato | + | . | + | . | . | + | . |
| Kawhia Harbour, Waikato | + | . | + | + | . | + | . |
| Matarangi Spit, Coromandel | . | + | . | . | + | + | . |
| Tauranga Harbour, Bay of Plenty | + | + | + | + | + | + | + |
| Ohiwa Harbour, Bay of Plenty | . | + | . | . | + | + | . |
| Farewell Spit, Northwest Nelson | + | + | + | + | + | + | . |
| Tasman Bay | + | + | + | + | . | . | . |
| Avon-Heathcote Estuary, Canterbury | + | + | . | + | . | . | . |
| Lake Ellesmere, Canterbury | . | . | + | + | . | + | + |
| Wainono Lagoon, Southland | . | . | + | + | . | + | . |
| Awarua Bay, Southland | . | + | . | . | + | + | . |
| **Sites of critical importance for single taxa** | | | | | | | |
| Upper Waitaki Basin, central South Island | . | . | . | + | . | . | . |
| Paterson Inlet, Stewart Island | . | . | . | . | + | . | . |
| Auckland Islands | . | . | . | . | . | + | . |

**Table 6.** Designated Ramsar Sites in New Zealand which are important for waders.

| Site | Date listed | Area (ha) |
|---|---|---|
| Farewell Spit, Northwest Nelson | 13 August 1976 | ~ 11,388 |
| Waituna Lagoon, Southland | 13 August 1976 | ~ 5,923 |
| Firth of Thames, South Auckland | 29 January 1990 | ~ 7,800 |
| Manawatu river mouth and estuary, Manawatu | 27 July 2005 | ~ 200 |

**Table 7.** Extinct wader species in New Zealand. Taxonomy follows Holdaway *et al*. (2001). Probable cause of extinction follows Tennyson and Martinson (2006).

| Species | Probable cause of extinction |
|---|---|
| Forbes' Snipe *Coenocorypha chathamica* | Pacific Rat *Rattus exulans*, cat *Felis catus* |
| South Island Snipe *Coenocorypha iredalei* | Weka *Gallirallus australis*, Pacific Rat, Ship Rat *Rattus rattus*, cat |
| North Island Snipe *Coenocorypha barrierensis* | Pacific Rat, cat |

## RESEARCH

Until recently research on waders in New Zealand has been largely focused on the biology of threatened endemic species, viz.: Chatham Island Oystercatcher (Schmechel 2001), Black Stilt (Pierce 1996), Wrybill (Davies 1991, 1997; Hay 1984; Riegen & Dowding 2003), New Zealand Shore Plover (Davis 1994a, 1994b), New Zealand Dotterel (Dowding 1994, 1999, Dowding & Chamberlain 1991, Dowding & Murphy 1993), and snipe species (Miskelly 1999a, 1999b, Miskelly & de Lange 2006). Studies of other native species include Pied Oystercatcher (Baker 1973, 1975, Sagar & Geddes 1999, Sagar *et al*. 2000, Sagar *et al*. 2002), Variable Oystercatcher (Baker 1973, Crossland 2001), and Banded Dotterel (Pierce 1989, 1999). Remarkably, a new population of Shore Plover was discovered as recently as 1999 (Bell & Bell 2000), although this is now thought extinct (Dowding *et al.* 2005), and a possible new snipe taxon discovered (Barker *et al*. 2005).

Research on migratory, arctic-breeding waders has included banding and migration studies (Battley 1997, 1999, Riegen 1999, Battley & Piersma 2005, Riegen *et al*. 2005), as well as counts (see above). Individual colour banding of Bar-tailed Godwit, Red Knot and Ruddy Turnstone started in 2003 to investigate movements within New Zealand and this has already provided extensive information within New Zealand as well as overseas (P.F. Battley, D.S. Melville, and R. Schuckard unpubl.), and has allowed elucidation of other aspects of the ecology of Bar-tailed Godwits (Battley 2006a, 2006b).

**Table 8**. Threat status of New Zealand waders.

| Species | Hitchmough *et al.* (2005) | IUCN (2006) |
|---|---|---|
| Black Stilt *Himantopus novaezelandiae* | Nationally critical | Critically endangered |
| Chatham Island Oystercatcher *Haematopus chathamensis* | Nationally critical | Endangered |
| New Zealand Shore Plover *Thinornis novaeseelandiae* | Nationally critical | Endangered |
| Southern New Zealand Dotterel *Charadrius obscurus obscurus* | Nationally critical | Endangered |
| Wrybill *Charadrius frontalis* | Nationally vulnerable | Vulnerable |
| Banded Dotterel *Charadrius bicinctus* | Gradual decline | Lower risk/Least concern |
| Northern New Zealand Dotterel *Charadrius obscurus aquilonius* | Sparse | Endangered |
| Chatham Island Snipe *Coenocorypha pusilla* | Range restricted | Vulnerable |
| Auckland Island Banded Dotterel *Charadrius bicinctus exilis* | Range restricted | |
| Auckland Island Snipe *Coenocorypha [aucklandica] aucklandica* | Range restricted | Near threatened |
| Snares Island Snipe *Coenocorypha [aucklandica] huegeli* | Range restricted | |
| Antipodes Island Snipe *Coenocorypha [aucklandica] meinertzhagenae* | Range restricted | |

Surveillance studies for avian influenza A virus, which are ongoing, have principally sampled Red Knot and Wrybill.

## THE FUTURE

### Endemic species

The taxonomy of the New Zealand snipe requires elucidation to ensure that all taxa are adequately protected and managed. Work is in progress to determine the taxonomic status of New Zealand oystercatchers. Predator control will be a continuing management requirement for species such as Black Stilt, New Zealand Dotterel, and increasingly Wrybill.

### Arctic-breeding species

The migration routes and use of stopover sites used by waders between New Zealand and their breeding grounds remain poorly known. Some Red Knots use northern Australia on northward migration but there is no detailed information on how many do so, how predictably, and whether those that do not stop there migrate direct to the Yellow Sea area or have other stopover sites. A further complication is if New Zealand hosts a mix of knots of the subspecies *rogersi* and *piersmai* (Tomkovich & Riegen 2000) that may have different migration schedules (Battley *et al*. 2005b). Locating the staging areas of Red Knots in the Yellow Sea on northward migration, and all southward migration staging sites, is a high priority. Whether Bar-tailed Godwits migrate direct to Asia from New Zealand is unknown (Battley & Piersma 2005). Resightings of colour-banded birds in Asia 11 days after last being seen in New Zealand (P.F. Battley unpubl.) indicates a quick migration of some individuals but does not rule out the possibility of a short stopover *en route*. The bulk of the population seems to reach Asia many weeks after migration starts in New Zealand, suggesting that some birds may make stopovers on their way north. Satellite telemetry studies of Bar-tailed Godwits during the northward migration in 2007 should allow the identification of any stopover area(s) used by birds that do not migrate directly to the Yellow Sea region. Global climate change is likely to affect weather patterns over the Pacific (Vecchi *et al.* 2006) and if wind patterns change this could seriously impact southward migrating Bar-tailed Godwits which are thought to make the 11,000 km journey non-stop with considerable wind assistance (Gill *et al*. 2005). The breeding grounds of Ruddy Turnstones visiting New Zealand are unknown and further work is required.

Censuses of non-breeding arctic shorebirds in New Zealand and Australia are the only practical way to determine population trends for a number of taxa. 'Implementation of statistically robust methodologies to monitor shorebird populations in priority countries' (including New Zealand and Australia) was a priority action in the *Action Plan for the Conservation of migratory shorebirds in the East Asian-Australasian Flyway: 2001-2005*. The timing of counts requires further consideration to ensure that these are undertaken at a time when populations are as stable as possible, and they should be coordinated in both countries (Wilson 2001). The ability to assess the proportions of juveniles in populations to measure breeding success (Minton *et al*. 2005) is limited in New Zealand due to relatively low catching activity and the tendency of young knots at least to occur predominantly in Australia, but the field identification of juvenile Bar-tailed Godwits is possible (http://osnz.org.nz/nzwaderstudy.htm#juv) and should be encouraged.

There is increasing demand for coastal and estuarine monitoring by local authorities to meet their obligations under the Local Government Act and the amended Resource Management Act. At present this usually relates to physico-chemical properties, but a wider ecological approach is being encouraged (Robertson *et al*. 2002). Understanding of the distribution of waders in relation to environmental variables is at an early stage (Whelan *et al*. 2003) but there is potential for including shorebirds in local authority 'state of the environment' monitoring.

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## REFERENCES


**Aikman, H., A. Davis, C. Miskelly, S. O'Connor & G. Taylor.** 2001. Management plan for Chatham Island Snipe, 2001-2011. in Chatham Islands threatened birds: Recovery and management plans. Department of Conservation, Wellington.

**Anon.** http://encarta.msn.com/encyclopedia_761555687/New_Zealand.html. Accessed 14 November 2006.

**Anon.** 2001. Chatham island oystercatcher recovery plan 2001-2011. Threatened Species Recovery Plan 38. Department of Conservation, Wellington.

**Baker, A.J.** 1973. Distribution and numbers of New Zealand oystercatchers. Notornis 20: 128-144.

**Baker, A.J.** 1975. Age structure and sex ratio of live-trapped samples of South Island Pied Oystercatchers (*Haematopus ostralegus finschi*). Notornis 22: 189-194.

**Barker, D., J.W.A. Carroll, H.K. Edmonds, J.R. Fraser and C.M. Miskelly.** 2005. Discovery of a previously unknown *Coenocorypha* snipe in the Campbell Island group, New Zealand subantarctic. Notornis 52: 143-149.

**Barlow, M.** 1972. The establishment, dispersal and distribution of the Spur-winged Plover in New Zealand. Notornis 19: 201-211.

**Battley, P.F.** 1996. The ecology of migrant waders in New Zealand, focusing on Farewell Spit, North-West Nelson. MSc thesis, Department of Ecology, Massey University, Palmerston North

**Battley, P.F.** 1997. The northward migration of Arctic waders in New Zealand: departure behaviour, timing and possible migration routes of Red Knots and Bar-tailed Godwits from Farewell Spit, North-West Nelson. Emu 97: 108-120

**Battley, P.F.** 1999. Seasonal mass changes of Lesser Knots (*Calidris canutus*) in New Zealand. Notornis 46: 143-154.

**Battley, P.F.** 2006a. Consistent annual schedules in a migratory shorebird. Biology Letters 2: 517-520.

**Battley, P.F.** 2006b. Plumage and timing of migration in bar-tailed godwits: a comment on Drent *et al*. (2003). Oikos 116: 349-352.

**Battley, P.F. & T. Piersma.** 2005. Body size, fat loads and organ masses of Bar-tailed Godwits (*Limosa lapponica baueri*) before their transoceanic northward migration from New Zealand. Auk 122: 922-937.

**Battley, P.F., D.S. Melville, R. Schuckard & P.F. Balance.** 2005a. Quantitative survey of the intertidal benthos of Farewell Spit, Golden Bay. Marine Biodiversity Biosecurity Report 7. Ministry of Fisheries, Wellington. http://www.biodiversity.govt.nz/pdfs/seas/MBBR_7_Battley_et_al_Farewell_Spit.pdf

**Battley, P.F., D.I. Rogers, J.A. van Gils, T. Piersma, C.J. Hassell, C.J., A, Boyle & Yang, H-Y.** 2005b. How do red knots leave Northwest Australia in May and reach the breeding grounds in June? Predictions of stopover times, fuelling rates and prey quality in the Yellow Sea. Journal of Avian Biology 36: 494-500.

**Battley, P.F., S.J. Moore & A.M. Habraken.** 2007. Shorebird counts in the Manukau Harbour and Firth of Thames (Tikapa Moana) 1960 – 2005. Chapter 2, in Battley, P.F. and Brownell, B. (eds) Population biology and foraging ecology of waders in the Firth of Thames: update 2006. Auckland Regional Council report, in press.

**Bell, D. & M. Bell.** 2000. Discovery of a second natural wild population of the New Zealand Shore Plover (*Thinornis novaeseelandiae*). Notornis 47: 166-167.

**Brownell, B.** 2004. Muddy feet. Firth of Thames Ramsar Site update 2004. EcoQuest Education Foundation Report Series 1. EcoQuest Education Foundation, Pokeno.

**Chadderton, W.L., D.J. Brown & R.T. Stephens.** 2004. Identifying freshwater ecosystems of national importance for biodiversity. Criteria, methods and candidate list of nationally important rivers. Discussion document. Department of Conservation, Wellington. pp. 112.

**Cromarty, P. & D.A. Scott.** 1996. A directory of wetlands in New Zealand. Department of Conservation, Wellington.

**Crossland, A.C.** 2001. Long-term changes in numbers of Variable Oystercatcher (*Haematopus unicolor*) at two wintering sites in Canterbury, South Island, New Zealand. Stilt 40: 2-6.

**Davies, S.J.** 1991. Longevity, breeding success, and faithfulness to wintering sites of Wrybill – as suggested by banding data. Stilt 19: 26-27.

**Davies, S.J.** 1997. Population structure, morphometrics, moult, migration, and wintering of the Wrybill (*Anarhynchos frontalis*). Notornis 44: 1-14.

**Davis, A.** 1994a. Status, distribution, and population trends of the New Zealand Shore Plover *Thinornis novaeseelandiae*. Notornis (Supplement) 41: 179-194.

**Davis, A.** 1994b. Breeding biology of the New Zealand Shore Plover *Thinornis novaeseelandiae*. Notornis (Supplement) 41: 195-208.

**Dinamani, P.** 1971. Occurrence of the Japanese oyster, *Crassostrea gigas* (Thunberg), in Northland, New Zealand. New Zealand Journal of Marine and Freshwater Research 5: 352-357.

**Dowding, J.E.** 1993. New Zealand Dotterel Recovery Plan. Threatened Species Recovery Plan Series 10. Department of Conservation, Wellington. http://www.doc.govt.nz/upload/documents/science-and-technical/tsrp10.pdf

**Dowding, J.E.** 1994. Morphometrics and ecology of the New Zealand Dotterel (*Charadrius obscurus*), with a description of a new subspecies. Notornis 41: 221-233.

**Dowding, J.E.** 1999. Past distribution and decline of the New Zealand Dotterel (*Charadrius obscurus*) in the South Island of New Zealand. Notornis 46: 167-180.

**Dowding, J.E. & S.P. Chamberlain.** 1991. Annual movement patterns and breeding-site fidelity of the New Zealand Dotterel (*Charadrius obscurus*). Notornis 38: 89-102.

**Dowding, J.E. & E.C. Murphy.** 1993. Decline of the Stewart Island population of the New Zealand Dotterel. Notornis 40: 1-13.

**Dowding, J.E., R. Collen, A.M. Davis, S.M. O'Connor & M.H. Smith.** 2005. Gains and losses in the New Zealand Shore Plover (*Thinornis novaeseelandiae*) recovery programme 1993-2003. pp. 36-42 in Straw, P. (ed.). Status and conservation of shorebirds in the East Asian-Australasian Flyway; Proceedings of the Australasian Shorebirds Conference 13-125 December 2003, Canberra, Australia. Wetlands International Global Series 18, International Wader Studies 17. Sydney, Australia.

**Dowding, J.E. & A.M. Davis.** 2007: New Zealand dotterel (*Charadrius obscurus*) recovery plan, 2004–14. Threatened Species Recovery Plan *58*. Department of Conservation, Wellington. 28 pages. http://doc.govt.nz/upload/documents/science-and-technical/tsrp58.pdf

**Dowding, J.E. & S.J. Moore.** 2006. Habitat networks of indigenous shorebirds in New Zealand. Science for Conservation 261. Department of Conservation, Wellington.

**Dowding, J.E. & E.C. Murphy.** 2001. The impact of predation by introduced mammals on endemic shorebirds in New Zealand: a conservation perspective. Biological Conservation 99: 47-64.

**Gill, R.E., T. Piersma, G. Hufford, R. Servranckx & A. Riegen.** 2005. Crossing the ultimate ecological barrier: evidence for an 11,000-km-long non-stop flight from Alaska to New Zealand and eastern Australia by Bar-tailed Godwits. Condor 107: 1-20.

**Green, M.O.** 2006. New Zealand estuaries: how they work and issues that affect them. NIWA Information Series 59. 101 pp. www.niwascience.co.nz/freshwater/nzestuaries.

**Green, M., J. Ellis, A-M. Schwarz, N. Green, D. Lind & B. Bluck.** 2003. For and against mangrove control. NIWA Information Series 31. pp. 8.

**Greene, B.** 1999. Genetic variation and hybridisation of Black Stilts (*Himantopus novaezelandiae*) and Pied Stilts (*H.h. leucocephalus*), Order Charadriiformes. New Zealand Journal of Zoology 26: 271-277.

**Hay, J.R.** 1984. The behavioural ecology of the Wrybill Plover *Anarhynchus frontalis*. Unpublished PhD thesis, University of Auckland, Auckland. 172p.

**Heather, B. & H. Robertson.** 1996. The Field Guide to the Birds of New Zealand. Viking, Auckland.

**Hill, C.** 2006. First record of a Stilt Sandpiper (*Mircopalama himantopus*) in New Zealand. Notornis 53: 320-321.

**Hitchmough, R., L. Bull, & P. Cromarty.** (Compilers). 2005. New Zealand threat classification system lists. Department of Conservation, Wellington.

**Holdaway, R.N.** 1995. A fossil record of the black stilt *Himantopus novaezelandiae* Gould, 1841. New Zealand natural sciences 22: 69-74.

**Holdaway, R.N., T.H. Worthy & A.J.D. Tennyson.** 2001. A working list of breeding bird species of the New Zealand region at first human contact. New Zealand Journal of Zoology 28: 119-187.

**IUCN.** 2006. 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 23 February 2007.

**Maloney, R.F. & D. Murray.** 2002. Kaki (Black Stilt) recovery plan 2001-2011. Department of Conservation.

**MAF.** 2006.Land cover database: North Island areas. http://www.maf.govt.nz/statistics/primaryindustries/landcover/tables/11-lc-ni.htm Accessed 14 November 2006

**Minton, C., R. Jessop, P. Collins & K. Gosbell.** 2005. Monitoring shorebird breeding productivity by the percentage of first year birds in populations in S.E. Australian non-breeding areas. pp. 73-85 in Straw, P. (ed.). Status and conservation of shorebirds n the East Asian-Australasian Flyway; Proceedings of the Australasian Shorebirds Conference 13-15 December 2003, Canberra, Australia. Wetlands International Global Series 18, International Wader Studies 17. Sydney, Australia.

**Miskelly, C.M.** 1999a. Breeding ecology of Snares Island Snipe (*Coenocorypha aucklandica buegeli*) and Chatham Island Snipe (*C. pusilla*). Notornis 46: 207-221.

**Miskelley, C.M.** 1999b. Social constraints on access to mates in a high density population of New Zealand Snipe (*Coenocorypha aucklandica*). Notornis 46: 223-239.

**Miskelly, C.M. & J.R. Fraser.** 2006. Campbell Island snipe (*Coenocorypha* undescribed sp.) recolonise subantarctic Campbell Island following rat eradication. Notornis 53: 353-359.

**Miskelly, C.M. & P.J. de Lange.** 2006. Notes on the breeding ecology of the extinct Stewart Island snipe (*Coenocorypha aucklandica iredalei*). Notornis 53: 339-352.

**Morton, J.** 2004. *Seashore ecology of New Zealand and the Pacific*. David Bateman, Auckland.

**Morton, J. & M. Miller.** 1973. The New Zealand seashore. 2nd edition Collins, Auckland.

**O'Donnell, C.** 2004. River bird communities. pp. 18.1-18.19 in Harding, J., Mosley, P., Pearson, C. and Sorrell, B. (eds.). Freshwaters of New Zealand. New Zealand Hydrological Society and New Zealand Limnological Society, Christchurch.

**Partridge, T.R.** 1987. *Spartina* in New Zealand. *New Zealand Journal of Botany* 25: 567-575.

**Petch, S., C. Hill & N. Allen.** 2002. First record of a Long-toed Stint (*Calidris subminuta*) in New Zealand. Notornis 49: 185-186.

**Pierce, R.J.** 1996. Ecology and management of the Black Stilt *Himantopus novaezelandiae*. Bird Conservation International 6: 81-88.

**Pierce, R.J.** 1989. Breeding and social patterns of the Banded Dotterels (*Charadrius bicinctus*) at Cas River. Notornis 36: 13-23.

**Pierce, R.J.** 1999. Regional patterns of migration in the Banded Dotterel (*Charadrius bicinctus bicinctus*). Notornis 46: 101-122.

**Rance, B. & W. Cooper.** 1997. Case Study 3: New Zealand. Waituna Wetlands Scientific Reserve. In Hails, A.J. (ed.), Wetlands, Biodiversity and the Ramsar Convention: The Role of the Convention on Wetlands in the Conservation and Wise Use of Biodiversity. Ramsar Convention Bureau, Gland, Switzerland

**Riegen, A.C.** 1999. Movements of banded Arctic waders to and from New Zealand. Notornis 46: 123-142.

**Riegen, A.C. & J.E. Dowding.** 2003. The Wrybill *Anarhynchus frontalis*: a brief review of status, threats and work in progress. Wader Study Group Bulletin 100: 20-24.

**Riegen, A., C.D.T. Minton, R. Jessop & P. Collins.** 2005. Movements of Red Knot between Australia and New Zealand. Pp. 175-182 *in* Straw, P. (ed.). Status and conservation of shorebirds in the East Asian-Australasian Flyway; Proceedings of the Australasian Shorebirds Conference 13-125 December 2003, Canberra, Australia. Wetlands International Global Series 18, International Wader Studies 17. Sydney, Australia.

**Robertson, B., P. Gillespie, R. Asher, S. Frisk, N. Keely, G. Hopkins, S. Thompson & B. Tuckey.** 2002. Estuarine environmental assessment and monitoring: a national protocol. Ministry for the Environment, Wellington.

**Sagar, P.M. & D. Geddes.** 1999. Dispersal of South Island Pied Oystercatchers (*Haematopus ostralegus finschi*) from an inland breeding area of New Zealand. Notornis 46: 89-99.

**Sagar, P.M., R.J. Barker & D. Geddes.** 2002. Survival of breeding Finch's oystercatchers (*Haematopus finschi*) on farmland in Canterbury, New Zealand. Notornis 49: 233-240.

**Sagar, P.M., D. Geddes, J. Banks & P. Howden.** 2000. Breeding of South Island Pied Oystercatchers (*Haematopus ostralegus finschi*) on farmland in mid-Canterbury, New Zealand. Notornis 47: 71-81.

**Sagar, P.M., U. Shankar & S. Brown.** 1999. Distribution and numbers of waders in New Zealand, 1983-1994. Notornis 46: 1-43.

**Schmechel, F.A.** 2001. Aspects of habitat selection, population dynamics, and breeding biology of the endangered Chatham Island Oystercatcher (*Haematopus chathamensis*). D. Phil. Thesis, Lincoln University.

**Schuckard, R.** 2002. Wader distribution at Farewell Spit, Golden Bay and Tasman Bay. Occasional Publication 54, Nelson/Marlborough Conservancy. Department of Conservation, Nelson.

**Taylor, R. & I. Smith.** 1997. The State of New Zealand's Environment. Ministry for the Environment, Wellington.

**Tennyson, A. & P. Martinson.** 2006. Extinct birds of New Zealand. Te Papa Press, Wellington.

**Thompson, R.M. & G.R. Ryder.** 2003. Waituna Lagoon: summary of extent of knowledge and identification of knowledge gaps. Science for Conservation 215. Department of Conservation, Wellington.

**Tomkovich, P.S. & A.C. Riegen.** 2000. Mixing of Red Knot populations in Australasia: some thoughts. Stilt 37: 25-27.

**Turbott, E.G.** 1990. Checklist of the Birds of New Zealand and Ross Dependency, Antarctica. Third Edition. Random Century, Auckland.

**Vecchi, G.A., B.J. Soden, A.T. Wittenberg, I.M. Held, A. Leetmaa & M.J. Harrison.** 2006. Weakening of tropical Pacific atmospheric circulation due to anthropogenic forcing. Nature 441: 73-76.

**Walker, K., P. Moore & G. Elliott.** 1991.The Auckland Island Dotterel has apparently increased. Notornis 38: 257-265

**Wardle, P.** 1991. Vegetation of New Zealand. Cambridge University Press, Cambridge.

**Wetlands International.** 2006. Waterbird population estimates. Fourth Edition. Wetlands International, Wageningen, The Netherlands.

**Whelan, M.B., T.M. Hume, P.M. Sagar, U. Shankar & R. Liefting.** 2003. Relationship between physical characteristics of estuaries and the size and diversity of wader populations in the North Island of New Zealand. Notornis 50: 11-22.

**Wilson, J.R.** 2001. The Australasian Wader Studies Group population monitoring project: where to now? Perspectives from the chair. Stilt 39: 13-26.

**Worthy, T.H. & R.N. Holdaway.** 2002. *The lost world of the Moa: prehistoric life of New Zealand*. Canterbury University Press, Christchurch.

**Woodley, K.** 2005. Threats to shorebirds: Managing mangrove expansion in the Firth of Thames, New Zealand. pp. 92-93 in Straw, P. (ed.). Status and conservation of shorebirds in the East Asian-Australasian Flyway; Proceedings of the Australasian Shorebirds Conference 13-125 December 2003, Canberra, Australia. Wetlands International Global Series 18, International Wader Studies 17. Sydney, Australia.